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2015 American Heart Association Guidelines Update for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care

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2015 American Heart Association and American Red Cross Guidelines Update for First Aid

Part 1: Executive Summary

2015 American Heart Association Guidelines Update for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care

Robert W. Neumar, Chair; Michael Shuster; Clifton W. Callaway; Lana M. Gent; Dianne L. Atkins; Farhan Bhanji; Steven C. Brooks; Allan R. de Caen; Michael W. Donnino; Jose Maria E. Ferrer; Monica E. Kleinman; Steven L. Kronick; Eric J. Lavonas; Mark S. Link; Mary E. Mancini; Laurie J. Morrison; Robert E. O'Connor; Ricardo A. Samson; Steven M. Schexnayder; Eunice M. Singletary; Elizabeth H. Sinz; Andrew H. Travers; Myra H. Wyckoff; Mary Fran Hazinski

Introduction

Publication of the *2015 American Heart Association* (AHA) *Guidelines Update for Cardiopulmonary Resuscitation* (CPR) *and Emergency Cardiovascular Care* (ECC) marks 49 years since the first CPR guidelines were published in 1966 by an Ad Hoc Committee on Cardiopulmonary Resuscitation established by the National Academy of Sciences of the National Research Council.[1] Since that time, periodic revisions to the Guidelines have been published by the AHA in 1974,[2] 1980,[3] 1986,[4] 1992,[5] 2000,[6] 2005,[7] 2010,[8] and now 2015. The *2010 AHA Guidelines for CPR and ECC* provided a comprehensive review of evidence-based recommendations for resuscitation, ECC, and first aid. The *2015 AHA Guidelines Update for CPR and ECC* focuses on topics with significant new science or ongoing controversy, and so serves as an update to the *2010 AHA Guidelines for CPR and ECC* rather than a complete revision of the Guidelines.

The purpose of this Executive Summary is to provide an overview of the new or revised recommendations contained in the 2015 Guidelines Update. This document does not contain extensive reference citations; the reader is referred to Parts 3 through 9 for more detailed review of the scientific evidence and the recommendations on which they are based.

There have been several changes to the organization of the 2015 Guidelines Update compared with 2010. "Part 4: Systems of Care and Continuous Quality Improvement" is an important new Part that focuses on the integrated structures and processes that are necessary to create systems of care for both in-hospital and out-of-hospital resuscitation capable of measuring and improving quality and patient outcomes. This Part replaces the "CPR Overview" Part of the 2010 Guidelines.

Another new Part of the 2015 Guidelines Update is "Part 14: Education," which focuses on evidence-based recommendations to facilitate widespread, consistent, efficient and effective implementation of the AHA Guidelines for CPR and ECC into practice. These recommendations will target resuscitation education of both lay rescuers and healthcare providers. This Part replaces the 2010 Part titled "Education, Implementation, and Teams." The 2015 Guidelines Update does not include a separate Part on adult stroke because the content would replicate that already offered in the most recent AHA/American Stroke Association guidelines for the management of acute stroke.[9,10]

Finally, the 2015 Guidelines Update marks the beginning of a new era for the AHA Guidelines for CPR and ECC, because the Guidelines will transition from a 5-year cycle of periodic revisions and updates to a Web-based format that is continuously updated. The first release of the Web-based integrated Guidelines, now available online at ECCguidelines.heart.org is based on the comprehensive 2010 Guidelines plus the 2015 Guidelines Update. Moving forward, these Guidelines will be updated by using a continuous evidence evaluation process to facilitate more rapid translation of new scientific discoveries into daily patient care.

Creation of practice guidelines is only 1 link in the chain of knowledge translation that starts with laboratory and clinical science and culminates in improved patient outcomes. The AHA ECC Committee has set an impact goal of doubling bystander CPR rates and doubling cardiac arrest survival by 2020. Much work will be needed across the entire spectrum of knowledge translation to reach this important goal.

Evidence Review and Guidelines Development Process

The process used to generate the *2015 AHA Guidelines Update for CPR and ECC* was significantly different from the process used in prior releases of the Guidelines, and marks the planned transition from a 5-year cycle of evidence review to a continuous evidence evaluation process. The AHA continues to partner with the International Liaison Committee on Resuscitation (ILCOR) in the evidence review process. However, for 2015, ILCOR prioritized topics for systematic review based on clinical significance and availability of new

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evidence. Each priority topic was defined as a question in PICO (population, intervention, comparator, outcome) format. Many of the topics reviewed in 2010 did not have new published evidence or controversial aspects, so they were not reviewed in 2015. In 2015, 165 PICO questions were addressed by systematic reviews, whereas in 2010, 274 PICO questions were addressed by evidence evaluation. In addition, ILCOR adopted the Grading of Recommendations Assessment, Development, and Evaluation (GRADE) process for evidence evaluation and expanded the opportunity for public comment. The output of the GRADE process was used to generate the *2015 International Consensus on CPR and ECC Science With Treatment Recommendations* (CoSTR).[11,12]

The recommendations of the ILCOR 2015 CoSTR were used to inform the recommendations in the *2015 AHA Guidelines Update for CPR and ECC*. The wording of these recommendations is based on the AHA classification system for evidentiary review (see "Part 2: Evidence Evaluation and Management of Conflicts of Interest").

The *2015 AHA Guidelines Update for CPR and ECC* contains 315 classified recommendations. There are 78 Class I recommendations (25%), 217 Class II recommendations (68%), and 20 Class III recommendations (7%). Overall, 3 (1%) are based on Level of Evidence (LOE) A, 50 (15%) are based on LOE B-R (randomized studies), 46 (15%) are based on LOE B-NR (nonrandomized studies), 145 (46%) are based on LOE C-LD (limited data), and 73 (23%) are based on LOE C-EO (consensus of expert opinion). These results highlight the persistent knowledge gap in resuscitation science that needs to be addressed through expanded research initiatives and funding opportunities.

As noted above, the transition from a 5-year cycle to a continuous evidence evaluation and Guidelines update process will be initiated by the 2015 online publication of the AHA Integrated Guidelines for CPR and ECC at ECCguidelines.heart.org. The initial content will be a compilation of the 2010 Guidelines and the 2015 Guidelines Update. In the future, the Scientific Evidence Evaluation and Review System (SEERS) Web-based resource will also be periodically updated with results of the ILCOR continuous evidence evaluation process at www.ilcor.org/seers.

Part 3: Ethical Issues

As resuscitation practice evolves, ethical considerations must also evolve. Managing the multiple decisions associated with resuscitation is challenging from many perspectives, especially when healthcare providers are dealing with the ethics surrounding decisions to provide or withhold emergency cardiovascular interventions.

Ethical issues surrounding resuscitation are complex and vary across settings (in or out of hospital), providers (basic or advanced), patient population (neonatal, pediatric, or adult), and whether to start or when to terminate CPR. Although the ethical principles involved have not changed dramatically since the 2010 Guidelines were published, the data that inform many ethical discussions have been updated through the evidence review process. The 2015 ILCOR evidence review process and resultant 2015 Guidelines Update include several recommendations that have implications for ethical decision making in these challenging areas.

Significant New and Updated Recommendations That May Inform Ethical Decisions

- The use of extracorporeal CPR (ECPR) for cardiac arrest
- Intra-arrest prognostic factors for infants, children, and adults
- Prognostication for newborns, infants, children, and adults after cardiac arrest
- Function of transplanted organs recovered after cardiac arrest

New resuscitation strategies, such as ECPR, have made the decision to discontinue cardiac arrest measures more complicated (see "Part 6: Alternative Techniques and Ancillary Devices for Cardiopulmonary Resuscitation" and "Part 7: Adult Advanced Cardiovascular Life Support"). Understanding the appropriate use, implications, and likely benefits related to such new treatments will have an impact on decision making. There is new information regarding prognostication for newborns, infants, children, and adults with cardiac arrest and/or after cardiac arrest (see "Part 13: Neonatal Resuscitation," "Part 12: Pediatric Advanced Life Support," and "Part 8: Post–Cardiac Arrest Care"). The increased use of targeted temperature management has led to new challenges for predicting neurologic outcomes in comatose post–cardiac arrest patients, and the latest data about the accuracy of particular tests and studies should be used to guide decisions about goals of care and limiting interventions.

With new information about the success rate for transplanted organs obtained from victims of cardiac arrest, there is ongoing discussion about the ethical implications around organ donation in an emergency setting. Some of the different viewpoints on important ethical concerns are summarized in "Part 3: Ethical Issues." There is also an enhanced awareness that although children and adolescents cannot make legally binding decisions, information should be shared with them to the extent possible, using appropriate language and information for their level of development. Finally, the phrase "limitations of care" has been changed to "limitations of interventions," and there is increasing availability of the Physician Orders for Life-Sustaining Treatment (POLST) form, a new method of legally identifying people who wish to have specific limits on interventions at the end of life, both in and out of healthcare facilities.

Part 4: Systems of Care and Continuous Quality Improvement

Almost all aspects of resuscitation, from recognition of cardiopulmonary compromise, through cardiac arrest and resuscitation and post–cardiac arrest care, to the return to productive life, can be discussed in terms of a system or systems of care. Systems of care consist of multiple working parts that are interdependent, each having an effect on every other aspect of the care within that system. To bring about any improvement, providers must recognize the interdependency of the various parts of the system. There is also increasing recognition that out-of-hospital cardiac arrest (OHCA) and in-hospital cardiac arrest (IHCA) systems of care must function differently. "Part 4: Systems of Care and Continuous Quality Improvement" in this 2015 Guidelines Update makes a clear distinction between the two systems, noting that OHCA frequently is the result of an unexpected event with a reactive element, whereas

the focus on IHCA is shifting from reactive resuscitation to prevention. New Chains of Survival are suggested for in-hospital and out-of-hospital systems of care, with relatively recent in-hospital focus on prevention of arrests. Additional emphasis should be on continuous quality improvement by identifying the problem that is limiting survival, and then by setting goals, measuring progress toward those goals, creating accountability, and having a method to effect change in order to improve outcomes.

This new Part of the AHA Guidelines for CPR and ECC summarizes the evidence reviewed in 2015 with a focus on the systems of care for both IHCA and OHCA, and it lays the framework for future efforts to improve these systems of care. A universal taxonomy of systems of care is proposed for stakeholders. There are evidence-based recommendations on how to improve these systems.

Significant New and Updated Recommendations

In a randomized trial, social media was used by dispatchers to notify nearby potential rescuers of a possible cardiac arrest. Although few patients ultimately received CPR from volunteers dispatched by the notification system, there was a higher rate of bystander-initiated CPR (62% versus 48% in the control group).[13] Given the low risk of harm and the potential benefit of such notifications, municipalities could consider incorporating these technologies into their OHCA system of care. It may be reasonable for communities to incorporate, where available, social media technologies that summon rescuers who are willing and able to perform CPR and are in close proximity to a suspected victim of OHCA (Class IIb, LOE B-R).

Specialized cardiac arrest centers can provide comprehensive care to patients after resuscitation from cardiac arrest. These specialized centers have been proposed, and new evidence suggests that a regionalized approach to OHCA resuscitation may be considered that includes the use of cardiac resuscitation centers.

A variety of early warning scores are available to help identify adult and pediatric patients at risk for deterioration. Medical emergency teams or rapid response teams have been developed to help respond to patients who are deteriorating. Use of scoring systems to identify these patients and creation of teams to respond to those scores or other indicators of deterioration may be considered, particularly on general care wards for adults and for children with high-risk illnesses, and may help reduce the incidence of cardiac arrest.

Evidence regarding the use of public access defibrillation was reviewed, and the use of automated external defibrillators (AEDs) by laypersons continues to improve survival from OHCA. We continue to recommend implementation of public access defibrillation programs for treatment of patients with OHCA in communities who have persons at risk for cardiac arrest.

Knowledge Gaps

- What is the optimal model for rapid response teams in the prevention of IHCA, and is there evidence that rapid response teams improve outcomes?
- What are the most effective methods for increasing bystander CPR for OHCA?
- What is the best composition for a team that responds to IHCA, and what is the most appropriate training for that team?

Part 5: Adult Basic Life Support and Cardiopulmonary Resuscitation Quality

New Developments in Basic Life Support Science Since 2010

The 2010 Guidelines were most notable for the reorientation of the universal sequence from A-B-C (Airway, Breathing, Compressions) to C-A-B (Compressions, Airway, Breathing) to minimize time to initiation of chest compressions. Since 2010, the importance of high-quality chest compressions has been reemphasized, and targets for compression rate and depth have been further refined by relevant evidence. For the untrained lay rescuer, dispatchers play a key role in the recognition of abnormal breathing or agonal gasps as signs of cardiac arrest, with recommendations for chest compression–only CPR.

This section presents the updated recommendations for the 2015 adult basic life support (BLS) guidelines for lay rescuers and healthcare providers. Key changes and continued points of emphasis in this 2015 Guidelines Update include the following: The crucial links in the adult Chain of Survival for OHCA are unchanged from 2010; however, there is increased emphasis on the rapid identification of potential cardiac arrest by dispatchers, with immediate provision of CPR instructions to the caller. These Guidelines take into consideration the ubiquitous presence of mobile phones that can allow the rescuer to activate the emergency response system without leaving the victim's side. For healthcare providers, these recommendations allow flexibility for activation of the emergency response to better match the provider's clinical setting. More data are available indicating that high-quality CPR improves survival from cardiac arrest. Components of high-quality CPR include

- Ensuring chest compressions of adequate rate
- Ensuring chest compressions of adequate depth
- Allowing full chest recoil between compressions
- Minimizing interruptions in chest compressions
- Avoiding excessive ventilation

Recommendations are made for a simultaneous, choreographed approach to performance of chest compressions, airway management, rescue breathing, rhythm detection, and shock delivery (if indicated) by an integrated team of highly trained rescuers in applicable settings.

Significant New and Updated Recommendations

Many studies have documented that the most common errors of resuscitation are inadequate compression rate and depth; both errors may reduce survival. New to this 2015 Guidelines Update are upper limits of recommended compression rate based on preliminary data suggesting that excessive rate may be associated with lower rate of return of spontaneous circulation (ROSC). In addition, an upper limit of compression depth is introduced

based on a report associating increased non–life-threatening injuries with excessive compression depth.

- In adult victims of cardiac arrest, it is reasonable for rescuers to perform chest compressions at a rate of 100 to 120/min (Class IIa, LOE C-LD). The addition of an upper limit of compression rate is the result of 1 large registry study associating extremely rapid compression rates with inadequate compression depth.
- During manual CPR, rescuers should perform chest compressions at a depth of at least 2 inches or 5 cm for an average adult, while avoiding excessive chest compression depths (greater than 2.4 inches [6 cm]) (Class I, LOE C-LD). The addition of an upper limit of compression depth followed review of 1 publication suggesting potential harm from excessive chest compression depth (greater than 6 cm, or 2.4 inches). Compression depth may be difficult to judge without use of feedback devices, and identification of upper limits of compression depth may be challenging.
- In adult cardiac arrest, total preshock and postshock pauses in chest compressions should be as short as possible (Class I, LOE C-LD) because shorter pauses can be associated with greater shock success, ROSC, and, in some studies, higher survival to hospital discharge. The need to reduce such pauses has received greater emphasis in this 2015 Guidelines Update.
- In adult cardiac arrest with an unprotected airway, it may be reasonable to perform CPR with the goal of a chest compression fraction as high as possible, with a target of at least 60% (Class IIb, LOE C-LD). The addition of this target compression fraction to the 2015 Guidelines Update is intended to limit interruptions in compressions and to maximize coronary perfusion and blood flow during CPR.
- For patients with known or suspected opioid addiction who have a definite pulse but no normal breathing or only gasping (ie, a respiratory arrest), in addition to providing standard BLS care, it is reasonable for appropriately trained BLS providers to administer intramuscular or intranasal naloxone (Class IIa, LOE C-LD). It is reasonable to provide opioid overdose response education with or without naloxone distribution to persons at risk for opioid overdose in any setting (Class IIa, LOE C-LD). For more information, see "Part 10: Special Circumstances of Resuscitation."
- For witnessed OHCA with a shockable rhythm, it may be reasonable for emergency medical service (EMS) systems with priority-based, multi-tiered response to delay positive-pressure ventilation by using a strategy of up to 3 cycles of 200 continuous compressions with passive oxygen insufflation and airway adjuncts (Class IIb, LOE C-LD).
- We do not recommend the routine use of passive ventilation techniques during conventional CPR for adults, because the usefulness/effectiveness of these techniques is unknown (Class IIb, LOE C-EO). However, in EMS systems that use bundles of care involving continuous chest compressions, the use of passive ventilation techniques may be considered as part of that bundle (Class IIb, LOE C-LD).
- It is recommended that emergency dispatchers determine if a patient is unconscious with abnormal breathing after acquiring the requisite information to determine the location of the event (Class I, LOE C-LD).
- If the patient is unconscious with abnormal or absent breathing, it is reasonable for the emergency dispatcher to assume that the patient is in cardiac arrest (Class IIa, LOE C-LD).
- Dispatchers should be educated to identify unconsciousness with abnormal and agonal gasps across a range of clinical presentations and descriptions (Class I, LOE C-LD).
- We recommend that dispatchers should provide chest compression–only CPR instructions to callers for adults with suspected OHCA (Class I, LOE C-LD).
- It is reasonable for healthcare providers to provide chest compressions and ventilation for all adult patients in cardiac arrest, from either a cardiac or a noncardiac cause (Class IIb, LOE C-LD). When the victim has an advanced airway in place during CPR, rescuers no longer deliver cycles of 30 compressions and 2 breaths (ie, they no longer interrupt compressions to deliver 2 breaths). Instead, it may be reasonable for the provider to deliver 1 breath every 6 seconds (10 breaths per minute) while continuous chest compressions are being performed (Class IIb, LOE C-LD). When the victim has an advanced airway in place during CPR, it may be reasonable for the provider to deliver 1 breath every 6 seconds (10 breaths per minute) while continuous chest compressions are being performed (Class IIb, LOE C-LD). This simple rate, rather than a range of breaths per minute, should be easier to learn, remember, and perform.
- There is insufficient evidence to recommend the use of artifact-filtering algorithms for analysis of electrocardiographic (ECG) rhythm during CPR. Their use may be considered as part of a research program or if an EMS system has already incorporated ECG artifact-filtering algorithms in its resuscitation protocols (Class IIb, LOE C-EO).
- It may be reasonable to use audiovisual feedback devices during CPR for real-time optimization of CPR performance (Class IIb, LOE B-R).
- For victims with suspected spinal injury, rescuers should initially use manual spinal motion restriction (eg, placing 1 hand on either side of the patient's head to hold it still) rather than immobilization devices, because use of immobilization devices by lay rescuers may be harmful (Class III: Harm, LOE C-LD).

Knowledge Gaps

- The optimal method for ensuring adequate depth of chest compressions during manual CPR
- The duration of chest compressions after which ventilation should be incorporated when using Hands-Only CPR
- The optimal chest compression fraction
- Optimal use of CPR feedback devices to increase patient survival

Part 6: Alternative Techniques and Ancillary Devices for Cardiopulmonary Resuscitation

High-quality conventional CPR (manual chest compressions with rescue breaths) generates about 25% to 33% of normal cardiac output and oxygen delivery. A variety of alternatives

and adjuncts to conventional CPR have been developed with the aim of enhancing coronary and cerebral perfusion during resuscitation from cardiac arrest. Since the 2010 Guidelines were published, a number of clinical trials have provided new data regarding the effectiveness of these alternatives. Compared with conventional CPR, many of these techniques and devices require specialized equipment and training. Some have been tested in only highly selected subgroups of cardiac arrest patients; this selection must be noted when rescuers or healthcare systems consider implementation of the devices.

Significant New and Updated Recommendations

- The Resuscitation Outcomes Consortium (ROC) Prehospital Resuscitation Impedance Valve and Early Versus Delayed Analysis (PRIMED) study (n=8718)[14] failed to demonstrate improved outcomes with the use of an impedance threshold device (ITD) as an adjunct to conventional CPR when compared with use of a sham device. This negative high-quality study prompted a Class III: No Benefit recommendation regarding routine use of the ITD.
- One large randomized controlled trial evaluated the use of active compression-decompression CPR plus an ITD.[15] The writing group found interpretation of the true clinical effect of active compression-decompression CPR plus an ITD challenging because of wide confidence intervals around the effect estimate and also because of methodological concerns. The finding of improved neurologically intact survival in the study, however, supported a recommendation that this combination may be a reasonable alternative with available equipment and properly trained providers.
- Three randomized clinical trials comparing the use of mechanical chest compression devices with conventional CPR have been published since the 2010 Guidelines. None of these studies demonstrated superiority of mechanical chest compressions over conventional CPR. Manual chest compressions remain the standard of care for the treatment of cardiac arrest, but mechanical chest compression devices may be a reasonable alternative for use by properly trained personnel. The use of the mechanical chest compression devices may be considered in specific settings where the delivery of high-quality manual compressions may be challenging or dangerous for the provider (eg, prolonged CPR during hypothermic cardiac arrest, CPR in a moving ambulance, CPR in the angiography suite, CPR during preparation for ECPR), provided that rescuers strictly limit interruptions in CPR during deployment and removal of the device (Class IIb, LOE C-EO).
- Although several observational studies have been published documenting the use of ECPR, no randomized controlled trials have evaluated the effect of this therapy on survival.

Knowledge Gaps

- Are mechanical chest compression devices superior to manual chest compressions in special situations such as a moving ambulance, prolonged CPR, or procedures such as coronary angiography?
- What is the impact of implementing ECPR as part of the system of care for OHCA?

Part 7: Adult Advanced Cardiovascular Life Support

The major changes in the 2015 advanced cardiovascular life support (ACLS) guidelines include recommendations regarding prognostication during CPR based on end-tidal carbon dioxide measurements, use of vasopressin during resuscitation, timing of epinephrine administration stratified by shockable or nonshockable rhythms, and the possibility of bundling steroids, vasopressin, and epinephrine administration for treatment of IHCA. In addition, vasopressin has been removed from the pulseless arrest algorithm. Recommendations regarding physiologic monitoring of CPR were reviewed, although there is little new evidence.

Significant New and Updated Recommendations

- Based on new data, the recommendation for use of the maximal feasible inspired oxygen during CPR was strengthened. This recommendation applies only while CPR is ongoing and does not apply to care after ROSC.
- The new 2015 Guidelines Update continues to state that physiologic monitoring during CPR may be useful, but there has yet to be a clinical trial demonstrating that goal-directed CPR based on physiologic parameters improves outcomes.
- Recommendations for ultrasound use during cardiac arrest are largely unchanged, except for the explicit proviso that the use of ultrasound should not interfere with provision of high-quality CPR and conventional ACLS therapy.
- Continuous waveform capnography remained a Class I recommendation for confirming placement of an endotracheal tube. Ultrasound was added as an additional method for confirmation of endotracheal tube placement.
- The defibrillation strategies addressed by the 2015 ILCOR review resulted in minimal changes in defibrillation recommendations.
- The Class of Recommendation for use of standard dose epinephrine (1 mg every 3 to 5 minutes) was unchanged but reinforced by a single new prospective randomized clinical trial demonstrating improved ROSC and survival to hospital admission that was inadequately powered to measure impact on long-term outcomes.
- Vasopressin was removed from the ACLS Cardiac Arrest Algorithm as a vasopressor therapy in recognition of equivalence of effect with other available interventions (eg, epinephrine). This modification valued the simplicity of approach toward cardiac arrest when 2 therapies were found to be equivalent.
- The recommendations for timing of epinephrine administration were updated and stratified based on the initial presenting rhythm, recognizing the potential difference in pathophysiologic disease. For those with a nonshockable rhythm, it may be reasonable to administer epinephrine as soon as feasible. For those with a shockable rhythm, there is insufficient evidence to make a recommendation

about the optimal timing of epinephrine administration, because defibrillation is a major focus of resuscitation.

- The use of steroids in cardiac arrest is controversial. In OHCA, administration of steroids did not improve survival to hospital discharge in 2 studies, and routine use is of uncertain benefit. The data regarding the use of steroids for IHCA were more vexing. In 2 randomized controlled trials led by the same investigators, a pharmacologic bundle that included methylprednisolone, vasopressin, and epinephrine administered during cardiac arrest followed by hydrocortisone given after ROSC improved survival. Whether the improved survival was a result of the bundle or of the steroid therapy alone could not be assessed. As a result of this study, in IHCA, the combination of intra-arrest vasopressin, epinephrine, and methylprednisolone and postarrest hydrocortisone as described by Mentzelopoulos et al[16] may be considered; however, further studies are needed before the routine use of this therapeutic strategy can be recommended (Class IIb, LOE C-LD).
- Prognostication during CPR was also a very active topic. There were reasonably good data indicating that low partial pressure of end-tidal carbon dioxide (P_{ETCO_2}) in intubated patients after 20 minutes of CPR is strongly associated with failure of resuscitation. Importantly, this parameter should not be used in isolation and should not be used in nonintubated patients.
- ECPR, also known as venoarterial extracorporeal membrane oxygenation, may be considered as an alternative to conventional CPR for select patients with refractory cardiac arrest when the suspected etiology of the cardiac arrest is potentially reversible during a limited period of mechanical cardiorespiratory support.

Knowledge Gaps

- More knowledge is needed about the impact on survival and neurologic outcome when physiologic targets and ultrasound are used to guide resuscitation during cardiac arrest.
- The dose-response curve for defibrillation of shockable rhythms is unknown, and the initial shock energy, subsequent shock energies, and maximum shock energies for each waveform are unknown.
- More information is needed to identify the ideal current delivery to the myocardium that will result in defibrillation, and the optimal way to deliver it. The selected energy is a poor comparator for assessing different waveforms, because impedance compensation and subtleties in waveform shape result in a different transmyocardial current among devices at any given selected energy.
- Is a hands-on defibrillation strategy with ongoing chest compressions superior to current hands-off strategies with pauses for defibrillation?
- What is the dose-response effect of epinephrine during cardiac arrest?
- The efficacy of bundled treatments, such as epinephrine, vasopressin, and steroids, should be evaluated, and further studies are warranted as to whether the bundle with synergistic effects or a single agent is related to any observed treatment effect.
- There are no randomized trials for any antiarrhythmic drug as a second-line agent for refractory ventricular fibrillation/pulseless ventricular tachycardia, and there are no trials evaluating the initiation or continuation of antiarrhythmics in the post–cardiac arrest period.
- Controlled clinical trials are needed to assess the clinical benefits of ECPR versus traditional CPR for patients with refractory cardiac arrest and to determine which populations would most benefit.

When ROSC is not rapidly achieved after cardiac arrest, several options exist to provide prolonged circulatory support. These options include mechanical CPR devices, and use of endovascular ventricular assist devices, intra-aortic balloon counterpulsation, and ECPR have all been described. The role of these modalities, alone or in combination, is not well understood. (For additional information, see "Part 6: Alternative Techniques and Ancillary Devices for Cardiopulmonary Resuscitation.")

Part 8: Post–Cardiac Arrest Care

Post–cardiac arrest care research has advanced significantly over the past decade. Multiple studies and trials detail the heterogeneity of patients and the spectrum of pathophysiology after cardiac arrest. Post–cardiac arrest care should be titrated based on arrest etiology, comorbid disease, and illness severity. Thus, the 2015 Guidelines Update integrates available data to help experienced clinicians make the complex set of therapeutic decisions required for these patients. The central principles of postarrest care are (1) to identify and treat the underlying etiology of the cardiac arrest, (2) to mitigate ischemia-reperfusion injury and prevent secondary organ injury, and (3) to make accurate estimates of prognosis to guide the clinical team and to inform the family when selecting goals of continued care.

New Developments

Early coronary angiography and coronary intervention are recommended for patients with ST elevation as well as for patients without ST elevation, when an acute coronary event is suspected. The decision to perform coronary angiography should not include consideration of neurologic status, because of the unreliability of early prognostic signs. Targeted temperature management is still recommended for at least 24 hours in comatose patients after cardiac arrest, but clinicians may choose a target temperature from the wider range of 32°C to 36°C. Estimating the prognosis of patients after cardiac arrest is best accomplished by using multiple modalities of testing: clinical examination, neurophysiological testing, and imaging.

Significant New and Updated Recommendations

One of the most common causes of cardiac arrest outside of the hospital is acute coronary occlusion. Quickly identifying and treating this cause is associated with better survival and better functional recovery. Therefore, coronary angiography should be performed emergently (rather than later in the hospital stay or not at all) for OHCA patients with suspected cardiac etiology of arrest and ST elevation on ECG. Emergency coronary angiography is reasonable for select (eg, electrically or hemodynamically unstable) adults who are without ST

elevation on ECG but are comatose after OHCA of suspected cardiac origin. Emergency coronary angiography is also reasonable for post–cardiac arrest patients for whom coronary angiography is indicated, regardless of whether the patient is comatose or awake.

- A high-quality randomized controlled trial did not identify any superiority of targeted temperature management at 36°C compared with management at 33°C. Excellent outcomes are possible when patients are actively managed at either temperature. All comatose (ie, lack of meaningful response to verbal commands) adult patients with ROSC after cardiac arrest should have targeted temperature management, with providers selecting and maintaining a constant temperature between 32°C and 36°C for at least 24 hours after achieving target temperature. It is also reasonable to actively prevent fever in comatose patients after targeted temperature management.
- Multiple randomized controlled trials tested prehospital infusion of cold intravenous fluids to initiate hypothermia after OHCA. The absence of any benefit and the presence of some complications in these trials led to a recommendation against the routine prehospital cooling of patients after ROSC by using rapid infusion of cold saline. However, this recommendation does not preclude the use of cold intravenous fluids in more controlled or more selected settings and did not address other methods of inducing hypothermia.
- Specific management of patients during postresuscitation intensive care includes avoiding and immediately correcting hypotension and hypoxemia. It is reasonable to use the highest available oxygen concentration until the arterial oxyhemoglobin saturation or the partial pressure of arterial oxygen can be measured. However, the benefits of any specific target ranges for blood pressure, ventilator management, or glucose management are uncertain.
- Multiple studies examined methods to determine prognosis in patients after cardiac arrest, and the use of multiple modalities of testing is recommended. The earliest time to prognosticate a poor neurologic outcome by using clinical examination in patients *not* treated with targeted temperature management is 72 hours after ROSC, but this time can be even longer after cardiac arrest if the residual effect of sedation or paralysis is suspected to confound the clinical examination. In patients treated *with* targeted temperature management, where sedation or paralysis could confound clinical examination, it is reasonable to wait until 72 hours after return to normothermia.
- Useful clinical findings that are associated with poor neurologic outcome include
  - The absence of pupillary reflex to light at ≥72 hours after cardiac arrest
  - The presence of status myoclonus during the first 72 hours after cardiac arrest
  - The absence of the N20 somatosensory evoked potential cortical wave 24 to 72 hours after cardiac arrest or after rewarming
  - The presence of a marked reduction of the gray-white ratio on brain computed tomography obtained within 2 hours after cardiac arrest
  - Extensive restriction of diffusion on brain magnetic resonance imaging at 2 to 6 days after cardiac arrest
  - Persistent absence of electroencephalographic reactivity to external stimuli at 72 hours after cardiac arrest
  - Persistent burst suppression or intractable status epilepticus on electroencephalogram after rewarming
  - *Note:* Absent motor movements, extensor posturing or myoclonus should not be used alone for predicting outcome.
- All patients who are resuscitated from cardiac arrest but who subsequently progress to death or brain death should be evaluated as potential organ donors. Patients who do not have ROSC after resuscitation efforts also may be considered candidates as kidney or liver donors in settings where programs exist.

Knowledge Gaps

- Which post–cardiac arrest patients without ST elevation are most likely to benefit from early coronary angiography?
- What are the optimal goals for blood pressure, ventilation, and oxygenation in specific groups of post–cardiac arrest patients?
- What are the optimal duration, timing, and methods for targeted temperature management?
- Will particular subgroups of patients benefit from management at specific temperatures?
- What strategies can be used to prevent or treat post–cardiac arrest cerebral edema and malignant electroencephalographic patterns (seizures, status myoclonus)?
- What is the most reliable strategy for prognostication of futility in comatose post–cardiac arrest survivors?

Part 9: Acute Coronary Syndromes

The 2015 Guidelines Update newly limits recommendations for the evaluation and management of acute coronary syndromes (ACS) to the care rendered during the prehospital and emergency department phases of care only, and specifically does not address management of patients after emergency department disposition. Within this scope, several important components of care can be classified as diagnostic interventions in ACS, therapeutic interventions in ACS, reperfusion decisions in ST-segment elevation myocardial infarction (STEMI), and hospital reperfusion decisions after ROSC. Diagnosis is focused on ECG acquisition and interpretation and the rapid identification of patients with chest pain who are safe for discharge from the emergency department. Therapeutic interventions focus on prehospital adenosine diphosphate receptor antagonists in STEMI, prehospital anticoagulation, and the use of supplementary oxygen. Reperfusion decisions include when and where to use fibrinolysis versus percutaneous coronary intervention (PCI) and when post-ROSC patients may benefit from having access to PCI.

Significant New and Updated Recommendations

A well-organized approach to STEMI care still requires integration of community, EMS, physician, and hospital resources in a bundled STEMI system of care. Two studies published since the 2010 evidence review confirm the importance of

acquiring a 12-lead ECG for patients with possible ACS as early as possible in the prehospital setting. These studies reaffirmed previous recommendations that when STEMI is diagnosed in the prehospital setting, prearrival notification of the hospital and/or prehospital activation of the catheterization laboratory should occur without delay. These updated recommendations place new emphasis on obtaining a prehospital ECG and on both the necessity for and the timing of receiving hospital notification.

- A prehospital 12-lead ECG should be acquired early for patients with possible ACS (Class I, LOE B-NR).
- Prehospital notification of the hospital (if fibrinolysis is the likely reperfusion strategy) and/or prehospital activation of the catheterization laboratory should occur for all patients with a recognized STEMI on prehospital ECG (Class I, LOE B-NR).

Because the rate of false-negative results of 12-lead ECGs may be unacceptably high, a computer reading of the ECG should not be a sole means to diagnose STEMI, but may be used in conjunction with physician or trained provider interpretation. New studies examining the accuracy of ECG interpretation by trained nonphysicians have prompted a revision of the recommendation to explicitly permit trained nonphysicians to interpret ECGs for the presence of STEMI.

- We recommend that computer-assisted ECG interpretation may be used in conjunction with physician or trained provider interpretation to recognize STEMI (Class IIb, LOE C-LD).
- While transmission of the prehospital ECG to the ED physician may improve the positive predictive value (PPV) and therapeutic decision making regarding adult patients with suspected STEMI, if transmission is not performed, it may be reasonable for trained nonphysician ECG interpretation to be used as the basis for decision making, including activation of the catheterization laboratory, administration of fibrinolysis, and selection of destination hospital. (Class IIa, LOE B-NR).

High-sensitivity cardiac troponin is now widely available. The 2015 CoSTR review examined whether a negative troponin test could reliably exclude a diagnosis of ACS in patients who did not have signs of STEMI on ECG. For emergency department patients with a presenting complaint consistent with ACS, high-sensitivity cardiac troponin T (hs-cTnT) and cardiac troponin I (cTnI) measured at 0 and 2 hours should not be interpreted in isolation (without performing clinical risk stratification) to exclude the diagnosis of ACS. In contrast, high-sensitivity cardiac troponin I (hs-cTnI), cTnI, or cardiac troponin T (cTnT) may be used in conjunction with a number of clinical scoring systems to identify patients at low risk for 30-day major adverse cardiac events (MACE) who may be safely discharged from the emergency department.

- We recommend that hs-cTnI measurements that are less than the 99th percentile, measured at 0 and 2 hours, may be used together with low risk stratification (Thrombolysis in Myocardial Infarction [TIMI] score of 0 or 1) to predict a less-than-1% chance of 30-day MACE (Class IIa, LOE B-NR).
- We recommend that negative cTnI or cTnT measurements at 0 and between 3 and 6 hours may be used together with very low risk stratification (Vancouver score of 0 or North American Chest Pain score of 0 and age less than 50 years) to predict a less-than-1% chance of 30-day MACE (Class IIa, LOE B-NR).

New recommendations have been made regarding several therapeutic interventions in ACS. New data from a case-control study that compared heparin and aspirin administered in the prehospital to the hospital setting found blood flow rates to be higher in infarct-related arteries when heparin and aspirin are administered in the prehospital setting. Because of the logistical difficulties in introducing heparin to EMS systems that do not currently use this drug and the limitations in interpreting data from a single study, initiation of adenosine diphosphate (ADP) inhibition may be reasonable in either the prehospital or the hospital setting in patients with suspected STEMI who intend to undergo primary PCI.

- We recommend that EMS systems that do not currently administer heparin to suspected STEMI patients not add this treatment, whereas those that do administer it may continue their current practice (Class IIb, LOE B-NR).
- In suspected STEMI patients for whom there is a planned primary PCI reperfusion strategy, administration of unfractionated heparin can occur either in the prehospital or the in-hospital setting (Class IIb, LOE B-NR).

Supplementary oxygen has been routinely administered to patients with suspected ACS for years. Despite this tradition, the usefulness of supplementary oxygen therapy has not been established in normoxemic patients.

- The usefulness of supplementary oxygen therapy has not been established in normoxic patients. In the prehospital, emergency department, and hospital settings, the withholding of supplementary oxygen therapy in normoxemic patients with suspected or confirmed ACS may be considered (Class IIb, LOE C-LD).

Timely restoration of blood flow to ischemic myocardium in acute STEMI remains the highest treatment priority. While the Class of Recommendation regarding reperfusion strategies remains unchanged from 2010, the choice between fibrinolysis and PCI has been reexamined to focus on clinical circumstances, system capabilities, and timing, and the recommendations have been updated accordingly. The anticipated time to PCI has been newly examined in 2015, and new time-dependent recommendations regarding the most effective reperfusion strategy are made. In STEMI patients, when long delays to primary PCI are anticipated (more than 120 minutes), a strategy of immediate fibrinolysis followed by routine early angiography (within 3 to 24 hours) and PCI, if indicated, is reasonable. It is acknowledged that fibrinolysis becomes significantly less effective at more than 6 hours after symptom onset, and thus a longer delay to primary PCI is acceptable in patients at more than 6 hours after symptom onset. To facilitate ideal treatment, systems of care must factor information about hospital

capabilities into EMS destination decisions and interfaculty transfers.

- In adult patients presenting with STEMI in the emergency department (ED) of a non–PCI-capable hospital, we recommend immediate transfer without fibrinolysis from the initial facility to a PCI center instead of immediate fibrinolysis at the initial hospital with transfer only for ischemia-driven PCI (Class I, LOE B-R).
- When STEMI patients cannot be transferred to a PCI-capable hospital in a timely manner, fibrinolytic therapy with routine transfer for angiography may be an acceptable alternative to immediate transfer to primary PCI (Class IIb, LOE C-LD).
- When fibrinolytic therapy is administered to STEMI patients in a non–PCI-capable hospital, it may be reasonable to transport all postfibrinolysis patients for early routine angiography in the first 3 to 6 hours and up to 24 hours rather than transport postfibrinolysis patients only when they require ischemia-guided angiography (Class IIb, LOE B-R).

Knowledge Gaps

- More knowledge is needed about the optimal diagnostic approach for patients with serial troponin levels lower than the 99th percentile who are identified as being at moderate or high risk based on clinical scoring rules.
- The role of a single troponin measurement in identifying patients who are safe for discharge from the emergency department is currently evolving.
- The time from symptom onset to first medical contact is highly variable. An ideal reperfusion strategy considering the contribution of this variability in time to presentation has yet to be determined.

Part 10: Special Circumstances of Resuscitation

"Part 10: Special Circumstances of Resuscitation" presents new guidelines for the prevention and management of resuscitation emergencies related to opioid toxicity, and for the role of intravenous lipid emulsion (ILE) therapy for treatment of cardiac arrest due to drug overdose. Updated guidelines for the management of cardiac arrest occurring during the second half of pregnancy, cardiac arrest caused by pulmonary embolism, and cardiac arrest occurring during PCI are included.

Significant New and Updated Recommendations

- The 2010 Guidelines included a Class I recommendation to perform bag-mask–assisted ventilation and administer naloxone for patients with known or suspected opioid overdose who have respiratory depression but are not in cardiac arrest. Since that time, significant experience has accumulated to show that naloxone can be administered with apparent safety and effectiveness in the first aid and BLS settings. Accordingly, the 2015 Guidelines Update contains new recommendations for naloxone administration by non–healthcare providers, with recommendations for simplified training. A new algorithm for management of unresponsive victims with suspected opioid overdose is provided.
- Administration of ILE for the treatment of local anesthetic systemic toxicity (LAST), particularly from bupivacaine, is supported by extensive animal research and human case reports. In the 2015 Guidelines Update, this science was reviewed and a weak recommendation supporting use of ILE for treatment of LAST was reaffirmed. Since 2010, animal studies and human case reports have been published that examined the use of ILE for patients with other forms of drug toxicity, with mixed results. The 2015 Guidelines Update contains a new recommendation that ILE may be considered in patients with cardiac arrest due to drug toxicity other than LAST who are failing standard resuscitative measures.
- Relief of aortocaval compression has long been recognized as an essential component of resuscitation for women who develop cardiac arrest in the latter half of pregnancy, and this remains an important area of emphasis in the Guidelines. In the 2010 Guidelines, relief of aortocaval compression with manual left uterine displacement was a Class IIb recommendation. Although no cardiac arrest outcome studies have been published that compared left uterine displacement to other strategies to relieve aortocaval compression during CPR, the critical importance of high-quality CPR has been further supported. Because alternative strategies to relieve aortocaval compression (eg, lateral tilt) do not seem to be compatible with delivery of high-quality CPR, the recommendation to perform left uterine displacement during CPR was strengthened. If the fundus height is at or above the level of the umbilicus, manual left uterine displacement can be beneficial in relieving aortocaval compression during chest compressions (Class IIa, LOE C-LD).
- In addition to providing the opportunity for separate resuscitation of a potentially viable fetus, perimortem cesarean delivery (PMCD) provides the ultimate relief of aortocaval compression and may improve maternal resuscitation outcomes. The 2010 Guidelines included a Class IIb recommendation to consider performing PMCD at 4 to 5 minutes after the onset of maternal cardiac arrest without ROSC. The 2015 Guidelines Update expands on these recommendations. In situations such as nonsurvivable maternal trauma or prolonged maternal pulselessness, in which maternal resuscitative efforts are obviously futile, there is no reason to delay performing PMCD (Class I, LOE C-LD). PMCD should be considered at 4 minutes after the onset of maternal cardiac arrest or resuscitative efforts (for the unwitnessed arrest) if there is no ROSC (Class IIa, LOE C-EO). The complexity and need for clinical judgment in this decision making is explicitly acknowledged.

Knowledge Gaps

- Although the recommendation to consider PMCD after 4 minutes of unsuccessful maternal resuscitation attempts has been promulgated since 1986, it is based on scientific rationale rather than experimental evidence or

critical analysis of prospectively collected data. A recent systematic review found that early time to PMCD (less than 10 minutes) was associated with improved survival of the mother but not of the child, and PMCD within 4 to 5 minutes may not be achievable in most settings. Although clinical trials are not feasible, large registry studies may be able to support evidence-based decision making in timing of PMCD to improve both maternal and neonatal outcomes.

- Since the first animal studies were published in 1998, a large body of literature has developed that describes the use of ILE in resuscitation from poisoning and drug toxicity. Although the experimental studies and human anecdotal reports are consistently positive for treatment of LAST from bupivacaine, more variable results are reported for treatment of LAST from other agents, and results achieved after ILE administration for other toxicants are mixed. Administration of ILE alters the effectiveness of epinephrine and vasopressin in animal resuscitation studies, may increase the absorption of lipophilic medications from the gastrointestinal tract, and sometimes interferes with the operation of veno-arterial extracorporeal membrane oxygenation circuits. Further research is needed to determine the role of ILE in the management of cardiac arrest and refractory shock due to poisoning.

Part 11: Pediatric Basic Life Support and Cardiopulmonary Resuscitation Quality

The 2015 Guidelines Update for pediatric BLS concentrated on modifications in the algorithms for lone- and 2-rescuer CPR, initial actions of rescuers, and CPR quality process measures. Algorithms for 1- and 2-person healthcare provider CPR have been separated to better guide rescuers through the initial stages of resuscitation. In an era where handheld cellular telephones with speakers are common, this technology can allow a single rescuer to activate the emergency response system while beginning CPR. Healthcare providers should perform an assessment of breathing and pulse check simultaneously, to minimize delays in starting CPR if the child is unresponsive with no breathing or only gasping.

Significant New and Updated Recommendations

The 3 major CPR process characteristics that were evaluated included C-A-B (Compressions, Airway, Breathing) versus A-B-C (Airway, Breathing, Compressions), compression-only CPR, and compression depth and rate. No major changes were made for the 2015 Guidelines Update; however, new concepts in CPR delivery were examined for children.

- Because of the limited amount and quality of the data, it may be reasonable to maintain the sequence from the 2010 Guidelines by initiating CPR with C-A-B over A-B-C (Class IIb, LOE C-EO). There are no pediatric human studies to evaluate C-A-B versus A-B-C, but manikin studies do demonstrate a shorter time to first chest compression. This recommendation was made to simplify training, provide consistency for teaching rescuers of adults and children, and hopefully increase the number of victims who receive bystander CPR.
- Compression depth of at least one third of the anterior-posterior diameter, approximately 1.5 inches (4 cm) for infants and approximately 2 inches (5 cm) for children, was affirmed (Updated). The Class of Recommendation was downgraded from Class I to Class IIa, primarily based on the rigor of the evidence evaluation. There are limited clinical data on the effect of compression depth on resuscitation outcomes, but 2 clinical studies suggest that compression depth is also associated with survival.
- Compression rate was not reviewed because of insufficient evidence, and we recommend that rescuers use the adult rate of 100 to 120/min (Updated).
- The asphyxial nature of the majority of pediatric cardiac arrests necessitates ventilation as part of effective CPR, and 2 large database studies documented worse 30-day outcomes with compression-only CPR compared with conventional CPR. For this reason, conventional CPR (chest compressions and rescue breaths) is a Class I recommendation (LOE B-NR) for children. However, because compression-only CPR is effective in patients with a primary cardiac event, if rescuers are unwilling or unable to deliver breaths, we recommend rescuers perform compression-only CPR for infants and children in cardiac arrest (Class I, LOE B-NR). Conventional CPR (chest compressions and rescue breaths) is a Class I recommendation (LOE B-NR).

Knowledge Gaps

- Much of the data supporting pediatric BLS is primarily extrapolated from studies in adults. Multicenter pediatric studies from both in-hospital and out-of-hospital arrest are needed to optimize outcomes for children.
- More knowledge is needed about the optimal sequence, feedback techniques and devices, and effect of different surfaces on CPR delivery in children.

Part 12: Pediatric Advanced Life Support

Significant New and Updated Recommendations

The following are the most important changes and reinforcements to recommendations made in the 2010 Guidelines:

- There is new evidence that when treating pediatric septic shock in specific settings, the use of restricted volume of isotonic crystalloid leads to improved survival, contrasting with the long-standing belief that all patients benefit from aggressive volume resuscitation. New guidelines suggest a cautious approach to fluid resuscitation, with frequent patient reassessment, to better tailor fluid therapy and supportive care to children with febrile illness.
- New literature suggests limited survival benefit to the routine use of atropine as a premedication for emergency tracheal intubation of non-neonates, and that any benefit in preventing arrhythmias is controversial. Recent literature also provides new evidence suggesting there is no minimum dose required for atropine use.
- Children in cardiac arrest may benefit from the titration of CPR to blood pressure targets, but this strategy is suggested only if they already have invasive blood pressure monitoring in place.

- New evidence suggests that either amiodarone *or* lidocaine is acceptable for treatment of shock-refractory pediatric ventricular fibrillation and pulseless ventricular tachycardia.
- Recent literature supports the need to avoid fever when caring for children remaining unconscious after OHCA.
- The writing group reviewed a newly published multicenter clinical trial of targeted temperature management that demonstrated that a period of either 2 days of moderate therapeutic hypothermia (32° to 34° C) or the strict maintenance of normothermia (36° to 37.5° C) were equally beneficial. As a result, the writing group feels either of these approaches is appropriate for infants and children remaining comatose after OHCA.
- Hemodynamic instability after cardiac arrest should be treated actively with fluids and/or inotropes/vasopressors to maintain systolic blood pressure greater than the fifth percentile for age. Continuous arterial pressure monitoring should be used when the appropriate resources are available.

Knowledge Gaps

- What clinical or physiologic parameters reflect high-quality pediatric CPR and improve outcome in children? Do devices to monitor these parameters improve survival?
- What is the role of targeted temperature management in the care of children who remain unconscious after *in-hospital* cardiac arrest?
- Does a postarrest bundle of care with specific targets for temperature, oxygenation and ventilation, and hemodynamic parameters improve outcomes after pediatric cardiac arrest?
- Does a combination of intra-arrest factors reliably predict successful resuscitation in children with either OHCA or IHCA?

Part 13: Neonatal Resuscitation

"Part 13: Neonatal Resuscitation" presents new guidelines for resuscitation of primarily newly born infants transitioning from intrauterine to extrauterine life. The recommendations are also applicable to neonates who have completed newborn transition and require resuscitation during the first weeks after birth.

Much of the neonatal resuscitation guidelines remains unchanged from 2010, but there is increasing focus on umbilical cord management, maintaining a normal temperature after birth, accurate determination of heart rate, optimizing oxygen use during resuscitation, and de-emphasis of routine suctioning for meconium in nonvigorous newborns. The etiology of neonatal arrest is almost always asphyxia, and therefore, establishing effective ventilation remains the most critical step.

Significant New and Updated Recommendations

Umbilical cord management: The 2015 Guidelines Update includes for the first time recommendations regarding umbilical cord management. Until recently, it was common practice to clamp the umbilical cord immediately after birth to facilitate rapid transfer of the baby to the pediatric provider for stabilization. A significant issue with the available evidence is that the published studies enrolled very few babies who were considered to need resuscitation.

- There is evidence, primarily in babies who do not require resuscitation, that delayed cord clamping is associated with less intraventricular hemorrhage, higher blood pressure and blood volume, less need for transfusion after birth, and less necrotizing enterocolitis. Delayed cord clamping conferred no benefit on mortality or severe intraventricular hemorrhage. The only negative consequence seems to be a slightly increased level of bilirubin, associated with more need for phototherapy.[17,18]
- Delayed cord clamping for longer than 30 seconds is reasonable for both term and preterm infants who do not require resuscitation at birth (Class IIa, LOE C-LD). There is still insufficient evidence to recommend an approach to cord clamping or cord "milking" for babies who require resuscitation at birth.

Assessment of heart rate: Immediately after birth, assessment of the newborn's heart rate is used to evaluate the effectiveness of spontaneous respiratory effort and determine the need for subsequent interventions. An increase in the newborn's heart rate is considered the most sensitive indicator of a successful response to resuscitation interventions. Therefore, identifying a rapid, reliable, and accurate method to measure the newborn's heart rate is critically important.

- Available evidence comparing clinical assessment with ECG in the delivery room and simultaneous pulse oximetry and ECG heart rate determination found that clinical assessment was both unreliable and inaccurate.
- ECG (3-lead) displayed a reliable heart rate faster than pulse oximetry. Pulse oximetry tended to underestimate the newborn's heart rate and would have led to potentially unnecessary interventions.[17,18]
- During resuscitation of term and preterm newborns, the use of 3-lead ECG for the rapid and accurate measurement of the newborn's heart rate may be reasonable (Class IIb, LOE C-LD).

Maintaining normal temperature of the newborn after birth: It is recommended that the temperature of newly born nonasphyxiated infants be maintained between 36.5°C and 37.5°C after birth through admission and stabilization (Class I, LOE C-LD).[15] There is new evidence supporting a variety of interventions that may be used alone or in combination to reduce hypothermia. Temperature must be monitored to avoid hyperthermia as well.

Management of the meconium stained infant: For more than a decade, vigorous infants born through meconium stained amniotic fluid have been treated no differently than if they had been born through clear fluid. However, there remained a long standing practice to intubate and suction infants born through meconium stained amniotic fluid who have poor muscle tone and inadequate breathing efforts at birth.

- Routine intubation for tracheal suction in this setting is not suggested because there is insufficient evidence to continue recommending this practice (Class IIb, LOE C-LD).[17,18]

- In making this suggested change, greater value has been placed on harm avoidance (delays in providing positive-pressure ventilation, potential harm of the procedure) over the unknown benefit of the intervention of routine trachea intubation and suctioning.

Oxygen use for preterm infants in the delivery room: Since the release of the 2010 Guidelines, additional randomized trials have been published that examine the use of oxygen during resuscitation and stabilization of preterm newborns. These additional publications have allowed an increase from Class IIb to a Class I recommendation.

- Meta-analysis of the randomized trials that compared initiating resuscitation of preterm newborns (less than 35 weeks of gestation) with high oxygen (65% or greater) versus low oxygen (21%–30%) showed no improvement in survival or morbidity to hospital discharge with the use of high oxygen.[17,18]
- Resuscitation of preterm newborns of less than 35 weeks of gestation should be initiated with low oxygen (21%–30%), and the oxygen concentration should be titrated to achieve preductal oxygen saturation approximating the interquartile range measured in healthy term infants after vaginal birth at sea level (Class I, LOE B-R). This recommendation reflects a preference for not exposing preterm newborns to additional oxygen without data demonstrating a proven benefit for important outcomes.

Oxygen use during neonatal cardiac compressions: The evidence for optimal oxygen use during neonatal cardiac compressions was not reviewed for the 2010 Guidelines. Unfortunately, there are no clinical studies to inform the neonatal guidelines, but the available animal evidence demonstrated no obvious advantage of 100% oxygen over air. However, by the time resuscitation of a newborn includes cardiac compressions, the steps of trying to improve the heart rate via effective ventilation with low concentrations of oxygen should have already been tried. Thus, the 2015 Guidelines Task Force thought it was reasonable to increase the supplementary oxygen concentration during cardiac compressions and then subsequently wean the oxygen as soon as the heart rate recovers (see "Part 13: Neonatal Resuscitation" in this 2015 Guidelines Update).

Structure of educational programs to teach neonatal resuscitation: Currently, neonatal resuscitation training that includes simulation and debriefing is recommended at 2-year intervals.

- Studies that examined how frequently healthcare providers or healthcare students should train showed no differences in patient outcomes, but demonstrated some advantages in psychomotor performance, knowledge, and confidence when focused task training occurred every 6 months or more frequently.[17,18]
- It is therefore suggested that neonatal resuscitation task training occur more frequently than the current 2-year interval (Class IIb, LOE B-R, LOE C-EO, LOE C-LD).[15]

Knowledge Gaps

Umbilical cord management for newborns needing resuscitation: As noted previously, the risks and benefits of delayed cord clamping for newborns who need resuscitation after birth remains unknown because such infants have thus far been excluded from the majority of trials. Concern remains that delay in establishing ventilation may be harmful. Further study is strongly endorsed.

- Some studies have suggested that cord milking might accomplish goals similar to delayed cord clamping.[17,18] Cord milking is rapid and can be accomplished within 15 seconds, before resuscitation might ordinarily be initiated. However, there is insufficient evidence of either the safety or utility of cord milking in babies requiring resuscitation.
- The effect of delayed cord clamping or cord milking on initial heart rate and oxygen saturations is also unknown. New normal ranges may need to be determined.
- The risks and benefits of inflating the lungs to establish breathing before clamping of the umbilical cord needs to be explored.

Utility of a sustained inflation during the initial breaths after birth: Several recent animal studies suggested that a longer sustained inflation may be beneficial for establishing functional residual capacity during transition from fluid-filled to air-filled lungs after birth. Some clinicians have suggested applying this technique for transition of human newborns.

- It was the consensus of the 2015 CoSTR and the 2015 Guidelines Task Force that there was inadequate study of the benefits and risks to recommend sustained inflation at this time. Further study using carefully designed protocols was endorsed (see "Part 13: Neonatal Resuscitation" in this 2015 Guidelines Update and Perlman et al[17,18]).

Determination of heart rate: Neonatal resuscitation success has classically been determined by detecting an increase in heart rate through auscultation. Heart rate also determines the need for changing interventions and escalating care. However, recent evidence demonstrates that auscultation of heart rate is inaccurate, and pulse oximetry takes several minutes to achieve a signal and also may be inaccurate during the early minutes after birth. Use of ECG in the delivery room has been suggested as a possible alternative.

- Although data suggest that the ECG provides a more accurate heart rate in the first 3 minutes of life, there are no available data to determine how outcomes would change by acting (or not acting) on the information.
- Some transient bradycardia may be normal and be reflective of timing of cord clamping. More studies are needed.
- The human factors issues associated with introducing ECG leads in the delivery room are unknown.
- In addition, improved technologies for rapid application of ECG are needed.

Part 14: Education

There remains strikingly low survival rates for both OHCA and IHCA despite scientific advances in the care of cardiac arrest victims. The Formula for Survival suggests that cardiac

arrest survival is influenced by high-quality science, education of lay providers and healthcare professionals, and a well-functioning Chain of Survival.[19] Considerable opportunities exist for education to close the gap between actual and desired performance of lay providers and healthcare teams. For lay providers, this includes proficient CPR and AED skills and the self-efficacy to use them, along with immediate support such as dispatch-guided CPR. For healthcare providers, the goals remain to recognize and respond to patients at risk of cardiac arrest, deliver high-quality CPR whenever CPR is required, and improve the entire resuscitation process through improved teamwork. Additionally, there needs to be a feedback loop focused on continuous quality improvement that can help the system improve as well as identify needs for targeted learning/performance improvement. Optimizing the knowledge translation of what is known from the science of resuscitation to the victim's bedside is a key step to potentially saving many more lives.

Evidence-based instructional design is essential to improve training of providers and ultimately improve resuscitation performance and patient outcomes. The quality of rescuer performance depends on learners integrating, retaining, and applying the cognitive, behavioral, and psychomotor skills required to successfully perform resuscitation. "Part 14: Education" provides an overview of the educational principles that the AHA has implemented to maximize learning from its educational programs. It is important to note that the systematic reviews from which the Guidelines were derived assigned a hierarchy of outcomes for educational studies that considered patient-related outcomes as "critical" and outcomes in educational settings as "important."

Significant New and Updated Recommendations

The key recommendations based on the systematic reviews include the following:

- The use of high-fidelity manikins for ALS training can be beneficial in programs that have the infrastructure, trained personnel, and resources to maintain the program. Standard manikins continue to be an appropriate choice for organizations that do not have this capacity.

Use of a CPR feedback device is recommended to learn the psychomotor skill of CPR. Devices that provide feedback on performance are preferred to devices that provide only prompts (such as a metronome). Instructors are not accurate at assessment of CPR quality by visual inspection, so an adjunctive tool is necessary to provide accurate guidance to learners developing these critical psychomotor skills. Improved manikins that better reflect patient characteristics may prove important for future training. Use of CPR quality feedback devices during CPR is reviewed in "Part 5: Adult Basic Life Support and CPR Quality."

- Two-year retraining cycles are not optimal. More frequent training of BLS and advanced life support skills may be helpful for providers likely to encounter a victim of cardiac arrest.
- Although prior CPR training is not required for potential rescuers to initiate CPR, training helps people learn the skills and develop the self-efficacy to provide CPR when necessary. BLS skills seem to be learned as well through self-instruction (video or computer based) with hands-on practice as with traditional instructor-led courses. The opportunity to train many more individuals to provide CPR while reducing the cost and resources required for training is important when considering the vast population of potential rescuers that should be trained.
- To reduce the time to defibrillation for cardiac arrest victims, the use of an AED should not be limited to trained individuals only (although training is still recommended). A combination of self-instruction and instructor-led teaching with hands-on training can be considered as an alternative to traditional instructor-led courses for lay providers.
- Precourse preparation, including review of appropriate content information, online/precourse testing, and/or practice of pertinent technical skills, may optimize learning from advanced life support courses.
- Given very small risk for harm and the potential benefit of team and leadership training, the inclusion of team and leadership training as part of ALS training is reasonable.
- Communities may consider training bystanders in compression-only CPR for adult OHCA as an alternative to training in conventional CPR.

Knowledge Gaps

- Research on resuscitation education needs higher-quality studies that address important educational questions. Outcomes from educational studies should focus on patient outcomes (where feasible), performance in the clinical environment, or at least long-term retention of psychomotor and behavioral skills in the simulated resuscitation environment. Too much of the current focus of educational research is on the immediate end-of-course performance, which may not be representative of participants' performance when they are faced with a resuscitation event months or years later. Assessment tools that have been empirically studied for evidence of validity and reliability are foundational to high-quality research. Standardizing the use of such tools across studies could potentially allow for meaningful comparisons when analyzing evidence in systematic reviews to more precisely determine the impact of certain interventions. Cost-effectiveness research is needed because many of the AHA education guidelines are developed in the absence of this information.
- The ideal methodology (ie, instructional design) and frequency of training required to enhance retention of skills and performance in simulated and actual resuscitations needs to be determined.

Part 15: First Aid

"Part 15: First Aid" reaffirms the definition of *first aid* as the helping behaviors and initial care provided for an acute illness or injury. The provision of first aid has been expanded to include any person, from layperson to professional healthcare provider, in a setting where first aid is needed. Goals and

competencies are now provided to give guidance and perspective beyond specific skills. While a basic tenet of first aid is the delivery of care using minimal or no equipment, it is increasingly recognized that in some cases first aid providers may have access to various adjuncts, such as commercial tourniquets, glucometers, epinephrine autoinjectors, or oxygen. The use of any such equipment mandates training, practice, and, in some cases, medical or regulatory oversight related to use and maintenance of that equipment.

Although there is a growing body of observational studies performed in the first aid setting, most recommendations set forth in "Part 15: First Aid" continue to be extrapolated from prehospital- and hospital-based studies. One important new development relates to the ability of a first aid provider to recognize the signs and symptoms of acute stroke. "Part 15: First Aid" describes the various stroke assessment systems that are available to first aid providers, and lists their sensitivities and specificities in identifying stroke based on included components. This new recommendation for use of a stroke assessment system complements previous recommendations for early stroke management by improving the recognition of stroke signs and symptoms at the first step of emergency care—first aid—thus potentially reducing the interval from symptom onset to definitive care.

Significant New and Updated Recommendations

- Evidence shows that the early recognition of stroke by using a stroke assessment system decreases the interval between the time of stroke onset and arrival at a hospital and definitive treatment. More than 94% of lay providers trained in a stroke assessment system are able to recognize signs and symptoms of a stroke, and this ability persists at 3 months after training. The use of a stroke assessment system by first aid providers is recommended (Class I, LOE B-NR). Compared to stroke assessment systems without glucose measurement, assessment systems that include glucose measurement have similar sensitivity but higher specificity for recognition of stroke.
- Hypoglycemia is a condition that is commonly encountered by first aid providers. Severe hypoglycemia, which may present with loss of consciousness or seizures, typically requires management by EMS providers. If a person with diabetes reports low blood sugar or exhibits signs or symptoms of mild hypoglycemia and is able to follow simple commands and swallow, oral glucose should be given to attempt to resolve the hypoglycemia. Glucose tablets, if available, should be used to reverse hypoglycemia in a patient who is able to take these orally (Class I, LOE B-R). If glucose tablets are not available, other specifically evaluated forms of sucrose- and fructose-containing foods, liquids, and candy can be effective as an alternative to glucose tablets for reversal of mild symptomatic hypoglycemia.
- The first aid management of an open chest wound was evaluated for the 2015 ILCOR Consensus Conference. The improper use of an occlusive dressing or device with potential subsequent development of unrecognized tension pneumothorax is of great concern. There are no human studies comparing the application of an occlusive dressing to a nonocclusive dressing, and only a single animal study showed benefit to use of a nonocclusive dressing. As a result of the lack of evidence for use of an occlusive dressing and the risk of unrecognized tension pneumothorax, we recommend against the application of an occlusive dressing or device by first aid providers for an individual with an open chest wound.
- First aid providers often encounter individuals with a concussion (minor traumatic brain injury). The myriad of signs and symptoms of concussion can make recognition of this injury a challenge. Although a simple validated single-stage concussion scoring system could possibly help first aid providers in the recognition of concussion, there is no evidence to support the use of such a scoring system. There are sport concussion assessment tools for use by healthcare professionals that require a 2-stage assessment, before competition and after concussion, but these are not appropriate as a single assessment tool for first aid providers. Therefore, it is recommended that a healthcare provider evaluate as soon as possible any person with a head injury that has resulted in a change in level of consciousness, who has progressive development of signs or symptoms of a concussion or traumatic brain injury, or who is otherwise a cause for concern to the first aid provider.
- Dental avulsion can result in permanent loss of a tooth. Immediate reimplantation of the avulsed tooth is thought by the dental community to afford the greatest chance of tooth survival. First aid providers may not be able to reimplant an avulsed tooth because of lack of training, skill, or personal protective equipment, or they may be reluctant to perform a painful procedure. The storage of an avulsed tooth in a variety of solutions (compared with saliva or milk) has been shown to prolong viability of dental cells by 30 to 120 minutes. In situations that do not allow for immediate reimplantation, the temporary storage of an avulsed tooth in one of these solutions may afford time until the tooth can be reimplanted.
- Evidence shows that education in first aid can increase survival rates, improve recognition of acute illness, and resolve symptomatology. We recommend that first aid education be universally available (Class I, LOE C-EO).
- Past Guidelines recommended that first aid providers assist the person with symptoms of anaphylaxis to administer that person's epinephrine.[20] Evidence supports the need for a second dose of epinephrine for acute anaphylaxis in persons not responding to a first dose. When a person with anaphylaxis does not respond to the initial dose and arrival of advanced care will exceed 5 to 10 minutes, a repeat dose may be considered (Class IIb, LOE C-LD).
- There is no evidence of any benefit from routine administration of supplementary oxygen by first aid providers. Limited evidence shows benefit from use of oxygen for decompression sickness in the first aid setting. The use of supplementary oxygen by first aid providers with specific training (eg, a diving first aid oxygen course) is

reasonable for cases of decompression sickness. Limited evidence suggests that supplementary oxygen may be effective for relief of dyspnea in advanced lung cancer patients with dyspnea and associated hypoxia, but not for similar patients without hypoxia.

- Newer-generation hemostatic agent–impregnated dressings have been shown to cause fewer complications and adverse effects and are effective in providing hemostasis in up to 90% of subjects in case series. First aid providers may consider use of hemostatic dressings when standard bleeding control (with direct pressure) is not effective.
- The use of cervical collars as a component of spinal motion restriction for blunt trauma was reviewed for the 2015 ILCOR consensus. No evidence was identified that showed a decrease in neurologic injury with use of a cervical collar. Evidence demonstrates adverse effects from use of a cervical collar, such as increased intracranial pressure and potential airway compromise. The ILCOR First Aid Task Force also expressed concern that proper technique for application of a cervical collar in high-risk individuals requires significant training and practice to be performed correctly and is not considered a standard first aid skill. Because of these concerns, and with a growing body of evidence demonstrating harmful effects and no good evidence showing clear benefit, we recommend against routine application of cervical collars by first aid providers.

Knowledge Gaps

- Control of severe bleeding is a topic that has gained public interest and importance with recent domestic terrorist attacks. The ideal order for the technique of bleeding control by first aid providers for severe bleeding of an extremity is not clear—ie, direct pressure → tourniquet → additional (double) tourniquet; direct pressure → hemostatic dressing → tourniquet. It is also unclear how tourniquets compare with hemostatic dressings (or double tourniquet) for control of bleeding in extremity wounds.
- First aid providers may have difficulty recognizing potentially life-threatening conditions. The development and validation of highly sensitive assessment systems or scales (such as for stroke) and other educational techniques may help first aid providers recognize these entities so that they can provide rapid, appropriate care. Conditions that may benefit from development of such assessment educational systems include anaphylaxis, hypoglycemia, chest pain of cardiac origin, high-risk cervical spine injury, concussion, poisoning or overdose, abnormal versus normal breathing, and shock.
- How should a first aid provider care for a person with a potential spinal injury while awaiting arrival of EMS? Is there a benefit to manual cervical spinal stabilization by a first aid provider, and, if so, which technique is best? If verbal instructions to not move are given to a conscious/responsive person with trauma and possible spine injury, are they effective or useful?

Summary

The *2015 AHA Guidelines Update for CPR and ECC* incorporated the evidence from the systematic reviews completed as part of the 2015 International Consensus on CPR and ECC Science With Treatment Recommendations. This 2015 Guidelines Update marks the transition from periodic review and publication of new science-based recommendations to a more continuous process of evidence evaluation and guideline optimization designed to more rapidly translate new science into resuscitation practice that will save more lives. The Appendix to this Part contains a list of all recommendations published in the 2015 Guidelines Update and, in addition, lists the recommendations from the 2010 Guidelines. The 2015 recommendations were made consistent with the new AHA Classification System for describing the risk-benefit ratio for each Class and the Levels of Evidence supporting them. (Please see Figure 1 in "Part 2: Evidence Evaluation and Management of Conflicts of Interest.")

Survival from both IHCA and OHCA has increased over the past decade, but there is still tremendous potential for improvement. It is clear that successful resuscitation depends on coordinated systems of care that start with prompt rescuer actions, require delivery of high-quality CPR, and continue through optimized ACLS and post–cardiac arrest care. Systems that monitor and report quality-of-care metrics and patient-centered outcomes will have the greatest opportunity through quality improvement to save the most lives.

Disclosures

Part 1: Executive Summary: 2015 Guidelines Update Writing Group Disclosures

Writing Group Member	Employment	Research Grant	Other Research Support	Speakers' Bureau/ Honoraria	Expert Witness	Ownership Interest	Consultant/ Advisory Board	Other
Robert W. Neumar	University of Michigan	NIH†	None	None	None	None	None	None
Dianne L. Atkins	University of Iowa	None	None	None	None	None	None	None
Farhan Bhanji	McGill University	None	None	None	None	None	None	None
Steven C. Brooks	Queen's University	Heart and Stroke Foundation of Canada†; CIHR†; NIH†	None	None	None	None	None	South Eastern Ontario Academic Medical Association†
Clifton W. Callaway	University of Pittsburgh	None	None	None	None	None	None	None
Allan R. de Caen	University of Alberta; Stollery Children's Hospital	None	None	None	None	None	None	None
Monica E. Kleinman	Children's Hospital Boston	None	None	None	None	None	None	None
Steven L. Kronick	University of Michigan	None	None	None	None	None	None	None
Eric J. Lavonas	Rocky Mountain Poison & Drug Center	None	None	None	None	None	None	None
Mark S. Link	Tufts Medical Center	None	None	None	None	None	None	None
Mary E. Mancini	University of Texas at Arlington	None	None	None	None	None	None	None
Laurie J. Morrison	University of Toronto	NIH†; CIHR†; HSFC†	None	None	None	None	None	None
Robert E. O'Connor	University of Virginia	None	None	None	None	None	None	None
Eunice M. Singletary	University of Virginia	None	None	None	None	None	American Red Cross Scientific Advisory Board*	None
Myra H. Wyckoff	UT Southwestern	None	None	None	None	None	None	None
Staff								
Jose Maria E. Ferrer	American Heart Association	None	None	None	None	None	None	None
Lana M. Gent	American Heart Association	None	None	None	None	None	None	None
Consultants								
Michael W. Donnino	Beth Israel Deaconess Med Center	None	None	None	None	None	American Heart Association†	None
Mary Fran Hazinski	Vanderbilt University	None	None	None	None	None	American Heart Association†	None
Ricardo A. Samson	University of Arizona	None	None	None	None	None	American Heart Association†	None
Steven M. Schexnayder	University of Arkansas; Arkansas Children's Hospital	None	None	None	None	None	American Heart Association†	None
Michael Shuster	Mineral Springs Hospital Emergency Medicine	None	None	None	None	None	American Heart Association†	None

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Part 1: Executive Summary: 2015 Guidelines Update Writing Group Disclosures, *Continued*

Writing Group Member	Employment	Research Grant	Other Research Support	Speakers' Bureau/ Honoraria	Expert Witness	Ownership Interest	Consultant/ Advisory Board	Other
Elizabeth H. Sinz	Pennsylvania State University College of Medicine	None	None	None	None	None	American Heart Association†	None
Andrew H. Travers	Emergency Health Services, Nova Scotia	None	None	None	None	None	American Heart Association†	None

This table represents the relationships of writing group members that may be perceived as actual or reasonably perceived conflicts of interest as reported on the Disclosure Questionnaire, which all members of the writing group are required to complete and submit. A relationship is considered to be "significant" if (a) the person receives $10 000 or more during any 12-month period, or 5% or more of the person's gross income; or (b) the person owns 5% or more of the voting stock or share of the entity, or owns $10 000 or more of the fair market value of the entity. A relationship is considered to be "modest" if it is less than "significant" under the preceding definition.

*Modest.

†Significant.

Appendix

2015 Guidelines Update: Master List of Recommendations

Year Last Reviewed	Topic	Recommendation	Comments
Part 3: Ethical Issues			
2015	The Use of Extracorporeal CPR in OHCA	There is insufficient evidence to recommend the routine use of ECPR for patients with cardiac arrest. In settings where it can be rapidly implemented, ECPR may be considered for select patients for whom the suspected etiology of the cardiac arrest is potentially reversible during a limited period of mechanical cardiorespiratory support (Class IIb, LOE C-LD).	new for 2015
2015	Intra-arrest Prognostic Factors for Cardiac Arrest in Infants and Children	Multiple variables should be used when attempting to prognosticate outcomes during cardiac arrest (Class I, LOE C-LD).	new for 2015
2015	The Use of a Prognostic Score in the Delivery Room for Preterm Infants	However, in individual cases, when counseling a family and constructing a prognosis for survival at gestations below 25 weeks, it is reasonable to consider variables such as perceived accuracy of gestational age assignment, the presence or absence of chorioamnionitis, and the level of care available for location of delivery. It is also recognized that decisions about appropriateness of resuscitation below 25 weeks of gestation will be influenced by region-specific guidelines. In making this statement, a higher value was placed on the lack of evidence for a generalized prospective approach to changing important outcomes over improved retrospective accuracy and locally validated counseling policies. The most useful data for antenatal counseling provides outcome figures for infants alive at the onset of labor, not only for those born alive or admitted to a neonatal intensive care unit (Class IIb, LOE C-LD)	new for 2015
2015	Terminating Resuscitative Efforts in Term Infants	We suggest that, in infants with an Apgar score of 0 after 10 minutes of resuscitation, if the heart rate remains undetectable, it may be reasonable to stop assisted ventilations; however, the decision to continue or discontinue resuscitative efforts must be individualized. Variables to be considered may include whether the resuscitation was considered optimal; availability of advanced neonatal care, such as therapeutic hypothermia; specific circumstances before delivery (eg, known timing of the insult); and wishes expressed by the family (Class IIb, LOE C-LD)	updated for 2015
2015	The Use of ECPR in IHCA	There is insufficient evidence to recommend the routine use of ECPR for patients with cardiac arrest. In settings where it can be rapidly implemented, ECPR may be considered for select cardiac arrest patients for whom the suspected etiology of the cardiac arrest is potentially reversible during a limited period of mechanical cardiorespiratory support. (Class IIb, LOE C-LD).	new for 2015
2015	The Use of ECPR in IHCA	ECPR may be considered for pediatric patients with cardiac diagnoses who have IHCA in settings with existing ECMO protocols, expertise, and equipment (Class IIb, LOE C-LD).	new for 2015
2015	Terminating Cardiac Arrest Resuscitative Efforts in Pediatric IHCA	Multiple variables should be used when attempting to prognosticate outcomes during cardiac arrest (Class I, LOE C-LD).	new for 2015
2015	Prognostication During CPR	In intubated patients, failure to achieve an $ETCO_2$ of greater than 10 mm Hg by waveform capnography after 20 minutes of CPR may be considered as one component of a multimodal approach to decide when to end resuscitative efforts but should not be used in isolation (Class IIb, LOE C-LD).	new for 2015

(*Continued*)

2015 Guidelines Update: Master List of Recommendations, *Continued*

Year Last Reviewed	Topic	Recommendation	Comments
2015	Prognostication During CPR	In nonintubated patients, a specific $ETCO_2$ cutoff value at any time during CPR should not be used as an indication to end resuscitative efforts (Class III: Harm, LOE C-EO).	new for 2015
2015	Predictive Factors After Cardiac Arrest in Pediatric Patients	EEGs performed within the first 7 days after pediatric cardiac arrest may be considered in prognosticating neurologic outcome at the time of hospital discharge (Class IIb, LOE C-LD) but should not be used as the sole criterion.	new for 2015
2015	Predictive Factors After Cardiac Arrest in Pediatric Patients	The reliability of any 1 variable for prognostication in children after cardiac arrest has not been established. Practitioners should consider multiple factors when predicting outcomes in infants and children who achieve ROSC after cardiac arrest (Class I, LOE C-LD).	new for 2015
2015	Timing of Prognostication in Post–Cardiac Arrest Adults	The earliest time for prognostication in patients treated with TTM using clinical examination where sedation or paralysis could be a confounder may be 72 hours after return to normothermia (Class IIb, LOE C-EO).	updated for 2015
2015	Timing of Prognostication in Post–Cardiac Arrest Adults	We recommend the earliest time to prognosticate a poor neurologic outcome in patients not treated with TTM using clinical examination is 72 hours after cardiac arrest (Class I, LOE B-NR).	updated for 2015
2015	Timing of Prognostication in Post–Cardiac Arrest Adults	This time can be even longer after cardiac arrest if the residual effect of sedation or paralysis confounds the clinical examination (Class IIa, LOE C-LD).	new for 2015
2015	Prognostic Testing in Adult Patients After Cardiac Arrest: Clinical Exam Findings	In comatose patients who are not treated with TTM, the absence of pupillary reflex to light at 72 hours or more after cardiac arrest is a reasonable exam finding with which to predict poor neurologic outcome (FPR, 0%; 95% CI, 0%–8%; Class IIa, LOE B-NR).	new for 2015
2015	Prognostic Testing in Adult Patients After Cardiac Arrest: Clinical Exam Findings	In comatose patients who are treated with TTM, the absence of pupillary reflex to light at 72 hours or more after cardiac arrest is useful to predict poor neurologic outcome (FPR, 0%; 95% CI, 0%–3%; Class I, LOE B-NR).	new for 2015
2015	Prognostic Testing in Adult Patients After Cardiac Arrest: Clinical Exam Findings	We recommend that, given their high FPRs, the findings of either absent motor movements or extensor posturing should not be used alone for predicting a poor neurologic outcome (FPR, 10%; 95% CI, 7%–15% to FPR, 15%; 95% CI, 5%–31%; Class III: Harm, LOE B-NR).	new for 2015
2015	Prognostic Testing in Adult Patients After Cardiac Arrest: Clinical Exam Findings	The motor examination may be a reasonable means to identify the population who need further prognostic testing to predict poor outcome (Class IIb, LOE B-NR).	new for 2015
2015	Prognostic Testing in Adult Patients After Cardiac Arrest: Clinical Exam Findings	We recommend that the presence of myoclonus, which is distinct from status myoclonus, should not be used to predict poor neurologic outcomes because of the high FPR (FPR, 5%; 95% CI, 3%–8% to FPR, 11%; 95% CI, 3%–26%; Class III: Harm, LOE B-NR).	new for 2015
2015	Prognostic Testing in Adult Patients After Cardiac Arrest: Clinical Exam Findings	In combination with other diagnostic tests at 72 or more hours after cardiac arrest, the presence of status myoclonus during the first 72 hours after cardiac arrest is a reasonable finding to help predict poor neurologic outcomes (FPR, 0%; 95% CI, 0%–4%; Class IIa, LOE B-NR).	new for 2015
2015	Prognostic Testing in Adult Patients After Cardiac Arrest: EEG	In comatose post–cardiac arrest patients who are treated with TTM, it may be reasonable to consider persistent absence of EEG reactivity to external stimuli at 72 hours after cardiac arrest, and persistent burst suppression on EEG after rewarming, to predict a poor outcome (FPR, 0%; 95% CI, 0%–3%; Class IIb, LOE B-NR).	updated for 2015
2015	Prognostic Testing in Adult Patients After Cardiac Arrest: EEG	Intractable and persistent (more than 72 hours) status epilepticus in the absence of EEG reactivity to external stimuli may be reasonable to predict poor outcome (Class IIb, LOE B-NR).	updated for 2015
2015	Prognostic Testing in Adult Patients After Cardiac Arrest: EEG	In comatose post–cardiac arrest patients who are not treated with TTM, it may be reasonable to consider the presence of burst suppression on EEG at 72 hours or more after cardiac arrest, in combination with other predictors, to predict a poor neurologic outcome (FPR, 0%; 95% CI, 0%–11%; Class IIb, LOE B-NR).	updated for 2015
2015	Prognostic Testing in Adult Patients After Cardiac Arrest: Evoked Potentials	In patients who are comatose after resuscitation from cardiac arrest regardless of treatment with TTM, it is reasonable to consider bilateral absence of the N20 SSEP wave 24 to 72 hours after cardiac arrest or after rewarming a predictor of poor outcome (FPR, 1%; 95% CI, 0%–3%; Class IIa, LOE B-NR).	updated for 2015
2015	Prognostic Testing in Adult Patients After Cardiac Arrest: Imaging Tests	In patients who are comatose after resuscitation from cardiac arrest and not treated with TTM, it may be reasonable to use the presence of a marked reduction of the grey white ratio (GWR) on brain CT obtained within 2 hours after cardiac arrest to predict poor outcome (Class IIb, LOE B-NR).	new for 2015
2015	Prognostic Testing in Adult Patients After Cardiac Arrest: Imaging Tests	It may be reasonable to consider extensive restriction of diffusion on brain MRI at 2 to 6 days after cardiac arrest in combination with other established predictors to predict a poor neurologic outcome (Class IIb, LOE B-NR).	new for 2015
2015	Prognostic Testing in Adult Patients After Cardiac Arrest: Blood Markers	Given the possibility of high FPRs, blood levels of NSE and S-100B should not be used alone to predict a poor neurologic outcome (Class III: Harm, LOE C-LD).	updated for 2015

(*Continued*)

2015 Guidelines Update: Master List of Recommendations, *Continued*

Year Last Reviewed	Topic	Recommendation	Comments
2015	Prognostic Testing in Adult Patients After Cardiac Arrest: Blood Markers	When performed with other prognostic tests at 72 hours or more after cardiac arrest, it may be reasonable to consider high serum values of NSE at 48 to 72 hours after cardiac arrest to support the prognosis of a poor neurologic outcome (Class IIb, LOE B-NR), especially if repeated sampling reveals persistently high values (Class IIb, LOE C-LD).	updated for 2015
2015	Ethics of Organ and Tissue Donation	We recommend that all patients who are resuscitated from cardiac arrest but who subsequently progress to death or brain death be evaluated for organ donation (Class I, LOE B-NR).	updated for 2015
2015	Ethics of Organ and Tissue Donation	Patients who do not have ROSC after resuscitation efforts and who would otherwise have termination of efforts may be considered candidates for kidney or liver donation in settings where programs exist (Class IIb, LOE B-NR).	new for 2015
The following recommendations were not reviewed in 2015. For more information, see the *2010 AHA Guidelines for CPR and ECC*, "Part 3: Ethics."			
2010	Principle of Futility	Conditions such as irreversible brain damage or brain death cannot be reliably assessed or predicted at the time of cardiac arrest. Withholding resuscitation and the discontinuation of life-sustaining treatment during or after resuscitation are ethically equivalent. In situations where the prognosis is uncertain, a trial of treatment may be initiated while further information is gathered to help determine the likelihood of survival, the patient's preferences, and the expected clinical course (Class IIb, LOE C).	not reviewed in 2015
2010	Terminating Resuscitative Efforts in a BLS Out-of-Hospital System	It is recommended that regional or local EMS authorities use the BLS termination rule to develop protocols for the termination of resuscitative efforts by BLS providers for adult victims of cardiac arrest in areas where advanced life support is not available or may be significantly delayed (Class I, LOE A).	not reviewed in 2015
2010	Terminating Resuscitative Efforts in a BLS Out-of-Hospital System	The reliability and validity of this rule is uncertain if modified (Class IIb, LOE A).	not reviewed in 2015
2010	Terminating Resuscitative Efforts in an ALS Out-of-Hospital System	An ALS termination of resuscitation rule was derived from a diverse population of rural and urban EMS settings. This rule recommends considering terminating resuscitation when ALL of the following criteria apply before moving to the ambulance for transport: (1) arrest was not witnessed; (2) no bystander CPR was provided; (3) no ROSC after full ALS care in the field; and (4) no AED shocks were delivered. This rule has been retrospectively externally validated for adult patients in several regions in the US, Canada, and Europe, and it is reasonable to employ this rule in all ALS services (Class IIa, LOE B).	not reviewed in 2015
2010	Terminating Resuscitative Efforts in a Combined BLS and ALS Out-of-Hospital System	In a tiered ALS- and BLS-provider system, the use of a universal rule can avoid confusion at the scene of a cardiac arrest without compromising diagnostic accuracy. The BLS rule is reasonable to use in these services (Class IIa, LOE B).	not reviewed in 2015
2010	Providing Emotional Support to the Family During Resuscitative Efforts in Cardiac Arrest	In the absence of data documenting harm and in light of data suggesting that it may be helpful, offering select family members the opportunity to be present during a resuscitation is reasonable and desirable (assuming that the patient, if an adult, has not raised a prior objection) (Class IIa, LOE C for adults and Class I, LOE B for pediatric patients).	not reviewed in 2015
2010	Providing Emotional Support to the Family During Resuscitative Efforts in Cardiac Arrest	In the absence of data documenting harm and in light of data suggesting that it may be helpful, offering select family members the opportunity to be present during a resuscitation is reasonable and desirable (assuming that the patient, if an adult, has not raised a prior objection) (Class IIa, LOE C for adults and Class I, LOE B for pediatric patients).	not reviewed in 2015
2010	Ethics of Organ and Tissue Donation	It is reasonable to suggest that all communities should optimize retrieval of tissue and organ donations in brain dead post–cardiac arrest patients (in-hospital) and those pronounced dead in the out-of-hospital setting (Class IIa, LOE B).	not reviewed in 2015
2010	Ethics of Organ and Tissue Donation	Medical directors of EMS agencies, emergency departments (EDs), and critical care units (CCUs) should develop protocols and implementation plans with the regional organ and tissue donation program to optimize donation following a cardiac arrest death (Class I, LOE C)	not reviewed in 2015
2010	Criteria for Not Starting CPR in Newly Born Infant IHCA	There are prescribed recommendations to guide the initiation of resuscitative efforts in newly born infants. When gestational age, birth weight, or congenital anomalies are associated with almost certain early death and when unacceptably high morbidity is likely among the rare survivors, resuscitation is not indicated. Examples may include extreme prematurity (gestational age <23 weeks or birth weight <400 g, anencephaly, and some major chromosomal abnormalities such as trisomy 13 (Class IIb, LOE C).	not reviewed in 2015
2010	Criteria for Not Starting CPR in Newly Born Infant IHCA	In conditions associated with uncertain prognosis where survival is borderline, the morbidity rate is relatively high, and the anticipated burden to the child is high, parental desires concerning initiation of resuscitation should be supported (Class IIb, LOE C).	not reviewed in 2015

(*Continued*)

2015 Guidelines Update: Master List of Recommendations, *Continued*

Year Last Reviewed	Topic	Recommendation	Comments
Part 4: Systems of Care and Continuous Quality Improvement			
2015	Prearrest Rapid Response Systems	For adult patients, RRT or MET systems can be effective in reducing the incidence of cardiac arrest, particularly in general care wards (Class IIa, LOE C-LD).	updated for 2015
2015	Prearrest Rapid Response Systems	Pediatric MET/RRT systems may be considered in facilities where children with high-risk illnesses are cared for on general in-patient units (Class IIb, LOE C-LD).	updated for 2015
2015	Prearrest Rapid Response Systems	The use of EWSS may be considered for adults and children (Class IIb, LOE C-LD).	updated for 2015
2015	Debriefing	It is reasonable for in-hospital systems of care to implement performance-focused debriefing of rescuers after IHCA in both adults and children (Class IIa, LOE C-LD).	updated for 2015
2015	Public-Access Defibrillation	It is recommended that PAD programs for patients with OHCA be implemented in communities at risk for cardiac arrest (Class I, LOE C-LD).	updated for 2015
2015	Dispatcher Recognition of Cardiac Arrest	It is recommended that emergency dispatchers determine if a patient is unconscious with abnormal breathing after acquiring the requisite information to determine the location of the event (Class I, LOE C-LD).	updated for 2015
2015	Dispatcher Recognition of Cardiac Arrest	If the patient is unconscious with abnormal or absent breathing, it is reasonable for the emergency dispatcher to assume that the patient is in cardiac arrest (Class IIa, LOE C-LD).	updated for 2015
2015	Dispatcher Recognition of Cardiac Arrest	Dispatchers should be educated to identify unconsciousness with abnormal and agonal gasps across a range of clinical presentations and descriptions (Class I, LOE C-LD).	updated for 2015
2015	Dispatcher Instruction in CPR	We recommend that dispatchers should provide chest compression–only CPR instructions to callers for adults with suspected OHCA (Class I, LOE C-LD).	updated for 2015
2015	Use of Social Media to Summon Rescuers	Given the low risk of harm and the potential benefit of such notifications, it may be reasonable for communities to incorporate, where available, social media technologies that summon rescuers who are willing and able to perform CPR and are in close proximity to a suspected victim of OHCA (Class IIb, LOE B-R).	updated for 2015
2015	Transport to Specialized Cardiac Arrest Centers	A regionalized approach to OHCA resuscitation that includes the use of cardiac resuscitation centers may be considered (Class IIb, LOE C-LD).	updated for 2015
2015	Immediate Recognition and Activation of the Emergency Response System	It is recommended that emergency dispatchers determine if a patient is unresponsive with abnormal breathing after acquiring the requisite information to determine the location of the event (Class I, LOE C-LD).	updated for 2015
2015	Immediate Recognition and Activation of the Emergency Response System	If the patient is unresponsive with abnormal or absent breathing, it is reasonable for the emergency dispatcher to assume that the patient is in cardiac arrest (Class IIa, LOE C-LD).	updated for 2015
2015	Immediate Recognition and Activation of the Emergency Response System	Dispatchers should be educated to identify unresponsiveness with abnormal breathing and agonal gasps across a range of clinical presentations and descriptions (Class I, LOE C-LD).	updated for 2015
2015	Early CPR	Similar to the 2010 Guidelines, it may be reasonable for rescuers to initiate CPR with chest compressions (Class IIb, LOE C-LD).	updated for 2015
2015	Untrained Lay Rescuer	Untrained lay rescuers should provide compression-only CPR, with or without dispatcher assistance (Class I, LOE C-LD).	updated for 2015
2015	Untrained Lay Rescuer	The rescuer should continue compression-only CPR until the arrival of an AED or rescuers with additional training (Class I, LOE C-LD).	updated for 2015
2015	Trained Lay Rescuer	All lay rescuers should, at a minimum, provide chest compressions for victims of cardiac arrest (Class I, LOE C-LD). In addition, if the trained lay rescuer is able to perform rescue breaths, he or she should add rescue breaths in a ratio of 30 compressions to 2 breaths.	updated for 2015
2015	Trained Lay Rescuer	The rescuer should continue CPR until an AED arrives and is ready for use or EMS providers take over care of the victim (Class I, LOE C-LD).	updated for 2015
2015	Healthcare Provider	It is reasonable for healthcare providers to provide chest compressions and ventilation for all adult patients in cardiac arrest, from either a cardiac or noncardiac cause (Class IIa, LOE C-LD).	updated for 2015
2015	Delayed Ventilation	For witnessed OHCA with a shockable rhythm, it may be reasonable for EMS systems with priority-based, multitiered response to delay positive-pressure ventilation by using a strategy of up to 3 cycles of 200 continuous compressions with passive oxygen insufflation and airway adjuncts (Class IIb, LOE C-LD).	new for 2015
2015	Recognition of Arrest	Dispatchers should instruct rescuers to provide CPR if the victim is unresponsive with no normal breathing, even when the victim demonstrates occasional gasps (Class I, LOE C-LD).	updated for 2015

(*Continued*)

2015 Guidelines Update: Master List of Recommendations, *Continued*

Year Last Reviewed	Topic	Recommendation	Comments
2015	Suspected Opioid-Related Life-Threatening Emergency	For a patient with known or suspected opioid overdose who has a definite pulse but no normal breathing or only gasping (ie, a respiratory arrest), in addition to providing standard BLS care, it is reasonable for appropriately trained BLS healthcare providers to administer intramuscular or intranasal naloxone (Class IIa, LOE C-LD).	new for 2015
2015	Suspected Opioid-Related Life-Threatening Emergency	For patients in cardiac arrest, medication administration is ineffective without concomitant chest compressions for drug delivery to the tissues, so naloxone administration may be considered after initiation of CPR if there is high suspicion for opiate overdose (Class IIb, LOE C-EO).	new for 2015
2015	Suspected Opioid-Related Life-Threatening Emergency	It is reasonable to provide opioid overdose response education with or without naloxone distribution to persons at risk for opioid overdose in any setting (Class IIa, LOE C-LD).	new for 2015
2015	Hand Position During Compressions	Consistent with the 2010 Guidelines, it is reasonable to position hands for chest compressions on the lower half of the sternum in adults with cardiac arrest. (Class IIa, LOE C-LD).	updated for 2015
2015	Chest Compression Rate	In adult victims of cardiac arrest, it is reasonable for rescuers to perform chest compressions at a rate of 100/min to 120/min (Class IIa, LOE C-LD).	updated for 2015
2015	Chest Compression Depth	During manual CPR, rescuers should perform chest compressions to a depth of at least 2 inches or 5 cm for an average adult, while avoiding excessive chest compression depths (greater than 2.4 inches or 6 cm) (Class I, LOE C-LD).	updated for 2015
2015	Chest Wall Recoil	It is reasonable for rescuers to avoid leaning on the chest between compressions to allow full chest wall recoil for adults in cardiac arrest (Class IIa, LOE C-LD).	updated for 2015
2015	Minimizing Interruptions in Chest Compressions	In adult cardiac arrest, total preshock and postshock pauses in chest compressions should be as short as possible (Class I, LOE C-LD).	updated for 2015
2015	Minimizing Interruptions in Chest Compressions	For adults in cardiac arrest receiving CPR without an advanced airway, it is reasonable to pause compressions for less than 10 seconds to deliver 2 breaths (Class IIa, LOE C-LD).	updated for 2015
2015	Minimizing Interruptions in Chest Compressions	In adult cardiac arrest with an unprotected airway, it may be reasonable to perform CPR with the goal of a chest compression fraction as high as possible, with a target of at least 60% (Class IIb, LOE C-LD).	new for 2015
2015	Compression-to-Ventilation Ratio	Consistent with the 2010 Guidelines, it is reasonable for rescuers to provide a compression-to-ventilation ratio of 30:2 for adults in cardiac arrest (Class IIa, LOE C-LD).	updated for 2015
2015	Layperson—Compression-Only CPR Versus Conventional CPR	Dispatchers should instruct untrained lay rescuers to provide compression-only CPR for adults with sudden cardiac arrest (Class I, LOE B-R).	updated for 2015
2015	Layperson—Compression-Only CPR Versus Conventional CPR	Compression-only CPR is a reasonable alternative to conventional CPR in the adult cardiac arrest patient (Class IIa, LOE C-LD).	updated for 2015
2015	Layperson—Compression-Only CPR Versus Conventional CPR	For trained rescuers, ventilation may be considered in addition to chest compressions for the adult in cardiac arrest (Class IIb, LOE C-LD).	updated for 2015
2015	Open the Airway: Lay Rescuer	For victims with suspected spinal injury, rescuers should initially use manual spinal motion restriction (eg, placing 1 hand on either side of the patient's head to hold it still) rather than immobilization devices, because use of immobilization devices by lay rescuers may be harmful (Class III: Harm, LOE C-LD).	updated for 2015
2015	Bag-Mask Ventilation	As long as the patient does not have an advanced airway in place, the rescuers should deliver cycles of 30 compressions and 2 breaths during CPR. The rescuer delivers breaths during pauses in compressions and delivers each breath over approximately 1 second (Class IIa, LOE C-LD).	updated for 2015
2015	Ventilation With an Advanced Airway	When the victim has an advanced airway in place during CPR, rescuers no longer deliver cycles of 30 compressions and 2 breaths (ie, they no longer interrupt compressions to deliver 2 breaths). Instead, it may be reasonable for the provider to deliver 1 breath every 6 seconds (10 breaths per minute) while continuous chest compressions are being performed (Class IIb, LOE C-LD).	updated for 2015
2015	Passive Oxygen Versus Positive-Pressure Oxygen During CPR	We do not recommend the routine use of passive ventilation techniques during conventional CPR for adults, because the usefulness/effectiveness of these techniques is unknown (Class IIb, LOE C-EO).	new for 2015
2015	Passive Oxygen Versus Positive-Pressure Oxygen During CPR	However, in EMS systems that use bundles of care involving continuous chest compressions, the use of passive ventilation techniques may be considered as part of that bundle (Class IIb, LOE C-LD).	new for 2015
2015	CPR Before Defibrillation	For witnessed adult cardiac arrest when an AED is immediately available, it is reasonable that the defibrillator be used as soon as possible (Class IIa, LOE C-LD).	updated for 2015

(*Continued*)

2015 Guidelines Update: Master List of Recommendations, *Continued*

Year Last Reviewed	Topic	Recommendation	Comments
2015	CPR Before Defibrillation	For adults with unmonitored cardiac arrest or for whom an AED is not immediately available, it is reasonable that CPR be initiated while the defibrillator equipment is being retrieved and applied and that defibrillation, if indicated, be attempted as soon as the device is ready for use (Class IIa, LOE B-R).	updated for 2015
2015	Analysis of Rhythm During Compressions	There is insufficient evidence to recommend the use of artifact-filtering algorithms for analysis of ECG rhythm during CPR. Their use may be considered as part of a research program or if an EMS system has already incorporated ECG artifact-filtering algorithms in its resuscitation protocols (Class IIb, LOE C-EO).	new for 2015
2015	Timing of Rhythm Check	It may be reasonable to immediately resume chest compressions after shock delivery for adults in cardiac arrest in any setting (Class IIb, LOE C-LD).	updated for 2015
2015	Chest Compression Feedback	It may be reasonable to use audiovisual feedback devices during CPR for real-time optimization of CPR performance (Class IIb, LOE B-R).	updated for 2015
The following recommendations were not reviewed in 2015. For more information, *see the 2010 AHA Guidelines for CPR and ECC*, "Part 5: Adult Basic Life Support" and "Part 6: Electrical Therapies: Automated External Defibrillators, Defibrillation, Cardioversion, and Pacing."			
2010	Activating the Emergency Response System	The EMS system quality improvement process, including review of the quality of dispatcher CPR instructions provided to specific callers, is considered an important component of a high-quality lifesaving program (Class IIa, LOE B).	not reviewed in 2015
2010	Pulse Check	The healthcare provider should take no more than 10 seconds to check for a pulse and, if the rescuer does not definitely feel a pulse within that time period, the rescuer should start chest compressions (Class IIa, LOE C).	not reviewed in 2015
2010	Chest Compressions	Effective chest compressions are essential for providing blood flow during CPR. For this reason all patients in cardiac arrest should receive chest compressions (Class I, LOE B).	not reviewed in 2015
2010	Rescue Breaths	Deliver each rescue breath over 1 second (Class IIa, LOE C).	not reviewed in 2015
2010	Rescue Breaths	Give a sufficient tidal volume to produce visible chest rise (Class IIa, LOE C).	not reviewed in 2015
2010	Early Defibrillation With an AED	When 2 or more rescuers are present, one rescuer should begin chest compressions while a second rescuer activates the emergency response system and gets the AED (or a manual defibrillator in most hospitals) (Class IIa, LOE C).	not reviewed in 2015
2010	Recognition of Arrest	The rescuer should treat the victim who has occasional gasps as if he or she is not breathing (Class I, LOE C).	not reviewed in 2015
2010	Technique: Chest Compressions	The rescuer should place the heel of one hand on the center (middle) of the victim's chest (which is the lower half of the sternum) and the heel of the other hand on top of the first so that the hands are overlapped and parallel (Class IIa, LOE B).	not reviewed in 2015
2010	Technique: Chest Compressions	Because of the difficulty in providing effective chest compressions while moving the patient during CPR, the resuscitation should generally be conducted where the patient is found (Class IIa, LOE C).	not reviewed in 2015
2010	Compression-Ventilation Ratio	Once an advanced airway is in place, 2 rescuers no longer need to pause chest compressions for ventilations. Instead, the compressing rescuer should give continuous chest compressions at a rate of at least 100 per minute without pauses for ventilation (Class IIa, LOE B).	not reviewed in 2015
2010	Open the Airway: Lay Rescuer	The trained lay rescuer who feels confident that he or she can perform both compressions and ventilations should open the airway using a head tilt–chin lift maneuver (Class IIa, LOE B).	not reviewed in 2015
2010	Open the Airway: Healthcare Provider	Although the head tilt–chin lift technique was developed using unconscious, paralyzed adult volunteers and has not been studied in victims with cardiac arrest, clinical and radiographic evidence and a case series have shown it to be effective (Class IIa, LOE B).	not reviewed in 2015
2010	Open the Airway: Healthcare Provider	If healthcare providers suspect a cervical spine injury, they should open the airway using a jaw thrust without head extension (Class IIb, LOE C).	not reviewed in 2015
2010	Open the Airway: Healthcare Provider	Because maintaining a patent airway and providing adequate ventilation are priorities in CPR (Class I, LOE C), use the head tilt–chin lift maneuver if the jaw thrust does not adequately open the airway.	not reviewed in 2015
2010	Rescue Breathing	Deliver each rescue breath over 1 second (Class IIa, LOE C).	not reviewed in 2015
2010	Rescue Breathing	Give a sufficient tidal volume to produce visible chest rise (Class IIa, LOE C).	not reviewed in 2015
2010	Rescue Breathing	During adult CPR, tidal volumes of approximately 500 to 600 mL (6 to 7 mL/kg) should suffice (Class IIa, LOE B).	not reviewed in 2015
2010	Rescue Breathing	Rescuers should avoid excessive ventilation (too many breaths or too large a volume) during CPR (Class III, LOE B).	not reviewed in 2015
2010	Mouth-to-Mouth Rescue Breathing	Give 1 breath over 1 second, take a "regular" (not a deep) breath, and give a second rescue breath over 1 second (Class IIb, LOE C).	not reviewed in 2015

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2015 Guidelines Update: Master List of Recommendations, *Continued*

Year Last Reviewed	Topic	Recommendation	Comments
2010	Mouth-to-Mouth Rescue Breathing	If an adult victim with spontaneous circulation (ie, strong and easily palpable pulses) requires support of ventilation, the healthcare provider should give rescue breaths at a rate of about 1 breath every 5 to 6 seconds, or about 10 to 12 breaths per minute (Class IIb, LOE C).	not reviewed in 2015
2010	Mouth-to-Nose and Mouth-to-Stoma Ventilation	Mouth-to-nose ventilation is recommended if ventilation through the victim's mouth is impossible (eg, the mouth is seriously injured), the mouth cannot be opened, the victim is in water, or a mouth-to-mouth seal is difficult to achieve (Class IIa, LOE C).	not reviewed in 2015
2010	Mouth-to-Nose and Mouth-to-Stoma Ventilation	A reasonable alternative is to create a tight seal over the stoma with a round, pediatric face mask (Class IIb, LOE C).	not reviewed in 2015
2010	Bag-Mask Ventilation	The rescuer should use an adult (1 to 2 L) bag to deliver approximately 600 mL tidal volume for adult victims. This amount is usually sufficient to produce visible chest rise and maintain oxygenation and normocarbia in apneic patients (Class IIa, LOE C).	not reviewed in 2015
2010	Bag-Mask Ventilation	The rescuer delivers ventilations during pauses in compressions and delivers each breath over 1 second (Class IIa, LOE C).	not reviewed in 2015
2010	Mouth-to-Nose and Mouth-to-Stoma Ventilation	Ventilation with a bag through these devices provides an acceptable alternative to bag-mask ventilation for well-trained healthcare providers who have sufficient experience to use the devices for airway management during cardiac arrest (Class IIa, LOE B).	not reviewed in 2015
2010	Cricoid Pressure	The routine use of cricoid pressure in adult cardiac arrest is not recommended (Class III, LOE B).	not reviewed in 2015
2010	AED Defibrillation	Rapid defibrillation is the treatment of choice for VF of short duration, such as for victims of witnessed out-of-hospital cardiac arrest or for hospitalized patients whose heart rhythm is monitored (Class I, LOE A).	not reviewed in 2015
2010	AED Defibrillation	There is insufficient evidence to recommend for or against delaying defibrillation to provide a period of CPR for patients in VF/pulseless VT out-of-hospital cardiac arrest. In settings with lay rescuer AED programs (AED onsite and available) and for in-hospital environments, or if the EMS rescuer witnesses the collapse, the rescuer should use the defibrillator as soon as it is available (Class IIa, LOE C).	not reviewed in 2015
2010	Recovery Position	The position should be stable, near a true lateral position, with the head dependent and with no pressure on the chest to impair breathing (Class IIa, LOE C).	not reviewed in 2015
2010	Acute Coronary Syndromes	If the patient has not taken aspirin and has no history of aspirin allergy and no evidence of recent gastrointestinal bleeding, EMS providers should give the patient nonenteric aspirin (160 to 325 mg) to chew (Class I, LOE C).	not reviewed in 2015
2010	Acute Coronary Syndromes	Although it is reasonable to consider the early administration of nitroglycerin in select hemodynamically stable patients, insufficient evidence exists to support or refute the routine administration of nitroglycerin in the ED or prehospital setting in patients with a suspected ACS (Class IIb, LOE B).	not reviewed in 2015
2010	Stroke	Patients at high risk for stroke, their family members, and BLS providers should learn to recognize the signs and symptoms of stroke and to call EMS as soon as any signs of stroke are present (Class I, LOE C).	not reviewed in 2015
2010	Stroke	EMS dispatchers should be trained to suspect stroke and rapidly dispatch emergency responders. EMS personnel should be able to perform an out-of-hospital stroke assessment (Class I, LOE B), establish the time of symptom onset when possible, provide cardiopulmonary support, and notify the receiving hospital that a patient with possible stroke is being transported.	not reviewed in 2015
2010	Stroke	EMS systems should have protocols that address triaging the patient when possible directly to a stroke center (Class I, LOE B).	not reviewed in 2015
2010	Stroke	Both out-of-hospital and in-hospital medical personnel should administer supplementary oxygen to hypoxemic (ie, oxygen saturation <94%) stroke patients (Class I, LOE C) or those with unknown oxygen saturation.	not reviewed in 2015
2010	Stroke	Unless the patient is hypotensive (systolic blood pressure <90 mm Hg), prehospital intervention for blood pressure is not recommended (Class III, LOE C).	not reviewed in 2015
2010	Drowning	Mouth-to-mouth ventilation in the water may be helpful when administered by a trained rescuer (Class IIb, LOE C).	not reviewed in 2015
Part 6: Alternative Techniques and Ancillary Devices for Cardiopulmonary Resuscitation			
2015	Devices to Support Circulation: Impedance Threshold Device	The routine use of the ITD as an adjunct during conventional CPR is not recommended (Class III: No Benefit, LOE A).	new for 2015
2015	Devices to Support Circulation: Active Compression-Decompression CPR and Impedance Threshold Device	The existing evidence, primarily from 1 large RCT of low quality, does not support the routine use of ACD-CPR+ITD as an alternative to conventional CPR. The combination may be a reasonable alternative in settings with available equipment and properly trained personnel (Class IIb, LOE C-LD).	new for 2015

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2015 Guidelines Update: Master List of Recommendations, *Continued*

Year Last Reviewed	Topic	Recommendation	Comments
2015	Devices to Support Circulation: Mechanical Chest Compression Devices: Piston Device	The evidence does not demonstrate a benefit with the use of mechanical piston devices for chest compressions versus manual chest compressions in patients with cardiac arrest. Manual chest compressions remain the standard of care for the treatment of cardiac arrest, but mechanical chest compressions using a piston device may be a reasonable alternative for use by properly trained personnel (Class IIb, LOE B-R).	new for 2015
2015	Devices to Support Circulation: Mechanical Chest Compression Devices: Piston Device	The use of piston devices for CPR may be considered in specific settings where the delivery of high-quality manual compressions may be challenging or dangerous for the provider (eg, prolonged CPR during hypothermic cardiac arrest, CPR in a moving ambulance, CPR in the angiography suite, CPR during preparation for extracorporeal CPR [ECPR]), provided that rescuers strictly limit interruptions in CPR during deployment and removal of the device (Class IIb, LOE C-EO).	new for 2015
2015	Devices to Support Circulation: Load-Distributing Band Devices	The evidence does not demonstrate a benefit with the use of LDB-CPR for chest compressions versus manual chest compressions in patients with cardiac arrest. Manual chest compressions remain the standard of care for the treatment of cardiac arrest, but LDB-CPR may be a reasonable alternative for use by properly trained personnel (Class IIb, LOE B-R).	new for 2015
2015	Devices to Support Circulation: Load-Distributing Band Devices	The use of LDB-CPR may be considered in specific settings where the delivery of high-quality manual compressions may be challenging or dangerous for the provider (eg, prolonged CPR during hypothermic cardiac arrest, CPR in a moving ambulance, CPR in the angiography suite, CPR during preparation for ECPR), provided that rescuers strictly limit interruptions in CPR during deployment and removal of the devices (Class IIb, LOE E).	new for 2015
2015	Extracorporeal Techniques and Invasive Perfusion Devices: Extracorporeal CPR	There is insufficient evidence to recommend the routine use of ECPR for patients with cardiac arrest. It may be considered for select patients for whom the suspected etiology of the cardiac arrest is potentially reversible during a limited period of mechanical cardiorespiratory support (Class IIb, LOE C-LD).	new for 2015
The following recommendations were not reviewed in 2015. For more information, see the *2010 AHA Guidelines for CPR and ECC*, "Part 7: CPR Techniques and Devices."			
2010	Open-Chest CPR	Open-chest CPR can be useful if cardiac arrest develops during surgery when the chest or abdomen is already open, or in the early postoperative period after cardiothoracic surgery (Class IIa, LOE C).	not reviewed in 2015
2010	Open-Chest CPR	A resuscitative thoracotomy to facilitate open-chest CPR may be considered in very select circumstances of adults and children with out-of-hospital cardiac arrest from penetrating trauma with short transport times to a trauma facility (Class IIb, LOE C).	not reviewed in 2015
2010	Interposed Abdominal Compression CPR	IAC-CPR may be considered during in-hospital resuscitation when sufficient personnel trained in its use are available (Class IIb, LOE B).	not reviewed in 2015
2010	"Cough" CPR	"Cough" CPR may be considered in settings such as the cardiac catheterization laboratory for conscious, supine, and monitored patients if the patient can be instructed and coached to cough forcefully every 1 to 3 seconds during the initial seconds of an arrhythmic cardiac arrest. It should not delay definitive treatment (Class IIb, LOE C).	not reviewed in 2015
2010	Prone CPR	When the patient cannot be placed in the supine position, it may be reasonable for rescuers to provide CPR with the patient in the prone position, particularly in hospitalized patients with an advanced airway in place (Class IIb, LOE C).	not reviewed in 2015
2010	Precordial Thump	The precordial thump should not be used for unwitnessed out-of-hospital cardiac arrest (Class III, LOE C).	not reviewed in 2015
2010	Precordial Thump	The precordial thump may be considered for patients with witnessed, monitored, unstable ventricular tachycardia including pulseless VT if a defibrillator is not immediately ready for use (Class IIb, LOE C), but it should not delay CPR and shock delivery.	not reviewed in 2015
2010	Automatic Transport Ventilators	During prolonged resuscitation efforts, the use of an ATV (pneumatically powered and time- or pressure-cycled) may provide ventilation and oxygenation similar to that possible with the use of a manual resuscitation bag, while allowing the Emergency Medical Services (EMS) team to perform other tasks (Class IIb, LOE C).	not reviewed in 2015
2010	Manually Triggered, Oxygen-Powered, Flow-Limited Resuscitators	Manually triggered, oxygen-powered, flow-limited resuscitators may be considered for the management of patients who do not have an advanced airway in place and for whom a mask is being used for ventilation during CPR (Class IIb, LOE C).	not reviewed in 2015
2010	Manually Triggered, Oxygen-Powered, Flow-Limited Resuscitators	Rescuers should avoid using the automatic mode of the oxygen-powered, flow-limited resuscitator during CPR because it may generate high positive end-expiratory pressure (PEEP) that may impede venous return during chest compressions and compromise forward blood flow (Class III, LOE C).	not reviewed in 2015
2010	Active Compression-Decompression CPR	There is insufficient evidence to recommend for or against the routine use of ACD-CPR. ACD-CPR may be considered for use when providers are adequately trained and monitored (Class IIb, LOE B).	not reviewed in 2015
Part 8: Adult Advanced Cardiovascular Life Support			
2015	Adjuncts to CPR	When supplementary oxygen is available, it may be reasonable to use the maximal feasible inspired oxygen concentration during CPR (Class IIb, LOE C-EO).	updated for 2015

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2015 Guidelines Update: Master List of Recommendations, *Continued*

Year Last Reviewed	Topic	Recommendation	Comments
2015	Adjuncts to CPR	Although no clinical study has examined whether titrating resuscitative efforts to physiologic parameters during CPR improves outcome, it may be reasonable to use physiologic parameters (quantitative waveform capnography, arterial relaxation diastolic pressure, arterial pressure monitoring, and central venous oxygen saturation) when feasible to monitor and optimize CPR quality, guide vasopressor therapy, and detect ROSC (Class IIb, LOE C-EO).	updated for 2015
2015	Adjuncts to CPR	Ultrasound (cardiac or noncardiac) may be considered during the management of cardiac arrest, although its usefulness has not been well established (Class IIb, LOE C-EO).	updated for 2015
2015	Adjuncts to CPR	If a qualified sonographer is present and use of ultrasound does not interfere with the standard cardiac arrest treatment protocol, then ultrasound may be considered as an adjunct to standard patient evaluation (Class IIb, LOE C-EO).	updated for 2015
2015	Adjuncts for Airway Control and Ventilation	Either a bag-mask device or an advanced airway may be used for oxygenation and ventilation during CPR in both the in-hospital and out-of-hospital setting (Class IIb, LOE C-LD).	updated for 2015
2015	Adjuncts for Airway Control and Ventilation	For healthcare providers trained in their use, either an SGA device or an ETT may be used as the initial advanced airway during CPR (Class IIb, LOE C-LD).	updated for 2015
2015	Adjuncts for Airway Control and Ventilation	Continuous waveform capnography is recommended in addition to clinical assessment as the most reliable method of confirming and monitoring correct placement of an ETT (Class I, LOE C-LD).	updated for 2015
2015	Adjuncts for Airway Control and Ventilation	If continuous waveform capnometry is not available, a nonwaveform CO_2 detector, esophageal detector device, or ultrasound used by an experienced operator is a reasonable alternative (Class IIa, LOE B-NR).	updated for 2015
2015	Adjuncts for Airway Control and Ventilation	After placement of an advanced airway, it may be reasonable for the provider to deliver 1 breath every 6 seconds (10 breaths/min) while continuous chest compressions are being performed (Class IIb, LOE C-LD).	updated for 2015
2015	Management of Cardiac Arrest	Defibrillators (using BTE, RLB, or monophasic waveforms) are recommended to treat atrial and ventricular arrhythmias (Class I, LOE B-NR).	updated for 2015
2015	Management of Cardiac Arrest	Based on their greater success in arrhythmia termination, defibrillators using biphasic waveforms (BTE or RLB) are preferred to monophasic defibrillators for treatment of both atrial and ventricular arrhythmias (Class IIa, LOE B-R).	updated for 2015
2015	Management of Cardiac Arrest	In the absence of conclusive evidence that 1 biphasic waveform is superior to another in termination of VF, it is reasonable to use the manufacturer's recommended energy dose for the first shock. If this is not known, defibrillation at the maximal dose may be considered (Class IIb, LOE C-LD).	updated for 2015
2015	Management of Cardiac Arrest	It is reasonable that selection of fixed versus escalating energy for subsequent shocks be based on the specific manufacturer's instructions (Class IIa, LOE C-LD).	updated for 2015
2015	Management of Cardiac Arrest	If using a manual defibrillator capable of escalating energies, higher energy for second and subsequent shocks may be considered (Class IIb, LOE C-LD).	updated for 2015
2015	Management of Cardiac Arrest	A single-shock strategy (as opposed to stacked shocks) is reasonable for defibrillation (Class IIa, LOE B-NR).	updated for 2015
2015	Management of Cardiac Arrest	Amiodarone may be considered for VF/pVT that is unresponsive to CPR, defibrillation, and a vasopressor therapy (Class IIb, LOE B-R).	updated for 2015
2015	Management of Cardiac Arrest	Lidocaine may be considered as an alternative to amiodarone for VF/pVT that is unresponsive to CPR, defibrillation, and vasopressor therapy (Class IIb, LOE C-LD).	updated for 2015
2015	Management of Cardiac Arrest	The routine use of magnesium for VF/pVT is not recommended in adult patients (Class III: No Benefit, LOE B-R).	updated for 2015
2015	Management of Cardiac Arrest	There is inadequate evidence to support the routine use of lidocaine after cardiac arrest. However, the initiation or continuation of lidocaine may be considered immediately after ROSC from cardiac arrest due to VF/pVT (Class IIb, LOE C-LD).	new for 2015
2015	Management of Cardiac Arrest	There is inadequate evidence to support the routine use of a β-blocker after cardiac arrest. However, the initiation or continuation of an oral or intravenous β-blocker may be considered early after hospitalization from cardiac arrest due to VF/pVT (Class IIb, LOE C-LD).	new for 2015
2015	Management of Cardiac Arrest	Standard-dose epinephrine (1 mg every 3 to 5 minutes) may be reasonable for patients in cardiac arrest (Class IIb, LOE B-R).	updated for 2015
2015	Management of Cardiac Arrest	High-dose epinephrine is not recommended for routine use in cardiac arrest (Class III: No Benefit, LOE B-R).	new for 2015
2015	Management of Cardiac Arrest	Vasopressin offers no advantage as a substitute for epinephrine in cardiac arrest (Class IIb, LOE B-R).	updated for 2015

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2015 Guidelines Update: Master List of Recommendations, *Continued*

Year Last Reviewed	Topic	Recommendation	Comments
2015	Management of Cardiac Arrest	Vasopressin in combination with epinephrine offers no advantage as a substitute for standard-dose epinephrine in cardiac arrest (Class IIb, LOE B-R).	new for 2015
2015	Management of Cardiac Arrest	It may be reasonable to administer epinephrine as soon as feasible after the onset of cardiac arrest due to an initial nonshockable rhythm (Class IIb, LOE C-LD).	updated for 2015
2015	Management of Cardiac Arrest	In IHCA, the combination of intra-arrest vasopressin, epinephrine, and methylprednisolone and post-arrest hydrocortisone as described by Mentzelopoulos et al may be considered; however, further studies are needed before recommending the routine use of this therapeutic strategy (Class IIb, LOE C-LD).	new for 2015
2015	Management of Cardiac Arrest	For patients with OHCA, use of steroids during CPR is of uncertain benefit (Class IIb, LOE C-LD).	new for 2015
2015	Management of Cardiac Arrest	In intubated patients, failure to achieve an $ETCO_2$ of greater than 10 mm Hg by waveform capnography after 20 minutes of CPR may be considered as one component of a multimodal approach to decide when to end resuscitative efforts but should not be used in isolation (Class IIb, LOE C-LD).	new for 2015
2015	Management of Cardiac Arrest	In nonintubated patients, a specific $ETCO_2$ cutoff value at any time during CPR should not be used as an indication to end resuscitative efforts (Class III: Harm, LOE C-EO).	new for 2015
2015	Management of Cardiac Arrest	There is insufficient evidence to recommend the routine use of ECPR for patients with cardiac arrest. In settings where it can be rapidly implemented, ECPR may be considered for select cardiac arrest patients for whom the suspected etiology of the cardiac arrest is potentially reversible during a limited period of mechanical cardiorespiratory support. (Class IIb, LOE C-LD).	new for 2015
The following recommendations were not reviewed in 2015. For more information, see the *2010 AHA Guidelines for CPR and ECC*, "Part 8: Adult Advanced Cardiovascular Life Support" and "Part 6: Electrical Therapies: Automated External Defibrillators, Defibrillation, Cardioversion, and Pacing."			
2010	Cricoid Pressure	The routine use of cricoid pressure in cardiac arrest is not recommended (Class III, LOE C).	not reviewed in 2015
2010	Oropharyngeal Airways	To facilitate delivery of ventilations with a bag-mask device, oropharyngeal airways can be used in unconscious (unresponsive) patients with no cough or gag reflex and should be inserted only by persons trained in their use (Class IIa, LOE C).	not reviewed in 2015
2010	Nasopharyngeal Airways	In the presence of known or suspected basal skull fracture or severe coagulopathy, an oral airway is preferred (Class IIa, LOE C).	not reviewed in 2015
2010	Postintubation Airway Management	The endotracheal tube should be secured with tape or a commercial device (Class I, LOE C).	not reviewed in 2015
2010	Postintubation Airway Management	One out-of-hospital study and 2 studies in an intensive care setting indicate that backboards, commercial devices for securing the endotracheal tube, and other strategies provide equivalent methods for preventing inadvertent tube displacement when compared with traditional methods of securing the tube (tape). These devices may be considered during patient transport (Class IIb, LOE C).	not reviewed in 2015
2010	Automatic Transport Ventilators	In both out-of-hospital and in-hospital settings, automatic transport ventilators (ATVs) can be useful for ventilation of adult patients in noncardiac arrest who have an advanced airway in place (Class IIb, LOE C).	not reviewed in 2015
2010	Automatic Transport Ventilators	During prolonged resuscitative efforts the use of an ATV (pneumatically powered and time- or pressure-cycled) may allow the EMS team to perform other tasks while providing adequate ventilation and oxygenation (Class IIb, LOE C).	not reviewed in 2015
2010	Automatic Versus Manual Modes for Multimodal Defibrillators	Current evidence indicates that the benefit of using a multimodal defibrillator in manual instead of automatic mode during cardiac arrest is uncertain (Class IIb, LOE C).	not reviewed in 2015
2010	CPR Before Defibrillation	Performing CPR while a defibrillator is readied for use is strongly recommended for all patients in cardiac arrest (Class I, LOE B)	not reviewed in 2015
2010	CPR Before Defibrillation	At this time the benefit of delaying defibrillation to perform CPR before defibrillation is unclear (Class IIb, LOE B).	not reviewed in 2015
2010	Drug Therapy for PEA/ Asystole	Available evidence suggests that the routine use of atropine during PEA or asystole is unlikely to have a therapeutic benefit (Class IIb, LOE B).	not reviewed in 2015
2010	Coronary Perfusion Pressure and Arterial Relaxation Pressure	It is reasonable to consider using arterial relaxation "diastolic" pressure to monitor CPR quality, optimize chest compressions, and guide vasopressor therapy. (Class IIb, LOE C).	not reviewed in 2015
2010	Coronary Perfusion Pressure and Arterial Relaxation Pressure	If the arterial relaxation "diastolic" pressure is <20 mm Hg, it is reasonable to consider trying to improve quality of CPR by optimizing chest compression parameters or giving a vasopressor or both (Class IIb, LOE C).	not reviewed in 2015

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2015 Guidelines Update: Master List of Recommendations, *Continued*

Year Last Reviewed	Topic	Recommendation	Comments
2010	Coronary Perfusion Pressure and Arterial Relaxation Pressure	Arterial pressure monitoring can also be used to detect ROSC during chest compressions or when a rhythm check reveals an organized rhythm (Class IIb, LOE C).	not reviewed in 2015
2010	Central Venous Oxygen Saturation	Therefore, when in place before cardiac arrest, it is reasonable to consider using continuous $Scv0_2$ measurement to monitor quality of CPR, optimize chest compressions, and detect ROSC during chest compressions or when rhythm check reveals an organized rhythm (Class IIb, LOE C).	not reviewed in 2015
2010	Central Venous Oxygen Saturation	If $Scv0_2$ is <30%, it is reasonable to consider trying to improve the quality of CPR by optimizing chest compression parameters (Class IIb, LOE C).	not reviewed in 2015
2010	Arterial Blood Gases	Routine measurement of arterial blood gases during CPR has uncertain value (Class IIb, LOE C).	not reviewed in 2015
2010	IO Drug Delivery	It is reasonable for providers to establish IO access if IV access is not readily available (Class IIa, LOE C).	not reviewed in 2015
2010	Central IV Drug Delivery	The appropriately trained provider may consider placement of a central line (internal jugular or subclavian) during cardiac arrest, unless there are contraindications (Class IIb, LOE C).	not reviewed in 2015
2010	Endotracheal Drug Delivery	If IV or IO access cannot be established, epinephrine, vasopressin, and lidocaine may be administered by the endotracheal route during cardiac arrest (Class IIb, LOE B).	not reviewed in 2015
2010	Atropine	Available evidence suggests that routine use of atropine during PEA or asystole is unlikely to have a therapeutic benefit (Class IIb, LOE B).	not reviewed in 2015
2010	Sodium Bicarbonate	Routine use of sodium bicarbonate is not recommended for patients in cardiac arrest (Class III, LOE B).	not reviewed in 2015
2010	Calcium	Routine administration of calcium for treatment of in-hospital and out-of-hospital cardiac arrest is not recommended (Class III, LOE B).	not reviewed in 2015
2010	Precordial Thump	The precordial thump may be considered for termination of witnessed monitored unstable ventricular tachyarrhythmias when a defibrillator is not immediately ready for use (Class IIb, LOE B), but should not delay CPR and shock delivery.	not reviewed in 2015
2010	Management of Symptomatic Bradycardia and Tachycardia	If bradycardia produces signs and symptoms of instability (eg, acutely altered mental status, ischemic chest discomfort, acute heart failure, hypotension, or other signs of shock that persist despite adequate airway and breathing), the initial treatment is atropine (Class IIa, LOE B).	not reviewed in 2015
2010	Management of Symptomatic Bradycardia and Tachycardia	If bradycardia is unresponsive to atropine, intravenous (IV) infusion of β-adrenergic agonists with rate-accelerating effects (dopamine, epinephrine) or transcutaneous pacing (TCP) can be effective (Class IIa, LOE B) while the patient is prepared for emergent transvenous temporary pacing if required.	not reviewed in 2015
2010	Management of Symptomatic Bradycardia and Tachycardia	If the tachycardic patient is unstable with severe signs and symptoms related to a suspected arrhythmia (eg, acute altered mental status, ischemic chest discomfort, acute heart failure, hypotension, or other signs of shock), immediate cardioversion should be performed (with prior sedation in the conscious patient) (Class I, LOE B).	not reviewed in 2015
2010	Management of Symptomatic Bradycardia and Tachycardia	In select cases of regular narrow-complex tachycardia with unstable signs or symptoms, a trial of adenosine before cardioversion is reasonable to consider (Class IIb, LOE C).	not reviewed in 2015
2010	Atropine	Atropine remains the first-line drug for acute symptomatic bradycardia (Class IIa, LOE B).	not reviewed in 2015
2010	Pacing	It is reasonable for healthcare providers to initiate TCP in unstable patients who do not respond to atropine (Class IIa, LOE B).	not reviewed in 2015
2010	Pacing	Immediate pacing might be considered in unstable patients with high-degree AV block when IV access is not available (Class IIb, LOE C).	not reviewed in 2015
2010	Pacing	If the patient does not respond to drugs or TCP, transvenous pacing is probably indicated (Class IIa, LOE C)	not reviewed in 2015
2010	Dopamine	Dopamine infusion may be used for patients with symptomatic bradycardia, particularly if associated with hypotension, in whom atropine may be inappropriate or after atropine fails (Class IIb, LOE B).	not reviewed in 2015
2010	Wide-Complex Tachycardia - Evaluation	Precordial thump may be considered for patients with witnessed, monitored, unstable ventricular tachycardia if a defibrillator is not immediately ready for use (Class IIb, LOE C).	not reviewed in 2015
2010	Therapy for Regular Wide-Complex Tachycardias	If the etiology of the rhythm cannot be determined, the rate is regular, and the QRS is monomorphic, recent evidence suggests that IV adenosine is relatively safe for both treatment and diagnosis (Class IIb, LOE B).	not reviewed in 2015

(*Continued*)

2015 Guidelines Update: Master List of Recommendations, *Continued*

Year Last Reviewed	Topic	Recommendation	Comments
2010	Therapy for Regular Wide-Complex Tachycardias	Adenosine should not be given for unstable or for irregular or polymorphic wide-complex tachycardias, as it may cause degeneration of the arrhythmia to VF (Class III, LOE C).	not reviewed in 2015
2010	Therapy for Regular Wide-Complex Tachycardias	Verapamil is contraindicated for wide-complex tachycardias unless known to be of supraventricular origin (Class III, LOE B).	not reviewed in 2015
2010	Therapy for Regular Wide-Complex Tachycardias	If IV antiarrhythmics are administered, procainamide (Class IIa, LOE B), amiodarone (Class IIb, LOE B), or sotalol (Class IIb, LOE B) can be considered.	not reviewed in 2015
2010	Therapy for Regular Wide-Complex Tachycardias	Procainamide and sotalol should be avoided in patients with prolonged QT. If one of these antiarrhythmic agents is given, a second agent should not be given without expert consultation (Class III, LOE B).	not reviewed in 2015
2010	Therapy for Regular Wide-Complex Tachycardias	If antiarrhythmic therapy is unsuccessful, cardioversion or expert consultation should be considered (Class IIa, LOE C).	not reviewed in 2015
2010	Rate Control	IV β-blockers and nondihydropyridine calcium channel blockers such as diltiazem are the drugs of choice for acute rate control in most individuals with atrial fibrillation and rapid ventricular response (Class IIa, LOE A).	not reviewed in 2015
2010	Polymorphic (Irregular) VT	Magnesium is unlikely to be effective in preventing polymorphic VT in patients with a normal QT interval (Class IIb, LOE C), but amiodarone may be effective (Class IIb, LOE C).	not reviewed in 2015
2010	Polymorphic (Irregular) VT	In the absence of a prolonged QT interval, the most common cause of polymorphic VT is myocardial ischemia. In this situation IV amiodarone and β-blockers may reduce the frequency of arrhythmia recurrence (Class IIb, LOE C).	not reviewed in 2015
2010	Ventilation and Oxygen Administration During CPR	Advanced airway placement in cardiac arrest should not delay initial CPR and defibrillation for VF cardiac arrest (Class I, LOE C).	not reviewed in 2015
2010	Advanced Airways	If advanced airway placement will interrupt chest compressions, providers may consider deferring insertion of the airway until the patient fails to respond to initial CPR and defibrillation attempts or demonstrates ROSC (Class IIb, LOE C).	not reviewed in 2015
2010	Endotracheal Intubation	EMS systems that perform prehospital intubation should provide a program of ongoing quality improvement to minimize complications (Class IIa, LOE B).	not reviewed in 2015
2010	VF Waveform Analysis to Predict Defibrillation Success	The value of VF waveform analysis to guide management of defibrillation in adults with in-hospital and out-of-hospital cardiac arrest is uncertain (Class IIb, LOE C).	not reviewed in 2015
2010	Fibrinolysis	Fibrinolytic therapy should not be routinely used in cardiac arrest (Class III, LOE B).	not reviewed in 2015
2010	Pacing	Electric pacing is not recommended for routine use in cardiac arrest (Class III, LOE B).	not reviewed in 2015
2010	Epinephrine	Epinephrine infusion may be used for patients with symptomatic bradycardia, particularly if associated with hypotension, for whom atropine may be inappropriate or after atropine fails (Class IIb, LOE B).	not reviewed in 2015
2010	Initial Evaluation and Treatment of Tachyarrhythmias	If not hypotensive, the patient with a regular narrow-complex SVT (likely due to suspected reentry, paroxysmal supraventricular tachycardia, as described below) may be treated with adenosine while preparations are made for synchronized cardioversion (Class IIb, LOE C).	not reviewed in 2015
2010	Therapy	If PSVT does not respond to vagal maneuvers, give 6 mg of IV adenosine as a rapid IV push through a large (eg, antecubital) vein followed by a 20 mL saline flush (Class I, LOE B).	not reviewed in 2015
2010	Therapy	If adenosine or vagal maneuvers fail to convert PSVT, PSVT recurs after such treatment, or these treatments disclose a different form of SVT (such as atrial fibrillation or flutter), it is reasonable to use longer-acting AV nodal blocking agents, such as the nondihydropyridine calcium channel blockers (verapamil and diltiazem) (Class IIa, LOE B) or β-blockers (Class IIa, LOE C).	not reviewed in 2015
2010	Therapy	Therefore, AV nodal blocking drugs should not be used for pre-excited atrial fibrillation or flutter (Class III, LOE C).	not reviewed in 2015
Part 8: Post–Cardiac Arrest Care			
2015	Cardiovascular Care	Coronary angiography should be performed emergently (rather than later in the hospital stay or not at all) for OHCA patients with suspected cardiac etiology of arrest and ST elevation on ECG (Class I, LOE B-NR).	updated for 2015
2015	Cardiovascular Care	Emergent coronary angiography is reasonable for select (e.g. electrically or hemodynamically unstable) adult patients who are comatose after OHCA of suspected cardiac origin but without ST elevation on ECG (Class IIa, LOE B-NR).	updated for 2015
2015	Cardiovascular Care	Coronary angiography is reasonable in post–cardiac arrest patients for whom coronary angiography is indicated regardless of whether the patient is comatose or awake (Class IIa, LOE C-LD).	updated for 2015
2015	Hemodynamic Goals	Avoiding and immediately correcting hypotension (systolic blood pressure less than 90 mm Hg, MAP less than 65 mm Hg) during postresuscitation care may be reasonable (Class IIb, LOE C-LD).	new for 2015

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2015 Guidelines Update: Master List of Recommendations, *Continued*

Year Last Reviewed	Topic	Recommendation	Comments
2015	Targeted Temperature Management	We recommend that comatose (ie, lack of meaningful response to verbal commands) adult patients with ROSC after cardiac arrest have TTM (Class I, LOE B-R for VF/pVT OHCA; Class I, LOE C-EO for non-VF/pVT (ie, "non-shockable") and in-hospital cardiac arrest).	updated for 2015
2015	Targeted Temperature Management	We recommend selecting and maintaining a constant temperature between 32ºC and 36ºC during TTM (Class I, LOE B-R).	updated for 2015
2015	Targeted Temperature Management	It is reasonable that TTM be maintained for at least 24 hours after achieving target temperature (Class IIa, LOE C-EO).	updated for 2015
2015	Targeted Temperature Management	We recommend against the routine prehospital cooling of patients after ROSC with rapid infusion of cold intravenous fluids (Class III: No Benefit, LOE A).	new for 2015
2015	Targeted Temperature Management	It may be reasonable to actively prevent fever in comatose patients after TTM (Class IIb, LOE C-LD).	new for 2015
2015	Other Neurologic Care	An EEG for the diagnosis of seizure should be promptly performed and interpreted, and then should be monitored frequently or continuously in comatose patients after ROSC (Class I, LOE C-LD).	updated for 2015
2015	Other Neurologic Care	The same anticonvulsant regimens for the treatment of status epilepticus caused by other etiologies may be considered after cardiac arrest (Class IIb, LOE C-LD).	updated for 2015
2015	Respiratory Care	Maintaining the $Paco_2$ within a normal physiological range, taking into account any temperature correction, may be reasonable (Class IIb, LOE B-NR).	updated for 2015
2015	Respiratory Care	To avoid hypoxia in adults with ROSC after cardiac arrest, it is reasonable to use the highest available oxygen concentration until the arterial oxyhemoglobin saturation or the partial pressure of arterial oxygen can be measured (Class IIa, LOE C-EO).	new for 2015
2015	Respiratory Care	When resources are available to titrate the Fio_2 and to monitor oxyhemoglobin saturation, it is reasonable to decrease the Fio_2 when oxyhemoglobin saturation is 100%, provided the oxyhemoglobin saturation can be maintained at 94% or greater (Class IIa, LOE C-LD).	updated for 2015
2015	Other Critical Care Interventions	The benefit of any specific target range of glucose management is uncertain in adults with ROSC after cardiac arrest (Class IIb, LOE B-R).	updated for 2015
2015	Prognostication of Outcome	The earliest time for prognostication using clinical examination in patients treated with TTM, where sedation or paralysis could be a confounder. May be 72 hours after normothermia (Class IIb, LOE C-EO).	updated for 2015
2015	Other Critical Care Interventions	We recommend the earliest time to prognosticate a poor neurologic outcome using clinical examination in patients not treated with TTM is 72 hours after cardiac arrest (Class I, LOE B-NR).	new for 2015
2015	Other Critical Care Interventions	This time until prognostication can be even longer than 72 hours after cardiac arrest if the residual effect of sedation or paralysis confounds the clinical examination (Class IIa, LOE C-LD).	new for 2015
2015	Other Critical Care Interventions	In comatose patients who are not treated with TTM, the absence of pupillary reflex to light at 72 hours or more after cardiac arrest is a reasonable exam finding with which to predict poor neurologic outcome (FPR, 0%; 95% CI, 0%–8%; Class IIa, LOE B-NR).	new for 2015
2015	Other Critical Care Interventions	In comatose patients who are treated with TTM, the absence of pupillary reflex to light at 72 hours or more after cardiac arrest is useful to predict poor neurologic outcome (FPR, 1%; 95% CI, 0%–3%; Class I, LOE B-NR).	new for 2015
2015	Other Critical Care Interventions	We recommend that, given their unacceptable FPRs, the findings of either absent motor movements or extensor posturing should not be used alone for predicting a poor neurologic outcome (FPR, 10%; 95% CI, 7%–15% to FPR, 15%; 95% CI, 5%–31%; Class III: Harm, LOE B-NR).	new for 2015
2015	Other Critical Care Interventions	The motor examination may be a reasonable means to identify the population who need further prognostic testing to predict poor outcome (Class IIb, LOE B-NR).	new for 2015
2015	Other Critical Care Interventions	We recommend that the presence of myoclonus, which is distinct from status myoclonus, should not be used to predict poor neurologic outcomes because of the high FPR (FPR, 5%; 95% CI, 3%–8% to FPR, 11%; 95% CI, 3%–26%; Class III: Harm, LOE B-NR).	updated for 2015
2015	Other Critical Care Interventions	In combination with other diagnostic tests at 72 or more hours after cardiac arrest, the presence of status myoclonus during the first 72 hours after cardiac arrest is a reasonable finding to help predict poor neurologic outcomes (FPR, 0%; 95% CI, 0%–4%; Class IIa, LOE B-NR).	new for 2015
2015	Other Critical Care Interventions	In comatose post–cardiac arrest patients who are treated with TTM, it may be reasonable to consider persistent absence of EEG reactivity to external stimuli at 72 hours after cardiac arrest, and persistent burst suppression on EEG after rewarming, to predict a poor outcome (FPR, 0%; 95% CI, 0%–3%; Class IIb, LOE B-NR).	updated for 2015
2015	Other Critical Care Interventions	Intractable and persistent (more than 72 hours) status epilepticus in the absence of EEG reactivity to external stimuli may be reasonable to predict poor outcome (Class IIb, LOE B-NR).	updated for 2015

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2015 Guidelines Update: Master List of Recommendations, *Continued*

Year Last Reviewed	Topic	Recommendation	Comments
2015	Other Critical Care Interventions	In comatose post–cardiac arrest patients who are not treated with TTM, it may be reasonable to consider the presence of burst suppression on EEG at 72 hours or more after cardiac arrest, in combination with other predictors, to predict a poor neurologic outcome (FPR, 1%; 95% CI, 0%–11%; Class IIb, LOE B-NR).	updated for 2015
2015	Other Critical Care Interventions	In patients who are comatose after resuscitation from cardiac arrest regardless of treatment with TTM, it is reasonable to consider bilateral absence of the N20 SSEP wave 24 to 72 hours after cardiac arrest or after rewarming a predictor of poor outcome (FPR, 1%; 95% CI, 0%–3%; Class IIa, LOE B-NR).	updated for 2015
2015	Other Critical Care Interventions	In patients who are comatose after resuscitation from cardiac arrest and not treated with TTM, it may be reasonable to use the presence of a marked reduction of the GWR on brain CT obtained within 2 hours after cardiac arrest to predict poor outcome (Class IIb, LOE B-NR).	new for 2015
2015	Other Critical Care Interventions	It may be reasonable to consider extensive restriction of diffusion on brain MRI at 2 to 6 days after cardiac arrest in combination with other established predictors to predict a poor neurologic outcome (Class IIb, LOE B-NR).	new for 2015
2015	Other Critical Care Interventions	Given the possibility of high FPRs, blood levels of NSE and S-100B should not be used alone to predict a poor neurologic outcome (Class III: Harm, LOE C-LD).	updated for 2015
2015	Other Critical Care Interventions	When performed with other prognostic tests at 72 hours or more after cardiac arrest, it may be reasonable to consider high serum values of NSE at 48 to 72 hours after cardiac arrest to support the prognosis of a poor neurologic outcome (Class IIb, LOE B-NR), especially if repeated sampling reveals persistently high values (Class IIb, LOE C-LD).	updated for 2015
2015	Other Critical Care Interventions	We recommend that all patients who are resuscitated from cardiac arrest but who subsequently progress to death or brain death be evaluated for organ donation (Class I, LOE B-NR).	updated for 2015
2015	Other Critical Care Interventions	Patients who do not have ROSC after resuscitation efforts and who would otherwise have termination of efforts may be considered candidates for kidney or liver donation in settings where programs exist (Class IIb, LOE B-NR).	new for 2015
The following recommendations were not reviewed in 2015. For more information, see the *2010 AHA Guidelines for CPR and ECC*, "Part 9: Post–Cardiac Arrest Care"			
2010	Systems of Care for Improving Post–Cardiac Arrest Outcomes	A comprehensive, structured, multidisciplinary system of care should be implemented in a consistent manner for the treatment of post–cardiac arrest patients (Class I, LOE B).	not reviewed in 2015
2010	Treatment of Pulmonary Embolism After CPR	In post–cardiac arrest patients with arrest due to presumed or known pulmonary embolism, fibrinolytics may be considered (Class IIb, LOE C).	not reviewed in 2015
2010	Sedation After Cardiac Arrest	It is reasonable to consider the titrated use of sedation and analgesia in critically ill patients who require mechanical ventilation or shivering suppression during induced hypothermia after cardiac arrest (Class IIb, LOE C).	not reviewed in 2015
2010	Cardiovascular System	A 12-lead ECG should be obtained as soon as possible after ROSC to determine whether acute ST elevation is present (Class I, LOE B).	not reviewed in 2015
2010	Neuroprotective Drugs	The routine use of coenzyme Q10 in patients treated with hypothermia is uncertain (Class IIb, LOE B).	not reviewed in 2015
2010	Evoked Potentials	Bilateral absence of the N20 cortical response to median nerve stimulation after 24 hours predicts poor outcome in comatose cardiac arrest survivors not treated with therapeutic hypothermia (Class IIa, LOE A).	not reviewed in 2015
Part 9: Acute Coronary Syndromes			
2015	Diagnostic Interventions in ACS	Prehospital 12-lead ECG should be acquired early for patients with possible ACS (Class I, LOE B-NR).	new for 2015
2015	Diagnostic Interventions in ACS	Prehospital notification of the receiving hospital (if fibrinolysis is the likely reperfusion strategy) and/or prehospital activation of the catheterization laboratory should occur for all patients with a recognized STEMI on prehospital ECG (Class I, LOE B-NR).	updated for 2015
2015	Diagnostic Interventions in ACS	Because of high false-negative rates, we recommend that computer-assisted ECG interpretation not be used as a sole means to diagnose STEMI (Class III: Harm, LOE B-NR).	new for 2015
2015	Diagnostic Interventions in ACS	We recommend that computer-assisted ECG interpretation may be used in conjunction with physician or trained provider interpretation to recognize STEMI (Class IIb, LOE C-LD).	updated for 2015
2015	Diagnostic Interventions in ACS	While transmission of the prehospital ECG to the ED physician may improve PPV and therapeutic decision-making regarding adult patients with suspected STEMI, if transmission is not performed, it may be reasonable for trained non-physician ECG interpretation to be used as the basis for decision-making, including activation of the catheterization laboratory, administration of fibrinolysis, and selection of destination hospital. (Class IIa, LOE B-NR).	new for 2015
2015	Diagnostic Interventions in ACS	We recommend against using hs-cTnT and cTnI alone measured at 0 and 2 hours (without performing clinical risk stratification) to exclude the diagnosis of ACS (Class III: Harm, LOE B-NR).	new for 2015

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2015 Guidelines Update: Master List of Recommendations, *Continued*

Year Last Reviewed	Topic	Recommendation	Comments
2015	Diagnostic Interventions in ACS	We recommend that hs-cTnI measurements that are less than the 99th percentile, measured at 0 and 2 hours, may be used together with low-risk stratification (TIMI score of 0 or 1) to predict a less than 1% chance of 30-day MACE (Class IIa, LOE B-NR,).	new for 2015
2015	Diagnostic Interventions in ACS	We recommend that negative cTnI or cTnT measurements at 0 and between 3 and 6 hours may be used together with very low-risk stratification (Vancouver score of 0 or North American Chest Pain score of 0 and age less than 50 years) to predict a less than 1% chance of 30-day MACE (Class IIa, LOE B-NR).	new for 2015
2015	Therapeutic Interventions in ACS	In patients with suspected STEMI intending to undergo primary PCI, initiation of ADP inhibition may be reasonable in either the prehospital or in-hospital setting (Class IIb, LOE C-LD).	new for 2015
2015	Therapeutic Interventions in ACS	We recommend that EMS systems that do not currently administer heparin to suspected STEMI patients do not add this treatment, whereas those that do administer it may continue their current practice (Class IIb, LOE B-NR).	new for 2015
2015	Therapeutic Interventions in ACS	In suspected STEMI patients for whom there is a planned primary PCI reperfusion strategy, administration of unfractionated heparin (UFH) can occur either in the prehospital or in-hospital setting (Class IIb, LOE B-NR).	new for 2015
2015	Therapeutic Interventions in ACS	It may be reasonable to consider the prehospital administration of UFH in STEMI patients or the prehospital administration of bivalirudin in STEMI patients who are at increased risk of bleeding (Class IIb, LOE B-R)	new for 2015
2015	Therapeutic Interventions in ACS	In systems in which UFH is currently administered in the prehospital setting for patients with suspected STEMI who are being transferred for PPCI, it is reasonable to consider prehospital administration of enoxaparin as an alternative to UFH (Class IIa, LOE B-R).	updated for 2015
2015	Therapeutic Interventions in ACS	The usefulness of supplementary oxygen therapy has not been established in normoxic patients. In the prehospital, ED, and hospital settings, the withholding of supplementary oxygen therapy in normoxic patients with suspected or confirmed acute coronary syndrome may be considered (Class IIb, LOE C-LD).	updated for 2015
2015	Therapeutic Interventions in ACS	Where prehospital fibrinolysis is available as part of a STEMI system of care, and in-hospital fibrinolysis is the alternative treatment strategy, it is reasonable to administer prehospital fibrinolysis when transport times are more than 30 minutes (Class IIa, LOE B-R).	updated for 2015
2015	Therapeutic Interventions in ACS	Where prehospital fibrinolysis is available as part of the STEMI system of care and direct transport to a PCI center is available, prehospital triage and transport directly to a PCI center may be preferred because of the small relative decrease in the incidence of intracranial hemorrhage without evidence of mortality benefit to either therapy (Class IIb, LOE B-R).	new for 2015
2015	Therapeutic Interventions in ACS	In the treatment of patients with suspected STEMI, the combined application of fibrinolytic therapy followed by immediate PCI (as contrasted with immediate PCI alone) is not recommended. (Class III: Harm, LOE B-R).	new for 2015
2015	Therapeutic Interventions in ACS	If fibrinolytic therapy is provided, immediate transfer to a PCI center for cardiac angiography within 3 to 24 hours may be considered (Class IIb, LOE C-LD).	new for 2015
2015	Therapeutic Interventions in ACS	Regardless of whether time of symptom onset is known, the interval between first medical contact and reperfusion should not exceed 120 minutes (Class I, LOE C-EO).	new for 2015
2015	Therapeutic Interventions in ACS	In STEMI patients presenting within 2 hours of symptom onset, immediate fibrinolysis rather than PPCI may be considered when the expected delay to PPCI is more than 60 minutes (Class IIb, LOE C-LD).	updated for 2015
2015	Therapeutic Interventions in ACS	In STEMI patients presenting within 2 to 3 hours after symptom onset, either immediate fibrinolysis or PPCI involving a possible delay of 60 to 120 minutes might be reasonable (Class IIb, LOE C-LD).	updated for 2015
2015	Therapeutic Interventions in ACS	In STEMI patients presenting within 3 to 12 hours after symptom onset, performance of PPCI involving a possible delay of up to 120 minutes may be considered rather than initial fibrinolysis (Class IIb, LOE C-LD).	updated for 2015
2015	Therapeutic Interventions in ACS	In STEMI patients when long delays to PPCI are anticipated (more than 120 minutes), a strategy of immediate fibrinolysis followed by routine early (within 3 to 24 hours) angiography and PCI if indicated, is reasonable (Class IIb, LOE B-R).	updated for 2015
2015	Therapeutic Interventions in ACS	In adult patients presenting with STEMI in the ED of a non–PCI-capable hospital, we recommend immediate transfer without fibrinolysis from the initial facility to a PCI center instead of immediate fibrinolysis at the initial hospital with transfer only for ischemia-driven PCI (Class I, LOE B-R).	new for 2015
2015	Therapeutic Interventions in ACS	When STEMI patients cannot be transferred to a PCI-capable hospital in a timely manner, fibrinolytic therapy with routine transfer for angiography may be an acceptable alternative to immediate transfer to PPCI (Class IIb, LOE C-LD).	new for 2015
2015	Therapeutic Interventions in ACS	When fibrinolytic therapy is administered to a STEMI patient in a non–PCI-capable hospital, it may be reasonable to transport all postfibrinolysis patients for early routine angiography in the first 3 to 6 hours and up to 24 hours rather than transport postfibrinolysis patients only when they require ischemia-guided angiography (Class IIb, LOE B-R).	new for 2015

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2015 Guidelines Update: Master List of Recommendations, *Continued*

Year Last Reviewed	Topic	Recommendation	Comments
2015	Hospital Reperfusion Decisions After ROSC	Coronary angiography should be performed emergently (rather than later in the hospital stay or not at all) for OHCA patients with suspected cardiac etiology of arrest and ST elevation on ECG (Class I, LOE B-NR).	updated for 2015
2015	Hospital Reperfusion Decisions After ROSC	Emergency coronary angiography is reasonable for select (e.g. electrically or hemodynamically instable) adult patients who are comatose after OHCA of suspected cardiac origin but without ST elevation on ECG (Class IIa, LOE B-NR).	updated for 2015
2015	Hospital Reperfusion Decisions After ROSC	Coronary angiography is reasonable in post–cardiac arrest patients where coronary angiography is indicated regardless of whether the patient is comatose or awake (Class IIa, LOE C-LD).	updated for 2015
2010	Prehospital ECGs	If providers are not trained to interpret the 12-lead ECG, field transmission of the ECG or a computer report to the receiving hospital is recommended (Class I, LOE B).	not reviewed in 2015
The following recommendations were not reviewed in 2015. For more information, see the *2010 AHA Guidelines for CPR and ECC*, "Part 10: Acute Coronary Syndromes."			
2010	Prehospital Fibrinolysis	It is strongly recommended that systems which administer fibrinolytics in the prehospital setting include the following features: protocols using fibrinolytic checklists, 12-lead ECG acquisition and interpretation, experience in advanced life support, communication with the receiving institution, medical director with training and experience in STEMI management, and continuous quality improvement (Class I, LOE C).	not reviewed in 2015
2010	Prehospital Triage and EMS Hospital Destination	If PCI is the chosen method of reperfusion for the prehospital STEMI patient, it is reasonable to transport patients directly to the nearest PCI facility, bypassing closer EDs as necessary, in systems where time intervals between first medical contact and balloon times are <90 minutes and transport times are relatively short (ie, <30 minutes) (Class IIa, LOE B).	not reviewed in 2015
2010	Focused Assessment and ECG Risk Stratification	This initial evaluation must be efficient because if the patient has STEMI, the goals of reperfusion are to administer fibrinolytics within 30 minutes of arrival (30-minute interval "door-to-drug") or to provide PCI within 90 minutes of arrival (90-minute interval "door-to-balloon") (Class I, LOE A).	not reviewed in 2015
2010	Cardiac Biomarkers	If biomarkers are initially negative within 6 hours of symptom onset, it is recommended that biomarkers should be remeasured between 6 to 12 hours after symptom onset (Class I, LOE A).	not reviewed in 2015
2010	STEMI	If the patient meets the criteria for fibrinolytic therapy, a door-to-needle time (initiation of fibrinolytic agent) <30 minutes is recommended—the earlier the better (Class I, LOE A).	not reviewed in 2015
2010	STEMI	Consultation delays therapy and is associated with increased hospital mortality rates (Class III, LOE B).	not reviewed in 2015
2010	Indicators for Early Invasive Strategies	An early invasive PCI strategy is indicated for patients with non–ST-elevation ACS who have no serious comorbidity and who have coronary lesions amenable to PCI and an elevated risk for clinical events (Class I, LOE A).	not reviewed in 2015
2010	Indicators for Early Invasive Strategies	An early invasive strategy (ie, diagnostic angiography with intent to perform revascularization) is indicated in non–ST-elevation ACS patients who have refractory angina or hemodynamic or electric instability (without serious comorbidities or contraindications to such procedures) (Class I, LOE B).	not reviewed in 2015
2010	Indicators for Early Invasive Strategies	In initially stabilized patients, an initially conservative (ie, a selectively invasive) strategy may be considered as a treatment strategy for non–ST-elevation ACS patients (without serious comorbidities or contraindications to such procedures) who have an elevated risk for clinical events including those with abnormal troponin elevations (Class IIb, LOE B).	not reviewed in 2015
2010	The Chest Pain Unit Model	In patients with suspicion for ACS, normal initial biomarkers, and nonischemic ECG, chest pain observation protocols may be recommended as a safe and effective strategy for evaluating patients in the ED (Class I, LOE A).	not reviewed in 2015
2010	Fibrinolytics	If fibrinolysis is chosen for reperfusion, the ED physician should administer fibrinolytics to eligible patients as early as possible according to a predetermined process of care developed by the ED and cardiology staff (Class I, LOE A).	not reviewed in 2015
2010	Fibrinolytics	In fact, fibrinolytic therapy is generally not recommended for patients presenting between 12 and 24 hours after onset of symptoms based on the results of the LATE and EMERAS trials, unless continuing ischemic pain is present with continuing ST-segment elevation (Class IIb, LOE B).	not reviewed in 2015
2010	Fibrinolytics	Fibrinolytic therapy should not be administered (Class III, LOE B) to patients who present greater than 24 hours after the onset of symptoms.	not reviewed in 2015
2010	Percutaneous Coronary Intervention (PCI)	Coronary angioplasty with or without stent placement is the treatment of choice for the management of STEMI when it can be performed effectively with a door-to-balloon time <90 minutes by a skilled provider (performing >75 PCIs per year) at a skilled PCI facility (performing >200 PCIs annually, of which at least 36 are primary PCI for STEMI) (Class I, LOE A).	not reviewed in 2015

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2015 Guidelines Update: Master List of Recommendations, *Continued*

Year Last Reviewed	Topic	Recommendation	Comments
2010	PCI Following ROSC After Cardiac Arrest	It is reasonable to include cardiac catheterization and coronary angiography in standardized post–cardiac arrest protocols as part of an overall strategy to improve neurologically intact survival in this patient group (Class IIa, LOE B)	not reviewed in 2015
2010	PCI Following ROSC After Cardiac Arrest	Angiography and/or PCI need not preclude or delay other therapeutic strategies including therapeutic hypothermia (Class IIa, LOE B).	not reviewed in 2015
2010	PCI Following ROSC After Cardiac Arrest	A 12-lead ECG should be performed as soon as possible after ROSC (Class I, LOE A).	not reviewed in 2015
2010	PCI Versus Fibrinolytic Therapy	In summary, for patients presenting within 12 hours of symptom onset and electrocardiographic findings consistent with STEMI, reperfusion should be initiated as soon as possible – independent of the method chosen (Class I, LOE A).	not reviewed in 2015
2010	PCI Versus Fibrinolytic Therapy	Primary PCI performed at a high-volume center within 90 minutes of first medical contact by an experienced operator that maintains an appropriate expert status is reasonable, as it improves morbidity and mortality as compared with immediate fibrinolysis (<30 minutes door-to-needle) (Class I, LOE A).	not reviewed in 2015
2010	PCI Versus Fibrinolytic Therapy	For those patients with a contraindication to fibrinolysis, PCI is recommended despite the delay, rather than foregoing reperfusion therapy (Class I, LOE A).	not reviewed in 2015
2010	Clopidogrel	On the basis of these findings, providers should administer a loading dose of clopidogrel in addition to standard care (aspirin, anticoagulants, and reperfusion) for patients determined to have moderate- to high-risk non-ST-segment elevation ACS and STEMI (Class I, LOE A).	not reviewed in 2015
2010	Clopidogrel	It is reasonable to administer a 300-mg oral dose of clopidogrel to ED patients with suspected ACS (without ECG or cardiac marker changes) who are unable to take aspirin because of hypersensitivity or major gastrointestinal intolerance (Class IIa, LOE B).	not reviewed in 2015
2010	Clopidogrel	Providers should administer a 300-mg oral dose of clopidogrel to ED patients up to 75 years of age with STEMI who receive aspirin, heparin, and fibrinolysis (Class I, LOE B).	not reviewed in 2015
2010	Prasugrel	Prasugrel (60 mg oral loading dose) may be substituted for clopidogrel after angiography in patients determined to have non-ST-segment elevation ACS or STEMI who are more than 12 hours after symptom onset prior to planned PCI (Class IIa, LOE B).	not reviewed in 2015
2010	Prasugrel	There is no direct evidence for the use of prasugrel in the ED or prehospital settings. In patients who are not at high risk for bleeding, administration of prasugrel (60-mg oral loading dose) prior to angiography in patients determined to have STEMI ≤12 hours after the initial symptoms may be substituted for administration of clopidogrel (Class IIa, LOE B).	not reviewed in 2015
2010	Initial EMS Care	Because aspirin should be administered as soon as possible after symptom onset to patients with suspected ACS, it is reasonable for EMS dispatchers to instruct patients with no history of aspirin allergy and without signs of active or recent gastrointestinal bleeding to chew an aspirin (160 to 325 mg) while awaiting the arrival of EMS providers (Class IIa, LOE C).	not reviewed in 2015
2010	Initial EMS Care	If the patient is dyspneic, hypoxemic, or has obvious signs of heart failure, providers should titrate therapy, based on monitoring of oxyhemoglobin saturation, to 94% (Class I, LOE C).	not reviewed in 2015
2010	Initial EMS Care	EMS providers should administer nonenteric aspirin (160 [Class I, LOE B] to 325 mg [Class I, LOE C]).	not reviewed in 2015
2010	Initial EMS Care	Morphine is indicated in STEMI when chest discomfort is unresponsive to nitrates (Class I, LOE C);	not reviewed in 2015
2010	Initial EMS Care	Morphine should be used with caution in unstable angina (UA)/NSTEMI due to an association with increased mortality in a large registry (Class IIa, LOE C).	not reviewed in 2015
2010	Interfacility Transfer	These include patients who are ineligible for fibrinolytic therapy or who are in cardiogenic shock (Class I, LOE C).	not reviewed in 2015
2010	Interfacility Transfer	Transfer of high-risk patients who have received primary reperfusion with fibrinolytic therapy is reasonable (Class IIa, LOE B).	not reviewed in 2015
2010	TIMI Risk Score	These findings confirm the value of the TIMI risk score as a guide to therapeutic decisions (Class IIa, LOE B).	not reviewed in 2015
2010	Indicators for Early Invasive Strategies	The decision to implement an initial conservative (versus initial invasive) strategy in these patients may be made by considering physician and patient preference (Class IIb, LOE C).	not reviewed in 2015
2010	Advanced Testing to Detect Coronary Ischemia and CAD	For ED/CPU patients who are suspected of having ACS, have nonischemic ECG's and negative biomarkers, a noninvasive test for inducible myocardial ischemia or anatomic evaluation of the coronary arteries (eg, computed tomography [CT] angiography, cardiac magnetic resonance, myocardial perfusion imaging, stress echocardiography) can be useful in identifying patients suitable for discharge from the ED (Class IIa, LOE B).	not reviewed in 2015
2010	Advanced Testing to Detect Coronary Ischemia and CAD	MPS can also be used for risk stratification, especially in low- to intermediate likelihood of cardiac events according to traditional cardiac markers (Class IIa, LOE B).	not reviewed in 2015

(*Continued*)

2015 Guidelines Update: Master List of Recommendations, *Continued*

Year Last Reviewed	Topic	Recommendation	Comments
2010	Advanced Testing to Detect Coronary Ischemia and CAD	The use of MDCT angiography for selected low-risk patients can be useful to allow for safe early discharge from the ED (Class IIa, LOE B).	not reviewed in 2015
2010	Safety of Discharge and Risk of Major Adverse Cardiac Events After Discharge From the ED/CPU	The use of inpatient-derived risk scoring systems are useful for prognosis (Class I, LOE A) but are not recommended to identify patients who may be safely discharged from the ED (Class III, LOE C).	not reviewed in 2015
2010	Aspirin and Nonsteroidal Anti-inflammatory Drugs	Therefore, unless the patient has a known aspirin allergy or active gastrointestinal hemorrhage, nonenteric aspirin should be given as soon as possible to all patients with suspected ACS (Class I, LOE A).	not reviewed in 2015
2010	Aspirin and Nonsteroidal Anti-inflammatory Drugs	NSAIDs (except for aspirin), both nonselective as well as COX-2 selective agents, should not be administered during hospitalization for STEMI because of the increased risk of mortality, reinfarction, hypertension, heart failure, and myocardial rupture associated with their use (Class III, LOE C).	not reviewed in 2015
2010	Nitroglycerin (or Glyceryl Trinitrate)	Patients with ischemic discomfort should receive up to 3 doses of sublingual or aerosol nitroglycerin at 3- to 5-minute intervals until pain is relieved or low blood pressure limits its use (Class I, LOE B).	not reviewed in 2015
2010	Nitroglycerin (or Glyceryl Trinitrate)	The use of nitrates in patients with hypotension (SBP <90 mm Hg or ≥30 mm Hg below baseline), extreme bradycardia (<50 bpm), or tachycardia in the absence of heart failure (>100 bpm) and in patients with right ventricular infarction is contraindicated (Class III, LOE C).	not reviewed in 2015
2010	Analgesia	Providers should administer analgesics, such as intravenous morphine, for chest discomfort unresponsive to nitrates. Morphine is the preferred analgesic for patients with STEMI (Class I, LOE C).	not reviewed in 2015
2010	β-Adrenergic Receptor Blockers	IV β-blocker therapy may be considered as reasonable in specific situations such as severe hypertension or tachyarrhythmias in patients without contraindications (Class IIa, LOE B).	not reviewed in 2015
2010	β-Adrenergic Receptor Blockers	In the absence of contraindications, PO β-blockers should be administered within the first 24 hours to patients with suspected ACS (Class I, LOE A).	not reviewed in 2015
2010	β-Adrenergic Receptor Blockers	It is reasonable to start oral β-blockers with low doses after the patient is stabilized prior to discharge (Class IIa, LOE B).	not reviewed in 2015
2010	Treatment Recommendations for UA/NSTEMI	For in-hospital patients with NSTEMI managed with a planned initial conservative approach, either fondaparinux (Class IIa, LOE B) or enoxaparin (Class IIa, LOE A) are reasonable alternatives to UFH or placebo.	not reviewed in 2015
2010	Treatment Recommendations for UA/NSTEMI	For in-hospital patients with NSTEMI managed with a planned invasive approach, either enoxaparin or UFH are reasonable choices (Class IIa, LOE A).	not reviewed in 2015
2010	Treatment Recommendations for UA/NSTEMI	Fondaparinux may be used in the setting of PCI, but requires co-administration of UFH and does not appear to offer an advantage over UFH alone (Class IIb, LOE A).	not reviewed in 2015
2010	Treatment Recommendations for UA/NSTEMI	For in-hospital patients with NSTEMI and renal insufficiency, bivalirudin or UFH may be considered (Class IIb, LOE A).	not reviewed in 2015
2010	Treatment Recommendations for UA/NSTEMI	For in-hospital patients with NSTEMI and increased bleeding risk, where anticoagulant therapy is not contraindicated, fondaparinux (Class IIa, LOE B) or bivalirudin (Class IIa, LOE A) are reasonable and UFH may be considered (Class IIb, LOE C)	not reviewed in 2015
2010	Enoxaparin	For patients with STEMI managed with fibrinolysis in the hospital, it is reasonable to administer enoxaparin instead of UFH (Class IIa, LOE A).	not reviewed in 2015
2010	Enoxaparin	In addition, for prehospital patients with STEMI managed with fibrinolysis, adjunctive enoxaparin instead of UFH may be considered (Class IIb, LOE A).	not reviewed in 2015
2010	Enoxaparin	Patients initially treated with enoxaparin should not be switched to UFH and vice versa because of increased risk of bleeding (Class III, LOE C).	not reviewed in 2015
2010	Enoxaparin	In younger patients <75 years the initial dose of enoxaparin is 30 mg IV bolus followed by 1 mg/kg SC every 12 hours (first SC dose shortly after the IV bolus) (Class IIb, LOE A).	not reviewed in 2015
2010	Enoxaparin	Patients ≥75 years may be treated with 0.75 mg/kg SC enoxaparin every 12 hours without an initial IV bolus (Class IIb, LOE B).	not reviewed in 2015
2010	Enoxaparin	Patients with impaired renal function (creatinine clearance <30 mL/min) may be given 1 mg/kg enoxaparin SC once daily (Class IIb, LOE B).	not reviewed in 2015
2010	Enoxaparin	Patients with known impaired renal function may alternatively be managed with UFH (Class IIb, LOE B).	not reviewed in 2015
2010	Fondaparinux	Fondaparinux (initially 2.5 mg IV followed by 2.5 mg SC once daily) may be considered in the hospital for patients treated specifically with non-fibrin-specific thrombolytics (ie, streptokinase), provided the creatinine is 3 mg/dL (Class IIb, LOE B).	not reviewed in 2015

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2015 Guidelines Update: Master List of Recommendations, *Continued*

Year Last Reviewed	Topic	Recommendation	Comments
2010	Unfractionated Heparin Versus Low-Molecular-Weight Heparin With PPCI in STEMI	For patients with STEMI undergoing contemporary PCI (ie, additional broad use of glycoprotein IIb/IIIa inhibitors and a thienopyridine) enoxaparin may be considered a safe and effective alternative to UFH (Class IIb, LOE B).	not reviewed in 2015
2010	Unfractionated Heparin Versus Low-Molecular-Weight Heparin With PPCI in STEMI	Patients initially treated with enoxaparin should not be switched to UFH and vice versa to avoid increased risk of bleeding. Fondaparinux may be considered as an alternative to UFH, however, there is an increased risk of catheter thrombi with fondaparinux alone. Additional UFH (50 to 100 U/kg bolus) may help to avoid this complication (Class IIb, LOE B), but using these two agents is not recommended over UFH alone.	not reviewed in 2015
2010	Unfractionated Heparin Versus Low-Molecular-Weight Heparin With PPCI in STEMI	For fondaparinux and enoxaparin it is necessary to adjust the dose in patients with renal impairment. Bivalirudin may be considered as an alternative to UFH and GP IIb/IIIa inhibitors (Class IIb, LOE A).	not reviewed in 2015
2010	ACE Inhibitors and ARBs in the Hospital	Administration of an oral ACE inhibitor is recommended within the first 24 hours after onset of symptoms in STEMI patients with pulmonary congestion or LV ejection fraction <40%, in the absence of hypotension (SBP <100 mm Hg or ≥30 mm Hg below baseline) (Class I, LOE A).	not reviewed in 2015
2010	ACE Inhibitors and ARBs in the Hospital	Oral ACE inhibitor therapy can also be useful for all other patients with AMI with or without early reperfusion therapy (Class IIa, LOE B).	not reviewed in 2015
2010	ACE Inhibitors and ARBs in the Hospital	IV administration of ACE inhibitors is contraindicated in the first 24 hours because of risk of hypotension (Class III, LOE C).	not reviewed in 2015
2010	ACE Inhibitors in the Prehospital Setting	In conclusion, although ACE inhibitors and ARBs have been shown to reduce long-term risk of mortality in patients suffering an AMI, there is insufficient evidence to support the routine initiation of ACE inhibitors and ARBs in the prehospital or ED setting (Class IIb, LOE C).	not reviewed in 2015
2010	HMG Coenzyme A Reductase Inhibitors (Statins)	There is little data to suggest that this therapy should be initiated within the ED; however, early initiation (within 24 hours of presentation) of statin therapy is recommended in patients with an ACS or AMI (Class I, LOE C).	not reviewed in 2015
2010	HMG Coenzyme A Reductase Inhibitors (Statins)	If patients are already on statin therapy, continue the therapy (Class IIb, LOE C).	not reviewed in 2015
2010	HMG Coenzyme A Reductase Inhibitors (Statins)	Statins should not be discontinued during the index hospitalization unless contraindicated (Class III, LOE C).	not reviewed in 2015
2010	HMG Coenzyme A Reductase Inhibitors (Statins)	In conclusion, intensive (target LDL values optimally 70 mg/dL) statin treatment should be initiated within the first 24 hours after onset of an ACS event (eg, immediately after hospital admission) in all patients presenting with any form of ACS unless strictly contraindicated (eg, by proven intolerance) (Class I, LOE A).	not reviewed in 2015
2010	Glucose-Insulin-Potassium	At this time there is little evidence to suggest that this intervention is helpful (Class IIb, LOE C).	not reviewed in 2015
2010	Ventricular Rhythm Disturbances	The practice of prophylactic administration of lidocaine is not recommended (Class III, LOE A).	not reviewed in 2015
2010	Ventricular Rhythm Disturbances	Sotalol has not been adequately studied (Class IIb, LOE C).	not reviewed in 2015
2010	Ventricular Rhythm Disturbances	Amiodarone in a single RCT did not appear to improve survival in low doses and may increase mortality in high doses when used early in patients with suspected myocardial infarction (Class IIb, LOE C).	not reviewed in 2015
2010	Ventricular Rhythm Disturbances	Prophylactic antiarrhythmics are not recommended for patients with suspected ACS or myocardial infarction in the prehospital or ED (Class III, LOE A).	not reviewed in 2015
2010	Ventricular Rhythm Disturbances	Routine IV administration of β-blockers to patients without hemodynamic or electric contraindications is associated with a reduced incidence of primary VF (Class IIb, LOE C).	not reviewed in 2015
2010	Ventricular Rhythm Disturbances	It is prudent clinical practice to maintain serum potassium >4 mEq/L and magnesium >2 mEq/L (Class IIB, LOE A).	not reviewed in 2015
Part 10: Special Circumstances of Resuscitation			
2015	Cardiac Arrest Associated With Pregnancy	Priorities for the pregnant woman in cardiac arrest are provision of high-quality CPR and relief of aortocaval compression (Class I, LOE C-LD).	new for 2015
2015	Cardiac Arrest Associated With Pregnancy	If the fundus height is at or above the level of the umbilicus, manual LUD can be beneficial in relieving aortocaval compression during chest compressions (Class IIa, LOE C-LD).	new for 2015
2015	Cardiac Arrest Associated With Pregnancy	Because immediate ROSC cannot always be achieved, local resources for a PMCD should be summoned as soon as cardiac arrest is recognized in a woman in the second half of pregnancy (Class I, LOE C-LD).	new for 2015
2015	Cardiac Arrest Associated With Pregnancy	Systematic preparation and training are the keys to a successful response to such rare and complex events. Care teams that may be called upon to manage these situations should develop and practice standard institutional responses to allow for smooth delivery of resuscitative care (Class I, LOE C-EO).	new for 2015

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2015 Guidelines Update: Master List of Recommendations, *Continued*

Year Last Reviewed	Topic	Recommendation	Comments
2015	Cardiac Arrest Associated With Pregnancy	During cardiac arrest, if the pregnant woman with a fundus height at or above the umbilicus has not achieved ROSC with usual resuscitation measures plus manual LUD, it is advisable to prepare to evacuate the uterus while resuscitation continues (Class I, LOE C-LD).	new for 2015
2015	Cardiac Arrest Associated With Pregnancy	In situations such as nonsurvivable maternal trauma or prolonged pulselessness, in which maternal resuscitative efforts are obviously futile, there is no reason to delay performing PMCD (Class I, LOE C-LD).	new for 2015
2015	Cardiac Arrest Associated With Pregnancy	PMCD should be considered at 4 minutes after onset of maternal cardiac arrest or resuscitative efforts (for the unwitnessed arrest) if there is no ROSC (Class IIa, LOE C-EO).	updated for 2015
2015	Cardiac Arrest Associated With Pulmonary Embolism	In patients with confirmed PE as the precipitant of cardiac arrest, thrombolysis, surgical embolectomy, and mechanical embolectomy are reasonable emergency treatment options (Class IIa, LOE C-LD).	new for 2015
2015	Cardiac Arrest Associated With Pulmonary Embolism	Thrombolysis can be beneficial even when chest compressions have been provided (Class IIa, LOE C-LD).	new for 2015
2015	Cardiac Arrest Associated With Pulmonary Embolism	Thrombolysis may be considered when cardiac arrest is suspected to be caused by PE (Class IIb, LOE C-LD).	updated for 2015
2015	Cardiac or Respiratory Arrest Associated With Opioid Overdose	It is reasonable to provide opioid overdose response education, either alone or coupled with naloxone distribution and training, to persons at risk for opioid overdose (Class IIa, LOE C-LD).	new for 2015
2015	Cardiac or Respiratory Arrest Associated With Opioid Overdose	It is reasonable to base this training on first aid and non–healthcare provider BLS recommendations rather than on more advanced practices intended for healthcare providers (Class IIa, LOE C-EO).	new for 2015
2015	Cardiac or Respiratory Arrest Associated With Opioid Overdose	Empiric administration of IM or IN naloxone to all unresponsive opioid-associated life-threatening emergency patients may be reasonable as an adjunct to standard first aid and non–healthcare provider BLS protocols (Class IIb, LOE C-EO).	new for 2015
2015	Cardiac or Respiratory Arrest Associated With Opioid Overdose	Victims who respond to naloxone administration should access advanced healthcare services (Class I, LOE C-EO).	new for 2015
2015	Cardiac or Respiratory Arrest Associated With Opioid Overdose	For patients with known or suspected opioid addiction who have a definite pulse but no normal breathing or only gasping (ie, a respiratory arrest), in addition to providing standard BLS care, it is reasonable for appropriately trained BLS healthcare providers to administer IM or IN naloxone (Class IIa, LOE C-LD).	new for 2015
2015	Cardiac or Respiratory Arrest Associated With Opioid Overdose	Standard resuscitative measures should take priority over naloxone administration (Class I, LOE C-EO), with a focus on high-quality CPR (compressions plus ventilation).	new for 2015
2015	Cardiac or Respiratory Arrest Associated With Opioid Overdose	It may be reasonable to administer IM or IN naloxone based on the possibility that the patient is not in cardiac arrest (Class IIb, LOE C-EO).	new for 2015
2015	Cardiac or Respiratory Arrest Associated With Opioid Overdose	Responders should not delay access to more-advanced medical services while awaiting the patient's response to naloxone or other interventions (Class I, LOE C-EO).	new for 2015
2015	Cardiac or Respiratory Arrest Associated With Opioid Overdose	Unless the patient refuses further care, victims who respond to naloxone administration should access advanced healthcare services (Class I, LOE C-EO).	new for 2015
2015	Cardiac or Respiratory Arrest Associated With Opioid Overdose	Bag-mask ventilation should be maintained until spontaneous breathing returns, and standard ACLS measures should continue if return of spontaneous breathing does not occur (Class I, LOE C-LD).	new for 2015
2015	Cardiac or Respiratory Arrest Associated With Opioid Overdose	After ROSC or return of spontaneous breathing, patients should be observed in a healthcare setting until the risk of recurrent opioid toxicity is low and the patient's level of consciousness and vital signs have normalized (Class I, LOE C-LD).	new for 2015
2015	Cardiac or Respiratory Arrest Associated With Opioid Overdose	If recurrent opioid toxicity develops, repeated small doses or an infusion of naloxone can be beneficial in healthcare settings (Class IIa, LOE C-LD).	new for 2015
2015	Cardiac or Respiratory Arrest Associated With Opioid Overdose	Naloxone administration in post–cardiac arrest care may be considered in order to achieve the specific therapeutic goals of reversing the effects of long-acting opioids (Class IIb, LOE C-EO).	new for 2015

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2015 Guidelines Update: Master List of Recommendations, *Continued*

Year Last Reviewed	Topic	Recommendation	Comments
2015	Role of Intravenous Lipid Emulsion Therapy in Management of Cardiac Arrest Due to Poisoning	It may be reasonable to administer ILE, concomitant with standard resuscitative care, to patients with local anesthetic systemic toxicity and particularly to patients who have premonitory neurotoxicity or cardiac arrest due to bupivacaine toxicity (Class IIb, LOE C-EO).	new for 2015
2015	Role of Intravenous Lipid Emulsion Therapy in Management of Cardiac Arrest Due to Poisoning	It may be reasonable to administer ILE to patients with other forms of drug toxicity who are failing standard resuscitative measures (Class IIb, LOE C-EO).	updated for 2015
2015	Cardiac Arrest During Percutaneous Coronary Intervention	It may be reasonable to use mechanical CPR devices to provide chest compressions to patients in cardiac arrest during PCI (Class IIb, LOE C-EO).	updated for 2015
2015	Cardiac Arrest During Percutaneous Coronary Intervention	It may be reasonable to use ECPR as a rescue treatment when initial therapy is failing for cardiac arrest that occurs during PCI (Class IIb, LOE C-LD).	new for 2015
2015	Cardiac Arrest During Percutaneous Coronary Intervention	Institutional guidelines should include the selection of appropriate candidates for use of mechanical support devices to ensure that these devices are used as a bridge to recovery, surgery or transplant, or other device (Class I, LOE C-EO).	new for 2015
The following recommendations were not reviewed in 2015. For more information, see the *2010 AHA Guidelines for CPR and ECC*, "Part 12: Cardiac Arrest in Special Situations."			
2010	Cardiac Arrest Associated With Asthma	Therefore, since the effects of auto-PEEP in an asthmatic patient with cardiac arrest are likely quite severe, a ventilation strategy of low respiratory rate and tidal volume is reasonable (Class IIa, LOE C).	not reviewed in 2015
2010	Cardiac Arrest Associated With Asthma	During arrest a brief disconnection from the bag mask or ventilator may be considered, and compression of the chest wall to relieve air-trapping can be effective (Class IIa, LOE C).	not reviewed in 2015
2010	Cardiac Arrest Associated With Asthma	For all asthmatic patients with cardiac arrest, and especially for patients in whom ventilation is difficult, the possible diagnosis of a tension pneumothorax should be considered and treated (Class I, LOE C).	not reviewed in 2015
2010	Cardiac Arrest Associated With Anaphylaxis	Given the potential for the rapid development of oropharyngeal or laryngeal edema, immediate referral to a health professional with expertise in advanced airway placement is recommended (Class I, LOE C).	not reviewed in 2015
2010	Cardiac Arrest Associated With Anaphylaxis	Epinephrine should be administered early by IM injection to all patients with signs of a systemic allergic reaction, especially hypotension, airway swelling, or difficulty breathing (Class I, LOE C).	not reviewed in 2015
2010	Cardiac Arrest Associated With Anaphylaxis	The recommended dose is 0.2 to 0.5 mg (1:1000) IM to be repeated every 5 to 15 minutes in the absence of clinical improvement (Class I, LOE C).	not reviewed in 2015
2010	Cardiac Arrest Associated With Anaphylaxis	In both anaphylaxis and cardiac arrest the immediate use of an epinephrine autoinjector is recommended if available (Class I, LOE C).	not reviewed in 2015
2010	Cardiac Arrest Associated With Anaphylaxis	Planning for advanced airway management, including a surgical airway, is recommended (Class I, LOE C).	not reviewed in 2015
2010	Cardiac Arrest Associated With Anaphylaxis	Vasogenic shock from anaphylaxis may require aggressive fluid resuscitation (Class IIa, LOE C).	not reviewed in 2015
2010	Cardiac Arrest Associated With Anaphylaxis	When an IV line is in place, it is reasonable to consider the IV route as an alternative to IM administration of epinephrine in anaphylactic shock (Class IIa, LOE C).	not reviewed in 2015
2010	Cardiac Arrest Associated With Anaphylaxis	Because fatal overdose of epinephrine has been reported, close hemodynamic monitoring is recommended (Class I, LOE B).	not reviewed in 2015
2010	Cardiac Arrest Associated With Anaphylaxis	IV infusion of epinephrine is a reasonable alternative to IV boluses for treatment of anaphylaxis in patients not in cardiac arrest (Class IIa, LOE C) and may be considered in postarrest management (Class IIb, LOE C).	not reviewed in 2015
2010	Cardiac Arrest Associated With Anaphylaxis	Alternative vasoactive drugs (vasopressin, norepinephrine, methoxamine, and metaraminol) may be considered in cardiac arrest secondary to anaphylaxis that does not respond to epinephrine (Class IIb, LOE C).	not reviewed in 2015
2010	Cardiac Arrest Associated With Anaphylaxis	Adjuvant use of antihistamines (H1 and H2 antagonist), inhaled β-adrenergic agents, and IV corticosteroids has been successful in management of the patient with anaphylaxis and may be considered in cardiac arrest due to anaphylaxis (Class IIb, LOE C).	not reviewed in 2015
2010	Cardiac Arrest Associated With Anaphylaxis	Cardiopulmonary bypass has been successful in isolated case reports of anaphylaxis followed by cardiac arrest. Use of these advanced techniques may be considered in clinical situations where the required professional skills and equipment are immediately available (Class IIb, LOE C).	not reviewed in 2015

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2015 Guidelines Update: Master List of Recommendations, *Continued*

Year Last Reviewed	Topic	Recommendation	Comments
2010	Cardiac Arrest Associated With Pregnancy	Bag-mask ventilation with 100% oxygen before intubation is especially important in pregnancy (Class IIa, LOE B).	not reviewed in 2015
2010	Cardiac Arrest Associated With Pregnancy	If internal or external fetal monitors are attached during cardiac arrest in a pregnant woman, it is reasonable to remove them (Class IIb, LOE C).	not reviewed in 2015
2010	Cardiac Arrest Associated With Pregnancy	Team planning should be done in collaboration with the obstetric, neonatal, emergency, anesthesiology, intensive care, and cardiac arrest services (Class I, LOE C).	not reviewed in 2015
2010	Cardiac Arrest Associated With Pregnancy	During therapeutic hypothermia of the pregnant patient, it is recommended that the fetus be continuously monitored for bradycardia as a potential complication, and obstetric and neonatal consultation should be sought (Class I, LOE C).	not reviewed in 2015
2010	Cardiac Arrest Associated With Pulmonary Embolism	In patients with cardiac arrest and without known PE, routine fibrinolytic treatment given during CPR shows no benefit and is not recommended (Class III, LOE A).	not reviewed in 2015
2010	Cardiac Arrest Associated With Life-Threatening Electrolyte Disturbances	When cardiac arrest occurs secondary to hyperkalemia, it may be reasonable to administer adjuvant IV therapy as outlined above for cardiotoxicity in addition to standard ACLS (Class IIb, LOE C).	not reviewed in 2015
2010	Cardiac Arrest Associated With Life-Threatening Electrolyte Disturbances	The effect of bolus administration of potassium for cardiac arrest suspected to be secondary to hypokalemia is unknown and ill advised (Class III, LOE C).	not reviewed in 2015
2010	Cardiac Arrest Associated With Life-Threatening Electrolyte Disturbances	Administration of calcium (calcium chloride [10%] 5 to 10 mL or calcium gluconate [10%] 15 to 30 mL IV over 2 to 5 minutes) may be considered during cardiac arrest associated with hypermagnesemia (Class IIb, LOE C).	not reviewed in 2015
2010	Cardiac Arrest Associated With Life-Threatening Electrolyte Disturbances	For cardiotoxicity and cardiac arrest, IV magnesium 1 to 2 g of MgSO4 bolus IV push is recommended (Class I, LOE C).	not reviewed in 2015
2010	Cardiac Arrest Associated With Life-Threatening Electrolyte Disturbances	Empirical use of calcium (calcium chloride [10%] 5 to 10 mL OR calcium gluconate [10%] 15 to 30 mL IV over 2 to 5 minutes) may be considered when hyperkalemia or hypermagnesemia is suspected as the cause of cardiac arrest (Class IIb, LOE C).	not reviewed in 2015
2010	Cardiac Arrest Associated With Toxic Ingestions	The administration of flumazenil to patients with undifferentiated coma confers risk and is not recommended (Class III, LOE B).	not reviewed in 2015
2010	Cardiac Arrest Associated With Toxic Ingestions	The recommended dose of glucagon is a bolus of 3 to 10 mg, administered slowly over 3 to 5 minutes, followed by an infusion of 3 to 5 mg/h (0.05 to 0.15 mg/kg followed by an infusion of 0.05 to 0.10 mg/kg per hour) (Class IIb, LOE C).	not reviewed in 2015
2010	Cardiac Arrest Associated With Toxic Ingestions	Administration of high-dose insulin in patients with shock refractory to other measures may be considered (Class IIb, LOE C).	not reviewed in 2015
2010	Cardiac Arrest Associated With Toxic Ingestions	Administration of calcium in patients with shock refractory to other measures may be considered (Class IIb, LOE C).	not reviewed in 2015
2010	Cardiac Arrest Associated With Toxic Ingestions	High-dose insulin, in the doses listed in the β-blocker section above, may be effective for restoring hemodynamic stability and improving survival in the setting of severe cardiovascular toxicity associated with toxicity from a calcium channel blocker overdose (Class IIb, LOE B).	not reviewed in 2015
2010	Cardiac Arrest Associated With Toxic Ingestions	Administration of calcium in patients with shock refractory to other measures may be considered (Class IIb, LOE C).	not reviewed in 2015
2010	Cardiac Arrest Associated With Toxic Ingestions	Antidigoxin Fab antibodies should be administered to patients with severe life-threatening cardiac glycoside toxicity (Class I, LOE B).	not reviewed in 2015
2010	Cardiac Arrest Associated With Toxic Ingestions	It may be reasonable to try agents that have shown efficacy in the management of acute coronary syndrome in patients with severe cardiovascular toxicity. β-Blockers (phentolamine), benzodiazepines (lorazepam, diazepam), calcium channel blockers (verapamil), morphine, and sublingual nitroglycerin may be used as needed to control hypertension, tachycardia, and agitation (Class IIb, LOE B).	not reviewed in 2015
2010	Cardiac Arrest Associated With Toxic Ingestions	The available data do not support the use of 1 agent over another in the treatment of cardiovascular toxicity due to cocaine (Class IIb, LOE B).	not reviewed in 2015
2010	Cardiac Arrest Associated With Toxic Ingestions	For cocaine-induced hypertension or chest discomfort, benzodiazepines, nitroglycerin, and/or morphine can be beneficial (Class IIa, LOE B).	not reviewed in 2015
2010	Cardiac Arrest Associated With Toxic Ingestions	Although contradictory evidence exists, current recommendations are that pure β-blocker medications in the setting of cocaine are not indicated (Class IIb, LOE C).	not reviewed in 2015
2010	Cardiac Arrest Associated With Toxic Ingestions	Administration of sodium bicarbonate for cardiac arrest due to cyclic antidepressant overdose may be considered (Class IIb, LOE C).	not reviewed in 2015

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2015 Guidelines Update: Master List of Recommendations, *Continued*

Year Last Reviewed	Topic	Recommendation	Comments
2010	Cardiac Arrest Associated With Toxic Ingestions	Sodium bicarbonate boluses of 1 mL/kg may be administered as needed to achieve hemodynamic stability (adequate mean arterial blood pressure and perfusion) and QRS narrowing (Class IIb, LOE C).	not reviewed in 2015
2010	Cardiac Arrest Associated With Toxic Ingestions	Because hyperbaric oxygen therapy appears to confer little risk, the available data suggest that hyperbaric oxygen therapy may be helpful in treatment of acute carbon monoxide poisoning in patients with severe toxicity (Class IIb, LOE C).	not reviewed in 2015
2010	Cardiac Arrest Associated With Toxic Ingestions	Based on the best evidence available, a treatment regimen of 100% oxygen and hydroxocobalamin, with or without sodium thiosulfate, is recommended (Class I, LOE B).	not reviewed in 2015
2010	Cardiac Arrest in Accidental Hypothermia	It may be reasonable to perform further defibrillation attempts according to the standard BLS algorithm concurrent with rewarming strategies (Class IIb, LOE C).	not reviewed in 2015
2010	Cardiac Arrest in Accidental Hypothermia	It may be reasonable to consider administration of a vasopressor during cardiac arrest according to the standard ACLS algorithm concurrent with rewarming strategies (Class IIb, LOE C).	not reviewed in 2015
2010	Cardiac Arrest in Avalanche Victims	Full resuscitative measures, including extracorporeal rewarming when available, are recommended for all avalanche victims without the characteristics outlined above that deem them unlikely to survive or with any obvious lethal traumatic injury (Class I, LOE C).	not reviewed in 2015
2010	Drowning	All victims of drowning who require any form of resuscitation (including rescue breathing alone) should be transported to the hospital for evaluation and monitoring, even if they appear to be alert and demonstrate effective cardiorespiratory function at the scene (Class I, LOE C).	not reviewed in 2015
2010	Drowning	Routine stabilization of the cervical spine in the absence of circumstances that suggest a spinal injury is not recommended (Class III, LOE B).	not reviewed in 2015
2010	Drowning	The routine use of abdominal thrusts or the Heimlich maneuver for drowning victims is not recommended (Class III, LOE C).	not reviewed in 2015
2010	Cardiac Arrest During Percutaneous Coronary Intervention	It is reasonable to use cough CPR during PCI (Class IIa, LOE C).	not reviewed in 2015
2010	Cardiac Arrest Caused by Cardiac Tamponade	In the arrest setting, in the absence of echocardiography, emergency pericardiocentesis without imaging guidance can be beneficial (Class IIa, LOE C).	not reviewed in 2015
2010	Cardiac Arrest Caused by Cardiac Tamponade	Emergency department thoracotomy may improve survival compared with pericardiocentesis in patients with pericardial tamponade secondary to trauma who are in cardiac arrest or who are prearrest, especially if gross blood causes clotting that blocks a pericardiocentesis needle (Class IIb, LOE C).	not reviewed in 2015
2010	Cardiac Arrest Following Cardiac Surgery	For patients with cardiac arrest following cardiac surgery, it is reasonable to perform resternotomy in an appropriately staffed and equipped intensive care unit (Class IIa, LOE B).	not reviewed in 2015
2010	Cardiac Arrest Following Cardiac Surgery	Despite rare case reports describing damage to the heart possibly due to external chest compressions, chest compressions should not be withheld if emergency resternotomy is not immediately available (Class IIa, LOE C).	not reviewed in 2015
Part 11: Pediatric Basic Life Support and Cardiopulmonary Resuscitation Quality			
2015	Sequence of CPR	Because of the limited amount and quality of the data, it may be reasonable to maintain the sequence from the 2010 Guidelines by initiating CPR with C-A-B over A-B-C (Class IIb, LOE C-EO). Knowledge gaps exist, and specific research will be required to examine the best approach to initiating CPR in children.	updated for 2015
2015	Components of High-Quality CPR: Chest Compression Rate and Depth	To maximize simplicity in CPR training, in the absence of sufficient pediatric evidence, it is reasonable to use the adult chest compression rate of 100/min to 120/min for infants and children (Class IIa, LOE C-EO).	updated for 2015
2015	Components of High-Quality CPR: Chest Compression Rate and Depth	Although the effectiveness of CPR feedback devices was not reviewed by this writing group, the consensus of the group is that the use of feedback devices likely helps the rescuer optimize adequate chest compression rate and depth, and we suggest their use when available (Class IIb, LOE C-EO).	updated for 2015
2015	Components of High-Quality CPR: Chest Compression Rate and Depth	It is reasonable that in pediatric patients (less than 1 year) rescuers provide chest compressions that depress the chest at least one third the anterior-posterior diameter of the chest. This equates to approximately 1.5 inches (4 cm) in infants to 2 inches (5 cm) in children. (Class IIa, LOE C-LD). Once children have reached puberty, the recommended adult compression depth of at least 5 cm, but no more than 6 cm, is used for the adolescent of average adult size.	updated for 2015
2015	Components of High-Quality CPR: Compression-Only CPR	Conventional CPR (rescue breathing and chest compressions) should be provided for pediatric cardiac arrests (Class I, LOE B-NR).	updated for 2015
2015	Components of High-Quality CPR: Compression-Only CPR	The asphyxial nature of the majority of pediatric cardiac arrests necessitates ventilation as part of effective CPR. However, because compression-only CPR is effective in patients with a primary cardiac event, if rescuers are unwilling or unable to deliver breaths, we recommend rescuers perform compression-only CPR for infants and children in cardiac arrest (Class I, LOE B-NR).	updated for 2015

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2015 Guidelines Update: Master List of Recommendations, *Continued*

Year Last Reviewed	Topic	Recommendation	Comments
The following recommendations were not reviewed in 2015. For more information, see the *2010 AHA Guidelines for CPR and ECC*, "Part 13: Pediatric Basic Life Support."			
2010	Check for Breathing	Formal training as well as "just in time" training, such as that provided by an emergency response system dispatcher, should emphasize how to recognize the difference between gasping and normal breathing; rescuers should be instructed to provide CPR even when the unresponsive victim has occasional gasps (Class IIa, LOE C).	not reviewed in 2015
2010	Start Chest Compressions	For an infant, lone rescuers (whether lay rescuers or healthcare providers) should compress the sternum with 2 fingers placed just below the intermammary line (Class IIb, LOE C).	not reviewed in 2015
2010	Start Chest Compressions	There are no data to determine if the 1- or 2-hand method produces better compressions and better outcome (Class IIb, LOE C), because children and rescuers come in all sizes, rescuers may use either 1 or 2 hands to compress the child's chest.	not reviewed in 2015
2010	Start Chest Compressions	After each compression, allow the chest to recoil completely (Class IIb, LOE B) because complete chest reexpansion improves the flow of blood returning to the heart and thereby blood flow to the body during CPR.	not reviewed in 2015
2010	Open the Airway and Give Ventilations	Open the airway using a head tilt–chin lift maneuver for both injured and noninjured victims (Class I, LOE B).	not reviewed in 2015
2010	Open the Airway and Give Ventilations	In an infant, if you have difficulty making an effective seal over the mouth and nose, try either mouth-to-mouth or mouth-to-nose ventilation (Class IIb, LOE C).	not reviewed in 2015
2010	Open the Airway and Give Ventilations	In either case make sure the chest rises when you give a breath. If you are the only rescuer, provide 2 effective ventilations using as short a pause in chest compressions as possible after each set of 30 compressions (Class IIa, LOE C).	not reviewed in 2015
2010	BLS Sequence for Healthcare Providers and Others Trained in 2-Rescuer CPR	It is reasonable for healthcare providers to tailor the sequence of rescue actions to the most likely cause of arrest. For example, if the arrest is witnessed and sudden (eg, sudden collapse in an adolescent or a child identified at high risk for arrhythmia or during an athletic event), the healthcare provider may assume that the victim has suffered a sudden VF–cardiac arrest and as soon as the rescuer verifies that the child is unresponsive and not breathing (or only gasping) the rescuer should immediately phone the emergency response system, get the AED and then begin CPR and use the AED. (Class IIa, LOE C).	not reviewed in 2015
2010	Pulse Check	If, within 10 seconds, you don't feel a pulse or are not sure if you feel a pulse, begin chest compressions (Class IIa, LOE C).	not reviewed in 2015
2010	Inadequate Breathing With Pulse	Reassess the pulse about every 2 minutes (Class IIa, LOE B) but spend no more than 10 seconds doing so.	not reviewed in 2015
2010	Ventilations	For healthcare providers and others trained in two person CPR, if there is evidence of trauma that suggests spinal injury, use a jaw thrust without head tilt to open the airway (Class IIb, LOE C).	not reviewed in 2015
2010	Coordinate Chest Compressions and Ventilations	Deliver ventilations with minimal interruptions in chest compressions (Class IIa, LOE C).	not reviewed in 2015
2010	Defibrillation	For infants a manual defibrillator is preferred when a shockable rhythm is identified by a trained healthcare provider (Class IIb, LOE C).	not reviewed in 2015
2010	Defibrillation	An AED with a pediatric attenuator is also preferred for children <8 year of age. If neither is available, an AED without a dose attenuator may be used (Class IIb, LOE C).	not reviewed in 2015
2010	Bag-Mask Ventilation (Healthcare Providers)	Avoid excessive ventilation (Class III, LOE C); use only the force and tidal volume necessary to just make the chest rise.	not reviewed in 2015
Part 12: Pediatric Advanced Life Support			
2015	Prearrest Care Updates	Pediatric medical emergency team/rapid response team systems may be considered in facilities where children with high-risk illnesses are cared for on general in-patient units (Class IIb, LOE C-LD).	updated for 2015
2015	Prearrest Care Updates	The use of PEWS may be considered, but its effectiveness in the in-hospital setting is not well established (Class IIb, LOE C-LD).	new for 2015
2015	Prearrest Care Updates	Administration of an initial fluid bolus of 20 mL/kg to infants and children with shock is reasonable, including those with conditions such as severe sepsis (Class IIa, LOE C-LD) malaria and Dengue (Class IIb, LOE B-R).	new for 2015
2015	Prearrest Care Updates	When caring for children with severe febrile illness (such as those included in the FEAST trial), in settings with limited access to critical care resources (ie, mechanical ventilation and inotropic support), administration of bolus intravenous fluids should be undertaken with extreme caution because it may be harmful (Class IIb, LOE B-R).	new for 2015

(*Continued*)

2015 Guidelines Update: Master List of Recommendations, *Continued*

Year Last Reviewed	Topic	Recommendation	Comments
2015	Prearrest Care Updates	Providers should reassess the patient after every fluid bolus (Class I, LOE C-EO).	new for 2015
2015	Prearrest Care Updates	Either isotonic crystalloids or colloids can be effective as the initial fluid choice for resuscitation (Class IIa, LOE B-R).	new for 2015
2015	Prearrest Care Updates	The available evidence does not support the routine use of atropine preintubation of critically ill infants and children. It may be reasonable for practitioners to use atropine as a premedication in specific emergent intubations when there is higher risk of bradycardia (eg, when giving succinylcholine as a neuromuscular blocker to facilitate intubation) (Class IIb, LOE C-LD).	new for 2015
2015	Prearrest Care Updates	A dose of 0.02 mg/kg of atropine with no minimum dose may be considered when atropine is used as a premedication for emergency intubation (Class IIb, LOE C-LD).	new for 2015
2015	Prearrest Care Updates	Venoarterial ECMO use may be considered in patients with acute fulminant myocarditis who are at high risk of imminent cardiac arrest (Class IIb, LOE C-EO).	new for 2015
2015	Intra-arrest Care Updates	ECPR may be considered for pediatric patients with cardiac diagnoses who have IHCA in settings with existing ECMO protocols, expertise, and equipment (Class IIb, LOE C-LD).	new for 2015
2015	Intra-arrest Care Updates	$ETCO_2$ monitoring may be considered to evaluate the quality of chest compressions, but specific values to guide therapy have not been established in children (Class IIb, LOE C-LD).	new for 2015
2015	Intra-arrest Care Updates	Multiple variables should be used when attempting to prognosticate outcomes during cardiac arrest (Class I, LOE C-LD).	new for 2015
2015	Intra-arrest Care Updates	For patients with invasive hemodynamic monitoring in place at the time of cardiac arrest, it may be reasonable for rescuers to use blood pressure to guide CPR quality (Class IIb, LOE C-EO).	new for 2015
2015	Intra-arrest Care Updates	It is reasonable to administer epinephrine in pediatric cardiac arrest (Class IIa, LOE C-LD).	new for 2015
2015	Intra-arrest Care Updates	For shock-refractory VF or pulseless VT, either amiodarone or lidocaine may be used (Class IIb, LOE C-LD).	new for 2015
2015	Intra-arrest Care Updates	It is reasonable to use an initial dose of 2 to 4 J/kg of monophasic or biphasic energy for defibrillation (Class IIa, LOE C-LD), but for ease of teaching, an initial dose of 2 J/kg may be considered (Class IIb, LOE C-EO).	updated for 2015
2015	Intra-arrest Care Updates	For refractory VF, it is reasonable to increase the dose to 4 J/kg (Class IIa, LOE C-LD).	updated for 2015
2015	Intra-arrest Care Updates	For subsequent energy levels, a dose of 4 J/kg may be reasonable and higher energy levels may be considered, though not to exceed 10 J/kg or the adult maximum dose (Class IIb, LOE C-LD).	updated for 2015
2015	Postarrest Care Updates	For infants and children remaining comatose after OHCA, it is reasonable either to maintain 5 days of continuous normothermia (36° to 37.5°C) or to maintain 2 days of initial continuous hypothermia (32° to 34°C) followed by 3 days of continuous normothermia (Class IIa, LOE B-R).	new for 2015
2015	Postarrest Care Updates	Continuous measurement of temperature during this time period is recommended (Class I, LOE B-NR).	new for 2015
2015	Postarrest Care Updates	Fever (temperature 38°C or higher) should be aggressively treated after ROSC (Class I, LOE B-NR).	new for 2015
2015	Postarrest Care Updates	It may be reasonable for rescuers to target normoxemia after ROSC (Class IIb, LOE B-NR).	new for 2015
2015	Postarrest Care Updates	It is reasonable for practitioners to target a $Paco_2$ after ROSC that is appropriate to the specific patient condition, and limit exposure to severe hypercapnia or hypocapnia (Class IIb, LOE C-LD).	new for 2015
2015	Postarrest Care Updates	After ROSC, we recommend that parenteral fluids and/or inotropes or vasoactive drugs be used to maintain a systolic blood pressure greater than fifth percentile for age (Class I, LOE C-LD).	new for 2015
2015	Postarrest Care Updates	When appropriate resources are available, continuous arterial pressure monitoring is recommended to identify and treat hypotension (Class I, LOE C-EO).	new for 2015
2015	Postarrest Care Updates	EEGs performed within the first 7 days after pediatric cardiac arrest may be considered in prognosticating neurologic outcome at the time of hospital discharge (Class IIb, LOE C-LD) but should not be used as the sole criterion.	new for 2015
2015	Postarrest Care Updates	The reliability of any one variable for prognostication in children after cardiac arrest has not been established. Practitioners should consider multiple factors when predicting outcomes in infants and children who achieve ROSC after cardiac arrest (Class I, LOE C-LD).	new for 2015
The following recommendations were not reviewed in 2015. For more information, see the *2010 AHA Guidelines for CPR and ECC*, "Part 14: Pediatric Advanced Life Support."			
2010	Family Presence During Resuscitation	Whenever possible, provide family members with the option of being present during resuscitation of an infant or child (Class I, LOE B).	not reviewed in 2015
2010	Laryngeal Mask Airway (LMA)	When bag-mask ventilation (see "Bag-Mask Ventilation," below) is unsuccessful and when endotracheal intubation is not possible, the LMA is acceptable when used by experienced providers to provide a patent airway and support ventilation (Class IIa, LOE C).	not reviewed in 2015

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2015 Guidelines Update: Master List of Recommendations, *Continued*

Year Last Reviewed	Topic	Recommendation	Comments
2010	Bag-Mask Ventilation	In the prehospital setting it is reasonable to ventilate and oxygenate infants and children with a bag-mask device, especially if transport time is short (Class IIa, LOE B).	not reviewed in 2015
2010	Precautions	Use only the force and tidal volume needed to just make the chest rise visibly (Class I, LOE C)	not reviewed in 2015
2010	Precautions	Avoid delivering excessive ventilation during cardiac arrest (Class III, LOE C).	not reviewed in 2015
2010	Precautions	If the infant or child is intubated, ventilate at a rate of about 1 breath every 6 to 8 seconds (8 to 10 times per minute) without interrupting chest compressions (Class I, LOE C).	not reviewed in 2015
2010	Precautions	It may be reasonable to do the same if an LMA is in place (Class IIb, LOE C).	not reviewed in 2015
2010	Precautions	In the victim with a perfusing rhythm but absent or inadequate respiratory effort, give 1 breath every 3 to 5 seconds (12 to 20 breaths per minute), using the higher rate for the younger child (Class I, LOE C).	not reviewed in 2015
2010	Two-Person Bag-Mask Ventilation	Applying cricoid pressure in an unresponsive victim to reduce air entry into the stomach (Class IIa, LOE B).	not reviewed in 2015
2010	Two-Person Bag-Mask Ventilation	Avoid excessive cricoid pressure so as not to obstruct the trachea (Class III, LOE B).	not reviewed in 2015
2010	Cricoid Pressure During Intubation	Do not continue cricoid pressure if it interferes with ventilation or the speed or ease of intubation (Class III, LOE C).	not reviewed in 2015
2010	Cuffed Versus Uncuffed Endotracheal Tubes	Both cuffed and uncuffed endotracheal tubes are acceptable for intubating infants and children (Class IIa, LOE C).	not reviewed in 2015
2010	Cuffed Versus Uncuffed Endotracheal Tubes	In certain circumstances (eg, poor lung compliance, high airway resistance, or a large glottic air leak) a cuffed endotracheal tube may be preferable to an uncuffed tube, provided that attention is paid to endotracheal tube size, position, and cuff inflation pressure (Class IIa, LOE B).	not reviewed in 2015
2010	Endotracheal Tube Size	For children between 1 and 2 years of age, it is reasonable to use a cuffed endotracheal tube with an internal diameter of 3.5 mm (Class IIa, LOE B).	not reviewed in 2015
2010	Endotracheal Tube Size	After age 2 it is reasonable to estimate tube size with the following formula (Class IIa, LOE B): Cuffed endotracheal tube ID (mm) 3.5+ (age/4).	not reviewed in 2015
2010	Esophageal Detector Device (EDD)	If capnography is not available, an esophageal detector device (EDD) may be considered to confirm endotracheal tube placement in children weighing >20 kg with a perfusing rhythm (Class IIb, LOE B), but the data are insufficient to make a recommendation for or against its use in children during cardiac arrest.	not reviewed in 2015
2010	Transtracheal Catheter Oxygenation and Ventilation	Attempt this procedure only after proper training and with appropriate equipment (Class IIb, LOE C).	not reviewed in 2015
2010	CPR Guidelines for Newborns With Cardiac Arrest of Cardiac Origin	It is reasonable to resuscitate newborns with a primary cardiac etiology of arrest, regardless of location, according to infant guidelines, with emphasis on chest compressions (Class IIa, LOE C).	not reviewed in 2015
2010	Echocardiography	When appropriately trained personnel are available, echocardiography may be considered to identify patients with potentially treatable causes of the arrest, particularly pericardial tamponade and inadequate ventricular filling (Class IIb, LOE C).	not reviewed in 2015
2010	Intraosseous (IO) Access	IO access is a rapid, safe, effective, and acceptable route for vascular access in children, and it is useful as the initial vascular access in cases of cardiac arrest (Class I, LOE C).	not reviewed in 2015
2010	Medication Dose Calculation	If the child's weight is unknown, it is reasonable to use a body length tape with precalculated doses (Class IIa, LOE C).	not reviewed in 2015
2010	Medication Dose Calculation	Regardless of the patient's habitus, use the actual body weight for calculating initial resuscitation drug doses or use a body length tape with precalculated doses (Class IIb, LOE C).	not reviewed in 2015
2010	Calcium	Calcium administration is not recommended for pediatric cardiopulmonary arrest in the absence of documented hypocalcemia, calcium channel blocker overdose, hypermagnesemia, or hyperkalemia (Class III, LOE B).	not reviewed in 2015
2010	Glucose	Check blood glucose concentration during the resuscitation and treat hypoglycemia promptly (Class I, LOE C).	not reviewed in 2015
2010	Sodium Bicarbonate	Routine administration of sodium bicarbonate is not recommended in cardiac arrest (Class III, LOE B).	not reviewed in 2015
2010	AEDs	If an AED with an attenuator is not available, use an AED with standard electrodes (Class IIa, LOE C).	not reviewed in 2015
2010	AEDs	An AED without a dose attenuator may be used if neither a manual defibrillator nor one with a dose attenuator is available (Class IIb, LOE C).	not reviewed in 2015
2010	Bradycardia	Continue to support airway, ventilation, oxygenation, and chest compressions (Class I, LOE B).	not reviewed in 2015

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2015 Guidelines Update: Master List of Recommendations, *Continued*

Year Last Reviewed	Topic	Recommendation	Comments
2010	Bradycardia	Emergency transcutaneous pacing may be lifesaving if the bradycardia is due to complete heart block or sinus node dysfunction unresponsive to ventilation, oxygenation, chest compressions, and medications, especially if it is associated with congenital or acquired heart disease (Class IIb, LOE C).	not reviewed in 2015
2010	Supraventricular Tachycardia	Attempt vagal stimulation first, unless the patient is hemodynamically unstable or the procedure will unduly delay chemical or electric cardioversion (Class IIa, LOE C).	not reviewed in 2015
2010	Supraventricular Tachycardia	An IV/IO dose of verapamil, 0.1 to 0.3 mg/kg is also effective in terminating SVT in older children, but it should not be used in infants without expert consultation (Class III, LOE C) because it may cause potential myocardial depression, hypotension, and cardiac arrest.	not reviewed in 2015
2010	Supraventricular Tachycardia	Use sedation, if possible. Start with a dose of 0.5 to 1 J/kg. If unsuccessful, increase the dose to 2 J/kg (Class IIb, LOE C).	not reviewed in 2015
2010	Supraventricular Tachycardia	Consider amiodarone 5 mg/kg IO/IV or procainamide 15 mg/kg IO/IV236 for a patient with SVT unresponsive to vagal maneuvers and adenosine and/or electric cardioversion; for hemodynamically stable patients, expert consultation is strongly recommended prior to administration (Class IIb, LOE C).	not reviewed in 2015
2010	Wide-Complex (>0.09 Second) Tachycardia	Consider electric cardioversion after sedation using a starting energy dose of 0.5 to 1 J/kg. If that fails, increase the dose to 2 J/kg (Class IIb, LOE C).	not reviewed in 2015
2010	Wide-Complex (>0.09 Second) Tachycardia	Electric cardioversion is recommended using a starting energy dose of 0.5 to 1 J/kg. If that fails, increase the dose to 2 J/kg (Class I, LOE C).	not reviewed in 2015
2010	Septic Shock	Early assisted ventilation may be considered as part of a protocol-driven strategy for septic shock (Class IIb, LOE C).	not reviewed in 2015
2010	Septic Shock	Etomidate has been shown to facilitate endotracheal intubation in infants and children with minimal hemodynamic effect, but do not use it routinely in pediatric patients with evidence of septic shock (Class III, LOE B).	not reviewed in 2015
2010	Trauma	Do not routinely hyperventilate even in case of head injury (Class III, LOE C).	not reviewed in 2015
2010	Trauma	If the patient has maxillofacial trauma or if you suspect a basilar skull fracture, insert an orogastric rather than a nasogastric tube (Class IIa, LOE C).	not reviewed in 2015
2010	Trauma	In the very select circumstances of children with cardiac arrest from penetrating trauma with short transport times, consider performing resuscitative thoracotomy (Class IIb, LOE C).	not reviewed in 2015
2010	Single Ventricle	Neonates in a prearrest state due to elevated pulmonary-to-systemic flow ratio prior to Stage I repair might benefit from a $Paco_2$ of 50 to 60 mm Hg, which can be achieved during mechanical ventilation by reducing minute ventilation, increasing the inspired fraction of CO_2, or administering opioids with or without chemical paralysis (Class IIb, LOE B).	not reviewed in 2015
2010	Single Ventricle	Neonates in a low cardiac output state following stage I repair may benefit from systemic vasodilators such as α-adrenergic antagonists (eg, phenoxybenzamine) to treat or ameliorate increased systemic vascular resistance, improve systemic oxygen delivery, and reduce the likelihood of cardiac arrest (Class IIa, LOE B).	not reviewed in 2015
2010	Single Ventricle	Other drugs that reduce systemic vascular resistance (eg, milrinone or nipride) may also be considered for patients with excessive Qp:Qs (Class IIa, LOE B).	not reviewed in 2015
2010	Single Ventricle	During cardiopulmonary arrest, it is reasonable to consider extracorporeal membrane oxygenation (ECMO) for patients with single ventricle anatomy who have undergone Stage I procedure (Class IIa, LOE B).	not reviewed in 2015
2010	Single Ventricle	Hypoventilation may improve oxygen delivery in patients in a prearrest state with Fontan or hemi-Fontan/bidirectional Glenn (BDG) physiology (Class IIa, LOE B).	not reviewed in 2015
2010	Single Ventricle	Negative pressure ventilation may improve cardiac output (Class IIa, LOE C).	not reviewed in 2015
2010	Single Ventricle	During cardiopulmonary arrest, it is reasonable to consider extracorporeal membrane oxygenation (ECMO) for patients with Fontan physiology (Class IIa, LOE C).	not reviewed in 2015
2010	Pulmonary Hypertension	If intravenous or inhaled therapy to decrease pulmonary hypertension has been interrupted, reinstitute it (Class IIa, LOE C).	not reviewed in 2015
2010	Pulmonary Hypertension	Consider administering inhaled nitric oxide (iNO) or aerosolized prostacyclin or analogue to reduce pulmonary vascular resistance (Class IIa, LOE C).	not reviewed in 2015
2010	Pulmonary Hypertension	If iNO is not available, consider giving an intravenous bolus of prostacyclin (Class IIa, LOE C).	not reviewed in 2015
2010	Pulmonary Hypertension	ECMO may be beneficial if instituted early in the resuscitation (Class IIa, LOE C).	not reviewed in 2015
2010	Cocaine	For coronary vasospasm consider nitroglycerin (Class IIa, LOE C), a benzodiazepine, and phentolamine (an α-adrenergic antagonist) (Class IIb, LOE C).	not reviewed in 2015

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2015 Guidelines Update: Master List of Recommendations, *Continued*

Year Last Reviewed	Topic	Recommendation	Comments
2010	Cocaine	Do not give α-adrenergic blockers (Class III, LOE C).	not reviewed in 2015
2010	Cocaine	For ventricular arrhythmia, consider sodium bicarbonate (1 to 2 mEq/kg) administration (Class IIb, LOE C) in addition to standard treatment.	not reviewed in 2015
2010	Cocaine	To prevent arrhythmias secondary to myocardial infarction, consider a lidocaine bolus followed by a lidocaine infusion (Class IIb, LOE C).	not reviewed in 2015
2010	Tricyclic Antidepressants and Other Sodium Channel Blockers	Do not administer Class IA (quinidine, procainamide), Class IC (flecainide, propafenone), or Class III (amiodarone and sotalol) antiarrhythmics, which may exacerbate cardiac toxicity (Class III, LOE C).	not reviewed in 2015
2010	Calcium Channel Blockers	The effectiveness of calcium administration is variable (Class IIb, LOE C).	not reviewed in 2015
2010	Calcium Channel Blockers	For bradycardia and hypotension, consider vasopressors and inotropes such as norepinephrine or epinephrine (Class IIb, LOE C)	not reviewed in 2015
2010	Beta-Adrenergic Blockers	High-dose epinephrine infusion may be effective (Class IIb, LOE C).	not reviewed in 2015
2010	Beta-Adrenergic Blockers	Consider glucagon (Class IIb, LOE C).	not reviewed in 2015
2010	Beta-Adrenergic Blockers	Consider an infusion of glucose and insulin (Class IIb, LOE C).	not reviewed in 2015
2010	Beta-Adrenergic Blockers	There are insufficient data to make a recommendation for or against using calcium (Class IIb, LOE C).	not reviewed in 2015
2010	Beta-Adrenergic Blockers	Calcium may be considered if glucagon and catecholamines are ineffective (Class IIb, LOE C).	not reviewed in 2015
2010	Opioids	Support of oxygenation and ventilation is the initial treatment for severe respiratory depression from any cause (Class I).	not reviewed in 2015
2010	Opioids	Naloxone reverses the respiratory depression of narcotic overdose (Class I, LOE B).	not reviewed in 2015
2010	Respiratory System	Monitor exhaled CO_2 (P_{ETCO_2}), especially during transport and diagnostic procedures (Class IIa, LOE B).	not reviewed in 2015
2010	Dopamine	Titrate dopamine to treat shock that is unresponsive to fluids and when systemic vascular resistance is low (Class IIb, LOE C).	not reviewed in 2015
2010	Inodilators	It is reasonable to use an inodilator in a highly monitored setting for treatment of myocardial dysfunction with increased systemic or pulmonary vascular resistance (Class IIa, LOE B).	not reviewed in 2015
2010	Neurologic System	It is reasonable for adolescents resuscitated from sudden, witnessed, out-of-hospital VF cardiac arrest (Class IIa, LOE C).	not reviewed in 2015
2010	Neurologic System	Monitor temperature continuously, if possible, and treat fever (>38°C) aggressively with antipyretics and cooling devices because fever adversely influences recovery from ischemic brain injury (Class IIa, LOE C).	not reviewed in 2015
2010	Interhospital Transport	Monitor exhaled CO_2 (qualitative colorimetric detector or capnography) during interhospital or intrahospital transport of intubated patients (Class IIa, LOE B).	not reviewed in 2015
2010	Family Presence During Resuscitation	Whenever possible, provide family members with the option of being present during resuscitation of an infant or child (Class I, LOE B).	not reviewed in 2015
2010	Family Presence During Resuscitation	If the presence of family members creates undue staff stress or is considered detrimental to the resuscitation, then family members should be respectfully asked to leave (Class IIa, LOE C).	not reviewed in 2015
2010	Sudden Unexplained Deaths	Refer families of patients that do not have a cause of death found on autopsy to a healthcare provider or center with expertise in arrhythmias (Class I, LOE C).	not reviewed in 2015
Part 13: Neonatal Resuscitation			
2015	Umbilical Cord Management	In summary, from the evidence reviewed in the 2010 CoSTR and subsequent review of DCC and cord milking in preterm newborns in the 2015 ILCOR systematic review, DCC for longer than 30 seconds is reasonable for both term and preterm infants who do not require resuscitation at birth (Class IIa, LOE C-LD).	new for 2015
2015	Umbilical Cord Management	There is insufficient evidence to recommend an approach to cord clamping for infants who require resuscitation at birth and more randomized trials involving such infants are encouraged. In light of the limited information regarding the safety of rapid changes in blood volume for extremely preterm infants, we suggest against the routine use of cord milking for infants born at less than 29 weeks of gestation outside of a research setting. Further study is warranted because cord milking may improve initial mean blood pressure, hematologic indices, and reduce intracranial hemorrhage, but thus far there is no evidence for improvement in long-term outcomes (Class IIb, LOE C-LD).	new for 2015

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2015 Guidelines Update: Master List of Recommendations, *Continued*

Year Last Reviewed	Topic	Recommendation	Comments
2015	Importance of Maintaining Normal Temperature in the Delivery Room	Preterm infants are especially vulnerable. Hypothermia is also associated with serious morbidities, such as increased respiratory issues, hypoglycemia, and late-onset sepsis. Because of this, admission temperature should be recorded as a predictor of outcomes as well as a quality indicator (Class I, LOE B-NR).	new for 2015
2015	Importance of Maintaining Normal Temperature in the Delivery Room	It is recommended that the temperature of newly born nonasphyxiated infants be maintained between 36.5°C and 37.5°C after birth through admission and stabilization (Class I, LOE C-LD).	new for 2015
2015	Interventions to Maintain Newborn Temperature in the Delivery Room	The use of radiant warmers and plastic wrap with a cap has improved but not eliminated the risk of hypothermia in preterms in the delivery room. Other strategies have been introduced, which include increased room temperature, thermal mattresses, and the use of warmed humidified resuscitation gases. Various combinations of these strategies may be reasonable to prevent hypothermia in infants born at less than 32 weeks of gestation (Class IIb, LOE B-R, B-NR, C-LD).	updated for 2015
2015	Interventions to Maintain Newborn Temperature in the Delivery Room	Compared with plastic wrap and radiant warmer, the addition of a thermal mattress, warmed humidified gases and increased room temperature plus cap plus thermal mattress were all effective in reducing hypothermia. For all the studies, hyperthermia was a concern, but harm was not shown. Hyperthermia (greater than 38.0°C) should be avoided due to the potential associated risks (Class III: Harm, LOE C-EO).	updated for 2015
2015	Warming Hypothermic Newborns to Restore Normal Temperature	The traditional recommendation for the method of rewarming neonates who are hypothermic after resuscitation has been that slower is preferable to faster rewarming to avoid complications such as apnea and arrhythmias. However, there is insufficient current evidence to recommend a preference for either rapid (0.5°C/h or greater) or slow rewarming (less than 0.5°C/h) of unintentionally hypothermic newborns (T° less than 36°C) at hospital admission. Either approach to rewarming may be reasonable (Class IIb, LOE C-LD).	new for 2015
2015	Maintaining Normothermia in Resource-Limited Settings	In resource-limited settings, to maintain body temperature or prevent hypothermia during transition (birth until 1 to 2 hours of life) in well newborn infants, it may be reasonable to put them in a clean food-grade plastic bag up to the level of the neck and swaddle them after drying (Class IIb, LOE C-LD).	new for 2015
2015	Maintaining Normothermia in Resource-Limited Settings	Another option that may be reasonable is to nurse such newborns with skin-to-skin contact or kangaroo mother care (Class IIb, LOE C-LD).	new for 2015
2015	Clearing the Airway When Meconium Is Present	However, if the infant born through meconium-stained amniotic fluid presents with poor muscle tone and inadequate breathing efforts, the initial steps of resuscitation should be completed under the radiant warmer. PPV should be initiated if the infant is not breathing or the heart rate is less than 100/min after the initial steps are completed. Routine intubation for tracheal suction in this setting is not suggested, because there is insufficient evidence to continue recommending this practice (Class IIb, LOE C-LD).	updated for 2015
2015	Assessment of Heart Rate	During resuscitation of term and preterm newborns, the use of 3-lead ECG for the rapid and accurate measurement of the newborn's heart rate may be reasonable (Class IIb, LOE C-LD).	new for 2015
2015	Administration of Oxygen in Preterm Infants	In all studies, irrespective of whether air or high oxygen (including 100%) was used to initiate resuscitation, most infants were in approximately 30% oxygen by the time of stabilization. Resuscitation of preterm newborns of less than 35 weeks of gestation should be initiated with low oxygen (21% to 30%), and the oxygen concentration should be titrated to achieve preductal oxygen saturation approximating the interquartile range measured in healthy term infants after vaginal birth at sea level (Class I, LOE B-R).	new for 2015
2015	Administration of Oxygen	Initiating resuscitation of preterm newborns with high oxygen (65% or greater) is not recommended (Class III: No Benefit, LOE B-R).	new for 2015
2015	Positive Pressure Ventilation (PPV)	There is insufficient data regarding short and long-term safety and the most appropriate duration and pressure of inflation to support routine application of sustained inflation of greater than 5 seconds' duration to the transitioning newborn (Class IIb, LOE B-R).	new for 2015
2015	Positive Pressure Ventilation (PPV)	In 2015, the Neonatal Resuscitation ILCOR and Guidelines Task Forces repeated their 2010 recommendation that, when PPV is administered to preterm newborns, approximately 5 cm H_2O PEEP is suggested (Class IIb, LOE B-R).	updated for 2015
2015	Positive Pressure Ventilation (PPV)	PPV can be delivered effectively with a flow-inflating bag, self-inflating bag, or T-piece resuscitator (Class IIa, LOE B-R).	updated for 2015
2015	Positive Pressure Ventilation (PPV)	Use of respiratory mechanics monitors have been reported to prevent excessive pressures and tidal volumes and exhaled CO_2 monitors may help assess that actual gas exchange is occurring during face-mask PPV attempts. Although use of such devices is feasible, thus far their effectiveness, particularly in changing important outcomes, has not been established (Class IIb, LOE C-LD).	new for 2015

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2015 Guidelines Update: Master List of Recommendations, *Continued*

Year Last Reviewed	Topic	Recommendation	Comments
2015	Positive Pressure Ventilation (PPV)	Laryngeal masks, which fit over the laryngeal inlet, can achieve effective ventilation in term and preterm newborns at 34 weeks or more of gestation. Data are limited for their use in preterm infants delivered at less than 34 weeks of gestation or who weigh less than 2000 g. A laryngeal mask may be considered as an alternative to tracheal intubation if face-mask ventilation is unsuccessful in achieving effective ventilation (Class IIb, LOE B-R).	updated for 2015
2015	Positive Pressure Ventilation (PPV)	A laryngeal mask is recommended during resuscitation of term and preterm newborns at 34 weeks or more of gestation when tracheal intubation is unsuccessful or is not feasible (Class I, LOE C-EO).	updated for 2015
2015	CPAP	Based on this evidence, spontaneously breathing preterm infants with respiratory distress may be supported with CPAP initially rather than routine intubation for administering PPV (Class IIb, LOE B-R).	updated for 2015
2015	Chest Compressions	Compressions are delivered on the lower third of the sternum to a depth of approximately one third of the anterior-posterior diameter of the chest (Class IIb, LOE C-LD).	updated for 2015
2015	Chest Compressions	Because the 2-thumb technique generates higher blood pressures and coronary perfusion pressure with less rescuer fatigue, the 2 thumb–encircling hands technique is suggested as the preferred method (Class IIb, LOE C-LD).	updated for 2015
2015	Chest Compressions	It is still suggested that compressions and ventilations be coordinated to avoid simultaneous delivery. The chest should be allowed to re-expand fully during relaxation, but the rescuer's thumbs should not leave the chest. The Neonatal Resuscitation ILCOR and Guidelines Task Forces continue to support use of a 3:1 ratio of compressions to ventilation, with 90 compressions and 30 breaths to achieve approximately 120 events per minute to maximize ventilation at an achievable rate (Class IIa, LOE C-LD).	updated for 2015
2015	Chest Compressions	A 3:1 compression-to-ventilation ratio is used for neonatal resuscitation where compromise of gas exchange is nearly always the primary cause of cardiovascular collapse, but rescuers may consider using higher ratios (eg, 15:2) if the arrest is believed to be of cardiac origin (Class IIb, LOE C-EO).	updated for 2015
2015	Chest Compressions	The Neonatal Guidelines Writing Group endorses increasing the oxygen concentration to 100% whenever chest compressions are provided (Class IIa, LOE C-EO).	new for 2015
2015	Chest Compressions	To reduce the risks of complications associated with hyperoxia the supplementary oxygen concentration should be weaned as soon as the heart rate recovers (Class I, LOE C-LD).	new for 2015
2015	Chest Compressions	The current measure for determining successful progress in neonatal resuscitation is to assess the heart rate response. Other devices, such as end-tidal CO_2 monitoring and pulse oximetry, may be useful techniques to determine when return of spontaneous circulation occurs. However, in asystolic/bradycardic neonates, we suggest against the routine use of any single feedback device such as $ETCO_2$ monitors or pulse oximeters for detection of return of spontaneous circulation as their usefulness for this purpose in neonates has not been well established (Class IIb, LOE C-LD).	new for 2015
2015	Induced Therapeutic Hypothermia Resource-Limited Areas	Evidence suggests that use of therapeutic hypothermia in resource-limited settings (ie, lack of qualified staff, inadequate equipment, etc) may be considered and offered under clearly defined protocols similar to those used in published clinical trials and in facilities with the capabilities for multidisciplinary care and longitudinal follow-up (Class IIb, LOE-B-R).	new for 2015
2015	Guidelines for Withholding and Discontinuing	However, in individual cases, when counseling a family and constructing a prognosis for survival at gestations below 25 weeks, it is reasonable to consider variables such as perceived accuracy of gestational age assignment, the presence or absence of chorioamnionitis, and the level of care available for location of delivery. It is also recognized that decisions about appropriateness of resuscitation below 25 weeks of gestation will be influenced by region-specific guidelines. In making this statement, a higher value was placed on the lack of evidence for a generalized prospective approach to changing important outcomes over improved retrospective accuracy and locally validated counseling policies. The most useful data for antenatal counseling provides outcome figures for infants alive at the onset of labor, not only for those born alive or admitted to a neonatal intensive care unit (Class IIb, LOE C-LD).	new for 2015
2015	Guidelines for Withholding and Discontinuing	We suggest that, in infants with an Apgar score of 0 after 10 minutes of resuscitation, if the heart rate remains undetectable, it may be reasonable to stop assisted ventilations; however, the decision to continue or discontinue resuscitative efforts must be individualized. Variables to be considered may include whether the resuscitation was considered optimal; availability of advanced neonatal care, such as therapeutic hypothermia; specific circumstances before delivery (eg, known timing of the insult); and wishes expressed by the family (Class IIb, LOE C-LD).	updated for 2015

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2015 Guidelines Update: Master List of Recommendations, *Continued*

Year Last Reviewed	Topic	Recommendation	Comments
2015	Structure of Educational Programs to Teach Neonatal Resuscitation: Instructors	Until more research is available to clarify the optimal instructor training methodology, it is suggested that neonatal resuscitation instructors be trained using timely, objective, structured, and individually targeted verbal and/or written feedback (Class IIb, LOE C-EO).	new for 2015
2015	Structure of Educational Programs to Teach Neonatal Resuscitation: Providers	Studies that explored how frequently healthcare providers or healthcare students should train showed no differences in patient outcomes (LOE C-EO) but were able to show some advantages in psychomotor performance (LOE B-R) and knowledge and confidence (LOE C-LD) when focused training occurred every 6 months or more frequently. It is therefore suggested that neonatal resuscitation task training occur more frequently than the current 2-year interval (Class IIb, LOE B-R, LOE C-EO, LOE C-LD).	new for 2015
The following recommendations were not reviewed in 2015. For more information, see the *2010 AHA Guidelines for CPR and ECC*, "Part 15: Neonatal Resuscitation."			
2010	Temperature Control	All resuscitation procedures, including endotracheal intubation, chest compression, and insertion of intravenous lines, can be performed with these temperature-controlling interventions in place (Class IIb, LOE C).	not reviewed in 2015
2010	Clearing the Airway When Amniotic Fluid Is Clear	Suctioning immediately after birth, whether with a bulb syringe or suction catheter, may be considered only if the airway appears obstructed or if PPV is required (Class IIb, LOE C).	not reviewed in 2015
2010	Assessment of Oxygen Need and Administration of Oxygen	It is recommended that oximetry be used when resuscitation can be anticipated, when PPV is administered, when central cyanosis persists beyond the first 5 to 10 minutes of life, or when supplementary oxygen is administered (Class I, LOE B).	not reviewed in 2015
2010	Administration of Oxygen in Term Infants	It is reasonable to initiate resuscitation with air (21% oxygen at sea level; Class IIb, LOE C).	not reviewed in 2015
2010	Administration of Oxygen in Term Infants	Supplementary oxygen may be administered and titrated to achieve a preductal oxygen saturation approximating the interquartile range measured in healthy term infants after vaginal birth at sea level (Class IIb, LOE B).	not reviewed in 2015
2010	Initial Breaths and Assisted Ventilation	Inflation pressure should be monitored; an initial inflation pressure of 20 cm H_2O may be effective, but ≥30 to 40 cm H_2O may be required in some term babies without spontaneous ventilation (Class IIb, LOE C).	not reviewed in 2015
2010	Initial Breaths and Assisted Ventilation	In summary, assisted ventilation should be delivered at a rate of 40 to 60 breaths per minute to promptly achieve or maintain a heart rate 100 per minute (Class IIb, LOE C).	not reviewed in 2015
2010	Assisted-Ventilation Devices	Target inflation pressures and long inspiratory times are more consistently achieved in mechanical models when T-piece devices are used rather than bags, although the clinical implications of these findings are not clear (Class IIb, LOE C).	not reviewed in 2015
2010	Assisted-Ventilation Devices	Resuscitators are insensitive to changes in lung compliance, regardless of the device being used (Class IIb, LOE C).	not reviewed in 2015
2010	Endotracheal Tube Placement	Although last reviewed in 2010, exhaled CO_2 detection remains the most reliable method of confirmation of endotracheal tube placement (Class IIa, LOE B).	not reviewed in 2015
2010	Chest Compressions	Respirations, heart rate, and oxygenation should be reassessed periodically, and coordinated chest compressions and ventilations should continue until the spontaneous heart rate is 60 per minute (Class IIb, LOE C).	not reviewed in 2015
2010	Epinephrine	Dosing recommendations remain unchanged from 2010. Intravenous administration of epinephrine may be considered at a dose of 0.01 to 0.03 mg/kg of 1:10 000 epinephrine. If an endotracheal administration route is attempted while intravenous access is being established, higher dosing will be needed at 0.05 to 0.1 mg/kg. (Class IIb, LOE C).	not reviewed in 2015
2010	Epinephrine	Given the lack of supportive data for endotracheal epinephrine, it is reasonable to provide drugs by the intravenous route as soon as venous access is established (Class IIb, LOE C).	not reviewed in 2015
2010	Volume Expansion	Volume expansion may be considered when blood loss is known or suspected (pale skin, poor perfusion, weak pulse) and the infant's heart rate has not responded adequately to other resuscitative measures (Class IIb, LOE C).	not reviewed in 2015
2010	Volume Expansion	An isotonic crystalloid solution or blood may be useful for volume expansion in the delivery room (Class IIb, LOE C).	not reviewed in 2015
2010	Volume Expansion	The recommended dose is 10 mL/kg, which may need to be repeated. When resuscitating premature infants, care should be taken to avoid giving volume expanders rapidly, because rapid infusions of large volumes have been associated with IVH (Class IIb, LOE C).	not reviewed in 2015
2010	Induced Therapeutic Hypothermia Resource-Abundant Areas	Induced therapeutic hypothermia was last reviewed in 2010; at that time it was recommended that infants born at more than 36 weeks of gestation with evolving moderate-to-severe hypoxic-ischemic encephalopathy should be offered therapeutic hypothermia under clearly defined protocols similar to those used in published clinical trials and in facilities with the capabilities for multidisciplinary care and longitudinal follow-up (Class IIa, LOE A).	not reviewed in 2015

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2015 Guidelines Update: Master List of Recommendations, *Continued*

Year Last Reviewed	Topic	Recommendation	Comments
2010	Guidelines for Withholding and Discontinuing	The 2010 Guidelines provide suggestions for when resuscitation is not indicated, when it is nearly always indicated, and that under circumstances when outcome remains unclear, that the desires of the parents should be supported (Class IIb, LOE C).	not reviewed in 2015
2010	Briefing/Debriefing	It is still suggested that briefing and debriefing techniques be used whenever possible for neonatal resuscitation (Class IIb, LOE C).	not reviewed in 2015
Part 14: Education			
2015	Basic Life Support Training	CPR self-instruction through video- and/or computer-based modules paired with hands-on practice may be a reasonable alternative to instructor-led courses (Class IIb, LOE C-LD).	updated for 2015
2015	Basic Life Support Training	A combination of self-instruction and instructor-led teaching with hands-on training can be considered as an alternative to traditional instructor-led courses for lay providers. If instructor-led training is not available, self-directed training may be considered for lay providers learning AED skills (Class IIb, LOE C-EO).	new for 2015
2015	Basic Life Support Training	Self-directed methods can be considered for healthcare professionals learning AED skills (Class IIb, LOE C-EO).	new for 2015
2015	Basic Life Support Training	Use of feedback devices can be effective in improving CPR performance during training (Class IIa, LOE A).	updated for 2015
2015	Basic Life Support Training	If feedback devices are not available, auditory guidance (eg, metronome, music) may be considered to improve adherence to recommendations for chest compression rate only (Class IIb, LOE B-R).	updated for 2015
2015	Basic Life Support Training	Given the rapidity with which BLS skills decay after training, coupled with the observed improvement in skill and confidence among students who train more frequently, it may be reasonable for BLS retraining to be completed more often by individuals who are likely to encounter cardiac arrest (Class IIb, LOE C-LD).	updated for 2015
2015	Advanced Life Support Training	Precourse preparation, including review of appropriate content information, online/precourse testing, and practice of pertinent technical skills are reasonable before attending ALS training programs (Class IIa, LOE C-EO).	updated for 2015
2015	Advanced Life Support Training	Given very small risk for harm and the potential benefit of team and leadership training, the inclusion of team and leadership training as part of ALS training is reasonable (Class IIa, LOE C-LD).	updated for 2015
2015	Advanced Life Support Training	The use of high-fidelity manikins for ALS training can be beneficial for improving skills performance at course conclusion (Class IIa, LOE B-R).	updated for 2015
2015	Advanced Life Support Training	Given the potential educational benefits of short, frequent retraining sessions coupled with the potential for cost savings from reduced training time and removal of staff from the clinical environment for standard refresher training, it is reasonable that individuals who are likely to encounter a cardiac arrest victim perform more frequent manikin-based retraining (Class IIa, LOE C-LD)	updated for 2015
2015	Special Considerations	Communities may consider training bystanders in compression-only CPR for adult out-of-hospital cardiac arrest as an alternative to training in conventional CPR (Class IIb, LOE C-LD).	new for 2015
2015	Special Considerations	It may be reasonable to use alternative instructional modalities for BLS and/or ALS teaching in resource-limited environments (Class IIb, LOE C-LD).	new for 2015
2015	Special Considerations	Training primary caregivers and/or family members of high-risk patients may be reasonable (Class IIb, LOE C-LD), although further work needs to help define which groups to preferentially target.	new for 2015
The following recommendations were not reviewed in 2015. For more information, see the *2010 AHA Guidelines for CPR and ECC*, "Part 16: Education, Implementation, and Teams."			
2010	Barriers to Recognition of Cardiac Arrest	Rescuers should be taught to initiate CPR if the adult victim is unresponsive and is not breathing or not breathing normally (eg, only gasping) (Class I, LOE B).	not reviewed in 2015
2010	Physical and Psychological Concerns for Rescuers	It is reasonable that participants undertaking CPR training be advised of the vigorous physical activity required during the skills portion of the training program (Class IIa, LOE B).	not reviewed in 2015
2010	Barriers to AED Use	To maximize willingness to use an AED, public access defibrillation training should continue to be encouraged for the lay public (Class I, LOE B).	not reviewed in 2015
2010	Course Design	Consistent with established methodologies for program evaluation, the effectiveness of resuscitation courses should be evaluated (Class I, LOE C).	not reviewed in 2015
2010	AED Training Requirement	Allowing the use of AEDs by untrained bystanders can be beneficial and may be lifesaving (Class IIa, LOE B).	not reviewed in 2015

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2015 Guidelines Update: Master List of Recommendations, *Continued*

Year Last Reviewed	Topic	Recommendation	Comments
2010	AED Training Requirement	Because even minimal training has been shown to improve performance in simulated cardiac arrests, training opportunities should be made available and promoted for the lay rescuer (Class I, LOE B).	not reviewed in 2015
2010	Course Delivery Formats	It is reasonable to consider alternative course scheduling formats for advanced life support courses (eg, ACLS or PALS), provided acceptable programmatic evaluation is conducted and learners meet course objectives (Class IIa, LOE B).	not reviewed in 2015
2010	Checklists/Cognitive Aids	Checklists or cognitive aids, such as the AHA algorithms, may be considered for use during actual resuscitation (Class IIb, LOE C).	not reviewed in 2015
2010	Debriefing	Debriefing as a technique to facilitate learning should be included in all advanced life support courses (Class I, LOE B).	not reviewed in 2015
2010	Regional Systems of (Emergency) Cardiovascular Care	It is reasonable that regional systems of care be considered as part of an overall approach to improve survival from cardiac arrest (Class IIa, LOE C).	not reviewed in 2015
2010	Barriers to Bystander CPR	Because panic can significantly impair a bystander's ability to perform in an emergency, it may be reasonable for CPR training to address the possibility of panic and encourage learners to consider how they will overcome it (Class IIb LOE C).	not reviewed in 2015
2010	Barriers to Bystander CPR	Despite the low risk of infections, it is reasonable to teach rescuers about the use of barrier devices emphasizing that CPR should not be delayed for their use (Class IIa, LOE C).	not reviewed in 2015
2010	Post-Course Assessment	A written test should not be used exclusively to assess learner competence following an advanced life support course (Class I, LOE B).	not reviewed in 2015
2010	Post-Course Assessment	End-of-course assessment may be useful in helping learners retain skills (Class IIb, LOE C).	not reviewed in 2015
2010	Training Intervals	Skill performance should be assessed during the 2-year certification with reinforcement provided as needed (Class I, LOE B).	not reviewed in 2015
Part 15: First Aid			
2015	First Aid Education	Education and training in first aid can be useful to decrease morbidity and mortality from injury and illness (Class IIa, LOE C-LD).	new for 2015
2015	First Aid Education	We recommend that first aid education be universally available (Class I, LOE C-EO).	new for 2015
2015	Positioning the Ill or Injured Person	If the area is unsafe for the first aid provider or the person, move to a safe location if possible (Class I, LOE C-EO).	updated for 2015
2015	Positioning the Ill or Injured Person	If a person is unresponsive and breathing normally, it may be reasonable to place him or her in a lateral side-lying recovery position (Class IIb, LOE C-LD).	updated for 2015
2015	Positioning the Ill or Injured Person	If a person has been injured and the nature of the injury suggests a neck, back, hip, or pelvic injury, the person should not be rolled onto his or her side and instead should be left in the position in which they were found, to avoid potential further injury (Class I, LOE C-EO).	updated for 2015
2015	Positioning the Ill or Injured Person	If leaving the person in the position found is causing the person's airway to be blocked, or if the area is unsafe, move the person only as needed to open the airway and to reach a safe location (Class I, LOE C-EO).	updated for 2015
2015	Position for Shock	If a person shows evidence of shock and is responsive and breathing normally, it is reasonable to place or maintain the person in a supine position (Class IIa, LOE C-LD).	updated for 2015
2015	Position for Shock	If there is no evidence of trauma or injury (eg, simple fainting, shock from nontraumatic bleeding, sepsis, dehydration), raising the feet about 6 to 12 inches (about 30° to 60°) from the supine position is an option that may be considered while awaiting arrival of EMS (Class IIb, LOE C-LD).	updated for 2015
2015	Position for Shock	Do not raise the feet of a person in shock if the movement or the position causes pain (Class III: Harm, LOE C-EO).	new for 2015
2015	Oxygen Use in First Aid	The use of supplementary oxygen by first aid providers with specific training is reasonable for cases of decompression sickness (Class IIa, LOE C-LD).	updated for 2015
2015	Oxygen Use in First Aid	For first aid providers with specific training in the use of oxygen, the administration of supplementary oxygen to persons with known advanced cancer with dyspnea and hypoxemia may be reasonable (Class IIb, LOE B-R).	new for 2015
2015	Oxygen Use in First Aid	Although no evidence was identified to support the use of oxygen, it might be reasonable to provide oxygen to spontaneously breathing persons who are exposed to carbon monoxide while waiting for advanced medical care (Class IIb, LOE C-EO).	new for 2015
2015	Medical Emergencies: Asthma	It is reasonable for first aid providers to be familiar with the available inhaled bronchodilator devices and to assist as needed with the administration of prescribed bronchodilators when a person with asthma is having difficulty breathing (Class IIa, LOE B-R).	updated for 2015
2015	Medical Emergencies: Stroke	The use of a stroke assessment system by first aid providers is recommended (Class I, LOE B-NR).	new for 2015

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2015 Guidelines Update: Master List of Recommendations, *Continued*

Year Last Reviewed	Topic	Recommendation	Comments
2015	Medical Emergencies: Chest Pain	Aspirin has been found to significantly decrease mortality due to myocardial infarction in several large studies and is therefore recommended for persons with chest pain due to suspected myocardial infarction (Class I, LOE B-R).	updated for 2015
2015	Medical Emergencies: Chest Pain	Call EMS immediately for anyone with chest pain or other signs of heart attack, rather than trying to transport the person to a healthcare facility yourself (Class I, LOE C-EO).	new for 2015
2015	Medical Emergencies: Chest Pain	While waiting for EMS to arrive, the first aid provider may encourage a person with chest pain to take aspirin if the signs and symptoms suggest that the person is having a heart attack and the person has no allergy or contraindication to aspirin, such as recent bleeding (Class IIa, LOE B-NR).	updated for 2015
2015	Medical Emergencies: Chest Pain	If a person has chest pain that does not suggest that the cause is cardiac in origin, or if the first aid provider is uncertain or uncomfortable with administration of aspirin, then the first aid provider should not encourage the person to take aspirin (Class III: Harm, LOE C-EO).	new for 2015
2015	Medical Emergencies: Anaphylaxis	The recommended dose of epinephrine is 0.3 mg intramuscularly for adults and children greater than 30 kg, 0.15 mg intramuscularly for children 15 to 30 kg, or as prescribed by the person's physician. First aid providers should call 9-1-1 immediately when caring for a person with suspected anaphylaxis or a severe allergic reaction (Class I, LOE C-EO).	new for 2015
2015	Medical Emergencies: Anaphylaxis	When a person with anaphylaxis does not respond to the initial dose, and arrival of advanced care will exceed 5 to 10 minutes, a repeat dose may be considered (Class IIb, LOE C-LD).	updated for 2015
2015	Medical Emergencies: Hypoglycemia	If the person is unconscious, exhibits seizures, or is unable to follow simple commands or swallow safely, the first aid provider should call for EMS immediately (Class I, LOE C-EO).	new for 2015
2015	Medical Emergencies: Hypoglycemia	If a person with diabetes reports low blood sugar or exhibits signs or symptoms of mild hypoglycemia and is able to follow simple commands and swallow, oral glucose should be given to attempt to resolve the hypoglycemia. Glucose tablets, if available, should be used to reverse hypoglycemia in a person who is able to take these orally (Class I, LOE B-R).	new for 2015
2015	Medical Emergencies: Hypoglycemia	It is reasonable to use these dietary sugars as an alternative to glucose tablets (when not available) for reversal of mild symptomatic hypoglycemia (Class IIa, LOE B-R).	new for 2015
2015	Medical Emergencies: Hypoglycemia	First aid providers should therefore wait at least 10 to 15 minutes before calling EMS and re-treating a diabetic with mild symptomatic hypoglycemia with additional oral sugars (Class I, LOE B-R).	new for 2015
2015	Medical Emergencies: Hypoglycemia	If the person's status deteriorates during that time or does not improve, the first aid provider should call EMS (Class I, LOE C-EO).	new for 2015
2015	Medical Emergencies: Dehydration	In the absence of shock, confusion, or inability to swallow, it is reasonable for first aid providers to assist or encourage individuals with exertional dehydration to orally rehydrate with CE drinks (Class IIa, LOE B-R)	new for 2015
2015	Medical Emergencies: Dehydration	If these alternative beverages are not available, potable water may be used (Class IIb, LOE B-R).	new for 2015
2015	Medical Emergencies: Toxic Eye Injury	It can be beneficial to rinse eyes exposed to toxic chemicals immediately and with a copious amount of tap water for at least 15 minutes or until advanced medical care arrives (Class IIa, LOE C-LD).	updated for 2015
2015	Medical Emergencies: Toxic Eye Injury	If tap water is not available, normal saline or another commercially available eye irrigation solution may be reasonable (Class IIb, LOE C-LD).	new for 2015
2015	Medical Emergencies: Chemical Eye Injury	First aid providers caring for individuals with chemical eye injury should contact their local poison control center or, if a poison control center is not available, seek help from a medical provider or 9-1-1 (Class I, LOE C-EO).	new for 2015
2015	Trauma Emergencies: Control of Bleeding	There continues to be no evidence to support the use of pressure points or elevation of an injury to control external bleeding. The use of pressure points or elevation of an extremity to control external bleeding is not indicated (Class III: No Benefit, LOE C-EO).	updated for 2015
2015	Trauma Emergencies: Control of Bleeding	The standard method for first aid providers to control open bleeding is to apply direct pressure to the bleeding site until it stops. Control open bleeding by applying direct pressure to the bleeding site (Class I, LOE B-NR).	updated for 2015
2015	Trauma Emergencies: Control of Bleeding	Local cold therapy, such as an instant cold pack, can be useful for these types of injuries to the extremity or scalp (Class IIa, LOE C-LD).	new for 2015
2015	Trauma Emergencies: Control of Bleeding	Cold therapy should be used with caution in children because of the risk of hypothermia in this population (Class I, LOE C-EO).	new for 2015
2015	Trauma Emergencies: Control of Bleeding	Because the rate of complications is low and the rate of hemostasis is high, first aid providers may consider the use of a tourniquet when standard first aid hemorrhage control does not control severe external limb bleeding (Class IIb, LOE C-LD).	updated for 2015

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2015 Guidelines Update: Master List of Recommendations, *Continued*

Year Last Reviewed	Topic	Recommendation	Comments
2015	Trauma Emergencies: Control of Bleeding	A tourniquet may be considered for initial care when a first aid provider is unable to use standard first aid hemorrhage control, such as during a mass casualty incident, with a person who has multisystem trauma, in an unsafe environment, or with a wound that cannot be accessed (Class IIb, LOE C-EO).	new for 2015
2015	Trauma Emergencies: Control of Bleeding	Although maximum time for tourniquet use was not reviewed by a 2015 ILCOR systematic review, it has been recommended that the first aid provider note the time that a tourniquet is first applied and communicate this information with EMS providers. It is reasonable for first aid providers to be trained in the proper application of tourniquets, both manufactured and improvised (Class IIa, LOE C-EO).	new for 2015
2015	Trauma Emergencies: Control of Bleeding	Hemostatic dressings may be considered by first aid providers when standard bleeding control (direct pressure with or without gauze or cloth dressing) is not effective for severe or life-threatening bleeding (Class IIb, LOE C-LD).	updated for 2015
2015	Trauma Emergencies: Control of Bleeding	Proper application of hemostatic dressings requires training (Class I, LOE C-EO).	updated for 2015
2015	Trauma Emergencies: Open Chest Wounds	We recommend against the application of an occlusive dressing or device by first aid providers for individuals with an open chest wound (Class III: Harm, LOE C-EO).	new for 2015
2015	Trauma Emergencies: Open Chest Wounds	In the first aid situation, it is reasonable to leave an open chest wound exposed to ambient air without a dressing or seal (Class IIa, LOE C-EO).	new for 2015
2015	Trauma Emergencies: Concussion	Any person with a head injury that has resulted in a change in level of consciousness, has progressive development of signs or symptoms as described above, or is otherwise a cause for concern should be evaluated by a healthcare provider or EMS personnel as soon as possible (Class I, LOE C-EO).	new for 2015
2015	Trauma Emergencies: Concussion	Using any mechanical machinery, driving, cycling, or continuing to participate in sports after a head injury should be deferred by these individuals until they are assessed by a healthcare provider and cleared to participate in those activities (Class I, LOE C-EO).	new for 2015
2015	Trauma Emergencies: Spinal Motion Restriction	With a growing body of evidence showing more actual harm and no good evidence showing clear benefit, we recommend against routine application of cervical collars by first aid providers (Class III: Harm, LOE C-LD).	updated for 2015
2015	Trauma Emergencies: Spinal Motion Restriction	If a first aid provider suspects a spinal injury, he or she should have the person remain as still as possible and await the arrival of EMS providers (Class I, LOE C-EO).	new for 2015
2015	Musculoskeletal Trauma	In general, first aid providers should not move or try to straighten an injured extremity (Class III: Harm, LOE C-EO).	updated for 2015
2015	Musculoskeletal Trauma	In such situations, providers should protect the injured person, including splinting in a way that limits pain, reduces the chance for further injury, and facilitates safe and prompt transport (Class I, LOE C-EO).	updated for 2015
2015	Musculoskeletal Trauma	If an injured extremity is blue or extremely pale, activate EMS immediately (Class I, LOE C-EO).	new for 2015
2015	Burns	Cool thermal burns with cool or cold potable water as soon as possible and for at least 10 minutes (Class I, LOE B-NR).	updated for 2015
2015	Burns	If cool or cold water is not available, a clean cool or cold, but not freezing, compress can be useful as a substitute for cooling thermal burns (Class IIa, LOE B-NR).	new for 2015
2015	Burns	Care should be taken to monitor for hypothermia when cooling large burns (Class I, LOE C-EO).	new for 2015
2015	Burns	After cooling of a burn, it may be reasonable to loosely cover the burn with a sterile, dry dressing (Class IIb, LOE C-LD).	updated for 2015
2015	Burns	In general, it may be reasonable to avoid natural remedies, such as honey or potato peel dressings (Class IIb, LOE C-LD).	new for 2015
2015	Burns	However, in remote or wilderness settings where commercially made topical antibiotics are not available, it may be reasonable to consider applying honey topically as an antimicrobial agent (Class IIb, LOE C-LD).	new for 2015
2015	Burns	Burns associated with or involving (1) blistering or broken skin; (2) difficulty breathing; (3) the face, neck, hands, or genitals; (4) a larger surface area, such as trunk or extremities; or (5) other cause for concern should be evaluated by a healthcare provider (Class I, LOE C-EO).	new for 2015
2015	Dental Injury	In situations that do not allow for immediate reimplantation, it can be beneficial to temporarily store an avulsed tooth in a variety of solutions shown to prolong viability of dental cells (Class IIa, LOE C-LD).	updated for 2015
2015	Dental Injury	If none of these solutions are available, it may be reasonable to store an avulsed tooth in the injured persons saliva (not in the mouth) pending reimplantation (Class IIb, LOE C-LD).	new for 2015

(*Continued*)

2015 Guidelines Update: Master List of Recommendations, *Continued*

Year Last Reviewed	Topic	Recommendation	Comments
2015	Dental Injury	Following dental avulsion, it is essential to seek rapid assistance with reimplantation (Class I, LOE C-EO).	new for 2015
The following recommendations were not reviewed in 2015. For more information, see the *2010 AHA and American Red Cross Guidelines for First Aid*, "Part 17: First Aid."			
2010	Oxygen	There is insufficient evidence to recommend routine use of supplementary oxygen by a first aid provider for victims complaining of chest discomfort or shortness of breath (Class IIb, LOE C).	not reviewed in 2015
2010	Anaphylaxis	First aid providers should also know how to administer the auto-injector if the victim is unable to do so, provided that the medication has been prescribed by a physician and state law permits it (Class IIb, LOE B).	not reviewed in 2015
2010	Tourniquets	Specifically designed tourniquets appear to be better than ones that are improvised, but tourniquets should only be used with proper training (Class IIa, LOE B).	not reviewed in 2015
2010	Thermal Burns	Don't apply ice directly to a burn; it can produce tissue ischemia (Class III, LOE B).	not reviewed in 2015
2010	Spine Stabilization	Because of the dire consequences if secondary injury does occur, maintain spinal motion restriction by manually stabilizing the head so that the motion of head, neck, and spine is minimized (Class IIb, LOE C).	not reviewed in 2015
2010	Sprains and Strains	Place a barrier, such as a thin towel, between the cold container and the skin (Class IIb, LOE C).	not reviewed in 2015
2010	Hypothermia	If the hypothermia victim is far from definitive health care, begin active rewarming (Class IIa, LOE B) although the effectiveness of active rewarming has not been evaluated.	not reviewed in 2015
2010	Seizures	Placing an object in the victim's mouth may cause dental damage or aspiration (Class IIa, LOE C).	not reviewed in 2015
2010	Wounds and Abrasions	Superficial wounds and abrasions should be thoroughly irrigated with a large volume of warm or room temperature potable water with or without soap until there is no foreign matter in the wound (Class I, LOE A).	not reviewed in 2015
2010	Wounds and Abrasions	Wounds heal better with less infection if they are covered with an antibiotic ointment or cream and a clean occlusive dressing (Class IIa, LOE A).	not reviewed in 2015
2010	Burn Blisters	Loosely cover burn blisters with a sterile dressing, but leave blisters intact because this improves healing and reduces pain (Class IIa, LOE B).	not reviewed in 2015
2010	Electric Injuries	Do not place yourself in danger by touching an electrocuted victim while the power is on (Class III, LOE C).	not reviewed in 2015
2010	Human and Animal Bites	Irrigate human and animal bites with copious amounts of water (Class I, LOE B).	not reviewed in 2015
2010	Snakebites	Do not apply suction as first aid for snakebites (Class III, LOE C).	not reviewed in 2015
2010	Snakebites	Applying a pressure immobilization bandage with a pressure between 40 and 70 mm Hg in the upper extremity and between 55 and 70 mm Hg in the lower extremity around the entire length of the bitten extremity is an effective and safe way to slow the dissemination of venom by slowing lymph flow (Class IIa, LOE C).	not reviewed in 2015
2010	Jellyfish Stings	To inactivate venom load and prevent further envenomation, jellyfish stings should be liberally washed with vinegar (4% to 6% acetic acid solution) as soon as possible for at least 30 seconds (Class IIa, LOE B).	not reviewed in 2015
2010	Jellyfish Stings	For the treatment of pain, after the nematocysts are removed or deactivated, jellyfish stings should be treated with hot-water immersion when possible (Class IIa, LOE B).	not reviewed in 2015
2010	Jellyfish Stings	If hot water is not available, dry hot packs or, as a second choice, dry cold packs may be helpful in decreasing pain but these are not as effective as hot water (Class IIb, LOE B).	not reviewed in 2015
2010	Jellyfish Stings	Topical application of aluminum sulfate or meat tenderizer, commercially available aerosol products, fresh water wash, and papain, an enzyme derived from papaya used as a local medicine, are even less effective in relieving pain (Class IIb, LOE B).	not reviewed in 2015
2010	Jellyfish Stings	Pressure immobilization bandages are not recommended for the treatment of jellyfish stings because animal studies show that pressure with an immobilization bandage causes further release of venom, even from already fired nematocysts (Class III, LOE C).	not reviewed in 2015
2010	Frostbite	Do not try to rewarm the frostbite if there is any chance that it might refreeze or if you are close to a medical facility (Class III, LOE C).	not reviewed in 2015
2010	Frostbite	Severe or deep frostbite should be rewarmed within 24 hours of injury and this is best accomplished by immersing the frostbitten part in warm (37° to 40°C or approximately body temperature) water for 20 to 30 minutes (Class IIb, LOE C).	not reviewed in 2015
2010	Frostbite	Chemical warmers should not be placed directly on frostbitten tissue because they can reach temperatures that can cause burns (Class III, LOE C).	not reviewed in 2015
2010	Chemical Burns	In case of exposure to an acid or alkali on the skin or eye, immediately irrigate the affected area with copious amounts of water (Class I, LOE B).	not reviewed in 2015

(*Continued*)

2015 Guidelines Update: Master List of Recommendations, *Continued*

Year Last Reviewed	Topic	Recommendation	Comments
2010	Treatment With Milk or Water	Do not administer anything by mouth for any poison ingestion unless advised to do so by a poison control center or emergency medical personnel because it may be harmful (Class III, LOE C).	not reviewed in 2015
2010	Activated Charcoal	Do not administer activated charcoal to a victim who has ingested a poisonous substance unless you are advised to do so by poison control center or emergency medical personnel (Class IIb, LOE C).	not reviewed in 2015
2010	Ipecac	Do not administer syrup of ipecac for ingestions of toxins (Class III, LOE B).	not reviewed in 2015

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KEY WORDS: cardiac arrest ■ cardiopulmonary resuscitation ■ emergency ■ resuscitation

Part 2: Evidence Evaluation and Management of Conflicts of Interest

2015 American Heart Association Guidelines Update for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care

Laurie J. Morrison, Chair; Lana M. Gent; Eddy Lang; Mark E. Nunnally; Melissa J. Parker; Clifton W. Callaway; Vinay M. Nadkarni; Antonio R. Fernandez; John E. Billi; Jonathan R. Egan; Russell E. Griffin; Michael Shuster; Mary Fran Hazinski

Introduction

This Part describes the process of creating the *2015 American Heart Association* (AHA) *Guidelines Update for Cardiopulmonary Resuscitation* (CPR) *and Emergency Cardiovascular Care* (ECC), informed by the *2015 International Consensus on CPR and ECC Science With Treatment Recommendations* (CoSTR) publication.[1,2] The process for the 2015 International Liaison Committee on Resuscitation (ILCOR) systematic review is quite different when compared with the process used in 2010.[1–3] For the 2015 systematic review process, ILCOR used the Grading of Recommendations Assessment, Development, and Evaluation (GRADE) (www.gradeworkinggroup.org) approach to systematic reviews and guideline development. For the development of this 2015 Guidelines Update, the AHA used the ILCOR reviews as well as the AHA definition of Classes of Recommendation (COR) and Levels of Evidence (LOE) (Table 1). This Part summarizes the application of the ILCOR GRADE process to inform the creation of 2015 Guidelines Update, and the process of assigning the AHA COR and LOE.

Development of the 2015 Consensus on Science With Treatment Recommendations

Grading of Recommendations Assessment, Development, and Evaluation

The 2015 CoSTR summarizes the published scientific evidence that was identified to answer specific resuscitation questions. ILCOR uses the GRADE system to summarize evidence and determine confidence in estimates of effect as well as to formulate treatment recommendations. GRADE is a consensus-crafted tool in wide use by many professional societies and reference organizations, including the American College of Physicians, the American Thoracic Society, and the Cochrane Collaboration, as well as the Centers for Disease Control and the World Health Organization. The choice of the GRADE approach was based on its increasingly ubiquitous use, practicality, and unique features. To our knowledge, the ILCOR evidence review process represents the largest application of the GRADE system in a healthcare-related review.

GRADE is a system to review evidence to determine the confidence in the estimate of effect of an intervention or the performance of a diagnostic test and to categorize the strength of a recommendation. GRADE requires explicit documentation of the evaluation of the evidence base specific to each outcome that was chosen and ranked as critical and important before the evidence review. The evidence is assessed by multiple criteria. Questions addressed in GRADE typically follow a PICO (population, intervention, comparator, outcome) structure for ease of mapping to available evidence (Figure 1).

Confidence in the estimates of effect, synonymous with and reported more succinctly as quality, is reported by a synthesis of evidence informed by 1 or more studies as opposed to studies themselves. Quality is adjudicated by a 4-part ranking of our confidence in the estimate of effect (high, moderate, low, very low) informed by study methodology and the risk of bias. Studies start but do not necessarily end at high confidence for randomized controlled trials (RCTs), and they start but do not necessarily end at low confidence for observational studies. Studies may be downgraded for inconsistency, imprecision, indirectness, and publication bias and nonrandomized observational studies may be upgraded as the result of effect size, dose-response gradient, and plausible negative confounding; in other words, an underestimation of the association. The direction and strength of recommendations are driven by certainty of evidence effect estimates, values and preferences of patients, and, to some degree, clinicians' balance of positive and negative effects, costs and resources, equity, acceptability, and feasibility (Table 2).

The GRADE Development Tool

The GRADE Guideline Development Tool (www.guidelinedevelopment.org) provides a uniform interface in the form

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*Co-chairs and equal first co-authors.

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***Circulation* is available at http://circ.ahajournals.org** **DOI: 10.1161/CIR.0000000000000253**

Table 1. Applying Class of Recommendations and Level of Evidence to Clinical Strategies, Interventions, Treatments, or Diagnostic Testing in Patient Care*

CLASS (STRENGTH) OF RECOMMENDATION	
CLASS I (STRONG)	**Benefit >>> Risk**
Suggested phrases for writing recommendations: ■ Is recommended ■ Is indicated/useful/effective/beneficial ■ Should be performed/administered/other ■ Comparative-Effectiveness Phrases†: ○ Treatment/strategy A is recommended/indicated in preference to treatment B ○ Treatment A should be chosen over treatment B	
CLASS IIa (MODERATE)	**Benefit >> Risk**
Suggested phrases for writing recommendations: ■ Is reasonable ■ Can be useful/effective/beneficial ■ Comparative-Effectiveness Phrases†: ○ Treatment/strategy A is probably recommended/indicated in preference to treatment B ○ It is reasonable to choose treatment A over treatment B	
CLASS IIb (WEAK)	**Benefit ≥ Risk**
Suggested phrases for writing recommendations: ■ May/might be reasonable ■ May/might be considered ■ Usefulness/effectiveness is unknown/unclear/uncertain or not well established	
CLASS III: No Benefit (MODERATE) *(Generally, LOE A or B use only)*	**Benefit = Risk**
Suggested phrases for writing recommendations: ■ Is not recommended ■ Is not indicated/useful/effective/beneficial ■ Should not be performed/administered/other	
CLASS III: Harm (STRONG)	**Risk > Benefit**
Suggested phrases for writing recommendations: ■ Potentially harmful ■ Causes harm ■ Associated with excess morbidity/mortality ■ Should not be performed/administered/other	

LEVEL (QUALITY) OF EVIDENCE‡	
LEVEL A	
■ High-quality evidence‡ from more than 1 RCTs ■ Meta-analyses of high-quality RCTs ■ One or more RCTs corroborated by high-quality registry studies	
LEVEL B-R	**(Randomized)**
■ Moderate-quality evidence‡ from 1 or more RCTs ■ Meta-analyses of moderate-quality RCTs	
LEVEL B-NR	**(Nonrandomized)**
■ Moderate-quality evidence‡ from 1 or more well-designed, well-executed nonrandomized studies, observational studies, or registry studies ■ Meta-analyses of such studies	
LEVEL C-LD	**(Limited Data)**
■ Randomized or nonrandomized observational or registry studies with limitations of design or execution ■ Meta-analyses of such studies ■ Physiological or mechanistic studies in human subjects	
LEVEL C-EO	**(Expert Opinion)**
Consensus of expert opinion based on clinical experience	

COR and LOE are determined independently (any COR may be paired with any LOE).

A recommendation with LOE C does not imply that the recommendation is weak. Many important clinical questions addressed in guidelines do not lend themselves to clinical trials. Although RCTs are unavailable, there may be a very clear clinical consensus that a particular test or therapy is useful or effective.

* The outcome or result of the intervention should be specified (an improved clinical outcome or increased diagnostic accuracy or incremental prognostic information).

† For comparative-effectiveness recommendations (COR I and IIa; LOE A and B only), studies that support the use of comparator verbs should involve direct comparisons of the treatments or strategies being evaluated.

‡ The method of assessing quality is evolving, including the application of standardized, widely used, and preferably validated evidence grading tools; and for systematic reviews, the incorporation of an Evidence Review Committee.

COR indicates Class of Recommendation; EO, expert opinion; LD, limited data; LOE, Level of Evidence; NR, nonrandomized; R, randomized; and RCT, randomized controlled trial.

of standardized evidence profiles and sets forth a framework that enables the reviewer to synthesize the evidence and make a treatment recommendation.[4]

GRADE uniquely unlocks the often rigid linkage between one's confidence in the estimate of effect from the strength of a recommendation. Although the two are related, different factors (eg, costs, values, preferences) influence the strength of the recommendation independent of one's confidence in the estimate of effect. GRADE mandates explicit reasons for judgments in a transparent structure. The GRADE Guideline Development Tool[4] requires consideration of all of these factors and documentation for each decision. To qualify recommendations, an evidence-to-recommendation framework is used to document all factors that shape the recommendation. Finally, with the GRADE Guideline Development Tool, summary of evidence and evidence profile tables are created. The tables summarize effect size, confidence in the estimates of effect (quality), and the judgments made to evaluate evidence at the level of outcomes. Quality is specified across each of multiple outcomes for the same population, intervention, and comparison, with judgments documented in explanatory notes.

Scientific Evidence and Evaluation Review System

In preparation for the 2015 systematic review process, ILCOR members, the AHA ECC staff, and compensated consultants

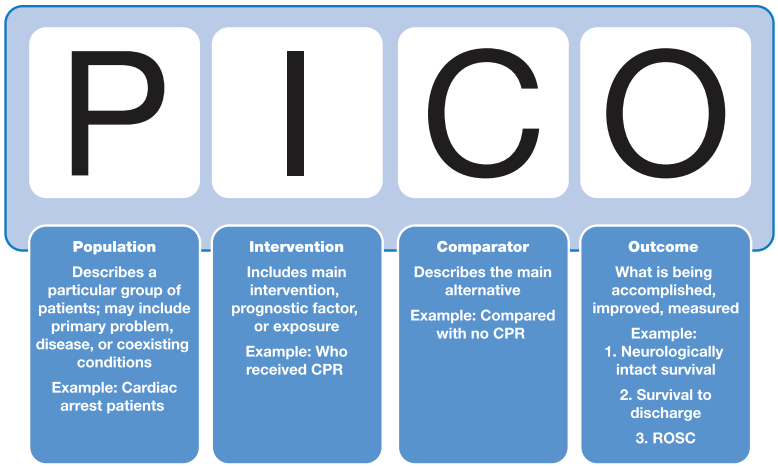

Figure 1. Structure of questions for evidence evaluation.

collaborated to develop an online systematic review website. The Systematic Evidence Evaluation and Review System (SEERS) website was designed to support the management of workflow steps required to complete the ILCOR systematic reviews (in 2010, these were called worksheets) and capture the evidence extraction and evaluation data in reusable formats (Figure 2). The SEERS website facilitated the structured and consistent evidence review process, which enabled the task force members to finalize the CoSTR for each PICO question. Successful completion of the systematic review process

Table 2. From GRADE Evidence to Decision Factors for Making Strong Versus Weak Recommendations

Factor	Relevant Question	Notes
Priority of problem	Is the problem addressed by the question important enough to make a recommendation?	Many problems may not be identified *a priori* as high enough importance to justify strong recommendations when weighed against other problems.
Balance of benefits and harms	Across outcomes, are the overall effects and confidence in those effects a net gain?	Most interventions, prognostications, and diagnostic tests have positive and negative consequences. Confidence in these estimates must be viewed in aggregate—do positive effects outweigh negative ones? Consideration must weigh outcomes by importance.
Certainty in the evidence	What is the overall certainty that these estimates will support a recommendation?	More certainty supports stronger recommendations, and vice versa.
Values and preferences	To what extent do the values and preferences of patients regarding outcomes or interventions vary?	Minimal variation and a strong endorsement of the outcomes or the interventions based on patients' values and preferences supports stronger recommendations. The lack of consistency in patients' values and preferences or a weak endorsement of the outcomes or the interventions supports weaker recommendations.
Costs and resources	Are these net results proportionate to the expenditures and demands of the recommended measure?	Factors such as manpower, time, distraction from other tasks, and monetary investment are viewed through local values. Lower costs of an intervention and greater cost-effectiveness support strong recommendations, and vice versa. Analysis should account for uncertainty in the calculated costs.
Equity	Are the net positive effects of the measure distributed justly?	Measures that improve disparities or benefit fairly may drive a stronger recommendation, and vice versa.
Acceptability	Across stakeholders, is the measure tractable?	To be strong, a recommendation ideally appeals to most.
Feasibility	Can the recommendation be implemented from a practical standpoint?	Something that is practical to achieve may support a strong recommendation, and vice versa.

Summary: To what extent do positive and negative consequences balance in the settings in question?

Negative *clearly* outweighs positive	Negative *probably* outweighs positive	Negative and positive consequences balanced	Positive *probably* outweighs negative	Positive *clearly* outweighs negative
Strong recommendation against	Weak recommendation against		Weak recommendation for	Strong recommendation for

Considerations: Are there important subgroups that might be treated differently? Are there important concerns for implementation?

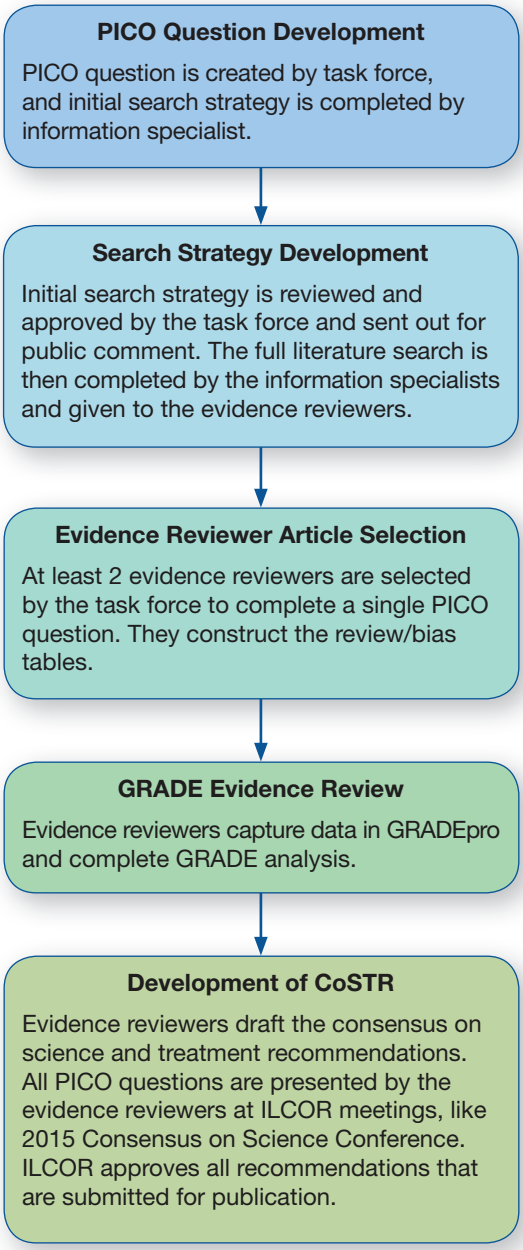

Figure 2. ILCOR 2015 Consensus on Science work flow for all systematic reviews.

ensured consistency in elements of the reviews from many different international reviewers.

Steps in the ILCOR 2015 Systematic Review Process

ILCOR created a comprehensive overview of the structured process that was used to support systematic reviews. The process was divided into 5 major categories, as outlined in Figure 2:

1. PICO question development: systematic review question development, using the PICO format (Figure 1)
2. Search strategy development
3. Evidence reviewer article selection
4. GRADE evidence review
5. Development of CoSTR

ILCOR PICO Question Development

Shortly after the *2010 International Consensus on CPR and ECC Science With Treatment Recommendations* and the *2010 AHA Guidelines for CPR and ECC* were published, the 2015 ILCOR task forces reviewed the 274 PICO questions that were addressed in 2010 and generated a comprehensive list of 336 questions for potential systematic reviews in 2015. In addition, the new ILCOR task force, First Aid, developed 55 PICO questions that were initially prioritized for review. Questions were prioritized based on clinical controversy, emerging literature, and previously identified knowledge gaps. ILCOR task forces debated and eventually voted to select a focused group of questions. Of the 391 potential PICO questions generated by the task forces, a total of 165 (42%) systematic reviews were completed for 2015 (Figures 3 and 4). The number of PICO questions addressed by systematic reviews varied across task forces (Figure 4).

Consistent with adopting the GRADE guideline writing process, clinical outcomes for each PICO were selected and ranked on a 9-point scale as critical and important for decision making by each task force. The GRADE evidence tables were reported by outcome, based on the priority of the clinical outcome. After task force selection of PICO questions for review in 2015, individuals without any conflicts of interest (COIs) or relevant commercial relationships were identified and selected from task force members to serve as task force question owners. Task force question owners provided the oversight control to ensure progress and completion of each systematic review.

ILCOR Search Strategy Development

Task force question owners worked in an iterative process with information specialists from St. Michael's Hospital Health Science Library in Toronto on contract as compensated consultants to the AHA. These information specialists created comprehensive literature search strategies. The information specialists collaborated with the task force question owners to create reproducible search strings that were customized for ease of use within the Cochrane Library (The Cochrane Collaboration, Oxford, England), PubMed (National Library of Medicine, Washington, DC), and Embase (Elsevier B.V., Amsterdam, Netherlands). Each search string was crafted with precision to meet the inclusion and exclusion criteria that were defined to balance the importance of sensitivity and specificity for a comprehensive literature search.

With commitment to a transparent systematic review process for 2015, ILCOR provided an opportunity for public comment on proposed literature search strategies. Members of the public were able to review search strategies and use the search strings to view the literature that would be captured. ILCOR received 18 public comments and suggestions based on the proposed search strategies and forwarded them to the task force chairs and task force question owners for consideration. This iterative process ensured that specific articles were captured during the evaluation process that may not have been initially retrieved by the search strategy.

ILCOR Evidence Reviewers' Article Selection

Upon completion of the public comment process, ILCOR invited topic experts from around the world to serve as

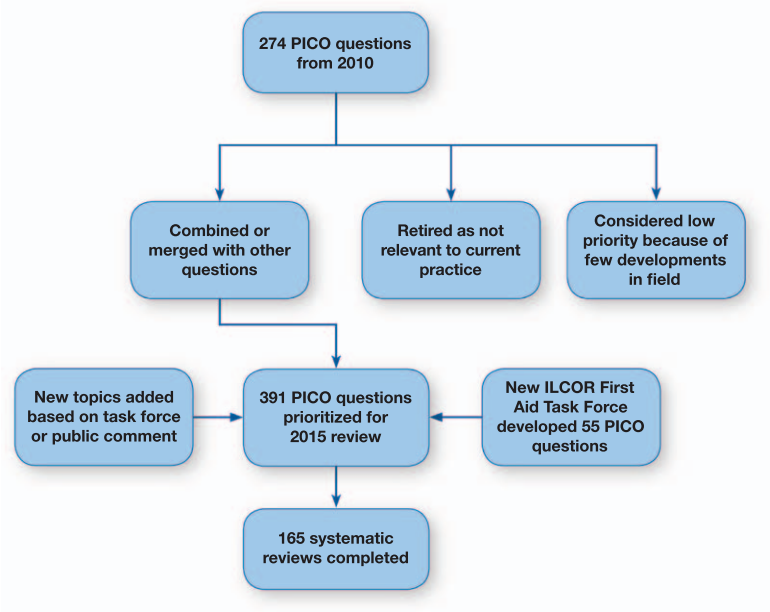

Figure 3. ILCOR process for prioritizing PICO questions for systematic reviews.

evidence reviewers. Specialty organizations were also solicited to suggest potential evidence reviewers. The qualifications of each reviewer were assessed by the task force, and potential COIs were disclosed and evaluated by the task force co-chairs and COI co-chairs. Evidence reviewers could not have any significant COI issues pertaining to their assigned topics. If a COI was identified, the topic was assigned to a different reviewer who was free from conflict.

Two evidence reviewers were invited to complete independent reviews of the literature for each PICO question. A total of 250 evidence reviewers from 39 countries completed 165 systematic reviews. The results of the search strategies were provided to the evidence reviewers. Each reviewer selected articles for inclusion, and the 2 reviewers came to agreement on articles to include before proceeding to the next step in the review process. If disagreement occurred in the selection process, the task force question owner served as a moderator to facilitate agreement between the reviewers. If necessary, the search strategy was modified and repeated based on feedback from the evidence reviewers. When final agreement was reached between the evidence reviewers on included studies, the systematic review process started.

ILCOR GRADE Evidence Review

The bias assessment process capitalized on existing frameworks for defining the risk of systematic error in research reporting through 3 distinct approaches. The Cochrane tool was used to evaluate risk of bias in randomized trials,[5,6] whereas the QUADAS-2 instrument[7] was used for included studies that supported diagnostic PICO questions. For non-RCTs that drew inferences on questions of therapy or prognosis, the GRADE working group risk-of-bias criteria[8] were used as a series of 4 questions that emphasized sampling bias, the integrity of predictor and outcome measurements, loss to follow-up, and adjusting for confounding influences.[8,9] Occasionally an existing systematic review would be uncovered that could formally address risk of bias as it pertained to a specific outcome. However, in most instances, the task forces used an empiric approach based on an amalgamation of risk from individual studies addressing a specific outcome. The 2 (or more) reviewers were encouraged to consolidate their judgments, with adjudication from the task force if needed. Agreed bias assessments were entered into a GRADE evidence profile table.

The GRADE Guideline Development Tool is a freely available online resource that includes the GRADE evidence profile table.[4a] GRADE Guideline Development Tool served as an invaluable aid to summarize important features, strengths, and limitations of the selected studies. To complete each cell of the evidence profile table, reviewers needed to apply judgments on the 5 dimensions of quality, including risk of bias, inconsistency, indirectness, imprecision, and other considerations (including publication bias). Quantitative data that described effect sizes and confidence intervals were also entered into the evidence profiles, although a more descriptive approach was used when pooling was deemed inappropriate. The GRADE Guideline Development Tool software calculated the quality of evidence for critical and important outcomes by row and, when therapy questions (the most common type) were addressed, generated impact estimates for groups at high, moderate, or low baseline risk as a function of the relative risk.

2015 ILCOR Development of Draft Consensus on Science With Treatment Recommendations

ILCOR developed a standardized template for drafting the consensus on science to capture a narrative of the evidence profile and reflect the outcome-centric approach emphasized by GRADE. The consensus on science reported (1) the importance of each outcome, (2) the quality of the evidence and (3) the confidence in estimate of effect of the treatment (or diagnostic accuracy) on each outcome, (4) the GRADE reasons for downgrading or upgrading the quality rating of the study, and (5) the effect size with confidence intervals or a description of effects when pooling was not done.

The ILCOR task forces created treatment recommendations when consensus could be reached. Within the GRADE

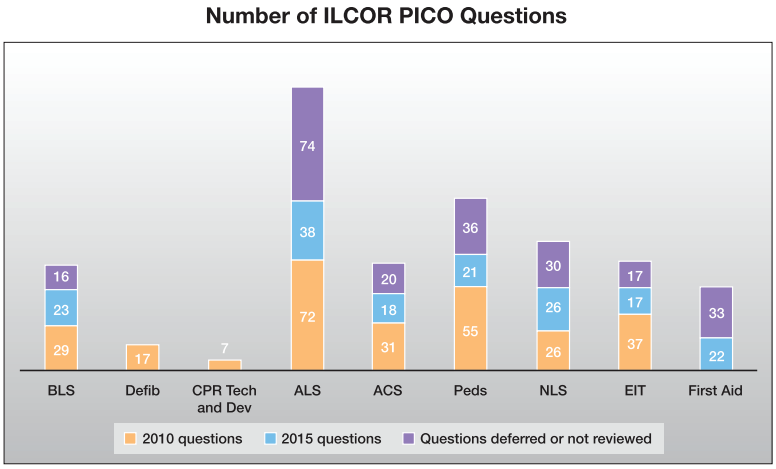

Figure 4. Comparison of the number of systematic review questions (PICO questions) addressed or deferred/not reviewed in 2015 versus 2010 reported by Part in the ILCOR *International Consensus on CPR and ECC Science With Treatment Recommendations* (CoSTR) publication. BLS indicates Basic Life Support; Defib: Defibrillation*; CPR Tech and Dev: Cardiopulmonary Resuscitation Techniques and Devices; ALS: Advanced Life Support; ACS: Acute Coronary Syndromes; Peds: Pediatrics; NLS: Neonatal Resuscitation; EIT, Education, Implementation, and Teams. *Note that defibrillation content (Defib) of 2010 was absorbed within the 2015 Basic Life Support, Advanced Life Support, and Pediatric CoSTR parts, and the CPR Techniques and Devices questions of 2010 were absorbed by the Advanced Life Support CoSTR part in 2015.

format, 4 recommendations are possible: (1) strong recommendation in favor of a treatment or diagnostic test, (2) strong recommendation against a treatment or diagnostic test, (3) weak recommendation in favor of a treatment or diagnostic test, or (4) weak recommendation against a treatment or diagnostic test. A strong recommendation is indicated by the words "we recommend" and a weak recommendation is indicated by the words "we suggest."

Within the GRADE Guideline Development Tool, an evidence-to-recommendation framework assisted reviewers in making explicit the values and preferences that drove their recommendations, especially when evidence was either uncertain or was a weaker determinant of the optimal course of action. In doing so, resource considerations were invoked rarely when an economic analysis was identified and reviewed as germane or when the balance of risks and harms were considered by the task force to be weighed clearly against potential benefits. When there was inadequate or conflicting evidence, the task force would indicate this insufficient evidence with language such as, "The confidence in effect estimates is so low that the panel feels a recommendation to change current practice is too speculative." If economic analyses were not available, or if the task forces thought that the appropriate recommendations could differ among the resuscitation councils based on training implications or structure or resources of out-of-hospital or in-hospital resuscitation systems, then the task forces occasionally made no recommendations, leaving that to the council guidelines.

The task force members reviewed, discussed and debated the evidence and developed consensus wording on the summary consensus on science statements and on the treatment recommendations during in-person meetings and after the 2015 ILCOR International Consensus on CPR and ECC Science With Treatment Recommendations Conference, held in Dallas, Texas, in February 2015. In addition, the task forces met frequently by webinar to develop the draft documents that were submitted for peer review on June 1, 2015. As in 2005 and 2010, strict COI monitoring and management continued throughout the process of developing the consensus on science statements and the treatment recommendations, as described in "Part 2: Evidence Evaluation and Management of Conflicts of Interest" in the 2015 CoSTR.[10,11]

Public Comment on the ILCOR Draft Consensus on Science With Treatment Recommendations

All draft recommendations were posted to allow approximately 6 weeks of public comment, including COI disclosure from those commenting. In addition, the ILCOR draft consensus on science statements and treatment recommendations developed during the January 2015 conference were posted the week after the conference, and 492 public comments were received through February 28, 2015, when the comment period closed. The CoSTR drafts were reposted to remain available through April 2015 to allow optimal stakeholder engagement and familiarity with the proposed recommendations.

Development of the 2015 Guidelines Update

The 2015 Guidelines Update serves as an update to the 2010 Guidelines. The 2015 Guidelines Update addresses the new recommendations that arose from the 2015 ILCOR evidence reviews of the treatment of cardiac arrest and advanced life support for newborns, infants, children, and adults.

Formation of the AHA Guidelines Writing Groups

The AHA exclusively sponsors the 2015 Guidelines Update and does not accept commercial support for the development or publication. The AHA ECC Committee proposed 14 Parts of the Guidelines, which differ slightly from the 2010 Parts (Table 3).

In particular, content from 2010 Parts (electrical therapies, adult stroke) have been incorporated into other Parts, and a new Part that addresses systems of care and continuous quality improvement has been added. The committee nominated a slate of writing group chairs and writing group members for each Part. Writing group chairs were chosen based on their knowledge, expertise, and previous experience with the Guidelines development process. Writing group members were chosen for their knowledge and expertise relevant to their Part of the Guidelines. In addition, each writing group included at least 1 young investigator. The ECC Committee approved the composition of all writing groups before submitting them to the AHA Officers and Manuscript Oversight Committee for approval.

Part 15 of the Guidelines Update, "First Aid," is jointly sponsored by the AHA and the American Red Cross. The writing

Table 3. Contents of 2010 Guidelines Compared With 2015 Guidelines Update

2010 Guidelines	2015 Guidelines Update
Executive Summary	Executive Summary
Evidence Evaluation and Management of Potential or Perceived Conflicts of Interest	Evidence Evaluation and Management of Conflicts of Interest
Ethics	Ethical Issues
CPR Overview	Systems of Care and Continuous Quality Improvement*†
Adult Basic Life Support	Adult Basic Life Support and Cardiopulmonary Resuscitation Quality*†
Electrical Therapies: Automated External Defibrillators, Defibrillation, Cardioversion, and Pacing	(Defibrillation content embedded in other Parts)
CPR Techniques and Devices	Alternative Techniques and Ancillary Devices for Cardiopulmonary Resuscitation
Adult Advanced Cardiovascular Life Support	Adult Advanced Cardiovascular Life Support‡
Post–Cardiac Arrest Care	Post–Cardiac Arrest Care
Acute Coronary Syndromes	Acute Coronary Syndromes
Adult Stroke	(Relevant stroke content embedded in other Parts)
Cardiac Arrest in Special Situations	Special Circumstances of Resuscitation
Pediatric Basic Life Support	Pediatric Basic Life Support and Cardiopulmonary Resuscitation Quality†
Pediatric Advance Life Support	Pediatric Advanced Life Support‡
Neonatal Resuscitation	Neonatal Resuscitation
Education, Implementation, and Teams	Education
First Aid	First Aid

*Includes prehospital stroke.
†Includes AED defibrillation.
‡Includes manual defibrillation.
AED indicates automated external defibrillator; and CPR, cardiopulmonary resuscitation.

group chair was selected by the AHA and the American Red Cross, and writing group members were nominated by both the AHA and the American Red Cross and approved by the ECC Committee. The evidence review for this Part was conducted through the ILCOR GRADE evidence review process.

Before confirmation, all Guidelines writing group chairs and members were required to complete an AHA COI disclosure of all current healthcare-related relationships. The declarations were reviewed by AHA staff and the AHA officers. All writing group chairs and a minimum of 50% of the writing group members were required to be free of relevant COIs and relationships with industry. During the 2015 Guidelines development process, writing group members were requested to update their disclosure statements every 3 months.

Classification of AHA Guidelines Recommendations

In developing the 2015 Guidelines Update, the writing groups used the latest version of the AHA format for COR and LOE (Table 1). The COR indicates the strength that the writing group assigns the recommendation, based on the anticipated magnitude and certainty of benefit relative to risk. The LOE is assigned based on the type, quality, quantity, and consistency of scientific evidence supporting the effect of the intervention.

2015 AHA Classes of Recommendation

Both the 2010 Guidelines and the 2015 Guidelines Update used the AHA Classification system that includes 3 main classes of positive recommendations: Class I, Class IIa, and Class IIb (Figure 5).

Distribution of Recommendations by Class in 2010 and 2015

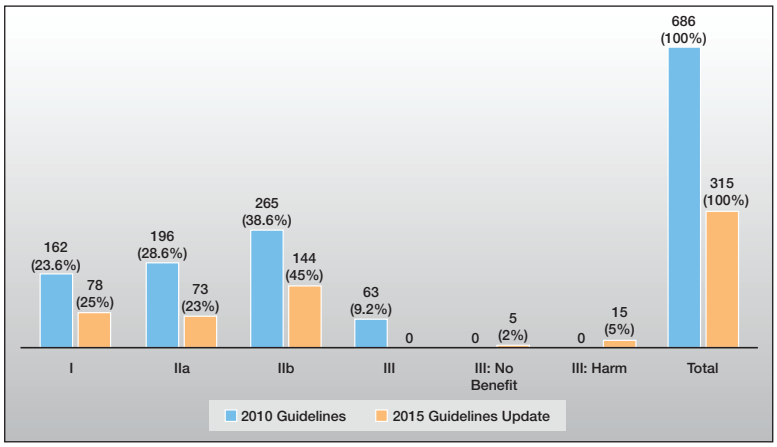

Figure 5. Class of Recommendation comparison between 2010 Guidelines and 2015 Guidelines Update.

A Class I recommendation is the strongest recommendation, indicating the writing group's judgment that the benefit of an intervention greatly outweighs its risk. Such recommendations are considered appropriate for the vast majority of clinicians to follow for the vast majority of patients, with infrequent exceptions based upon the judgment of practitioners in the context of the circumstances of individual cases; there is greater expectation of adherence to a Class I recommendation.

Class IIa recommendations are considered moderate in strength, indicating that an intervention is reasonable and generally useful. Most clinicians will follow these recommendations most of the time, although some notable exceptions exist. Class IIb recommendations are the weakest of the positive recommendations for interventions or diagnostic studies. Class IIb recommendations are identified by language (eg, "may/might be reasonable or may/might be considered") that indicates the intervention or diagnostic study is optional because its effect is unknown or unclear. Although the clinician may consider the treatment or diagnostic study with a Class IIb recommendation, it is also reasonable to consider other approaches.

The past AHA format for COR contained only 1 negative classification, a Class III recommendation. This classification indicated that the therapy or diagnostic test was not helpful, could be harmful, and should not be used. In the 2015 Guidelines Update, there are 2 types of Class III recommendations, to clearly distinguish treatments or tests that may cause harm from those that have been disproven. A Class III: Harm recommendation is a strong one, signifying that the risk of the intervention (potential harm) outweighs the benefit, and the intervention or test should not be used. The second type of Class III recommendation, the Class III: No Benefit, is a moderate recommendation, generally reserved for therapies or tests that have been shown in high-level studies (generally LOE A or B) to provide no benefit when tested against a placebo or control. This recommendation signifies that there is equal likelihood of benefit and risk, and experts agree that the intervention or test should not be used.

2015 AHA Levels of Evidence

In the 2010 Guidelines, only 3 LOEs were used to indicate the quality of the data: LOEs A, B, and C. LOE A indicated evidence from multiple populations, specifically from multiple randomized clinical trials or meta-analyses. LOE B indicated that limited populations were evaluated, and evidence was derived from a single randomized trial or nonrandomized studies. LOE C indicated that either limited populations were studied or the evidence consisted of case series or expert consensus. In this 2015 Guidelines Update, there are now 2 types of LOE B evidence, LOE B-R and LOE B-NR: LOE B-R (randomized) indicates moderate-quality evidence from 1 or more RCTs or meta-analyses of moderate-quality RCTs; LOE B-NR (nonrandomized) indicates moderate-quality evidence from 1 or more well-designed and executed nonrandomized studies, or observational or registry studies, or meta-analyses of such studies. LOE C-LD (limited data) now is used to indicate randomized or nonrandomized observational or registry studies with limitations of design or execution or meta-analyses of such studies, or physiologic or mechanistic studies in humans. LOE C-EO (expert opinion), indicates that evidence is based on consensus of expert opinion when evidence is insufficient, vague, or conflicting. Animal studies are also listed as LOE C-EO (Figure 6).

Development of AHA Classes of Recommendation and Levels of Evidence Informed by the 2015 ILCOR Evidence Review Using GRADE

The AHA COR and LOE framework (Table 1) differs from the framework used by GRADE. As a result, the leadership of the ECC Committee identified a group of experts in methodology to create tools for the 2015 Guidelines Update writing groups to use in developing recommendations informed by the ILCOR GRADE evidence review. Members of this writing group met by conference call weekly from October 27, 2014, to January 12, 2015, to validate the tools and ensure consistency in application. Frameworks for conversion were debated, settled by consensus, and then validated by applying them to specific ILCOR evidence reviews, again using a consensus process. Table 4 and Figures 7, 8, and 9 demonstrate the final tools that were used to guide the various guideline writing groups.

Identification of 2015 Guidelines Update Levels of Evidence, Informed by ILCOR Consensus on Science and GRADE Systematic Review

As the first step in the development of a Guidelines recommendation, the writing group reviewed the studies cited in

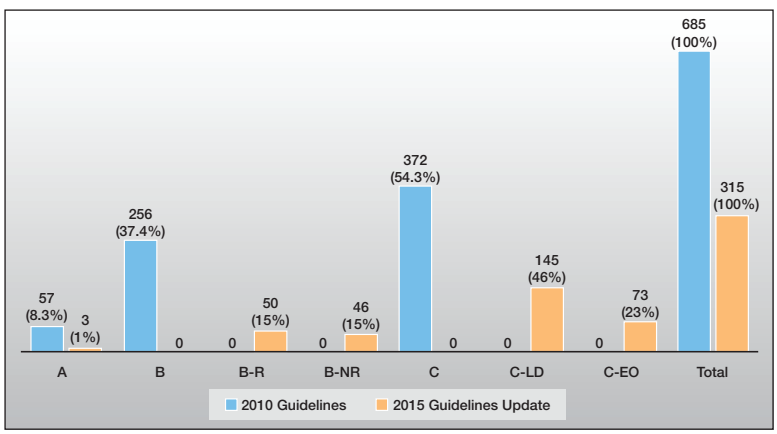

Figure 6. Level of Evidence comparison between 2010 Guidelines and 2015 Guidelines Update. B-R indicates Level of Evidence B-Randomized; B-NR, Level of Evidence B-Nonrandomized; C-LD, Level of Evidence C-Limited Data; and C-EO, Level of Evidence C-Expert Opinion. (One recommendation in the 2010 Guidelines publication has no listed LOE.)

Table 4. Converting the GRADE Level of Evidence to the AHA ECC Level of Evidence

GRADE Level of Evidence*	Starting Point for AHA ECC Level of Evidence (to be adjusted as determined by the writing group)
High GRADE LOE/confidence in the estimates of effect	**Convert to AHA ECC LOE A for:** High-quality evidence exists (well-designed, well-executed studies, each directly answers question, uses adequate randomization, blinding, allocation concealment, and is adequately powered, uses ITT analysis, with high follow-up rates). Evidence from >1 RCT, meta-analysis of high-quality RCTs, RCTs corroborated by high-quality registry studies.
Moderate GRADE LOE/confidence in the estimates of effect	**Convert to AHA ECC LOE B-R for:** Moderate-quality evidence from RCTs or meta-analysis of moderate quality RCTs.
Low GRADE LOE/confidence in the estimates of effect (low or very low confidence is caused by limitations in risk of bias for included studies, inconsistency, imprecision, indirectness, and publication bias)	**Convert to AHA ECC LOE B-NR for:** Moderate-quality evidence from well-designed and well-executed nonrandomized, observational, or registry studies or meta-analysis of same.
Very low GRADE LOE/confidence in the estimate of effect (low or very low confidence is caused by limitations in risk of bias for included studies, inconsistency, imprecision, indirectness, and publication bias)	**Convert to AHA ECC LOE C-LD for:** Randomized or nonrandomized observational or registry studies with limitations of design or execution (including but not limited to inadequate randomization, lack of blinding, inadequate power, outcomes of interest are not prespecified, inadequate follow-up, or based on subgroup analysis) or meta-analyses with such limitations; *or* if physiologic or mechanistic studies in human subjects.
GRADE nonrecommendation	**Convert to AHA ECC LOE C-EO for:** Consensus of expert opinion based on clinical experience.

Clarification: The AHA classification is applied to the body of evidence supporting an individual recommendation, based largely on design and quality of studies addressing the clinical question (see above). Although the International Liaison Committee on Resuscitation (ILCOR) Grading of Recommendations Assessment, Development, and Evaluation (GRADE) recommendation attempts to consider factors such as resource allocation, the individual councils (eg, the AHA) are best able to identify the patients or subsets of patients, outcomes, and conditions that are most important to consider in the translation of science to guidelines.

*The GRADE process labels a body of evidence across outcomes based on the lowest Level of Evidence (LOE) for the most critical outcome.

ECC indicates Emergency Cardiovascular Care; ITT, intention-to-treat; and RCT, randomized controlled trial.

the GRADE evidence profile (Table 4) and assigned an LOE by using the AHA definitions for LOEs (Table 1). Evidence characterized as "high" by the GRADE process generally is consistent with an AHA LOE A. Evidence characterized as moderate in the GRADE process generally corresponds to an AHA LOE B-R for randomized or LOE B-NR for nonrandomized, and evidence characterized by the GRADE process as low or very low generally meets the definitions of AHA LOE C-LD or LOE C-EO. If the Guidelines writing group determined that there was insufficient evidence, the writing group could make a recommendation noting that it was based on expert opinion (LOE C-EO) or could make no recommendation at all. It is important to note that this framework is not absolute; the writing group's judgment may determine that the LOE is higher or lower than the ILCOR characterization of the evidence when a treatment or diagnostic test is applied to the population or under the conditions for which a Guidelines recommendation is made. In this circumstance, the writing group will explain the discrepancy between the GRADE analysis of evidence and the AHA LOE. This will help maintain transparency and make the process reproducible in the future (see Table 4).

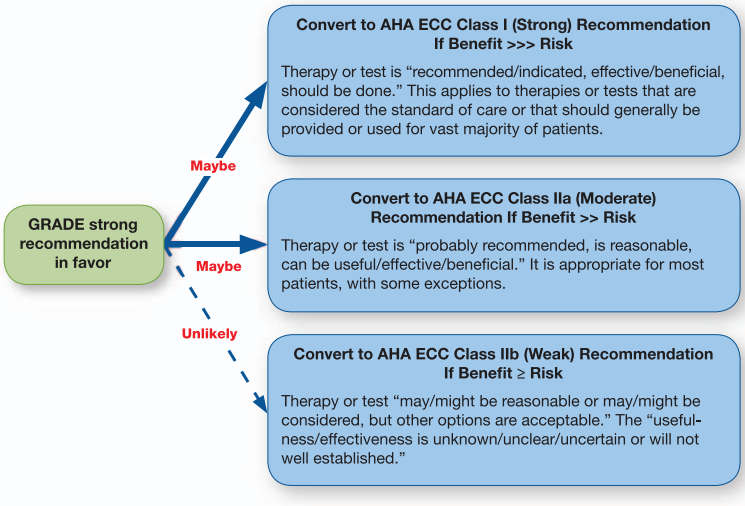

Figure 7. Developing an AHA ECC recommendation that is informed by a GRADE strong recommendation in favor of a therapy or diagnostic or prognostic test.

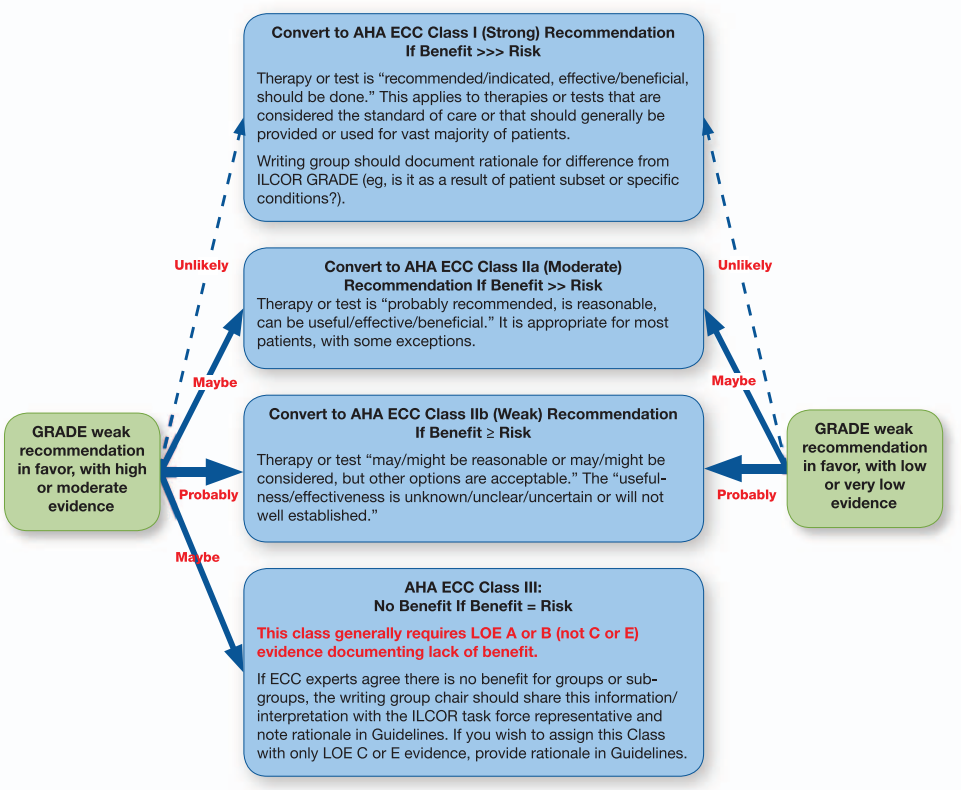

Figure 8. Developing an AHA ECC recommendation that is informed by a GRADE weak recommendation in favor of a therapy or diagnostic or prognostic test.

Identification of 2015 Guidelines Class of Recommendation, Informed by ILCOR Consensus Treatment Recommendation Based on GRADE

The second step in making a 2015 Guidelines Update recommendation is to determine the strength of the recommendation. In many cases, after an extensive evidence review such as that completed by ILCOR, the strength and direction of the ILCOR treatment recommendation will be similar to the strength and direction of the recommendation in the 2015 Guidelines Update. However, in its Clinical Practice Guidelines Methodology Summit Report, the AHA task force on practice guidelines[12] notes that the strength of recommendation and strength of evidence are each hierarchical but separate. The classification table itself notes "COR and LOE are determined independently, ie, any Class of Recommendation may be paired with any Level of Evidence" (Table 1).

The writing groups for the 2015 Guidelines Update were charged to carefully consider the 2015 ILCOR evidence review and the ILCOR consensus treatment recommendations in light of local training systems and the structure and resources of out-of-hospital and in-hospital resuscitation systems. In addition, the writing groups weighed the balance between benefits and risks and the quality of studies providing the evidence. The writing group considered the precision, qualifications, conditions, setting, outcomes, and limitations of the evidence reviewed when making a final assessment. Generally, when strong ILCOR recommendations were in favor of a treatment or diagnostic test, the AHA Guidelines writing groups also provided Class I or IIa recommendations (Figure 7). When weak ILCOR recommendations were in favor of a treatment or diagnostic test, the AHA Guidelines writing groups typically provided a Class IIa, IIb, or a Class III: No Benefit recommendation (Figure 8). If the AHA Guidelines writing group reached a decision that significantly differed in either strength (eg, a strong GRADE recommendation conversion to an AHA Class IIb recommendation) or direction of a recommendation, from that reported by the ILCOR evidence review, the writing group typically included a brief explanation of the rationale for the difference.

Ideally, strong recommendations from a scientific organization are supported by a high LOE. However, there are few prospective RCTs and blinded clinical trials conducted in resuscitation. As a result, it may be necessary for authors of this 2015 Guidelines Update to make recommendations to improve survival, even in the absence of such high-quality evidence. Such was the case in 2005, when the AHA and many other resuscitation councils changed the treatment of pulseless arrest associated with a shockable rhythm (ie, ventricular fibrillation [VF] or pulseless ventricular tachycardia [pVT]) from a recommendation of 3 stacked shocks to recommending delivery of single shocks followed by immediate CPR. Although there were no studies documenting improved survival from VF/pVT cardiac arrest with this approach, single shocks delivered by biphasic defibrillators had a much higher first-shock success than monophasic defibrillators, and experts felt strongly that reducing interruptions in compressions would improve survival. This change in 2005, coupled with emphasis to minimize interruptions in chest compressions, was associated with

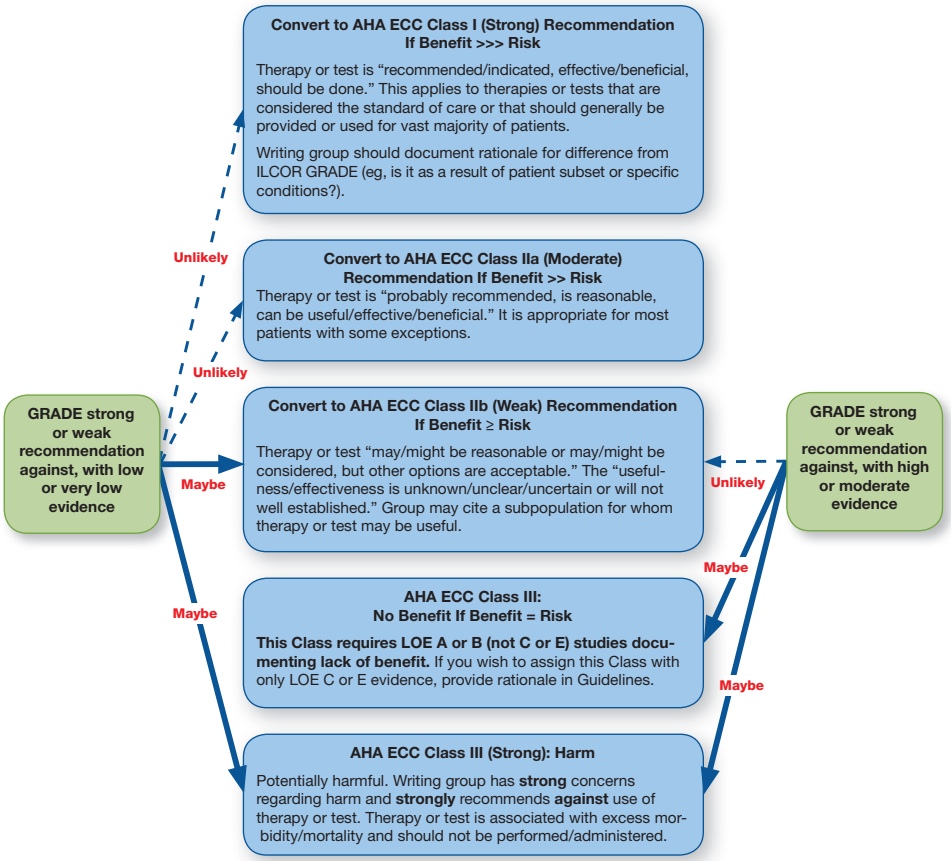

Figure 9. Developing an AHA ECC recommendation that is informed by a GRADE strong or weak recommendation *against* a therapy or diagnostic or prognostic test.

significant increases in survival from prehospital cardiac arrest associated with VF or pVT.[13,14]

It is important to note that the AHA CORs are generally positive, whereas the ILCOR recommendations based on the GRADE process may recommend for or against an intervention or diagnostic study. This will inevitably create some inconsistency between ILCOR recommendations and AHA Guidelines recommendations. For treatments and diagnostic tests that ILCOR provided a weak recommendation against, the AHA Guidelines writing groups might reach a decision to recommend for or against a therapy with a Class IIb (weak, permissive) recommendation for the therapy under particular circumstances or a Class III: No Benefit or Class III: Harm recommendation. When ILCOR provided no recommendation, the AHA Guidelines writing group often reached a decision to provide a Class IIb or a Class III: No Benefit recommendation (Figure 9). As noted previously, if the AHA Guidelines writing group reached a decision that significantly differed in either strength (eg, a weak GRADE recommendation but a strong AHA COR) or direction of a recommendation from that reported by the ILCOR evidence review, the writing group typically included a brief explanation of the rationale for the difference. The writing group chair of any of the AHA Guidelines was free to direct questions to the ILCOR task force writing group co-chairs to clarify the evidence or even to suggest wording or qualification of a recommendation.

Writing Group Voting Procedures

During the writing of the 2015 Guidelines Update, writing group members were asked to express support for or disagreement with the wording of the recommendations, and the recommendations were reworded until consensus was reached. During every discussion, writing group members disclosed any COIs before they spoke on a topic. Writing group chairs were aware of the conflicts reported by the writing group members, and the chairs were charged with ensuring that such disclosure occurred consistently. The writing group also formally voted on every recommendation contained in the 2015 Guidelines Update, after review by the AHA Science Advisory Coordinating Committee. Writing group members recused themselves from voting on any recommendations that involve relevant relationships with industry or any other COI. A tracking sheet was developed and ballots maintained as part of the permanent files of the 2015 Guidelines Update.

Integrating Science Into Practice Guidelines

Implementation or knowledge translation is both a continuum and an iterative process, and it is integral to improving survival[15] (Figure 10).

In the first instance, systematic review and synthesis are required to define the current state of knowledge. Results must then be conveyed in a manner that is appropriate

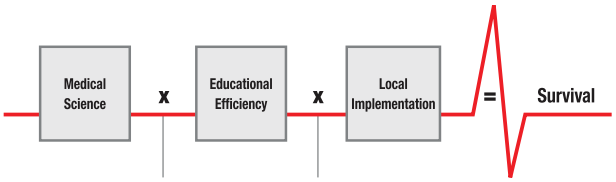

Figure 10. The Utstein Formula of Survival, emphasizing the 3 components essential to improve survival. Redrawn from Søreide E, Morrison LJ, Hillman K, Monsieurs K, Sunde K, Zideman D, Eisenberg M, Sterz F, Nadkarni VM, Soar J, Nolan JP. The formula for survival in resuscitation. *Resuscitation.* 2013;84:1487–1493, with permission from Elsevier. www.resuscitationjournal.com.

and understandable to knowledge users, such as the 2015 Guidelines Update. Despite various societies investing heavily in evidence synthesis and guideline renewal, downstream translation of evidence into practice is frequently deficient and/or delayed.[16,17] The developing field of implementation science is the study of interventions aimed at addressing deficiencies in knowledge translation. The National Institutes of Health defines implementation science as "the study of methods to promote the integration of research findings and evidence into healthcare policy and practice. It seeks to understand the behavior of healthcare professionals and other stakeholders as a key variable in the sustainable uptake, adoption, and implementation of evidence-based interventions."[18] Both knowledge translation and implementation science are critical to continual quality improvement. It is not sufficient to define best practices; evaluation of implementation and adherence are needed (implementation science), and where gaps in evidence uptake exist, tools and strategies to remedy the situation are required (knowledge translation). Ultimately, an iterative plan-do-study-act process can help move policy and clinical care toward best practices over time.[19] More on continuous quality improvement and viewing resuscitation as a system of care can be found in "Part 4: Systems of Care."

Performance metrics are a crucial component of the iterative implementation cycle. Many common assessments of healthcare professionals' competence and performance have inherent strength and weaknesses.[20] Although challenging, the development and adoption of performance measures have been shown to improve processes of care linked to improvements in patient outcome.[21] The value of standardized performance measures lies in the ability to reliably assess clinical care and identify gaps. Metrics allow for self-assessment, regional and national benchmarking, and evaluation of clinical interventions. The importance of standardized performance measures has been recognized by The Joint Commission, Centers for Medicare and Medicaid Services, and the National Quality Forum,[22] and the recently released Institute of Medicine Report on Cardiac Arrest.[23] The AHA Get With The Guidelines® initiative builds on this by providing additional financial, educational, and analytical resources to facilitate performance measure adoption, data collection, and assessments of quality.[21] The AHA Get With The Guidelines program has led to improvements in the care of patients with cardiovascular disease that are significant and beyond what would typically be expected over time.[21] Additionally, the Get With The Guidelines program has been integral in identifying and reducing or eliminating disparities in care based on race and sex.[21] The success of in-hospital performance measures and the investment in prehospital clinical trials in cardiac arrest have led to the creation and adoption of national performance measures for care provided in the prehospital environment.[24] The Resuscitation Outcomes Consortium's focus on quality of CPR metrics as a requirement of the RCTs has led to a steady increase in survival across all participating sites.[14]

A variety of tools and strategies can be used to promote evidence uptake and guideline adherence. Protocol driven care bundles[25] and checklists[26] have been shown to reduce the incidence of serious complications[25,26] and mortality.[26] Simple interventions, such as institutional-specific protocols and order sets, are effective at improving guideline compliance.[27] Smart technology, such as real-time CPR feedback devices, provides data on factors such as chest compression rate, depth, and fraction, prompting provider self-correction and improved performance[28] and improved survival.[14] Both high- and low-fidelity simulation offer healthcare practitioners the ability to learn and practice evidence-based clinical care in an environment that does not risk patient safety but allows experiential learning that can take place in the typical patient care environment.[29] Selection of knowledge translation tools and strategies for a given situation or setting should be informed by the best available evidence.

The Future of ECC Guidelines

In previous cycles, we conducted comprehensive literature reviews and systematic reviews in a batch-and-queue manner to update consensus on science with treatment recommendations every 5 years. The new recommendations then informed revision of training materials every 5 years. This model may not be optimal for responding to emerging peer-reviewed data and might delay implementation of new or emerging research findings. This 2015 cycle marks the transition from batch-and-queue to a continuous evidence-review process. A critical feature of this continuous-review process will be the creation of a transparent and easily accessible, editable version of the most recent systematic reviews and treatment recommendations. This format of comprehensive systematic review with treatment recommendations will occur in an online, living website that will be updated as ILCOR completes evidence reviews.

At any time, the ILCOR task forces may identify clinical questions as high priority for review based on new clinical trials, perceived controversies in patient care, emerging differences in constituent council training materials or algorithms, new publications, Cochrane Reviews, or feedback from the public. On an ongoing basis, the task force will conduct systematic reviews and evidence evaluations for the questions designated as highest priority. Any change in treatment recommendations resulting from these reviews that is endorsed by the task force and the ILCOR Resuscitation Councils will be incorporated into existing resuscitation recommendations and posted to the ILCOR online comprehensive treatment recommendations (http://www.ilcor.org/seers to follow these developments). Any change in treatment recommendation may be immediately peer reviewed and published as an interim Scientific Statement in traditional journals if the task force thinks that enhanced dissemination is required. If the treatment recommendation is not changed or not of critical impact for immediate implementation for patient care, the

Table 5. Class of Recommendation and Levels of Evidence for the 2015 Guidelines Update: Demonstrating the Gap in Resuscitation Science

Class of Recommendation	LOE A	LOE B-R	LOE B-NR	LOE C-LD	LOE C-EO	Total
I	0	8	17	24	29	**78**
IIa	1	11	12	40	9	**73**
IIb	0	25	13	78	28	**144**
III: No Benefit	2	3	0	0	0	**5**
III: Harm	0	1	4	3	7	**15**
Total	**3**	**50**	**46**	**145**	**73**	**315**

LOE indicates Level of Evidence; NR, nonrandomized; and R, randomized.

new recommendation will be updated simply by indicating the date of the most recent systematic review posted to the website and periodically summarized on a routine basis.

The continuous review process should allow more rapid translation of prioritized new science to treatment recommendations and, ultimately, implementation. This process also should improve the workflow for the task forces by allowing concentrated effort on the highest-priority clinical questions rather than an every-5-year effort to review a large number of selected clinical questions.

Summary

The process used to generate the 2015 Guidelines Update has been remarkably different from prior releases of the Guidelines. The combination of (1) ILCOR process of selecting a reduced number of priority topics for review, (2) using the GRADE process of evaluation, and (3) merging the Grade recommendations with the current prescribed AHA classification system to assign LOE and COR is unique to the 2015 Guidelines Update. Thus, the 2015 Guidelines Update is leaner compared with the 2010 Guidelines publication because fewer topics were addressed by the 2015 ILCOR evidence review process than were reviewed in 2010. There were a total of 685 recommendations in the 2010 Guidelines, and there are a total of 315 recommendations in the 2015 Guidelines Update. The number of systematic reviews is lower in 2015; however, the quality of the reviews may be higher and more consistent based on the involvement of information specialists, the rigorous oversight of the SEERS process, and the use of the GRADE process of review.

An examination of the data in Table 5 reveals a substantial gap in resuscitation science available to answer important resuscitation questions. Of all 315 recommendations made in the 2015 Guidelines Update, only 3 (1%) are based on Level A evidence, and only 78 (25%) are a Class I recommendation. **Most of the guidelines are based on Level C evidence (218/315, 69%) or Class II recommendations (217/315, 69%)** (Table 5). When comparing levels of recommendations, there is a modest increase from 23.6% of Class I recommendations in 2010 to 25% in 2015 without much change in Class II recommendations, at 67% in 2010 and 68% in 2015 (Figure 5). There was a decrease in recommendations classified as Level B evidence from 37% in 2010 to 30% (LOE B-R and LOE B-NR) in 2015 (Figure 6). However, in contrast, **there was an increase in recommendations based on Level C evidence from 54% in 2010 to 69% in 2015**. These observations must be tempered with the fact that the PICO questions were selected by the task force in 2015 based on their critical or controversial nature or new science and, as such, their inclusion reflects a selection bias in the sample, whereas PICO questions in 2010 represented the true scope of work as determined by the task force. Nonetheless, even without comparative statistics, these data suggest a persistent huge knowledge gap for resuscitation science that has not been sufficiently addressed in the past 5 years. This gap in resuscitation science needs to be addressed through targeted future research funding. It is anticipated that new science will quickly be translated into Guideline Updates as a result of the continuous review process ILCOR will employ.

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Disclosures

Part 2: Evidence Evaluation and Management of Conflicts of Interest: 2015 Guidelines Update Writing Group Disclosures

Writing Group Member	Employment	Research Grant	Other Research Support	Speakers' Bureau/ Honoraria	Expert Witness	Ownership Interest	Consultant/ Advisory Board	Other
Laurie J. Morrison	Li Ka Shing Knowledge Institute; St Michael's Hospital, University of Toronto	Heart and Stroke Foundation of Canada†; Canadian Institute of Health Research†	None	None	None	None	None	None
John E. Billi	The University of Michigan Medical School	None	None	None	None	None	None	None
Clifton W. Callaway	University of Pittsburgh	None	None	None	None	None	None	None
Jonathan R. Egan	The Children's Hospital at Westmead	None	None	None	None	None	None	None
Antonio R. Fernandez	University of North Carolina	The Duke Endowment/North Carolina Department of Health & Human Services, Department of Facility Services, Office of Emergency Medical Services†; The Duke Endowment/South Carolina Department of Health and Environmental Control, Division of Emergency Medical Services & Trauma†; Department of Homeland Security/Office of Health Affairs†	None	None	None	None	None	None
Vinay M. Nadkarni	Children's Hospital of Philadelphia	None	None	None	None	None	None	None
Mark E. Nunnally	University of Chicago	None	None	None	None	None	None	None
Melissa J. Parker	Division of Pediatric Critical Care	None	None	None	None	None	None	None
Staff								
Lana M. Gent	American Heart Association	None	None	None	None	None	None	None
Russell E. Griffin	American Heart Association	None	None	None	None	None	None	None
Consultants								
Mary Fran Hazinski	Vanderbilt University	None	None	None	None	None	American Heart Association†	None
Eddy Lang	University of Calgary	None	None	None	None	None	American Heart Association†	None
Michael Shuster	Mineral Springs Hospital Emergency Medicine	None	None	None	None	None	American Heart Association†	None

This table represents the relationships of writing group members that may be perceived as actual or reasonably perceived conflicts of interest as reported on the Disclosure Questionnaire, which all members of the writing group are required to complete and submit. A relationship is considered to be "significant" if (a) the person receives $10 000 or more during any 12-month period, or 5% or more of the person's gross income; or (b) the person owns 5% or more of the voting stock or share of the entity, or owns $10 000 or more of the fair market value of the entity. A relationship is considered to be "modest" if it is less than "significant" under the preceding definition.

*Modest.

†Significant.

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KEY WORDS: cardiac arrest ■ cardiopulmonary resuscitation ■ emergency ■ resuscitation

Part 3: Ethical Issues

2015 American Heart Association Guidelines Update for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care

Mary E. Mancini, Chair; Douglas S. Diekema; Theresa A. Hoadley; Kelly D. Kadlec; Marygrace H. Leveille; Jane E. McGowan; Michele M. Munkwitz; Ashish R. Panchal; Michael R. Sayre; Elizabeth H. Sinz

The goals of resuscitation are to preserve life; restore health; relieve suffering; limit disability; and respect individuals' decisions, rights, and privacy. Because cardiopulmonary resuscitation (CPR) efforts must be initiated immediately at the time of arrest, a rescuer may not know who the victim is, what that individual's goals of care are, or if an advance directive exists. As a result, administration of CPR may be contrary to the individual's desires or best interests.[1–3] This Part of the *2015 American Heart Association* (AHA) *Guidelines Update for CPR and Emergency Cardiovascular Care* provides updates to the 2010 AHA Guidelines[4] for healthcare providers who are faced with the difficult decision to provide or withhold emergency cardiovascular care.

Ethical Principles

Ethical, legal, and cultural factors influence decisions about resuscitation. Ideally, these decisions are guided by science, patient or surrogate preferences, local policies and legal requirements, and established ethical principles.

Principle of Respect for Autonomy

Respect for autonomy is an important social value in medical ethics and law.[5] This principle is based on society's respect for a competent individual's ability to make decisions about his or her own health care. Adults are presumed to have decision-making capability unless they are incapacitated or declared incompetent by a court of law. Informed decisions require that individuals receive and understand accurate information about their condition and prognosis as well as the nature, risks, benefits, and alternatives of any proposed interventions. Individuals must deliberate and choose among alternatives by linking their decisions to their values and personal goals of care.

When physicians strive to understand patients' goals of care, decisions can be made based on the likelihood that together they will achieve the patients' goals of care. The following 3-step process may assist healthcare providers in ensuring each patient understands and makes informed decisions: (1) the patient receives and understands accurate information about his or her condition, prognosis, nature of any proposed interventions, alternatives, and risks and benefits; (2) the patient is asked to paraphrase the information to give providers the opportunity to assess the patient's understanding and correct any misimpressions; and (3) the patient deliberates and chooses among alternatives and justifies his or her decisions.[6]

When decision-making capacity is temporarily impaired by conditions such as active illness, treatment of these conditions may restore capacity. When an individual's preferences are unknown or uncertain, it is ethically appropriate to treat emergency conditions until further information is available.

Pediatric Decision Making

As a general rule, minors are considered incompetent to provide legally binding consent about their health care. Parents or guardians are generally empowered to make healthcare decisions on the behalf of minors, and in most situations, parents are given wide latitude in terms of the decisions they make on behalf of their children. Ethically, however, a child should be involved in decision making at a level appropriate for the child's maturity. Children under 14 years of age in Canada and under 18 years of age in the United States rarely possess the legal authority to consent to their health care except under specific legally defined situations (eg, emancipated minors; mature minors; minors who have specific health conditions, such as those with sexually transmitted diseases or in need of pregnancy-related care). However, as older children develop the capacity to make decisions, it is ethically appropriate to include them in discussions about their care and the treatments using language and explanations suitable for the child's level of maturity and cognitive function.

Withholding and Withdrawing CPR (Termination of Resuscitative Efforts) Related to Out-of-Hospital Cardiac Arrest

Criteria for Not Starting CPR

While the general rule is to provide emergency treatment to a victim of cardiac arrest, there are a few exceptions where withholding CPR would be considered appropriate:

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- Situations where attempts to perform CPR would place the rescuer at risk of serious injury or mortal peril (eg, exposure to infectious diseases).
- Obvious clinical signs of irreversible death (eg, rigor mortis, dependent lividity, decapitation, transection, decomposition).
- A valid advance directive, a Physician Orders for Life-Sustaining Treatment (POLST) form[7] (www.polst.org) indicating that resuscitation is not desired, or a valid Do Not Attempt Resuscitation (DNAR) order.

Terminating Resuscitative Efforts in Neonatal, Pediatric, or Adult Out-of-Hospital Cardiac Arrest

The 2010 Guidelines contain a complete discussion of clinical decision rules for terminating resuscitative efforts.[4] In 2015, the International Liaison Committee on Resuscitation (ILCOR) Neonatal Life Support Task Force and the Pediatric Life Support Task Force completed systematic reviews to examine whether the presence of certain prognostic factors in the newly born or in infants or children enabled prediction of good neurologic outcome (see "Part 12: Pediatric Advanced Life Support" and "Part 13: Neonatal Resuscitation").

In the absence of clinical decision rules for the neonate, infant, child, or adult out-of-hospital cardiac arrest (OHCA) victim, CPR and advanced life support protocols are used by responsible prehospital providers in consultation with medical direction in real-time or as the victim is transported to the most appropriate facility per local directives. The impact of the availability of advanced hospital-based interventions, including extracorporeal membrane oxygenation (ECMO) during refractory CPR and the use of targeted temperature management (TTM), is now being considered in the local evaluation for continuing resuscitation and transport in some emergency medical service systems.[8–10]

Use of Extracorporeal CPR for Adults With OHCA—Updated

The use of extracorporeal CPR (ECPR) may allow providers additional time to treat reversible underlying causes of cardiac arrest (eg, acute coronary artery occlusion, pulmonary embolism, refractory ventricular fibrillation, profound hypothermia, cardiac injury, myocarditis, cardiomyopathy, congestive heart failure, drug intoxication) or serve as a bridge for left ventricular assist device implantation or cardiac transplant.

2015 Evidence Summary

The 2015 ILCOR systematic review evaluated the use of ECPR techniques (including ECMO or cardiopulmonary bypass) compared with manual CPR or mechanical CPR. One post hoc analysis of data from a prospective, observational cohort of 162 OHCA patients who did not achieve return of spontaneous circulation (ROSC) with more than 20 minutes of conventional CPR, including propensity score matching, showed that at 3-month follow-up ECPR was associated with a higher rate of neurologically intact survival than continued conventional CPR.[11]

A single prospective, observational study that enrolled 454 patients with OHCA who were treated with ECPR if they did not achieve ROSC with more than 15 minutes of conventional CPR after hospital arrival demonstrated improved neurologic outcomes at 1-month and 6-month follow-ups.[12]

Pediatric OHCA was not included in the 2015 ILCOR systematic review.

2015 Recommendation[ALS 723]—Revised

There is insufficient evidence to recommend the routine use of ECPR for patients with cardiac arrest. In settings where it can be rapidly implemented, ECPR may be considered for select cardiac arrest patients for whom the suspected etiology of the cardiac arrest is potentially reversible during a limited period of mechanical cardiorespiratory support (Class IIb, LOE C-LD).

Intra-arrest Prognostic Factors for Cardiac Arrest in Infants and Children—Updated

The ILCOR Pediatric Life Support Task Force reviewed the available evidence to determine if there were intra-arrest prognostic indicators that reliably predict survival with good neurologic outcome for OHCA.

2015 Evidence Summary

For infants and children with OHCA, age of less than 1 year,[13,14] longer duration of cardiac arrest,[15–17] and presentation with a nonshockable as opposed to a shockable rhythm[13,14,16] are all predictors of poor patient outcome.

2015 Recommendation[Peds 814]—New

Multiple variables should be used when attempting to prognosticate outcomes during cardiac arrest (Class I, LOE C-LD). Although there are factors associated with better or worse outcomes, no single factor that was studied predicts outcome with sufficient accuracy to recommend termination or continuation of CPR.

Withholding and Withdrawing CPR (Termination of Resuscitative Efforts) Related to In-Hospital Cardiac Arrest

Limitation of Interventions and Withdrawal of Life-Sustaining Therapies

This topic was last reviewed in 2010. Since that time, the term *limitation of interventions* has replaced *limitations of care*.[4] In the 2010 Guidelines, it was noted that not initiating resuscitation and discontinuing life-sustaining treatment of in-hospital cardiac arrest (IHCA) during or after resuscitation are ethically equivalent, and clinicians should not hesitate to withdraw support on ethical grounds when functional survival is highly unlikely.

Criteria for Withholding and Discontinuing CPR in Newly Born Infant IHCA

In the 2010 Guidelines, the data regarding management of neonates born at the margins of viability or those with conditions that predict a high risk of mortality or morbidity were reviewed, and it was concluded that there was variation in attitudes and practice by region and availability of resources. Moreover, it was emphasized that parents desire a larger role in decisions related to initiation of resuscitation and continuation of support of severely compromised newborns. Guidelines were provided for when resuscitation is not indicated or when

it is nearly always indicated. Under circumstances when the outcome remains unclear, the desires of the parents should be supported.[4]

Use of a Prognostic Score in the Delivery Room for Preterm Infants[NRP 805]—Updated

The 2015 ILCOR systematic review evaluated studies about prognostic scores applied to extremely preterm infants (below 25 weeks) compared with assessment of gestational age only.

2015 Recommendation—Updated

The data regarding prognostic scores are challenging to evaluate because of the difficulty in distinguishing between outcomes that are driven by practice and current belief about survivability, decision making by parents, and actual physiologic limitations of prematurity.

Antenatal assignment of prognosis for survival and/or disability of the neonate born extremely preterm has generally been made on the basis of gestational age alone. Scoring systems for including additional variables such as gender, use of maternal antenatal steroids, and multiplicity have been developed in an effort to improve prognostic accuracy. Indeed, it was suggested in the 2010 Guidelines that decisions regarding morbidity and risks of mortality may be augmented by the use of published tools based on data from specific populations.[18]

There is no evidence to support the prospective use of any particular delivery room prognostic score presently described, over gestational age assessment alone, in preterm infants at less than 25 weeks of gestation. Importantly, no score has been shown to improve the clinician's ability to estimate likelihood of survival through the first 18 to 22 months after birth. However, in individual cases, when counseling a family and constructing a prognosis for survival at gestations below 25 weeks, it is reasonable to consider variables such as perceived accuracy of gestational age assignment, the presence or absence of chorioamnionitis, and the level of care available for the location of delivery. It is also recognized that decisions about appropriateness of resuscitation below 25 weeks of gestation will be influenced by region-specific guidelines. In making this statement, a higher value was placed on the lack of evidence for a generalized prospective approach to changing important outcomes over improved retrospective accuracy and locally validated counseling policies. The most useful data for antenatal counseling provides outcome figures for infants alive at the onset of labor, not only for those born alive or admitted to a neonatal intensive care unit[19–24] (Class IIb, LOE C-LD).

Terminating Resuscitative Efforts in Late Preterm and Term Infants[NRP 896]—Updated

The 2015 ILCOR systematic review examined whether outcome is changed by continuing resuscitative efforts in late preterm and term infants with an Apgar score of 0 after 10 minutes of adequate resuscitation.

2015 Recommendation—Updated

An Apgar score of 0 at 10 minutes is a strong predictor of mortality and morbidity in late preterm and term infants. We suggest that, in infants with an Apgar score of 0 after 10 minutes of resuscitation, if the heart rate remains undetectable, it may be reasonable to stop assisted ventilation; however, the decision to continue or discontinue resuscitative efforts must be individualized. Variables to be considered may include whether the resuscitation was considered optimal; availability of advanced neonatal care, such as therapeutic hypothermia; specific circumstances before delivery (eg, known timing of the insult); and wishes expressed by the family[23,25–29] (Class IIb, LOE C-LD). For further information, see "Part 13: Neonatal Resuscitation."

Terminating Resuscitative Efforts in Pediatric or Adult IHCA

Use of ECPR in IHCA[ALS 723, Peds 407]—Updated

To answer the question of whether outcome is changed by the use of ECPR for individuals in IHCA, the available evidence was reviewed by the ILCOR Advanced Life Support and Pediatric Task Forces.

2015 Evidence Summary

The 2015 ILCOR review process evaluated the use of ECPR techniques (including ECMO or cardiopulmonary bypass) compared with manual CPR or mechanical CPR for adult survival from IHCA in any setting. One propensity-matched, prospective, observational study that enrolled 172 patients with IHCA reported greater likelihood of ROSC and improved survival at hospital discharge, 30-day follow-up, and 1-year follow-up with the use of ECPR among patients who received more than 10 minutes of CPR. However, this study showed no difference in neurologic outcomes.[30] A single propensity-matched, retrospective, observational study that enrolled 118 patients with IHCA who underwent more than 10 minutes of CPR and then ECPR after cardiac arrest of cardiac origin showed no survival or neurologic benefit over conventional CPR at the time of hospital discharge, 30-day follow-up, or 1-year follow-up.[30–32] A single retrospective, observational study that enrolled 120 patients with witnessed IHCA who underwent more than 10 minutes of CPR reported a modest benefit over historical controls with the use of ECPR over continued conventional CPR in both survival and neurologic outcome at discharge and 6-month follow-up.[32]

For infants and children in IHCA, the evidence comparing standard resuscitation with standard resuscitation plus ECMO was reviewed. Most studies were not robust, and there was little evidence of benefit overall; however, the outcome of some patients, such as those with underlying heart disease, may be improved.[33–38]

2015 Recommendations—New

There is insufficient evidence to recommend the routine use of ECPR for patients with cardiac arrest. In settings where it can be rapidly implemented, ECPR may be considered for select cardiac arrest patients for whom the suspected etiology of the cardiac arrest is potentially reversible during a limited period of mechanical cardiorespiratory support (Class IIb, LOE C-LD). ECPR may be considered for pediatric patients with cardiac diagnoses who have IHCA in settings with existing ECMO protocols, expertise, and equipment (Class IIb, LOE C-LD).

In making these recommendations, the reviewers noted that the published series used rigorous inclusion criteria to select patients for ECPR, and this recommendation should apply to similar populations. ECMO is a resource-intensive and invasive therapy with potential for harm that must be balanced against the potential for benefit based on individual clinical situations.

Terminating Cardiac Arrest Resuscitative Efforts in Pediatric IHCA[Peds 814]—Updated

In the 2010 Guidelines, it was noted that no predictors of pediatric (infant or child) resuscitative success or failure have been established. The 2015 ILCOR systematic review examined whether there were any intra-arrest prognostic indicators that reliably predicted survival with good neurologic outcome for IHCA in infants and children and updated several of the prior recommendations.

2015 Evidence Summary

For infants and children with IHCA, negative predictive factors include age of over 1 year[39] and longer durations of cardiac arrest.[39–42] The evidence is contradictory as to whether a nonshockable (as opposed to shockable) initial cardiac arrest rhythm is a negative predictive factor in the in-hospital setting.[39,43,44]

2015 Recommendation—Updated

Multiple variables should be used when attempting to prognosticate outcomes during cardiac arrest (Class I, LOE C-LD). Although there are factors associated with better or worse outcomes, no single factor studied predicts outcome with sufficient accuracy to recommend termination or prolongation of CPR.

Prognostication During CPR

The 2015 ILCOR ALS systematic review considered one intra-arrest modality, end-tidal CO_2 ($ETCO_2$) measurement, in prognosticating outcome from cardiac arrest in adults. This section focuses on whether a specific $ETCO_2$ threshold can reliably predict ROSC and survival or inform a decision to terminate resuscitation efforts. For further information on the use of $ETCO_2$, see "Part 7: Adult Advanced Cardiovascular Life Support."

2015 Evidence Summary

Studies on the predictive capacity of $ETCO_2$ among intubated patients during cardiac arrest resuscitation are observational, and none have investigated survival with intact neurologic outcome. An $ETCO_2$ less than 10 mm Hg immediately after intubation and 20 minutes after the initiation of resuscitation was associated with extremely poor chances for ROSC and survival in several observational studies.[45–49] Although these results suggest that $ETCO_2$ can be a valuable tool to predict futility during CPR, potential confounding reasons for a low $ETCO_2$ and the relatively small numbers of patients in these studies suggest that the $ETCO_2$ should not be used alone as an indication to terminate resuscitative efforts. However, the failure to achieve an $ETCO_2$ greater than 10 mm Hg despite optimized resuscitation efforts may be a valuable component of a multimodal approach to deciding when to terminate resuscitation.

There are no studies that assess the prognostic value of $ETCO_2$ measurements sampled from a supraglottic airway or bag-mask device in predicting outcomes from a cardiac arrest.

2015 Recommendations[ALS 459]—New

In intubated patients, failure to achieve an $ETCO_2$ of greater than 10 mm Hg by waveform capnography after 20 minutes of CPR may be considered as one component of a multimodal approach to decide when to end resuscitative efforts, but should not be used in isolation (Class IIb, LOE C-LD).

The above recommendation is made with respect to $ETCO_2$ in patients who are intubated, because the studies examined included only those who were intubated.

In nonintubated patients, a specific $ETCO_2$ cutoff value at any time during CPR should not be used as an indication to end resuscitative efforts (Class III: Harm, LOE C-EO).

Prognostication After Cardiac Arrest

Predicting Neurologic Outcome in Pediatric Patients After ROSC

There continues to be insufficient evidence to recommend or describe an approach to accurately predict the neurologic outcome of pediatric patients after cardiac arrest. Since the publication of the 2010 Guidelines, there have been an increasing number of publications associating a variety of findings with poor neurologic prognosis in these populations. Early and reliable prognostication of neurologic outcome in pediatric survivors of cardiac arrest is helpful for effective planning and family support and can inform decisions to continue or discontinue life-sustaining therapy.

Postresuscitation Use of Electroencephalography for Prognosis in Pediatric Survivors of Cardiac Arrest—Updated

The 2015 ILCOR Pediatric Life Support Task Force examined the usefulness of electroencephalography (EEG) or evoked potential assessment to predict long-term good neurologic outcome in infants and children who have survived cardiac arrest.

2015 Evidence Summary

Observational data from 2 small pediatric studies[50,51] showed that a continuous and reactive tracing on EEG performed in the first 7 days after cardiac arrest was associated with a significantly higher likelihood of good neurologic outcome at hospital discharge, whereas an EEG demonstrating a discontinuous or isoelectric tracing was associated with a poorer neurologic outcome at hospital discharge.

Predictive Factors After Cardiac Arrest in Pediatric Patients[Peds 822, Peds 813]

The 2015 systematic review examined whether there were factors that could assist with prognostication for pediatric patients who remained unconscious after cardiac arrest.

2015 Evidence Summary

Four observational studies supported the use of pupillary reactivity at 12 to 24 hours after cardiac arrest in predicting survival to discharge,[16,42,51,52] while 1 observational study found

that reactive pupils 24 hours after cardiac arrest were associated with improved survival at 180 days with favorable neurologic outcome.[53]

Several serum biomarkers of neurologic injury have been considered for their prognostic value. Two small observational studies found that lower neuron-specific enolase (NSE) and S-100B serum levels post-arrest were associated with improved survival to hospital discharge and improved survival with favorable neurologic outcome.[53,54]

One observational study found that children with lower lactate levels in the first 12 hours after arrest had an improved survival to hospital discharge.[55]

2015 Recommendations—New

EEGs performed within the first 7 days after pediatric cardiac arrest may be considered in prognosticating neurologic outcome at the time of hospital discharge (Class IIb, LOE C-LD) but should not be used as the sole criterion.

The reliability of any 1 variable for prognostication in children after cardiac arrest has not been established. Practitioners should consider multiple factors when predicting outcomes in infants and children who achieve ROSC after cardiac arrest (Class I, LOE C-LD).

In situations where children have minimal prospects for recovery, we emphasize the use of multiple variables to inform treatment decisions. Given the greater neuroplasticity and potential for recovery in the developing brain, we place greater value on preserving opportunities for neonatal and pediatric recovery than on limiting therapy based on not-yet-validated prognostic tools. Accordingly, the decision to withdraw life-sustaining therapies is complex and continues to rest with the treating physician and family. Further research in this area is needed.

Predicting Neurologic Outcomes in Adult Patients After Cardiac Arrest

Scientists and clinicians continue to attempt to identify clinical, electrographic, radiographic, and biomarker data, which may be able to prognosticate neurologic outcome in patients. The primary purpose in accurately correlating specific data with poor neurologic outcome is to allow clinicians and families to make informed, but often difficult, choices for a patient who remains comatose after cardiac arrest with subsequent ROSC. There is a growing body of data that correlates specific findings with poor neurologic outcome after cardiac arrest. To date, however, there is no one specific test that can predict with certainty a poor neurologic recovery in this patient population. In making decisions, particularly the decision of whether to continue or withdraw life-sustaining therapies, clinicians and families need the most accurate information possible; typically, this information is an aggregate of clinical, electrographic, radiographic, and laboratory (eg, biomarkers) findings (see "Part 8: Post–Cardiac Arrest Care").

Timing of Prognostication in Post–Cardiac Arrest Adults[ALS 450, ALS 713]

In 2010, it was noted that there are no clinical neurologic signs, electrophysiologic studies, biomarkers, or imaging modalities that can reliably predict death or poor neurologic outcome (eg, Cerebral Performance Category of 3, 4, or 5) within the first 24 hours after cardiac arrest in patients treated with or without TTM. In 1 registry study,[56] it was noted that 63% of patients who survived an IHCA were given a DNAR status, and 43% had medical interventions actively withdrawn. These patients were often young and had no terminal illnesses but experienced death after withdrawal of life support in a time frame that was inadequate to allow thorough examination. This tendency to withdraw interventions prematurely in patients after cardiac arrest may have contributed to a selection bias in the current literature on prognostic testing. As the data are continuing to evolve, it is important to consider the potential for premature withdrawal of life support (see "Part 8: Post–Cardiac Arrest Care").

Sedatives or neuromuscular blockers received during TTM may be metabolized more slowly in patients after cardiac arrest, and injured brains may be more sensitive to the depressant effects of many drugs than normal brains. Residual sedation or paralysis can confound accurate clinical examinations.

2015 Recommendations—Updated

The earliest time for prognostication in patients treated with TTM using clinical examination where sedation or paralysis could be a confounder may be 72 hours after return to normothermia (Class IIb, LOE C-EO).

We recommend the earliest time to prognosticate a poor neurologic outcome in patients not treated with TTM using clinical examination is 72 hours after cardiac arrest (Class I, LOE B-NR). This time can be even longer after cardiac arrest if the residual effect of sedation or paralysis confounds the clinical examination (Class IIa, LOE C-LD).

Operationally, the timing for prognostication is typically 4.5 to 5 days after ROSC for patients treated with TTM. This approach minimizes the possibility of obtaining false-positive (ie, erroneously pessimistic) results because of drug-induced depression of neurologic function. In making this recommendation, it is recognized that in some instances, withdrawal of life support may occur appropriately before 72 hours because of underlying terminal disease, brain herniation, or other clearly nonsurvivable situations.

Prognostic Testing in Adult Patients After Cardiac Arrest[ALS 713, ALS 450]

The 2015 systematic evidence reviews examined numerous studies on the diagnostic accuracy of a wide range of tests for patients who did or did not receive TTM therapy.

The 2010 Guidelines recommended clinical examination, electrophysiologic measurements, imagining studies, and blood or cerebrospinal fluid markers of brain injury to estimate the prognosis for neurologic impairment in adult patients who remain comatose after cardiac arrest.[4] Updated guidelines for prognostication have been proposed by other international organizations[57] as well as the AHA in this 2015 Guidelines Update; for further information, see "Part 8: Post–Cardiac Arrest Care."

This topic continues to be an area of active research. The use of TTM has demonstrated the potential to improve the neurologic outcome in certain adult patients after cardiac arrest who might otherwise have a poor neurologic outcome. Although the data and literature are becoming more robust on this particular topic, there are few differences in the types of tests used in those who are and are not treated with TTM as relates to prognosticating neurologic outcome.

2015 Evidence Summary—New

For a full description of the evidence reviewed for each assessment of neurologic function and prognosis for adults who have had cardiac arrest, refer to "Part 8: Post–Cardiac Arrest Care."

2015 Recommendations: Clinical Examination Findings—New

In comatose patients who are not treated with TTM, the absence of pupillary reflex to light at 72 hours or more after cardiac arrest is a reasonable exam finding with which to predict poor neurologic outcome (FPR [false-positive rate], 0%; 95% CI, 0%–8%; Class IIa, LOE B-NR).

In comatose patients who are treated with TTM, the absence of pupillary reflex to light at 72 hours or more after cardiac arrest is useful to predict poor neurologic outcome (FPR, 0%; 95% CI, 0%–3%; Class I, LOE B-NR).

We recommend that, given their high FPRs, the findings of either absent motor movements or extensor posturing *should not* be used alone for predicting a poor neurologic outcome (FPR, 10%; 95% CI, 7%–15% to FPR, 15%; 95% CI, 5%–31%; Class III: Harm, LOE B-NR). The motor examination may be a reasonable means to identify the population who need further prognostic testing to predict poor outcome (Class IIb, LOE B-NR).

We recommend that the presence of myoclonus, which is distinct from status myoclonus, *should not* be used to predict poor neurologic outcomes because of the high FPR (FPR, 5%; 95% CI, 3%–8% to FPR, 11%; 95% CI, 3%–26%; Class III: Harm, LOE B-NR).

In combination with other diagnostic tests at 72 or more hours after cardiac arrest, the presence of status myoclonus during the first 72 hours after cardiac arrest is a reasonable finding to help predict poor neurologic outcomes (FPR, 0%; 95% CI, 0%–4%; Class IIa, LOE B-NR).

2015 Recommendations: EEG[ALS 450, ALS 713]—Updated

In comatose post–cardiac arrest patients who are treated with TTM, it may be reasonable to consider persistent absence of EEG reactivity to external stimuli at 72 hours after cardiac arrest, and persistent burst suppression on EEG after rewarming, to predict a poor outcome (FPR, 0%; 95% CI, 0%–3%; Class IIb, LOE B-NR).

Intractable and persistent (more than 72 hours) status epilepticus in the absence of EEG reactivity to external stimuli may be reasonable to predict poor outcome (Class IIb, LOE B-NR).

In comatose post–cardiac arrest patients who are not treated with TTM, it may be reasonable to consider the presence of burst suppression on EEG at 72 hours or more after cardiac arrest, in combination with other predictors, to predict a poor neurologic outcome (FPR, 0%; 95% CI, 0%–11%; Class IIb, LOE B-NR).

2015 Recommendation: Evoked Potentials[ALS 450]—Updated

In patients who are comatose after resuscitation from cardiac arrest regardless of treatment with TTM, it is reasonable to consider bilateral absence of the N20 somatosensory evoked potentials (SSEP) wave 24 to 72 hours after cardiac arrest or after rewarming a predictor of poor outcome (FPR, 1%; 95% CI, 0%–3%; Class IIa, LOE B-NR).

SSEP recording requires appropriate skills and experience, and utmost care should be taken to avoid electrical interference from muscle artifacts or from the intensive care unit environment. However, sedative drugs or temperature manipulation affect SSEPs less than they affect the EEG and clinical examination.[58,59]

2015 Recommendations: Imaging Tests[ALS 713]—New

In patients who are comatose after resuscitation from cardiac arrest and are not treated with TTM, it may be reasonable to use the presence of a marked reduction of the gray-white ratio on brain computed tomography obtained within 2 hours after cardiac arrest to predict poor outcome (Class IIb, LOE B-NR).

It may be reasonable to consider extensive restriction of diffusion on brain magnetic resonance imaging at 2 to 6 days after cardiac arrest in combination with other established predictors for predicting a poor neurologic outcome (Class IIb, LOE B-NR).

Note that acquisition and interpretation of imaging studies have not been fully standardized and are affected by interobserver variability.[60] Therefore, brain imaging studies for prognostication should be performed only in centers where specific experience is available.

2015 Recommendations: Blood Markers[ALS 713, ALS 450] Updated

Given the possibility of high FPRs, blood levels of NSE and S-100B should not be used alone to predict a poor neurologic outcome (Class III: Harm, LOE C-LD). When performed with other prognostic tests at 72 hours or more after cardiac arrest, it may be reasonable to consider high serum values of NSE at 48 to 72 hours after cardiac arrest to support the prognosis of a poor neurologic outcome (Class IIb, LOE B-NR), especially if repeated sampling reveals persistently high values (Class IIb, LOE C-LD).

Laboratory standards for NSE and S-100B measurement vary between centers, making comparison of absolute values difficult. The kinetics of these markers have not been studied, particularly during or after TTM in cardiac arrest patients. Finally, NSE and S-100B are not specific to neuronal damage and can be produced by extra–central nervous system sources (hemolysis, neuroendocrine tumors, myenteric plexus, muscle and adipose tissue breakdown). If care is not taken when drawing NSE levels and if multiple time points are not assessed, false-positive results could occur secondary to hemolysis. All of these limitations led the writing group to conclude that NSE should be limited to a confirmatory test rather than a primary method for estimating prognosis.

Ethics of Organ and Tissue Donation—Updated

Situations that offer the opportunity for organ donation include donation after neurologic determination of death, controlled donation after circulatory determination of death, and uncontrolled donation after circulatory determination of death. Controlled donation after circulatory death usually takes place in the hospital after a patient whose advanced directives or surrogate, family, and medical team agree to allow natural death and withdraw life support. Uncontrolled donation usually takes place in an emergency department after exhaustive efforts at resuscitation have failed to achieve ROSC. In 2015, the ILCOR Advanced Life Support Task Force reviewed the evidence that might address the question of whether an organ retrieved from a donor who has had CPR that was initially successful (controlled donation) or unsuccessful (uncontrolled donation) would impact survival or complications compared with an organ from a donor who did not require CPR (controlled donation).

2015 Evidence Summary

Studies comparing transplanted organ function between those organs from donors who had received successful CPR before donation and those whose donors had not received CPR before donation have found no difference in transplanted organ function. This includes immediate graft function, 1-year graft function, and 5-year graft function. Studies have also shown no evidence of worse outcome in transplanted kidneys and livers from adult donors who have not had restoration of circulation after CPR compared with those from other types of donors.[61–64]

2015 Recommendations[ALS 449]—Updated

We recommend that all patients who are resuscitated from cardiac arrest but who subsequently progress to death or brain death be evaluated for organ donation (Class I, LOE B-NR).

Patients who do not have ROSC after resuscitation efforts and who would otherwise have termination of efforts may be considered candidates for kidney or liver donation in settings where programs exist (Class IIb, LOE B-NR).

In making this recommendation, the decisions for termination of resuscitative efforts and the pursuit of organ donation need to be independent processes (see "Part 8: Post–Cardiac Arrest Care").

The 2010 Guidelines outlined the debate regarding the ethics of organ donation.[65] The debate continues today. Points to consider are outlined in Table 1, with opposing viewpoints on the issue.[66–73] Although this material was not reviewed as part of the ILCOR review process, this section is intended to highlight some of the ethical issues around organ donation.

Table 1. Ethical Questions and Issues Surrounding Organ Donation

Ethical Question	Viewpoint	Alternative Viewpoint
How long after loss of circulation can a practitioner declare death?	Between 2 and 10 minutes, based on current literature documenting length of time that autoresuscitation (unassisted return of spontaneous circulation) has occurred, as long as the decision to allow natural death has been made.	Not until the point in time that resuscitative efforts could not restore spontaneous circulation. Currently we do not have evidence to support how long this would be.
	Between 7 and 10 minutes after resuscitative efforts have stopped in uncontrolled donation after circulatory determination of death.	
Are individuals and surrogates truly and fully informed when consenting for organ donation?	Individuals may consent by designating the decision on a driver's license, in advance directives and wills, or through an online donor registry. If no previous consent by a patient exists, a surrogate will usually have to give consent if the patient is unable.	Individuals who consent to organ donation may not understand the dying process or be aware of the ethical dilemmas involved in organ donation.
Are there conflicts of interest?	Organ donation should not be considered until the decision has been made to allow natural death and withdraw life support.	There is perception that those who care for patients and participate in withdrawal decisions are providers who care for organ recipients and may be biased.
	Organ procurement teams and transplant surgeons are not to be involved in the decisions or act of withdrawing support or declaring death.	Some believe that it is impossible to not consider organ donation as decisions to withdraw life support are being made and, therefore, could influence the decision to withdraw support.
	Consent for donation should be requested by a trained individual who is not part of the care team.	
Should antemortem interventions be performed (eg, administration of heparin, vasodilators, bronchoscopy, cannulating large vessels—all for the purpose of preserving organ function)?	If the actual risk to the donor is low and is fully disclosed to patients and families, the procedure is ethically acceptable.	There is concern that these procedures pose risks to the donor and benefit only the recipient.
What postmortem procedures are ethically acceptable (eg, procedures such as extracorporeal membrane oxygenation that restore circulation and oxygenation)?	Restoring circulation to organs can result in better outcomes of transplanted organs. As long as oxygen and circulation are not supplied to the brain by the procedure, the diagnosis of death is still valid.	Procedures that restore oxygenation and circulation are unacceptable because they could reverse death.

A full discussion of the merits of each of these viewpoints is beyond the scope of this publication.

Summary

Managing the multiple decisions associated with resuscitation is challenging from many perspectives, and no more so than when healthcare providers are dealing with the ethics surrounding decisions to provide or withhold emergency cardiovascular care. This is especially true with the increasing availability of technologies that hold the promise of improved outcomes after cardiac arrest, such as ECPR and TTM.

In this 2015 Guidelines Update, we have provided the evidence identified by 7 systematic reviews and the clarifying language to several other topics that were covered in the 2010 systematic review process but were not subjected to a full evidence review in 2015.

There is often insufficient evidence to recommend for or against specific interventions due to the uncertainty of determining a prognosis and predicting a particular outcome. As such, a solid understanding of the ethical principles surrounding autonomy and decision making must be coupled with the best information available at the time. Beyond decisions regarding the initiation and termination of life support, family presence during resuscitations and organ donation also require healthcare providers to consider both science and ethics when providing patient-centered care.

As the science that informs resuscitation efforts continues to advance, so too must our efforts to understand the ethical implications that accompany them.

Disclosures

Part 3: Ethical Issues: 2015 Guidelines Update Writing Group Disclosures

Writing Group Member	Employment	Research Grant	Other Research Support	Speakers' Bureau/ Honoraria	Expert Witness	Ownership Interest	Consultant/ Advisory Board	Other
Mary E. Mancini	University of Texas at Arlington	None	None	None	None	None	None	None
Douglas S. Diekema	University of Washington School of Medicine	None	None	None	None	None	None	None
Theresa A. Hoadley	St. Francis Medical Center College of Nursing	None	None	None	None	None	None	None
Kelly D. Kadlec	Children's Hospital Medical Center	None	None	None	None	None	None	None
Marygrace H. Leveille	Baylor University Medical Center	None	None	None	None	None	None	None
Jane E. McGowan	St. Christopher's Hospital for Children	None	None	None	St. Christopher's Hospital*; USDOJ*	None	None	None
Michele M. Munkwitz	University of Arizona	None	None	None	None	None	None	None
Ashish R. Panchal	Ohio State University	None	None	None	None	None	None	None
Michael R. Sayre	University of Washington	None	None	None	None	None	None	None
Consultant								
Elizabeth H. Sinz	Pennsylvania State University College of Medicine	None	None	None	None	None	American Heart Association†	None

This table represents the relationships of writing group members that may be perceived as actual or reasonably perceived conflicts of interest as reported on the Disclosure Questionnaire, which all members of the writing group are required to complete and submit. A relationship is considered to be "significant" if (a) the person receives $10 000 or more during any 12-month period, or 5% or more of the person's gross income; or (b) the person owns 5% or more of the voting stock or share of the entity, or owns $10 000 or more of the fair market value of the entity. A relationship is considered to be "modest" if it is less than "significant" under the preceding definition.

*Modest.

†Significant.

Appendix

2015 Guidelines Update: Part 3 Recommendations

Year Last Reviewed	Guidelines Part	Topic	Recommendation	Comments
2015	Part 3: Ethical Issues	The Use of Extracorporeal CPR in OHCA	There is insufficient evidence to recommend the routine use of ECPR for patients with cardiac arrest. In settings where it can be rapidly implemented, ECPR may be considered for select patients for whom the suspected etiology of the cardiac arrest is potentially reversible during a limited period of mechanical cardiorespiratory support (Class IIb, LOE C-LD).	new for 2015
2015	Part 3: Ethical Issues	Intra-arrest Prognostic Factors for Cardiac Arrest in Infants and Children	Multiple variables should be used when attempting to prognosticate outcomes during cardiac arrest (Class I, LOE C-LD).	new for 2015
2015	Part 3: Ethical Issues	The Use of a Prognostic Score in the Delivery Room for Preterm Infants	However, in individual cases, when counseling a family and constructing a prognosis for survival at gestations below 25 weeks, it is reasonable to consider variables such as perceived accuracy of gestational age assignment, the presence or absence of chorioamnionitis, and the level of care available for location of delivery. It is also recognized that decisions about appropriateness of resuscitation below 25 weeks of gestation will be influenced by region-specific guidelines. In making this statement, a higher value was placed on the lack of evidence for a generalized prospective approach to changing important outcomes over improved retrospective accuracy and locally validated counseling policies. The most useful data for antenatal counseling provides outcome figures for infants alive at the onset of labor, not only for those born alive or admitted to a neonatal intensive care unit (Class IIb, LOE C-LD).	new for 2015
2015	Part 3: Ethical Issues	Terminating Resuscitative Efforts in Term Infants	We suggest that, in infants with an Apgar score of 0 after 10 minutes of resuscitation, if the heart rate remains undetectable, it may be reasonable to stop assisted ventilations; however, the decision to continue or discontinue resuscitative efforts must be individualized. Variables to be considered may include whether the resuscitation was considered optimal; availability of advanced neonatal care, such as therapeutic hypothermia; specific circumstances before delivery (eg, known timing of the insult); and wishes expressed by the family (Class IIb, LOE C-LD).	updated for 2015
2015	Part 3: Ethical Issues	The Use of ECPR in IHCA	There is insufficient evidence to recommend the routine use of ECPR for patients with cardiac arrest. In settings where it can be rapidly implemented, ECPR may be considered for select cardiac arrest patients for whom the suspected etiology of the cardiac arrest is potentially reversible during a limited period of mechanical cardiorespiratory support. (Class IIb, LOE C-LD).	new for 2015
2015	Part 3: Ethical Issues	The Use of ECPR in IHCA	ECPR may be considered for pediatric patients with cardiac diagnoses who have IHCA in settings with existing ECMO protocols, expertise, and equipment (Class IIb, LOE C-LD).	new for 2015
2015	Part 3: Ethical Issues	Terminating Cardiac Arrest Resuscitative Efforts in Pediatric IHCA	Multiple variables should be used when attempting to prognosticate outcomes during cardiac arrest (Class I, LOE C-LD).	new for 2015
2015	Part 3: Ethical Issues	Prognostication During CPR	In intubated patients, failure to achieve an $ETCO_2$ of greater than 10 mm Hg by waveform capnography after 20 minutes of CPR may be considered as one component of a multimodal approach to decide when to end resuscitative efforts but should not be used in isolation (Class IIb, LOE C-LD).	new for 2015
2015	Part 3: Ethical Issues	Prognostication During CPR	In nonintubated patients, a specific $ETCO_2$ cutoff value at any time during CPR should not be used as an indication to end resuscitative efforts (Class III: Harm, LOE C-EO).	new for 2015
2015	Part 3: Ethical Issues	Predictive Factors After Cardiac Arrest in Pediatric Patients	EEGs performed within the first 7 days after pediatric cardiac arrest may be considered in prognosticating neurologic outcome at the time of hospital discharge (Class IIb, LOE C-LD) but should not be used as the sole criterion.	new for 2015
2015	Part 3: Ethical Issues	Predictive Factors After Cardiac Arrest in Pediatric Patients	The reliability of any 1 variable for prognostication in children after cardiac arrest has not been established. Practitioners should consider multiple factors when predicting outcomes in infants and children who achieve ROSC after cardiac arrest (Class I, LOE C-LD).	new for 2015
2015	Part 3: Ethical Issues	Timing of Prognostication in Post–Cardiac Arrest Adults	The earliest time for prognostication in patients treated with TTM using clinical examination where sedation or paralysis could be a confounder may be 72 hours after return to normothermia (Class IIb, LOE C-EO).	updated for 2015

(*Continued*)

2015 Guidelines Update: Part 3 Recommendations, *Continued*

Year Last Reviewed	Guidelines Part	Topic	Recommendation	Comments
2015	Part 3: Ethical Issues	Timing of Prognostication in Post–Cardiac Arrest Adults	We recommend the earliest time to prognosticate a poor neurologic outcome in patients not treated with TTM using clinical examination is 72 hours after cardiac arrest (Class I, LOE B-NR).	updated for 2015
2015	Part 3: Ethical Issues	Timing of Prognostication in Post–Cardiac Arrest Adults	This time can be even longer after cardiac arrest if the residual effect of sedation or paralysis confounds the clinical examination (Class IIa, LOE C-LD).	new for 2015
2015	Part 3: Ethical Issues	Prognostic Testing in Adult Patients After Cardiac Arrest: Clinical Exam Findings	In comatose patients who are not treated with TTM, the absence of pupillary reflex to light at 72 hours or more after cardiac arrest is a reasonable exam finding with which to predict poor neurologic outcome (FPR, 0%; 95% CI, 0%–8%; Class IIa, LOE B-NR).	new for 2015
2015	Part 3: Ethical Issues	Prognostic Testing in Adult Patients After Cardiac Arrest: Clinical Exam Findings	In comatose patients who are treated with TTM, the absence of pupillary reflex to light at 72 hours or more after cardiac arrest is useful to predict poor neurologic outcome (FPR, 0%; 95% CI, 0%–3%; Class I, LOE B-NR).	new for 2015
2015	Part 3: Ethical Issues	Prognostic Testing in Adult Patients After Cardiac Arrest: Clinical Exam Findings	We recommend that, given their high FPRs, the findings of either absent motor movements or extensor posturing should not be used alone for predicting a poor neurologic outcome (FPR, 10%; 95% CI, 7%–15% to FPR, 15%; 95% CI, 5%–31%; Class III: Harm, LOE B-NR).	new for 2015
2015	Part 3: Ethical Issues	Prognostic Testing in Adult Patients After Cardiac Arrest: Clinical Exam Findings	The motor examination may be a reasonable means to identify the population who need further prognostic testing to predict poor outcome (Class IIb, LOE B-NR).	new for 2015
2015	Part 3: Ethical Issues	Prognostic Testing in Adult Patients After Cardiac Arrest: Clinical Exam Findings	We recommend that the presence of myoclonus, which is distinct from status myoclonus, should not be used to predict poor neurologic outcomes because of the high FPR (FPR, 5%; 95% CI, 3%–8% to FPR, 11%; 95% CI, 3%–26%; Class III: Harm, LOE B-NR).	new for 2015
2015	Part 3: Ethical Issues	Prognostic Testing in Adult Patients After Cardiac Arrest: Clinical Exam Findings	In combination with other diagnostic tests at 72 or more hours after cardiac arrest, the presence of status myoclonus during the first 72 hours after cardiac arrest is a reasonable finding to help predict poor neurologic outcomes (FPR, 0%; 95% CI, 0%–4%; Class IIa, LOE B-NR).	new for 2015
2015	Part 3: Ethical Issues	Prognostic Testing in Adult Patients After Cardiac Arrest: EEG	In comatose post–cardiac arrest patients who are treated with TTM, it may be reasonable to consider persistent absence of EEG reactivity to external stimuli at 72 hours after cardiac arrest, and persistent burst suppression on EEG after rewarming, to predict a poor outcome (FPR, 0%; 95% CI, 0%–3%; Class IIb, LOE B-NR).	updated for 2015
2015	Part 3: Ethical Issues	Prognostic Testing in Adult Patients After Cardiac Arrest: EEG	Intractable and persistent (more than 72 hours) status epilepticus in the absence of EEG reactivity to external stimuli may be reasonable to predict poor outcome (Class IIb, LOE B-NR).	updated for 2015
2015	Part 3: Ethical Issues	Prognostic Testing in Adult Patients After Cardiac Arrest: EEG	In comatose post–cardiac arrest patients who are not treated with TTM, it may be reasonable to consider the presence of burst suppression on EEG at 72 hours or more after cardiac arrest, in combination with other predictors, to predict a poor neurologic outcome (FPR, 0%; 95% CI, 0%–11%; Class IIb, LOE B-NR).	updated for 2015
2015	Part 3: Ethical Issues	Prognostic Testing in Adult Patients After Cardiac Arrest: Evoked Potentials	In patients who are comatose after resuscitation from cardiac arrest regardless of treatment with TTM, it is reasonable to consider bilateral absence of the N20 SSEP wave 24 to 72 hours after cardiac arrest or after rewarming a predictor of poor outcome (FPR, 1%; 95% CI, 0%–3%; Class IIa, LOE B-NR).	updated for 2015
2015	Part 3: Ethical Issues	Prognostic Testing in Adult Patients After Cardiac Arrest: Imaging Tests	In patients who are comatose after resuscitation from cardiac arrest and not treated with TTM, it may be reasonable to use the presence of a marked reduction of the gray-white ratio (GWR) on brain CT obtained within 2 hours after cardiac arrest to predict poor outcome (Class IIb, LOE B-NR).	new for 2015
2015	Part 3: Ethical Issues	Prognostic Testing in Adult Patients After Cardiac Arrest: Imaging Tests	It may be reasonable to consider extensive restriction of diffusion on brain MRI at 2 to 6 days after cardiac arrest in combination with other established predictors to predict a poor neurologic outcome (Class IIb, LOE B-NR).	new for 2015
2015	Part 3: Ethical Issues	Prognostic Testing in Adult Patients After Cardiac Arrest: Blood Markers	Given the possibility of high FPRs, blood levels of NSE and S-100B should not be used alone to predict a poor neurologic outcome (Class III: Harm, LOE C-LD).	updated for 2015
2015	Part 3: Ethical Issues	Prognostic Testing in Adult Patients After Cardiac Arrest: Blood Markers	When performed with other prognostic tests at 72 hours or more after cardiac arrest, it may be reasonable to consider high serum values of NSE at 48 to 72 hours after cardiac arrest to support the prognosis of a poor neurologic outcome (Class IIb, LOE B-NR), especially if repeated sampling reveals persistently high values (Class IIb, LOE C-LD).	updated for 2015

(*Continued*)

2015 Guidelines Update: Part 3 Recommendations, *Continued*

Year Last Reviewed	Guidelines Part	Topic	Recommendation	Comments
2015	Part 3: Ethical Issues	Ethics of Organ and Tissue Donation	We recommend that all patients who are resuscitated from cardiac arrest but who subsequently progress to death or brain death be evaluated for organ donation (Class I, LOE B-NR).	updated for 2015
2015	Part 3: Ethical Issues	Ethics of Organ and Tissue Donation	Patients who do not have ROSC after resuscitation efforts and who would otherwise have termination of efforts may be considered candidates for kidney or liver donation in settings where programs exist (Class IIb, LOE B-NR).	new for 2015
The following recommendations were not reviewed in 2015. For more information, see the *2010 AHA Guidelines for CPR and ECC*, "Part 3: Ethics."				
2010	Part 3: Ethical Issues	Principle of Futility	Conditions such as irreversible brain damage or brain death cannot be reliably assessed or predicted at the time of cardiac arrest. Withholding resuscitation and the discontinuation of life-sustaining treatment during or after resuscitation are ethically equivalent. In situations where the prognosis is uncertain, a trial of treatment may be initiated while further information is gathered to help determine the likelihood of survival, the patient's preferences, and the expected clinical course (Class IIb, LOE C).	not reviewed in 2015
2010	Part 3: Ethical Issues	Terminating Resuscitative Efforts in a BLS Out-of-Hospital System	It is recommended that regional or local EMS authorities use the BLS termination rule to develop protocols for the termination of resuscitative efforts by BLS providers for adult victims of cardiac arrest in areas where advanced life support is not available or may be significantly delayed (Class I, LOE A).	not reviewed in 2015
2010	Part 3: Ethical Issues	Terminating Resuscitative Efforts in a BLS Out-of-Hospital System	The reliability and validity of this rule is uncertain if modified (Class IIb, LOE A).	not reviewed in 2015
2010	Part 3: Ethical Issues	Terminating Resuscitative Efforts in an ALS Out-of-Hospital System	An ALS termination of resuscitation rule was derived from a diverse population of rural and urban EMS settings. This rule recommends considering terminating resuscitation when ALL of the following criteria apply before moving to the ambulance for transport: (1) arrest was not witnessed; (2) no bystander CPR was provided; (3) no ROSC after full ALS care in the field; and (4) no AED shocks were delivered. This rule has been retrospectively externally validated for adult patients in several regions in the US, Canada, and Europe, and it is reasonable to employ this rule in all ALS services (Class IIa, LOE B).	not reviewed in 2015
2010	Part 3: Ethical Issues	Terminating Resuscitative Efforts in a Combined BLS and ALS Out-of-Hospital System	In a tiered ALS- and BLS-provider system, the use of a universal rule can avoid confusion at the scene of a cardiac arrest without compromising diagnostic accuracy. The BLS rule is reasonable to use in these services (Class IIa, LOE B).	not reviewed in 2015
2010	Part 3: Ethical Issues	Providing Emotional Support to the Family During Resuscitative Efforts in Cardiac Arrest	In the absence of data documenting harm and in light of data suggesting that it may be helpful, offering select family members the opportunity to be present during a resuscitation is reasonable and desirable (assuming that the patient, if an adult, has not raised a prior objection) (Class IIa, LOE C for adults and Class I, LOE B for pediatric patients).	not reviewed in 2015
2010	Part 3: Ethical Issues	Providing Emotional Support to the Family During Resuscitative Efforts in Cardiac Arrest	In the absence of data documenting harm and in light of data suggesting that it may be helpful, offering select family members the opportunity to be present during a resuscitation is reasonable and desirable (assuming that the patient, if an adult, has not raised a prior objection) (Class IIa, LOE C for adults and Class I, LOE B for pediatric patients).	not reviewed in 2015
2010	Part 3: Ethical Issues	Ethics of Organ and Tissue Donation	It is reasonable to suggest that all communities should optimize retrieval of tissue and organ donations in brain dead post–cardiac arrest patients (in-hospital) and those pronounced dead in the out-of-hospital setting (Class IIa, LOE B).	not reviewed in 2015
2010	Part 3: Ethical Issues	Ethics of Organ and Tissue Donation	Medical directors of EMS agencies, emergency departments (EDs), and critical care units (CCUs) should develop protocols and implementation plans with the regional organ and tissue donation program to optimize donation following a cardiac arrest death (Class I, LOE C).	not reviewed in 2015
2010	Part 3: Ethical Issues	Criteria for Not Starting CPR in Newly Born Infant IHCA	There are prescribed recommendations to guide the initiation of resuscitative efforts in newly born infants. When gestational age, birth weight, or congenital anomalies are associated with almost certain early death and when unacceptably high morbidity is likely among the rare survivors, resuscitation is not indicated. Examples may include extreme prematurity (gestational age <23 weeks or birth weight <400 g), anencephaly, and some major chromosomal abnormalities such as trisomy 13 (Class IIb, LOE C).	not reviewed in 2015
2010	Part 3: Ethical Issues	Criteria for Not Starting CPR in Newly Born Infant IHCA	In conditions associated with uncertain prognosis where survival is borderline, the morbidity rate is relatively high, and the anticipated burden to the child is high, parental desires concerning initiation of resuscitation should be supported (Class IIb, LOE C).	not reviewed in 2015

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Part 4: Systems of Care and Continuous Quality Improvement

2015 American Heart Association Guidelines Update for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care

Steven L. Kronick, Chair; Michael C. Kurz; Steve Lin; Dana P. Edelson; Robert A. Berg; John E. Billi; Jose G. Cabanas; David C. Cone; Deborah B. Diercks; James (Jim) Foster; Reylon A. Meeks; Andrew H. Travers; Michelle Welsford

Introduction

The science and recommendations discussed in the other Parts of the *2015 American Heart Association* (AHA) *Guidelines Update for Cardiopulmonary Resuscitation* (CPR) *and Emergency Cardiovascular Care* (ECC) form the backbone of resuscitation. They answer the "why", "what," and "when" of performing resuscitation steps. In a perfectly controlled and predictable environment, such as a laboratory setting, those answers often suffice, but the "how" of actual implementation depends on knowing the "who" and "where" as well. The ideal work flow to accomplish resuscitation successfully is highly dependent on the system of care as a whole.

Healthcare delivery requires structure (eg, people, equipment, education, prospective registry data collection) and process (eg, policies, protocols, procedures), which, when integrated, produce a system (eg, programs, organizations, cultures) leading to outcomes (eg, patient safety, quality, satisfaction). An effective system of care (Figure 1) comprises all of these elements—structure, process, system, and patient outcomes—in a framework of continuous quality improvement (CQI).

In this Part, we will focus on 2 distinct systems of care: the system for patients who arrest inside the hospital and the one for those who arrest outside it. We will set into context the building blocks for a system of care for cardiac arrest, with consideration of the setting, team, and available resources, as well as CQI from the moment the patient becomes unstable until after the patient is discharged.

The chain of survival metaphor, first used almost 25 years ago,[1] is still very relevant. However, it may be helpful to create 2 separate chains (Figure 2) to reflect the differences in the steps needed for response to cardiac arrest in the hospital (in-hospital cardiac arrest [IHCA]) and out of the hospital (out of hospital cardiac arrest [OHCA]). Regardless of where an arrest occurs, the care following resuscitation converges in the hospital, generally in an emergency department (ED) or intensive care unit (ICU). This post–cardiac arrest care is depicted as the final link in both chains, symbolized by a hospital bed with a monitor and thermometer, which represent advanced monitoring and targeted temperature management. As noted above, the structure and process elements before the convergence of the 2 chains, however, vary significantly.

Patients with OHCA depend on elements within the community for support. Lay rescuers must recognize the patient's arrest, call for help, and initiate CPR and early defibrillation (public-access defibrillation [PAD]) until a team of professionally trained emergency medical services (EMS) providers assumes responsibility and then transports the patient to an ED and/or cardiac catheterization lab, and then on to an ICU for post–cardiac arrest care. Ideally, all victims of OHCA receive bystander CPR and defibrillation; if not, CPR and defibrillation won't occur until EMS personnel arrive, and the victim's chance of survival is then much lower.

In contrast, patients with IHCA depend on a system of appropriate surveillance and prevention of cardiac arrest, which is represented by a magnifying glass in the first link. When cardiac arrest occurs, prompt notification and response to a cardiac arrest should result in the smooth interaction of a multidisciplinary team of professional providers, including physicians, nurses, respiratory therapists, and others. This team provides high-quality CPR, prompt defibrillation, and advanced cardiovascular life support when appropriate. The chain metaphor endures: in any resuscitation, the chain is no stronger than its weakest link.

The level of complexity is high for both in-hospital and out-of-hospital systems. The challenges encountered, however, are different. Teamwork and coordination among responders is a critical determinant of patient outcomes. An in-hospital multidisciplinary team has immediate access to additional personnel as well as all the resources of the ED, ICU, and laboratories, whereas in out-of-hospital settings, 2 paramedics may find themselves alone with no resources except those they brought with them. Factors such as crowd control, family presence, space constraints, transportation,

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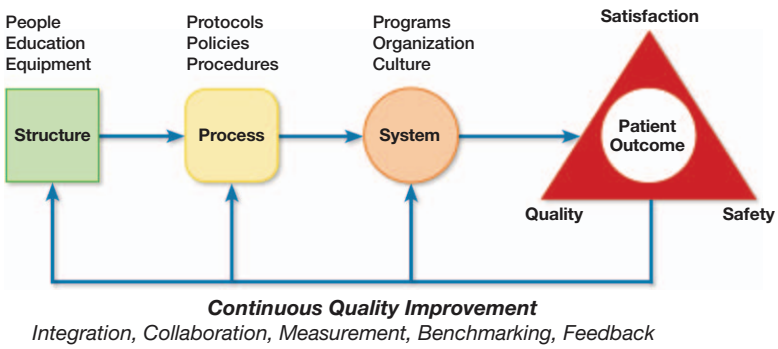

Figure 1. Taxonomy of systems of care.

and device failures can be common to both settings. In both settings, systems must be in place to address expected and unexpected challenges and must be continually monitored and re-examined to address their flaws and failures.

The classic resuscitation Chain of Survival concept linked the community to EMS and EMS to hospitals, with hospital care as the destination.[1] But patients with a cardiac emergency may enter the system of care at one of many different points (Figure 3).

A cardiac arrest can present anywhere, any time—on the street or at home, but also in the hospital's ED, inpatient bed, ICU, operating suite, catheterization suite, or imaging department. The system of care must be able to manage cardiac emergencies wherever they occur.

The concept of a system of care has been applied previously in emergency care, including regional systems of care for trauma, stroke, and ST-segment elevation myocardial infarction (STEMI). This Part addresses the idea that IHCA has similarities to, but is very different from, OHCA. It also considers how the elements of a system of care apply to the comprehensive management of cardiac arrest.

In-Hospital Cardiac Arrest

Epidemiology

IHCA is a major patient safety and public health concern. Approximately 209 000 adults[2] and more than 6000 children[3] receive CPR for IHCAs in the United States annually. In contrast to adult OHCAs, which are mostly due to presumed cardiac etiologies and occur unexpectedly, most IHCAs are secondary to presumed acute respiratory compromise and/or circulatory shock, with predictable progressive deterioration before the event.[4–6] Although CPR training programs have tended to focus on out-of-hospital CPR, professional in-hospital CPR is provided to similar numbers of adults and children each year as professional out-of-hospital CPR, and the patient characteristics, rescuers, and systems of care are quite different.

Figure 2. System-specific Chains of Survival.

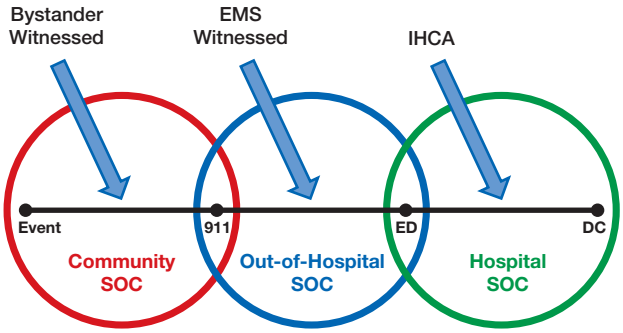

Figure 3. Patient's point of entry.

Outcomes from in-hospital CPR have improved over the past 10 to 15 years within hospitals participating in the AHA's Get With The Guidelines®-Resuscitation program. For adults, there has been improvement, with risk-adjusted rates of survival to discharge increased by 4% per year, from 13.7% in 2000 to 22.3% in 2009.[5] Importantly, more than 80% of these adult IHCA survivors had relatively favorable neurologic outcomes, with Cerebral Performance Category (CPC) scores of 1 or 2 at hospital discharge.[5] For children, risk-adjusted rates of survival to discharge increased by 8% per year from 2000 to 2009, with unadjusted survival rates increasing from 14.3% to 39.4%.[6]

Notably, case-mix–adjusted IHCA incidence rates and survival rates vary considerably across hospitals. For example, case-mix–adjusted incidence of adult cardiac arrest was twice as high in the bottom quartile of Get With The Guidelines-Resuscitation hospitals compared with the top quartile (1.3/1000 bed-days versus 0.7/1000 bed-days).[7] Conversely, the case-mix–adjusted rates of survival to discharge were nearly double in the top decile of Get With The Guidelines-Resuscitation hospitals compared with the bottom decile (22.7% versus 12.4%).[8] These data also showed a 42% greater likelihood of patients with identical covariates surviving to hospital discharge at one randomly selected Get With The Guidelines-Resuscitation hospital compared with another.[8] Similarly, the range of risk-standardized survival rates for pediatric cardiac arrest varied from 29% to 48%.[9] These variabilities in incidences and outcomes suggest that more cardiac arrests can be prevented and that survival rates can be improved through effective quality improvement strategies.

Other IHCA data raise concerns about potential deficiencies in our systems for treatment of IHCAs in the United States. As with other medical issues, survival rates from IHCAs are substantially lower on nights and weekends compared with weekdays,[10] which suggests differential quality within hospitals by both time and day. In addition, lower-income patients and African-American patients have lower survival rates after an IHCA.[7,11] After controlling for the hospital site where the cardiac arrest occurred, the disparity was essentially ameliorated, which suggests differential quality across hospitals.[11]

Because most IHCAs are secondary to respiratory failure and/or circulatory shock, quality improvement efforts with rapid response teams and medical emergency teams have focused on early recognition of respiratory failure, shock, and neurologic deterioration of patients at risk, with targeted interventions and transfers to highly monitored intensive care settings. Perhaps as a result of such efforts, cardiac arrests and CPR on general wards are much less common than cardiac arrests and CPR in ICUs and other highly monitored units, such as the ED, operating suites, and cardiac catheterization suites. Only 5% of pediatric in-hospital CPR occurred on general wards in Get With The Guidelines-Resuscitation hospitals from 2000 to 2010, compared with 74% in ICUs, 10% in the ED, 5% in the operating suite, and 6% in a procedural suite, such as interventional radiology or cardiac catheterization suites. In addition, the relative frequency of ward CPR decreased substantially over that decade.[12] Similarly, 19% of adult CPR was provided on unmonitored wards, 16% in telemetry, 48% in ICUs units, and 18% in EDs or operating or procedural suites.[13] These data suggest that most in-hospital CPR is provided in ICUs, EDs, operating rooms, and other procedural units where teams and systems can be optimized to provide the highest level of care.

Prearrest Rapid Response Systems

Recognition[EIT 638, Peds 818]

The wide variability in incidence and location of cardiac arrest in the hospital suggests potential areas for standardization of quality and prevention of at least some cardiac arrests. More than half of cardiac arrests in the hospital are the result of respiratory failure or hypovolemic shock, and the majority of these events are foreshadowed by changes in physiology, such as tachypnea, tachycardia, and hypotension. As such, cardiac arrest in the hospital often represents the progression of physiologic instability and a failure to identify and stabilize the patient in a timely manner. This scenario is more common on the general wards, outside of critical care and procedural areas, where patient-to-nurse ratios are higher and monitoring of patients less intense. In this setting, intermittent manual vital sign monitoring with less frequent direct observation by clinicians may increase the likelihood of delayed recognition. An observational study of both surgical and medical wards reported that approximately 1 in 5 patients developed abnormal vital signs, and more than 50% of these events went unnoticed by nursing staff. Patients with abnormal vital signs had a threefold higher 30-day mortality rate.[14]

Strategies to combat delayed recognition of patient deterioration include increased electronic monitoring of high-risk patients in the form of traditional electrocardiogram (ECG)-based telemetry, newer heart and respiratory rate sensors, or increased clinician surveillance. In addition, composite risk scores, such as the Modified Early Warning Score (MEWS) and more complex, statistically derived algorithms, which can include laboratory data, increase the discrimination for detection compared with single-parameter criteria.

Early Warning Sign Systems, Rapid Response Teams, and Medical Emergency Team Systems—Updated

Rapid response teams (RRTs) or medical emergency teams (METs) were established for early intervention in patients whose conditions were deteriorating, with the goal of preventing IHCA.[15,16] They can be composed of varying combinations of physicians, nurses, and respiratory therapists. These teams are usually summoned to patient bedsides when an acute

deterioration is recognized by other hospital staff. Monitoring and resuscitation equipment and drug therapies often accompany the team. The 2015 ILCOR systematic review addressed the use of early warning sign systems (EWSS), RRTs, and METs in children and adults.

The evidence for EWSS was demonstrated in 1 before-after study by using an aggregated weighted scoring system (MEWS), which reported significantly higher cardiac arrest rates in MEWS bands 3 and 4 after intervention but not in MEWS bands 0 through 2 or 5 through 15; however, overall cardiac arrest rate significance was not reported.[17] The evidence for RRTs or METs in adults consists of a ward-randomized trial[18] and numerous observational studies. The introduction of a MET system was associated with a significant improvement in hospital survival[19–33] and a decrease in the incidence of IHCA.[19–29,31,33–40] A cluster-randomized trial and several other observational studies failed to confirm those results.[17,34,36,39,41–51]

The evidence for RRTs or METs and the usefulness of a Pediatric Early Warning System (PEWS) in children is observational but contradictory, and it is not as consistent in showing a decrease in either the incidence of cardiac and/or respiratory arrest outside of the ICU setting[52–54] or hospital mortality[53,55–59] for either PEWS or a MET. However, in a single observational study, PEWS use was associated with a reduction in cardiac arrest rate when used in a single hospital with an established MET system.[60]

2015 Recommendations—Modified

For adult patients, RRT or MET systems can be effective in reducing the incidence of cardiac arrest, particularly in general care wards (Class IIa, LOE C-LD).

Pediatric MET/RRT systems may be considered in facilities where children with high-risk illnesses are cared for on general in-patient units (Class IIb, LOE C-LD).

The use of EWSS may be considered for adults and children (Class IIb, LOE C-LD).

Continuous Assessment

Once patients with acute decompensation or gradual deterioration are recognized and cared for by RRTs, these patients require continuous assessments until stabilized. Patients who are recognized to be at high risk of IHCA or who are refractory to early interventions are generally transferred to high-acuity hospital units (eg, ICUs). With more personnel and resources available (eg, technology, drug therapies), these high-acuity units enable improved monitoring and treatments. Further, there is increasing data indicating that delays in transfer to an ICU are associated with increased mortality. In 1 study, every hour of delay was associated with a 1.5% increase in hospital mortality.[61] Interestingly, the pediatric community of providers has had remarkable success in nearly eradicating cardiac arrest on the general wards and could serve as a model for the adult community. The focus on prevention has been emphasized for pediatrics, as evidenced by the 1998 departure from the traditional Chain of Survival to one that included prevention as a first link in the chain. Pediatric resuscitation experts also led this change in hospitals, and pediatric arrests that occur on general care wards are becoming a thing of the past.

Do Not Attempt Resuscitation and Palliative Care

One of the unintended consequences of the success in developing and promoting modern resuscitation is that, currently, many people who are in the natural process of dying receive CPR at the end of life. Resuscitation has become the default expectation for everyone and, unless specifically noted to the contrary as with an advanced directive or a Do Not Attempt Resuscitation (DNAR) order, is likely to be performed, at least for witnessed deaths. As such, another proposed mechanism for the decrease in cardiac arrest rates associated with RRTs is increased use of palliative care services and DNAR orders for patients who are dying and for whom resuscitation attempts are likely to be futile or inconsistent with their goals of care. Once a patient has a cardiac arrest, institution of a DNAR order to prevent further resuscitation attempts is frequently entertained. However, many of these patients may have been appropriate for consideration of such an order before the arrest, and failure to properly consider it could result in an unwanted aggressive end to life and a waste of considerable resources. As such, it is consistent with a system of care to seek patient or family preferences regarding aggressive resuscitation measures, such as CPR and mechanical ventilation, in patients with advanced age or terminal condition and short life expectancy who are admitted to a hospital, and to issue a DNAR order based on patient or family preference as well as expectation of outcome, taking into account the clinical judgment of experienced providers.

Cardiac Arrest

Even in high-risk, in-hospital environments, cardiac arrests and CPR are relatively uncommon, and the members of the resuscitation teams may be different with each cardiac arrest. Therefore, optimal performance depends on rigorous pre-event interdisciplinary collaborative planning and practice. Excellent outcomes can occur after well-choreographed, high-quality CPR with effective chest compressions, ventilation and early defibrillation.[62] Hospital leaders have the opportunity to optimize outcomes with rigorous resuscitation programs that include the cycle of quality improvement: measurement of performance and outcomes, comparison, interventions to improve outcomes, and continuous measurement of performance and outcomes after interventions.

Activating the IHCA System of Care

Once IHCA is recognized, hospitals are expected to have a standardized method for promptly notifying and activating a team that specializes in treating cardiac arrest. A survey of hospitals revealed that 93% used a hospital-wide public address system, 53% paged or called team members, and 11% used a local alarm.[63]

Crisis Resource Management Principles for Resuscitation Teams

The quality of bedside resuscitation team leadership affects team performance.[64–68] Crisis resource management principles suggest that resuscitation teams will function best when the team knows who is leading the resuscitation efforts, what their individual roles are, and how to communicate and work

together most effectively.[69,70] Crisis resource management techniques that have been incorporated for use during in-hospital CPR efforts include training to be an advanced life support team leader, using checklists for leadership activities, standardizing communication, and performing cross-checks for safety of team members before defibrillation (eg, "all clear").[70–74]

Resuscitation Team

Crisis resource management principles suggest that preparation for cardiac arrests and resuscitations include a designated, dedicated resuscitation team available 24 hours a day, 7 days a week, with adequate experience, expertise, and training and retraining to maintain skills, minimize errors, and optimize outcomes.[71,75–77] Although 77% of hospitals from a survey of US hospitals have a predesignated resuscitation team, nearly one quarter do not. Such teams usually consist of varying combinations of physicians, nurses, respiratory therapists, and pharmacists.[63] Some centers include security personnel, clergy, social workers, and others. Furthermore, just-in-time, just-in-place training is an excellent manner for the team members to practice so that they can be prepared to use the equipment and work with their colleagues in their own practice setting.[75] Just-in-time or just-in-place training ranges from activities as simple as training on a manikin in basic life support and the use of a defibrillator[78–80] to interdisciplinary advanced life support at a simulation room embedded in the clinical unit. Hospitals with training programs may require that resuscitation teams include an attending physician with resuscitation experience and expertise to supervise the physician in training on the resuscitation team during the resuscitation.

Training

Few studies have evaluated training programs that improve the early identification of prearrest patients. A longitudinal, multicenter study of the Acute Life-Threatening Events Recognition and Treatment (ALERT) course suggested an increase in prearrest calls, a reduction in the number of IHCAs, and an improved survival-to-discharge rate after IHCA.[81] After the initial training, interval training updates are necessary to maintain these important skills. Recognition of patient deterioration is an element of an IHCA system of care, with physicians, nurses, and staff being able to recognize that deterioration.

Standard advanced cardiovascular life support or pediatric advanced life support courses may not adequately train providers with specific processes unique to individual hospitals. Hospital-specific resuscitation training can be contextualized for the individual wards and hospital settings to increase familiarity and effectiveness of the resuscitation team and responses to cardiac arrest.

Debriefing—Updated[EIT 645]

Acute debriefing for either an individual or the team immediately after the resuscitation event ("hot debriefing") has been a time-honored approach to improve care and has been previously recommended in AHA Guidelines for CPR and ECC.[75] However, finding the time to do this properly in the highly intense and sometimes chaotic postarrest setting is problematic when practitioners are focused on postarrest care and/or communicating time-sensitive and emotionally sensitive information to families and staff. These acute postarrest debriefings may address several domains, including psychomotor skill issues, cognitive issues, team issues, family emotional issues, and professional staff emotional issues.

Another approach to debriefing an individual or the team is to communicate about the various domains at a later time ("cold debriefing"). The advantages of cold debriefing are adequate time for the debriefing personnel to prepare for optimal communication, availability of experienced debriefing personnel, and adequate time for the debriefing communication session to meet and discuss the resuscitation. However, it is often difficult to reconvene the same resuscitation team members at a later meeting.

Alternatively, cold debriefing can include both the resuscitation team that was present at the event and the broader multidisciplinary team of the entire unit so that all can learn from both their own and others' experiences. This allows many more unit members to profit from the experience, and it can result in quality improvement in the unit-wide resuscitation culture. The 2015 ILCOR systematic review examined the utility of briefing and/or debriefing to determine if there was an impact on outcome.

2015 Evidence Review

Data from 2 in-hospital observational before-after studies, 1 in adults[82] and 1 in pediatrics[83] that involved a total 318 patients and 2494 epochs of chest compressions, demonstrated improved outcomes (eg, favorable neurologic outcome at discharge and compression depth, compression rate within target range) after implementation of a data-driven, performance-focused debriefing program for resuscitation team members using CPR-quality defibrillator transcripts.

2015 Recommendation—Updated

It is reasonable for in-hospital systems of care to implement performance-focused debriefing of rescuers after IHCA in both adults and children (Class IIa, LOE C-LD).

Post–Cardiac Arrest

Patients who achieve return of spontaneous circulation (ROSC) after cardiac arrest in any setting have a complex combination of pathophysiologic processes described as post–cardiac arrest syndrome, which includes postarrest brain injury, postarrest myocardial dysfunction, systemic ischemia/reperfusion response, and persistent acute and chronic pathology that may have precipitated the cardiac arrest.[84] Post–cardiac arrest syndrome plays a significant role in patient mortality. Survival rates in IHCA patients who achieve ROSC range from 32% to 54%.[85] Higher-volume hospitals and teaching hospitals have the highest survival rate, with an average survival of 38% for patients who have an arrest outside the ICU and 32% for patients who have an arrest in the ICU.[4]

Comprehensive post–cardiac arrest care requires optimization of hemodynamics, treatment and reversal of precipitating factors, and targeted temperature management and is discussed fully in "Part 8: Post–Cardiac Arrest Care." Routine implementation of existing post–cardiac arrest protocols and order sets helps maintain consistent and optimal care to

attenuate the detrimental effects of post–cardiac arrest syndrome. These patients also require access to a collaborative and multidisciplinary team of providers, including cardiologists, interventional cardiologists, cardiac electrophysiologists, intensivists, neurologists, nurses, respiratory therapists, and social workers. If these services are not readily available within the hospital, an effective system of care would include appropriate structures and processes for interhospital transfer to ensure access to these collaborative resources.

Out-of-Hospital Cardiac Arrest

Introduction

OHCA affects approximately 326 000 victims annually in the United States.[2] Given that OHCA has an annual incidence of 132/100 000 population, communities of all sizes should prepare a system of care for the eventual OHCA event.[2] Organized community programs that prepare the lay public to provide bystander CPR and early defibrillation offer the best opportunity for successful resuscitation in the initial minutes after OHCA and represent the community link in the OHCA Chain of Survival. This preparation begins with a surveillance system to measure the incidence and outcomes of OHCA. The AHA Scientific Statement "Essential Features of Designating Out-of-Hospital Cardiac Arrest as a Reportable Event"[86] makes recommendations to achieve the measurement of this public health burden as well as capture the data points needed to address quality improvements for continuous improvement in outcomes from OHCA.

Community

Bystander CPR is a potentially lifesaving procedure that can be performed by community members without equipment or professional credentials. Although bystander CPR plus early defibrillation can more than double the rate of survival from OHCA,[87] the number of OHCA victims who receive bystander CPR remains between 10% and 65%.[2] Recent evidence suggests that chest compression–only CPR is no less effective than traditional CPR when performed by bystanders for adult victims of cardiac arrest in the out-of-hospital setting.[87] CPR training can be accomplished via traditional classes or brief self-instruction media, public policy initiatives such as CPR training as a high school graduation requirement, training of likely rescuers (primarily family members and caregivers of populations at high risk for cardiac arrest), or mass community CPR training in large public venues. CPR training programs can help build a culture of expectation for chest compressions to be performed in whatever setting cardiac arrest occurs.

Further opportunities to provide community CPR training can coincide with the implementation of PAD initiatives. PAD programs provide bystanders with automatic electronic defibrillators (AEDs) that can be used by the lay public to deliver shocks to victims of ventricular fibrillation OHCA.

Public-Access Defibrillation—Updated[BLS 347]

The 2015 ILCOR systematic review compared the implementation of a PAD program with traditional EMS response to determine if there was an impact on outcome from OHCA.

2015 Evidence Review

The ILCOR Basic Life Support Task Force reviewed the evidence involving PAD and its effect on outcome from OHCA. This evidence is derived from many observational studies and 1 randomized controlled trial[88] with associated variations in rates of witnessed arrests, EMS programs, and recommended practice of bystander CPR.[89,90] Evidence from 3 observational studies[91–93] that enrolled 182 119 patients demonstrated improved survival to 30 days with favorable neurologic outcome with PAD compared with no community program. Improved clinical outcomes favoring PAD programs were seen consistently across the studies.[89,90] Some studies included in the ILCOR *2015 International Consensus on CPR and ECC Science With Treatment Recommendations*[89,90] may involve repeat analysis and reporting of the same cardiac arrest population, which limits the ability to provide a summative effect measure in the reported analyses.

2015 Recommendation—Modified

It is recommended that PAD programs for patients with OHCA be implemented in communities with individuals at risk for OHCA (Class I, LOE C-LD).

A system-of-care approach for OHCA might include public policy that encourages reporting of public AED locations to public service access points (PSAPs; PSAPs have replaced the less-precise term "EMS dispatch centers"). Such a policy would enable PSAPs to direct bystanders to retrieve nearby AEDs and assist in their use when OHCA occurs.

Many municipalities as well as the US federal government have enacted legislation to place AEDs in municipal buildings, large public venues, airports, casinos, and schools. For the 20% of OHCAs that occur in public, these community programs represent an important link in the Chain of Survival between recognition and activation of the emergency response system.

Victims of OHCAs that occur in private residences are much less likely to receive chest compressions than are victims who experience cardiac arrest in public settings. Real-time instructions provided by emergency dispatchers may help push in-home callers past the stress or fear that may be inhibiting their willingness to act. These improved outcomes can be achieved by having robust community CPR training programs for cardiac arrest in place in conjunction with effective, prearrival dispatch protocols.

Emergency Medical Services[BLS 740, BLS 359]

PSAPs are the interface between EMS and the communities they serve. While individuals may be unsure of what to do in the setting of a cardiac arrest, the general population knows to call 9-1-1. Herein lies the opportunity to leverage the call for help into strategies for the initiation of early treatment as part of a larger system of care. Communities are best served by PSAPs that are designed to quickly recognize the occurrence of cardiac arrest, dispatch the nearest appropriate resources, and help bystanders provide immediate care before the arrival of EMS.

The link between the call for help to the PSAP and arrival of first medical care is the emergency dispatcher. In disease states that are time dependent, such as cardiac arrest, acute coronary

syndrome (ACS), stroke, and trauma, recognition of symptoms and initiation of intervention can result in improved outcomes. In cardiac arrest, dispatcher-guided CPR has been extensively described.[94,95] In these descriptive studies, dispatcher-guided CPR has been shown to reduce time to first compression.

Dispatcher Recognition of Cardiac Arrest—Updated

The 2015 ILCOR systematic review addressed whether there are descriptions of any specific symptoms among adults and children who are in cardiac arrest outside a hospital compared with no description that helped emergency dispatchers identify cardiac arrest. Appropriate recognition of a patient in cardiac arrest is an important component of the discussion between a dispatcher and the bystanders with a cardiac arrest victim. This identification can lead to initiation of dispatcher-guided CPR and provide valuable information to EMS providers.

2015 Evidence Review

Evidence is derived from observational investigations that involve more than 17 000 patients from 27 different studies. In 2 studies that evaluated emergency dispatcher recognition alone, the sensitivity of recognition ranged from 18% to 83%.[96,97] In systems that currently have protocols to aid dispatchers in the recognition of cardiac arrest, the sensitivity when using protocols ranged from 38% to 96.9%, with a specificity exceeding 99%. Use of these scripted protocols has been shown to increase the rate of dispatcher-guided CPR.[98–100] The identification of abnormal breathing or agonal gasps is particularly important in the recognition of cardiac arrest by emergency dispatchers. This abnormal pattern is described by a wide range of heterogeneous words and phrases: difficulty breathing, poorly breathing, impaired breathing, occasional breathing, barely/hardly breathing, heavy breathing, labored breathing, sighing, and strange breathing.[96,101] The presence of agonal gasps is a factor that negatively affects the identification of cardiac arrest. One study reported agonal gasps were present in 50% of cardiac arrests that were not identified.[99] Training of emergency dispatchers in the recognition of agonal gasps has been associated with increased dispatcher-guided CPR.[102,103]

2015 Recommendations—Updated

It is recommended that emergency dispatchers determine if a patient is unconscious with abnormal breathing after acquiring the requisite information to determine the location of the event (Class I, LOE C-LD).

If the patient is unconscious with abnormal or absent breathing, it is reasonable for the emergency dispatcher to assume that the patient is in cardiac arrest (Class IIa, LOE C-LD).

Dispatchers should be educated to identify unconsciousness with abnormal and agonal gasps across a range of clinical presentations and descriptions (Class I, LOE C-LD).

There are limited data regarding the use of emergency dispatchers to appropriately identify patients with myocardial infarction. Using a protocol-driven approach, emergency dispatchers have been able to instruct patients with symptoms to self-administer aspirin, but there has not been a study that showed this improved outcomes.[104] However, in a system of care, identification by emergency dispatchers of symptoms that suggest a myocardial infarction may assist in the triage of these patients by EMS personnel and result in rapid transport to hospitals with adequate resources. In stroke patients, there is also evidence for reduced time from scene to hospital,[105] and identification of stroke symptoms by emergency dispatchers and prehospital providers is consistent with a system of care for the appropriate triage of stroke patients within that system of care.

Dispatcher Instruction in CPR—Updated

It has been hypothesized that dispatcher-initiated CPR instruction will improve outcomes, and the ILCOR systematic review sought to identify evidence of improved outcomes. Dispatcher-initiated CPR instruction has become integrated into many systems of care and viewed as an important link between the community and the EMS system.

2015 Evidence Review—Updated

Evidence related to this question was assessed in several studies (1 meta-analysis, 3 randomized clinical trials, and 11 observational studies). There was no statistical benefit in survival with favorable neurologic outcome at the time of hospital discharge to 1 year.[103,106–108] A meta-analysis showed an absolute survival benefit of 2.4% (95% confidence interval, 0.1%–4.9%) with the use of dispatcher instructions for continuous compressions over traditional CPR.[109] There is no evidence, however, to show that dispatcher instructions were associated with ROSC.[99,106] When the use of dispatcher instructions on CPR parameters was evaluated, dispatcher-guided CPR with bystander CPR initiation increased performance of chest compressions and ventilation.[107,110] There is no evidence that dispatcher-guided CPR decreases time to commence CPR.[98,100,103,111,112]

2015 Recommendation—Updated

We recommend that dispatchers should provide chest compression–only CPR instructions to callers for adults with suspected OHCA (Class I, LOE C-LD).

Use of Social Media to Summon Rescuers—Updated[EIT 878]

Summoning rescuers to the scene of an OHCA may lead to initiation of CPR or defibrillation before the arrival of dispatched EMS providers. In a few localities, a system of care has been evaluated that includes emergency dispatcher activation of social media to summon nearby willing rescuers to provide bystander CPR until EMS providers arrive. The 2015 ILCOR systematic review addressed whether EMS dispatchers summoning rescuers with the use of technology or other social media improves patient outcomes.

2015 Evidence Review

Two case series examined the use of computer-generated phone calls and text messages sent to lay responders within 500 or 1000 meters of patients with suspected cardiac arrest. In one study, lay responders arrived first in 44.6% of episodes,[113] while in the second study, time to first shock was improved.[114] In a randomized trial, social media was used by dispatchers to notify nearby potential rescuers of a possible cardiac arrest. Although few patients ultimately received CPR from volunteers dispatched by the notification system, there was a higher rate of bystander-initiated CPR (62% vs 48% in control group).[114a]

2015 Recommendation—New

Given the low risk of harm and the potential benefit of such notifications, it may be reasonable for communities to incorporate, where available, social media technologies that summon rescuers who are willing and able to perform CPR and are in close proximity to a suspected victim of OHCA (Class IIb, LOE B-R).

EMS and Transition to the Hospital

High-performance EMS is a key component of the OHCA system of care. An EMS culture of excellence reinforces itself through CQI, whereby successful OHCA resuscitations are considered the norm rather than the exception. Focused CQI review, supported by comprehensive data collection, seeks to evaluate what went right and what went wrong during the resuscitation and apply lessons learned to future resuscitation efforts.

OHCA Quality Metrics

Continuous efforts to improve resuscitation outcomes are impossible without data capture. The collection of resuscitation process measures is the underpinning of a system of care's quality improvement efforts. The ILCOR Consensus Statement "Cardiac Arrest and Cardiopulmonary Resuscitation Outcome Reports: Update of the Utstein Resuscitation Registry Templates for Out-of-Hospital Cardiac Arrest"[115] includes recommendations for cardiac arrest data collection based on updated and simplified Utstein templates. The core Utstein data set capture is recommended as the minimum data required for CQI. These data form the data set for CPR registries at all levels. In addition, supplementary data are essential for further resuscitation research. Examples of supplementary data would be 12-lead ECG and CPR quality measurement—interventions available in some prehospital settings but not all.

High-performance EMS responders understand that high-quality CPR is the foundation on which all of their resuscitation efforts depend. Furthermore, when CPR quality is measured, responders strive to perform the highest quality of CPR. Actual CPR performance improves when providers know that their performance is being measured—the well-known Hawthorne effect. Chest compression fraction (the percent of total resuscitation time spent compressing the chest), chest compression quality (rate, depth, and chest recoil), and ventilation rate are fundamental metrics defining high-quality CPR. CPR quality measurement is needed to provide timely feedback to the responding providers.

Advanced life support (ALS) bridges the transition from OHCA care to the receiving facility. ALS can provide the OHCA patient with advanced cardiac monitoring, 12-lead ECG, additional defibrillation and cardioversion interventions, vascular access, appropriate pharmacologic interventions, and advanced airway care. This same broad scope of practice for ALS providers can be further leveraged to provide comprehensive postresuscitation care (eg, hemodynamic optimization, oxygen- and volume-limiting ventilation) once ROSC is achieved.

ACS and STEMI Systems of Care

A systems-of-care approach to STEMI encompasses a well-organized approach with system-wide integration that includes primary prevention and recognition, EMS, ED, in-hospital, specialty cardiac center, rehabilitation, and secondary prevention community resources. This approach has all of the required elements and characteristics of a system of care. The STEMI system of care starts with rapid identification by EMS providers in the field. The goal for the EMS system is early identification, initial management, and transport to an appropriate facility for definitive care.

The system begins with the community recognizing the signs of a potential ACS and calling 9-1-1 early. Approximately 40% to 60% of STEMI patients call 9-1-1, and the remaining patients present directly to the hospital.[116,117] Given the risk of sudden cardiac arrest in these patients, improving the rate of calling 9-1-1 is a clear goal. The dispatchers may provide prearrival advice (eg, early aspirin administration). On scene, the paramedics will assess quickly; perform a prehospital 12-lead ECG; and administer aspirin, nitrates, and other medications. Prompt identification of STEMI is the key that allows consideration of the method of reperfusion: prehospital fibrinolysis, notification of the hospital for early in-hospital fibrinolysis, and/or specific hospital destination with notification of the catheterization team for primary percutaneous coronary intervention (PPCI). Interpretation of the prehospital ECG is critical to the process. The methods to interpret that ECG, which are consistent with a system of care, are reviewed in "Part 9: Acute Coronary Syndromes."

Prehospital fibrinolysis requires a system including provider expertise, well-established protocols, comprehensive training programs, medical oversight, and quality assurance. Not all systems may be able to support such a program. Similarly, PPCI requires an infrastructure of high-volume local or regional cardiac catheterization facilities and experienced providers. Thus, the decision regarding prehospital fibrinolysis, in-hospital fibrinolysis, or transport directly to a PPCI center is determined by the local system's resources.

The cardiac arrest and STEMI systems of care are linked in that a disproportionally high number of patients with ACS and STEMI also have sudden cardiac arrest. A key part of the postarrest management is consideration of patient evaluation in the catheterization laboratory. To achieve prompt recognition and treatment of ACS, the 2 systems of care—out of hospital care and in-hospital care—must be integrated.

Transport to Specialized Cardiac Arrest Centers[EIT 624]

The 2015 ILCOR systematic review addressed whether transport of OHCA patients by EMS directly to a specialist cardiac arrest center improves outcomes.

A cardiac resuscitation center is a hospital that provides evidence-based practice in resuscitation and post–cardiac arrest care, including 24-hour, 7-day PCI capability; targeted temperature management, cardiorespiratory and systems support with an adequate annual volume of cases; and commitment

to ongoing performance improvement that includes measurement, benchmarking, and both feedback and process change.

2015 Evidence Review—Updated

Only 1 prospective study[118] compared survival outcomes in OHCA patients who were transported to a critical care medical center with those who were transported to a noncritical care hospital, while 20 observational studies performed comparisons of patient destination based on differences in hospital characteristics,[85,119–126] transport times,[127–131] or before-and-after implementation of regionalized systems of care.[132–137] These studies, reporting on more than 120 000 patients surviving to hospital discharge, suggest an association between improved survival (or neurologically intact survival when reported) and patient transport to specialist cardiac arrest centers.

2015 Recommendation—Updated

A regionalized approach to OHCA resuscitation that includes the use of cardiac resuscitation centers may be considered (Class IIb, LOE C-LD).

Continuous Quality Improvement

Over the past 15 years, we have seen considerable improvements in the number of survivors from both IHCA and OHCA. These improvements have been associated with increased focus and attention in areas such as increasing bystander CPR, improving CPR quality, early defibrillation and optimizing rapid response systems and post–cardiac arrest care. The wide variability in survival that remains across systems, however, highlights the success that individual high-performing systems have accomplished and pushes the envelope on what is possible.

Certain qualities of a system of care make it effective and lead to desired outcomes. Whether it spans organizations or is located within 1 unit, systems benefit from conscious pursuit of clarity, focus, discipline, and engagement.[138] Successful systems of care in both the in-hospital and out-of-hospital settings engage in CQI. There are numerous approaches to quality improvement that have been used across industries, but all of them share several key concepts, including goal setting, a process-centric focus, measurement, and accountability.

Goal Setting

It is difficult to be successful without first defining what success is. And the definition of success, or the goal, has to be defined specifically enough that a person and/or system can be held accountable to it. For most quality improvement goals, that means specifying both the quantity of change expected and the date by which that change is to be completed. For example, the AHA ECC 2020 Impact Goals include doubling survival from cardiac arrests between 2010 and 2020 from 19% to 38% in hospitalized adults and from 7.9% to 15% for all out-of hospital arrests. The goals also set a target of doubling bystander CPR rates from 31% to 62% and increasing survival from cardiac arrests from 35% to 50% in hospitalized children.[139] These highly specific goals enable evaluation of the current survival and bystander CPR rates in the context of both the progress made and work needed to achieve the stated goals by 2020.

Individual systems of care need to define their own goals based on their assessment of what the most important outcomes are. In their book, *The 4 Disciplines of Execution* (4DX), McChesney and colleagues termed these the "wildly important goals," or WIGs, and cautioned against focusing on more than 1 or 2 at a time to ensure success.[140] Subsystems can, in turn, focus on 1 to 2 WIGs in pursuit of system-wide WIGs. An example of a WIG is the ECC Systems of Care Subcommittee's including doubling of the number of states with CPR/AED training as a high school graduation requirement, a metric the advocacy committee has been working hard to achieve. Individual EMS systems may target the percentage of 9-1-1 calls for cardiac arrest with dispatcher instructions, enabling the caller to start CPR within 1 minute. Hospitals, in pursuit of the ultimate goal of decreasing cardiac arrest on the general wards, might target the number of RRT calls made for patients with physiologic evidence of deterioration. The key is that these process-oriented measures, or lead measures, as they are referred to in 4DX language, are in a system's control to modify and are the ones most expected to move the needle on the outcome metric of interest. The 4DX principle is to focus on the "wildly important" (but lagging) goals while acting on the leading measures.

Effecting Change

Those responsible for improving a resuscitation system can choose from a number of scientific problem-solving models to achieve continuous improvement (eg, Lean, Six Sigma, Total Quality Management, Plan-Do-Check-Act or Adjust, Plan-Do-Study-Act). While each has its own language and approach (eg, Lean, the continuous transformation of waste into customer value by workers; Six Sigma, the continuous decrease of variation; and PDCA, the iterative process of continuous small improvements; Figure 4), each uses data to drive the process improvement.

The framework used is not as important as an agreed-upon method and language and an established process whereby improvements are made after direct observation and analysis of root causes, with changes piloted as experiments, ideally by the workers who propose them. This drive—to improve

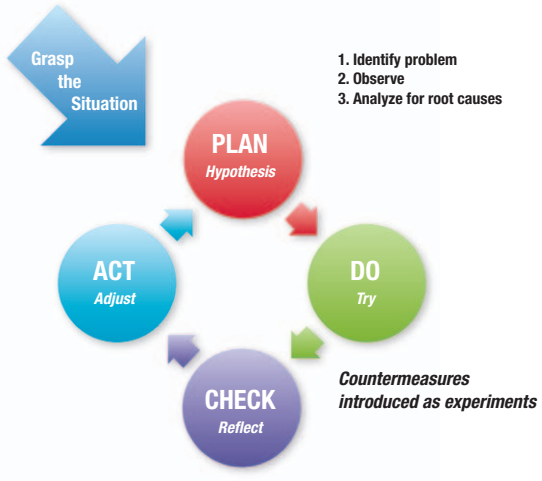

Figure 4. The Plan-Do-Check-Act cycle.

continually a complex system's performance to meet its goal—characterizes the best systems, sometimes described as complex adaptive systems. The individuals and leaders in the system continually assess processes, form hypotheses, design possible improvements, run experiments, check results, and reflect—and then start again.[141]

Measurement

Goal setting and effecting change are data-driven processes. As such, they are dependent on regular and accurate measurement of the process and outcome variables. Candidate measures have been defined in Utstein guidelines and AHA consensus statements for the benefit of generalizability and to enable comparisons across systems, but they are not consistently used. Registries such as Get With The Guidelines-Resuscitation and the Cardiac Arrest Registry to Enhance Survival exist for this purpose as well, but they currently represent only a small fraction of existing hospitals and EMS systems.[142–144] Significant improvement in arrest outcomes depends on collection, analysis, feedback, and interventions based on data and observations. This includes measuring structure, process, and outcomes of the steps involved in the resuscitation system of care. Only once these data are routinely collected will it be possible to continuously evaluate and improve what is done.

Accountability

For data to be useful, it has to be fed back to the team and used to assess progress toward the goal. That requires people to be accountable to that data for making the next round of changes. In the OHCA system of care, such stakeholders should come equally from the community, the EMS and the hospital systems of care. In the hospital, candidates for accountability include resuscitation team members; CPR committee members; and senior executives, including the chief quality, nursing, or medical officer. In the United Kingdom, every hospital is required to have a resuscitation officer for oversight of the IHCA program at that facility. The resuscitation officer's responsibilities include ensuring appropriate and timely recognition of cardiac arrest, effective and timely interventions, and the necessary processes and training to optimize outcome. Strong leadership is considered a necessary component for a highly performing enterprise. In light of the number of IHCAs, the variability of IHCA incidences and outcomes, and the potential to save more lives, perhaps it is time for US hospitals to have resuscitation officers with appropriate authority, responsibility, resources, and accountability to lead hospital resuscitation programs.

Conclusion

Using a systems-of-care approach as well as a rigorous process for CQI that is based on data can lead to improvements in the process for managing patients with cardiac arrest and improving their outcomes. We have learned a lot from high-performing systems and have made considerable progress over the past decade. But the current variability in survival from cardiac arrest shows that both IHCA and OHCA systems have the potential for substantial improvement. Continued improvement in the processes of managing patients before, during, and after cardiac arrest will require intense focus on consistent, clear goals aimed at decreasing incidence of and improving survival from cardiac arrest. Change will depend on engaged team members willing to be accountable for seeing those goals to fruition while actively working on improving process. And all of these aspects will demand high-quality data measurement, feedback, and comparison.

Disclosures

Part 4: Systems of Care and Continuous Quality Improvement: 2015 Guidelines Update Writing Group Disclosures

Writing Group Member	Employment	Research Grant	Other Research Support	Speakers' Bureau/ Honoraria	Expert Witness	Ownership Interest	Consultant/ Advisory Board	Other
Steven L. Kronick	University of Michigan	None	None	None	None	None	None	None
Robert A. Berg	Children's Hospital of Philadelphia	None	None	None	None	None	None	None
John E. Billi	The University of Michigan Medical School	None	None	None	None	None	None	None
Jose G. Cabanas	City of Austin	None	None	None	None	None	None	None
David C. Cone	Yale University School of Medicine	None	None	None	None	None	None	None
Deborah B. Diercks	University of California Davis Medical Center	Astra Zeneca*; PCORI*	None	None	None	None	None	Society of Cardiovascular Patient Care*
Dana P. Edelson	University of Chicago	American Heart Association/ Laerdal Medical†; NIH†	None	None	None	QuantHC†; Patent Pending ARCD. P0535US.P2†	None	None
James (Jim) Foster	University of Alaska	None	None	None	None	None	None	None
Michael C. Kurz	University of Alabama at Birmingham	NIH†; RPS*	None	Zoll Medical Corporation*	None	None	None	None
Steve Lin	Li Ka Shing Knowledge Institute of St. Michael's Hospital	Canadian Institutes of Health Research†; Academic Health Sciences Centre (AHSC) Alternative Funding Plan Innovation Fund†; Physicians' Services Incorporated (PSI) Foundation†; Canadian Association of Emergency Physicians*	None	None	None	None	None	None
Reylon A. Meeks	Blank Children's Hospital	None	None	None	None	None	None	None
Michelle Welsford	Centre for Paramedic Education and Research, Hamilton Health Sciences Centre	None	None	None	None	None	None	None
Consultant								
Andrew H. Travers	Emergency Health Services, Nova Scotia	None	None	None	None	None	American Heart Association†	None

This table represents the relationships of writing group members that may be perceived as actual or reasonably perceived conflicts of interest as reported on the Disclosure Questionnaire, which all members of the writing group are required to complete and submit. A relationship is considered to be "significant" if (a) the person receives $10 000 or more during any 12-month period, or 5% or more of the person's gross income; or (b) the person owns 5% or more of the voting stock or share of the entity, or owns $10 000 or more of the fair market value of the entity. A relationship is considered to be "modest" if it is less than "significant" under the preceding definition.

*Modest.

†Significant.

Appendix

2015 Guidelines Update: Part 4 Recommendations

Year Last Reviewed	Topic	Recommendation	Comments
2015	Prearrest Rapid Response Systems	For adult patients, RRT or MET systems can be effective in reducing the incidence of cardiac arrest, particularly in general care wards (Class IIa, LOE C-LD).	updated for 2015
2015	Prearrest Rapid Response Systems	Pediatric MET/RRT systems may be considered in facilities where children with high-risk illnesses are cared for on general in-patient units (Class IIb, LOE C-LD).	updated for 2015
2015	Prearrest Rapid Response Systems	The use of EWSS may be considered for adults and children (Class IIb, LOE C-LD).	updated for 2015
2015	Debriefing	It is reasonable for in-hospital systems of care to implement performance-focused debriefing of rescuers after IHCA in both adults and children (Class IIa, LOE C-LD).	updated for 2015
2015	Public-Access Defibrillation	It is recommended that PAD programs for patients with OHCA be implemented in communities at risk for cardiac arrest (Class I, LOE C-LD).	updated for 2015
2015	Dispatcher Recognition of Cardiac Arrest	It is recommended that emergency dispatchers determine if a patient is unconscious with abnormal breathing after acquiring the requisite information to determine the location of the event (Class I, LOE C-LD).	updated for 2015
2015	Dispatcher Recognition of Cardiac Arrest	If the patient is unconscious with abnormal or absent breathing, it is reasonable for the emergency dispatcher to assume that the patient is in cardiac arrest (Class IIa, LOE C-LD).	updated for 2015
2015	Dispatcher Recognition of Cardiac Arrest	Dispatchers should be educated to identify unconsciousness with abnormal and agonal gasps across a range of clinical presentations and descriptions (Class I, LOE C-LD).	updated for 2015
2015	Dispatcher Instruction in CPR	We recommend that dispatchers should provide chest compression–only CPR instructions to callers for adults with suspected OHCA (Class I, LOE C-LD).	updated for 2015
2015	Use of Social Media to Summon Rescuers	It may be reasonable for communities to incorporate, where available, social media technologies that summon rescuers who are willing and able to perform CPR and are in close proximity to a suspected victim of OHCA (Class IIb, LOE C-LD).	updated for 2015
2015	Transport to Specialized Cardiac Arrest Centers	A regionalized approach to OHCA resuscitation that includes the use of cardiac resuscitation centers may be considered (Class IIb, LOE C-LD).	updated for 2015

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KEY WORDS: cardiac arrest ■ cardiopulmonary resuscitation ■ emergency ■ resuscitation

Part 5: Adult Basic Life Support and Cardiopulmonary Resuscitation Quality

2015 American Heart Association Guidelines Update for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care

Monica E. Kleinman, Chair; Erin E. Brennan; Zachary D. Goldberger; Robert A. Swor; Mark Terry; Bentley J. Bobrow; Raúl J. Gazmuri; Andrew H. Travers; Thomas Rea

Introduction

As with other Parts of the *2015 American Heart Association* (AHA) *Guidelines Update for Cardiopulmonary Resuscitation* (CPR) *and Emergency Cardiovascular Care* (ECC), Part 5 is based on the International Liaison Committee on Resuscitation (ILCOR) 2015 international evidence review process. ILCOR Basic Life Support (BLS) Task Force members identified and prioritized topics and questions with the newest or most controversial evidence, or those that were thought to be most important for resuscitation. This 2015 Guidelines Update is based on the systematic reviews and recommendations of the *2015 International Consensus on CPR and ECC Science With Treatment Recommendations*, "Part 3: Adult Basic Life Support and Automated External Defibrillation."[1,2] In the online version of this document, live links are provided so the reader can connect directly to the systematic reviews on the ILCOR Scientific Evidence Evaluation and Review System (SEERS) website. These links are indicated by a combination of letters and numbers (eg, BLS **7**40). We encourage readers to use the links and review the evidence and appendix.

As with all AHA Guidelines, each 2015 recommendation is labeled with a Class of Recommendation (COR) and a Level of Evidence (LOE). The 2015 Guidelines Update uses the newest AHA COR and LOE classification system, which contains modifications of the Class III recommendation and introduces LOE B-R (randomized studies) and B-NR (nonrandomized studies) as well as LOE C-LD (based on limited data) and LOE C-EO (consensus of expert opinion).

The AHA process for identification and management of potential conflicts of interest was used, and potential conflicts for writing group members are listed at the end of each Part of the 2015 Guidelines Update. For additional information about the systematic review process or management of potential conflicts of interest, see "Part 2: Evidence Evaluation and Management of Conflicts of Interest" in this 2015 Guidelines Update and the related publication, "Part 2: Evidence Evaluation and Management of Conflicts of Interest" in the ILCOR *2015 International Consensus on CPR and ECC Science With Treatment Recommendations*.[2a]

Because this 2015 publication represents the first Guidelines Update, it includes an appendix with all the 2015 recommendations for adult BLS as well as the recommendations from the 2010 Guidelines. If the 2015 ILCOR review resulted in a new or significantly revised Guidelines recommendation, that recommendation will be labeled *New* or *Updated*.

It is important to note that the 2010 recommendations used a previous version of the AHA COR and LOE classification system that was current in 2010. Any of the 2010 algorithms that have been revised as a result of recommendations in the 2015 Guidelines Update are contained in this publication. To emphasize that the algorithm has been modified, the words *2015 Update* will appear in the title of the algorithm.

Adult BLS and CPR Quality Overview

Sudden cardiac arrest remains a leading cause of death in the United States. Seventy percent of out-of-hospital cardiac arrests (OHCAs) occur in the home, and approximately 50% are unwitnessed. Outcome from OHCA remains poor: only 10.8% of adult patients with nontraumatic cardiac arrest who have received resuscitative efforts from emergency medical services (EMS) survive to hospital discharge.[3] In-hospital cardiac arrest (IHCA) has a better outcome, with 22.3% to 25.5% of adults surviving to discharge.[4]

BLS is the foundation for saving lives after cardiac arrest. Fundamental aspects of adult BLS include immediate recognition of sudden cardiac arrest and activation of the emergency response system, early CPR, and rapid defibrillation with an automated external defibrillator (AED). Initial recognition and response to heart attack and stroke are also considered part of BLS. This section presents the updated recommendations for adult BLS guidelines for lay rescuers and healthcare providers. Key changes and continued points of emphasis in this 2015 Guidelines Update include the following:

- The crucial links in the adult out-of-hospital Chain of Survival are unchanged from 2010; however, there is increased emphasis on the rapid identification of

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potential cardiac arrest by dispatchers, with immediate provision of CPR instructions to the caller.
- This Guidelines Update takes into consideration the ubiquitous presence of mobile phones that can allow the rescuer to activate the emergency response system without leaving the victim's side. For healthcare providers, these recommendations allow flexibility for activation of the emergency response to better match the provider's clinical setting.
- More data are available showing that high-quality CPR improves survival from cardiac arrest, including
  - Ensuring chest compressions of adequate rate
  - Ensuring chest compressions of adequate depth
  - Allowing full chest recoil between compressions
  - Minimizing interruptions in chest compressions
  - Avoiding excessive ventilation
- This Guidelines Update includes an updated recommendation for a simultaneous, choreographed approach to performance of chest compressions, airway management, rescue breathing, rhythm detection, and shocks (if indicated) by an integrated team of highly trained rescuers in applicable settings.

When the links in the Chain of Survival are implemented in an effective way, survival can approach 50% in EMS-treated patients after witnessed out-of-hospital ventricular fibrillation (VF) arrest.[5,6] Unfortunately, survival rates in many out-of-hospital and in-hospital settings fall far short of this figure. For example, survival rates after cardiac arrest due to VF vary from approximately 5% to 50% in both out-of-hospital and in-hospital settings.[7–9] This variation in outcome underscores the opportunity for improvement in many settings. The remaining links in the AHA Chain of Survival, namely advanced life support and integrated postarrest care, are covered in later Parts of this 2015 Guidelines Update (see "Part 7: Adult Advanced Cardiovascular Life Support" and "Part 8: Post–Cardiac Arrest Care").

Adult BLS Sequence—Updated

The steps of BLS consist of a series of sequential assessments and actions, which are illustrated in a simplified BLS algorithm that is unchanged from 2010.[10] The intent of the algorithm is to present the steps of BLS in a logical and concise manner that is easy for all types of rescuers to learn, remember, and perform. Integrated teams of highly trained rescuers may use a choreographed approach that accomplishes multiple steps and assessments simultaneously rather than in the sequential manner used by individual rescuers (eg, one rescuer activates the emergency response system while another begins chest compressions, a third either provides ventilation or retrieves the bag-mask device for rescue breaths, and a fourth retrieves and sets up a defibrillator). Moreover, trained rescuers are encouraged to simultaneously perform some steps (ie, checking for breathing and pulse at the same time) in an effort to reduce the time to first compressions. BLS assessments and actions for specific types of rescuers are summarized in Table 1.

Immediate Recognition and Activation of the Emergency Response System[BLS 740, BLS 359]—Updated

Emergency medical dispatch is an integral component of the EMS response.[11] Bystanders (lay responders) should immediately call their local emergency number to initiate a response any time they find an unresponsive adult victim. Healthcare providers should call for nearby help upon finding the victim unresponsive, but it would be practical for a healthcare provider to continue to assess for breathing and pulse simultaneously before fully activating the emergency response system.

For OHCA, a recent Scientific Statement recommended that all emergency dispatchers have protocols to guide the lay rescuer to check for breathing and to perform the steps of CPR, if needed.[12] When dispatchers ask bystanders to determine if breathing is present, bystanders often misinterpret agonal gasps or abnormal breathing as normal breathing. This erroneous information can result in failure by dispatchers to identify potential cardiac arrest and failure to instruct bystanders to initiate CPR immediately.[13–18] An important consideration is that brief, generalized seizures may be the first manifestation of cardiac arrest.[17,18]

2015 Evidence Review

Patients who are unresponsive and not breathing normally have a high likelihood of being in cardiac arrest.[15,18–25] Dispatcher CPR instructions substantially increase the likelihood of bystander CPR performance[26] and improve survival from cardiac arrest.[27–29]

2015 Recommendations—Updated

It is recommended that emergency dispatchers determine if a patient is unresponsive with abnormal breathing after acquiring the requisite information to determine the location of the event (Class I, LOE C-LD). If the patient is unresponsive with abnormal or absent breathing, it is reasonable for the emergency dispatcher to assume that the patient is in cardiac arrest (Class IIa, LOE C-LD). Dispatchers should be educated to identify unresponsiveness with abnormal breathing and agonal gasps across a range of clinical presentations and descriptions (Class I, LOE C-LD).

The role of dispatcher-guided CPR and recommendations for dispatcher training are more fully described in "Part 4: Systems of Care and Continuous Quality Improvement."

Pulse Check

As recommended in the 2010 Guidelines, healthcare providers will continue to check for a pulse, limiting the time to no more than 10 seconds to avoid delay in initiation of chest compressions. Ideally, the pulse check is performed simultaneously with the check for no breathing or only gasping, to minimize delay in detection of cardiac arrest and initiation of CPR. Lay rescuers will not check for a pulse.

Early CPR[BLS 661]—Updated

Begin chest compressions as quickly as possible after recognition of cardiac arrest. The 2010 Guidelines included a major change for trained rescuers, who were instructed to begin the CPR sequence with chest compressions rather than breaths **(C-A-B versus A-B-C)** to minimize the time to initiation

Table 1. Basic Life Support Sequence

Step	Lay Rescuer Not Trained	Lay Rescuer Trained	Healthcare Provider
1	Ensure scene safety.	Ensure scene safety.	Ensure scene safety.
2	Check for response.	Check for response.	Check for response.
3	Shout for nearby help. Phone or ask someone to phone 9-1-1 (the phone or caller with the phone remains at the victim's side, with the phone on speaker).	Shout for nearby help and activate the emergency response system (9-1-1, emergency response). If someone responds, ensure that the phone is at the side of the victim if at all possible.	Shout for nearby help/activate the resuscitation team; can activate the resuscitation team at this time or after checking breathing and pulse.
4	Follow the dispatcher's instructions.	Check for no breathing or only gasping; if none, begin CPR with compressions.	Check for no breathing or only gasping and check pulse (ideally simultaneously). Activation and retrieval of the AED/emergency equipment by either the lone healthcare provider or by the second person sent by the rescuer must occur no later than immediately after the check for no normal breathing and no pulse identifies cardiac arrest.
5	Look for no breathing or only gasping, at the direction of the dispatcher.	Answer the dispatcher's questions, and follow the dispatcher's instructions.	Immediately begin CPR, and use the AED/defibrillator when available.
6	Follow the dispatcher's instructions.	Send the second person to retrieve an AED, if one is available.	When the second rescuer arrives, provide 2-person CPR and use AED/defibrillator.

AED indicates automated external defibrillator; and CPR, cardiopulmonary resuscitation.

of chest compressions. The 2015 ILCOR BLS Task Force reviewed the most recent evidence evaluating the impact of this change in sequence on resuscitation.

2015 Evidence Review

Additional evidence published since 2010 showed that beginning the CPR sequence with compressions minimized time to first chest compression.[30–32]

2015 Recommendation—Updated

Similar to the 2010 Guidelines, it may be reasonable for rescuers to initiate CPR with chest compressions (Class IIb, LOE C-LD). The characteristics of effective chest compressions are described in the following section on BLS skills. As in the 2010 sequence, once chest compressions have been started, a trained rescuer delivers rescue breaths by mouth-to-mask or bag-mask device to provide oxygenation and ventilation. Recommendations regarding the duration of each breath and the need to make the chest rise were not updated in 2015.

Early Defibrillation With an AED

After activating the emergency response system, the lone rescuer retrieves an AED (if nearby and easily accessible) and then returns to the victim to attach and use the AED and provide CPR. When 2 or more trained rescuers are present, 1 rescuer begins CPR, starting with chest compressions, while a second rescuer activates the emergency response system and gets the AED (or a manual defibrillator in most hospitals) and other emergency equipment. The AED or manual defibrillator is used as rapidly as possible, and both rescuers are expected to provide CPR with chest compressions and ventilation. The sequence for using an AED has not been updated from the 2010 Guidelines.

Rescuer-Specific CPR Strategies: Putting It All Together[BLS 359, BLS 372]

This section summarizes the sequence of CPR interventions to be performed by 3 types of prototypical rescuers after they activate the emergency response system. The specific steps for rescuers and healthcare providers (compression-only [Hands-Only™] CPR, conventional CPR with rescue breaths, and CPR with AED use) are determined by the rescuer's level of training.

Untrained Lay Rescuer—Updated

Bystander CPR may prevent VF from deteriorating to asystole, and it also increases the chance of defibrillation, contributes to preservation of heart and brain function, and improves survival from OHCA.[33] Bystander CPR rates remain unacceptably low in many communities. Because compression-only CPR is easier to teach, remember, and perform, it is preferred for "just-in-time" teaching for untrained lay rescuers.

2015 Evidence Review

When telephone guidance is needed, survival is improved when compression-only CPR is provided as compared with conventional CPR for adult victims of cardiac arrest.[34] Multiple studies have shown no difference in survival when adult victims of OHCA receive compression-only CPR versus conventional CPR.[27,29,35–42]

2015 Recommendations—Updated

Untrained lay rescuers should provide compression-only CPR, with or without dispatcher assistance (Class I, LOE C-LD). The rescuer should continue compression-only CPR until the arrival of an AED or rescuers with additional training (Class I, LOE C-LD).

Trained Lay Rescuer

The 2010 Guidelines recommended that trained rescuers should provide rescue breaths in addition to chest compressions because they may encounter victims with asphyxial causes of cardiac arrest or they may be providing CPR for prolonged periods of time before additional help arrives.

2015 Recommendations—Updated

All lay rescuers should, at a minimum, provide chest compressions for victims of cardiac arrest (Class I, LOE C-LD). In

addition, if the trained lay rescuer is able to perform rescue breaths, he or she should add rescue breaths in a ratio of 30 compressions to 2 breaths. The rescuer should continue CPR until an AED arrives and is ready for use or EMS providers take over care of the victim (Class I, LOE C-LD).

Healthcare Provider—Updated

Optimally, all healthcare providers should be trained in BLS. As in past Guidelines, healthcare providers are trained to provide both compressions and ventilation.

2015 Evidence Review

There is concern that delivery of chest compressions without assisted ventilation for prolonged periods could be less effective than conventional CPR (compressions plus breaths) because the arterial oxygen content will decrease as CPR duration increases. This concern is especially pertinent in the setting of asphyxial cardiac arrest.[36] For the 2015 ILCOR evidence review, the Adult BLS Task Force reviewed observational studies and randomized controlled trials (RCTs), including studies of dispatcher-guided CPR; much of the research involved patients whose arrests were presumed to be of cardiac origin and in settings with short EMS response times. It is likely that a time threshold exists beyond which the absence of ventilation may be harmful,[35,37] and the generalizability of the findings to all settings must be considered with caution.

2015 Recommendation—Updated

It is reasonable for healthcare providers to provide chest compressions and ventilation for all adult patients in cardiac arrest, from either a cardiac or noncardiac cause (Class IIa, LOE C-LD). In addition, it is realistic for healthcare providers to tailor the sequence of rescue actions to the most likely cause of arrest. For example, if a lone healthcare provider sees an adolescent suddenly collapse, the provider may assume that the victim has had a sudden arrhythmic arrest and call for help, get a nearby AED, return to the victim to use the AED, and then provide CPR.

Delayed Ventilation[BLS 360]

Several EMS systems have tested a strategy of initial continuous chest compressions with delayed positive-pressure ventilation for adult OHCA.

2015 Evidence Review

During adult OHCA, survival to hospital discharge was improved by the use of an initial period of continuous chest compressions.[43,44] Three observational studies showed improved survival with favorable neurologic status when EMS providers performed a set of continuous chest compressions with delayed ventilation for victims with witnessed arrest or shockable rhythm.[45–47] These studies were performed in systems that use priority-based, multitiered response in both urban and rural communities, and all included a "bundled" package of care that included up to 3 cycles of passive oxygen insufflation, airway adjunct insertion, and 200 continuous chest compressions with interposed shocks. Providers received additional training with emphasis on provision of high-quality chest compressions.

2015 Recommendation—New

For witnessed OHCA with a shockable rhythm, it may be reasonable for EMS systems with priority-based, multitiered response to delay positive-pressure ventilation by using a strategy of up to 3 cycles of 200 continuous compressions with passive oxygen insufflation and airway adjuncts (Class IIb, LOE C-LD).

Adult BLS Skills

The sequence of BLS skills for the healthcare provider is depicted in the BLS Healthcare Provider Adult Cardiac Arrest Algorithm (Figure 1). There are minor changes to the 2010 Guidelines as the result of new evidence regarding compression rate, feedback received from the training network, and new evidence regarding the incidence of opioid overdose and the effects of naloxone-administration programs.

Verify Scene Safety

Rescuers arriving on the scene of an emergency should verify that the environment in which they are approaching a patient is safe for the provider. This is accomplished by a quick scan of the patient's location and surroundings to make sure there are no imminent physical threats such as toxic or electrical hazards.

Recognition of Arrest[BLS 359, BLS 740]—Updated

The necessary first step in the treatment of cardiac arrest is immediate recognition. Initial major steps for bystanders remain unchanged from the 2010 Guidelines. CPR training, both formal classroom training and "just-in-time" training such as that given through a dispatch center, should emphasize how to recognize occasional gasps. Dispatchers should instruct rescuers to provide CPR if the victim is unresponsive with no normal breathing, even when the victim demonstrates occasional gasps (Class I, LOE C-LD).

Scenario: Pulse Present, Normal Breathing

Closely monitor the patient, and activate the emergency response system as indicated by location and patient condition.

Scenario: Pulse Present, No Normal Breathing[BLS 811, BLS 891]—Updated

This topic was last reviewed in 2010. The 2015 ILCOR systematic review addressed whether bystander-administered naloxone to patients with suspected opioid-associated cardiopulmonary arrest affected resuscitation outcomes. The evaluation did not focus on opioid-associated respiratory arrest.

The authors acknowledge the epidemiologic data demonstrating the large burden of disease from lethal opioid overdoses as well as targeted national strategies for bystander-administered naloxone for people at risk. Since the 2014 US Food and Drug Administration approval of the use of a naloxone autoinjector by lay rescuers and healthcare providers,[48] the training network has requested information regarding the best way to incorporate such a device in the BLS sequence. In response to requests, the ILCOR BLS Task Force performed an additional search for evidence of effectiveness of the use of naloxone for opioid overdose.

2015 Summary of Evidence

There were no published studies to determine if adding intranasal or intramuscular naloxone to conventional CPR

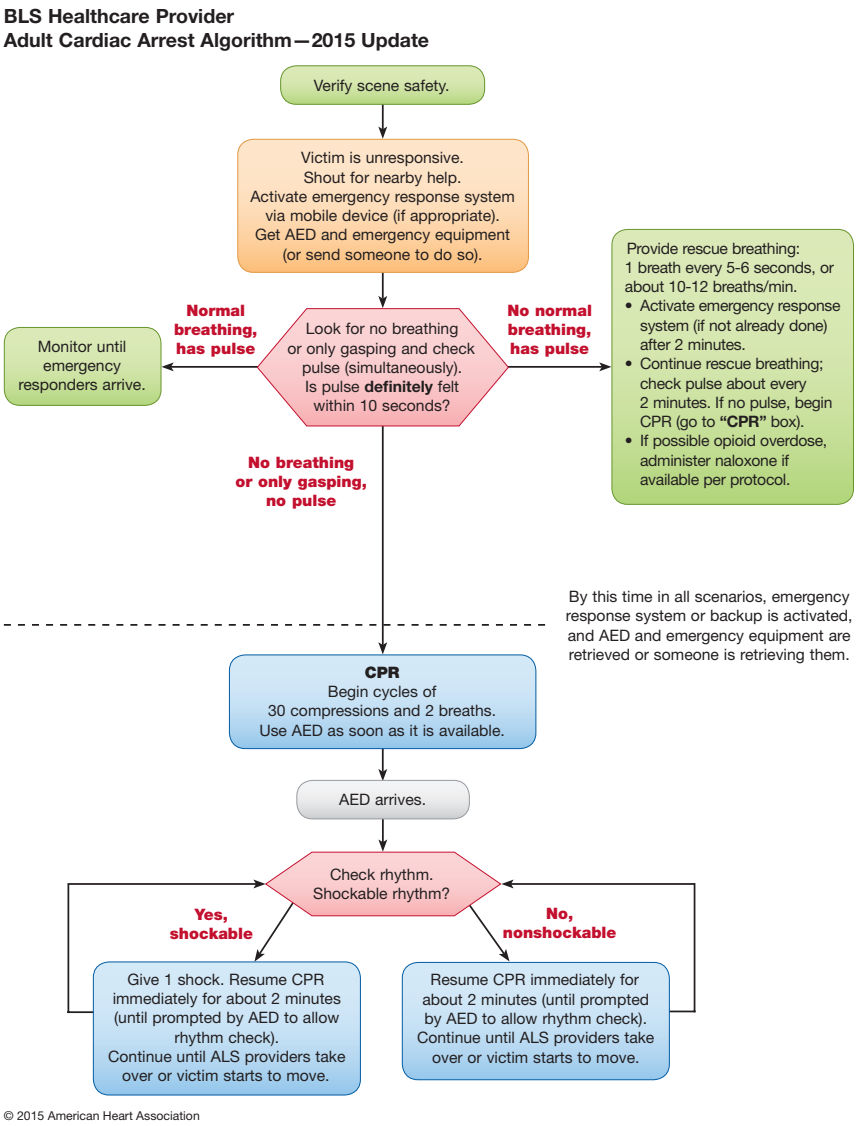

Figure 1. BLS Healthcare Provider Adult Cardiac Arrest Algorithm—2015 Update.

is superior to conventional CPR alone for the management of adults and children with suspected opioid-associated cardiac or respiratory arrest in the prehospital setting. However, the additional search for available evidence regarding overdose education and naloxone distribution programs yielded 3 observational before-and-after studies. One study observed a dose-response effect with 0.73 (95% confidence interval [CI], 0.57–0.91) and 0.54 (95% CI, 0.39–0.76) adjusted rate ratios for lethal overdose in communities with low and high implementation, respectively.[49] The remaining 2 observational studies reported reductions in rate ratios for lethal overdose of 0.62 (95% CI, 0.54–0.72)[50] and 0.70 (95% CI, 0.65–0.74) in individual communities that implemented programs to address opioid overdose.[51]

2015 Recommendations—New

For a patient with known or suspected opioid overdose who has a definite pulse but no normal breathing or only gasping (ie, a respiratory arrest), in addition to providing standard BLS care, it is reasonable for appropriately trained BLS healthcare providers to administer intramuscular or intranasal naloxone (Class IIa, LOE C-LD). For patients in cardiac arrest, medication administration is ineffective without concomitant chest compressions for drug delivery to the tissues, so naloxone administration may be considered after initiation of CPR if there is high suspicion for opiate overdose (Class IIb, LOE C-EO). It is reasonable to provide opioid overdose response education with or without naloxone distribution to persons at risk for opioid overdose (or those living with or in frequent contact with such persons) (Class IIa, LOE C-LD). Information regarding lay rescuer education and the use of naloxone for known or suspected victims of opioid overdose is discussed in "Part 10: Special Circumstances of Resuscitation."

Scenario: Pulse Absent, No Breathing or Only Gasping

As in the 2010 Guidelines, rescuers should initiate CPR and use an AED as soon as possible. By this point in all potential scenarios, the emergency response system is activated, and a defibrillator and emergency equipment are retrieved or requested.

Technique: Chest Compressions—Updated

Chest compressions are the key component of effective CPR. Characteristics of chest compressions include their depth, rate, and degree of recoil. The quality of CPR can also be characterized by the frequency and duration of interruptions in chest compressions—when such interruptions are minimized, the chest compression fraction (percent of total resuscitation time that compressions are performed) is higher. Finally, with high-quality CPR, the rescuer avoids excessive ventilation. These CPR performance elements affect intrathoracic pressure, coronary perfusion pressure, cardiac output, and, in turn, clinical outcomes.

Hand Position During Compressions[BLS 357]—Updated

The 2015 ILCOR systematic review addressed whether hand position placement for chest compressions affected resuscitation outcomes. Different rescuer hand positions alter the mechanics of chest compressions and may, in turn, influence their quality and effectiveness.

2015 Summary of Evidence

Only a few human studies involving a total of fewer than 100 cardiac arrest patients have evaluated hand position during CPR.[52–54] These investigations assessed hand placement on the lower third of the sternum compared with the center of the chest in a crossover design, and they measured physiologic endpoints, such as blood pressure and end-tidal carbon dioxide ($ETCO_2$). The studies have not provided conclusive or consistent results about the effects of hand placement on resuscitation outcomes.

2015 Recommendation—Unchanged

Consistent with the 2010 Guidelines, it is reasonable to position hands for chest compressions on the lower half of the sternum in adults with cardiac arrest (Class IIa, LOE C-LD).

Chest Compression Rate[BLS 343]—Updated

In the 2010 Guidelines, the recommended compression rate was *at least* 100 compressions per minute. The 2015 Guidelines Update incorporates new evidence about the potential for an upper threshold of rate beyond which outcome may be adversely affected.

The 2015 ILCOR systematic review addressed whether compression rates different from 100/min influence physiologic or clinical outcomes. Chest compression rate is defined as the actual rate used during each continuous period of chest compressions. This rate differs from the number of chest compressions delivered per unit of time, which takes into account any interruptions in chest compressions.

2015 Summary of Evidence

Evidence involving compression rate is derived from observational human studies that evaluate the relationship between compression rate and outcomes including survival to hospital discharge, return of spontaneous circulation (ROSC), and various physiologic measures, such as blood pressure and end-tidal CO_2. These investigations suggest that there may be an optimal zone for the rate of manual chest compressions—between 100/min and 120/min—that on average is associated with improved survival.[55,56] Importantly, there is an interdependent relationship between compression rate and compression depth during manual chest compressions: as rate increases to greater than 120/min, depth decreases in a dose-dependent manner.[55] For example, the proportion of compressions less than 38 mm (less than 3.8 cm or 1.5 inches) was about 35% for a compression rate of 100 to 119/min but increased to 50% for a compression rate of 120 to 139/min and 70% for a compression rate of greater than 140/min.

2015 Recommendation—Updated

In adult victims of cardiac arrest, it is reasonable for rescuers to perform chest compressions at a rate of 100/min to 120/min (Class IIa, LOE C-LD).

Chest Compression Depth[BLS 366]—Updated

The 2015 ILCOR systematic review addressed whether a chest compression depth different from 2 inches (5 cm) influences physiologic or clinical outcomes. The depth of chest compression can affect the relative increase in intrathoracic pressure and, in turn, influence forward blood flow from the heart and great vessels to the systemic circulation. In the 2010 Guidelines, the recommended compression depth was *at least* 2 inches (5 cm). The 2015 Guidelines Update incorporates new evidence about the potential for an upper threshold of compression depth beyond which outcomes may be adversely affected.

2015 Summary of Evidence

Evidence involving compression depth is derived from observational human studies that evaluate the relationship between compression depth and outcomes including survival with favorable neurologic outcome, survival to hospital discharge, and ROSC. Studies often classify compression depth differently, using distinct categories of depth or using an average depth for a given portion of the resuscitation.

Even with this heterogeneity, there is consistent evidence that achieving compression depth of approximately 5 cm is associated with greater likelihood of favorable outcomes compared with shallower compressions.[57–65] In the largest study to date (n=9136), the optimal compression depth with regard to survival occurred within the range of 41 to 55 mm (4.1 to 5.5 cm, or 1.61 to 2.2 inches).[60] Less evidence is available about whether there is an upper threshold beyond which compressions may be too deep. During manual CPR, injuries are more common when compression depth is greater than 6 cm (2.4 inches) than when it is between 5 and 6 cm (2 and 2.4 inches).[66] Importantly, chest compressions performed by professional rescuers are more likely to be too shallow (ie, less than 40 mm [4 cm] or 1.6 inches) and less likely to exceed 55 mm (5.5 cm or 2.2 inches).[60]

2015 Recommendation—Updated

During manual CPR, rescuers should perform chest compressions to a depth of at least 2 inches or 5 cm for an average adult, while avoiding excessive chest compression depths (greater than 2.4 inches or 6 cm) (Class I, LOE C-LD).

Chest Wall Recoil[BLS 367]

The 2015 ILCOR systematic reviews addressed whether full chest wall recoil compared with incomplete recoil influenced

physiologic or clinical outcomes. Full chest wall recoil occurs when the sternum returns to its natural or neutral position during the decompression phase of CPR. Chest wall recoil creates a relative negative intrathoracic pressure that promotes venous return and cardiopulmonary blood flow. Leaning on the chest wall between compressions precludes full chest wall recoil. Incomplete recoil could increase intrathoracic pressure and reduce venous return, coronary perfusion pressure, and myocardial blood flow and could potentially influence resuscitation outcomes.[67,68] Observational studies indicate that leaning is common during CPR in adults and children.[69,70]

2015 Summary of Evidence

There are no human studies reporting the relationship between chest wall recoil and clinical outcomes. The evidence is derived from 2 animal studies and a pediatric study of patients not in cardiac arrest.[67,71,72] In all 3 studies, an increased force of leaning (incomplete recoil) was associated with a dose-dependent decrease in coronary perfusion pressure. Based on 2 studies, the relationship between leaning and cardiac output was inconsistent.[67,71]

2015 Recommendation—Updated

It is reasonable for rescuers to avoid leaning on the chest between compressions to allow full chest wall recoil for adults in cardiac arrest (Class IIa, LOE C-LD).

Minimizing Interruptions in Chest Compressions[BLS 358]—Updated

As in the 2010 Guidelines, minimizing interruptions in chest compressions remains a point of emphasis. The 2015 ILCOR systematic review addressed whether shorter compared with longer interruptions in chest compressions influenced physiologic or clinical outcomes. Interruptions in chest compressions can be intended as part of required care (ie, rhythm analysis and ventilation) or unintended (ie, rescuer distraction).

Chest compression fraction is a measurement of the proportion of time that compressions are performed during a cardiac arrest. An increase in chest compression fraction can be achieved by minimizing pauses in chest compressions. The optimal goal for chest compression fraction has not been defined. The AHA expert consensus is that a chest compression fraction of 80% is achievable in a variety of settings.[73]

2015 Summary of Evidence

Evidence involving the consequences of compression interruptions is derived from observational and randomized human studies of cardiac arrest. These studies provide heterogeneous results. Observational studies demonstrate an association between a shorter duration of compression interruption for the perishock period and a greater likelihood of shock success,[62] ROSC,[74] and survival to hospital discharge.[75,76] Other observational studies have demonstrated an association between higher chest compression fraction and likelihood of survival among patients with shockable rhythms, and return of circulation among patients with nonshockable rhythms.[77,78] In contrast, the results of a randomized trial comparing a bundle of changes between the 2000 and 2005 Guidelines showed no survival difference when perishock pauses were reduced.[79] In an investigation of first responders equipped with AEDs, the duration of pauses specific to ventilation was not associated with survival.[80]

2015 Recommendations—Updated

In adult cardiac arrest, total preshock and postshock pauses in chest compressions should be as short as possible (Class I, LOE C-LD). For adults in cardiac arrest receiving CPR without an advanced airway, it is reasonable to pause compressions for less than 10 seconds to deliver 2 breaths (Class IIa, LOE C-LD). In adult cardiac arrest with an unprotected airway, it may be reasonable to perform CPR with the goal of a chest compression fraction as high as possible, with a target of at least 60% (Class IIb, LOE C-LD).

Compression-to-Ventilation Ratio[BLS 362]—Updated

In 2005, the recommended compression-to-ventilation ratio for adults in cardiac arrest was changed from 15:2 to 30:2. The 2015 ILCOR systematic review addressed whether compression-to-ventilation ratios different from 30:2 influenced physiologic or clinical outcomes. In cardiac arrest patients without an advanced airway, chest compressions are briefly paused to provide rescue breaths in order to achieve adequate air entry.

2015 Summary of Evidence

Evidence involving the compression-to-ventilation ratio is derived from observational before-and-after human studies in the out-of-hospital setting.[81–84] These studies compared the compression-to-ventilation ratio of 30:2 with 15:2 for survival and other outcomes. However, the treatment of the comparison groups also differed in other respects that typically reflected changes from the 2000 to 2005 Guidelines, such as an increase in the duration of CPR cycles between rhythm analyses from 1 to 2 minutes. Overall, outcomes were typically better in the 30:2 group compared with the 15:2 group.

2015 Recommendation—Unchanged

Consistent with the 2010 Guidelines, it is reasonable for rescuers to provide a compression-to-ventilation ratio of 30:2 for adults in cardiac arrest (Class IIa, LOE C-LD).

Layperson—Compression-Only CPR Versus Conventional CPR[BLS 372] (Chest Compressions Plus Rescue Breaths)—Updated

The 2015 ILCOR systematic review addressed whether layperson CPR consisting of chest compressions alone compared with conventional CPR (compressions plus rescue breaths) influenced physiologic or clinical outcomes.

2015 Summary of Evidence

Evidence comparing layperson compression-only CPR with conventional CPR is derived from RCTs of dispatcher-guided CPR and observational studies. There were no short-term survival differences in any of the 3 individual randomized trials comparing the 2 types of dispatcher instructions.[27,29,85] Based on meta-analysis of the 2 largest randomized trials (total n=2496), dispatcher instruction in compression-only CPR was associated with long-term survival benefit compared with instruction in chest compressions and rescue breathing.[34]

Among the observational studies, survival outcomes were not different when comparing the 2 types of CPR.[35–42,86–90]

2015 Recommendations—Updated

The following recommendations are consistent with 2010 Guidelines involving layperson CPR. Dispatchers should provide chest compression–only CPR instructions to callers for adults with suspected OHCA (Class I, LOE C-LD). For lay rescuers, compression-only CPR is a reasonable alternative to conventional CPR in the adult cardiac arrest patient (Class IIa, LOE C-LD). For trained lay rescuers, it is reasonable to provide ventilation in addition to chest compressions for the adult in cardiac arrest (Class IIa, LOE C-LD).

Managing the Airway

A significant change in the 2010 Guidelines was the initiation of chest compressions before ventilation (ie, a change in the sequence from A-B-C to C-A-B). The prioritization of circulation (C) over ventilation reflected the overriding importance of blood flow generation for successful resuscitation and practical delays inherent to initiation of rescue breaths (B). Physiologically, in cases of sudden cardiac arrest, the need for assisted ventilation is a lower priority because of the availability of adequate arterial oxygen content at the time of a sudden cardiac arrest. The presence of this oxygen and its renewal through gasping and chest compressions (provided there is a patent airway) also supported the use of compression-only CPR and the use of passive oxygen delivery.

Open the Airway: Lay Rescuer[FA 772]—Updated

The recommendation for trained and untrained lay rescuers remains the same as in 2010. For victims with suspected spinal injury, rescuers should initially use manual spinal motion restriction (eg, placing 1 hand on either side of the patient's head to hold it still) rather than immobilization devices, because use of immobilization devices by lay rescuers may be harmful (Class III: Harm, LOE C-LD). Spinal immobilization devices may interfere with maintaining a patent airway,[91,92] but ultimately the use of such a device may be necessary to maintain spinal alignment during transport. This treatment recommendation is explored in depth in "Part 15: First Aid."

Open the Airway: Healthcare Provider

A healthcare provider uses the head tilt–chin lift maneuver to open the airway of a victim with no evidence of head or neck trauma. The evidence for this was last reviewed in 2010. For victims with suspected spinal cord injury, this evidence was last reviewed in 2010 and there is no change in treatment recommendation.

Rescue Breathing—Updated

The 2015 Guidelines Update makes many of the same recommendations regarding rescue breathing as were made in 2005 and 2010. Effective performance of rescue breathing or bag-mask or bag-tube ventilation is an essential skill and requires training and practice. During CPR without an advanced airway, a compression-to-ventilation ratio of 30:2 is used.

Mouth-to-Mouth Rescue Breathing

The technique for mouth-to-mouth rescue breathing was last reviewed in 2010.[10]

Mouth–to–Barrier Device Breathing

The technique for mouth–to–barrier device breathing was last reviewed in 2010.[10]

Mouth-to-Nose and Mouth-to-Stoma Ventilation

The technique for mouth-to-nose and mouth-to-stoma ventilation was last reviewed in 2010.[10]

Ventilation With Bag-Mask Device

When using a self-inflating bag, rescuers can provide bag-mask ventilation with room air or oxygen. A bag-mask device can provide positive-pressure ventilation without an advanced airway and may result in gastric inflation and its potential complications.

The Bag-Mask Device

The elements of a bag-mask device are the same as those used in 2010.[10]

Bag-Mask Ventilation

Bag-mask ventilation is a challenging skill that requires considerable practice for competency. As long as the patient does not have an advanced airway in place, the rescuers should deliver cycles of 30 compressions and 2 breaths during CPR. The rescuer delivers breaths during pauses in compressions and delivers each breath over approximately 1 second (Class IIa, LOE C-LD).

Ventilation With an Advanced Airway[BLS 808]—Updated

When the victim has an advanced airway in place during CPR, rescuers no longer deliver cycles of 30 compressions and 2 breaths (ie, they no longer interrupt compressions to deliver 2 breaths). Instead, it may be reasonable for the provider to deliver 1 breath every 6 seconds (10 breaths per minute) while continuous chest compressions are being performed (Class IIb, LOE C-LD). This represents a simplification of the 2010 Guidelines recommendations, to provide a single number that rescuers will need to remember for ventilation rate, rather than a range of numbers.

Passive Oxygen Versus Positive-Pressure Oxygen During CPR[BLS 352]—Updated

Some EMS systems have studied the use of passive oxygen flow during chest compressions without positive-pressure ventilation, an option known as passive oxygen administration.

2015 Evidence Summary

Two studies compared positive-pressure ventilation through an endotracheal tube to continuous delivery of oxygen or air directly into the trachea after intubation by using a modified endotracheal tube that had microcannulas inserted into its inner wall.[93,94] A third study compared bag-mask ventilation to high-flow oxygen delivery by nonrebreather face mask after oropharyngeal airway insertion as part of a resuscitation

bundle that also included uninterrupted preshock and postshock chest compressions and early epinephrine administration.[45] Continuous tracheal delivery of oxygen or air through the modified endotracheal tube was associated with lower arterial P_{CO_2}[93] but no additional improvement in ROSC,[93,94] hospital admission,[94] or ICU discharge[94] when compared with positive-pressure ventilation. High-flow oxygen delivery via a face mask with an oropharyngeal airway as part of a resuscitation bundle was associated with improved survival with favorable neurologic outcome. This study, however, included only victims who had witnessed arrest from VF or pulseless ventricular tachycardia (pVT).[45]

2015 Recommendations—New

We do not recommend the routine use of passive ventilation techniques during conventional CPR for adults (Class IIb, LOE C-LD). However, in EMS systems that use bundles of care involving continuous chest compressions, the use of passive ventilation techniques may be considered as part of that bundle (Class IIb, LOE C-LD).

AED Defibrillation

Ideally, all BLS providers are trained on use of an AED given that VF and pVT are treatable cardiac arrest rhythms with outcomes closely related to the rapidity of recognition and treatment.[95] Survival in victims of VF/pVT is highest when bystanders deliver CPR and defibrillation is attempted within 3 to 5 minutes of collapse.[8,33,96–99] Accordingly, in 2010, we recommended that BLS providers immediately apply an AED in witnessed OHCA or for monitored patients who develop IHCA. In 2015, the review focused on (1) the evidence surrounding the clinical benefit of automatic external defibrillators in the out-of-hospital setting by laypeople and healthcare providers, and (2) the complex choreography of care needed to ensure high-quality CPR and effective defibrillation.

CPR Before Defibrillation[BLS 363]—Updated

The 2015 ILCOR systematic review addressed whether a specified period (typically 1.5 to 3 minutes) of chest compressions before shock delivery compared with a short period of chest compressions before shock delivery affected resuscitation outcomes. When cardiac arrest is unwitnessed, experts have debated whether a period of CPR might be beneficial before attempting defibrillation, especially in the out-of-hospital setting when access to defibrillation may be delayed until arrival of professional rescuers. Observational clinical studies and mechanistic studies in animal models suggest that CPR under conditions of prolonged untreated VF might help restore metabolic conditions of the heart favorable to defibrillation. Others have suggested that prolonged VF is energetically detrimental to the ischemic heart, justifying rapid defibrillation attempts regardless of the duration of arrest.

2015 Evidence Summary

Five RCTs,[100–104] 4 observational cohort studies,[105–108] 3 meta-analyses,[109–111] and 1 subgroup analysis of an RCT[112] addressed the question of CPR before defibrillation. The duration of CPR before defibrillation ranged from 90 to 180 seconds, with the control group having a shorter CPR interval lasting only as long as the time required for defibrillator deployment, pad placement, initial rhythm analysis, and AED charging. These studies showed that outcomes were not different when CPR was provided for a period of up to 180 seconds before attempted defibrillation compared with rhythm analysis and attempted defibrillation first for the various outcomes examined, ranging from 1-year survival with favorable neurologic outcome to ROSC. Subgroup analysis suggested potential benefit from CPR before defibrillation in patients with prolonged EMS response intervals (4 to 5 minutes or longer)[100] and in EMS agencies with high baseline survival to hospital discharge,[112] but these findings conflict with other subset analyses.[103] Accordingly, the current evidence suggests that for unmonitored patients with cardiac arrest outside of the hospital and an initial rhythm of VF or pVT, there is no benefit from a period of CPR of 90 to 180 seconds before attempted defibrillation.

2015 Recommendations—Updated

For witnessed adult cardiac arrest when an AED is immediately available, it is reasonable that the defibrillator be used as soon as possible (Class IIa, LOE C-LD). For adults with unmonitored cardiac arrest or for whom an AED is not immediately available, it is reasonable that CPR be initiated while the defibrillator equipment is being retrieved and applied and that defibrillation, if indicated, be attempted as soon as the device is ready for use (Class IIa, LOE B-R).

Analysis of Rhythm During Compressions[BLS 373]—Updated

The 2015 ILCOR systematic review addressed whether analysis of cardiac rhythm during chest compressions compared with analysis of cardiac rhythm during pauses in chest compressions affected resuscitation outcomes.

Although the performance of chest compressions during AED rhythm analysis would reduce the time that CPR is paused, motion artifacts currently preclude reliable AED assessment of heart rhythm during chest compressions and may delay VF/pVT identification and defibrillation.

2015 Evidence Summary

There are currently no published human studies that address whether compressions during manual defibrillator or AED rhythm analysis affect patient outcome. New technology to assess the potential benefit of filtering electrocardiogram (ECG) compression artifacts has not been evaluated in humans.

2015 Recommendation—New

There is insufficient evidence to recommend the use of artifact-filtering algorithms for analysis of ECG rhythm during CPR. Their use may be considered as part of a research protocol or if an EMS system, hospital, or other entity has already incorporated ECG artifact-filtering algorithms in its resuscitation protocols (Class IIb, LOE C-EO).

Timing of Rhythm Check[BLS 346]—Updated

The 2015 ILCOR evidence review process considered whether the assessment of rhythm immediately after shock delivery,

as opposed to immediate resumption of chest compressions, affected resuscitation outcomes. In 2010, the Guidelines emphasized the importance of avoiding pauses in cardiac compressions during CPR. Assessment of rhythm after shock delivery lengthens the period of time that chest compressions are not delivered.

2015 Evidence Summary

Three before-and-after observational studies of OHCA[44,47,113] evaluated the impact of omitting a rhythm check immediately after attempted defibrillation as part of a bundle of interventions to minimize pauses in chest compressions (eg, elimination of 3 stacked shocks and postshock rhythm and pulse checks). The observational studies documented improved survival with favorable neurologic outcome at hospital discharge associated with the bundle of care, including resumption of chest compressions immediately after shock delivery. One RCT[79] comparing immediate postshock CPR to rhythm checks failed to demonstrate improved ROSC or survival to hospital admission or discharge. One small, low-quality RCT evaluated the ability to identify recurrence of VF and showed no benefit to checking rhythm immediately after defibrillation.[114]

2015 Recommendation—Updated

It may be reasonable to immediately resume chest compressions after shock delivery for adults in cardiac arrest in any setting (Class IIb, LOE C-LD).

CPR Quality, Accountability, and Healthcare Systems

The quality of CPR in both in-hospital and OHCA events is variable. CPR quality encompasses the traditional metrics of chest compression rate and depth and chest recoil, but it also includes parameters such as chest compression fraction and avoiding excessive ventilation. Other important aspects of CPR quality include resuscitation team dynamics, system performance, and quality monitoring.

Today, despite clear evidence that providing high-quality CPR significantly improves cardiac resuscitation outcomes, few healthcare organizations consistently apply strategies of systematically monitoring CPR quality.[115] As a consequence, there is an unacceptable disparity in the quality of resuscitation care and outcomes, as well an enormous opportunity to save more lives.[59]

Like other urgent healthcare conditions, the use of a relatively simple, iterative continuous quality improvement approach to CPR can dramatically improve CPR quality and optimize outcomes.[116–118] Similar to successful approaches toward mitigating medical errors, programs aimed at system-wide CPR data collection, implementation of best practices, and continuous feedback on performance have been shown to be effective.[73]

Chest Compression Feedback[BLS 361]—Updated

Technology allows for real-time monitoring, recording, and feedback about CPR quality, including both physiologic patient parameters and rescuer performance metrics. This important data can be used in real time during resuscitation, for debriefing after resuscitation, and for system-wide quality improvement programs.[73]

2015 Evidence Review

In studies to date, the use of CPR feedback devices has not been shown to significantly improve performance of chest compression depth, chest compression fraction, and ventilation rate.[58,61,65,119–121] There is some evidence that the use of CPR feedback may be effective in modifying chest compression rates that are too fast.[61,120] Additionally, there is evidence that CPR feedback decreases the leaning force during chest compressions.[70] For the outcome of ROSC, there is conflicting evidence,[61,65,119,120,122–124] with the majority of studies showing no difference in the number of patients that achieved ROSC and only 2 studies showing an increase in ROSC with the use of CPR feedback.[58,65,121,124] However, studies to date have not demonstrated a significant improvement in favorable neurologic outcome[58,120,121,124] or survival to hospital discharge[58,61,119–121,124] related to the use of CPR feedback devices during actual cardiac arrest events.

2015 Recommendation—Updated

It may be reasonable to use audiovisual feedback devices during CPR for real-time optimization of CPR performance (Class IIb, LOE B-R).

Team-Based Resuscitation

Resuscitation from cardiac arrest most often involves a team of caregivers, with team composition and level of experience varying depending on location (in- versus out-of-hospital), setting (field, emergency department, hospital ward), and circumstances. Despite the varied environments and team members, a designated team leader is needed to direct and coordinate all components of the resuscitation with a central focus on delivering high-quality CPR. The team leader choreographs team activities with an aim to minimize interruptions in CPR and, through the use of real-time feedback, ensures delivery of adequate compression rate and depth, minimization of leaning, and interruptions in chest compressions, and avoidance of excessive ventilation.[73] More information on team training is available in "Part 14: Education" and "Part 4: Systems of Care and Continuous Quality Improvement."

Duration of Resuscitation

Investigators have published relatively few studies that examine the impact of resuscitation duration on clinical outcomes, and most of these studies have important limitations. In an older series of 313 IHCA patients, the percentage who survived to discharge was 45% when resuscitation lasted less than 5 minutes and less than 5% when the resuscitation extended beyond 20 minutes.[125] More recently, an analysis from a single-hospital registry in Taiwan suggested that the rate of achieving ROSC was higher than 90% among patients resuscitated for less than 10 minutes but approximately 50% for those resuscitated for 30 minutes or more.[126]

Two observational cohort studies of patients with in-hospital arrests from the Get With The Guidelines®-Resuscitation

registry were recently published suggesting that extending the duration of resuscitation efforts may result in improved cardiac arrest survival. For adult patients, hospitals that systematically practiced longer durations of resuscitation had improved outcomes of ROSC and survival to discharge, with no apparent detriment in neurologic outcomes.[127] Another report of pediatric patients demonstrated an intact survival of 16.2% after more than 35 minutes of CPR in certain patient populations.[128] While investigators can define neither an optimal duration of resuscitation before the termination of efforts nor which patients may benefit from prolonged efforts at resuscitation, extending the duration of resuscitation may be a means of improving survival in selected hospitalized patients.

CPR Registry Data

Ideally, RCTs will be used to advance the science and practice of resuscitation. However, conducting clinical trials in cardiac arrest patients is exceedingly challenging, given the small number of patients at single-center sites. Moreover, such research confers unique limitations and ethical concerns. Given these challenges, real-world observational data from registries can be a valuable resource for studying and reporting resuscitation processes and outcomes. Registries are available for both in-hospital and out-of-hospital arrests.[129]

Formerly known as the National Registry of Cardiopulmonary Resuscitation, the AHA's Get With The Guidelines-Resuscitation registry is the largest prospective, multicenter, observational registry of IHCA.[130,131] At present, more than 600 hospitals in the United States and Canada participate in the registry, and more than 200 000 index arrests have been recorded since 2000.

To date, the Get With The Guidelines-Resuscitation registry has provided important insights into several aspects of IHCA. Recent work has highlighted the survival gains by reducing time to defibrillation,[132] reducing racial differences and trends in IHCA incidence and survival,[133] and gathering evidence to support lengthier durations of CPR.[134]

The Resuscitation Outcomes Consortium (ROC) is a clinical research network designed to evaluate the effectiveness of prehospital emergency care for patients with OHCA or life-threatening injury.[135] Data collection began in 2007 and stems from 264 EMS agencies in 11 sites (8 in the United States and 3 in Canada), altogether representing 10% of the North American population. The ROC has afforded insights on several aspects of OHCA,[136–138] including regional variation in incidence and outcomes[7] and chest compression rates.[56]

The Cardiac Arrest Registry to Enhance Survival (CARES) is a central repository of OHCA events of presumed cardiac etiology treated with CPR and/or defibrillation throughout the United States.[3,139,140] CARES was designed as a quality improvement project, with the aims of providing performance indicators to EMS medical and administrative directors to improve processes and outcomes. As of 2011, it has collected data on more than 31 000 OHCAs from 46 EMS agencies in 36 communities in 20 states.[141] CARES has offered important insight into bystander CPR,[142] prehospital termination of resuscitation,[143] and variation in EMS systems of care.[144]

Family Presence During Resuscitation

Studies that explicitly examined the association between family presence and outcomes have shown mixed results. In an analysis of simulated resuscitations in an urban emergency department, investigators demonstrated that family presence may have a significant effect on physicians' ability to perform critical interventions as well as on resuscitation-based performance outcomes.[145] Specifically, the presence of a witness to resuscitation was associated with longer mean times to defibrillation (2.6 versus 1.7 minutes) and fewer shocks (4.0 versus 6.0).

A recent observational study using the Get With The Guidelines-Resuscitation registry demonstrated that implementing a hospital policy that allows family presence had no impact on survival or the processes of attempted resuscitations.[146] Overall, given the evidence for improved psychological benefits for families present during out-of-hospital resuscitation, and without an apparent negative effect on outcomes at hospitals that allow families to be present, family presence represents an important dimension in the paradigm of resuscitation quality.

Special Resuscitation Situations

Acute Coronary Syndrome

Acute coronary syndrome (ACS) is a term that subtends a spectrum of diseases leading to myocardial ischemia or infarction. The subtypes of ACS are principally stratified through a combination of electrocardiographic changes and/or the elevations of cardiac biomarkers, in the context of symptoms consistent with ACS (eg, substernal chest pain or discomfort with or without characteristic radiation, shortness of breath, weakness, diaphoresis, nausea or vomiting, light-headedness). ACS may manifest as an ST-segment elevation myocardial infarction (STEMI) or non–ST-segment elevation myocardial infarction (NSTEMI)/unstable angina (UA), now called *non–ST-segment acute coronary syndromes* (NSTE-ACS). Both diagnoses are pathophysiologically linked to varying degrees of a reduction in coronary blood flow due to atherosclerotic plaque progression, instability, or rupture with or without luminal thrombosis and vasospasm.

Since 2010, the American College of Cardiology and the AHA have published targeted clinical practice guidelines pertaining to the management of patients with STEMI[147] and NSTE-ACS.[148] These guidelines should be referred to for full details on the specific management of ACS. In addition, other parts of the *2015 AHA Guidelines Update for CPR and ECC* include updates on basic and advanced life support for prehospital providers who care for these patients ("Part 9: Acute Coronary Syndromes," "Part 4: Systems of Care and Continuous Quality Improvement," and "Part 10: Special Circumstances of Resuscitation"; aspirin and chest pain are presented in "Part 15: First Aid").

Stroke

Approximately 800 000 people have a stroke each year in the United States, and stroke is a leading cause of severe, long-term disability and death.[4] Fibrinolytic therapy administered within the first hours of the onset of symptoms limits neurologic injury and improves outcome in selected patients with acute ischemic stroke. Effective therapy requires early detection of the signs of stroke; prompt activation of the EMS system and dispatch of EMS personnel; appropriate triage to a stroke center; prearrival notification; rapid triage, evaluation, and management in the emergency department; and prompt delivery of fibrinolytic therapy to eligible patients. Since 2010, the AHA and the American Stroke Association have published clinical practice guidelines pertaining to the early management of patients with acute ischemic stroke.[149,150]

Drowning

Drowning is a leading cause of unintentional injury and death worldwide and a preventable cause of death for more than 4000 Americans annually.[151,152] The highest rates of morbidity and mortality are among children aged 1 to 4 years.[152] The incidence of fatal drowning has declined from 1.45 deaths per 100 000 population in 2000 to 1.26 in 2013.[152] Immediate resuscitation to restore oxygenation and ventilation—especially by bystanders—is essential for survival after a drowning incident.

This topic was last reviewed in 2010, and the treatment recommendations have not changed.

Since the 2010 Guidelines, there has been a growing appreciation for the fact that the response to the submersion victim often involves a multiagency approach with several different organizations responsible for different phases of the victim's care, from the initial aquatic rescue, on-scene resuscitation, transport to hospital, and in-hospital care. Attempting the rescue of a submerged victim has substantial resource implications and may place rescuers at risk themselves.

Unintentional Hypothermia

This topic was last reviewed in 2010, and the treatment recommendations have not changed.

Foreign-Body Airway Obstruction

This topic was last reviewed in 2010, and the treatment recommendations have not changed.

Disclosures

Part 5: Adult Basic Life Support and Cardiopulmonary Resuscitation Quality: 2015 Guidelines Update Writing Group Disclosures

Writing Group Member	Employment	Research Grant	Other Research Support	Speakers' Bureau/ Honoraria	Expert Witness	Ownership Interest	Consultant/ Advisory Board	Other
Monica E. Kleinman	Boston Children's Hospital	None	None	None	None	None	None	None
Bentley J. Bobrow	Arizona Department of Health Services	Medtronic Foundation†	None	None	None	None	None	None
Erin E. Brennan	Queen's University	None	None	None	None	None	None	None
Raúl J. Gazmuri	Rosalind Franklin University of Medicine and Science	VA Merit Review Grant†; Defense Medical Research and Development Program (DMRDP), Applied Research and Technology Development Award (ARADTA)†; Chicago Medical School and Advocate Lutheran General Hospital Translational Research Pilot Grant Program†; Baxter Healthcare Corporation†; Friends Medical Research Institute†; ZOLL Medical Corporation†	None	None	None	None	None	None
Zachary D. Goldberger	University of Washington	None	None	None	None	None	None	None
Thomas Rea	Department of Medicine, University of Washington; Public Health-Seattle and King County, Emergency Medical Services Division	Philips*; Medtronic Foundation*; NIH*; Laerdal Foundation*; Life Sciences Discovery Fund*	None	None	None	None	None	University of Washington*
Robert A. Swor	William Beaumont Hospital	None	None	None	None	None	None	None
Mark Terry	Johnson County MED-ACT	None	None	None	None	None	None	None
Consultant								
Andrew H. Travers	Emergency Health Services, Nova Scotia	None	None	None	None	None	American Heart Association†	None

This table represents the relationships of writing group members that may be perceived as actual or reasonably perceived conflicts of interest as reported on the Disclosure Questionnaire, which all members of the writing group are required to complete and submit. A relationship is considered to be "significant" if (a) the person receives $10 000 or more during any 12-month period, or 5% or more of the person's gross income; or (b) the person owns 5% or more of the voting stock or share of the entity, or owns $10 000 or more of the fair market value of the entity. A relationship is considered to be "modest" if it is less than "significant" under the preceding definition.

*Modest.

†Significant.

Appendix

2015 Guidelines Update: Part 5 Recommendations

Year Last Reviewed	Topic	Recommendation	Comments
2015	Immediate Recognition and Activation of the Emergency Response System	It is recommended that emergency dispatchers determine if a patient is unresponsive with abnormal breathing after acquiring the requisite information to determine the location of the event (Class I, LOE C-LD).	updated for 2015
2015	Immediate Recognition and Activation of the Emergency Response System	If the patient is unresponsive with abnormal or absent breathing, it is reasonable for the emergency dispatcher to assume that the patient is in cardiac arrest (Class IIa, LOE C-LD).	updated for 2015
2015	Immediate Recognition and Activation of the Emergency Response System	Dispatchers should be educated to identify unresponsiveness with abnormal breathing and agonal gasps across a range of clinical presentations and descriptions (Class I, LOE C-LD).	updated for 2015
2015	Early CPR	Similar to the 2010 Guidelines, it may be reasonable for rescuers to initiate CPR with chest compressions (Class IIb, LOE C-LD).	updated for 2015
2015	Untrained Lay Rescuer	Untrained lay rescuers should provide compression-only CPR, with or without dispatcher assistance (Class I, LOE C-LD).	updated for 2015
2015	Untrained Lay Rescuer	The rescuer should continue compression-only CPR until the arrival of an AED or rescuers with additional training (Class I, LOE C-LD).	updated for 2015
2015	Trained Lay Rescuer	All lay rescuers should, at a minimum, provide chest compressions for victims of cardiac arrest (Class I, LOE C-LD). In addition, if the trained lay rescuer is able to perform rescue breaths, he or she should add rescue breaths in a ratio of 30 compressions to 2 breaths.	updated for 2015
2015	Trained Lay Rescuer	The rescuer should continue CPR until an AED arrives and is ready for use or EMS providers take over care of the victim (Class I, LOE C-LD).	updated for 2015
2015	Healthcare Provider	It is reasonable for healthcare providers to provide chest compressions and ventilation for all adult patients in cardiac arrest, from either a cardiac or noncardiac cause (Class IIa, LOE C-LD).	updated for 2015
2015	Delayed Ventilation	For witnessed OHCA with a shockable rhythm, it may be reasonable for EMS systems with priority-based, multitiered response to delay positive-pressure ventilation by using a strategy of up to 3 cycles of 200 continuous compressions with passive oxygen insufflation and airway adjuncts (Class IIb, LOE C-LD).	new for 2015
2015	Recognition of Arrest	Dispatchers should instruct rescuers to provide CPR if the victim is unresponsive with no normal breathing, even when the victim demonstrates occasional gasps (Class I, LOE C-LD).	updated for 2015
2015	Suspected Opioid-Related Life-Threatening Emergency	For a patient with known or suspected opioid addiction who has a definite pulse but no normal breathing or only gasping (ie, a respiratory arrest), in addition to providing standard BLS care, it is reasonable for appropriately trained BLS healthcare providers to administer intramuscular or intranasal naloxone (Class IIa, LOE C-LD).	new for 2015
2015	Suspected Opioid-Related Life-Threatening Emergency	For patients in cardiac arrest, medication administration is ineffective without concomitant chest compressions for drug delivery to the tissues, so naloxone administration may be considered after initiation of CPR if there is high suspicion for opiate overdose (Class IIb, LOE C-EO).	new for 2015
2015	Suspected Opioid-Related Life-Threatening Emergency	It is reasonable to provide opioid overdose response education with or without naloxone distribution to persons at risk for opioid overdose in any setting (Class IIa, LOE C-LD).	new for 2015
2015	Hand Position During Compressions	Consistent with the 2010 Guidelines, it is reasonable to position hands for chest compressions on the lower half of the sternum in adults with cardiac arrest (Class IIa, LOE C-LD).	updated for 2015
2015	Chest Compression Rate	In adult victims of cardiac arrest, it is reasonable for rescuers to perform chest compressions at a rate of 100/min to 120/min (Class IIa, LOE C-LD).	updated for 2015
2015	Chest Compression Depth	During manual CPR, rescuers should perform chest compressions to a depth of at least 2 inches or 5 cm for an average adult, while avoiding excessive chest compression depths (greater than 2.4 inches or 6 cm) (Class I, LOE C-LD).	updated for 2015
2015	Chest Wall Recoil	It is reasonable for rescuers to avoid leaning on the chest between compressions to allow full chest wall recoil for adults in cardiac arrest (Class IIa, LOE C-LD).	updated for 2015
2015	Minimizing Interruptions in Chest Compressions	In adult cardiac arrest, total preshock and postshock pauses in chest compressions should be as short as possible (Class I, LOE C-LD).	updated for 2015
2015	Minimizing Interruptions in Chest Compressions	For adults in cardiac arrest receiving CPR without an advanced airway, it is reasonable to pause compressions for less than 10 seconds to deliver 2 breaths (Class IIa, LOE C-LD).	updated for 2015

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2015 Guidelines Update: Part 5 Recommendations, *Continued*

Year Last Reviewed	Topic	Recommendation	Comments
2015	Minimizing Interruptions in Chest Compressions	In adult cardiac arrest with an unprotected airway, it may be reasonable to perform CPR with the goal of a chest compression fraction as high as possible, with a target of at least 60% (Class IIb, LOE C-LD).	new for 2015
2015	Compression-to-Ventilation Ratio	Consistent with the 2010 Guidelines, it is reasonable for rescuers to provide a compression-to-ventilation ratio of 30:2 for adults in cardiac arrest (Class IIa, LOE C-LD).	updated for 2015
2015	Layperson—Compression-Only CPR Versus Conventional CPR	Dispatchers should instruct untrained lay rescuers to provide compression-only CPR for adults with sudden cardiac arrest (Class I, LOE B-R).	updated for 2015
2015	Layperson—Compression-Only CPR Versus Conventional CPR	Compression-only CPR is a reasonable alternative to conventional CPR in the adult cardiac arrest patient (Class IIa, LOE C-LD).	updated for 2015
2015	Layperson—Compression-Only CPR Versus Conventional CPR	For trained rescuers, ventilation may be considered in addition to chest compressions for the adult in cardiac arrest (Class IIb, LOE C-LD).	updated for 2015
2015	Open the Airway: Lay Rescuer	For victims with suspected spinal injury, rescuers should initially use manual spinal motion restriction (eg, placing 1 hand on either side of the patient's head to hold it still) rather than immobilization devices, because use of immobilization devices by lay rescuers may be harmful (Class III: Harm, LOE C-LD).	updated for 2015
2015	Bag-Mask Ventilation	As long as the patient does not have an advanced airway in place, the rescuers should deliver cycles of 30 compressions and 2 breaths during CPR. The rescuer delivers breaths during pauses in compressions and delivers each breath over approximately 1 second (Class IIa, LOE C-LD).	updated for 2015
2015	Ventilation With an Advanced Airway	When the victim has an advanced airway in place during CPR, rescuers no longer deliver cycles of 30 compressions and 2 breaths (ie, they no longer interrupt compressions to deliver 2 breaths). Instead, it may be reasonable for the provider to deliver 1 breath every 6 seconds (10 breaths per minute) while continuous chest compressions are being performed (Class IIb, LOE C-LD).	updated for 2015
2015	Passive Oxygen Versus Positive-Pressure Oxygen During CPR	We do not recommend the routine use of passive ventilation techniques during conventional CPR for adults, because the usefulness/effectiveness of these techniques is unknown (Class IIb, LOE C-EO).	new for 2015
2015	Passive Oxygen Versus Positive-Pressure Oxygen During CPR	However, in EMS systems that use bundles of care involving continuous chest compressions, the use of passive ventilation techniques may be considered as part of that bundle (Class IIb, LOE C-LD).	new for 2015
2015	CPR Before Defibrillation	For witnessed adult cardiac arrest when an AED is immediately available, it is reasonable that the defibrillator be used as soon as possible (Class IIa, LOE C-LD).	updated for 2015
2015	CPR Before Defibrillation	For adults with unmonitored cardiac arrest or for whom an AED is not immediately available, it is reasonable that CPR be initiated while the defibrillator equipment is being retrieved and applied and that defibrillation, if indicated, be attempted as soon as the device is ready for use (Class IIa, LOE B-R).	updated for 2015
2015	Analysis of Rhythm During Compressions	There is insufficient evidence to recommend the use of artifact-filtering algorithms for analysis of ECG rhythm during CPR. Their use may be considered as part of a research program or if an EMS system has already incorporated ECG artifact-filtering algorithms in its resuscitation protocols (Class IIb, LOE C-EO).	new for 2015
2015	Timing of Rhythm Check	It may be reasonable to immediately resume chest compressions after shock delivery for adults in cardiac arrest in any setting (Class IIb, LOE C-LD).	updated for 2015
2015	Chest Compression Feedback	It may be reasonable to use audiovisual feedback devices during CPR for real-time optimization of CPR performance (Class IIb, LOE B-R).	updated for 2015
The following recommendations were not reviewed in 2015. For more information, see the *2010 AHA Guidelines for CPR and ECC*, "Part 5: Adult Basic Life Support."			
2010	Activating the Emergency Response System	The EMS system quality improvement process, including review of the quality of dispatcher CPR instructions provided to specific callers, is considered an important component of a high-quality lifesaving program (Class IIa, LOE B).	not reviewed in 2015
2010	Pulse Check	The healthcare provider should take no more than 10 seconds to check for a pulse and, if the rescuer does not definitely feel a pulse within that time period, the rescuer should start chest compressions (Class IIa, LOE C).	not reviewed in 2015
2010	Chest Compressions	Effective chest compressions are essential for providing blood flow during CPR. For this reason all patients in cardiac arrest should receive chest compressions (Class I, LOE B).	not reviewed in 2015
2010	Rescue Breaths	Deliver each rescue breath over 1 second (Class IIa, LOE C).	not reviewed in 2015
2010	Rescue Breaths	Give a sufficient tidal volume to produce visible chest rise (Class IIa, LOE C).	not reviewed in 2015

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2015 Guidelines Update: Part 5 Recommendations, *Continued*

Year Last Reviewed	Topic	Recommendation	Comments
2010	Early Defibrillation With an AED	When 2 or more rescuers are present, one rescuer should begin chest compressions while a second rescuer activates the emergency response system and gets the AED (or a manual defibrillator in most hospitals) (Class IIa, LOE C).	not reviewed in 2015
2010	Recognition of Arrest	The rescuer should treat the victim who has occasional gasps as if he or she is not breathing (Class I, LOE C).	not reviewed in 2015
2010	Technique: Chest Compressions	The rescuer should place the heel of one hand on the center (middle) of the victim's chest (which is the lower half of the sternum) and the heel of the other hand on top of the first so that the hands are overlapped and parallel (Class IIa, LOE B).	not reviewed in 2015
2010	Technique: Chest Compressions	Because of the difficulty in providing effective chest compressions while moving the patient during CPR, the resuscitation should generally be conducted where the patient is found (Class IIa, LOE C).	not reviewed in 2015
2010	Compression-Ventilation Ratio	Once an advanced airway is in place, 2 rescuers no longer need to pause chest compressions for ventilations. Instead, the compressing rescuer should give continuous chest compressions at a rate of at least 100 per minute without pauses for ventilation (Class IIa, LOE B).	not reviewed in 2015
2010	Open the Airway: Lay Rescuer	The trained lay rescuer who feels confident that he or she can perform both compressions and ventilations should open the airway using a head tilt–chin lift maneuver (Class IIa, LOE B).	not reviewed in 2015
2010	Open the Airway: Healthcare Provider	Although the head tilt–chin lift technique was developed using unconscious, paralyzed adult volunteers and has not been studied in victims with cardiac arrest, clinical and radiographic evidence and a case series have shown it to be effective (Class IIa, LOE B).	not reviewed in 2015
2010	Open the Airway: Healthcare Provider	If healthcare providers suspect a cervical spine injury, they should open the airway using a jaw thrust without head extension (Class IIb, LOE C).	not reviewed in 2015
2010	Open the Airway: Healthcare Provider	Because maintaining a patent airway and providing adequate ventilation are priorities in CPR (Class I, LOE C), use the head tilt–chin lift maneuver if the jaw thrust does not adequately open the airway.	not reviewed in 2015
2010	Rescue Breathing	During adult CPR, tidal volumes of approximately 500 to 600 mL (6 to 7 mL/kg) should suffice (Class IIa, LOE B).	not reviewed in 2015
2010	Rescue Breathing	Rescuers should avoid excessive ventilation (too many breaths or too large a volume) during CPR (Class III, LOE B).	not reviewed in 2015
2010	Mouth-to-Mouth Rescue Breathing	Give 1 breath over 1 second, take a "regular" (not a deep) breath, and give a second rescue breath over 1 second (Class IIb, LOE C).	not reviewed in 2015
2010	Mouth-to-Mouth Rescue Breathing	If an adult victim with spontaneous circulation (ie, strong and easily palpable pulses) requires support of ventilation, the healthcare provider should give rescue breaths at a rate of about 1 breath every 5 to 6 seconds, or about 10 to 12 breaths per minute (Class IIb, LOE C).	not reviewed in 2015
2010	Mouth-to-Nose and Mouth-to-Stoma Ventilation	Mouth-to-nose ventilation is recommended if ventilation through the victim's mouth is impossible (eg, the mouth is seriously injured), the mouth cannot be opened, the victim is in water, or a mouth-to-mouth seal is difficult to achieve (Class IIa, LOE C).	not reviewed in 2015
2010	Mouth-to-Nose and Mouth-to-Stoma Ventilation	A reasonable alternative is to create a tight seal over the stoma with a round, pediatric face mask (Class IIb, LOE C).	not reviewed in 2015
2010	Bag-Mask Ventilation	The rescuer should use an adult (1 to 2 L) bag to deliver approximately 600 mL tidal volume for adult victims. This amount is usually sufficient to produce visible chest rise and maintain oxygenation and normocarbia in apneic patients (Class IIa, LOE C).	not reviewed in 2015
2010	Bag-Mask Ventilation	The rescuer delivers ventilations during pauses in compressions and delivers each breath over 1 second (Class IIa, LOE C).	not reviewed in 2015
2010	Mouth-to-Nose and Mouth-to-Stoma Ventilation	Ventilation with a bag through these devices provides an acceptable alternative to bag-mask ventilation for well-trained healthcare providers who have sufficient experience to use the devices for airway management during cardiac arrest (Class IIa, LOE B).	not reviewed in 2015
2010	Cricoid Pressure	The routine use of cricoid pressure in adult cardiac arrest is not recommended (Class III, LOE B).	not reviewed in 2015
2010	AED Defibrillation	Rapid defibrillation is the treatment of choice for VF of short duration, such as for victims of witnessed out-of-hospital cardiac arrest or for hospitalized patients whose heart rhythm is monitored (Class I, LOE A).	not reviewed in 2015
2010	AED Defibrillation	There is insufficient evidence to recommend for or against delaying defibrillation to provide a period of CPR for patients in VF/pulseless VT out-of-hospital cardiac arrest. In settings with lay rescuer AED programs (AED onsite and available) and for in-hospital environments, or if the EMS rescuer witnesses the collapse, the rescuer should use the defibrillator as soon as it is available (Class IIa, LOE C).	not reviewed in 2015
2010	Recovery Position	The position should be stable, near a true lateral position, with the head dependent and with no pressure on the chest to impair breathing (Class IIa, LOE C).	not reviewed in 2015

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2015 Guidelines Update: Part 5 Recommendations, *Continued*

Year Last Reviewed	Topic	Recommendation	Comments
2010	Acute Coronary Syndromes	If the patient has not taken aspirin and has no history of aspirin allergy and no evidence of recent gastrointestinal bleeding, EMS providers should give the patient nonenteric aspirin (160 to 325 mg) to chew (Class I, LOE C).	not reviewed in 2015
2010	Acute Coronary Syndromes	Although it is reasonable to consider the early administration of nitroglycerin in select hemodynamically stable patients, insufficient evidence exists to support or refute the routine administration of nitroglycerin in the ED or prehospital setting in patients with a suspected ACS (Class IIb, LOE B).	not reviewed in 2015
2010	Stroke	Patients at high risk for stroke, their family members, and BLS providers should learn to recognize the signs and symptoms of stroke and to call EMS as soon as any signs of stroke are present (Class I, LOE C).	not reviewed in 2015
2010	Stroke	EMS dispatchers should be trained to suspect stroke and rapidly dispatch emergency responders. EMS personnel should be able to perform an out-of-hospital stroke assessment (Class I, LOE B), establish the time of symptom onset when possible, provide cardiopulmonary support, and notify the receiving hospital that a patient with possible stroke is being transported.	not reviewed in 2015
2010	Stroke	EMS systems should have protocols that address triaging the patient when possible directly to a stroke center (Class I, LOE B).	not reviewed in 2015
2010	Stroke	Both out-of-hospital and inhospital medical personnel should administer supplementary oxygen to hypoxemic (ie, oxygen saturation <94%) stroke patients (Class I, LOE C) or those with unknown oxygen saturation.	not reviewed in 2015
2010	Stroke	Unless the patient is hypotensive (systolic blood pressure <90 mm Hg), prehospital intervention for blood pressure is not recommended (Class III, LOE C).	not reviewed in 2015
2010	Drowning	Mouth-to-mouth ventilation in the water may be helpful when administered by a trained rescuer (Class IIb, LOE C).	not reviewed in 2015

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KEY WORDS: cardiac arrest ■ cardiopulmonary resuscitation ■ defibrillation ■ emergency

Part 6: Alternative Techniques and Ancillary Devices for Cardiopulmonary Resuscitation

2015 American Heart Association Guidelines Update for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care

Steven C. Brooks, Chair; Monique L. Anderson; Eric Bruder; Mohamud R. Daya; Alan Gaffney; Charles W. Otto; Adam J. Singer; Ravi R. Thiagarajan; Andrew H. Travers

Introduction

Conventional cardiopulmonary resuscitation (CPR) consisting of manual chest compressions with rescue breaths is inherently inefficient with respect to generating cardiac output. A variety of alternatives and adjuncts to conventional CPR have been developed, with the aim of enhancing perfusion during resuscitation from cardiac arrest. Since the publication of the *2010 American Heart Association* (AHA) *Guidelines for CPR and Emergency Cardiovascular Care* (ECC),[1] a number of clinical trials have provided additional data on the effectiveness of these alternatives and adjuncts. Compared with conventional CPR, many of these techniques and devices require specialized equipment and training. Some have only been tested in highly selected subgroups of cardiac arrest patients; this context must be considered when rescuers or healthcare systems are considering implementation.

Methodology

The recommendations in this *2015 AHA Guidelines Update for CPR and ECC* are based on an extensive evidence review process that was begun by the International Liaison Committee on Resuscitation (ILCOR) after the publication of the ILCOR *2010 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science With Treatment Recommendations*[2,3] and was completed in February 2015.[4,5]

In this in-depth evidence review process, the ILCOR Advanced Life Support (ALS) Task Force examined topics and then generated a prioritized list of questions for systematic review. Questions were first formulated in PICO (population, intervention, comparator, outcome) format,[6] search strategies and criteria for inclusion and exclusion of articles were defined, and then a search for relevant articles was performed. The evidence was evaluated by the ILCOR ALS Task Force by using the standardized methodological approach proposed by the Grading of Recommendations Assessment, Development, and Evaluation (GRADE) Working Group.[7]

The quality of the evidence was categorized based on the study methodologies and the 5 core GRADE domains of risk of bias, inconsistency, indirectness, imprecision, and other considerations (including publication bias). Then, where possible, consensus-based treatment recommendations were created.

To create this *2015 AHA Guidelines Update for CPR and ECC*, the AHA formed 15 writing groups, with careful attention to manage conflicts of interest, to assess the ILCOR treatment recommendations, and to write AHA Guidelines and treatment recommendations by using the AHA Class of Recommendation and Level of Evidence (LOE) system. The recommendations made in the *2015 AHA Guidelines Update for CPR and ECC* are informed by the ILCOR recommendations and GRADE classification, in the context of the delivery of medical care in North America. Throughout the online version of this publication, live links are provided so the reader can connect directly to the systematic reviews on the ILCOR Scientific Evidence Evaluation and Review System (SEERS) website. These links are indicated by a superscript combination of letters and numbers (eg, ALS 579). We encourage readers to use the links and review the evidence and appendixes, such as the GRADE tables. For further information, please see Part 2 of this supplement, "Evidence Evaluation and Management of Conflicts of Interest."

The following CPR techniques and devices were last reviewed in 2010[2,3]: open-chest CPR, interposed abdominal compression, "cough" CPR, prone CPR, precordial thump, percussion pacing, and devices to assist ventilation. The reader is referred to the 2010 Guidelines for details of those recommendations.[1] A listing of all of the recommendations in this 2015 Guidelines Update and the recommendations from "Part 7: CPR Techniques and Devices" of the 2010 Guidelines can be found in the Appendix.

Devices to Support Circulation

Impedance Threshold Device[ALS 579]

The impedance threshold device (ITD) is a pressure-sensitive valve that is attached to an endotracheal tube (ETT), supraglottic airway, or face mask. The ITD limits air entry into the lungs

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during the decompression phase of CPR, enhancing the negative intrathoracic pressure generated during chest wall recoil, thereby improving venous return to the heart and cardiac output during CPR. It does so without impeding positive-pressure ventilation or passive exhalation. The ITD is removed after return of spontaneous circulation (ROSC) is achieved. The ITD has been used alone as a circulatory adjunct as well as in conjunction with active compression-decompression CPR (ACD-CPR) devices. The ITD and ACD-CPR are thought to act synergistically to enhance venous return and improve cardiac output during CPR.[8,9] Although initially used as part of a circuit with a cuffed ETT during bag-tube ventilation, the ITD can also be used with a face mask, provided that a tight seal is maintained between the face and mask.

2015 Evidence Summary

Three randomized controlled trials (RCTs) in humans have examined the benefits of incorporating the ITD as an adjunct to conventional CPR in out-of-hospital cardiac arrest (OHCA). One small single-site RCT of 22 patients with femoral artery catheters demonstrated that a functioning ITD applied to an ETT significantly increased systolic blood pressures as compared with a sham device, although there was no difference in ROSC rates.[10] The second RCT examined the safety and survival to intensive care unit admission of a functioning versus sham ITD in 230 patients.[11] The ITD was initially placed on a face mask and was relocated to the ETT after intubation. This study found no difference in ROSC, intensive care unit admission, or 24-hour survival between the 2 groups. The third and largest RCT examined the impact of a functioning ITD versus a sham device at 10 sites in the United States and Canada as part of the Resuscitation Outcomes Consortium (ROC) Prehospital Resuscitation Impedance Valve and Early Versus Delayed Analysis (PRIMED) study.[12] Of the 8718 patients included in this high-quality RCT, 4345 were randomized to resuscitation with a sham ITD and 4373 were assigned to resuscitation with the functioning ITD. The ROC PRIMED study permitted placement of the ITD on a face mask, supraglottic airway, or ETT. This large multicenter RCT did not show a benefit from the addition of the ITD to conventional CPR for neurologically intact survival to hospital discharge or survival to hospital discharge. There were no differences in adverse events (pulmonary edema or airway bleeding) between the 2 groups.

2015 Recommendation—New

The routine use of the ITD as an adjunct during conventional CPR is not recommended (Class III: No Benefit, LOE A). This Class of Recommendation, new in 2015, indicates that high-quality evidence did not demonstrate benefit or harm associated with the ITD when used as an adjunct to conventional CPR.

Active Compression-Decompression CPR and Impedance Threshold Device[ALS 579]

ACD-CPR is performed by using a handheld device with a suction cup applied over the midsternum of the chest. After chest compression, the device is used to actively lift up the anterior chest during decompressions. The application of external negative suction during decompression enhances the negative intrathoracic pressure (vacuum) generated by chest recoil, thereby increasing venous return (preload) to the heart and cardiac output during the next chest compression. ACD-CPR is believed to act synergistically with the ITD to enhance venous return during chest decompression and improves blood flow to vital organs during CPR. Commercially available ACD-CPR devices have a gauge meter to guide compression and decompression forces and a metronome to guide duty cycle and chest compression rate. The use of ACD-CPR in comparison with conventional CPR was last reviewed for the 2010 Guidelines. Since the 2010 Guidelines, new evidence is available regarding the use of ACD-CPR in combination with the ITD.

2015 Evidence Summary

The combination of ACD-CPR with an ITD has been studied in 4 RCTs reported in 5 publications.[9,13–16] Two of these trials evaluated ACD-CPR with the ITD in comparison with ACD-CPR alone.[9,13] The first of these used femoral artery catheters to measure improved hemodynamic parameters but found no difference in ROSC, 24-hour survival, or survival to hospital discharge.[9] In a follow-up RCT of 400 patients, the ACD-CPR with a functioning ITD increased 24-hour survival, but again there was no difference in survival to hospital discharge or survival with good neurologic function as compared with the ACD-CPR with sham ITD group.[13]

The remaining 2 RCTs compared ACD-CPR with the ITD versus conventional CPR. The first was a single-center RCT in which 210 patients were randomly assigned to ACD-CPR+ITD or conventional CPR after intubation by the advanced life support team, which arrived on scene a mean of 9.5 minutes after the 9-1-1 call.[14] The chest compression and ventilation rates in both arms were 100/min and 10 to 12 breaths/min, respectively. The ROSC, 1-hour, and 24-hour rates of survival were all significantly improved in the ACD-CPR+ITD group as compared with conventional CPR, but survival to hospital discharge and survival with favorable neurologic outcome were not significantly different. The second trial is the ResQ trial, which was conducted in 7 distinct geographic regions of the United States. In the ResQ trial, conventional CPR was performed with compressions at 100/min, with a compression-to-ventilation ratio of 30:2 during basic life support and ventilation rate of 10/min after intubation. In the ACD-CPR+ITD group, compressions were performed at a rate of 80/min and ventilation at a rate of 10/min. In the intervention arm, a metronome was used to guide the compression rate, a force gauge was used to guide compression depth and recoil, and timing lights on the ITD were used to guide ventilation rate. Two analyses of data from the ResQ trial have been published; the first was restricted to OHCA of presumed cardiac etiology,[15] and the second included all enrolled patients.[16] The complete trial enrolled 2738 patients (conventional CPR=1335, ACD-CPR+ITD=1403) before it was terminated early because of funding constraints.[16] Survival to hospital discharge with favorable neurologic function (modified Rankin Scale score of 3 or less) was greater in the ACD-CPR+ITD group as compared with the conventional CPR group: 7.9% versus 5.7% (odds ratio, 1.42; 95% confidence interval, 1.04–1.95), and this difference was maintained

out to 1 year. For survival to hospital discharge with favorable neurologic function, this translates into a number needed to treat of 45 with very wide confidence limits (95% confidence interval, 25–333), making interpretation of the true clinical effect challenging. There was no difference in the overall incidence of adverse events, although pulmonary edema was more common with ACD-CPR+ITD as compared with conventional CPR (11.3% versus 7.9%; *P*=0.002). The ResQ Trial had a number of important limitations, including lack of blinding, different CPR feedback elements between the study arms (ie, co-intervention), lack of CPR quality assessment, and early termination. Although improved neurologic function was noted with the use of the ACD-CPR+ITD combination at both hospital discharge and 1-year follow-up, additional trials are needed to confirm these findings.

2015 Recommendation—New

The existing evidence, primarily from 1 large RCT of low quality, does not support the routine use of ACD-CPR+ITD as an alternative to conventional CPR. The combination may be a reasonable alternative in settings with available equipment and properly trained personnel (Class IIb, LOE C-LD).

Mechanical Chest Compression Devices: Piston Device[ALS 782]

A mechanical piston device consists of an automated compressed gas- or electric-powered plunger positioned over the sternum, which compresses the chest at a set rate. Some devices incorporate a suction cup at the end of the piston that is designed to actively decompress the chest after each compression, whereas others do not.

2015 Evidence Review

The Lund University Cardiac Arrest System (LUCAS) is a gas- (oxygen or air) or electric-powered piston device that produces a consistent chest compression rate and depth. It incorporates a suction cup on the end of the piston that attaches to the sternum and returns the sternum to the starting position when it retracts. A small pilot RCT found similar survival in patients randomly assigned to mechanical versus manual chest compressions.[17] Subsequently, 2 large RCTs, the Prehospital Randomised Assessment of a Mechanical Compression Device in Cardiac Arrest (PARAMEDIC)[18] and LUCAS in Cardiac Arrest (LINC)[19] trials, have compared the use of LUCAS against manual compressions for patients with OHCA. Together, these studies enrolled 7060 patients, and neither demonstrated a benefit for mechanical CPR over manual CPR with respect to early (4-hour) and late (1- and 6-month) survival.[18,19] The PARAMEDIC study demonstrated a negative association between mechanical chest compressions and survival with good neurologic outcome (Cerebral Performance Category 1–2) at 3 months as compared with manual compressions.

A number of other mechanical piston devices have been compared with manual chest compressions in studies of OHCA. There are no large-scale RCTs with these devices. Three small (largest sample size of 50 patients) RCTs found no differences in early survival[20–22] despite improvements in end-tidal CO_2 in patients randomly assigned to mechanical piston devices in 2 of these 3 studies.[21,22] However, in neither of these studies did any patient survive to hospital discharge. Time-motion analysis of manual versus mechanical chest compressions showed that it took considerable time to deploy the mechanical piston device, prolonging the no-chest compression interval during CPR.[23]

2015 Recommendations—New

The evidence does not demonstrate a benefit with the use of mechanical piston devices for chest compressions versus manual chest compressions in patients with cardiac arrest. Manual chest compressions remain the standard of care for the treatment of cardiac arrest, but mechanical piston devices may be a reasonable alternative for use by properly trained personnel (Class IIb, LOE B-R). The use of mechanical piston devices may be considered in specific settings where the delivery of high-quality manual compressions may be challenging or dangerous for the provider (eg, limited rescuers available, prolonged CPR, during hypothermic cardiac arrest, in a moving ambulance, in the angiography suite, during preparation for extracorporeal CPR [ECPR]), provided that rescuers strictly limit interruptions in CPR during deployment and removal of the devices (Class IIb, LOE C-EO).

Load-Distributing Band Devices[ALS 782]

The load-distributing band (LDB) is a circumferential chest compression device composed of a pneumatically or electrically actuated constricting band and backboard.

2015 Evidence Summary

While early case series[24–26] of patients treated with LDB-CPR were encouraging, an observational study exploring a number of treatments related to new guideline implementation suggested that the use of LDB-CPR was associated with lower odds of 30-day survival when compared with concurrent patients receiving only manual CPR.[27] One multicenter prospective RCT[28] comparing LDB-CPR (Autopulse device) with manual CPR for OHCA demonstrated no improvement in 4-hour survival and worse neurologic outcome when the device was compared with manual CPR. Site-specific factors[29] and experience with deployment of the device[30] may have influenced the outcomes in this study. In a high-quality multicenter RCT of 4753 OHCA patients, LDB-CPR (Autopulse device) and manual chest compressions were shown to be equivalent with respect to the outcome of survival to hospital discharge. Both approaches in this study were carefully monitored to minimize hands-off time and to optimize compression technique.[31]

2015 Recommendations—New

The evidence does not demonstrate a benefit with the use of LDB-CPR for chest compressions versus manual chest compressions in patients with cardiac arrest. Manual chest compressions remain the standard of care for the treatment of cardiac arrest, but LDB-CPR may be a reasonable alternative for use by properly trained personnel (Class IIb, LOE B-R). The use of LDB-CPR may be considered in specific settings where the delivery of high-quality manual compressions may be challenging or dangerous for the provider (eg, limited rescuers available, prolonged CPR, during hypothermic cardiac arrest, in a moving ambulance, in the angiography suite,

during preparation for ECPR), provided that rescuers strictly limit interruptions in CPR during deployment and removal of the devices (Class IIb, LOE C-EO).

Extracorporeal Techniques and Invasive Perfusion Devices

Extracorporeal CPR[ALS 723]

For the purpose of this Guidelines Update, the term *ECPR* is used to describe the initiation of cardiopulmonary bypass during the resuscitation of a patient in cardiac arrest. This involves the emergency cannulation of a large vein and artery (eg, femoral vessels) and initiation of venoarterial extracorporeal circulation and oxygenation. The goal of ECPR is to support patients between cardiac arrest and restoration of spontaneous circulation while potentially reversible conditions are addressed. ECPR is a complex process that requires a highly trained team, specialized equipment, and multidisciplinary support within the local healthcare system.

2015 Evidence Summary

There are no data on the use of ECPR from RCTs. Early observational studies in small numbers of witnessed in-hospital cardiac arrest (IHCA) and OHCA patients younger than 75 years with potentially reversible conditions suggested improved survival when compared with conventional CPR.[32–36] Patients receiving ECPR in these studies tended to be younger, with more witnessed arrests and bystander CPR.

The 2015 ILCOR ALS Task Force reviewed several observational studies, some of which used propensity matching. The results of the studies are mixed. One propensity-matched prospective observational study enrolling 172 IHCA patients reported greater likelihood of return of spontaneous beating in the ECPR group (compared with ROSC in the conventional CPR group) and improved survival at hospital discharge, 30-day, and 1-year follow-up with the use of ECPR. However, this study showed no difference in neurologic outcomes.[37] A retrospective observational study including 120 IHCA patients with historic control reported a modest benefit in both survival and neurologic outcome at discharge and 6-month follow-up with the use of ECPR versus conventional CPR.[38] A propensity-matched retrospective observational study enrolling 118 IHCA patients showed no survival or neurologic benefit with ECPR at the time of hospital discharge, 30-day, or 1-year follow-up.[36] One post hoc analysis of data from a prospective, observational cohort of 162 OHCA patients, including propensity score matching, showed that ECPR was associated with a higher rate of neurologically intact survival at 3-month follow-up.[39] A prospective observational study enrolling 454 OHCA patients demonstrated improved neurologic outcomes with the use of ECPR at 1-month and 6-month follow-up after arrest.[40]

2015 Recommendation—New

There is insufficient evidence to recommend the routine use of ECPR for patients with cardiac arrest. In settings where it can be rapidly implemented, ECPR may be considered for select patients for whom the suspected etiology of the cardiac arrest is potentially reversible during a limited period of mechanical cardiorespiratory support (Class IIb, LOE C-LD). Published series have used rigorous inclusion and exclusion criteria to select patients for ECPR. Although these inclusion criteria are highly variable, most included only patients aged 18 to 75 years, with arrest of cardiac origin, after conventional CPR for more than 10 minutes without ROSC. Such inclusion criteria should be considered in a provider's selection of potential candidates for ECPR.

Disclosures

Part 6: Alternative Techniques and Ancillary Devices for Cardiopulmonary Resuscitation: 2015 Guidelines Update Writing Group Disclosures

Writing Group Member	Employment	Research Grant	Other Research Support	Speakers' Bureau/ Honoraria	Expert Witness	Ownership Interest	Consultant/ Advisory Board	Other
Steven C. Brooks	Queen's University	Heart and Stroke Foundation†; South Eastern Ontario Academic Medical Organization†; Canadian Institutes of Health Research†; National Institutes of Health Research†; Department of Defense, Canada†; US Military†; Heart and Stroke Foundation of Canada†	None	None	None	None	None	South Eastern Ontario Academic Medicine Organization†
Monique L. Anderson	Duke Clinical Research Institute	None	None	None	None	None	None	None
Eric Bruder	Emergency Medicine	None	None	None	None	None	None	None
Mohamud R. Daya	Oregon Health and Science University	NIH-NHLBI†; NIH*; NIH-NINR*	None	None	None	None	Philips Health Care –Uncompensated*	None
Alan Gaffney	Columbia University Medical Center; University of Arizona	None	None	None	None	None	None	None
Charles W. Otto	University of Arizona College of Medicine	None	None	None	None	None	None	None
Adam J. Singer	Stony Brook University	AHA*; NY State*	None	None	None	None	None	None
Ravi R. Thiagarajan	Children's Hospital, Boston	NHLBI*	None	None	None	None	None	None
Consultant								
Andrew H. Travers	Emergency Health Services, Nova Scotia	None	None	None	None	None	American Heart Association†	None

This table represents the relationships of writing group members that may be perceived as actual or reasonably perceived conflicts of interest as reported on the Disclosure Questionnaire, which all members of the writing group are required to complete and submit. A relationship is considered to be "significant" if (a) the person receives $10 000 or more during any 12-month period, or 5% or more of the person's gross income; or (b) the person owns 5% or more of the voting stock or share of the entity, or owns $10 000 or more of the fair market value of the entity. A relationship is considered to be "modest" if it is less than "significant" under the preceding definition.

*Modest.

†Significant.

Appendix

2015 Guidelines Update: Part 6 Recommendations

Year Last Reviewed	Topic	Recommendation	Comments
2015	Devices to Support Circulation: Impedance Threshold Device	The routine use of the ITD as an adjunct during conventional CPR is not recommended (Class III: No Benefit, LOE A).	new for 2015
2015	Devices to Support Circulation: Active Compression-Decompression CPR and Impedance Threshold Device	The existing evidence, primarily from 1 large RCT of low quality, does not support the routine use of ACD-CPR+ITD as an alternative to conventional CPR. The combination may be a reasonable alternative in settings with available equipment and properly trained personnel (Class IIb, LOE C-LD).	new for 2015
2015	Devices to Support Circulation: Mechanical Chest Compression Devices: Piston Device	The evidence does not demonstrate a benefit with the use of mechanical piston devices for chest compressions versus manual chest compressions in patients with cardiac arrest. Manual chest compressions remain the standard of care for the treatment of cardiac arrest, but mechanical chest compressions using a piston device may be a reasonable alternative for use by properly trained personnel (Class IIb, LOE B-R).	new for 2015
2015	Devices to Support Circulation: Mechanical Chest Compression Devices: Piston Device	The use of piston devices for CPR may be considered in specific settings where the delivery of high-quality manual compressions may be challenging or dangerous for the provider (eg, limited rescuers available, prolonged CPR, during hypothermic cardiac arrest, in a moving ambulance, in the angiography suite, during preparation for extracorporeal CPR [ECPR]), provided that rescuers strictly limit interruptions in CPR during deployment and removal of the device (Class IIb, LOE C-EO).	new for 2015
2015	Devices to Support Circulation: Load-Distributing Band Devices	The evidence does not demonstrate a benefit with the use of LDB-CPR for chest compressions versus manual chest compressions in patients with cardiac arrest. Manual chest compressions remain the standard of care for the treatment of cardiac arrest, but LDB-CPR may be a reasonable alternative for use by properly trained personnel (Class IIb, LOE B-R).	new for 2015
2015	Devices to Support Circulation: Load-Distributing Band Devices	The use of LDB-CPR may be considered in specific settings where the delivery of high-quality manual compressions may be challenging or dangerous for the provider (eg, limited rescuers available, prolonged CPR, during hypothermic cardiac arrest, in a moving ambulance, in the angiography suite, during preparation for extracorporeal CPR [ECPR]), provided that rescuers strictly limit interruptions in CPR during deployment and removal of the devices (Class IIb, LOE E).	new for 2015
2015	Extracorporeal Techniques and Invasive Perfusion Devices: Extracorporeal CPR	There is insufficient evidence to recommend the routine use of ECPR for patients with cardiac arrest. It may be considered for select patients for whom the suspected etiology of the cardiac arrest is potentially reversible during a limited period of mechanical cardiorespiratory support (Class IIb, LOE C-LD).	new for 2015
The following recommendations were not reviewed in 2015. For more information, see the *2010 AHA Guidelines for CPR and ECC*, "Part 7: CPR Techniques and Devices"			
2010	Open-Chest CPR	Open-chest CPR can be useful if cardiac arrest develops during surgery when the chest or abdomen is already open, or in the early postoperative period after cardiothoracic surgery (Class IIa, LOE C).	not reviewed in 2015
2010	Open-Chest CPR	A resuscitative thoracotomy to facilitate open-chest CPR may be considered in very select circumstances of adults and children with out-of-hospital cardiac arrest from penetrating trauma with short transport times to a trauma facility (Class IIb, LOE C).	not reviewed in 2015
2010	Interposed Abdominal Compression-CPR	IAC-CPR may be considered during in-hospital resuscitation when sufficient personnel trained in its use are available (Class IIb, LOE B).	not reviewed in 2015
2010	"Cough" CPR	"Cough" CPR may be considered in settings such as the cardiac catheterization laboratory for conscious, supine, and monitored patients if the patient can be instructed and coached to cough forcefully every 1 to 3 seconds during the initial seconds of an arrhythmic cardiac arrest. It should not delay definitive treatment (Class IIb, LOE C).	not reviewed in 2015
2010	Prone CPR	When the patient cannot be placed in the supine position, it may be reasonable for rescuers to provide CPR with the patient in the prone position, particularly in hospitalized patients with an advanced airway in place (Class IIb, LOE C).	not reviewed in 2015
2010	Precordial Thump	The precordial thump should not be used for unwitnessed out-of-hospital cardiac arrest (Class III, LOE C).	not reviewed in 2015

(*Continued*)

2015 Guidelines Update: Part 6 Recommendations, *Continued*

Year Last Reviewed	Topic	Recommendation	Comments
2010	Precordial Thump	The precordial thump may be considered for patients with witnessed, monitored, unstable ventricular tachycardia including pulseless VT if a defibrillator is not immediately ready for use (Class IIb, LOE C), but it should not delay CPR and shock delivery.	not reviewed in 2015
2010	Automatic Transport Ventilators	During prolonged resuscitation efforts, the use of an ATV (pneumatically powered and time- or pressure-cycled) may provide ventilation and oxygenation similar to that possible with the use of a manual resuscitation bag, while allowing the Emergency Medical Services (EMS) team to perform other tasks (Class IIb, LOE C).	not reviewed in 2015
2010	Manually Triggered, Oxygen-Powered, Flow-Limited Resuscitators	Manually triggered, oxygen-powered, flow-limited resuscitators may be considered for the management of patients who do not have an advanced airway in place and for whom a mask is being used for ventilation during CPR (Class IIb, LOE C).	not reviewed in 2015
2010	Manually Triggered, Oxygen-Powered, Flow-Limited Resuscitators	Rescuers should avoid using the automatic mode of the oxygen-powered, flow-limited resuscitator during CPR because it may generate high positive end-expiratory pressure (PEEP) that may impede venous return during chest compressions and compromise forward blood flow (Class III, LOE C).	not reviewed in 2015
2010	Active Compression-Decompression CPR	There is insufficient evidence to recommend for or against the routine use of ACD-CPR. ACD-CPR may be considered for use when providers are adequately trained and monitored (Class IIb, LOE B).	not reviewed in 2015

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KEY WORDS: cardiac arrest ■ cardiopulmonary resuscitation ■ emergency ■ ventricular fibrillation

Part 7: Adult Advanced Cardiovascular Life Support

2015 American Heart Association Guidelines Update for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care

Mark S. Link, Chair; Lauren C. Berkow; Peter J. Kudenchuk; Henry R. Halperin; Erik P. Hess; Vivek K. Moitra; Robert W. Neumar; Brian J. O'Neil; James H. Paxton; Scott M. Silvers; Roger D. White; Demetris Yannopoulos; Michael W. Donnino

Introduction

Basic life support (BLS), advanced cardiovascular life support (ACLS), and post–cardiac arrest care are labels of convenience that each describe a set of skills and knowledge that are applied sequentially during the treatment of patients who have a cardiac arrest. There is overlap as each stage of care progresses to the next, but generally ACLS comprises the level of care between BLS and post–cardiac arrest care.

ACLS training is recommended for advanced providers of both prehospital and in-hospital medical care. In the past, much of the data regarding resuscitation was gathered from out-of-hospital arrests, but in recent years, data have also been collected from in-hospital arrests, allowing for a comparison of cardiac arrest and resuscitation in these 2 settings. While there are many similarities, there are also some differences between in- and out-of-hospital cardiac arrest etiology, which may lead to changes in recommended resuscitation treatment or in sequencing of care. The consideration of steroid administration for in-hospital cardiac arrest (IHCA) versus out-of-hospital cardiac arrest (OHCA) is one such example discussed in this Part.

The recommendations in this *2015 American Heart Association* (AHA) *Guidelines Update for Cardiopulmonary Resuscitation* (CPR) *and Emergency Cardiovascular Care* (ECC) are based on an extensive evidence review process that was begun by the International Liaison Committee on Resuscitation (ILCOR) after the publication of the ILCOR *2010 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science With Treatment Recommendations*[1] and was completed in February 2015.[2]

In this in-depth evidence review process, the ILCOR task forces examined topics and then generated prioritized lists of questions for systematic review. Questions were first formulated in PICO (population, intervention, comparator, outcome) format,[3] and then a search strategy and inclusion and exclusion criteria were defined and a search for relevant articles was performed. The evidence was evaluated by using the standardized methodological approach proposed by the Grading of Recommendations Assessment, Development, and Evaluation (GRADE) Working Group.[4]

The quality of the evidence was categorized based on the study methodologies and the 5 core GRADE domains of risk of bias, inconsistency, indirectness, imprecision, and other considerations (including publication bias). Then, where possible, consensus-based treatment recommendations were created.

To create this 2015 Guidelines Update, the AHA formed 15 writing groups, with careful attention to avoid or manage conflicts of interest, to assess the ILCOR treatment recommendations and to write AHA treatment recommendations by using the AHA Class of Recommendation and Level of Evidence (LOE) system.

The recommendations made in this 2015 Guidelines Update are informed by the ILCOR recommendations and GRADE classification, in the context of the delivery of medical care in North America. The AHA ACLS writing group made new recommendations only on topics specifically reviewed by ILCOR in 2015. This chapter delineates any instances where the AHA writing group developed recommendations that are substantially different than the ILCOR statements. In the online version of this document, live links are provided so the reader can connect directly to the systematic reviews on the Scientific Evidence Evaluation and Review System (SEERS) website. These links are indicated by a superscript combination of letters and numbers (eg, ALS 433).

This update uses the newest AHA COR and LOE classification system, which contains modifications of the Class III recommendation and introduces LOE B-R (randomized studies) and B-NR (nonrandomized studies) as well as LOE C-LD (limited data) and LOE C-EO (consensus of expert opinion). All recommendations made in this 2015 Guidelines Update, as well as in the 2010 Guidelines, are listed in the Appendix. For further information, see "Part 2: Evidence Evaluation and Management of Conflicts of Interest."

The ILCOR ACLS Task Force addressed 37 PICO questions related to ACLS care (presented in this Part) in 2015. These questions included oxygen dose during CPR,

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advanced airway devices, ventilation rate during CPR, exhaled carbon dioxide (CO_2) detection for confirmation of airway placement, physiologic monitoring during CPR, prognostication during CPR, defibrillation, antiarrhythmic drugs, and vasopressors. The 2 new topics are steroids and hormones in cardiac arrest, and extracorporeal CPR (ECPR), perhaps better known to the inpatient provider community as extracorporeal life support (ECMO). The 2010 Guidelines Part on electrical therapies (defibrillation and emergency pacing) has been eliminated, and relevant material from it is now included in this ACLS Part.

The major changes in the 2015 ACLS guidelines include recommendations about prognostication during CPR based on exhaled CO_2 measurements, timing of epinephrine administration stratified by shockable or nonshockable rhythms, and the possibility of bundling treatment of steroids, vasopressin, and epinephrine for treatment of in-hospital arrests. In addition, the administration of vasopressin as the sole vasoactive drug during CPR has been removed from the algorithm.

Adjuncts to CPR

Oxygen Dose During CPR[ALS 889]

The 2015 ILCOR systematic review considered inhaled oxygen delivery both during CPR and in the post–cardiac arrest period. This 2015 Guidelines Update evaluates the optimal inspired concentration of oxygen during CPR. The immediate goals of CPR are to restore the energy state of the heart so it can resume mechanical work and to maintain the energy state of the brain to minimize ischemic injury. Adequate oxygen delivery is necessary to achieve these goals. Oxygen delivery is dependent on both blood flow and arterial oxygen content. Because blood flow is typically the major limiting factor to oxygen delivery during CPR, it is theoretically important to maximize the oxygen content of arterial blood by maximizing inspired oxygen concentration. Maximal inspired oxygen can be achieved with high-flow oxygen into a resuscitation bag device attached to a mask or an advanced airway.

2015 Evidence Summary

There were no adult human studies identified that directly compared maximal inspired oxygen with any other inspired oxygen concentration. However, 1 observational study of 145 OHCA patients evaluated arterial Po_2 measured during CPR and cardiac arrest outcomes.[5] In this study, during which all patients received maximal inspired oxygen concentration, patients were divided into low, intermediate, and high arterial Po_2 ranges (less than 61, 61–300, and greater than 300 mm Hg, respectively). The higher ranges of arterial Po_2 during CPR were associated with an increase in hospital admission rates (low, 18.8%; intermediate, 50.6%; and high, 83.3%). However, there was no statistical difference in overall neurologic survival (low, 3.1%; intermediate, 13.3%; and high, 23.3%). Of note, this study did not evaluate the provision of various levels of inspired oxygen, so differences between groups likely reflect patient-level differences in CPR quality and underlying pathophysiology. This study did not find any association between hyperoxia during CPR and poor outcome.

2015 Recommendation—Updated

When supplementary oxygen is available, it may be reasonable to use the maximal feasible inspired oxygen concentration during CPR (Class IIb, LOE C-EO).

Evidence for detrimental effects of hyperoxia that may exist in the immediate post–cardiac arrest period should not be extrapolated to the low-flow state of CPR where oxygen delivery is unlikely to exceed demand or cause an increase in tissue Po_2. Therefore, until further data are available, physiology and expert consensus support providing the maximal inspired oxygen concentration during CPR.

Monitoring Physiologic Parameters During CPR[ALS 656]

Monitoring both provider performance and patient physiologic parameters during CPR is essential to optimizing CPR quality. The 2010 Guidelines put a strong emphasis on CPR quality. In 2013, the AHA published a Consensus Statement focused on strategies to improve CPR quality.[6] In 2015, the ILCOR ACLS Task Force evaluated the available clinical evidence to determine whether using physiologic feedback to guide CPR quality improved survival and neurologic outcome.

2015 Evidence Summary

Animal and human studies indicate that monitoring physiologic parameters during CPR provides valuable information about the patient's condition and response to therapy. Most important, end-tidal CO_2 ($ETCO_2$), coronary perfusion pressure, arterial relaxation pressure, arterial blood pressure, and central venous oxygen saturation correlate with cardiac output and myocardial blood flow during CPR, and threshold values have been reported below which return of spontaneous circulation (ROSC) is rarely achieved.[7–13] These parameters can be monitored continuously, without interrupting chest compressions. An abrupt increase in any of these parameters is a sensitive indicator of ROSC.[14–31] There is evidence that these and other physiologic parameters can be modified by interventions aimed at improving CPR quality.[7,32–43]

The 2015 ILCOR systematic review was unable to identify any clinical trials that have studied whether titrating resuscitative efforts to a single or combined set of physiologic parameters during CPR results in improved survival or neurologic outcome.

2015 Recommendation—Updated

Although no clinical study has examined whether titrating resuscitative efforts to physiologic parameters during CPR improves outcome, it may be reasonable to use physiologic parameters (quantitative waveform capnography, arterial relaxation diastolic pressure, arterial pressure monitoring, and central venous oxygen saturation) when feasible to monitor and optimize CPR quality, guide vasopressor therapy, and detect ROSC (Class IIb, LOE C-EO).

Previous guidelines specified physiologic parameter goals; however, because the precise numerical targets for these parameters during resuscitation have not as yet been established, these were not specified in 2015.

Ultrasound During Cardiac Arrest[ALS 658]

Bedside cardiac and noncardiac ultrasound are frequently used as diagnostic and prognostic tools for critically ill patients.[44] Ultrasound may be applied to patients receiving CPR to help assess myocardial contractility and to help identify potentially treatable causes of cardiac arrest such as hypovolemia, pneumothorax, pulmonary thromboembolism, or pericardial tamponade.[45] However, it is unclear whether important clinical outcomes are affected by the routine use of ultrasound among patients experiencing cardiac arrest.

2015 Evidence Summary

One limited study with a small sample size was identified that specifically addressed the utility of ultrasound during cardiac arrest. This study evaluated bedside cardiac ultrasound use during ACLS among adult patients in pulseless electrical activity arrest and found no difference in the incidence of ROSC when ultrasound was used.[46]

2015 Recommendations—Updated

Ultrasound (cardiac or noncardiac) may be considered during the management of cardiac arrest, although its usefulness has not been well established (Class IIb, LOE C-EO).

If a qualified sonographer is present and use of ultrasound does not interfere with the standard cardiac arrest treatment protocol, then ultrasound may be considered as an adjunct to standard patient evaluation (Class IIb, LOE C-EO).

Adjuncts for Airway Control and Ventilation

This portion of the 2015 Guidelines Update focuses on recommendations for airway management based on rate of survival and favorable neurologic outcome.

Bag-Mask Ventilation Compared With Any Advanced Airway During CPR[ALS 783]

Bag-mask ventilation is a commonly used method for providing oxygenation and ventilation in patients with respiratory insufficiency or arrest. When cardiac arrest occurs, providers must determine the best way to support ventilation and oxygenation. Options include standard bag-mask ventilation versus the placement of an advanced airway (ie, endotracheal tube [ETT], supraglottic airway device [SGA]). Previous guidelines recommended that prolonged interruptions in chest compressions should be avoided during transitions from bag-mask ventilation to an advanced airway device. In 2015, ILCOR evaluated the evidence comparing the effect of bag-mask ventilation versus advanced airway placement on overall survival and neurologic outcome from cardiac arrest.

2015 Evidence Summary

There is inadequate evidence to show a difference in survival or favorable neurologic outcome with the use of bag-mask ventilation compared with endotracheal intubation[47–53] or other advanced airway devices.[47,49–51,54] The majority of these retrospective observational studies demonstrated slightly worse survival with the use of an advanced airway when compared with bag-mask ventilation. However, interpretation of these results is limited by significant concerns of selection bias. Two additional observational studies[54,55] showed no difference in survival.

Advanced Airway Placement Choice

Advanced airway devices are frequently placed by experienced providers during CPR if bag-mask ventilation is inadequate or as a stepwise approach to airway management. Placement of an advanced airway may result in interruption of chest compressions, and the ideal timing of placement to maximize outcome has not been adequately studied. The use of an advanced airway device such as an ETT or SGA and the effect of ventilation technique on overall survival and neurologic outcome was evaluated in 2015.

2015 Evidence Summary

Endotracheal Intubation Versus Bag-Mask Ventilation

There is no high-quality evidence favoring the use of endotracheal intubation compared with bag-mask ventilation or an advanced airway device in relation to overall survival or favorable neurologic outcome.[47–53] Evaluating retrospective studies that compare bag-mask ventilation to endotracheal intubation is challenging because patients with more severe physiologic compromise will typically receive more invasive care (including endotracheal intubation) than patients who are less compromised and more likely to survive. Within that context, a number of retrospective studies show an association of worse outcome in those who were intubated as compared with those receiving bag-mask ventilation. While the studies did attempt to control for confounders, bias still may have been present, limiting the interpretation of these investigations. These studies illustrate that endotracheal intubation can be associated with a number of complications and that the procedure requires skill and experience. Risks of endotracheal intubation during resuscitation include unrecognized esophageal intubation and increased hands-off time.

Supraglottic Airway Devices

Several retrospective studies compared a variety of supraglottic devices (laryngeal mask airway, laryngeal tube, Combitube, esophageal obturator airway) to both bag-mask ventilation and endotracheal intubation. There is no high-quality evidence demonstrating a difference in survival rate or favorable neurologic outcome from use of an SGA compared with bag-mask ventilation[47,49–51] or endotracheal intubation.[47,49,50,54,56–61] Three observational studies demonstrated a lower rate of both overall survival and favorable neurologic outcome when SGA use was compared with bag-mask ventilation,[47,49,51] whereas another observational study demonstrated similar survival rates.[50]

In studies comparing SGA insertion to endotracheal intubation, no high-quality studies have demonstrated a difference in overall survival or favorable neurologic outcome.[50,54,56–58,61] Several retrospective observational studies show more favorable outcome with the use of an SGA device, whereas other studies favor the use of endotracheal intubation.[47,49,50,59–61]

2015 Recommendations—Updated

Either a bag-mask device or an advanced airway may be used for oxygenation and ventilation during CPR in both the in-hospital and out-of-hospital setting (Class IIb, LOE C-LD).

For healthcare providers trained in their use, either an SGA device or an ETT may be used as the initial advanced airway during CPR (Class IIb, LOE C-LD).

Recommendations for advanced airway placement presume that the provider has the initial training and skills as well as the ongoing experience to insert the airway and verify proper position with minimal interruption in chest compressions. Bag-mask ventilation also requires skill and proficiency. The choice of bag-mask device versus advanced airway insertion, then, will be determined by the skill and experience of the provider.

Clinical Assessment of Tracheal Tube Placement[ALS 469]

The 2015 ILCOR systematic review considered tracheal tube placement during CPR. This section evaluates methods for confirming correct tracheal tube placement.

Attempts at endotracheal intubation during CPR have been associated with unrecognized tube misplacement or displacement as well as prolonged interruptions in chest compression. Inadequate training, lack of experience, patient physiology (eg, low pulmonary blood flow, gastric contents in the trachea, airway obstruction), and patient movement may contribute to tube misplacement. After correct tube placement, tube displacement or obstruction may develop. In addition to auscultation of the lungs and stomach, several methods (eg, waveform capnography, CO_2 detection devices, esophageal detector device, tracheal ultrasound, fiberoptic bronchoscopy) have been proposed to confirm successful tracheal intubation in adults during cardiac arrest.

2015 Evidence Summary

The evidence regarding the use of tracheal detection devices during cardiac arrest is largely observational. Observational studies and 1 small randomized study of waveform capnography to verify ETT position in victims of cardiac arrest report a specificity of 100% for correct tube placement.[62–64] Although the sensitivity of waveform capnography for detecting tracheal tube placement immediately after prehospital intubation was 100% in 1 study,[62] several other studies showed that the sensitivity of waveform capnography decreases after a prolonged cardiac arrest.[63–65] Differences in sensitivity can be explained by the low pulmonary blood flow during cardiac arrest, which will decrease $ETCO_2$ concentration.

Although exhaled CO_2 detection suggests correct tracheal tube placement, false-positive results (CO_2 detection with esophageal intubation) can occur after ingestion of carbonated liquids.[66] False-negative results (ie, absent exhaled CO_2 in the presence of tracheal intubation) can occur in the setting of pulmonary embolism, significant hypotension, contamination of the detector with gastric contents, and severe airflow obstruction.[15,67,68] The use of CO_2-detecting devices to determine the correct placement of other advanced airways (eg, Combitube, laryngeal mask airway) has not been studied, but, as with an ETT, effective ventilation should produce a capnography waveform during CPR and after ROSC.

Colorimetric and nonwaveform CO_2 detectors can identify the presence of exhaled CO_2 from the respiratory tract, but there is no evidence that these devices are accurate for continued monitoring of ETT placement.[15,62,69–73] Moreover, because a minimal threshold of CO_2 must be reached to activate the detector and exhaled CO_2 is low in cardiac arrest, proper placement of an ETT may not be confirmed with this qualitative methodology.

While observational studies and a small randomized controlled trial (RCT) of esophageal detector devices report a low false-positive rate for confirming tracheal placement, there is no evidence that these devices are accurate or practical for the continued monitoring of ETT placement.[63–65,69,74,75]

An ultrasound transducer can be placed transversely on the anterior neck above the suprasternal notch to identify endotracheal or esophageal intubation. In addition, ultrasound of the thoracic cavity can identify pleural movement as lung sliding. Unlike capnography, confirmation of ETT placement via ultrasonography is not dependent on adequate pulmonary blood flow and CO_2 in exhaled gas.[76–78] One small prospective study of experienced clinicians compared tracheal ultrasound to waveform capnography and auscultation during CPR and reported a positive predictive value for ultrasound of 98.8% and negative predictive value of 100%.[78] The usefulness of tracheal and pleural ultrasonography, like fiberoptic bronchoscopy, may be limited by abnormal anatomy, availability of equipment, and operator experience.

2015 Recommendations—Updated

Continuous waveform capnography is recommended in addition to clinical assessment as the most reliable method of confirming and monitoring correct placement of an ETT (Class I, LOE C-LD).

If continuous waveform capnometry is not available, a nonwaveform CO_2 detector, esophageal detector device, or ultrasound used by an experienced operator is a reasonable alternative (Class IIa, LOE C-LD).

Ventilation After Advanced Airway Placement[ALS 808]

The 2015 ILCOR systematic review addressed the optimal ventilation rate during continuous chest compressions among adults in cardiac arrest with an advanced airway. This 2015 Guidelines Update for ACLS applies only to patients who have been intubated and are in cardiac arrest. The effect of tidal volume and any other ventilation parameters during CPR are not addressed in this recommendation.

Except for respiratory rate, it is unknown whether monitoring ventilatory parameters (eg, minute ventilation, peak pressure) during CPR can influence outcome. However, positive pressure ventilation increases intrathoracic pressure and may reduce venous return and cardiac output, especially in patients with hypovolemia or obstructive airway disease. Ventilation at inappropriately high respiratory rates (greater than 25 breaths/min) is common during resuscitation from cardiac arrest.[79,80] There is concern that excessive ventilation in the setting of cardiac arrest may be associated with worse outcome.

2015 Evidence Summary

No human clinical trials were found addressing whether a ventilation rate of 10 breaths/min, compared with any other ventilation rate, changes survival with favorable neurologic or functional outcome. Although there have been a number of animal studies[79,81–89] and 1 human observational study[90] evaluating ventilation rates during CPR, the design and data from these studies did not allow for the assessment of the effect of a

ventilation rate of 10 per minute compared with any other rate for ROSC or other outcomes.

2015 Recommendation—Updated

After placement of an advanced airway, it may be reasonable for the provider to deliver 1 breath every 6 seconds (10 breaths/min) while continuous chest compressions are being performed (Class IIb, LOE C-LD).

Management of Cardiac Arrest

Defibrillation Strategies for Ventricular Fibrillation or Pulseless Ventricular Tachycardia: Waveform Energy and First-Shock Success[ALS 470]

Currently manufactured manual and automated external defibrillators use biphasic waveforms of 3 different designs: biphasic truncated exponential (BTE), rectilinear biphasic (RLB), and pulsed biphasic waveforms; they deliver different peak currents at the same programmed energy setting and may adjust their energy output in relation to patient impedance in differing ways. These factors can make comparisons of shock efficacy between devices from different manufacturers challenging even when the same programmed energy setting is used. A substantial body of evidence now exists for the efficacy of BTE and RLB waveforms, with a smaller body of evidence for the pulsed waveform. An impedance-compensated version of the pulsed biphasic waveform is now clinically available, but no clinical studies were identified to define its performance characteristics.

2015 Evidence Summary

There is no evidence indicating superiority of one biphasic waveform or energy level for the termination of ventricular fibrillation (VF) with the first shock (termination is defined as absence of VF at 5 seconds after shock). All published studies support the effectiveness (consistently in the range of 85%–98%)[91] of biphasic shocks using 200 J or less for the first shock.[91] Defibrillators using the RLB waveform typically deliver more shock energy than selected, based on patient impedance. Thus, in the single study in which a manufacturer's nonescalating energy device was programmed to deliver 150 J shocks, comparison with other devices was not possible because shock energy delivery in other devices is adjusted for measured patient impedance. For the RLB, a selected energy dose of 120 J typically provides nearly 150 J for most patients.

2015 Recommendations—Updated

Defibrillators (using BTE, RLB, or monophasic waveforms) are recommended to treat atrial and ventricular arrhythmias (Class I, LOE B-NR).

Based on their greater success in arrhythmia termination, defibrillators using biphasic waveforms (BTE or RLB) are preferred to monophasic defibrillators for treatment of both atrial and ventricular arrhythmias (Class IIa, LOE B-R).

In the absence of conclusive evidence that 1 biphasic waveform is superior to another in termination of VF, it is reasonable to use the manufacturer's recommended energy dose for the first shock. If this is not known, defibrillation at the maximal dose may be considered (Class IIb, LOE C-LD).

Defibrillation Strategies for Ventricular Fibrillation or Pulseless Ventricular Tachycardia: Energy Dose for Subsequent Shocks

The 2010 Guidelines regarding treatment of VF/pulseless ventricular tachycardia (pVT) recommended that if the first shock dose did not terminate VF/pVT, the second and subsequent doses should be equivalent, and higher doses may be considered. The evidence supporting energy dose for subsequent shocks was evaluated for this 2015 Guidelines Update.

2015 Evidence Summary

Observational data indicate that an automated external defibrillator administering a high peak current at 150 J biphasic fixed energy can terminate initial, as well as persistent or recurrent VF, with a high rate of conversion.[92] In fact, the high conversion rate achieved with all biphasic waveforms for the first shock makes it difficult to study the energy requirements for second and subsequent shocks when the first shock is not successful. A 2007 study attempted to determine if a fixed lower energy dose or escalating higher doses were associated with better outcome in patients requiring more than 1 shock. Although termination of VF at 5 seconds after shock was higher in the escalating higher-energy group (82.5% versus 71.2%), there were no significant differences in ROSC, survival to discharge, or survival with favorable neurologic outcome between the 2 groups. In this study, only 1 manufacturer's nonescalating energy device, programmed to deliver 150-J shocks, was used. Thus, it is not possible to compare this 150-J shock with that delivered by any other device set to deliver 150 J.

There is a decline in shock success with repeated shocks. One nonrandomized trial that used a BTE waveform reported a decline in shock success when repeated shocks at the same energy were administered.[93] For the RLB waveform, 1 observational study reported an initial VF termination rate of 87.8% at a selected energy setting of 120 J and an 86.4% termination rate for persistent VF. Recurrence of VF did not affect ultimate shock success, ROSC, or discharge survival.[94]

2015 Recommendations—Updated

It is reasonable that selection of fixed versus escalating energy for subsequent shocks be based on the specific manufacturer's instructions (Class IIa, LOE C-LD).

If using a manual defibrillator capable of escalating energies, higher energy for second and subsequent shocks may be considered (Class IIb, LOE C-LD).

Defibrillation Strategies for Ventricular Fibrillation or Pulseless Ventricular Tachycardia: Single Shocks Versus Stacked Shocks

The 2010 Guidelines recommended a 2-minute period of CPR after each shock instead of immediate successive shocks for persistent VF. The rationale for this is at least 3-fold: First, VF is terminated with a very high rate of success with biphasic waveforms. Second, when VF is terminated, a brief period of asystole or pulseless electrical activity (PEA) typically ensues and a perfusing rhythm is unlikely to be present immediately. Third, this provides for a period of uninterrupted CPR following a shock before repeat rhythm analysis.

The evidence for single versus stacked shocks was reviewed again in 2015.

2015 Evidence Summary

One RCT that comprised 845 OHCA patients found no difference in 1-year survival when a single shock protocol with 2 minutes of CPR between successive shocks was compared against a previous resuscitation protocol employing 3 initial stacked shocks with 1 minute of CPR between subsequent shocks (odds ratio, 1.64; 95% confidence interval, 0.53–5.06).[95] An RCT published in 2010 showed no difference in frequency of VF recurrence when comparing the 2 treatment protocols.[96] In that study, increased time in recurrent VF was associated with decreased favorable neurologic survival under either protocol.

There is evidence that resumption of chest compressions immediately after a shock can induce recurrent VF, but the benefit of CPR in providing myocardial blood flow is thought to outweigh the benefit of immediate defibrillation for the VF.[97] Another study of patients presenting in VF after a witnessed arrest concluded that recurrence of VF within 30 seconds of a shock was not affected by the timing of resumption of chest compressions.[98] Thus, the effect of chest compressions on recurrent VF is not clear. It is likely that in the future, algorithms that recognize recurrent VF during chest compressions with high sensitivity and specificity will allow us to deliver a shock earlier in the CPR cycle, thereby reducing the length of time the myocardium is fibrillating and the duration of postshock CPR.[99]

2015 Recommendation—Updated

A single-shock strategy (as opposed to stacked shocks) is reasonable for defibrillation (Class IIa, LOE B-NR).

Antiarrhythmic Drugs During and Immediately After Cardiac Arrest[ALS 428]

The 2015 ILCOR systematic review addressed whether the administration of antiarrhythmic drugs for cardiac arrest due to refractory VF or pVT results in better outcome.

Antiarrhythmic Drugs During and Immediately After Cardiac Arrest: Antiarrhythmic Therapy for Refractory VF/pVT Arrest

Refractory VF/pVT refers to VF or pVT that persists or recurs after 1 or more shocks. It is unlikely that an antiarrhythmic drug will itself pharmacologically convert VF/pVT to an organized perfusing rhythm. Rather, the principal objective of antiarrhythmic drug therapy in shock-refractory VF/pVT is to facilitate the restoration and maintenance of a spontaneous perfusing rhythm in concert with the shock termination of VF. Some antiarrhythmic drugs have been associated with increased rates of ROSC and hospital admission, but none have yet been proven to increase long-term survival or survival with good neurologic outcome. Thus, establishing vascular access to enable drug administration should not compromise the quality of CPR or timely defibrillation, which are known to improve survival. The optimal sequence of ACLS interventions, including administration of antiarrhythmic drugs during resuscitation and the preferred manner and timing of drug administration in relation to shock delivery, is not known. Previous ACLS guidelines addressed the use of magnesium in cardiac arrest with polymorphic ventricular tachycardia (ie, *torsades de pointes*) or suspected hypomagnesemia, and this has not been reevaluated in this 2015 Guidelines Update. These previous guidelines recommended defibrillation for termination of polymorphic VT (ie, *torsades de pointes*), followed by consideration of intravenous magnesium sulfate when secondary to a long QT interval.

The 2015 ILCOR systematic review did not specifically address the selection or use of second-line antiarrhythmic medications in patients who are unresponsive to a maximum therapeutic dose of the first administered drug, and there are limited data available to direct such treatment.

2015 Evidence Summary

Amiodarone

Intravenous amiodarone is available in 2 approved formulations in the United States, one containing polysorbate 80, a vasoactive solvent that can provoke hypotension, and one containing captisol, which has no vasoactive effects. In blinded RCTs in adults with refractory VF/pVT in the out-of-hospital setting, paramedic administration of amiodarone in polysorbate (300 mg or 5 mg/kg) after at least 3 failed shocks and administration of epinephrine improved hospital admission rates when compared to placebo with polysorbate[100] or 1.5 mg/kg lidocaine with polysorbate.[101] Survival to hospital discharge and survival with favorable neurologic outcome, however, was not improved by amiodarone compared with placebo or amiodarone compared with lidocaine, although these studies were not powered for survival or favorable neurologic outcome.

Lidocaine

Intravenous lidocaine is an alternative antiarrhythmic drug of long-standing and widespread familiarity. Compared with no antiarrhythmic drug treatment, lidocaine did not consistently increase ROSC and was not associated with improvement in survival to hospital discharge in observational studies.[102,103] In a prospective, blinded, randomized clinical trial, lidocaine was less effective than amiodarone in improving hospital admission rates after OHCA due to shock-refractory VF/pVT, but there were no differences between the 2 drugs in survival to hospital discharge.[101]

Procainamide

Procainamide is available only as a parenteral formulation in the United States. In conscious patients, procainamide can be given only as a controlled infusion (20 mg/min) because of its hypotensive effects and risk of QT prolongation, making it difficult to use during cardiac arrest. Procainamide was recently studied as a second-tier antiarrhythmic agent in patients with OHCA due to VF/pVT that was refractory to lidocaine and epinephrine. In this study, the drug was given as a rapid infusion of 500 mg (repeated as needed up to 17 mg/kg) during ongoing CPR. An unadjusted analysis showed lower rates of hospital admission and survival among the 176 procainamide recipients as compared with 489 nonrecipients. After adjustment for patients' clinical and resuscitation characteristics, no association was found between use of the drug and hospital

admission or survival to hospital discharge, although a modest survival benefit from the drug could not be excluded.[104]

Magnesium

Magnesium acts as a vasodilator and is an important cofactor in regulating sodium, potassium, and calcium flow across cell membranes. In 3 randomized clinical trials, magnesium was not found to increase rates of ROSC for cardiac arrest due to any presenting rhythm,[105] including VF/pVT.[106,107] In these RCTs and in 1 additional randomized clinical trial, the use of magnesium in cardiac arrest for any rhythm presentation of cardiac arrest[105,108] or strictly for VF arrest[106,107] did not improve survival to hospital discharge or neurologic outcome.[108]

2015 Recommendations—Updated

Amiodarone may be considered for VF/pVT that is unresponsive to CPR, defibrillation, and a vasopressor therapy (Class IIb, LOE B-R).

Lidocaine may be considered as an alternative to amiodarone for VF/pVT that is unresponsive to CPR, defibrillation, and vasopressor therapy (Class IIb, LOE C-LD).

The routine use of magnesium for VF/pVT is not recommended in adult patients (Class III: No Benefit, LOE B-R).

No antiarrhythmic drug has yet been shown to increase survival or neurologic outcome after cardiac arrest due to VF/pVT. Accordingly, recommendations for the use of antiarrhythmic medications in cardiac arrest are based primarily on the potential for benefit on short-term outcome until more definitive studies are performed to address their effect on survival and neurologic outcome.

Antiarrhythmic Drugs During and Immediately After Cardiac Arrest: Antiarrhythmic Drugs After Resuscitation[ALS 493]

The 2015 ILCOR systematic review addressed whether, after successful termination of VF or pVT cardiac arrest, the prophylactic administration of antiarrhythmic drugs for cardiac arrest results in better outcome. The only medications studied in this context are β-adrenergic blocking drugs and lidocaine, and the evidence for their use is limited.

2015 Evidence Summary

β-Adrenergic Blocking Drugs

β-Adrenergic blocking drugs blunt heightened catecholamine activity that can precipitate cardiac arrhythmias. The drugs also reduce ischemic injury and may have membrane-stabilizing effects. In 1 observational study of oral or intravenous metoprolol or bisoprolol during hospitalization after cardiac arrest due to VF/pVT, recipients had a significantly higher adjusted survival rate than nonrecipients at 72 hours after ROSC and at 6 months.[109] Conversely, β-blockers can cause or worsen hemodynamic instability, exacerbate heart failure, and cause bradyarrhythmias, making their routine administration after cardiac arrest potentially hazardous. There is no evidence addressing the use of β-blockers after cardiac arrest precipitated by rhythms other than VF/pVT.

Lidocaine

Early studies in patients with acute myocardial infarction found that lidocaine suppressed premature ventricular complexes and nonsustained VT, rhythms that were believed to presage VF/pVT. Later studies noted a disconcerting association between lidocaine and higher mortality after acute myocardial infarction, possibly due to a higher incidence of asystole and bradyarrhythmias; the routine practice of administering prophylactic lidocaine during acute myocardial infarction was abandoned.[110,111] The use of lidocaine was explored in a multivariate and propensity score–adjusted analysis of patients resuscitated from out-of-hospital VF/pVT arrest. In this observational study of 1721 patients, multivariate analysis found the prophylactic administration of lidocaine before hospitalization was associated with a significantly lower rate of recurrent VF/pVT and higher rates of hospital admission and survival to hospital discharge. However, in a propensity score–adjusted analysis, rates of hospital admission and survival to hospital discharge did not differ between recipients of prophylactic lidocaine as compared with nonrecipients, although lidocaine was associated with less recurrent VF/pVT and there was no evidence of harm.[112] Thus, evidence supporting a role for prophylactic lidocaine after VF/pVT arrest is weak at best, and nonexistent for cardiac arrest initiated by other rhythms.

2015 Recommendations—New

There is inadequate evidence to support the routine use of lidocaine after cardiac arrest. However, the initiation or continuation of lidocaine may be considered immediately after ROSC from cardiac arrest due to VF/pVT (Class IIb, LOE C-LD).

There is inadequate evidence to support the routine use of a β-blocker after cardiac arrest. However, the initiation or continuation of an oral or intravenous β-blocker may be considered early after hospitalization from cardiac arrest due to VF/pVT (Class IIb, LOE C-LD).

There is insufficient evidence to recommend for or against the routine initiation or continuation of other antiarrhythmic medications after ROSC from cardiac arrest.

Vasopressors in Cardiac Arrest

The 2015 ILCOR systematic review addresses the use of the vasopressors epinephrine and vasopressin during cardiac arrest. The new recommendations in this 2015 Guidelines Update apply only to the use of these vasopressors for this purpose.

Vasopressors in Cardiac Arrest: Standard-Dose Epinephrine[ALS 788]

Epinephrine produces beneficial effects in patients during cardiac arrest, primarily because of its α-adrenergic (ie, vasoconstrictor) effects. These α-adrenergic effects of epinephrine can increase coronary perfusion pressure and cerebral perfusion pressure during CPR. The value and safety of the β-adrenergic effects of epinephrine are controversial because they may increase myocardial work and reduce subendocardial perfusion. The 2010 Guidelines stated that it is reasonable to consider administering a 1-mg dose of IV/IO epinephrine every 3 to 5 minutes during adult cardiac arrest.

2015 Evidence Summary

One trial[113] assessed short-term and longer-term outcomes when comparing standard-dose epinephrine to placebo.

Standard-dose epinephrine was defined as 1 mg given IV/IO every 3 to 5 minutes. For both survival to discharge and survival to discharge with good neurologic outcome, there was no benefit with standard-dose epinephrine; however, the study was stopped early and was therefore underpowered for analysis of either of these outcomes (enrolled approximately 500 patients as opposed to the target of 5000). There was, nevertheless, improved survival to hospital admission and improved ROSC with the use of standard-dose epinephrine. Observational studies were performed that evaluated epinephrine, with conflicting results.[114,115]

2015 Recommendation—Updated

Standard-dose epinephrine (1 mg every 3 to 5 minutes) may be reasonable for patients in cardiac arrest (Class IIb, LOE B-R).

Vasopressors in Cardiac Arrest: Standard Dose Epinephrine Versus High-Dose Epinephrine[ALS 778]

High doses of epinephrine are generally defined as doses in the range of 0.1 to 0.2 mg/kg. In theory, higher doses of epinephrine may increase coronary perfusion pressure, resulting in increased ROSC and survival from cardiac arrest. However, the adverse effects of higher doses of epinephrine in the postarrest period may negate potential advantages during the intra-arrest period. Multiple case series followed by randomized trials have been performed to evaluate the potential benefit of higher doses of epinephrine. In the 2010 Guidelines, the use of high-dose epinephrine was not recommended except in special circumstances, such as for β-blocker overdose, calcium channel blocker overdose, or when titrated to real-time physiologically monitored parameters. In 2015, ILCOR evaluated the use of high-dose epinephrine compared with standard doses.

2015 Evidence Summary

A number of trials have compared outcomes from standard-dose epinephrine with those of high-dose epinephrine. These trials did not demonstrate any benefit for high-dose epinephrine over standard-dose epinephrine for survival to discharge with a good neurologic recovery (ie, Cerebral Performance Category score),[116,117] survival to discharge,[116–120] or survival to hospital admission.[116–118,121] There was, however, a demonstrated ROSC advantage with high-dose epinephrine.[116–121]

2015 Recommendation—New

High-dose epinephrine is not recommended for routine use in cardiac arrest (Class III: No Benefit, LOE B-R).

Vasopressors in Cardiac Arrest: Epinephrine Versus Vasopressin[ALS 659]

Vasopressin is a nonadrenergic peripheral vasoconstrictor that also causes coronary[122,123] and renal vasoconstriction.[124]

2015 Evidence Summary

A single RCT[125] enrolling 336 patients compared multiple doses of standard-dose epinephrine with multiple doses of standard-dose vasopressin (40 units IV) in the emergency department after OHCA. The trial had a number of limitations but showed no benefit with the use of vasopressin for ROSC or survival to discharge with or without good neurologic outcome.

2015 Recommendation—Updated

Vasopressin offers no advantage as a substitute for epinephrine in cardiac arrest (Class IIb, LOE B-R).

The removal of vasopressin has been noted in the Adult Cardiac Arrest Algorithm (Figure 1).

Vasopressors in Cardiac Arrest: Epinephrine Versus Vasopressin in Combination With Epinephrine[ALS 789]

2015 Evidence Summary

A number of trials have compared outcomes from standard-dose epinephrine to those using the combination of epinephrine and vasopressin. These trials showed no benefit with the use of the epinephrine/vasopressin combination for survival to hospital discharge with Cerebral Performance Category score of 1 or 2 in 2402 patients,[126–128] no benefit for survival to hospital discharge or hospital admission in 2438 patients,[126–130] and no benefit for ROSC.[126–131]

2015 Recommendation—New

Vasopressin in combination with epinephrine offers no advantage as a substitute for standard-dose epinephrine in cardiac arrest (Class IIb, LOE B-R).

The removal of vasopressin has been noted in the Adult Cardiac Arrest Algorithm (Figure 1).

Vasopressors in Cardiac Arrest: Timing of Administration of Epinephrine[ALS 784]

2015 Evidence Summary: IHCA

One large (n=25 905 patients) observational study of IHCA with nonshockable rhythms was identified,[132] in which outcomes from early administration of epinephrine (1 to 3 minutes) were compared with outcomes from administration of epinephrine at 4 to 6 minutes, 7 to 9 minutes, and greater than 9 minutes. In this study, the early administration of epinephrine in nonshockable rhythms was associated with increased ROSC, survival to hospital discharge, and neurologically intact survival. No studies were identified specifically examining the effect of timing of administration of epinephrine after IHCA with shockable rhythms.

2015 Evidence Summary: OHCA

For nonshockable rhythms, 3 studies showed improved survival to hospital discharge with early administration of epinephrine. A study of 209 577 OHCA patients[133] showed improved 1-month survival when outcomes from administration of epinephrine at less than 9 minutes of EMS-initiated CPR were compared with those in which epinephrine was administered at greater than 10 minutes. Another study enrolling 212 228 OHCA patients[134] showed improved survival to discharge with early epinephrine (less than 10 minutes after EMS-initiated CPR) compared with no epinephrine. A smaller study of 686 OHCA patients[135] showed improved rates of ROSC with early epinephrine (less than 10 minutes after 9-1-1 call) when the presenting rhythm was pulseless electrical activity. For shockable rhythms, there was no benefit with early administration of epinephrine, but there was a negative association of outcome

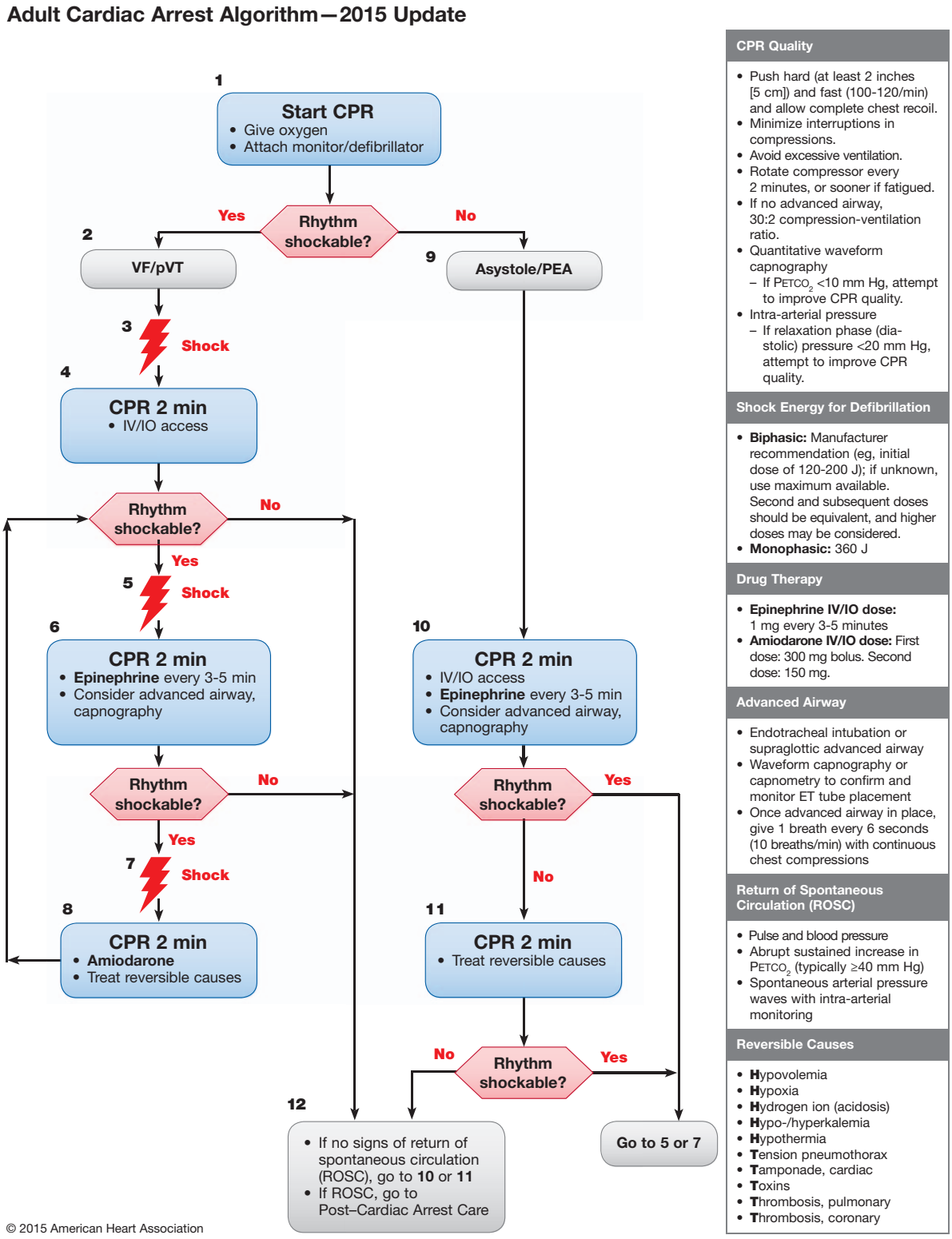

Figure 1. Adult Cardiac Arrest Algorithm—2015 Update.

with late administration. When neurologically intact survival to discharge was assessed,[133,134,136] however, there was variable benefit with early administration of epinephrine for both shockable and nonshockable rhythms. Later administration of epinephrine was associated with a worse outcome. ROSC was generally improved with early administration of epinephrine in studies of more than 210 000 patients.[120,133,135,137] Design flaws in the majority of these observational OHCA studies, however, included the use of a "no epinephrine" control arm as the comparator (thus not allowing for estimates on the effect of timing), and the lack of known timing of epinephrine administration upon arrival in the emergency department. In addition,

the relationship of timing of defibrillation to timing of epinephrine is unknown for studies that included shockable rhythms.

2015 Recommendations—Updated

It may be reasonable to administer epinephrine as soon as feasible after the onset of cardiac arrest due to an initial nonshockable rhythm (Class IIb, LOE C-LD).

There is insufficient evidence to make a recommendation as to the optimal timing of epinephrine, particularly in relation to defibrillation, when cardiac arrest is due to a shockable rhythm, because optimal timing may vary based on patient factors and resuscitation conditions.

Steroids[ALS 433]

The use of steroids in cardiac arrest has been assessed in 2 clinical settings: IHCA and OHCA. In IHCA, steroids were combined with a vasopressor bundle or cocktail of epinephrine and vasopressin. Because the results of IHCA and OHCA were so different, these situations are discussed separately.

2015 Evidence Summary: IHCA

In an initial RCT involving 100 IHCA patients at a single center, the use of a combination of methylprednisolone, vasopressin, and epinephrine during cardiac arrest and hydrocortisone after ROSC for those with shock significantly improved survival to hospital discharge compared with the use of only epinephrine and placebo.[138] In a subsequent 3-center study published in 2013,[138] of 268 patients with IHCA (the majority coming from the same center as in the first study), the same combination of methylprednisolone, vasopressin, and epinephrine during cardiac arrest, and hydrocortisone for those with post-ROSC shock, significantly improved survival to discharge with good neurologic outcome compared with only epinephrine and placebo.

The same 2 RCTs provided evidence that the use of methylprednisolone and vasopressin in addition to epinephrine improved ROSC compared with the use of placebo and epinephrine alone.[138,139]

2015 Evidence Summary: OHCA

In OHCA, steroids have been evaluated in 1 RCT[140] and 1 observational study.[141] In these studies, steroids were not bundled as they were in the IHCA but studied as a sole treatment. When dexamethasone was given during cardiac arrest, it did not improve survival to hospital discharge or ROSC as compared with placebo.[140] The observational study[141] showed no benefit in survival to discharge but did show an association of improved ROSC with hydrocortisone compared with no hydrocortisone.

2015 Recommendations—New

There are no data to recommend for or against the routine use of steroids alone for IHCA patients.

In IHCA, the combination of intra-arrest vasopressin, epinephrine, and methylprednisolone and post-arrest hydrocortisone as described by Mentzelopoulos et al[139] may be considered; however, further studies are needed before recommending the routine use of this therapeutic strategy (Class IIb, LOE C-LD).

For patients with OHCA, use of steroids during CPR is of uncertain benefit (Class IIb, LOE C-LD).

Prognostication During CPR: End-Tidal CO_2[ALS 459]

The 2015 ILCOR systematic review considered one intra-arrest modality, $ETCO_2$ measurement, in prognosticating outcome from cardiac arrest. This section focuses on whether a specific $ETCO_2$ threshold can reliably predict ROSC and survival or inform a decision to terminate resuscitation efforts. The potential value of using $ETCO_2$ as a physiologic monitor to optimize resuscitation efforts is discussed elsewhere (See Monitoring Physiologic Parameters During CPR, earlier in this Part).

$ETCO_2$ is the partial pressure of exhaled carbon dioxide at the end of expiration and is determined by CO_2 production, alveolar ventilation, and pulmonary blood flow. It is most reliably measured using waveform capnography, where the visualization of the actual CO_2 waveform during ventilation ensures accuracy of the measurement. During low-flow states with relatively fixed minute ventilation, pulmonary blood flow is the primary determinant of $ETCO_2$. During cardiac arrest, $ETCO_2$ levels reflect the cardiac output generated by chest compression. Low $ETCO_2$ values may reflect inadequate cardiac output, but $ETCO_2$ levels can also be low as a result of bronchospasm, mucous plugging of the ETT, kinking of the ETT, alveolar fluid in the ETT, hyperventilation, sampling of an SGA, or an airway with an air leak. It is particularly important to recognize that all of the prognostication studies reviewed in this section included only intubated patients. In nonintubated patients (those with bag-mask ventilation or SGA), $ETCO_2$ may not consistently reflect the true value, making the measurement less reliable as a prognostication tool.

2015 Evidence Summary

Studies on the predictive capacity of $ETCO_2$ among intubated patients during cardiac arrest resuscitation are observational, and none have investigated survival with intact neurologic outcome. An $ETCO_2$ less than 10 mm Hg immediately after intubation and 20 minutes after the initial resuscitation is associated with extremely poor chances for ROSC and survival.[9,13,16,19,142]

A prospective observational study of 127 IHCA patients found that an $ETCO_2$ less than 10 mm Hg at any point during the resuscitation was predictive of mortality, and only 1 patient with an $ETCO_2$ value less than 10 mm Hg survived to discharge.[142] In that same study, an $ETCO_2$ greater than 20 mm Hg after 20 minutes of resuscitation was associated with improved survival to discharge.[142] Another prospective observational study of 150 OHCA patients reported no survival to hospital admission when the $ETCO_2$ was less than 10 mm Hg after 20 minutes of resuscitation.[9] Although these results suggest that $ETCO_2$ can be a valuable tool to predict futility during CPR, potential confounding reasons for a low $ETCO_2$ as listed above and the relatively small numbers of patients in these studies suggest that the $ETCO_2$ should not be used alone as an indication to terminate resuscitative efforts. However, the failure to achieve an $ETCO_2$ greater than 10 mm Hg despite optimized resuscitation efforts may be a valuable component of a multimodal approach to deciding when to terminate resuscitation.

There are no studies that assess the prognostic value of $ETCO_2$ measurements sampled from an SGA or bag-mask airway in predicting outcomes from a cardiac arrest.

2015 Recommendations—New

In intubated patients, failure to achieve an $ETCO_2$ of greater than 10 mm Hg by waveform capnography after 20 minutes of CPR may be considered as one component of a multimodal approach to decide when to end resuscitative efforts, but it should not be used in isolation (Class IIb, LOE C-LD).

The above recommendation is made with respect to $ETCO_2$ in patients who are intubated, because the studies examined included only those who were intubated.

In nonintubated patients, a specific $ETCO_2$ cutoff value at any time during CPR *should not* be used as an indication to end resuscitative efforts (Class III: Harm, LOE C-EO).

Overview of Extracorporeal CPR[ALS 723]

The 2015 ILCOR systematic review compared the use of ECPR (or ECMO) techniques for adult patients with IHCA and OHCA to conventional (manual or mechanical) CPR, in regard to ROSC, survival, and good neurologic outcome. The recommendations in this update apply only to the use of ECPR in this context.

ECPR refers to venoarterial extracorporeal membrane oxygenation during cardiac arrest, including extracorporeal membrane oxygenation and cardiopulmonary bypass. These

Table 1. Inclusion and Exclusion Criteria for Key Extracorporeal CPR Articles

Study	CA Type	Inclusion Criteria	Exclusion Criteria
Chen, 2008[143]	IHCA	Witnessed CA of cardiac origin (elevated cardiac enzymes before CA, sudden collapse without obvious cause, or sudden collapse with pre-existing cardiovascular disease)	Age less than 18 years or greater than 75 years
			Known severe irreversible brain damage
			Terminal malignancy
		No ROSC during first 10 minutes of conventional CPR	Traumatic origin with uncontrolled bleeding
			Postcardiotomy shock with inability to be weaned from cardiopulmonary bypass
Shin, 2011[144]	IHCA	Witnessed CA of cardiac origin	Age less than 18 years or greater than 80 years
		No ROSC during first 10 minutes of conventional CPR	Known severe neurologic damage
			Current intracranial hemorrhage
			Terminal malignancy
			Traumatic origin with uncontrolled bleeding
			Noncardiac origin* (submersion, drug overdose, asphyxia, exsanguination, sepsis)
			Irreversible organ failure (liver failure, late stage of adult respiratory distress syndrome, etc)
Lin, 2010[145]	IHCA	Witnessed CA of cardiac origin	Age less than 18 years or greater than 75 years
		No sustained (20 minutes or more) ROSC during first 10 minutes of conventional CPR	Known severe irreversible brain damage
			Terminal malignancy
			Severe trauma
			Uncontrolled bleeding
Maekawa, 2013[146]	OHCA	Witnessed CA of presumed cardiac origin	Age less than 16 years
			Terminal malignancy
		No ROSC during first 20 minutes of conventional CPR	Poor level of activities of daily living before onset of CA
			Noncardiac origin (trauma, submersion, hypothermia, drug overdose, asphyxia, exsanguination, intracranial hemorrhage, acute aortic dissection)
Sakamoto, 2014[147]	OHCA	VF/pVT on initial ECG	Age less than 20 years or 75 years or older
		CA of presumed cardiac origin on hospital arrival with or without prehospital ROSC	Poor level of activities of daily living before onset of CA
		Arrival to hospital 45 minutes or less after reception of emergency call or onset of CA	Noncardiac origin (trauma, drug intoxication, primary cerebral disorders, acute aortic dissection, terminal malignancy)
		No ROSC (1 minute or more of continuing confirmation of pulsation) during first 15 minutes of conventional CPR in hospital	Core body temperature less than 30°C

CA indicates cardiac arrest; CPR, cardiopulmonary resuscitation; ECG, electrocardiogram; IHCA, in-hospital cardiac arrest; OHCA, out-of-hospital cardiac arrest; pVT, pulseless ventricular tachycardia; ROSC, return of spontaneous circulation; and VF, ventricular fibrillation.

*Postcardiotomy bleeding considered to be of cardiac origin.

techniques require adequate vascular access and specialized equipment. The use of ECPR may allow providers additional time to treat reversible underlying causes of cardiac arrest (eg, acute coronary artery occlusion, pulmonary embolism, refractory VF, profound hypothermia, cardiac injury, myocarditis, cardiomyopathy, congestive heart failure, drug intoxication etc) or serve as a bridge for left ventricular assist device implantation or cardiac transplantation.

2015 Evidence Summary

All of the literature reviewed in the 2015 ILCOR systematic review comparing ECPR to conventional CPR was in the form of reviews, case reports, and observational studies. The low-quality evidence suggests a benefit in regard to survival and favorable neurologic outcome with the use of ECPR when compared with conventional CPR. There are currently no data from RCTs to support the use of ECPR for cardiac arrest in any setting.

One propensity-matched prospective observational study enrolling 172 patients with IHCA reported greater likelihood of ROSC and improved survival at hospital discharge, 30-day follow-up, and 1-year follow-up with the use of ECPR among patients who received more than 10 minutes of CPR. However, this study showed no difference in neurologic outcomes.[143]

A single retrospective, observational study enrolling 120 patients with witnessed IHCA who underwent more than 10 minutes of CPR reported a modest benefit over historic controls with the use of ECPR over continued conventional CPR in both survival and neurologic outcome at discharge and 6-month follow-up.[144]

A single propensity-matched, retrospective, observational study enrolling 118 patients with IHCA who underwent more than 10 minutes of CPR and then ECPR after cardiac arrest of cardiac origin showed no survival or neurologic benefit over conventional CPR at the time of hospital discharge, 30-day follow-up, or 1-year follow-up.[145]

One post hoc analysis of data from a prospective, observational cohort of 162 patients with OHCA who did not achieve ROSC with more than 20 minutes of conventional CPR, including propensity score matching, showed that ECPR was associated with a higher rate of neurologically intact survival than continued conventional CPR at 3-month follow-up.[146]

A single prospective, observational study enrolling 454 patients with OHCA who were treated with ECPR if they did not achieve ROSC with more than 15 minutes of conventional CPR after hospital arrival demonstrated improved neurologic outcomes at 1-month and 6-month follow-up.[147]

The key articles reviewed in the 2015 ILCOR systematic review comparing ECPR to conventional CPR feature some variability in their inclusion and exclusion criteria (Table 1), which may affect the generalizability of their results and could explain some of the inconsistencies in outcomes between studies.

2015 Recommendation—New

There is insufficient evidence to recommend the routine use of ECPR for patients with cardiac arrest. In settings where it can be rapidly implemented, ECPR may be considered for select cardiac arrest patients for whom the suspected etiology of the cardiac arrest is potentially reversible during a limited period of mechanical cardiorespiratory support (Class IIb, LOE C-LD).

Disclosures

Part 7: Adult Advanced Cardiovascular Life Support: 2015 Guidelines Update Writing Group Disclosures

Writing Group Member	Employment	Research Grant	Other Research Support	Speakers' Bureau/ Honoraria	Expert Witness	Ownership Interest	Consultant/ Advisory Board	Other
Mark S. Link	Tufts Medical Center	None	None	None	None	None	None	None
Lauren C. Berkow	Johns Hopkins Anesthesia	None	None	None	Bonezzi Switzer Polito & Hupp Co. L.P.A.*	None	Teleflex*	None
Henry R. Halperin	Johns Hopkins University	Zoll Circulation†	None	None	Zoll Medical†	None	Zoll Circulation†	None
Erik P. Hess	Mayo Clinic	None	None	None	None	None	None	None
Peter J. Kudenchuk	University of Washington Medical Center	NIH-NHLBI†	None	None	None	None	None	Public Health - Seattle/ King County†
Vivek K. Moitra	Columbia University Medical Center	None	None	None	Reviewed records for plaintiff and defense on perioperative management*	None	None	None
Robert W. Neumar	University of Michigan	NIH/NHLBI†; AHA†	None	None	None	None	None	None
Brian J. O'Neil	Wayne State University	Zoll*	None	None	None	None	None	None
James H. Paxton	Wayne State University School of Medicine	Vidacare / Teleflex LLC†	None	None	None	None	None	None
Scott M. Silvers	Mayo Clinic	None	None	None	None	None	None	None
Roger D. White	Mayo Clinic	None	None	None	None	None	None	None
Demetris Yannopoulos	University of Minnesota	NIH*	None	None	None	None	None	None
Consultant								
Michael W. Donnino	Beth Israel Deaconess Med Center	None	None	None	None	None	American Heart Association†	None

This table represents the relationships of writing group members that may be perceived as actual or reasonably perceived conflicts of interest as reported on the Disclosure Questionnaire, which all members of the writing group are required to complete and submit. A relationship is considered to be "significant" if (a) the person receives $10 000 or more during any 12-month period, or 5% or more of the person's gross income; or (b) the person owns 5% or more of the voting stock or share of the entity, or owns $10 000 or more of the fair market value of the entity. A relationship is considered to be "modest" if it is less than "significant" under the preceding definition.

*Modest.

†Significant.

Appendix

2015 Guidelines Update: Part 7 Recommendations

Year Last Reviewed	Topic	Recommendation	Comments
2015	Adjuncts to CPR	When supplementary oxygen is available, it may be reasonable to use the maximal feasible inspired oxygen concentration during CPR (Class IIb, LOE C-EO).	updated for 2015
2015	Adjuncts to CPR	Although no clinical study has examined whether titrating resuscitative efforts to physiologic parameters during CPR improves outcome, it may be reasonable to use physiologic parameters (quantitative waveform capnography, arterial relaxation diastolic pressure, arterial pressure monitoring, and central venous oxygen saturation) when feasible to monitor and optimize CPR quality, guide vasopressor therapy, and detect ROSC (Class IIb, LOE C-EO).	updated for 2015
2015	Adjuncts to CPR	Ultrasound (cardiac or noncardiac) may be considered during the management of cardiac arrest, although its usefulness has not been well established (Class IIb, LOE C-EO).	updated for 2015
2015	Adjuncts to CPR	If a qualified sonographer is present and use of ultrasound does not interfere with the standard cardiac arrest treatment protocol, then ultrasound may be considered as an adjunct to standard patient evaluation (Class IIb, LOE C-EO).	updated for 2015
2015	Adjuncts for Airway Control and Ventilation	Either a bag-mask device or an advanced airway may be used for oxygenation and ventilation during CPR in both the in-hospital and out-of-hospital setting (Class IIb, LOE C-LD).	updated for 2015
2015	Adjuncts for Airway Control and Ventilation	For healthcare providers trained in their use, either an SGA device or an ETT may be used as the initial advanced airway during CPR (Class IIb, LOE C-LD).	updated for 2015
2015	Adjuncts for Airway Control and Ventilation	Continuous waveform capnography is recommended in addition to clinical assessment as the most reliable method of confirming and monitoring correct placement of an ETT (Class I, LOE C-LD).	updated for 2015
2015	Adjuncts for Airway Control and Ventilation	If continuous waveform capnometry is not available, a nonwaveform CO_2 detector, esophageal detector device, or ultrasound used by an experienced operator is a reasonable alternative (Class IIa, LOE B-NR).	updated for 2015
2015	Adjuncts for Airway Control and Ventilation	After placement of an advanced airway, it may be reasonable for the provider to deliver 1 breath every 6 seconds (10 breaths/min) while continuous chest compressions are being performed (Class IIb, LOE C-LD).	updated for 2015
2015	Management of Cardiac Arrest	Defibrillators (using BTE, RLB, or monophasic waveforms) are recommended to treat atrial and ventricular arrhythmias (Class I, LOE B-NR).	updated for 2015
2015	Management of Cardiac Arrest	Based on their greater success in arrhythmia termination, defibrillators using biphasic waveforms (BTE or RLB) are preferred to monophasic defibrillators for treatment of both atrial and ventricular arrhythmias (Class IIa, LOE B-R).	updated for 2015
2015	Management of Cardiac Arrest	In the absence of conclusive evidence that 1 biphasic waveform is superior to another in termination of VF, it is reasonable to use the manufacturer's recommended energy dose for the first shock. If this is not known, defibrillation at the maximal dose may be considered (Class IIb, LOE C-LD).	updated for 2015
2015	Management of Cardiac Arrest	It is reasonable that selection of fixed versus escalating energy for subsequent shocks be based on the specific manufacturer's instructions (Class IIa, LOE C-LD).	updated for 2015
2015	Management of Cardiac Arrest	If using a manual defibrillator capable of escalating energies, higher energy for second and subsequent shocks may be considered (Class IIb, LOE C-LD).	updated for 2015
2015	Management of Cardiac Arrest	A single-shock strategy (as opposed to stacked shocks) is reasonable for defibrillation (Class IIa, LOE B-NR).	updated for 2015
2015	Management of Cardiac Arrest	Amiodarone may be considered for VF/pVT that is unresponsive to CPR, defibrillation, and a vasopressor therapy (Class IIb, LOE B-R).	updated for 2015
2015	Management of Cardiac Arrest	Lidocaine may be considered as an alternative to amiodarone for VF/pVT that is unresponsive to CPR, defibrillation, and vasopressor therapy (Class IIb, LOE C-LD).	updated for 2015
2015	Management of Cardiac Arrest	The routine use of magnesium for VF/pVT is not recommended in adult patients (Class III: No Benefit, LOE B-R).	updated for 2015
2015	Management of Cardiac Arrest	There is inadequate evidence to support the routine use of lidocaine after cardiac arrest. However, the initiation or continuation of lidocaine may be considered immediately after ROSC from cardiac arrest due to VF/pVT (Class IIb, LOE C-LD).	new for 2015
2015	Management of Cardiac Arrest	There is inadequate evidence to support the routine use of a β-blocker after cardiac arrest. However, the initiation or continuation of an oral or intravenous β-blocker may be considered early after hospitalization from cardiac arrest due to VF/pVT (Class IIb, LOE C-LD).	new for 2015

(*Continued*)

2015 Guidelines Update: Part 7 Recommendations, *Continued*

Year Last Reviewed	Topic	Recommendation	Comments
2015	Management of Cardiac Arrest	Standard-dose epinephrine (1 mg every 3 to 5 minutes) may be reasonable for patients in cardiac arrest (Class IIb, LOE B-R).	updated for 2015
2015	Management of Cardiac Arrest	High-dose epinephrine is not recommended for routine use in cardiac arrest (Class III: No Benefit, LOE B-R).	new for 2015
2015	Management of Cardiac Arrest	Vasopressin offers no advantage as a substitute for epinephrine in cardiac arrest (Class IIb, LOE B-R).	updated for 2015
2015	Management of Cardiac Arrest	Vasopressin in combination with epinephrine offers no advantage as a substitute for standard-dose epinephrine in cardiac arrest (Class IIb, LOE B-R).	new for 2015
2015	Management of Cardiac Arrest	It may be reasonable to administer epinephrine as soon as feasible after the onset of cardiac arrest due to an initial nonshockable rhythm (Class IIb, LOE C-LD).	updated for 2015
2015	Management of Cardiac Arrest	In IHCA, the combination of intra-arrest vasopressin, epinephrine, and methylprednisolone and post-arrest hydrocortisone as described by Mentzelopoulos et al may be considered; however, further studies are needed before recommending the routine use of this therapeutic strategy (Class IIb, LOE C-LD).	new for 2015
2015	Management of Cardiac Arrest	For patients with OHCA, use of steroids during CPR is of uncertain benefit (Class IIb, LOE C-LD).	new for 2015
2015	Management of Cardiac Arrest	In intubated patients, failure to achieve an $ETCO_2$ of greater than 10 mm Hg by waveform capnography after 20 minutes of CPR may be considered as one component of a multimodal approach to decide when to end resuscitative efforts but should not be used in isolation (Class IIb, LOE C-LD).	new for 2015
2015	Management of Cardiac Arrest	In nonintubated patients, a specific $ETCO_2$ cutoff value at any time during CPR should not be used as an indication to end resuscitative efforts (Class III: Harm, LOE C-EO).	new for 2015
2015	Management of Cardiac Arrest	There is insufficient evidence to recommend the routine use of ECPR for patients with cardiac arrest. In settings where it can be rapidly implemented, ECPR may be considered for select cardiac arrest patients for whom the suspected etiology of the cardiac arrest is potentially reversible during a limited period of mechanical cardiorespiratory support. (Class IIb, LOE C-LD).	new for 2015
The following recommendations were not reviewed in 2015. For more information, see the *2010 AHA Guidelines for CPR and ECC*, "Part 8: Adult Advanced Cardiovascular Life Support."			
2010	Cricoid Pressure	The routine use of cricoid pressure in cardiac arrest is not recommended (Class III, LOE C).	not reviewed in 2015
2010	Oropharyngeal Airways	To facilitate delivery of ventilations with a bag-mask device, oropharyngeal airways can be used in unconscious (unresponsive) patients with no cough or gag reflex and should be inserted only by persons trained in their use (Class IIa, LOE C).	not reviewed in 2015
2010	Nasopharyngeal Airways	In the presence of known or suspected basal skull fracture or severe coagulopathy, an oral airway is preferred (Class IIa, LOE C).	not reviewed in 2015
2010	Postintubation Airway Management	The endotracheal tube should be secured with tape or a commercial device (Class I, LOE C).	not reviewed in 2015
2010	Postintubation Airway Management	One out-of-hospital study and 2 studies in an intensive care setting indicate that backboards, commercial devices for securing the endotracheal tube, and other strategies provide equivalent methods for preventing inadvertent tube displacement when compared with traditional methods of securing the tube (tape). These devices may be considered during patient transport (Class IIb, LOE C).	not reviewed in 2015
2010	Automatic Transport Ventilators	In both out-of-hospital and in-hospital settings, automatic transport ventilators (ATVs) can be useful for ventilation of adult patients in noncardiac arrest who have an advanced airway in place (Class IIb, LOE C).	not reviewed in 2015
2010	Automatic Transport Ventilators	During prolonged resuscitative efforts the use of an ATV (pneumatically powered and time- or pressure-cycled) may allow the EMS team to perform other tasks while providing adequate ventilation and oxygenation (Class IIb, LOE C).	not reviewed in 2015
2010	Automatic Versus Manual Modes for Multimodal Defibrillators	Current evidence indicates that the benefit of using a multimodal defibrillator in manual instead of automatic mode during cardiac arrest is uncertain (Class IIb, LOE C).	not reviewed in 2015
2010	CPR Before Defibrillation	Performing CPR while a defibrillator is readied for use is strongly recommended for all patients in cardiac arrest (Class I, LOE B).	not reviewed in 2015
2010	CPR Before Defibrillation	At this time the benefit of delaying defibrillation to perform CPR before defibrillation is unclear (Class IIb, LOE B).	not reviewed in 2015
2010	Drug Therapy for PEA/ Asystole	Available evidence suggests that the routine use of atropine during PEA or asystole is unlikely to have a therapeutic benefit (Class IIb, LOE B).	not reviewed in 2015

(*Continued*)

2015 Guidelines Update: Part 7 Recommendations, *Continued*

Year Last Reviewed	Topic	Recommendation	Comments
2010	Coronary Perfusion Pressure and Arterial Relaxation Pressure	It is reasonable to consider using arterial relaxation "diastolic" pressure to monitor CPR quality, optimize chest compressions, and guide vasopressor therapy (Class IIb, LOE C).	not reviewed in 2015
2010	Coronary Perfusion Pressure and Arterial Relaxation Pressure	If the arterial relaxation "diastolic" pressure is <20 mm Hg, it is reasonable to consider trying to improve quality of CPR by optimizing chest compression parameters or giving a vasopressor or both (Class IIb, LOE C).	not reviewed in 2015
2010	Coronary Perfusion Pressure and Arterial Relaxation Pressure	Arterial pressure monitoring can also be used to detect ROSC during chest compressions or when a rhythm check reveals an organized rhythm (Class IIb, LOE C).	not reviewed in 2015
2010	Central Venous Oxygen Saturation	Therefore, when in place before cardiac arrest, it is reasonable to consider using continuous $Scvo_2$ measurement to monitor quality of CPR, optimize chest compressions, and detect ROSC during chest compressions or when rhythm check reveals an organized rhythm (Class IIb, LOE C).	not reviewed in 2015
2010	Central Venous Oxygen Saturation	If $Scvo_2$ is <30%, it is reasonable to consider trying to improve the quality of CPR by optimizing chest compression parameters (Class IIb, LOE C).	not reviewed in 2015
2010	Arterial Blood Gases	Routine measurement of arterial blood gases during CPR has uncertain value (Class IIb, LOE C).	not reviewed in 2015
2010	IO Drug Delivery	It is reasonable for providers to establish IO access if IV access is not readily available (Class IIa, LOE C).	not reviewed in 2015
2010	Central IV Drug Delivery	The appropriately trained provider may consider placement of a central line (internal jugular or subclavian) during cardiac arrest, unless there are contraindications (Class IIb, LOE C).	not reviewed in 2015
2010	Endotracheal Drug Delivery	If IV or IO access cannot be established, epinephrine, vasopressin, and lidocaine may be administered by the endotracheal route during cardiac arrest (Class IIb, LOE B).	not reviewed in 2015
2010	Atropine	Available evidence suggests that routine use of atropine during PEA or asystole is unlikely to have a therapeutic benefit (Class IIb, LOE B).	not reviewed in 2015
2010	Sodium Bicarbonate	Routine use of sodium bicarbonate is not recommended for patients in cardiac arrest (Class III, LOE B).	not reviewed in 2015
2010	Calcium	Routine administration of calcium for treatment of in-hospital and out-of-hospital cardiac arrest is not recommended (Class III, LOE B).	not reviewed in 2015
2010	Precordial Thump	The precordial thump may be considered for termination of witnessed monitored unstable ventricular tachyarrhythmias when a defibrillator is not immediately ready for use (Class IIb, LOE B), but should not delay CPR and shock delivery.	not reviewed in 2015
2010	Management of Symptomatic Bradycardia and Tachycardia	If bradycardia produces signs and symptoms of instability (eg, acutely altered mental status, ischemic chest discomfort, acute heart failure, hypotension, or other signs of shock that persist despite adequate airway and breathing), the initial treatment is atropine (Class IIa, LOE B).	not reviewed in 2015
2010	Management of Symptomatic Bradycardia and Tachycardia	If bradycardia is unresponsive to atropine, intravenous (IV) infusion of β-adrenergic agonists with rate-accelerating effects (dopamine, epinephrine) or transcutaneous pacing (TCP) can be effective (Class IIa, LOE B) while the patient is prepared for emergent transvenous temporary pacing if required.	not reviewed in 2015
2010	Management of Symptomatic Bradycardia and Tachycardia	If the tachycardic patient is unstable with severe signs and symptoms related to a suspected arrhythmia (eg, acute altered mental status, ischemic chest discomfort, acute heart failure, hypotension, or other signs of shock), immediate cardioversion should be performed (with prior sedation in the conscious patient) (Class I, LOE B).	not reviewed in 2015
2010	Management of Symptomatic Bradycardia and Tachycardia	In select cases of regular narrow-complex tachycardia with unstable signs or symptoms, a trial of adenosine before cardioversion is reasonable to consider (Class IIb, LOE C).	not reviewed in 2015
2010	Atropine	Atropine remains the first-line drug for acute symptomatic bradycardia (Class IIa, LOE B).	not reviewed in 2015
2010	Pacing	It is reasonable for healthcare providers to initiate TCP in unstable patients who do not respond to atropine (Class IIa, LOE B).	not reviewed in 2015
2010	Pacing	Immediate pacing might be considered in unstable patients with high-degree AV block when IV access is not available (Class IIb, LOE C).	not reviewed in 2015
2010	Pacing	If the patient does not respond to drugs or TCP, transvenous pacing is probably indicated (Class IIa, LOE C).	not reviewed in 2015
2010	Dopamine	Dopamine infusion may be used for patients with symptomatic bradycardia, particularly if associated with hypotension, in whom atropine may be inappropriate or after atropine fails (Class IIb, LOE B).	not reviewed in 2015
2010	Wide-Complex Tachycardia - Evaluation	Precordial thump may be considered for patients with witnessed, monitored, unstable ventricular tachycardia if a defibrillator is not immediately ready for use (Class IIb, LOE C).	not reviewed in 2015

(*Continued*)

2015 Guidelines Update: Part 7 Recommendations, *Continued*

Year Last Reviewed	Topic	Recommendation	Comments
2010	Therapy for Regular Wide-Complex Tachycardias	If the etiology of the rhythm cannot be determined, the rate is regular, and the QRS is monomorphic, recent evidence suggests that IV adenosine is relatively safe for both treatment and diagnosis (Class IIb, LOE B).	not reviewed in 2015
2010	Therapy for Regular Wide-Complex Tachycardias	Adenosine should not be given for unstable or for irregular or polymorphic wide-complex wide-complex tachycardias, as it may cause degeneration of the arrhythmia to VF (Class III, LOE C).	not reviewed in 2015
2010	Therapy for Regular Wide-Complex Tachycardias	Verapamil is contraindicated for wide-complex tachycardias unless known to be of supraventricular origin (Class III, LOE B).	not reviewed in 2015
2010	Therapy for Regular Wide-Complex Tachycardias	If IV antiarrhythmics are administered, procainamide (Class IIa, LOE B), amiodarone (Class IIb, LOE B), or sotalol (Class IIb, LOE B) can be considered.	not reviewed in 2015
2010	Therapy for Regular Wide-Complex Tachycardias	Procainamide and sotalol should be avoided in patients with prolonged QT. If one of these antiarrhythmic agents is given, a second agent should not be given without expert consultation (Class III, LOE B).	not reviewed in 2015
2010	Therapy for Regular Wide-Complex Tachycardias	If antiarrhythmic therapy is unsuccessful, cardioversion or expert consultation should be considered (Class IIa, LOE C).	not reviewed in 2015
2010	Rate Control	IV β-blockers and nondihydropyridine calcium channel blockers such as diltiazem are the drugs of choice for acute rate control in most individuals with atrial fibrillation and rapid ventricular response (Class IIa, LOE A).	not reviewed in 2015
2010	Polymorphic (Irregular) VT	In the absence of a prolonged QT interval, the most common cause of polymorphic VT is myocardial ischemia. In this situation IV amiodarone and β-blockers may reduce the frequency of arrhythmia recurrence (Class IIb, LOE C).	not reviewed in 2015
2010	Polymorphic (Irregular) VT	Magnesium is unlikely to be effective in preventing polymorphic VT in patients with a normal QT interval (Class IIb, LOE C), but amiodarone may be effective (Class IIb, LOE C).	not reviewed in 2015
2010	Ventilation and Oxygen Administration During CPR	Advanced airway placement in cardiac arrest should not delay initial CPR and defibrillation for VF cardiac arrest (Class I, LOE C).	not reviewed in 2015
2010	Advanced Airways	If advanced airway placement will interrupt chest compressions, providers may consider deferring insertion of the airway until the patient fails to respond to initial CPR and defibrillation attempts or demonstrates ROSC (Class IIb, LOE C).	not reviewed in 2015
2010	Endotracheal Intubation	EMS systems that perform prehospital intubation should provide a program of ongoing quality improvement to minimize complications (Class IIa, LOE B).	not reviewed in 2015
2010	VF Waveform Analysis to Predict Defibrillation Success	The value of VF waveform analysis to guide management of defibrillation in adults with in-hospital and out-of-hospital cardiac arrest is uncertain (Class IIb, LOE C).	not reviewed in 2015
2010	Fibrinolysis	Fibrinolytic therapy should not be routinely used in cardiac arrest (Class III, LOE B).	not reviewed in 2015
2010	Pacing	Electric pacing is not recommended for routine use in cardiac arrest (Class III, LOE B).	not reviewed in 2015
2010	Epinephrine	Epinephrine infusion may be used for patients with symptomatic bradycardia, particularly if associated with hypotension, for whom atropine may be inappropriate or after atropine fails (Class IIb, LOE B).	not reviewed in 2015
2010	Initial Evaluation and Treatment of Tachyarrhythmias	If not hypotensive, the patient with a regular narrow-complex SVT (likely due to suspected reentry, paroxysmal supraventricular tachycardia, as described below) may be treated with adenosine while preparations are made for synchronized cardioversion (Class IIb, LOE C).	not reviewed in 2015
2010	Therapy	If PSVT does not respond to vagal maneuvers, give 6 mg of IV adenosine as a rapid IV push through a large (eg, antecubital) vein followed by a 20 mL saline flush (Class I, LOE B).	not reviewed in 2015
2010	Therapy	If adenosine or vagal maneuvers fail to convert PSVT, PSVT recurs after such treatment, or these treatments disclose a different form of SVT (such as atrial fibrillation or flutter), it is reasonable to use longer-acting AV nodal blocking agents, such as the nondihydropyridine calcium channel blockers (verapamil and diltiazem) (Class IIa, LOE B) or β-blockers (Class IIa, LOE C).	not reviewed in 2015
2010	Therapy	Therefore, AV nodal blocking drugs should not be used for pre-excited atrial fibrillation or flutter (Class III, LOE C).	not reviewed in 2015

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Part 8: Post–Cardiac Arrest Care

2015 American Heart Association Guidelines Update for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care

Clifton W. Callaway, Chair; Michael W. Donnino; Ericka L. Fink; Romergryko G. Geocadin; Eyal Golan; Karl B. Kern; Marion Leary; William J. Meurer; Mary Ann Peberdy; Trevonne M. Thompson; Janice L. Zimmerman

Introduction

The recommendations in this *2015 American Heart Association* (AHA) *Guidelines Update for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care* are based on an extensive evidence review process that was begun by the International Liaison Committee on Resuscitation (ILCOR) after the publication of the *2010 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science With Treatment Recommendations*[1,2] and was completed in February 2015.[3,4]

In this in-depth evidence review process, ILCOR examined topics and then generated a prioritized list of questions for systematic review. Questions were first formulated in PICO (population, intervention, comparator, outcome) format,[5] and then search strategies and inclusion and exclusion criteria were defined and a search for relevant articles was performed. The evidence was evaluated by the ILCOR task forces by using the standardized methodological approach proposed by the Grading of Recommendations Assessment, Development and Evaluation (GRADE) Working Group.[6]

The quality of the evidence was categorized based on the study methodologies and the 5 core GRADE domains of risk of bias, inconsistency, indirectness, imprecision, and other considerations (including publication bias). Then, where possible, consensus-based treatment recommendations were created.

To create this 2015 Guidelines Update, the AHA formed 15 writing groups, with careful attention to manage conflicts of interest, to assess the ILCOR treatment recommendations and to write AHA treatment recommendations by using the AHA Class of Recommendation (COR) and Level of Evidence (LOE) system. The recommendations made in the Guidelines are informed by the ILCOR recommendations and GRADE classification, in the context of the delivery of medical care in North America. The AHA writing group made new recommendations only on topics specifically reviewed by ILCOR in 2015. This chapter delineates instances where the AHA writing group developed recommendations that are significantly stronger or weaker than the ILCOR statements. In the online version of this publication, live links are provided so the reader can connect directly to the systematic reviews on the Scientific Evidence Evaluation and Review System (SEERS) website. These links are indicated by a combination of letters and numbers (eg, ALS 790). We encourage readers to use the links and review the evidence and appendixes, including the GRADE tables.

This update uses the newest AHA COR and LOE classification system, which contains modifications of the Class III recommendation and introduces LOE B-R (randomized studies) and B-NR (nonrandomized studies) as well as LOE C-LD (limited data) and LOE C-EO (consensus of expert opinion). All recommendations made in this 2015 Guidelines Update, as well as in the 2010 Guidelines for post–cardiac arrest care, are listed in the Appendix. For further information, see "Part 2: Evidence Evaluation and Management of Conflicts of Interest" in this 2015 Guidelines Update.

Overview of Post–Cardiac Arrest Care

The 2010 Guidelines emphasized that cardiac arrest can result from many different diseases. Regardless of cause, the hypoxemia, ischemia, and reperfusion that occur during cardiac arrest and resuscitation may cause damage to multiple organ systems.[7] The severity of damage can vary widely among patients and among organ systems within individual patients. Therefore, effective post–cardiac arrest care consists of identification and treatment of the precipitating cause of cardiac arrest combined with the assessment and mitigation of ischemia-reperfusion injury to multiple organ systems. Care must be tailored to the particular disease and dysfunction that affect each patient. Therefore, individual patients may require few, many, or all of the specific interventions discussed in the remainder of this Part.

Cardiovascular Care

Acute Cardiovascular Interventions[ACS 340, ACS 885]

The 2010 Guidelines recommended obtaining a 12-lead electrocardiogram (ECG) as soon as possible after return of spontaneous circulation (ROSC) to identify if acute ST elevation is present, and to perform urgent coronary angiography with prompt recanalization of any infarct-related artery in select

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post–cardiac arrest patients in whom ST-segment elevation was identified. Acute coronary syndromes are a common etiology for out-of-hospital cardiac arrest (OHCA) in adults with no obvious extracardiac cause of arrest[8–10] and also can precipitate some in-hospital cardiac arrest. In series in which consecutive post–cardiac arrest patients with suspected cardiovascular cause were taken to coronary angiography, a coronary artery lesion amenable to emergency treatment was found in 96% of patients with ST elevation and in 58% of patients without ST elevation.[10]

The 2015 ILCOR systematic review examined immediate coronary angiography for patients after cardiac arrest.

2015 Evidence Summary

Numerous observational studies evaluate the relationship between coronary angiography, survival, and functional outcome in post–cardiac arrest patients, but there are no prospective randomized trials evaluating an interventional strategy in postarrest patients. The timing of immediate coronary angiography was defined in various ways in different studies, but all studies considered immediate angiography as a procedure performed on the same day as the cardiac arrest, as opposed to later in the hospital stay. Fifteen observational studies reported improved survival to hospital discharge associated with emergency coronary angiography in patients with ST elevation after cardiac arrest.[11–25] Nine observational studies showed improved neurologically favorable outcome associated with emergency coronary angiography in patients with ST elevation after cardiac arrest.[11–13,16,18–21,23]

Fewer data are available to evaluate coronary angiography in patients without ST elevation on the initial ECG. Two observational studies reported improved survival to hospital discharge and improved neurologically favorable outcome associated with emergency coronary angiography in patients without ST elevation on initial ECG.[11,16]

2015 Recommendations—Updated

Coronary angiography should be performed emergently (rather than later in the hospital stay or not at all) for OHCA patients with suspected cardiac etiology of arrest and ST elevation on ECG (Class I, LOE B-NR).

Emergency coronary angiography is reasonable for select (eg, electrically or hemodynamically unstable) adult patients who are comatose after OHCA of suspected cardiac origin but without ST elevation on ECG (Class IIa, LOE B-NR).

Coronary angiography is reasonable in post–cardiac arrest patients for whom coronary angiography is indicated regardless of whether the patient is comatose or awake (Class IIa, LOE C-LD).

Early invasive approaches are preferred for patients with ST-segment elevation myocardial infarction (STEMI), making these recommendations for post–cardiac arrest patients consistent with global recommendations for all patients with STEMI.[26] Early invasive approaches also are suggested for treatment of select post–cardiac arrest patients with acute coronary syndromes without ST elevation. Considerations for selecting patients are complex and may consider factors such as hemodynamic or electrical instability as well as comorbidities, evidence of ongoing ischemia, and other patient characteristics.[27] Knowledge of coronary anatomy and opportunity for placement of temporary support devices are other potential benefits derived from early catheterization. Therefore, these recommendations for post–cardiac arrest care are consistent with recommendations for all patients with non-STEMI acute coronary syndromes. Both the European Society of Cardiology and the combined entity of the American College of Cardiology Foundation and the AHA have published STEMI guidelines recommending immediate coronary angiography, and percutaneous coronary intervention when indicated, for resuscitated OHCA patients whose ECGs show STEMI.[26,28] None of these guidelines recommended different treatment of patients based on the initial cardiac arrest rhythm (ventricular fibrillation [VF] or non-VF).

Previous consensus statements have discussed how public reporting of postprocedure death creates an incentive to avoid emergency coronary angiography in comatose patients who are at higher risk of death as a consequence of poor neurologic recovery.[29] However, the probability of neurologic recovery cannot be determined reliably at the time that emergency cardiovascular interventions are performed (see Prognostication of Outcome section in this Part). Therefore, the best care for the patient requires separation of decisions about cardiovascular intervention from assessment of neurologic prognosis.

Hemodynamic Goals[ALS 570]

Post–cardiac arrest patients are often hemodynamically unstable, which can occur for multiple reasons that include the underlying etiology of the arrest as well as the ischemia-reperfusion injury from the arrest. Management of these patients can be challenging, and optimal hemodynamic goals remain undefined. In 2015, ILCOR evaluated the optimal hemodynamic targets in post–cardiac arrest patients, primarily considering blood pressure goals.

2015 Evidence Summary

There are several observational studies evaluating the relationship between blood pressure and outcome in post–cardiac arrest patients, but there are no interventional studies targeting blood pressure in isolation and no trials evaluating one specific strategy for improving blood pressure over another (ie, fluids, vasopressors). Observational studies found that post–cardiac arrest systolic blood pressure less than 90 mm Hg[30,31] or greater than 100 mm Hg[32] was associated with higher mortality and diminished functional recovery. One observational study found that mean arterial pressure (MAP) greater than 100 mm Hg during 2 hours after ROSC was associated with better neurologic recovery at hospital discharge.[33] Another observational study found that survivors, compared with nonsurvivors, had higher MAP at 1 hour (96 versus 84 mm Hg) and at 6 hours (96 versus 90 mm Hg).[34]

While no studies evaluated blood pressure in isolation, several before-and-after studies implemented bundles of care that included blood pressure goals. In these studies, the individual effect of blood pressure was impossible to separate from the effects of the remainder of the bundle. One bundle with a MAP target of greater than 80 mm Hg improved mortality and neurologic outcome at hospital discharge.[35] One bundle with a goal of MAP over 75 mm Hg found no change in functional recovery at hospital discharge.[36] One bundle with

MAP greater than 65 mm Hg increased survival to hospital discharge, with a favorable neurologic outcome at 1 year.[37] Another bundle with a goal MAP greater than 65 mm Hg within 6 hours found no change in in-hospital mortality or functional recovery at hospital discharge.[38]

2015 Recommendation—New

Avoiding and immediately correcting hypotension (systolic blood pressure less than 90 mm Hg, MAP less than 65 mm Hg) during postresuscitation care may be reasonable (Class IIb, LOE C-LD).

A specific MAP or systolic blood pressure that should be targeted as part of the bundle of postresuscitation interventions could not be identified, although published protocols targeted MAP goals of greater than 65 mm Hg to greater than 80 mm Hg. Moreover, identifying an optimal MAP goal for the overall patient population may be complicated by individual patient variability, because baseline blood pressures vary among patients. The true optimal blood pressure would be that which allows for optimal organ and brain perfusion, and different patients and different organs may have different optimal pressures.

Targets for other hemodynamic or perfusion measures (such as cardiac output, mixed/central venous oxygen saturation, and urine output) remain undefined in post–cardiac arrest patients. The systematic reviews did not identify specific targets for other variables, and individual goals likely vary based on patient-specific comorbidities and underlying physiology. In the absence of evidence for specific targets, the writing group made no recommendations to target any hemodynamic goals other than those that would be used for other critically ill patients.

Targeted Temperature Management

The 2010 Guidelines strongly advised induced hypothermia (32ºC to 34ºC) for the subgroup of patients with out-of-hospital VF/pulseless ventricular tachycardia (pVT) cardiac arrest and post-ROSC coma (the absence of purposeful movements), and encouraged that induced hypothermia be considered for most other comatose patients after cardiac arrest. Precise duration and optimal temperature targets were unknown, and the Guidelines recommended 12 to 24 hours at 32ºC to 34ºC based on the regimens studied in prior trials. The 2015 ILCOR systematic review identified multiple new randomized controlled trials testing different target temperatures and different timing for initiation of temperature control after cardiac arrest.[39] Reflecting that a variety of temperature targets are now used, the term *targeted temperature management* (TTM) has been adopted to refer to induced hypothermia as well as to active control of temperature at any target.

Induced Hypothermia ALS 790, ALS 791

2015 Evidence Summary

For patients with VF/pVT OHCA, combined outcome data from 1 randomized and 1 quasi-randomized clinical trial reported increased survival and increased functional recovery with induced hypothermia to 32ºC to 34ºC.[40,41]

For patients with OHCA and nonshockable rhythms, observational data were conflicting and no randomized data were available. Three observational studies found no difference in neurologic outcome at hospital discharge in patients treated with induced hypothermia.[42–44] One study reported an increase in poor neurologic outcome at hospital discharge; however, the analysis of this study was confounded perhaps most notably by lack of information on whether analyzed patients were eligible for induced hypothermia (ie, unknown if patients were following commands).[45] One study reported reduced mortality at 6 months with induced hypothermia.[43]

For patients with in-hospital cardiac arrest, no randomized data were available. One observational study found no association between induced hypothermia and survival or functionally favorable status at hospital discharge. However, the analysis of this study was also confounded by multiple factors, including the lack of information on which patients were comatose and, therefore, potential candidates for induced hypothermia.[46]

One well-conducted randomized controlled trial found that neurologic outcomes and survival at 6 months after OHCA were not superior when temperature was controlled at 36ºC versus 33ºC.[47] Both arms of this trial involved a form of TTM as opposed to no TTM.

There are no direct comparisons of different durations of TTM in post–cardiac arrest patients. The largest trials and studies of TTM maintained temperatures for 24 hours[40] or 28 hours[47] followed by a gradual (approximately 0.25ºC/hour) return to normothermia.

2015 Recommendations—Updated

We recommend that comatose (ie, lack of meaningful response to verbal commands) adult patients with ROSC after cardiac arrest have TTM (Class I, LOE B-R for VF/pVT OHCA; Class I, LOE C-EO for non-VF/pVT (ie, "nonshockable") and in-hospital cardiac arrest).

We recommend selecting and maintaining a constant temperature between 32ºC and 36ºC during TTM (Class I, LOE B-R).

In making these strong recommendations, the writing group was influenced by the recent clinical trial data enrolling patients with all rhythms, the rarity of adverse effects in trials, the high neurologic morbidity and mortality without any specific interventions, and the preponderance of data suggesting that temperature is an important variable for neurologic recovery. Of note, there are essentially no patients for whom temperature control somewhere in the range between 32ºC and 36ºC is contraindicated. Specific features of the patient may favor selection of one temperature over another for TTM. Higher temperatures might be preferred in patients for whom lower temperatures convey some risk (eg, bleeding),[48,49] and lower temperatures might be preferred when patients have clinical features that are worsened at higher temperatures (eg, seizures, cerebral edema).[50–52] Therefore, all patients in whom intensive care is continued are eligible. The initial temperature of the patient may influence selection of the temperature for TTM. For example, those who present at the lower end of the TTM range might be maintained at that lower temperature (as opposed to warming them to a higher target). Alternatively, passive warming to a maximum temperature of 36ºC might be acceptable as well. Of note is that the recent randomized trial did not use active warming for the 36ºC group.[47] Therefore, while it is stated that choosing a temperature within the 32ºC to 36ºC range is acceptable, actively or rapidly warming patients is not suggested. Conversely, patients who present on

the higher end of the TTM range might be kept at 36ºC without much additional effort. Providers should note that allowing patients to warm to temperatures above 36ºC would be more akin to the control group of the earlier trials and not consistent with the current TTM recommendations.

The recommendations for TTM for nonshockable rhythms and for patients following in-hospital arrest are stronger than those made in 2015 by ILCOR[3,4] and are stronger than the recommendations in "Part 9: Post–Cardiac Arrest Care" in the 2010 Guidelines. The writing group felt that the option for TTM at 36ºC diminished theoretical concerns about side effects of TTM for these populations. In addition, the writing group was influenced by the high rate of neurologic morbidity in historical cohorts that did not use TTM.

It is reasonable that TTM be maintained for at least 24 hours after achieving target temperature (Class IIa, LOE C-EO).

Even if the selected target temperature is not achieved during this time frame, clinicians should still try to control temperature for at least 24 hours after cardiac arrest. Temperature sensitivity of the brain after cardiac arrest may continue for as long as brain dysfunction (ie, coma) is present, making the upper limit of duration for temperature management unknown. The duration of at least 24 hours was used in 2 of the largest trials, although there are no comparative data for this duration. For these reasons, 24 hours was selected as the minimum recommended time for TTM.

Hypothermia in the Prehospital Setting[ALS 802]

The initiation of hypothermia has been popularized in the prehospital setting, though the original studies showing efficacy from induced hypothermia did not systematically study the prehospital setting. A logical assumption for the widespread implementation of this practice stemmed from the concept that earlier provision of an effective intervention would be more beneficial. However, induction of prehospital hypothermia was not extensively evaluated by large-scale randomized trials in 2010. Since that time, a number of additional trials have been published, including at least 1 large-scale investigation. In 2015, ILCOR examined the question of whether early provision of TTM was beneficial, with a focus on the prehospital period.

2015 Evidence Summary

Five randomized controlled trials[53–57] compared the post-ROSC use of cold intravenous fluids to induce hypothermia to no fluids. One trial compared cold intravenous fluid during resuscitation to no cooling,[58] and another trial compared intra-arrest intranasal cooling to no cooling.[59] When cooling maneuvers were initiated in the prehospital setting, neither survival nor neurologic recovery differed for any of these trials alone or when combined in a meta-analysis. One trial found an increase in pulmonary edema and rearrest among patients treated with a goal of prehospital infusion of 2 L of cold fluids.[57]

2015 Recommendation—New

We recommend **against** the routine prehospital cooling of patients after ROSC with rapid infusion of cold intravenous fluids (Class III: No Benefit, LOE A).

During the past few years, infusion of cold intravenous fluids has become a popular prehospital intervention that may influence the system of care. Initiation of a temperature management strategy en route to the hospital may increase the probability that temperature management continues during the hospitalization. Adverse effects of the rapid infusion of cold intravenous fluids in the prehospital setting must be weighed against this potential positive effect of earlier intervention. Current evidence indicates that there is no direct patient benefit from these interventions and that the intravenous fluid administration in the prehospital setting may have some potential harm, albeit with no increase in overall mortality. Whether different methods or devices for temperature control outside of the hospital are beneficial is unknown.

Avoidance of Hyperthermia[ALS 879]

After the completion of TTM for a set duration (such as 24 hours), the optimal approach to subsequent temperature management remains unknown. In 2015, the ILCOR systematic review evaluated both the approach to hyperthermia on presentation (before initiation of TTM) and after rewarming. The treatment recommendation to maintain a targeted temperature between 32ºC and 36ºC for postarrest patients will prevent early hyperthermia. Therefore, treatment recommendations for the avoidance of hyperthermia focus on the post-rewarming period.

2015 Evidence Summary

Observational studies consistently report that fever in the post–cardiac arrest patient who is not treated with TTM is associated with poor outcome.[60–64]

After rewarming to normothermia from TTM, many studies have noted that fever occurs in a significant proportion of patients.[64–71] Occurrence of hyperthermia during the first few days after cardiac arrest was associated with worse outcome in 2 studies[70,71] but not in others.[64–69]

2015 Recommendation—New

It may be reasonable to actively prevent fever in comatose patients after TTM (Class IIb, LOE C-LD).

Fever will not occur during the first 24 to 48 hours after cardiac arrest when patients are treated with TTM. Though the evidence that supports avoiding hyperthermia is weak in postarrest patients, the intervention is relatively benign. In addition, fever is associated with worsened neurologic injury in comatose patients receiving intensive care for other conditions.[72,73] Therefore, the recommendation of the avoidance of fever is based on expert opinion that a relatively benign procedure is reasonable to perform in the face of a potential for worsening ischemic brain injury. The simplest method to accomplish prolonged hyperthermia prevention may be to leave the devices or strategies used for TTM in place.

Other Neurologic Care

The 2010 Guidelines emphasized advanced neurocritical care for patients who have brain injury after cardiac arrest, including electroencephalography (EEG) for detection of seizures, and prompt treatment of seizures. The 2015 ILCOR systematic review considered detection and treatment of seizures.

Seizure Management[ALS 868, ALS 431]

2015 Evidence Summary

The prevalence of seizures, nonconvulsive status epilepticus, and other epileptiform activity among patients who are comatose after cardiac arrest is estimated to be 12% to 22%.[74–76] Nonconvulsive status epilepticus may be a reason that patients are not awakening from coma. Three case series looked at 47 post–cardiac arrest patients who were treated for seizures or status epilepticus and found that only 1 patient survived with good neurologic function.[77–79]

Available evidence does not support prophylactic administration of anticonvulsant drugs. Two randomized clinical trials comparing anticonvulsants (thiopental[80] in one study and diazepam[74] in the other study) to placebo found no difference in any outcome when these drugs were administered shortly after ROSC. In addition, 1 nonrandomized clinical trial with historic controls did not find outcome differences when a combination of thiopental and phenobarbital[81] was provided after ROSC.

Prolonged epileptiform discharges are associated with secondary brain injury in other situations, making detection and treatment of nonconvulsive status epilepticus a priority.[82] However, there are no direct comparative studies in post–cardiac arrest patients of treating seizures versus not treating seizures. The 2015 ILCOR systematic review did not identify any evidence that 1 specific drug or combination of drugs was superior for treatment of epileptiform activity after cardiac arrest.

2015 Recommendations—Updated

An EEG for the diagnosis of seizure should be promptly performed and interpreted, and then should be monitored frequently or continuously in comatose patients after ROSC (Class I, LOE C-LD).

The same anticonvulsant regimens for the treatment of status epilepticus caused by other etiologies may be considered after cardiac arrest (Class IIb, LOE C-LD).

Respiratory Care

The 2010 Guidelines emphasized the identification of pulmonary dysfunction after cardiac arrest. The 2015 ILCOR systematic review evaluated whether a particular strategy of ventilator management should be employed for postarrest patients, with a specific focus on a target range for $Paco_2$.

Ventilation[ALS 571]

2015 Evidence Summary

Systematic reviews examined whether ventilation to achieve and maintain a particular $Paco_2$ was associated with improved outcome. Two observational studies[83,84] found hypocapnia to be associated with a worse neurologic outcome, and 1 observational study found hypocapnia was associated with failure to be discharged home.[85] Observational studies did not find any consistent association between hypercapnia and outcome.[83–86]

2015 Recommendation—Updated

Maintaining the $Paco_2$ within a normal physiological range, taking into account any temperature correction, may be reasonable (Class IIb, LOE B-NR).

Normocarbia (end-tidal CO_2 30–40 mm Hg or $Paco_2$ 35–45 mm Hg) may be a reasonable goal unless patient factors prompt more individualized treatment. Other $Paco_2$ targets may be tolerated for specific patients. For example, a higher $Paco_2$ may be permissible in patients with acute lung injury or high airway pressures. Likewise, mild hypocapnia might be useful as a temporizing measure when treating cerebral edema, but hyperventilation might cause cerebral vasoconstriction. The need to avoid potential hyperventilation-induced cerebral vasoconstriction needs to be weighed against the correction of metabolic acidosis by hyperventilation. Providers should note that when patient temperature is below normal, laboratory values reported for $Paco_2$ might be higher than the actual values in the patient.

Oxygenation[ALS 448]

Previous guidelines suggested that the optimal titration of supplementary oxygen targets avoidance of prolonged hyperoxia. Episodes of hypoxia that can add to organ injury should also be prevented.

2015 Evidence Summary

The systematic review identified recent observational studies suggesting that excessively high arterial oxygen concentrations (hyperoxia) may harm various organs or worsen outcomes.[87–89] Other studies did not confirm this finding.[83,86,90–92] One small randomized trial comparing 30% inspired oxygen for 60 minutes after ROSC versus 100% inspired oxygen for 60 minutes after ROSC found no difference in either survival to hospital discharge or survival with favorable neurologic outcome.[93] Most studies defined hypoxia as Pao_2 less than 60 mm Hg, and hyperoxia as a Pao_2 greater than 300 mm Hg. However, the optimum upper and lower limits of Pao_2 are not known.

The 2010 Guidelines defined an arterial oxygen saturation (Sao_2) of less than 94% as hypoxemia, and there were no new data to suggest modifying this threshold. Minimizing risk of hyperoxia must be weighed against the need to avoid hypoxia, which has a well established detrimental effect.[88,91,94] Preventing hypoxic episodes is considered more important than avoiding any potential risk of hyperoxia.

2015 Recommendations—New and Updated

To avoid hypoxia in adults with ROSC after cardiac arrest, it is reasonable to use the highest available oxygen concentration until the arterial oxyhemoglobin saturation or the partial pressure of arterial oxygen can be measured (Class IIa, LOE C-EO).

When resources are available to titrate the Fio_2 and to monitor oxyhemoglobin saturation, it is reasonable to decrease the Fio_2 when oxyhemoglobin saturation is 100%, provided the oxyhemoglobin saturation can be maintained at 94% or greater (Class IIa, LOE C-LD).

Shortly after ROSC, patients may have peripheral vasoconstriction that makes measurement of oxyhemoglobin saturation by pulse oximetry difficult or unreliable. In those situations, arterial blood sampling may be required before titration of Fio_2. Attempts to limit the concentration of inspired oxygen rely on having proper equipment available. For example, oxygen blenders may not be available immediately after return of pulses, and these recommendations remind providers using bag-mask devices and oxygen cylinders to simply provide the highest available oxygen concentration until titration is possible.

Other Critical Care Interventions

Glucose Control[ALS 580]

The 2010 Guidelines acknowledged that the optimum blood glucose concentration and interventional strategy to manage blood glucose in the post–cardiac arrest period are unknown. Glycemic control in critically ill patients is controversial, and efforts to tightly control glucose at low levels have been associated with increased frequency of hypoglycemic episodes that may be detrimental.

2015 Evidence Summary

The 2015 ILCOR systematic review found no new evidence that a specific target range for blood glucose management improved relevant clinical outcomes after cardiac arrest. One randomized trial in post–cardiac arrest patients comparing strict (72 to 108 mg/dL) versus moderate (108 to 144 mg/dL) glucose control found no difference in 30-day mortality.[95] One before-and-after study of a bundle of care that included a target glucose range (90 to 144 mg/dL) reported better survival and functional recovery at hospital discharge, but the effects of glucose control could not be separated from the remainder of the bundle.[37] No data suggest that the approach to glucose management chosen for other critically ill patients should be modified for cardiac arrest patients.[96–98]

2015 Recommendation—Updated

The benefit of any specific target range of glucose management is uncertain in adults with ROSC after cardiac arrest (Class IIb, LOE B-R).

Prognostication of Outcome

The 2010 Guidelines discussed the use of clinical examination, electrophysiologic measurements, imaging studies, and evaluation of blood or cerebrospinal fluid markers of brain injury to estimate the prognosis for neurologic improvement in patients who are comatose after cardiac arrest. The 2015 ILCOR systematic review examined numerous studies of the diagnostic accuracy of clinical findings, electrophysiologic modalities, imaging modalities, and blood markers for predicting neurologic outcome in comatose post–cardiac arrest patients who receive TTM, and examined recent studies of these modalities in comatose post–cardiac arrest patients who do not receive TTM. Updated guidelines for prognostication have also been proposed by other international organizations.[99]

Most studies examined the accuracy of diagnostic tests for predicting a poor outcome (as defined by a Cerebral Performance Category score of 3 to 5) and focused on patients receiving TTM with a goal of 32°C to 34°C. The writing group assumed that the accuracy of prognostic tests is similar in patients receiving TTM with a goal of 36°C when similar sedation and paralysis are used as in patients receiving TTM with a goal of 32°C to 34°C. Recognizing the need for high certainty when predicting that outcomes will be poor, the writing group focused recommendations on diagnostic tests for which the systematic review identified false-positive rates (FPRs) close to 0%, with narrow 95% confidence intervals (CIs; 0%–10%).

Experienced clinicians should select the proper tests and studies for individual patients. Some patients will recover quickly and will require no special testing. For other patients, prediction of their recovery trajectory may be impossible despite collecting every available test and imaging study. The following recommendations are designed to provide guidance to clinicians about the performance of specific findings and tests, recognizing that not every patient will require every study.

Timing of Outcome Prediction[ALS 450, ALS 713]

It is important to consider the optimal timing for prognostication in post–cardiac arrest patients. In 2015, the ILCOR task force evaluated the timing of prognostication for patients receiving TTM and for those not receiving TTM.

2015 Evidence Summary

Sedatives or neuromuscular blockers received during TTM may be metabolized more slowly in post–cardiac arrest patients, and injured brains may be more sensitive to the depressant effects of various medications. Residual sedation or paralysis can confound the accuracy of clinical examinations.[100,101] The optimal time for prognostication is when the FPRs of the various prognostic tools approach zero. Multiple investigations suggest that it is necessary to wait to prognosticate for a minimum of 72 hours after ROSC to minimize the rate of false-positive results in patients who had not undergone TTM[102] and to wait for some period of time after return of normothermia for those using TTM.[103]

2015 Recommendations—New and Updated

The earliest time for prognostication using clinical examination in patients treated with TTM, where sedation or paralysis could be a confounder, may be 72 hours after return to normothermia (Class IIb, LOE C-EO).

We recommend the earliest time to prognosticate a poor neurologic outcome using clinical examination in patients not treated with TTM is 72 hours after cardiac arrest (Class I, LOE B-NR). This time until prognostication can be even longer than 72 hours after cardiac arrest if the residual effect of sedation or paralysis confounds the clinical examination (Class IIa, LOE C-LD).

Operationally, the timing for prognostication is typically 4.5 to 5 days after ROSC for patients treated with TTM. This approach minimizes the possibility of obtaining false-positive results (ie, inaccurately suggesting a poor outcome) because of drug-induced depression of neurologic function. In making this recommendation, it is recognized that in some instances, withdrawal of life support may occur appropriately before 72 hours because of underlying terminal disease, brain herniation, or other clearly nonsurvivable situations.

Clinical Examination Findings That Predict Outcome[ALS 450, ALS 713]

Prediction of outcome based on clinical examination may be challenging. In 2015, the ILCOR Advanced Life Support Task Force evaluated a series of clinical exam findings to determine their value in outcome prediction.

2015 Evidence Summary

The 2015 ILCOR systematic review examined pupillary light reflexes, corneal reflexes, and motor response for prediction

of poor functional recovery in patients treated with TTM. Bilaterally absent pupillary light reflex at 72 to 108 hours after cardiac arrest predicted poor outcome, with an FPR of 1% (95% CI, 0%–3%).[104–108] Bilaterally absent corneal reflexes at 72 to 120 hours after cardiac arrest predicted poor outcome, with a 2% FPR (95% CI, 0%–7%).[106–109] Extensor posturing or no motor response to pain at 36 to 108 hours after cardiac arrest predicted poor outcome, with a 10% FPR (95% CI, 7%–15%).[104,106,108,110–112] Only the absent pupillary light reflex at 72 to 108 hours achieved an FPR of 0% (95% CI, 0%–3%).

In patients not treated with TTM, absent pupillary light reflex 72 hours after cardiac arrest predicts poor outcome, with 0% FPR (95% CI, 0%–8%).[113,114] Absent corneal reflex at 24 hours and 48 hours after cardiac arrest predicted poor outcome, with an FPR of 17% (95% CI, 9%–27%) and an FPR of 7% (95% CI, 2%–20%), respectively.[114–116] Extensor posturing or no motor response to pain at 72 hours after cardiac arrest predicted a poor outcome, with 15% FPR (95% CI, 5%–31%).[114,117] As in TTM-treated patients, only the absent pupillary light reflex at 72 to 108 hours achieved 0% FPR (95% CI, 0%–8%).

The 2015 ILCOR systematic review distinguished myoclonus from status myoclonus (continuous, repetitive myoclonic jerks lasting more than 30 minutes) in patients treated with TTM. Any myoclonus within 72 hours after cardiac arrest predicted a poor outcome, with a 5% FPR (95% CI, 3%–8%).[78,104,110,111,118,119] In 1 study,[112] presence of myoclonus within 7 days after ROSC predicted poor outcome, with 11% FPR (95% CI, 3%–26%) and 54% FPR (95% CI, 41%–66%) sensitivity. In 3 studies,[75,107,108] presence of status myoclonus (defined as a continuous prolonged and generalized myoclonus) within 72 to 120 hours after ROSC predicted poor outcome, with a 0% FPR (95% CI, 0%–4%). However, some series report good neurologic recovery in which an early-onset and prolonged myoclonus evolved into a chronic action myoclonus (Lance-Adams syndrome).[118,121–123] Therefore, the presence of any myoclonus is not a reliable predictor of poor functional recovery, but status myoclonus during the first 72 hours after cardiac arrest achieved an FPR of 0% (95% CI, 0%–4%).

In patients not treated with TTM, status myoclonus on admission (FPR, 0%; 95% CI, 0%–5%)[124] at 24 hours after cardiac arrest[116] (FPR, 0%; 95% CI, 0%–7%) or within 72 hours of cardiac arrest[114,125] (FPR, 0%; 95% CI, 0%–14%) is associated with poor outcome. The older studies were less precise in distinguishing myoclonus from status myoclonus, lowering confidence in their estimated predictive value.

2015 Recommendations—New and Updated

In comatose patients who are not treated with TTM, the absence of pupillary reflex to light at 72 hours or more after cardiac arrest is a reasonable exam finding with which to predict poor neurologic outcome (FPR, 0%; 95% CI, 0%–8%; Class IIa, LOE B-NR).

In comatose patients who are treated with TTM, the absence of pupillary reflex to light at 72 hours or more after cardiac arrest is useful to predict poor neurologic outcome (FPR, 1%; 95% CI, 0%–3%; Class I, LOE B-NR).

We recommend that, given their unacceptable FPRs, the findings of either absent motor movements or extensor posturing *should not* be used alone for predicting a poor neurologic outcome (FPR, 10%; 95% CI, 7%–15% to FPR, 15%; 95% CI, 5%–31%; Class III: Harm, LOE B-NR). The motor examination may be a reasonable means to identify the population who need further prognostic testing to predict poor outcome (Class IIb, LOE B-NR).

We recommend that the presence of myoclonus, which is distinct from status myoclonus, *should not* be used to predict poor neurologic outcomes because of the high FPR (FPR, 5%; 95% CI, 3%–8% to FPR, 11%; 95% CI, 3%–26%; Class III: Harm, LOE B-NR).

In combination with other diagnostic tests at 72 or more hours after cardiac arrest, the presence of status myoclonus during the first 72 to 120 hours after cardiac arrest is a reasonable finding to help predict poor neurologic outcomes (FPR, 0%; 95% CI, 0%–4%; Class IIa, LOE B-NR).

EEG Findings to Predict Outcome[ALS 450, ALS 713]

EEG is a widely used tool to assess brain cortical activity and diagnose seizures. EEG is the standard tool used to assess brain electrical activity (ie, EEG rhythms) and paroxysmal activity (ie, seizures and bursts). While EEG has been used widely in the diagnosis of seizures and prognostication after cardiac arrest, the lack of standardized EEG terminology continues to be a major limitation in research and practice.[126]

2015 Evidence Summary

In patients treated with TTM, the 2015 ILCOR systematic review identified EEG with burst suppression, epileptiform activity, and reactivity as potential predictors of poor outcome. Two studies reported that burst suppression on initial EEG predicted poor outcome, with a 0% FPR (95% CI, 0%–5%),[127,128] but 2 other studies reported that EEG during TTM predicted poor outcome, with a 6% FPR (95% CI, 1%–15%).[111,129] Burst suppression after rewarming was associated with poor outcome[128] (FPR, 0%; 95% CI, 0%–5%). Some studies reported good outcome despite the presence of epileptiform discharges during TTM.[110,130] In several case series, no patients with electrographic seizures during or after TTM had good outcome,[78,110,130–132] but other studies reported cases with good outcome when seizures occurred in the presence of a reactive EEG background.[118,128] Absence of EEG reactivity during TTM predicted poor outcome, with an FPR of 2% (95% CI, 1%–7%),[78,111,119] and absence of EEG reactivity after rewarming predicted poor outcome, with an FPR of 0% (95% CI, 0%–3%).[78,110,111] Low-voltage EEG,[128] low bispectral index,[133] and EEG grades[78] were not reliably associated with poor outcome.

In patients not treated with TTM, the 2015 ILCOR systematic review identified EEG grades, burst suppression, and amplitude as potential predictors of poor outcome. EEG grades 4 to 5 at 72 hours or less after cardiac arrest predicted poor outcome, with a 0% FPR (95% CI, 0%–8%),[134–136] and burst suppression at 72 hours after cardiac arrest predicted poor outcome, with a 0% FPR (95% CI, 0%–11%).[114] EEG grades were not defined consistently between studies. Low-voltage EEG (≤20 to 21 μV) predicted poor outcome, with 0%

FPR (95% CI, 0%–5%) within 48 hours after cardiac arrest (1 study)[116] and with 0% FPR (95% CI, 0%–11%) at 72 hours after cardiac arrest.[114] However, low-voltage EEG is not reliable, because a variety of technical factors can affect EEG amplitude.

2015 Recommendations—Updated

In comatose post–cardiac arrest patients who are treated with TTM, it may be reasonable to consider persistent absence of EEG reactivity to external stimuli at 72 hours after cardiac arrest, and persistent burst suppression on EEG after rewarming, to predict a poor outcome (FPR, 0%; 95% CI, 0%–3%; Class IIb, LOE B-NR).

Intractable and persistent (more than 72 hours) status epilepticus in the absence of EEG reactivity to external stimuli may be reasonable to predict poor outcome (Class IIb, LOE B-NR).

In comatose post–cardiac arrest patients who are not treated with TTM, it may be reasonable to consider the presence of burst suppression on EEG at 72 hours or more after cardiac arrest, in combination with other predictors, to predict a poor neurologic outcome (FPR, 0%; 95% CI, 0%–11%; Class IIb, LOE B-NR).

Evoked Potentials to Predict Outcome[ALS 450, ALS 713]

The 2010 Guidelines advised that somatosensory evoked potentials (SSEPs) could be used as a prognostic tool in cardiac arrest survivors. The N20 waveform recorded from the primary cortical somatosensory area after median nerve stimulation was evaluated as a predictor of neurologic recovery in post–cardiac arrest patients.

2015 Evidence Summary

The 2015 systematic review found that in patients who are comatose after resuscitation from cardiac arrest and who are treated with TTM, bilaterally absent N20 was highly predictive of poor outcome. Absent N20 during TTM predicted poor outcome, with a 2% FPR (95% CI, 0%–4%).[104,129,137,138] Absent N20 after rewarming predicted poor outcome, with a 1% FPR (95% CI, 0%–3%).[104–106,108,110–112,119,139,140] One caution about these data is that SSEP has been used by healthcare providers and families as the parameter for withdrawal of life-sustaining therapies both in studies[103] and in bedside care, a practice that may inflate the apparent predictive accuracy of the test.

In patients not treated with TTM, bilateral absence of the N20 predicts poor outcome at 24, 48, or 72 hours after cardiac arrest (FPR, 0%; 95% CI, 0%–3% and 0%–12%).[115,138,141–149] Only 1 case of a false-positive result from absent SSEP in a patient not treated with TTM was identified.[116] Again, these studies may have allowed treating teams to act on the results of the SSEP, potentially inflating the accuracy of this test.

2015 Recommendations—Updated

In patients who are comatose after resuscitation from cardiac arrest regardless of treatment with TTM, it is reasonable to consider bilateral absence of the N20 SSEP wave 24 to 72 hours after cardiac arrest or after rewarming a predictor of poor outcome (FPR, 1%; 95% CI, 0%–3%; Class IIa, LOE B-NR).

SSEP recording requires appropriate skills and experience, and utmost care should be taken to avoid electrical interference from muscle artifacts or from the intensive care unit environment. However, sedative drugs or temperature manipulation affect SSEPs less than they affect the EEG or clinical examination.[138,150]

Imaging Tests to Predict Outcome[ALS 450, ALS 713]

Previous guidelines did not suggest specific imaging tests for prognosis in post–cardiac arrest coma. Brain imaging studies, including computed tomography (CT) or magnetic resonance imaging (MRI) can define structural brain injury or detect focal injury. On brain CT, some post–cardiac arrest patients exhibit brain edema, which can be quantified as the gray-white ratio (GWR), defined as the ratio between the x-ray attenuation measured in Hounsfield units of the gray matter and the white matter. Normal brain has GWR around 1.3, and this number decreases with edema.[105] Brain edema on MRI is a sensitive marker of focal injury and is detected by restricted diffusion on diffusion-weighted imaging (DWI) sequences[151] and can be quantified by using apparent diffusion coefficient (ADC). Normal ADC values range between 700 and 800 × 10^{-6} mm^2/s and decrease with edema.[152]

2015 Evidence Summary

The 2015 ILCOR systematic review identified 4 studies of CT scan performed within 2 hours after cardiac arrest in patients treated with TTM. A reduced GWR at the level of the basal ganglia on brain CT predicted poor outcome, with FPR ranging from 0% to 8%.[105,153–155] Measurement techniques and thresholds for GWR varied among studies. Global cerebral edema on brain CT at a median of 1 day after cardiac arrest also predicted poor outcome[107] (FPR, 0%; 95% CI, 0%–5%).

The 2015 ILCOR systematic review found 3 studies of CT scan on patients not treated with TTM. At 72 hours after cardiac arrest, the presence of diffuse brain swelling on CT predicted a poor outcome, with a 0% FPR (95% CI, 0%–45%).[156] In 2 studies, a GWR between the caudate nucleus and the posterior limb of internal capsule below 1.22 within 24 hours (FPR, 0%; 95% CI, 0%–28%) or below 1.18 within 48 hours (FPR, 17%; 95% CI, 0%–64%) after cardiac arrest predicted poor outcome.[157,158]

In patients treated with TTM, the 2015 systematic review identified two studies relating MRI findings to outcome. Presence of more than 10% of brain volume with ADC less than 650 × 10^{-6} mm^2/s predicted poor outcome[159] (FPR, 0%; 95% CI, 0%–78%). Low ADC at the level of putamen, thalamus, or occipital cortex predicted poor outcome, with 0% FPR[160] (95% CIs, from 0%–24%), although the ADC threshold in each region varied.

In patients not treated with TTM, 6 studies related MRI findings to poor outcome. Diffuse DWI abnormalities in cortex or brainstem at a median of 80 hours after cardiac arrest predicted poor outcome, with a 0% FPR (95% CI, 0%–35%).[151] Extensive (cortex, basal ganglia, and cerebellum) DWI changes predicted poor outcome, with a 0% FPR (95% CI, 0%–45%).[161] Whole-brain ADC less than 665 × 10^{-6} mm^2/s predicted poor outcome, with 0% FPR (95% CI, 0%–21%).[162] More than 10% of brain volume with ADC less than 650 × 10^{-6} mm^2/s predicted

poor outcome, with 0% FPR (95% CI, 0%–28%).[159] ADC below various thresholds at the level of putamen, thalamus, or occipital cortex at less than 120 hours after cardiac arrest predicted poor outcome, with 0% FPR (95% CI, 0%–31%). The presence of extensive cortical global DWI or fluid-attenuated inversion recovery changes within 7 days from arrest-predicted poor outcome, with a 0% FPR (95% CI, 0%–78%).[117,152]

MRI testing may be difficult in unstable patients, which may lead to selection bias. Studies report that DWI changes are most apparent more than 48 hours after cardiac arrest,[159] with most studies examining patients 3 to 7 days after cardiac arrest.

2015 Recommendations—New

In patients who are comatose after resuscitation from cardiac arrest and not treated with TTM, it may be reasonable to use the presence of a marked reduction of the GWR on brain CT obtained within 2 hours after cardiac arrest to predict poor outcome (Class IIb, LOE B-NR).

It may be reasonable to consider extensive restriction of diffusion on brain MRI at 2 to 6 days after cardiac arrest in combination with other established predictors to predict a poor neurologic outcome (Class IIb, LOE B-NR).

Acquisition and interpretation of imaging studies have not been fully standardized and are subject to interobserver variability.[163] In addition, the recommendations for brain imaging studies for prognostication are made with the assumption that images are performed in centers with expertise in this area.

Blood Markers to Predict Outcome[ALS 450, ALS 713]

Many blood markers have been examined for the prognostication of post–cardiac arrest patients. In 2015, the ILCOR Advanced Life Support Task Force evaluated whether blood markers can be used alone or in conjunction with other neurologic testing to prognosticate outcome in postarrest patients.

2015 Evidence Summary

The 2015 ILCOR systematic review examined many studies of blood markers to predict neurologic outcomes at various times after cardiac arrest, both in patients treated and not treated with TTM.[104,106–108,111,114,119,132,133,145,147,155,160,164–176] Neuron-specific enolase (NSE) and S-100B are the 2 most commonly examined blood markers.

Studies of NSE and S-100B reported that initial S-100B levels were higher in patients with poor outcome compared to patients with good outcome, and that NSE levels would increase over 72 hours in patients with poor outcome relative to patients with good outcome. However, studies did not identify specific blood levels of these proteins that enable prediction of poor neurologic outcome with perfect specificity and narrow confidence intervals. Therefore, no threshold values that enable prediction of poor outcome with confidence were identified.

2015 Recommendations—Updated

Given the possibility of high FPRs, blood levels of NSE and S-100B **should not** be used alone to predict a poor neurologic outcome (Class III: Harm, LOE C-LD).

When performed with other prognostic tests at 72 hours or more after cardiac arrest, it may be reasonable to consider high serum values of NSE at 48 to 72 hours after cardiac arrest to support the prognosis of a poor neurologic outcome (Class IIb, LOE B-NR), especially if repeated sampling reveals persistently high values (Class IIb, LOE C-LD).

Laboratory standards for NSE and S-100B measurement vary between centers, making comparison of absolute values difficult. The kinetics of these markers have not been studied, particularly during or after TTM in cardiac arrest patients. Finally, NSE and S-100B are not specific to neuronal damage and can be produced by extra–central nervous system sources (hemolysis, neuroendocrine tumors, myenteric plexus, muscle, and adipose tissue breakdown). If care is not taken when drawing NSE levels and if multiple time points are not assessed, false-positive results could occur secondary to hemolysis. All of these limitations led the writing group to conclude that NSE should be limited to a confirmatory test rather than a primary method for estimating prognosis.

Organ Donation[ALS 449]

The 2010 Guidelines emphasized that adult patients who progress to brain death after resuscitation from cardiac arrest should be considered as potential organ donors.

2015 Evidence Summary

The 2015 ILCOR systematic reviews considered the success rate of transplants when organs are taken from adult and pediatric donors who progressed to death or brain death after cardiac arrest. Post–cardiac arrest patients are an increasing proportion of the pool of organ donors.[177] When patients who have previously had cardiopulmonary resuscitation proceed to become organ donors, each donor provides a mean of 3.9[178] or 2.9[177] organs. Multiple studies found no difference in immediate or long-term function of organs from donors who reach brain death after cardiac arrest when compared with donors who reach brain death from other causes. In addition, some patients have withdrawal of life support after cardiac arrest as a consequence of failure to improve neurologically or as part of advanced directives, which can lead to cardiovascular death in a predictable time frame that may allow donation of kidney or liver. Organs transplanted from these donors also have success rates comparable to similar donors with other conditions. These studies examined adult hearts,[177,179–185] pediatric hearts,[177,186–189] adult lungs,[177,183,190] pediatric lungs,[177] adult kidneys,[177,191] pediatric kidneys,[177,188] adult livers,[177,179] pediatric livers,[177,188] adult intestines,[177,192] and pediatric intestines.[177] Finally, tissue donation (cornea, skin, and bone) is almost always possible if post–cardiac arrest patients die.

A few programs have developed procedures for recovery of kidney and liver when return of pulses cannot be achieved. Existing programs rely on continued mechanical circulatory support and very rapid mobilization of surgeons and transplant teams after a patient is unexpectedly pronounced dead. The resources to accomplish these donations require significant institutional preparation. These programs also require careful and thoughtful safeguards to prevent donation efforts from interfering with ongoing resuscitation efforts. A mean of 1.5[193] or 3.2[194] organs were procured from each donor in these programs. Function of adult kidneys[195–197] or adult livers[193,196,198] from these donors was similar immediately, 1 year, and 5 years after transplantation.

2015 Recommendations—Updated and New

We recommend that all patients who are resuscitated from cardiac arrest but who subsequently progress to death or brain death be evaluated for organ donation (Class I, LOE B-NR).

Patients who do not have ROSC after resuscitation efforts and who would otherwise have termination of efforts may be considered candidates for kidney or liver donation in settings where programs exist (Class IIb, LOE B-NR). The ethics and practical aspects of these programs are quite complex and beyond the scope of this review.

Conclusions and Future Directions

The field of post–cardiac arrest care has increased in rigor and depth over the past decade. Investigations over this period illustrate the heterogeneity of patients hospitalized after cardiac arrest in terms of etiology, comorbid disease, and illness severity. Future interventional trials should ideally be designed to take into account patient heterogeneity and focus interventions on the specific subgroups most likely to benefit. By tailoring interventions to patient physiology and disease, a greater chance exists that the right therapies will be matched to the patients who will benefit.

Disclosures

Part 8: Post–Cardiac Arrest Care: 2015 Guidelines Update Writing Group Disclosures

Writing Group Member	Employment	Research Grant	Other Research Support	Speakers' Bureau/Honoraria	Expert Witness	Ownership Interest	Consultant/ Advisory Board	Other
Clifton W. Callaway	University of Pittsburgh; UPMC Health System	None	None	None	None	None	None	None
Ericka L. Fink	Children's Hospital of Pittsburgh of UPMC	NIH†; Laerdal Foundation†	None	None	None	None	None	None
Romergryko G. Geocadin	Johns Hopkins University School of Medicine	NIH†	None	None	Medicolegal consulting*	None	None	None
Eyal Golan	University Health Network	None	None	None	None	None	None	None
Karl B. Kern	University of Arizona	Zoll Medical†; PhysioControl†; Arizona Biomedical Research Association†	None	BARD, Inc.	None	None	None	None
Marion Leary	University of Pennsylvania	American Heart Association†; Laerdal†	None	None	None	Resuscor*	PhysioControl*; Laerdal*	None
William J. Meurer	University of Michigan	None	None	None	None	None	None	None
Mary Ann Peberdy	Virginia Commonwealth University	Zoll Medical†	None	None	None	None	None	None
Trevonne M. Thompson	University of Illinois at Chicago	None	None	None	None	None	None	None
Janice L. Zimmerman	The Methodist Hospital Physician Organization	None	None	None	None	None	Decisio Health, Inc*	None
Consultant								
Michael W. Donnino	Beth Israel Deaconess Med Center	American Heart Association†	None	None	None	None	American Heart Association†	None

This table represents the relationships of writing group members that may be perceived as actual or reasonably perceived conflicts of interest as reported on the Disclosure Questionnaire, which all members of the writing group are required to complete and submit. A relationship is considered to be "significant" if (a) the person receives $10 000 or more during any 12-month period, or 5% or more of the person's gross income; or (b) the person owns 5% or more of the voting stock or share of the entity, or owns $10 000 or more of the fair market value of the entity. A relationship is considered to be "modest" if it is less than "significant" under the preceding definition.

*Modest.

†Significant.

Appendix

2015 Guidelines Update: Part 8 Recommendations

Year Last Reviewed	Topic	Recommendation	Comments
2015	Cardiovascular Care	Coronary angiography should be performed emergently (rather than later in the hospital stay or not at all) for OHCA patients with suspected cardiac etiology of arrest and ST elevation on ECG (Class I, LOE B-NR).	updated for 2015
2015	Cardiovascular Care	Emergent coronary angiography is reasonable for select (e.g. electrically or hemodynamically unstable) adult patients who are comatose after OHCA of suspected cardiac origin but without ST elevation on ECG (Class IIa, LOE B-NR).	updated for 2015
2015	Cardiovascular Care	Coronary angiography is reasonable in post–cardiac arrest patients for whom coronary angiography is indicated regardless of whether the patient is comatose or awake (Class IIa, LOE C-LD).	updated for 2015
2015	Hemodynamic Goals	Avoiding and immediately correcting hypotension (systolic blood pressure less than 90 mm Hg, MAP less than 65 mm Hg) during postresuscitation care may be reasonable (Class IIb, LOE C-LD).	new for 2015
2015	Targeted Temperature Management	We recommend that comatose (ie, lack of meaningful response to verbal commands) adult patients with ROSC after cardiac arrest have TTM (Class I, LOE B-R for VF/pVT OHCA; Class I, LOE C-EO for non-VF/pVT (ie, "nonshockable") and in-hospital cardiac arrest).	updated for 2015
2015	Targeted Temperature Management	We recommend selecting and maintaining a constant temperature between 32ºC and 36ºC during TTM (Class I, LOE B-R).	updated for 2015
2015	Targeted Temperature Management	It is reasonable that TTM be maintained for at least 24 hours after achieving target temperature (Class IIa, LOE C-EO).	updated for 2015
2015	Targeted Temperature Management	We recommend against the routine prehospital cooling of patients after ROSC with rapid infusion of cold intravenous fluids (Class III: No Benefit, LOE A).	new for 2015
2015	Targeted Temperature Management	It may be reasonable to actively prevent fever in comatose patients after TTM (Class IIb, LOE C-LD).	new for 2015
2015	Other Neurologic Care	An EEG for the diagnosis of seizure should be promptly performed and interpreted, and then should be monitored frequently or continuously in comatose patients after ROSC (Class I, LOE C-LD).	updated for 2015
2015	Other Neurologic Care	The same anticonvulsant regimens for the treatment of status epilepticus caused by other etiologies may be considered after cardiac arrest (Class IIb, LOE C-LD).	updated for 2015
2015	Respiratory Care	Maintaining the $Paco_2$ within a normal physiological range, taking into account any temperature correction, may be reasonable (Class IIb, LOE B-NR).	updated for 2015
2015	Respiratory Care	To avoid hypoxia in adults with ROSC after cardiac arrest, it is reasonable to use the highest available oxygen concentration until the arterial oxyhemoglobin saturation or the partial pressure of arterial oxygen can be measured (Class IIa, LOE C-EO).	new for 2015
2015	Respiratory Care	When resources are available to titrate the Fio_2 and to monitor oxyhemoglobin saturation, it is reasonable to decrease the Fio_2 when oxyhemoglobin saturation is 100%, provided the oxyhemoglobin saturation can be maintained at 94% or greater (Class IIa, LOE C-LD).	updated for 2015
2015	Other Critical Care Interventions	The benefit of any specific target range of glucose management is uncertain in adults with ROSC after cardiac arrest (Class IIb, LOE B-R).	updated for 2015
2015	Prognostication of Outcome	The earliest time for prognostication using clinical examination in patients treated with TTM, where sedation or paralysis could be a confounder, may be 72 hours after normothermia (Class IIb, LOE C-EO).	updated for 2015
2015	Other Critical Care Interventions	We recommend the earliest time to prognosticate a poor neurologic outcome using clinical examination in patients not treated with TTM is 72 hours after cardiac arrest (Class I, LOE B-NR).	new for 2015
2015	Other Critical Care Interventions	This time until prognostication can be even longer than 72 hours after cardiac arrest if the residual effect of sedation or paralysis confounds the clinical examination (Class IIa, LOE C-LD).	new for 2015
2015	Other Critical Care Interventions	In comatose patients who are not treated with TTM, the absence of pupillary reflex to light at 72 hours or more after cardiac arrest is a reasonable exam finding with which to predict poor neurologic outcome (FPR, 0%; 95% CI, 0%–8%; Class IIa, LOE B-NR).	new for 2015
2015	Other Critical Care Interventions	In comatose patients who are treated with TTM, the absence of pupillary reflex to light at 72 hours or more after cardiac arrest is useful to predict poor neurologic outcome (FPR, 1%; 95% CI, 0%–3%; Class I, LOE B-NR).	new for 2015
2015	Other Critical Care Interventions	We recommend that, given their unacceptable FPRs, the findings of either absent motor movements or extensor posturing should not be used alone for predicting a poor neurologic outcome (FPR, 10%; 95% CI, 7%–15% to FPR, 15%; 95% CI, 5%–31%; Class III: Harm, LOE B-NR).	new for 2015
2015	Other Critical Care Interventions	The motor examination may be a reasonable means to identify the population who need further prognostic testing to predict poor outcome (Class IIb, LOE B-NR).	new for 2015
2015	Other Critical Care Interventions	We recommend that the presence of myoclonus, which is distinct from status myoclonus, should not be used to predict poor neurologic outcomes because of the high FPR (FPR, 5%; 95% CI, 3%–8% to FPR, 11%; 95% CI, 3%–26%; Class III: Harm, LOE B-NR).	updated for 2015

(*Continued*)

2015 Guidelines Update: Part 8 Recommendations, *Continued*

Year Last Reviewed	Topic	Recommendation	Comments
2015	Other Critical Care Interventions	In combination with other diagnostic tests at 72 or more hours after cardiac arrest, the presence of status myoclonus during the first 72 to 120 hours after cardiac arrest is a reasonable finding to help predict poor neurologic outcomes (FPR, 0%; 95% CI, 0%–4%; Class IIa, LOE B-NR).	new for 2015
2015	Other Critical Care Interventions	In comatose post–cardiac arrest patients who are treated with TTM, it may be reasonable to consider persistent absence of EEG reactivity to external stimuli at 72 hours after cardiac arrest, and persistent burst suppression on EEG after rewarming, to predict a poor outcome (FPR, 0%; 95% CI, 0%–3%; Class IIb, LOE B-NR).	updated for 2015
2015	Other Critical Care Interventions	Intractable and persistent (more than 72 hours) status epilepticus in the absence of EEG reactivity to external stimuli may be reasonable to predict poor outcome (Class IIb, LOE B-NR).	updated for 2015
2015	Other Critical Care Interventions	In comatose post–cardiac arrest patients who are not treated with TTM, it may be reasonable to consider the presence of burst suppression on EEG at 72 hours or more after cardiac arrest, in combination with other predictors, to predict a poor neurologic outcome (FPR, 0%; 95% CI, 0%–11%; Class IIb, LOE B-NR).	updated for 2015
2015	Other Critical Care Interventions	In patients who are comatose after resuscitation from cardiac arrest regardless of treatment with TTM, it is reasonable to consider bilateral absence of the N20 SSEP wave 24 to 72 hours after cardiac arrest or after rewarming a predictor of poor outcome (FPR, 1%; 95% CI, 0%–3%; Class IIa, LOE B-NR).	updated for 2015
2015	Other Critical Care Interventions	In patients who are comatose after resuscitation from cardiac arrest and not treated with TTM, it may be reasonable to use the presence of a marked reduction of the GWR on brain CT obtained within 2 hours after cardiac arrest to predict poor outcome (Class IIb, LOE B-NR).	new for 2015
2015	Other Critical Care Interventions	It may be reasonable to consider extensive restriction of diffusion on brain MRI at 2 to 6 days after cardiac arrest in combination with other established predictors to predict a poor neurologic outcome (Class IIb, LOE B-NR).	new for 2015
2015	Other Critical Care Interventions	Given the possibility of high FPRs, blood levels of NSE and S-100B should not be used alone to predict a poor neurologic outcome (Class III: Harm, LOE C-LD).	updated for 2015
2015	Other Critical Care Interventions	When performed with other prognostic tests at 72 hours or more after cardiac arrest, it may be reasonable to consider high serum values of NSE at 48 to 72 hours after cardiac arrest to support the prognosis of a poor neurologic outcome (Class IIb, LOE B-NR), especially if repeated sampling reveals persistently high values (Class IIb, LOE C-LD).	updated for 2015
2015	Other Critical Care Interventions	We recommend that all patients who are resuscitated from cardiac arrest but who subsequently progress to death or brain death be evaluated for organ donation (Class I, LOE B-NR).	updated for 2015
2015	Other Critical Care Interventions	Patients who do not have ROSC after resuscitation efforts and who would otherwise have termination of efforts may be considered candidates for kidney or liver donation in settings where programs exist (Class IIb, LOE B-NR).	new for 2015
The following recommendations were not reviewed in 2015. For more information, see the *2010 AHA Guidelines for CPR and ECC*, "Part 9: Post–Cardiac Arrest Care."			
2010	Systems of Care for Improving Post–Cardiac Arrest Outcomes	A comprehensive, structured, multidisciplinary system of care should be implemented in a consistent manner for the treatment of post–cardiac arrest patients (Class I, LOE B).	not reviewed in 2015
2010	Treatment of Pulmonary Embolism After CPR	In post–cardiac arrest patients with arrest due to presumed or known pulmonary embolism, fibrinolytics may be considered (Class IIb, LOE C).	not reviewed in 2015
2010	Sedation After Cardiac Arrest	It is reasonable to consider the titrated use of sedation and analgesia in critically ill patients who require mechanical ventilation or shivering suppression during induced hypothermia after cardiac arrest (Class IIb, LOE C).	not reviewed in 2015
2010	Cardiovascular System	A 12-lead ECG should be obtained as soon as possible after ROSC to determine whether acute ST elevation is present (Class I, LOE B).	not reviewed in 2015
2010	Neuroprotective Drugs	The routine use of coenzyme Q10 in patients treated with hypothermia is uncertain (Class IIb, LOE B).	not reviewed in 2015
2010	Evoked Potentials	Bilateral absence of the N20 cortical response to median nerve stimulation after 24 hours predicts poor outcome in comatose cardiac arrest survivors not treated with therapeutic hypothermia (Class IIa, LOE A).	not reviewed in 2015

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KEY WORDS: cardiac arrest ■ drug ■ imaging ■ moderate hypothermia

Part 9: Acute Coronary Syndromes

2015 American Heart Association Guidelines Update for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care

Robert E. O'Connor, Chair; Abdulaziz S. Al Ali; William J. Brady; Chris A. Ghaemmaghami; Venu Menon; Michelle Welsford; Michael Shuster

Introduction

Clinicians often struggle with uncertainty and complexity in deciding which course of treatment will likely lead to an optimal outcome for an individual patient. Scientific research provides information on how patient populations have responded to treatment regimens, and this information, combined with a knowledge of the individual patient, can help guide the clinician's decisions.

The recommendations in this *2015 American Heart Association* (AHA) *Guidelines Update for Cardiopulmonary Resuscitation* (CPR) *and Emergency Cardiovascular Care* (ECC) are based on an extensive evidence review process that was begun by the International Liaison Committee on Resuscitation (ILCOR) after the publication of the ILCOR *2010 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science With Treatment Recommendations*[1,2] and was completed in February 2015.[3,4]

In this in-depth evidence review process, ILCOR examined topics and then generated a prioritized list of questions for systematic review. Questions were first formulated in PICO (population, intervention, comparator, outcome) format,[5] and then a search for relevant articles was performed. The evidence was evaluated by the ILCOR task forces by using the standardized methodologic approach proposed by the Grading of Recommendations Assessment, Development and Evaluation (GRADE) Working Group.[6]

The quality of the evidence was categorized based on the study methodologies and the 5 core GRADE domains of risk of bias, inconsistency, indirectness, imprecision, and other considerations (including publication bias). Then, where possible, consensus-based treatment recommendations were created.

To create this *2015 AHA Guidelines Update for CPR and ECC*, the AHA formed 15 writing groups, with careful attention to avoid conflicts of interest, to assess the ILCOR treatment recommendations, and to write AHA treatment recommendations by using the AHA Class of Recommendation and Level of Evidence (LOE) system. The recommendations made in the *2015 Guidelines Update for CPR and ECC* are informed by the ILCOR recommendations and GRADE classification, in the context of the delivery of medical care in North America. In the online version of this publication, live links are provided so the reader can connect directly to the systematic reviews on the Scientific Evidence Evaluation and Review System (SEERS) website. These links are indicated by a superscript combination of letters and numbers (eg, ACS 873).

This 2015 Guidelines Update offers recommendations for the care of patients with acute coronary syndromes (ACS). The recommendations made here update those made in the 2010 Guidelines and address only those issues that were reviewed in 2015. The ILCOR ACS Task Force did not review areas in which it found a paucity of new evidence between 2010 and 2015; therefore, the 2010 Guidelines for these unreviewed areas remain current. For example, acetylsalicylic acid administration has been shown to be of benefit in ACS and was recommended by the 2010 Guidelines.[7] Acetylsalicylic acid was not reviewed by the ACS Task Force in 2015, so the recommendations from 2010 should be used. (Note: The First Aid section of this 2015 Guidelines Update makes recommendations on acetylsalicylic acid administration by nonmedical personnel—see "Part 15: First Aid"). The recommendations that were not reviewed in 2015 will either be reviewed and included in future *AHA Guidelines for CPR and ECC* or will be in the most recent ACC/AHA Guidelines.[8–10]

A table of recommendations made in this update, as well as the recommendations made in "Part 10: Acute Coronary Syndromes" of the 2010 Guidelines,[7] can be found in the Appendix.

The 2015 Guidelines for ACS are directed toward practitioners who provide care for patients with suspected ACS from the time of first medical contact until disposition from the emergency department (ED). Care providers during this time may include emergency medical service (EMS) dispatchers, first responders, EMT-Bs, paramedics, nurses, physicians, and other independent practitioners.

Methodology

ILCOR performed 18 systematic reviews (14 based on meta-analyses) on more than 110 relevant studies that span

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40 years. Based on these reviews, the ACS Writing Group assessed the evidence and assigned an LOE by using AHA definitions. The LOE for a given intervention supports the class or "strength" of recommendation that the writing group assigned. This update uses the newest AHA Class of Recommendation and LOE classification system, which contains modifications to the Class III recommendation and introduces LOE B-R (randomized studies) and B-NR (nonrandomized studies), as well as LOE C-LD (limited data) and LOE C-EO (consensus of expert opinion). For further information, see "Part 2: Evidence Evaluation and Management of Conflicts of Interest."

Diagnostic Interventions in ACS

Prehospital ECG and Prehospital STEMI Activation of the Catheterization Laboratory[ACS 873, ACS 336]

Prehospital acquisition of 12-lead electrocardiograms (ECGs) has been recommended by the *AHA Guidelines for CPR and Emergency Cardiovascular Care* since 2000. The 2015 ILCOR systematic review examined whether acquisition of a prehospital ECG with transmission of the ECG to the hospital, notification of the hospital of the need for fibrinolysis, or activation of the catheterization laboratory changes any major outcome.

2015 Evidence Summary

Obtaining an ECG early in the assessment of patients with possible ACS ensures that dynamic ECG changes suggestive of cardiac ischemia and ACS will be identified, even if they normalize before initial treatment.[11]

An early ECG may also enable ST elevation myocardial infarction (STEMI) to be recognized earlier. Acquiring a prehospital ECG and determining the presence of STEMI effectively makes the prehospital provider the first medical contact. The prehospital ECG can reliably enable identification of STEMI before arrival at the hospital,[12] but if notification of the receiving facility does not occur, any benefit to prehospital STEMI recognition is lost.

Prehospital ECG acquisition coupled with hospital notification if STEMI is identified consistently reduces the time to reperfusion in-hospital (first medical contact–to–balloon time, first medical contact–to–needle time, door-to-balloon time, door-to-needle time).[13] To reduce time to STEMI reperfusion in-hospital, rapid transport and early treatment must occur in parallel with hospital preparation for the arriving patient.

Prehospital ECGs reduce the time to reperfusion with fibrinolytic therapy and also reduce the time to primary percutaneous coronary intervention (PPCI) and facilitate triage of STEMI patients to specific hospitals.[4] Prehospital activation of the catheterization laboratory (as opposed to delaying cardiac catheterization laboratory activation until the patient arrives at the hospital) is independently associated with improved times to PPCI and reduced mortality.[4]

Prehospital ECG acquisition and hospital notification reduce mortality by 32% when PPCI is the reperfusion strategy (benefit is accentuated when prehospital activation occurs) and by 24% when ED fibrinolysis is the reperfusion strategy.[4]

2015 Recommendations—Updated

Prehospital 12-lead ECG should be acquired early for patients with possible ACS (Class I, LOE B-NR).

Prehospital notification of the receiving hospital (if fibrinolysis is the likely reperfusion strategy) and/or prehospital activation of the catheterization laboratory should occur for all patients with a recognized STEMI on prehospital ECG (Class I, LOE B-NR).

Computer-Assisted ECG STEMI Interpretation[ACS 559]

The identification of STEMI in patients with suspected STEMI is often made on clinical grounds in combination with ECG findings as interpreted by a physician. The 2015 ILCOR systematic review addressed whether computer-assisted ECG interpretation improves identification of STEMI while minimizing unnecessary intervention.

2015 Evidence Summary

Studies examined both underdiagnosis (false-negative results) and overdiagnosis (false-positive results)[14,15] or overdiagnosis alone[16–20] by computer ECG interpretation. There was wide variation in the proportion of false-positive results (0% to 42%) and of false-negative results (22% to 42%).

These variations in accuracy seemed to occur because different ECG machines use different algorithms and because the computer interpretations are compared variously with interpretation by cardiologists, emergency physicians, and discharge diagnosis of STEMI. Moreover, the sensitivity and specificity of the test will differ depending on the prevalence of STEMI.

Both studies that examined false-negative results suggest that computer interpretation of ECG tracing produces unacceptably high rates of false-negative results in the identification of STEMI. A few studies show that computer interpretation can produce an unacceptably high rate of false-positive diagnoses. Interpretation by trained personnel in conjunction with computer interpretation may lower the rate of false results obtained when using computer interpretation alone.

2015 Recommendations—New

Because of high false-negative rates, we recommend that computer-assisted ECG interpretation not be used as a sole means to diagnose STEMI (Class III: Harm, LOE B-NR).

We recommend that computer-assisted ECG interpretation may be used in conjunction with physician or trained provider interpretation to recognize STEMI (Class IIb, LOE C-LD).

Nonphysician STEMI ECG Interpretation[ACS 884]

When physicians are not present or not available to interpret an ECG, other methods for interpretation must be used so that timely patient care is not adversely affected. The 2015 ILCOR systematic review examined whether nonphysicians such as paramedics and nurses could identify STEMI on an ECG so that earlier identification of STEMI could be made with acceptable rates of either underdiagnosis (false-negative results) or overdiagnosis (false-positive results).

2015 Evidence Summary

Three observational studies compared the diagnostic accuracy of the interpretation of ECGs as either STEMI or No STEMI

by physicians and paramedics.[21–23] While the studies used different methods to adjudicate the diagnosis, including World Health Organization criteria,[21] discharge diagnosis,[22] and catheterization laboratory activation,[23] all 3 studies showed a fairly high rate of agreement between physician and paramedic rates of distinguishing STEMI from No STEMI.

Overidentification of STEMI may have a significant adverse effect on resource utilization. An additional 6 studies examined the accuracy of paramedic identification of STEMI and reported false-positive rates (patients incorrectly diagnosed with STEMI by paramedics when no STEMI was present) ranging from 8% to 40%.[17,24–28] One study reported that transmission of the ECG to the ED for emergency physician interpretation, compared with paramedic interpretation alone, improves the positive predictive value of the prehospital 12-lead ECG for triage and therapeutic decision making.[24] The time from hospital arrival to percutaneous coronary intervention (PCI) with balloon inflation was significantly shorter if EMS activated the catheterization laboratory than if the laboratory was activated by hospital staff[25,26,28] or if the patient was directly admitted to the catheterization laboratory.[27]

2015 Recommendation—New

While transmission of the prehospital ECG to the ED physician may improve positive predictive value (PPV) and therapeutic decision-making regarding adult patients with suspected STEMI, if transmission is not performed, it may be reasonable for trained nonphysician ECG interpretation to be used as the basis for decision-making, including activation of the catheterization laboratory, administration of fibrinolysis, and selection of destination hospital (Class IIa, LOE B-NR).

Biomarkers in ACS[ACS 737]

Cardiac troponin measurement, along with the ECG, is an integral part of the evaluation of patients with signs and symptoms suspicious for ACS. The detection of an elevated troponin (Tn) above the 99th percentile upper reference limit is highly sensitive and specific for myocardial necrosis, and is required in the universal definition of myocardial infarction (MI).[29]

Contemporary troponin assays are termed "high-sensitivity" (hs) if they are able to detect measurable troponin levels even in healthy individuals, with a threshold of detection of 0.006 ng/ml for hs-cTnI and 0.005 for hs-cTnT. Positive results are an order of magnitude higher than the threshold for detection and are usually defined as exceeding the 99th percentile of values with a coefficient of variation of less than 10%.[30]

More than 8 million patients are evaluated for potential ischemic chest pain in US EDs each year, with troponin measurement serving as one of the crucial diagnostic tests.[31] Because of this vast number of patients with potential ischemic chest pain, it is highly desirable to find some combination of diagnostic testing that can reliably identify patients who are not experiencing ischemia and can be safely discharged from the ED.

The 2015 ILCOR systematic review examined whether a negative troponin test could be used to identify patients at low risk for ACS when they did not have signs of STEMI, ischemia, or changes on the ECG that could mask signs of acute ischemia or MI.

The clinician should bear in mind that unstable angina can present without any objective data of myocardial ischemic injury (ie, with normal ECG and normal troponin), in which case the initial diagnosis depends solely on the patient's clinical history and the clinician's interpretation and judgment.

2015 Evidence Summary

Two observational studies used troponin (cTnI, cTnT, or hs-cTnT) measured at 0 and 2 hours to assess whether patients could be safely discharged from the ED.[32,33] In these studies, 2.5% to 7.8% of patients with ACS had (false-) negative tests. That is, ACS would have been missed in 2.5% to 7.8% of the patients studied. With an unstructured risk assessment used in addition to the troponin testing, 2.3% of patients identified as being at low risk have a major adverse cardiac event (MACE) on 30-day follow-up. A formal risk assessment instrument was not used in either of these 2 studies.

Six additional observational studies combined troponin testing (using cTnI, cTnT, hs-cTnI, or hs-cTnT) with use of clinical decision rules such as TIMI, Vancouver, North American, or HEART. The proportion of false-negative results among patients with 30-day MACE ranged from 0% to 1.2%.[34–39] When the age cutoff for low-risk patients was increased from 50 years to 60 years for the North American Chest Pain Rule, the proportion of false-negative results rose from 0% to 1.1%.[37] Because the rules were used in combination with different troponin measurements, and each test identified 99% of patients with ACS as defined by 30-day MACE, it was difficult to directly compare rule or assay performance. One study[36] identified 1 additional ACS patient by using the Vancouver rule when the hs-cTnI was used instead of the cTnI.

2015 Recommendations—New

We recommend against using hs-cTnT and cTnI alone measured at 0 and 2 hours (without performing clinical risk stratification) to identify patients at low risk for ACS (Class III: Harm, LOE B-NR).

We recommend that hs-cTnI measurements that are less than the 99th percentile, measured at 0 and 2 hours, may be used together with low-risk stratification (TIMI score of 0 or 1 or low risk per Vancouver rule) to predict a less than 1% chance of 30-day MACE (Class IIa, LOE B-NR).

We recommend that negative cTnI or cTnT measurements at 0 and between 3 and 6 hours may be used together with very low-risk stratification (TIMI score of 0, low-risk score per Vancouver rule, North American Chest Pain score of 0 and age less than 50 years, or low-risk HEART score) to predict a less than 1% chance of 30-day MACE (Class IIa, LOE B-NR).

Therapeutic Interventions in ACS

ADP Inhibition: Adjunctive Therapy in Patients With Suspected STEMI—ADP Inhibitors[ACS 335]

The 2015 ILCOR systematic review addressed the clinical impact of the timing of administration of adenosine diphosphate (ADP) inhibition in the treatment of patients with suspected STEMI. The relative merit of early prehospital as compared with hospital administration of ADP inhibition as a

general treatment strategy was assessed. Differences between individual ADP inhibitors were not examined.

The preferred reperfusion strategy for patients with STEMI is identification and restoration of normal flow in the infarct-related artery using primary percutaneous intervention. The use of potent dual antiplatelet therapy in STEMI patients undergoing PPCI is associated with improved clinical outcomes as well as lower rates of acute stent thrombosis.[40,41] Given the short time from first medical contact to balloon inflation, treatment with oral ADP inhibitors in a prehospital setting has the potential to enhance platelet inhibition and improve procedural and clinical outcomes after PCI.

2015 Evidence Summary

Three randomized controlled trials (RCTs)[42–44] showed no additional benefit to the outcome of 30-day mortality and no additional benefit or harm with respect to major bleeding with prehospital administration compared with in-hospital administration of an ADP-receptor antagonist.

2015 Recommendation—New

In patients with suspected STEMI intending to undergo PPCI, initiation of ADP inhibition may be reasonable in either the prehospital or in-hospital setting (Class IIb, LOE C-LD).

Prehospital Anticoagulants Versus None in STEMI[ACS 562]

In patients with suspected STEMI, anticoagulation is standard treatment recommended by the American College of Cardiology Foundation/AHA Guidelines.[9,10] The 2015 ILCOR systematic review sought to determine if any important outcome measure was affected if an anticoagulant was administered prehospital compared with whether that same anticoagulant was administered in-hospital.

2015 Evidence Summary

A single nonrandomized, case-control study found that while flow rates were higher in an infarct-related artery when heparin and aspirin were administered in the prehospital setting versus the ED, there was no significant difference in death, PCI success rate, major bleeding, or stroke.[45]

2015 Recommendations—New

While there seems to be neither benefit nor harm to administering heparin to patients with suspected STEMI before their arrival at the hospital, prehospital administration of medication adds complexity to patient care. We recommend that EMS systems that do not currently administer heparin to suspected STEMI patients do not add this treatment, whereas those that do administer it may continue their current practice (Class IIb, LOE B-NR).

In suspected STEMI patients for whom there is a planned PPCI reperfusion strategy, administration of unfractionated heparin (UFH) can occur either in the prehospital or in-hospital setting (Class IIb, LOE B-NR).

Prehospital Anticoagulation for STEMI[ACS 568]

The 2015 ILCOR systematic review examined whether the prehospital administration of an anticoagulant such as bivalirudin, dalteparin, enoxaparin, or fondaparinux instead of UFH, in suspected STEMI patients who are transferred for PPCI, changes any major outcome.

2015 Evidence Summary

One RCT provided evidence in patients transferred for PCI for STEMI that there was no significant difference between prehospital bivalirudin compared with prehospital UFH with respect to 30-day mortality, stroke, or reinfarction. However, this same study did demonstrate a decreased incidence of major bleeding with bivalirudin.[46] Another study (this one a non-RCT) also demonstrated no difference between prehospital bivalirudin compared with prehospital UFH with respect to 30-day mortality, stroke, and reinfarction. In contrast to the RCT, this study did not find a difference in major bleeding.[47]

Although stent thrombosis was not considered as an *a priori* outcome, bivalirudin was strongly associated with the risk of acute stent thrombosis (relative risk, 6.11; 95% confidence interval, 1.37–27.24).[46] Such association is also consistently reported in other published in-hospital studies and meta-analyses of this agent in patients undergoing PCI.[48–50] While the benefit of bivalirudin over UFH alone in reducing bleeding complications has been shown, this benefit may be offset by the risk of stent thrombosis.

We have identified 1 RCT[51] enrolling 910 patients transferred for PPCI for STEMI that showed no significant difference between prehospital enoxaparin compared with prehospital UFH with respect to 30-day mortality, stroke, reinfarction, or major bleeding.

It is important to consider the results of the comparison between anticoagulants given in prehospital versus in-hospital settings in STEMI patients. Only UFH has been evaluated directly in this setting, and because there is no clear evidence of benefit, we are not recommending that EMS systems implement anticoagulant administration in the prehospital setting.

2015 Recommendations—New

It may be reasonable to consider the prehospital administration of UFH in STEMI patients or the prehospital administration of bivalirudin in STEMI patients who are at increased risk of bleeding (Class IIb, LOE B-R).

In systems in which UFH is currently administered in the prehospital setting for patients with suspected STEMI who are being transferred for PPCI, it is reasonable to consider prehospital administration of enoxaparin as an alternative to UFH (Class IIa, LOE B-R).

Routine Supplementary Oxygen Therapy in Patients Suspected of ACS[ACS 887]

The *2010 AHA Guidelines for CPR and ECC* noted that there was insufficient evidence to recommend the routine use of oxygen therapy in patients who had an uncomplicated ACS without signs of hypoxemia or heart failure and that older literature suggested harm with supplementary oxygen administration in uncomplicated ACS without demonstrated need for supplementary oxygen.[52,53] The 2010 Guidelines, however, did recommend that oxygen be administered to patients with breathlessness, signs of heart failure, shock, or an oxygen saturation less than 94%.[7]

In 2015, the ILCOR systematic review specifically addressed the use of oxygen as an adjunctive medication in the

treatment of patients who had normal oxygen saturation but had suspected ACS. The 2 treatment approaches (either providing or withholding oxygen) were compared with respect to outcomes: rate of death, infarction size, resolution of chest pain, and ECG abnormality resolution. The new recommendation in this 2015 Guidelines Update applies only to the use of oxygen for patients suspected of ACS who have normal oxygen saturations.

Adjunctive Therapy in Patients Suspected of ACS: Oxygen

Respiratory compromise, manifested by oxygen desaturation, can occur during ACS, most often as a result of either acute pulmonary edema or chronic pulmonary disease. Supplementary oxygen has previously been considered standard therapy for the patient suspected of ACS, even in patients with normal oxygen saturation. The rationale for oxygen therapy was a belief that maximization of oxygen saturation may improve delivery of oxygen to the tissues and thus reduce the ischemic process and related negative outcomes. In other patient groups, such as resuscitated cardiac arrest patients, hyperoxia has been associated with worse outcomes as compared with normoxia.[54–56]

2015 Evidence Summary

There is limited evidence regarding the use of supplementary oxygen therapy in suspected ACS patients with normal oxygen saturation. The practice of administering oxygen to all patients regardless of their oxygen saturation is based on both rational conjecture and research performed before the current reperfusion era in acute cardiac care.[52] More recent study of this issue is also limited,[57,58] although 2 trials addressing this question are in progress or are recently completed. The AVOID trial,[59] a multicentered prospective RCT published since the 2015 ILCOR systematic review, compared oxygen administration with no oxygen administration in suspected STEMI patients without respiratory compromise. When oxygen was administered, the patients experienced increased myocardial injury at presentation and larger infarction size at 6 months. Reinfarction and the incidence of cardiac arrhythmias were also increased in the oxygen therapy group.[59] Because this study was published after the ILCOR systematic review, it was not considered in our treatment recommendation.

There is no evidence that withholding supplementary oxygen therapy in normoxic patients suspected of ACS affects the rate of death and/or resolution of chest pain; there is only a very low level of evidence that withholding supplementary oxygen reduces infarction size, and there is no evidence that withholding supplementary oxygen therapy affects the resolution of ECG abnormality.[52,53,57,58]

2015 Recommendation—Updated

The provision of supplementary oxygen to patients with suspected ACS who are normoxic has not been shown to reduce mortality or hasten the resolution of chest pain. Withholding supplementary oxygen in these patients has been shown to minimally reduce infarct size.

The usefulness of supplementary oxygen therapy has not been established in normoxic patients. In the prehospital, ED, and hospital settings, the withholding of supplementary oxygen therapy in normoxic patients with suspected or confirmed acute coronary syndrome may be considered (Class IIb, LOE C-LD).

Reperfusion Decisions in STEMI Patients

The 2010 ILCOR systematic review addressed the use of reperfusion therapy, including fibrinolysis and PPCI, in patients with STEMI who present initially to non–PCI-capable hospitals. The *2015 AHA Guidelines Update for CPR and ECC* examines the most appropriate reperfusion therapy in STEMI patients presenting to non–PCI-capable hospitals as well as the need for hospital transfer for PCI, or ischemia-guided (ie, rescue) coronary angiography and/or PCI.

Prehospital Fibrinolysis, Hospital Fibrinolysis, and Prehospital Triage to PCI Center[ACS 338, ACS 341]

Prehospital fibrinolysis requires a sophisticated system of provider expertise, well-established protocols, comprehensive training programs, medical oversight, and quality assurance.[4] In many European systems, a physician provides prehospital fibrinolysis, but nonphysicians can also safely administer fibrinolytics.[60] The 2015 ILCOR systematic review evaluated whether prehospital fibrinolysis is preferred to reperfusion in-hospital where the prehospital fibrinolysis expertise, education, and system support exists.

2015 Evidence Summary

Prehospital fibrinolysis will achieve earlier treatment as compared with ED fibrinolysis. Where transport times are more than 30 to 60 minutes, the time advantage conferred by prehospital fibrinolysis provides a mortality benefit.[4] This benefit from prehospital fibrinolysis was found consistently by 3 RCTs performed more than 20 years ago.[61–63] However, these studies were performed at a time when hospital fibrinolytic administration typically took well in excess of 60 minutes. It is not clear the extent to which that mortality benefit would be maintained today when the hospital time to fibrinolytic treatment is typically considerably shorter than it was 20 years ago. The only recent evidence for this therapy comes from a non-RCT that confirms a small mortality benefit to prehospital fibrinolysis.[64] When transport times are shorter than 30 to 60 minutes, the mortality benefit from administering fibrinolytics before hospital arrival may be lost and may no longer outweigh the relative complexity of providing this therapy outside of a hospital.

However, PPCI is generally preferred to in-hospital fibrinolysis for STEMI reperfusion.[65] Prehospital providers can transport STEMI patients directly to PCI centers, and activation of the team before arrival allows the team to assemble and prepare in parallel with transport. Several studies in the past 15 years have compared transport directly for PPCI with prehospital fibrinolysis and found no mortality benefit of either therapy, although the relatively rare harm from intracranial hemorrhage is greater with fibrinolysis.[66–69]

2015 Recommendations—Updated

Where prehospital fibrinolysis is available as part of a STEMI system of care, and in-hospital fibrinolysis is the alternative treatment strategy, it is reasonable to administer prehospital

fibrinolysis when transport times are more than 30 minutes (Class IIa, LOE B-R).

Where prehospital fibrinolysis is available as part of the STEMI system of care and direct transport to a PCI center is available, prehospital triage and transport directly to a PCI center may be preferred because of the small relative decrease in the incidence of intracranial hemorrhage without evidence of mortality benefit to either therapy (Class IIb, LOE B-R).

ED Fibrinolysis and Immediate PCI Versus Immediate PCI Alone[ACS 882]

Delays in the performance of PPCI are commonly observed in clinical practice. In many regions, the delay arises because of the relative paucity of dedicated PPCI centers, resulting in the need for prolonged transfer times. In this context, combining the availability and ease of administration of fibrinolytic with the downstream certainty of mechanical reperfusion with facilitated PCI was an attractive concept, with its promise of both restoring early flow to the infarct-related artery while addressing the concerns of pharmacologic failure and need for rescue. This was counterbalanced by the concern for a heightened risk of bleeding complications and detrimental procedural outcomes in this prothrombotic milieu.

The 2015 ILCOR systematic review addressed the merits for reperfusion in STEMI patients with a strategy of initial fibrinolysis followed by immediate PCI versus immediate PCI alone.

2015 Evidence Summary

A number of randomized clinical trials have addressed clinical outcomes after initial treatment with a half- or full-dose fibrinolytic agent followed by dedicated immediate PCI compared with immediate PCI alone.

The studies showed no benefit to mortality,[70–74] nonfatal MI,[70–74] or target vessel revascularization[70–73] when fibrinolytic administration is combined with immediate PCI as compared with immediate PCI alone.

The studies did, however, identify harm from intracranial hemorrhage[70–72] or major bleeding[70–74] when fibrinolytic administration is combined with immediate PCI versus immediate PCI alone.

2015 Recommendation—New

In the treatment of patients with suspected STEMI, the combined application of fibrinolytic therapy followed by immediate PCI (as contrasted with immediate PCI alone) is not recommended (Class III: Harm, LOE B-R).

Delayed PCI Versus Fibrinolysis Stratified by Time From Symptom Onset[ACS 337]

Although the overall survivability benefits of reperfusion therapy are time dependent, the loss of efficacy caused by delay is more pronounced with fibrinolysis than with PCI.[75] The success of PCI in achieving TIMI-3 flow in the early hours after STEMI does not change with time, whereas the ability of fibrinolytic therapy to achieve TIMI-3 flow decreases significantly with increasing ischemic time.[76] In this context, the choice of reperfusion therapy for a STEMI patient when access to PCI is delayed is a challenging one. The clinician has to weigh the advantages of immediate fibrinolysis, which includes ease of administration and potential to open the infarct-related artery in a timely manner versus the limitations of fibrinolysis, which include the risk of intracranial hemorrhage and bleeding and the time sensitivity of the intervention's efficacy to open the infarct-related artery. Thus, total ischemic time is an important variable in weighing the merits of delayed PCI versus immediate fibrinolysis.

In the *2010 AHA Guidelines for CPR and ECC*,[7] the recommendations were directed at patients in whom PCI could not be accomplished within 90 minutes of first medical contact.

The 2015 ILCOR systematic review compared the relative benefits of immediate fibrinolysis versus primary but delayed PCI in treating STEMI patients, stratifying patients by time from initial medical contact.

2015 Evidence Summary

In STEMI patients presenting less than 2 hours after symptom onset in whom immediate PPCI will delay treatment 60 to 160 minutes compared with fibrinolysis, 2 RCTs (combined into a single analysis) using an outcome of 30-day mortality[77] and 1 RCT using an outcome of 5-year mortality showed greater harm with delayed PPCI compared with fibrinolysis.[78] No differences were found to incidence of reinfarction[77] or severe bleeding.[79]

For STEMI patients presenting 2 to 6 hours after symptom onset in whom PPCI will delay treatment 60 to 160 minutes compared with fibrinolysis, 2 RCTs using an outcome of 1-year mortality[77] and 1 RCT using an outcome of 5-year mortality showed no benefit of delayed PPCI over fibrinolysis.[78] There was also no difference in the incidence of reinfarction,[77] but 1 RCT[79] showed more severe bleeding with fibrinolysis as compared with delayed PPCI.

In STEMI patients presenting 3 to 12 hours after symptom onset in whom PPCI will delay treatment 60 to 120 minutes as compared with fibrinolysis, 1 RCT[80] using a 30-day mortality outcome showed that delayed PPCI conferred a benefit as compared with immediate fibrinolysis.

A reanalysis of the raw data from 16 RCTs[81] has suggested that the acceptable fibrinolysis to PPCI delay varies depending on the patient's baseline risk and delay to presentation. A pragmatic simplification of the formula derived in the analysis has been suggested in an editorial[82] associated with the publication of the analysis: Patients older than 65 years and all patients in Killip class greater than 1 should be treated with PPCI. Patients older than 65 years in Killip class 1 should have PPCI unless delay is greater than 35 minutes.

2015 Recommendations—Updated

The following recommendations are not in conflict with, and do not replace, the 2013 ACC/AHA STEMI Guidelines, which are endorsed by this ACS Writing Group. These 2015 Guidelines Update recommendations are derived from a different set of studies that examined the interval between *symptom onset* and reperfusion, rather than the interval between *first medical contact* and reperfusion. The symptom onset interval is appropriate to consider when time of symptom onset is known. However, time from symptom onset may be difficult to ascertain or may be unreliable. When time from symptom onset is uncertain, it is appropriate to follow the ACC/AHA

STEMI Guidelines recommendation that PPCI is the preferred reperfusion strategy when time from symptom onset is less than 12 hours and time to PPCI from first medical contact in these patients is anticipated to be less than 120 minutes. Regardless of whether time of symptom onset is known, the interval between first medical contact and reperfusion should not exceed 120 minutes (Class I, LOE C-EO).

In STEMI patients presenting within 2 hours of symptom onset, immediate fibrinolysis rather than PPCI may be considered when the expected delay to PPCI is more than 60 minutes (Class IIb, LOE C-LD).

In STEMI patients presenting within 2 to 3 hours after symptom onset, either immediate fibrinolysis or PPCI involving a possible delay of 60 to 120 minutes might be reasonable (Class IIb, LOE C-LD).

In STEMI patients presenting within 3 to 12 hours after symptom onset, performance of PPCI involving a possible delay of up to 120 minutes may be considered rather than initial fibrinolysis (Class IIb, LOE C-LD).

It is acknowledged that fibrinolysis becomes significantly less effective more than 6 hours after symptom onset, and thus a longer delay to PPCI may be the better option for patients more than 6 hours after symptom onset.

In STEMI patients, when delay from first medical contact to PPCI is anticipated to exceed 120 minutes, a strategy of immediate fibrinolysis followed by routine early (within 3 to 24 hours) angiography and PCI if indicated may be reasonable for patients with STEMI (Class IIb, LOE B-R).

Reperfusion Therapy for STEMI in Non–PCI-Capable Hospitals[ACS 332, ACS 334, ACS 779]

The rapid restoration of perfusion in the infarct-related coronary artery, using either fibrinolytic therapy or PPCI, provides the opportunity for an optimal outcome.

Fibrinolytic therapy unequivocally improves survival in patients presenting with STEMI and has widespread availability.[83] STEMI patients with contraindications to fibrinolytic therapy and who are in cardiogenic shock are not appropriate candidates for this form of reperfusion therapy.[84] PPCI is superior to fibrinolytic therapy in the management of STEMI,[85] because PPCI also improves survival rates and enhances other important outcomes in the STEMI patient. However, this form of reperfusion therapy is not widely available.

The superiority of PPCI over fibrinolytic therapy is not absolute. For STEMI patients presenting to a non–PCI-capable hospital, the decision to administer fibrinolytic therapy at the initial facility as compared with immediate-transfer PPCI requires consideration of several factors, including the location of the MI, patient age, the duration of STEMI at time of initial ED presentation, time required to complete transfer for and performance of PPCI, and the abilities of the PPCI cardiologist and hospital.[85] Furthermore, the hemodynamic status of the patient is important; specifically, patients in cardiogenic shock are most appropriately managed with PPCI.[84]

2015 Evidence Summary

Fibrinolysis Versus Transfer for PPCI

In a non–PCI-capable hospital, the choice of reperfusion therapy in the STEMI patient is either immediate fibrinolytic therapy or transfer for PPCI; the time required for transfer of the patient to a PCI-capable hospital must be considered in making the choice. Comparison studies showed benefit of immediate transfer to a PCI center with respect to 30-day mortality, stroke, and/or reinfarction.[80,86–92] There was no difference in major hemorrhage.[88,91]

Fibrinolysis and Routine Transfer for Angiography Versus Immediate Transfer for PPCI

When immediate fibrinolysis in a non–PCI-capable hospital followed by routine transfer for angiography was compared with immediate transfer to a PCI center for PPCI, 3 studies showed no benefit to 30-day mortality, stroke, and/or reinfarction and no difference in the rates of intracranial hemorrhage or major bleeding.[67,93,94]

Fibrinolysis and Routine Transfer for Angiography Versus No Routine Transfer: 30-Day Mortality

In patients who received a fibrinolytic agent for STEMI in a non–PCI-capable hospital, studies comparing either routine transfer for angiography at 3 to 6 hours and up to 24 hours or no transfer except for ischemia-driven PCI (rescue PCI) in the first 24 hours showed no benefit with respect to 30-day mortality[67,92,95–99] or 1-year mortality.[67,95,96,99–101]

Fibrinolysis and Routine Transfer for Angiography Versus No Routine Transfer: Intracranial Hemorrhage or Major Bleeding

In patients who received a fibrinolytic agent for STEMI in a non–PCI-capable hospital, studies comparing either routine transfer for angiography at 3 to 6 hours and up to 24 hours or no transfer except for ischemia-driven PCI (rescue PCI) in the first 24 hours demonstrated no difference in incidence of intracranial hemorrhage,[67,95–99] major bleeding,[67,95–99] or stroke.[92,95,97,99]

Fibrinolysis and Routine Transfer for Angiography Versus No Routine Transfer: Reinfarction

When immediate fibrinolysis for STEMI was followed by routine transfer for angiography at 3 to 6 hours and up to 24 hours as compared with no transfer except for ischemia-driven PCI (rescue PCI) in the first 24 hours, a decrease in the rate of reinfarction was demonstrated.[67,92,95–99]

2015 Recommendations—New

In adult patients presenting with STEMI in the ED of a non–PCI-capable hospital, we recommend immediate transfer without fibrinolysis from the initial facility to a PCI center instead of immediate fibrinolysis at the initial hospital with transfer only for ischemia-driven PCI (Class I, LOE B-R). When STEMI patients cannot be transferred to a PCI-capable hospital in a timely manner, fibrinolytic therapy with routine transfer for angiography may be an acceptable alternative to immediate transfer to PPCI (Class IIb, LOE C-LD).

When fibrinolytic therapy is administered to a STEMI patient in a non–PCI-capable hospital, it may be reasonable to transport all postfibrinolysis patients for early routine angiography in the first 3 to 6 hours and up to 24 hours rather than transport postfibrinolysis patients only when they require ischemia-guided angiography (Class IIb, LOE B-R). It is recognized that there may be practical and logistical circumstances, including geographic limitations, where transfer

for angiography within 24 hours is difficult or impossible. In these cases, the small but measurable decrease in reinfarction rates may not justify a prolonged or difficult transfer.

Hospital Reperfusion Decisions After ROSC

PCI After ROSC With and Without ST Elevation[ACS 340, ACS 885]

In 2010, the ILCOR systematic review combined ST-elevation and non–ST-elevation patients after ROSC. However, the *2010 AHA Guidelines for CPR and ECC* did make separate recommendations for each of these distinct groups of patients, recommending emergency coronary angiography for ST-elevation patients after ROSC, while supporting the consideration of coronary angiography for non–ST-elevation patients after ROSC.

The 2015 ILCOR systematic review examined whether immediate coronary angiography (angiography performed within 24 hours after ROSC) for patients with and without ST elevation after cardiac arrest improved outcomes.

2015 Evidence Summary

Evidence regarding the timing of coronary angiography immediately after cardiac arrest (defined variously, but within 24 hours) is limited to observational studies.

Aggregated data from 15 studies of 3800 patients having ST elevation on ECG after ROSC after cardiac arrest demonstrated a benefit of immediate coronary angiography, favoring survival to hospital discharge,[102–116] while 9 of these studies enrolling a total of 2819 patients also demonstrated a benefit favoring neurologically favorable outcomes.[102–104,107,109–111,114,117]

In patients without ST elevation on initial postarrest ECG, 2 studies demonstrated a benefit favoring improved survival to hospital discharge and improved neurologically favorable outcome when patients received immediate coronary angiography.[102,107]

In these studies, the decision to undertake the intervention was influenced by a variety of factors such as patient age, duration of CPR, hemodynamic instability, presenting cardiac rhythm, neurologic status upon hospital arrival, and perceived likelihood of cardiac etiology.

2015 Recommendations—Updated

Coronary angiography should be performed emergently (rather than later in the hospital stay or not at all) for OHCA patients with suspected cardiac etiology of arrest and ST elevation on ECG (Class I, LOE B-NR).

Emergency coronary angiography is reasonable for select (eg, electrically or hemodynamically unstable) adult patients who are comatose after OHCA of suspected cardiac origin but without ST elevation on ECG (Class IIa, LOE B-NR).

Coronary angiography is reasonable in post–cardiac arrest patients where coronary angiography is indicated regardless of whether the patient is comatose or awake (Class IIa, LOE C-LD).

Disclosures

Part 9: Acute Coronary Syndromes: 2015 Guidelines Update Writing Group Disclosures

Writing Group Member	Employment	Research Grant	Other Research Support	Speakers' Bureau/ Honoraria	Expert Witness	Ownership Interest	Consultant/ Advisory Board	Other
Robert E. O'Connor	University of Virginia	None	None	None	None	None	None	None
Abdulaziz S. Al Ali	McMaster University	None	None	None	None	None	None	None
William J. Brady	University of Virginia	Siemens Medical Diagnostics*	None	None	Medicolegal consulting*	None	EvidenceCare†	None
Chris A. Ghaemmaghami	University of Virginia	None	None	None	None	None	None	None
Venu Menon	Cleveland Clinic	Astra Zeneca*	None	None	None	None	Astra Zeneca*; Takeda Pharmaceuticals†	None
Michelle Welsford	Centre for Paramedic Education and Research	None	None	None	None	None	None	None
Consultant								
Michael Shuster	Mineral Springs Hospital	None	None	None	None	None	American Heart Association†	None

This table represents the relationships of writing group members that may be perceived as actual or reasonably perceived conflicts of interest as reported on the Disclosure Questionnaire, which all members of the writing group are required to complete and submit. A relationship is considered to be "significant" if (a) the person receives $10 000 or more during any 12-month period, or 5% or more of the person's gross income; or (b) the person owns 5% or more of the voting stock or share of the entity, or owns $10 000 or more of the fair market value of the entity. A relationship is considered to be "modest" if it is less than "significant" under the preceding definition.

*Modest.

†Significant.

Appendix

2015 Guidelines Update: Part 9 Recommendations

Year Last Reviewed	Topic	Recommendation	Comments
2015	Diagnostic Interventions in ACS	Prehospital 12-lead ECG should be acquired early for patients with possible ACS (Class I, LOE B-NR).	new for 2015
2015	Diagnostic Interventions in ACS	Prehospital notification of the receiving hospital (if fibrinolysis is the likely reperfusion strategy) and/or prehospital activation of the catheterization laboratory should occur for all patients with a recognized STEMI on prehospital ECG (Class I, LOE B-NR).	updated for 2015
2015	Diagnostic Interventions in ACS	Because of high false-negative rates, we recommend that computer-assisted ECG interpretation not be used as a sole means to diagnose STEMI (Class III: Harm, LOE B-NR).	new for 2015
2015	Diagnostic Interventions in ACS	We recommend that computer-assisted ECG interpretation may be used in conjunction with physician or trained provider interpretation to recognize STEMI (Class IIb, LOE C-LD).	updated for 2015
2015	Diagnostic Interventions in ACS	While transmission of the prehospital ECG to the ED physician may improve PPV and therapeutic decision-making regarding adult patients with suspected STEMI, if transmission is not performed, it may be reasonable for trained non-physician ECG interpretation to be used as the basis for decision-making, including activation of the catheterization laboratory, administration of fibrinolysis, and selection of destination hospital (Class IIa, LOE B-NR).	new for 2015
2015	Diagnostic Interventions in ACS	We recommend against using hs-cTnT and cTnI alone measured at 0 and 2 hours (without performing clinical risk stratification) to exclude the diagnosis of ACS (Class III: Harm, LOE B-NR).	new for 2015
2015	Diagnostic Interventions in ACS	We recommend that hs-cTnI measurements that are less than the 99th percentile, measured at 0 and 2 hours, may be used together with low-risk stratification (TIMI score of 0 or 1) to predict a less than 1% chance of 30-day MACE (Class IIa, LOE B-NR).	new for 2015
2015	Diagnostic Interventions in ACS	We recommend that negative cTnI or cTnT measurements at 0 and between 3 and 6 hours may be used together with very low-risk stratification (Vancouver score of 0 or North American Chest Pain score of 0 and age less than 50 years) to predict a less than 1% chance of 30-day MACE (Class IIa, LOE B-NR).	new for 2015
2015	Therapeutic Interventions in ACS	In patients with suspected STEMI intending to undergo PPCI, initiation of ADP inhibition may be reasonable in either the prehospital or in-hospital setting (Class IIb, LOE C-LD).	new for 2015
2015	Therapeutic Interventions in ACS	We recommend that EMS systems that do not currently administer heparin to suspected STEMI patients do not add this treatment, whereas those that do administer it may continue their current practice (Class IIb, LOE B-NR).	new for 2015
2015	Therapeutic Interventions in ACS	In suspected STEMI patients for whom there is a planned PPCI reperfusion strategy, administration of unfractionated heparin (UFH) can occur either in the prehospital or in-hospital setting (Class IIb, LOE B-NR).	new for 2015
2015	Therapeutic Interventions in ACS	It may be reasonable to consider the prehospital administration of UFH in STEMI patients or the prehospital administration of bivalirudin in STEMI patients who are at increased risk of bleeding (Class IIb, LOE B-R).	new for 2015
2015	Therapeutic Interventions in ACS	In systems in which UFH is currently administered in the prehospital setting for patients with suspected STEMI who are being transferred for PPCI, it is reasonable to consider prehospital administration of enoxaparin as an alternative to UFH (Class IIa, LOE B-R).	updated for 2015
2015	Therapeutic Interventions in ACS	The usefulness of supplementary oxygen therapy has not been established in normoxic patients. In the prehospital, ED, and hospital settings, the withholding of supplementary oxygen therapy in normoxic patients with suspected or confirmed acute coronary syndrome may be considered (Class IIb, LOE C-LD).	updated for 2015
2015	Therapeutic Interventions in ACS	Where prehospital fibrinolysis is available as part of a STEMI system of care, and in-hospital fibrinolysis is the alternative treatment strategy, it is reasonable to administer prehospital fibrinolysis when transport times are more than 30 minutes (Class IIa, LOE B-R).	updated for 2015
2015	Therapeutic Interventions in ACS	Where prehospital fibrinolysis is available as part of the STEMI system of care and direct transport to a PCI center is available, prehospital triage and transport directly to a PCI center may be preferred because of the small relative decrease in the incidence of intracranial hemorrhage without evidence of mortality benefit to either therapy (Class IIb, LOE B-R).	new for 2015
2015	Therapeutic Interventions in ACS	In the treatment of patients with suspected STEMI, the combined application of fibrinolytic therapy followed by immediate PCI (as contrasted with immediate PCI alone) is not recommended. (Class III: Harm, LOE B-R).	new for 2015
2015	Therapeutic Interventions in ACS	If fibrinolytic therapy is provided, immediate transfer to a PCI center for cardiac angiography within 3 to 24 hours may be considered (Class IIb, LOE C-LD).	new for 2015

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2015 Guidelines Update: Part 9 Recommendations, *Continued*

Year Last Reviewed	Topic	Recommendation	Comments
2015	Therapeutic Interventions in ACS	Regardless of whether time of symptom onset is known, the interval between first medical contact and reperfusion should not exceed 120 minutes (Class I, LOE C-EO).	new for 2015
2015	Therapeutic Interventions in ACS	In STEMI patients presenting within 2 hours of symptom onset, immediate fibrinolysis rather than PPCI may be considered when the expected delay to PPCI is more than 60 minutes (Class IIb, LOE C-LD).	updated for 2015
2015	Therapeutic Interventions in ACS	In STEMI patients presenting within 2 to 3 hours after symptom onset, either immediate fibrinolysis or PPCI involving a possible delay of 60 to 120 minutes might be reasonable (Class IIb, LOE C-LD).	updated for 2015
2015	Therapeutic Interventions in ACS	In STEMI patients presenting within 3 to 12 hours after symptom onset, performance of PPCI involving a possible delay of up to 120 minutes may be considered rather than initial fibrinolysis (Class IIb, LOE C-LD).	updated for 2015
2015	Therapeutic Interventions in ACS	In STEMI patients when long delays to PPCI are anticipated (more than 120 minutes), a strategy of immediate fibrinolysis followed by routine early (within 3 to 24 hours) angiography and PCI if indicated, is reasonable (Class IIb, LOE B-R).	updated for 2015
2015	Therapeutic Interventions in ACS	In adult patients presenting with STEMI in the ED of a non–PCI-capable hospital, we recommend immediate transfer without fibrinolysis from the initial facility to a PCI center instead of immediate fibrinolysis at the initial hospital with transfer only for ischemia-driven PCI (Class I, LOE B-R).	new for 2015
2015	Therapeutic Interventions in ACS	When STEMI patients cannot be transferred to a PCI-capable hospital in a timely manner, fibrinolytic therapy with routine transfer for angiography may be an acceptable alternative to immediate transfer to PPCI (Class IIb, LOE C-LD).	new for 2015
2015	Therapeutic Interventions in ACS	When fibrinolytic therapy is administered to a STEMI patient in a non–PCI-capable hospital, it may be reasonable to transport all postfibrinolysis patients for early routine angiography in the first 3 to 6 hours and up to 24 hours rather than transport postfibrinolysis patients only when they require ischemia-guided angiography (Class IIb, LOE B-R).	new for 2015
2015	Hospital Reperfusion Decisions After ROSC	Coronary angiography should be performed emergently (rather than later in the hospital stay or not at all) for OHCA patients with suspected cardiac etiology of arrest and ST elevation on ECG (Class I, LOE B-NR).	updated for 2015
2015	Hospital Reperfusion Decisions After ROSC	Emergency coronary angiography is reasonable for select (eg, electrically or hemodynamically unstable) adult patients who are comatose after OHCA of suspected cardiac origin but without ST elevation on ECG (Class IIa, LOE B-NR).	updated for 2015
2015	Hospital Reperfusion Decisions After ROSC	Coronary angiography is reasonable in post–cardiac arrest patients where coronary angiography is indicated regardless of whether the patient is comatose or awake (Class IIa, LOE C-LD).	updated for 2015
The following recommendations were not reviewed in 2015. For more information, see the *2010 AHA Guidelines for CPR and ECC*, "Part 10: Acute Coronary Syndromes."			
2010	Prehospital ECGs	If providers are not trained to interpret the 12-lead ECG, field transmission of the ECG or a computer report to the receiving hospital is recommended (Class I, LOE B).	not reviewed in 2015
2010	Prehospital Fibrinolysis	It is strongly recommended that systems which administer fibrinolytics in the prehospital setting include the following features: protocols using fibrinolytic checklists, 12-lead ECG acquisition and interpretation, experience in advanced life support, communication with the receiving institution, medical director with training and experience in STEMI management, and continuous quality improvement (Class I, LOE C).	not reviewed in 2015
2010	Prehospital Triage and EMS Hospital Destination	If PCI is the chosen method of reperfusion for the prehospital STEMI patient, it is reasonable to transport patients directly to the nearest PCI facility, bypassing closer EDs as necessary, in systems where time intervals between first medical contact and balloon times are <90 minutes and transport times are relatively short (ie, <30 minutes) (Class IIa, LOE B).	not reviewed in 2015
2010	Focused Assessment and ECG Risk Stratification	This initial evaluation must be efficient because if the patient has STEMI, the goals of reperfusion are to administer fibrinolytics within 30 minutes of arrival (30-minute interval "door-todrug") or to provide PCI within 90 minutes of arrival (90-minute interval "door-to-balloon") (Class I, LOE A).	not reviewed in 2015
2010	Cardiac Biomarkers	If biomarkers are initially negative within 6 hours of symptom onset, it is recommended that biomarkers should be remeasured between 6 to 12 hours after symptom onset (Class I, LOE A).	not reviewed in 2015
2010	STEMI	If the patient meets the criteria for fibrinolytic therapy, a door-to-needle time (initiation of fibrinolytic agent) <30 minutes is recommended—the earlier the better (Class I, LOE A).	not reviewed in 2015

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2015 Guidelines Update: Part 9 Recommendations, *Continued*

Year Last Reviewed	Topic	Recommendation	Comments
2010	STEMI	Consultation delays therapy and is associated with increased hospital mortality rates (Class III, LOE B).	not reviewed in 2015
2010	Indicators for Early Invasive Strategies	An early invasive PCI strategy is indicated for patients with non–ST-elevation ACS who have no serious comorbidity and who have coronary lesions amenable to PCI and an elevated risk for clinical events (Class I, LOE A).	not reviewed in 2015
2010	Indicators for Early Invasive Strategies	An early invasive strategy (ie, diagnostic angiography with intent to perform revascularization) is indicated in non–ST-elevation ACS patients who have refractory angina or hemodynamic or electric instability (without serious comorbidities or contraindications to such procedures) (Class I, LOE B).	not reviewed in 2015
2010	Indicators for Early Invasive Strategies	In initially stabilized patients, an initially conservative (ie, a selectively invasive) strategy may be considered as a treatment strategy for non–ST-elevation ACS patients (without serious comorbidities or contraindications to such procedures) who have an elevated risk for clinical events including those with abnormal troponin elevations (Class IIb, LOE B).	not reviewed in 2015
2010	The Chest Pain Unit Model	In patients with suspicion for ACS, normal initial biomarkers, and nonischemic ECG, chest pain observation protocols may be recommended as a safe and effective strategy for evaluating patients in the ED (Class I, LOE A).	not reviewed in 2015
2010	Fibrinolytics	If fibrinolysis is chosen for reperfusion, the ED physician should administer fibrinolytics to eligible patients as early as possible according to a predetermined process of care developed by the ED and cardiology staff (Class I, LOE A).	not reviewed in 2015
2010	Fibrinolytics	In fact, fibrinolytic therapy is generally not recommended for patients presenting between 12 and 24 hours after onset of symptoms based on the results of the LATE and EMERAS trials, unless continuing ischemic pain is present with continuing ST-segment elevation (Class IIb, LOE B).	not reviewed in 2015
2010	Fibrinolytics	Fibrinolytic therapy should not be administered (Class III, LOE B) to patients who present greater than 24 hours after the onset of symptoms.	not reviewed in 2015
2010	Percutaneous Coronary Intervention (PCI)	Coronary angioplasty with or without stent placement is the treatment of choice for the management of STEMI when it can be performed effectively with a door-to-balloon time <90 minutes by a skilled provider (performing >75 PCIs per year) at a skilled PCI facility (performing >200 PCIs annually, of which at least 36 are primary PCI for STEMI) (Class I, LOE A).	not reviewed in 2015
2010	PCI Following ROSC After Cardiac Arrest	It is reasonable to include cardiac catheterization and coronary angiography in standardized post– cardiac arrest protocols as part of an overall strategy to improve neurologically intact survival in this patient group (Class IIa, LOE B).	not reviewed in 2015
2010	PCI Following ROSC After Cardiac Arrest	Angiography and/or PCI need not preclude or delay other therapeutic strategies including therapeutic hypothermia (Class IIa, LOE B).	not reviewed in 2015
2010	PCI Following ROSC After Cardiac Arrest	A 12-lead ECG should be performed as soon as possible after ROSC (Class I, LOE A).	not reviewed in 2015
2010	PCI Versus Fibrinolytic Therapy	In summary, for patients presenting within 12 hours of symptom onset and electrocardiographic findings consistent with STEMI, reperfusion should be initiated as soon as possible – independent of the method chosen (Class I, LOE A).	not reviewed in 2015
2010	PCI Versus Fibrinolytic Therapy	Primary PCI performed at a high-volume center within 90 minutes of first medical contact by an experienced operator that maintains an appropriate expert status is reasonable, as it improves morbidity and mortality as compared with immediate fibrinolysis (<30 minutes door-to-needle) (Class I, LOE A).	not reviewed in 2015
2010	PCI Versus Fibrinolytic Therapy	For those patients with a contraindication to fibrinolysis, PCI is recommended despite the delay, rather than foregoing reperfusion therapy (Class I, LOE A).	not reviewed in 2015
2010	Clopidogrel	On the basis of these findings, providers should administer a loading dose of clopidogrel in addition to standard care (aspirin, anticoagulants, and reperfusion) for patients determined to have moderate- to high-risk non-ST-segment elevation ACS and STEMI (Class I, LOE A).	not reviewed in 2015
2010	Clopidogrel	It is reasonable to administer a 300-mg oral dose of clopidogrel to ED patients with suspected ACS (without ECG or cardiac marker changes) who are unable to take aspirin because of hypersensitivity or major gastrointestinal intolerance (Class IIa, LOE B).	not reviewed in 2015
2010	Clopidogrel	Providers should administer a 300-mg oral dose of clopidogrel to ED patients up to 75 years of age with STEMI who receive aspirin, heparin, and fibrinolysis (Class I, LOE B).	not reviewed in 2015
2010	Prasugrel	Prasugrel (60 mg oral loading dose) may be substituted for clopidogrel after angiography in patients determined to have non-ST-segment elevation ACS or STEMI who are more than 12 hours after symptom onset prior to planned PCI (Class IIa, LOE B).	not reviewed in 2015

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2015 Guidelines Update: Part 9 Recommendations, *Continued*

Year Last Reviewed	Topic	Recommendation	Comments
2010	Prasugrel	There is no direct evidence for the use of prasugrel in the ED or prehospital settings. In patients who are not at high risk for bleeding, administration of prasugrel (60-mg oral loading dose) prior to angiography in patients determined to have STEMI ≤12 hours after the initial symptoms may be substituted for administration of clopidogrel (Class IIa, LOE B).	not reviewed in 2015
2010	Initial EMS Care	Because aspirin should be administered as soon as possible after symptom onset to patients with suspected ACS, it is reasonable for EMS dispatchers to instruct patients with no history of aspirin allergy and without signs of active or recent gastrointestinal bleeding to chew an aspirin (160 to 325 mg) while awaiting the arrival of EMS providers (Class IIa, LOE C).	not reviewed in 2015
2010	Initial EMS Care	If the patient is dyspneic, hypoxemic, or has obvious signs of heart failure, providers should titrate therapy, based on monitoring of oxyhemoglobin saturation, to 94% (Class I, LOE C).	not reviewed in 2015
2010	Initial EMS Care	EMS providers should administer nonenteric aspirin (160 [Class I, LOE B] to 325 mg [Class I, LOE C]).	not reviewed in 2015
2010	Initial EMS Care	Morphine is indicated in STEMI when chest discomfort is unresponsive to nitrates (Class I, LOE C).	not reviewed in 2015
2010	Initial EMS Care	Morphine should be used with caution in unstable angina (UA)/NSTEMI due to an association with increased mortality in a large registry (Class IIa, LOE C).	not reviewed in 2015
2010	Interfacility Transfer	These include patients who are ineligible for fibrinolytic therapy or who are in cardiogenic shock (Class I, LOE C).	not reviewed in 2015
2010	Interfacility Transfer	Transfer of high-risk patients who have received primary reperfusion with fibrinolytic therapy is reasonable (Class IIa, LOE B).	not reviewed in 2015
2010	TIMI Risk Score	These findings confirm the value of the TIMI risk score as a guide to therapeutic decisions (Class IIa, LOE B).	not reviewed in 2015
2010	Indicators for Early Invasive Strategies	The decision to implement an initial conservative (versus initial invasive) strategy in these patients may be made by considering physician and patient preference (Class IIb, LOE C).	not reviewed in 2015
2010	Advanced Testing to Detect Coronary Ischemia and CAD	For ED/CPU patients who are suspected of having ACS, have nonischemic ECG's and negative biomarkers, a noninvasive test for inducible myocardial ischemia or anatomic evaluation of the coronary arteries (eg, computed tomography [CT] angiography, cardiac magnetic resonance, myocardial perfusion imaging, stress echocardiography) can be useful in identifying patients suitable for discharge from the ED (Class IIa, LOE B).	not reviewed in 2015
2010	Advanced Testing to Detect Coronary Ischemia and CAD	MPS can also be used for risk stratification, especially in low- to intermediatelikelihood of cardiac events according to traditional cardiac markers (Class IIa, LOE B).	not reviewed in 2015
2010	Advanced Testing to Detect Coronary Ischemia and CAD	The use of MDCT angiography for selected low-risk patients can be useful to allow for safe early discharge from the ED (Class IIa, LOE B).	not reviewed in 2015
2010	Safety of Discharge and Risk of Major Adverse Cardiac Events After Discharge From the ED/CPU	The use of inpatient-derived risk scoring systems are useful for prognosis (Class I, LOE A) but are not recommended to identify patients who may be safely discharged from the ED (Class III, LOE C).	not reviewed in 2015
2010	Aspirin and Nonsteroidal Anti-inflammatory Drugs	Therefore, unless the patient has a known aspirin allergy or active gastrointestinal hemorrhage, nonenteric aspirin should be given as soon as possible to all patients with suspected ACS (Class I, LOE A).	not reviewed in 2015
2010	Aspirin and Nonsteroidal Anti-inflammatory Drugs	NSAIDs (except for aspirin), both nonselective as well as COX-2 selective agents, should not be administered during hospitalization for STEMI because of the increased risk of mortality, reinfarction, hypertension, heart failure, and myocardial rupture associated with their use (Class III, LOE C).	not reviewed in 2015
2010	Nitroglycerin (or Glyceryl Trinitrate)	Patients with ischemic discomfort should receive up to 3 doses of sublingual or aerosol nitroglycerin at 3- to 5-minute intervals until pain is relieved or low blood pressure limits its use (Class I, LOE B).	not reviewed in 2015
2010	Nitroglycerin (or Glyceryl Trinitrate)	The use of nitrates in patients with hypotension (SBP <90 mm Hg or ≥30 mm Hg below baseline), extreme bradycardia (<50 bpm), or tachycardia in the absence of heart failure (>100 bpm) and in patients with right ventricular infarction is contraindicated (Class III, LOE C).	not reviewed in 2015
2010	Analgesia	Providers should administer analgesics, such as intravenous morphine, for chest discomfort unresponsive to nitrates. Morphine is the preferred analgesic for patients with STEMI (Class I, LOE C).	not reviewed in 2015
2010	β-Adrenergic Receptor Blockers	IV β-blocker therapy may be considered as reasonable in specific situations such as severe hypertension or tachyarrhythmias in patients without contraindications (Class IIa, LOE B).	not reviewed in 2015

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2015 Guidelines Update: Part 9 Recommendations, *Continued*

Year Last Reviewed	Topic	Recommendation	Comments
2010	β-Adrenergic Receptor Blockers	In the absence of contraindications, PO β-blockers should be administered within the first 24 hours to patients with suspected ACS (Class I, LOE A).	not reviewed in 2015
2010	β-Adrenergic Receptor Blockers	It is reasonable to start oral β-blockers with low doses after the patient is stabilized prior to discharge (Class IIa, LOE B).	not reviewed in 2015
2010	Treatment Recommendations for UA/NSTEMI	For in-hospital patients with NSTEMI managed with a planned initial conservative approach, either fondaparinux (Class IIa, LOE B) or enoxaparin (Class IIa, LOE A) are reasonable alternatives to UFH or placebo.	not reviewed in 2015
2010	Treatment Recommendations for UA/NSTEMI	For in-hospital patients with NSTEMI managed with a planned invasive approach, either enoxaparin or UFH are reasonable choices (Class IIa, LOE A).	not reviewed in 2015
2010	Treatment Recommendations for UA/NSTEMI	Fondaparinux may be used in the setting of PCI, but requires co-administration of UFH and does not appear to offer an advantage over UFH alone (Class IIb, LOE A).	not reviewed in 2015
2010	Treatment Recommendations for UA/NSTEMI	For in-hospital patients with NSTEMI and renal insufficiency, bivalirudin or UFH may be considered (Class IIb, LOE A).	not reviewed in 2015
2010	Treatment Recommendations for UA/NSTEMI	For in-hospital patients with NSTEMI and increased bleeding risk, where anticoagulant therapy is not contraindicated, fondaparinux (Class IIa, LOE B) or bivalirudin (Class IIa, LOE A) are reasonable and UFH may be considered (Class IIb, LOE C).	not reviewed in 2015
2010	Enoxaparin	For patients with STEMI managed with fibrinolysis in the hospital, it is reasonable to administer enoxaparin instead of UFH (Class IIa, LOE A).	not reviewed in 2015
2010	Enoxaparin	In addition, for prehospital patients with STEMI managed with fibrinolysis, adjunctive enoxaparin instead of UFH may be considered (Class IIb, LOE A).	not reviewed in 2015
2010	Enoxaparin	Patients initially treated with enoxaparin should not be switched to UFH and vice versa because of increased risk of bleeding (Class III, LOE C).	not reviewed in 2015
2010	Enoxaparin	In younger patients <75 years the initial dose of enoxaparin is 30 mg IV bolus followed by 1 mg/kg SC every 12 hours (first SC dose shortly after the IV bolus) (Class IIb, LOE A).	not reviewed in 2015
2010	Enoxaparin	Patients ≥75 years may be treated with 0.75 mg/kg SC enoxaparin every 12 hours without an initial IV bolus (Class IIb, LOE B).	not reviewed in 2015
2010	Enoxaparin	Patients with impaired renal function (creatinine clearance <30 mL/min) may be given 1 mg/kg enoxaparin SC once daily (Class IIb, LOE B).	not reviewed in 2015
2010	Enoxaparin	Patients with known impaired renal function may alternatively be managed with UFH (Class IIb, LOE B).	not reviewed in 2015
2010	Fondaparinux	Fondaparinux (initially 2.5 mg IV followed by 2.5 mg SC once daily) may be considered in the hospital for patients treated specifically with non-fibrin-specific thrombolytics (ie, streptokinase), provided the creatinine is 3 mg/dL (Class IIb, LOE B).	not reviewed in 2015
2010	Unfractionated Heparin Versus Low-Molecular-Weight Heparin With PPCI in STEMI	For patients with STEMI undergoing contemporary PCI (ie, additional broad use of glycoprotein IIb/IIIa inhibitors and a thienopyridine) enoxaparin may be considered a safe and effective alternative to UFH (Class IIb, LOE B).	not reviewed in 2015
2010	Unfractionated Heparin Versus Low-Molecular-Weight Heparin With PPCI in STEMI	Patients initially treated with enoxaparin should not be switched to UFH and vice versa to avoid increased risk of bleeding. Fondaparinux may be considered as an alternative to UFH, however, there is an increased risk of catheter thrombi with fondaparinux alone. Additional UFH (50 to 100 U/kg bolus) may help to avoid this complication (Class IIb, LOE B), but using these two agents is not recommended over UFH alone.	not reviewed in 2015
2010	Unfractionated Heparin Versus Low-Molecular-Weight Heparin With PPCI in STEMI	For fondaparinux and enoxaparin it is necessary to adjust the dose in patients with renal impairment. Bivalirudin may be considered as an alternative to UFH and GP IIb/IIIa inhibitors (Class IIb, LOE A).	not reviewed in 2015
2010	ACE Inhibitors and ARBs in the Hospital	Administration of an oral ACE inhibitor is recommended within the first 24 hours after onset of symptoms in STEMI patients with pulmonary congestion or LV ejection fraction <40%, in the absence of hypotension (SBP <100 mm Hg or ≥30 mm Hg below baseline) (Class I, LOE A).	not reviewed in 2015
2010	ACE Inhibitors and ARBs in the Hospital	Oral ACE inhibitor therapy can also be useful for all other patients with AMI with or without early reperfusion therapy (Class IIa, LOE B).	not reviewed in 2015
2010	ACE Inhibitors and ARBs in the Hospital	IV administration of ACE inhibitors is contraindicated in the first 24 hours because of risk of hypotension (Class III, LOE C).	not reviewed in 2015
2010	ACE Inhibitors in the Prehospital Setting	In conclusion, although ACE inhibitors and ARBs have been shown to reduce long-term risk of mortality in patients suffering an AMI, there is insufficient evidence to support the routine initiation of ACE inhibitors and ARBs in the prehospital or ED setting (Class IIb, LOE C).	not reviewed in 2015

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2015 Guidelines Update: Part 9 Recommendations, *Continued*

Year Last Reviewed	Topic	Recommendation	Comments
2010	HMG Coenzyme A Reductase Inhibitors (Statins)	There is little data to suggest that this therapy should be initiated within the ED; however, early initiation (within 24 hours of presentation) of statin therapy is recommended in patients with an ACS or AMI (Class I, LOE C).	not reviewed in 2015
2010	HMG Coenzyme A Reductase Inhibitors (Statins)	If patients are already on statin therapy, continue the therapy (Class IIb, LOE C).	not reviewed in 2015
2010	HMG Coenzyme A Reductase Inhibitors (Statins)	Statins should not be discontinued during the index hospitalization unless contraindicated (Class III, LOE C).	not reviewed in 2015
2010	HMG Coenzyme A Reductase Inhibitors (Statins)	In conclusion, intensive (target LDL values optimally 70 mg/dL) statin treatment should be initiated within the first 24 hours after onset of an ACS event (eg, immediately after hospital admission) in all patients presenting with any form of ACS unless strictly contraindicated (eg, by proven intolerance) (Class I, LOE A).	not reviewed in 2015
2010	Glucose-Insulin-Potassium	At this time there is little evidence to suggest that this intervention is helpful (Class IIb, LOE C).	not reviewed in 2015
2010	Ventricular Rhythm Disturbances	the practice of prophylactic administration of lidocaine is not recommended (Class III, LOE A).	not reviewed in 2015
2010	Ventricular Rhythm Disturbances	Sotalol has not been adequately studied (Class IIb, LOE C).	not reviewed in 2015
2010	Ventricular Rhythm Disturbances	Amiodarone in a single RCT did not appear to improve survival in low doses and may increase mortality in high doses when used early in patients with suspected myocardial infarction (Class IIb, LOE C).	not reviewed in 2015
2010	Ventricular Rhythm Disturbances	prophylactic antiarrhythmics are not recommended for patients with suspected ACS or myocardial infarction in the prehospital or ED (Class III, LOE A).	not reviewed in 2015
2010	Ventricular Rhythm Disturbances	Routine IV administration of β-blockers to patients without hemodynamic or electric contraindications is associated with a reduced incidence of primary VF (Class IIb, LOE C).	not reviewed in 2015
2010	Ventricular Rhythm Disturbances	It is prudent clinical practice to maintain serum potassium >4 mEq/L and magnesium >2 mEq/L (Class IIB, LOE A).	not reviewed in 2015

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KEY WORDS: electrocardiogram ■ fibrinolytics ■ myocardial infarction ■ ST-segment elevation ■ unstable angina

Part 10: Special Circumstances of Resuscitation

2015 American Heart Association Guidelines Update for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care

Eric J. Lavonas, Chair; Ian R. Drennan; Andrea Gabrielli; Alan C. Heffner; Christopher O. Hoyte; Aaron M. Orkin; Kelly N. Sawyer; Michael W. Donnino

Introduction

This Part of the *2015 American Heart Association* (AHA) *Guidelines Update for Cardiopulmonary Resuscitation* (CPR) *and Emergency Cardiovascular Care* (ECC) addresses cardiac arrest in situations that require special treatments or procedures other than those provided during basic life support (BLS) and advanced cardiovascular life support (ACLS).

This Part summarizes recommendations for the management of resuscitation in several critical situations, including cardiac arrest associated with pregnancy (Part 10.1), pulmonary embolism (PE) (10.2), and opioid-associated resuscitative emergencies, with or without cardiac arrest (10.3). Part 10.4 provides recommendations on intravenous lipid emulsion (ILE) therapy, an emerging therapy for cardiac arrest due to drug intoxication. Finally, updated guidance for the management of cardiac arrest during percutaneous coronary intervention (PCI) is presented in Part 10.5. A table of all recommendations made in this 2015 Guidelines Update as well as those made in the 2010 Guidelines is contained in the Appendix.

The special situations of resuscitation section (Part 12) of the *2010 AHA Guidelines for CPR and ECC*[1] covered 15 distinct topic areas. The following topics were last updated in 2010:

- Management of cardiac arrest associated with asthma (Part 12.1)
- Anaphylaxis (12.2)
- Morbid obesity (12.4)
- Electrolyte imbalance (12.6)
- Trauma (12.8)
- Accidental hypothermia (12.9)
- Avalanche (12.10)
- ACLS treatment of cardiac arrest due to drowning (12.11)
- Electric shock or lightning strikes (12.12)
- Cardiac tamponade (12.14)
- Cardiac surgery (12.15)
- Toxic effects of benzodiazepines, β-blockers, calcium channel blockers, digoxin, cocaine, cyclic antidepressants, carbon monoxide, and cyanide (12.7)

Additional information about drowning is presented in Part 5 of this publication, "Adult Basic Life Support and Cardiopulmonary Resuscitation Quality."

The recommendations in this 2015 Guidelines Update are based on an extensive evidence review process that was begun by the International Liaison Committee on Resuscitation (ILCOR) with the publication of the ILCOR *2010 International Consensus on CPR and ECC Science With Treatment Recommendations* (CoSTR)[2] and was completed with the preparation of the 2015 CoSTR publication.[3,4]

In the in-depth international evidence review process, the ILCOR task forces examined topics and then generated prioritized lists of questions for systematic review. The process by which topics were prioritized for review are described in the CoSTR publication.[5,6] Questions were first formulated in PICO (population, intervention, comparator, outcome) format,[7] the search strategy and inclusion and exclusion criteria were defined, and then a search for relevant articles was performed. The evidence was evaluated by using the standardized methodological approach proposed by the Grading of Recommendations Assessment, Development and Evaluation (GRADE) Working Group.[8]

The quality of the evidence was categorized based on the study methodologies and the 5 core GRADE domains of risk of bias, inconsistency, indirectness, imprecision, and other considerations (including publication bias). Then, where possible, consensus-based treatment recommendations were created. Further information about this international evidence evaluation process can be found in the 2015 CoSTR, "Part 2: Evidence Evaluation and Management of Conflicts of Interest."[9,10]

To create this 2015 Guidelines Update, the AHA formed 15 writing groups, with careful attention to avoid or manage conflicts of interest, to assess the ILCOR treatment recommendations and to write AHA treatment recommendations by using the AHA Class of Recommendation and Level of Evidence (LOE) system. The recommendations made in this 2015 Guidelines Update are informed by the ILCOR recommendations and GRADE classification of the systematic reviews in the context of the delivery of medical care in North America. In the online version of this publication, live links

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are provided so the reader can connect directly to those systematic reviews on the ILCOR Scientific Evidence Evaluation and Review System (SEERS) website. These links are indicated by a combination of letters and numbers (eg, ALS 436). We encourage readers to use the links and review the evidence and appendixes, such as the GRADE tables. Further information about this evidence evaluation process can be found in "Part 2: Evidence Evaluation and Management of Conflicts of Interest" of this 2015 Guidelines Update.

Contemporaneous with the ILCOR evidence-review process, the AHA ECC Committee; Council on Cardiopulmonary, Critical Care, Perioperative, and Resuscitation; Council on Cardiovascular Diseases in the Young; and Council on Clinical Cardiology have developed an AHA Scientific Statement on cardiac arrest in pregnancy.[11] While Part 10.1 of this 2015 Guidelines Update provides treatment recommendations for the intra-arrest management of pregnant patients, a full discussion of preparation, prevention, resuscitation, emergency delivery, and postresuscitation care are beyond the scope of this article. Readers are directed to the full Scientific Statement for more complete recommendations.

Part 10.1: Cardiac Arrest Associated With Pregnancy[ALS 436]

Cardiac arrest associated with pregnancy is rare in high-income countries. Maternal cardiac arrest occurs in approximately 1:12 000 admissions for delivery in the United States.[12] Maternal cardiac arrest rates appear to be increasing in the United States, from 7.2 deaths per 100 000 live births in 1987 to 17.8 deaths per 100 000 live births in 2009.[13] Maternal mortality rates are lower in Canada, where maternal mortality is reported as 6.1 deaths per 100 000 deliveries, with a decreasing trend from 2001 until 2011.[14,15]

The best outcomes for both mother and fetus are likely to be achieved by successful maternal resuscitation. The most common causes of maternal cardiac arrest are hemorrhage, cardiovascular diseases (including myocardial infarction, aortic dissection, and myocarditis), amniotic fluid embolism, sepsis, aspiration pneumonitis, PE, and eclampsia.[12,16] Important iatrogenic causes of maternal cardiac arrest include hypermagnesemia from magnesium sulfate administration and anesthetic complications.

The 2015 ILCOR systematic review addressed the questions of patient positioning during CPR and the role of perimortem cesarean delivery (PMCD) in the management of pregnant women in cardiac arrest during the second half of pregnancy.

2015 Evidence Summary

The evidence regarding advanced treatment strategies for cardiac arrest in pregnancy is largely observational. As a result, the recommendations are based on application of physiologic principles and on close examination of observational studies that are susceptible to bias. The lack of high-quality studies examining treatment of cardiac arrest in late pregnancy represents a major scientific gap.

Patient Positioning During CPR

Patient position has emerged as an important strategy to improve the quality of CPR and resultant compression force and cardiac output. The gravid uterus can compress the inferior vena cava, impeding venous return, thereby reducing stroke volume and cardiac output. In general, aortocaval compression can occur for singleton pregnancies at approximately 20 weeks of gestational age,[17] at about the time when the fundus is at or above the umbilicus. Although chest compressions in the left lateral tilt position are feasible in a manikin study,[18] they result in decreased CPR quality (less forceful chest compressions) than is possible in the supine position.[19] Manual left lateral uterine displacement (LUD) effectively relieves aortocaval pressure in patients with hypotension[20] (Figure 1). No cardiac arrest outcome studies have been published examining the effect of LUD or other strategies to relieve aortocaval compression during resuscitation.

Emergency Cesarean Delivery in Cardiac Arrest

Evacuation of the gravid uterus relieves aortocaval compression and may improve resuscitative efforts.[21–25] In the latter half of pregnancy, PMCD may be considered part of maternal resuscitation, regardless of fetal viability.[26] In a case series, 12 of 20 women for whom maternal outcome was recorded who underwent PMCD during resuscitation had return of spontaneous circulation (ROSC) immediately after delivery,

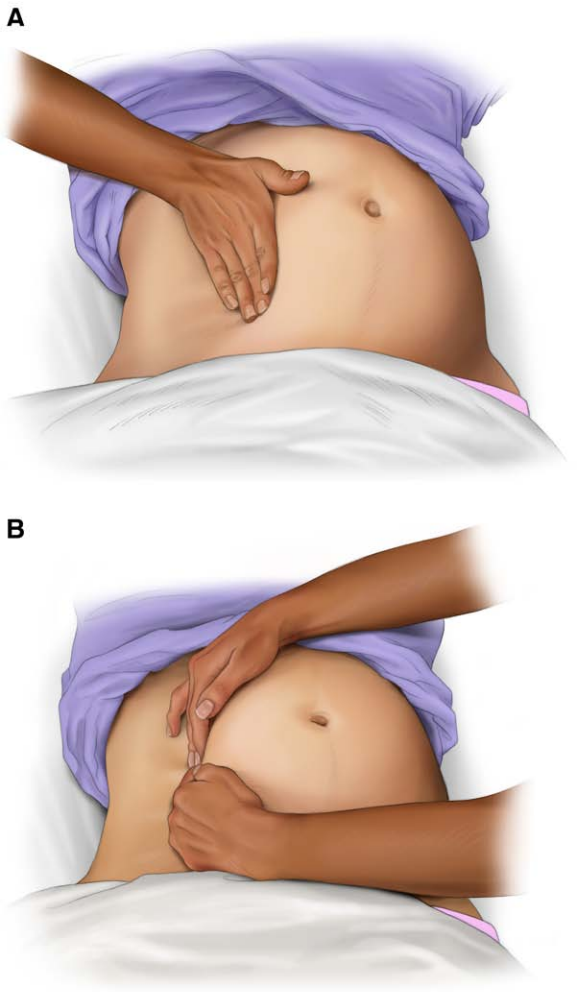

Figure 1. A, Manual LUD, performed with one-handed technique. **B**, Two-handed technique during resuscitation.

and no cases of worsening maternal status were reported.[27] A systematic review of the literature evaluated all case reports of cardiac arrest in pregnancy, but the wide range of case heterogeneity and reporting bias does not allow for any conclusions regarding the timing of PMCD.[28] Survival of the mother has been reported up to 15 minutes after the onset of maternal cardiac arrest.[21,29–31] Neonatal survival has been documented with PMCD performed up to 30 minutes after the onset of maternal cardiac arrest.[21]

2015 Recommendations—New and Updated

BLS Modification: Relief of Aortocaval Compression

Priorities for the pregnant woman in cardiac arrest are provision of high-quality CPR and relief of aortocaval compression (Class I, LOE C-LD). If the fundus height is at or above the level of the umbilicus, manual LUD can be beneficial in relieving aortocaval compression during chest compressions (Class IIa, LOE C-LD).

ALS Modification: Emergency Cesarean Delivery in Cardiac Arrest

Because immediate ROSC cannot always be achieved, local resources for a PMCD should be summoned as soon as cardiac arrest is recognized in a woman in the second half of pregnancy (Class I, LOE C-LD). Systematic preparation and training are the keys to a successful response to such rare and complex events. Care teams that may be called upon to manage these situations should develop and practice standard institutional responses to allow for smooth delivery of resuscitative care (Class I, LOE C-EO).

During cardiac arrest, if the pregnant woman with a fundus height at or above the umbilicus has not achieved ROSC with usual resuscitation measures plus manual LUD, it is advisable to prepare to evacuate the uterus while resuscitation continues (Class I, LOE C-LD). In situations such as nonsurvivable maternal trauma or prolonged pulselessness, in which maternal resuscitative efforts are obviously futile, there is no reason to delay performing PMCD (Class I, LOE C-LD). PMCD should be considered at 4 minutes after onset of maternal cardiac arrest or resuscitative efforts (for the unwitnessed arrest) if there is no ROSC (Class IIa, LOE C-EO). The clinical decision to perform a PMCD—and its timing with respect to maternal cardiac arrest—is complex because of the variability in level of practitioner and team training, patient factors (eg, etiology of arrest, gestational age), and system resources.

Part 10.2: Cardiac Arrest Associated With Pulmonary Embolism[ALS 435]

PE is a potentially reversible cause of shock and cardiac arrest. Acute increase in right ventricular pressure due to pulmonary artery obstruction and liberation of vasoactive mediators produces cardiogenic shock that may rapidly progress to cardiovascular collapse. Management of acute PE is determined by disease severity.[32] Fulminant PE, characterized by cardiac arrest or severe hemodynamic instability, defines the subset of massive PE that is the focus of these recommendations.[33]

Less than 5% of patients with acute PE progress to cardiac arrest. Disease of this severity is associated with mortality of 65% to 90%.[34–36] PE-related cardiac arrests may occur within hours of symptom onset. Between 5% and 13% of unexplained cardiac arrests are associated with fulminant PE.[37,38]

Because establishing the diagnosis of acute PE in cardiac arrest situations is often difficult, separate systematic reviews were performed for management of patients with suspected and confirmed PE. Although clinical markers specific to fulminant PE are limited, acute symptoms frequently prompt medical attention before cardiac arrest. Conventional thromboembolism risk factors, prodromal dyspnea or respiratory distress, and witnessed arrest are features associated with cardiac arrest due to PE.[37,39] Pulseless electrical activity is the presenting rhythm in 36% to 53% of PE-related cardiac arrests, while primary shockable rhythms are uncommon.[37,40,41] Specific recommendations about the use of diagnostic ultrasonography during resuscitation can be found in "Part 7: Adult Advanced Cardiovascular Life Support" in this 2015 Guidelines Update.

Prompt systemic anticoagulation is generally indicated for patients with massive and submassive PE to prevent clot propagation and support endogenous clot dissolution over weeks.[42] Anticoagulation alone is inadequate for patients with fulminant PE. Pharmacologic and mechanical therapies to rapidly reverse pulmonary artery occlusion and restore adequate pulmonary and systemic circulation have emerged as primary therapies for massive PE, including fulminant PE.[32,43] Current advanced treatment options include systemic thrombolysis, surgical or percutaneous mechanical embolectomy, and extracorporeal cardiopulmonary resuscitation (ECPR).

The 2015 ILCOR systematic review addressed the treatment of PE as the known or suspected cause of cardiac arrest. The role of thrombolytic medications in the management of undifferentiated cardiac arrest was last reviewed in the 2010 Guidelines and is not reviewed again here.[44]

2015 Evidence Summary

The evidence regarding advanced treatment strategies for fulminant PE is largely observational. The lack of high-quality studies examining treatment of cardiac arrest due to PE represents a major scientific gap.

Confirmed Pulmonary Embolism

Systemic thrombolysis is associated with ROSC and short-term survival in PE-related cardiac arrest in nonrandomized observational studies.[37,45–54]

There is no consensus on the ideal dose of thrombolytic therapy in PE-associated cardiac arrest. Contemporary examples of accelerated emergency thrombolysis dosing regimens for fulminant PE include alteplase 50 mg intravenous (IV) bolus with an option for repeat bolus in 15 minutes, or single-dose weight-based tenecteplase; thrombolytics are administered with or followed by systemic anticoagulation.[55–57] Early administration of systemic thrombolysis is associated with improved resuscitation outcomes compared with use after failure of conventional ACLS.[46]

Successful surgical and percutaneous mechanical embolectomy in cases of PE-related cardiac arrest have been reported in limited series.[58–60] Many of these patients developed cardiac arrest before or during embolectomy. The feasibility of embolectomy under uncontrolled CPR conditions is not known.

Suspected Pulmonary Embolism

No evidence is available to support or refute the effectiveness of empiric thrombolysis in suspected but unconfirmed PE.

2015 Recommendations—New and Updated

ALS Modification: Confirmed Pulmonary Embolism

In patients with confirmed PE as the precipitant of cardiac arrest, thrombolysis, surgical embolectomy, and mechanical embolectomy are reasonable emergency treatment options (Class IIa, LOE C-LD). Comparative data are not available to recommend one strategy over another. Patient location, local intervention options, and patient factors (including thrombolysis contraindications) are recognized elements to be considered. Thrombolysis can be beneficial even when chest compressions have been provided (Class IIa, LOE C-LD). Given the poor outcomes associated with fulminant PE in the absence of clot-directed therapy, standard contraindications to thrombolysis may be superseded by the need for potentially lifesaving intervention.

ALS Modifications: Suspected Pulmonary Embolism

Thrombolysis may be considered when cardiac arrest is suspected to be caused by PE (Class IIb, LOE C-LD). There is no consensus on inclusion criteria (eg, risk factors, signs, or symptoms that constitute suspected PE), thrombolytic timing, drug, or dose in this situation. There are insufficient data on surgical and mechanical embolectomy to evaluate these therapies for cardiac arrest associated with suspected but unconfirmed PE.

Part 10.3: Cardiac or Respiratory Arrest Associated With Opioid Overdose[ALS 441,BLS 811,BLS 891]

In the United States in 2013, 16 235 people died of prescription opioid toxicity, and an additional 8257 died of heroin overdose.[61,62] In the United States in 2012, opioid overdose became the leading cause of unintentional injurious death in people aged 25 to 60 years, accounting for more deaths than motor vehicle collisions.[63] A majority of these deaths are associated with prescription opioids. Statistics are similar in Canada.[64]

Isolated opioid toxicity is associated with central nervous system (CNS) and respiratory depression that can progress to respiratory and cardiac arrest. Most opioid deaths involve the co-ingestion of multiple drugs or medical and mental health comorbidities.[65–68] In addition, methadone and propoxyphene can cause *torsades de pointes*, and cardiotoxicity has been reported with other opioids.[69–75] Except in specific clinical settings (eg, unintended opioid overdose during a medical procedure), rescuers cannot be certain that the patient's clinical condition is due to opioid-induced CNS and respiratory depression toxicity alone, and might therefore misidentify opioid-associated cardiac arrest as unconsciousness or *vice versa*. This is particularly true in the first aid and BLS contexts, where determination of the presence or absence of a pulse is unreliable.[76,77] Any treatment recommendations intended for use in the first aid or BLS settings must therefore have benefit that exceeds harm when applied to a mixed patient population that may include people with severe CNS and respiratory depression, respiratory arrest, and cardiac arrest.

In creating this 2015 Guidelines Update, the writing group considered the difficulty in accurately differentiating opioid-associated resuscitative emergencies from other causes of cardiac and respiratory arrest. Opioid-associated resuscitative emergencies are defined by the presence of cardiac arrest; respiratory arrest; or severe life-threatening instability (such as severe CNS or respiratory depression, hypotension, or cardiac arrhythmia) that is suspected to be due to opioid toxicity. The term "opioid-associated life-threatening emergency" is used for first aid and non-healthcare providers.

Naloxone is a potent opioid receptor antagonist in the brain, spinal cord, and gastrointestinal system. Naloxone has an excellent safety profile and can rapidly reverse CNS and respiratory depression in a patient with an opioid-associated resuscitative emergency. Based on the rescuer's training and clinical circumstance, naloxone can be administered intravenously,[78–81] intramuscularly,[78,79,82] intranasally,[80,82–86] or subcutaneously[87]; nebulized for inhalation[88,89]; or instilled into the bronchial tree via endotracheal tube.[90] Appropriate dose and concentrations differ by route.

There are no known harms or major clinical effects associated with the administration of naloxone in typical doses to patients who are not opioid-intoxicated or dependent.[91,92] Naloxone administration may precipitate acute withdrawal syndrome in patients with opioid dependency, with signs and symptoms including hypertension, tachycardia, piloerection, vomiting, agitation, and drug cravings. These signs and symptoms are rarely life-threatening, and they may be minimized by using the lowest effective dose of naloxone.[93] Pulmonary edema has been reported with naloxone administration, but it also may be caused primarily by opioid toxicity.[93]

The ideal dose of naloxone is not known. In the 2010 Guidelines, an empiric starting dose of 0.04 to 0.4 mg IV or intramuscular (IM) was recommended to avoid provoking severe opioid withdrawal in patients with opioid dependency and to allow for consideration of a range of doses, depending on the clinical scenario.[1] Repeat doses or dose escalation to 2 mg IV or IM was recommended if the initial response was inadequate. Few comparative data exist about the appropriate dose of intranasal (IN) naloxone; most studies used a fixed dose of 2 mg, repeated in 3 to 5 minutes if necessary.[80,82–86,94] Nebulized naloxone has been studied and well-tolerated in opioid-intoxicated patients at a dose of 2 mg diluted in 3 mL normal saline.[88,89] Regardless of the care setting and route of administration, the initial goal of therapy is to restore and maintain patent airway and ventilation, preventing respiratory and cardiac arrest, without provoking severe opioid withdrawal.

The 2015 ILCOR systematic review addressed the questions of whether opioid overdose response education (with or without naloxone distribution) improves outcomes related to opioid overdose and whether naloxone administration or any other therapy improves outcomes in the patients with opioid-associated cardio/respiratory arrest in the first aid, BLS, or ACLS settings.

2015 Evidence Summary

Opioid Overdose Response Education and Naloxone Training and Distribution

Several studies have shown that community-based opioid overdose response education and naloxone distribution programs are feasible and that naloxone administration occurs frequently by persons trained by these programs.[95] Because patients who have CNS and respiratory depression from opioid overdose cannot self-administer naloxone, naloxone is typically administered in the first aid setting by friends, family, or bystanders.[96,97]

In 2014, the US Food and Drug Administration approved of the use of a naloxone autoinjector by lay rescuers[98] as well as healthcare providers. Both the IM and IN[95] routes of administration have been successfully used in first aid settings, with commercially available devices or kits containing a naloxone vial or prefilled syringe and a nasal atomizer or other administration device. IM, IN, and nebulized routes of administration have also been used to treat opioid-associated resuscitative emergencies in the BLS and ACLS settings.[79,80,88,99] Recent recommendations by an international working group called for uniform training standards based on simplified (first aid) resuscitation principles for community-based naloxone distribution programs.[100]

Administration of Naloxone in Opioid-Associated Resuscitation Emergencies

Respiratory Arrest

Two clinical trials and 12 observational studies examined outcomes after naloxone treatment for opioid-induced respiratory arrest or severe CNS and respiratory depression. Of these, 5 studies compared routes of naloxone administration,[80,82,83,87,101] and 9 assessed the safety of naloxone use or were observational studies of naloxone use alone.[79,102–109] All studies reported improvement in level of consciousness and spontaneous breathing after naloxone administration in the majority of patients treated, and complication rates were low. No study compared resuscitation outcomes achieved with naloxone with those achieved through standard therapy alone (eg, manual or mechanical ventilation).

Cardiac Arrest

One small observational study noted an improvement in cardiac rhythm in some patients after naloxone administration, but it did not compare outcomes in patients managed with and without naloxone administration.[110]

2015 Recommendations—New

Opioid Overdose Response Education and Naloxone Training and Distribution

It is reasonable to provide opioid overdose response education, either alone or coupled with naloxone distribution and training, to persons at risk for opioid overdose (Class IIa, LOE C-LD). Some populations that may benefit from opioid overdose response interventions are listed in Table 1. It is reasonable to base this training on first aid and non–healthcare provider BLS recommendations rather than on more advanced practices intended for healthcare providers (Class IIa, LOE C-EO).

Table 1. Groups That May Benefit From Opioid Overdose Response Education and/or Naloxone Distribution and Training[100,111–119]

- Persons who abuse prescription opioids or heroin
- Patients who have required emergency care for opioid overdose
- Patients enrolled in opioid dependence treatment programs, including methadone and buprenorphine maintenance programs, particularly at high-risk periods, such as induction or discharge
- Persons with a history of opioid abuse or dependence who are being released from prison
- Patients receiving prescription opioid therapy with risk factors for adverse effects
  - Coprescriptions of benzodiazepines or other sedatives
  - Ongoing alcohol use
  - High-dose prescription opioid therapy
- Persons living with or in frequent contact with those listed above

First Aid and Non–Healthcare Provider BLS Modification: Administration of Naloxone

Although naloxone has no clear role in the management of confirmed cardiac arrest, first aid and other non-healthcare providers are not instructed to attempt to determine whether an unresponsive person is pulseless. Empiric administration of IM or IN naloxone to all unresponsive opioid-associated life-threatening emergency patients may be reasonable as an adjunct to standard first aid and non–healthcare provider BLS protocols (Class IIb, LOE C-EO). Standard resuscitation, including activation of emergency medical services, should not be delayed for naloxone administration. However, family members and friends of those known to be addicted to opiates are likely to have naloxone available and ready to use if someone known or suspected to be addicted to opiates is found unresponsive and not breathing normally or only gasping (see sequence in Figure 2). Victims who respond to naloxone administration should access advanced healthcare services (Class I, LOE C-EO).

Healthcare Provider BLS Modification: Administration of Naloxone

Respiratory Arrest

For patients with known or suspected opioid overdose who have a definite pulse but no normal breathing or only gasping (ie, a respiratory arrest), in addition to providing standard BLS care, it is reasonable for appropriately trained BLS healthcare providers to administer IM or IN naloxone (Class IIa, LOE C-LD). For further information, see "Part 5: Adult Basic Life Support and Cardiopulmonary Resuscitation Quality."

Cardiac Arrest

Patients with no definite pulse may be in cardiac arrest or may have an undetected weak or slow pulse. These patients should be managed as cardiac arrest patients. Standard resuscitative measures should take priority over naloxone administration (Class I, LOE C-EO), with a focus on high-quality CPR (compressions plus ventilation). It may be reasonable to administer IM or IN naloxone based on the possibility that the patient is not in cardiac arrest (Class IIb, LOE C-EO). Responders should not delay access to more-advanced medical services while

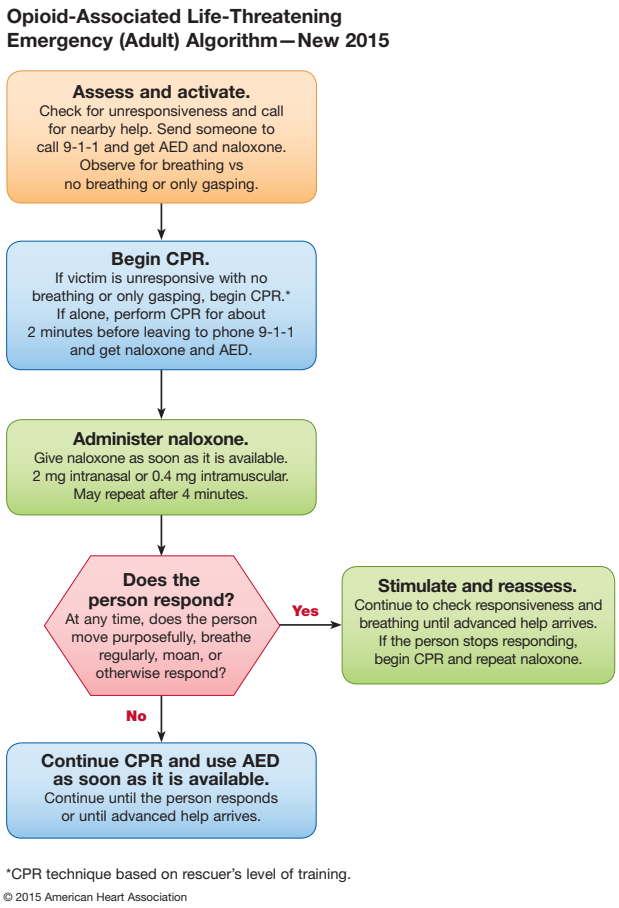

Figure 2. Opioid-Associated Life-Threatening Emergency (Adult) Algorithm.

awaiting the patient's response to naloxone or other interventions (Class I, LOE C-EO). Unless the patient refuses further care, victims who respond to naloxone administration should access advanced healthcare services (Class I, LOE C-EO).

ACLS Modification: Administration of Naloxone

Respiratory Arrest

ACLS providers should support ventilation and administer naloxone to patients with a perfusing cardiac rhythm and opioid-associated respiratory arrest or severe respiratory depression. Bag-mask ventilation should be maintained until spontaneous breathing returns, and standard ACLS measures should continue if return of spontaneous breathing does not occur (Class I, LOE C-LD).

Cardiac Arrest

We can make no recommendation regarding the administration of naloxone in confirmed opioid-associated cardiac arrest. Patients with opioid-associated cardiac arrest are managed in accordance with standard ACLS practices.

Observation and Post-Resuscitation Care

After ROSC or return of spontaneous breathing, patients should be observed in a healthcare setting until the risk of recurrent opioid toxicity is low and the patient's level of consciousness and vital signs have normalized (Class I, LOE C-LD). If recurrent opioid toxicity develops, repeated small doses or an infusion of naloxone can be beneficial in healthcare settings (Class IIa, LOE C-LD).

Patients who respond to naloxone administration may develop recurrent CNS and/or respiratory depression. Although abbreviated observation periods may be adequate for patients with fentanyl, morphine, or heroin overdose,[102,109,120–123] longer periods of observation may be required to safely discharge a patient with life-threatening overdose of a long-acting or sustained-release opioid.[93,124,125]

Naloxone administration in post–cardiac arrest care may be considered in order to achieve the specific therapeutic goals of reversing the effects of long-acting opioids (Class IIb, LOE C-EO).

Part 10.4: Role of Intravenous Lipid Emulsion Therapy in Management of Cardiac Arrest Due to Poisoning[ALS 834]

The use of ILE therapy was first developed as a treatment for cardiac arrest resulting from the local anesthetic bupivacaine.[126–128] Local anesthetics inhibit voltage at the cell membrane sodium channels, limiting action potential and the conduction of nerve signals. Local anesthetic systemic toxicity (LAST) can present with fulminant cardiovascular collapse that is refractory to standard resuscitative measures. A CNS toxicity phase (agitation evolving to frank seizures or CNS depression) may precede cardiovascular collapse. A recent review of peripheral nerve anesthetic blocks estimated the incidence of LAST equal to 0.87/1000 patients.[129] When a local anesthetic is administered, professional organizations recommend continuous neurologic and cardiovascular monitoring, dose fractionation, slow injection, concurrent use of an intravascular marker of systemic absorption (epinephrine 10 to 15 µg), and the use of ultrasound techniques.[130]

Administration of ILE creates a lipid compartment in the serum, reducing by sequestration the concentration of lipophilic medications in the tissues.[131] Administration of ILE also increases cardiac inotropy by other mechanisms.[132–134]

Over time, common use of this modality has been expanded to include poisoning by other local anesthetics and other medications.[135–138]

The 2015 ILCOR systematic review addressed the question of whether administration of lipid emulsion improves outcomes for patients who develop cardiac arrest due to drug toxicity, including that caused by local anesthetics and other drugs.

2015 Evidence Summary

To date, we identified no human studies that compared outcomes of patients in cardiac arrest treated with ILE plus supportive care versus supportive care alone. A small controlled trial of adults with poisoning from drugs other than local anesthetics showed a more rapid improvement in level of consciousness in the group that received ILE, but all patients survived in both groups.[139] Patients with glyphosate-surfactant herbicide ingestion treated with ILE had less hypotension and fewer arrhythmias than historic controls, but there was no difference in survival outcomes.[140] Registry studies of patients receiving ILE are difficult to interpret because of a lack of comparison groups.[141,142]

Animal studies in rats consistently show a benefit of ILE in LAST caused by bupivacaine.[137,143] Studies are less consistently positive in porcine models of LAST and from poisoning by drugs other than local anesthetics.[138] In a recent systematic review of human case reports, the majority (81/103) reported clinical improvement, such as ROSC, relief of hypotension, resolution of dysrhythmia, improved mental status, or termination of status epilepticus, after ILE administration.[138] In this review, all 21 published cases of the use of ILE to treat LAST from bupivacaine demonstrated clinical improvement after ILE administration.

Comparative dose studies are not available. The most commonly reported strategy is to use a 20% emulsion of long-chain triglycerides, giving an initial bolus of 1.5 mL/kg lean body mass over 1 minute followed by an infusion of 0.25 mL/kg per minute for 30 to 60 minutes. The bolus can be repeated once or twice as needed for persistent cardiovascular collapse; the suggested maximum total dose is 10 mL/kg over the first hour.[137,144–146] The safety of prolonged infusions (beyond 1 hour) has not been established.[147]

The most common adverse effect of ILE therapy is interference with diagnostic laboratory testing[148]; rare cases of pancreatitis[148] and pulmonary changes similar to those observed with acute respiratory distress syndrome[149] have also been reported. There appear to be complex pharmacodynamic interactions between ILE and epinephrine given during resuscitation, and in some situations, treatment with ILE alters the effectiveness of epinephrine and vasopressin in animal resuscitation studies.[150] Although some organizations recommend modification of the pharmacologic treatment of cardiac arrest after ILE administration,[151,152] there are no human data to support a modification in ACLS recommendations. More recently, concern has been raised that ILE administration may increase the absorption of lipophilic medications from the gastrointestinal tract[153] and interfere with the operation of venoarterial extracorporeal membrane oxygenation circuits.[154]

2015 Recommendations—New and Updated

ACLS Modifications

It may be reasonable to administer ILE, concomitant with standard resuscitative care, to patients with local anesthetic systemic toxicity and particularly to patients who have premonitory neurotoxicity or cardiac arrest due to bupivacaine toxicity (Class IIb, LOE C-EO). It may be reasonable to administer ILE to patients with other forms of drug toxicity who are failing standard resuscitative measures (Class IIb, LOE C-EO).

Part 10.5: Cardiac Arrest During Percutaneous Coronary Intervention[ALS 479]

Cardiac arrest during PCI is rare, occurring in approximately 1.3% of catheterization procedures.[155,156] Although the risk of cardiac arrest during PCI is present in both elective and emergency procedures, the incidence is higher in emergency cases.[157]

In general, patients who develop cardiac arrest during PCI have superior outcomes to patients in cardiac arrest that occurs in other settings, including in-hospital units.[158] Many patients will respond to standard ACLS resuscitation, including high-quality CPR and rapid defibrillation. Rapid defibrillation (within 1 minute) is associated with survival to hospital discharge rates as high as 100% in this population.[159]

A subset of patients who develop cardiac arrest during PCI will require prolonged resuscitation efforts. Providing effective prolonged resuscitation in the catheterization laboratory has unique challenges, and a number of interventions and adjuncts for management of cardiac arrest during PCI have been described. Inconsistent availability and lack of comparative studies limit recommendations of one approach over another.

The 2015 ILCOR systematic review addressed the question of whether any special interventions or changes in care, compared with standard ACLS resuscitation alone, can improve outcomes in patients who develop cardiac arrest during PCI.

There are a number of mechanical devices available to provide hemodynamic support during cardiac catheterization in high-risk patients presenting with cardiogenic shock. The use of these devices in cardiogenic shock was not reviewed by ILCOR in 2015. Therefore, the *2015 AHA Guidelines Update for CPR and ECC* does not make recommendations on the use of mechanical support devices in patients presenting in cardiogenic shock who undergo PCI. Recent recommendations for the use of mechanical support devices in these situations can be found in the *2013 American College of Cardiology Foundation (ACCF)/AHA Guideline for the Management of ST-Elevation Myocardial Infarction*.[160]

2015 Evidence Summary

The feasibility of using mechanical CPR devices during PCI has been demonstrated in both animal[161] and human[162–165] studies. No comparative studies have examined the use of mechanical CPR devices compared with manual chest compressions during PCI procedures. However, a number of case reports[161,162,166] and case series[164,165] have reported the use of mechanical CPR devices to facilitate prolonged resuscitation in patients who have a cardiac arrest during PCI. One study demonstrated that the use of a mechanical CPR device for cardiac arrest during PCI was feasible; however, no patients survived to hospital discharge.[164] Other studies have reported good patient outcomes, including ROSC, survival to discharge, and functional outcome at hospital discharge, after use of mechanical devices in resuscitation from cardiac arrest during PCI.[161,165] Mechanical CPR devices may also allow the use of fluoroscopy during chest compressions without direct irradiation of personnel.

Patients in cardiogenic shock or with other high-risk features (eg, multivessel coronary disease) may be at increased risk for adverse outcomes during or after PCI. Ventricular assist devices, intraaortic balloon pumps (IABP), and ECPR are all rescue treatment options available to support circulation and permit completion of the PCI. Not all interventions are available or can be rapidly deployed in all centers.

Rapid initiation of ECPR or cardiopulmonary bypass is associated with good patient outcomes in patients with hemodynamic collapse and cardiac arrest in the

catheterization lab.[167–173] The use of ECPR is also feasible and associated with good outcomes when used as a bridge to coronary artery bypass grafting.[167,173–175] The combination of ECPR and IABP has been associated with increased survival when compared with IABP alone for patients who present with cardiogenic shock, including those who have a cardiac arrest while undergoing PCI.[168,172,176] Available observational studies often implement ECPR 20 to 30 minutes after cardiac arrest.[168,170]

IABP counterpulsation increases coronary perfusion, decreases myocardial oxygen demand, and improves hemodynamics in cardiogenic shock states, but it is not associated with improved patient survival in cardiogenic shock.[177–185] The role of IABP in patients who have a cardiac arrest in the catheterization laboratory is not known.

Several case series have reported on the use of emergency coronary artery bypass graft surgery after failed PCI.[186,187] In patients with cardiogenic shock or cardiac arrest and failed PCI, mechanical CPR devices and/or ECPR have been used as rescue bridges to coronary artery bypass graft. Although no comparison studies have examined the use of this therapy as an adjunct to PCI, survival to hospital discharge rates as high as 64% have been reported.[167,168,173,175]

2015 Recommendations—New and Updated

ACLS Modifications

It may be reasonable to use mechanical CPR devices to provide chest compressions to patients in cardiac arrest during PCI (Class IIb, LOE C-EO).

It may be reasonable to use ECPR as a rescue treatment when initial therapy is failing for cardiac arrest that occurs during PCI (Class IIb, LOE C-LD). Because patients can remain on ECPR support for extended periods of time without possibility of recovery, practical and ethical considerations must be taken into account in determining which victims of cardiac arrest should receive ECPR support. Institutional guidelines should include the selection of appropriate candidates for use of mechanical support devices to ensure that these devices are used as a bridge to recovery, surgery or transplant, or other device (Class I, LOE C-EO).

Due to a lack of comparative studies, it is not possible to recommend one approach (manual CPR, mechanical CPR, or ECPR) over another when options exist.

Disclosures

Part 10: Special Circumstances of Resuscitation: 2015 Guidelines Update Writing Group Disclosures

Writing Group Member	Employment	Research Grant	Other Research Support	Speakers' Bureau/ Honoraria	Expert Witness	Ownership Interest	Consultant/ Advisory Board	Other
Eric J. Lavonas	Rocky Mountain Poison & Drug Center; Denver Health and Hospital Authority	None	None	None	None	None	None	BTG International, Inc. – relationship between Employer and BTG†
Ian R. Drennan	St. Michael's Hospital Rescu	None	None	None	None	None	None	None
Andrea Gabrielli	University of Florida College of Medicine	None	None	None	For intraoperative cardiac ischemia*	None	None	None
Alan C. Heffner	UNC School of Medicine	None	None	Edwards Lifesciences*	Defense and plaintiff consultant and causation expert in cases focused on airway management and CPR*	None	None	None
Christopher O. Hoyte	University of Colorado School of Medicine	None	None	None	None	None	None	None
Aaron M. Orkin	University of Toronto	Canadian Institutes of Health Research*	None	None	None	None	None	Remote Health Initiative*
Kelly N. Sawyer	William Beaumont Hospital	None	None	None	None	None	None	None
Consultant								
Michael W. Donnino	Beth Israel Deaconess Med Center	None	None	None	None	None	American Heart Association†	None

This table represents the relationships of writing group members that may be perceived as actual or reasonably perceived conflicts of interest as reported on the Disclosure Questionnaire, which all members of the writing group are required to complete and submit. A relationship is considered to be "significant" if (a) the person receives $10 000 or more during any 12-month period, or 5% or more of the person's gross income; or (b) the person owns 5% or more of the voting stock or share of the entity, or owns $10 000 or more of the fair market value of the entity. A relationship is considered to be "modest" if it is less than "significant" under the preceding definition.

*Modest.

†Significant.

Appendix

2015 Guidelines Update: Part 10 Recommendations

Year Last Reviewed	Topic	Recommendation	Comments
2015	Cardiac Arrest Associated With Pregnancy	Priorities for the pregnant woman in cardiac arrest are provision of high-quality CPR and relief of aortocaval compression (Class I, LOE C-LD).	new for 2015
2015	Cardiac Arrest Associated With Pregnancy	If the fundus height is at or above the level of the umbilicus, manual LUD can be beneficial in relieving aortocaval compression during chest compressions (Class IIa, LOE C-LD).	new for 2015
2015	Cardiac Arrest Associated With Pregnancy	Because immediate ROSC cannot always be achieved, local resources for a PMCD should be summoned as soon as cardiac arrest is recognized in a woman in the second half of pregnancy (Class I, LOE C-LD).	new for 2015
2015	Cardiac Arrest Associated With Pregnancy	Systematic preparation and training are the keys to a successful response to such rare and complex events. Care teams that may be called upon to manage these situations should develop and practice standard institutional responses to allow for smooth delivery of resuscitative care (Class I, LOE C-EO).	new for 2015

(*Continued*)

2015 Guidelines Update: Part 10 Recommendations, *Continued*

Year Last Reviewed	Topic	Recommendation	Comments
2015	Cardiac Arrest Associated With Pregnancy	During cardiac arrest, if the pregnant woman with a fundus height at or above the umbilicus has not achieved ROSC with usual resuscitation measures plus manual LUD, it is advisable to prepare to evacuate the uterus while resuscitation continues (Class I, LOE C-LD).	new for 2015
2015	Cardiac Arrest Associated With Pregnancy	In situations such as nonsurvivable maternal trauma or prolonged pulselessness, in which maternal resuscitative efforts are obviously futile, there is no reason to delay performing PMCD (Class I, LOE C-LD).	new for 2015
2015	Cardiac Arrest Associated With Pregnancy	PMCD should be considered at 4 minutes after onset of maternal cardiac arrest or resuscitative efforts (for the unwitnessed arrest) if there is no ROSC (Class IIa, LOE C-EO).	updated for 2015
2015	Cardiac Arrest Associated With Pulmonary Embolism	In patients with confirmed PE as the precipitant of cardiac arrest, thrombolysis, surgical embolectomy, and mechanical embolectomy are reasonable emergency treatment options (Class IIa, LOE C-LD).	new for 2015
2015	Cardiac Arrest Associated With Pulmonary Embolism	Thrombolysis can be beneficial even when chest compressions have been provided (Class IIa, LOE C-LD).	new for 2015
2015	Cardiac Arrest Associated With Pulmonary Embolism	Thrombolysis may be considered when cardiac arrest is suspected to be caused by PE (Class IIb, LOE C-LD).	updated for 2015
2015	Cardiac or Respiratory Arrest Associated With Opioid Overdose	It is reasonable to provide opioid overdose response education, either alone or coupled with naloxone distribution and training, to persons at risk for opioid overdose (Class IIa, LOE C-LD).	new for 2015
2015	Cardiac or Respiratory Arrest Associated With Opioid Overdose	It is reasonable to base this training on first aid and non–healthcare provider BLS recommendations rather than on more advanced practices intended for healthcare providers (Class IIa, LOE C-EO).	new for 2015
2015	Cardiac or Respiratory Arrest Associated With Opioid Overdose	Empiric administration of IM or IN naloxone to all unresponsive opioid-associated life-threatening emergency patients may be reasonable as an adjunct to standard first aid and non–healthcare provider BLS protocols (Class IIb, LOE C-EO).	new for 2015
2015	Cardiac or Respiratory Arrest Associated With Opioid Overdose	Victims who respond to naloxone administration should access advanced healthcare services (Class I, LOE C-EO).	new for 2015
2015	Cardiac or Respiratory Arrest Associated With Opioid Overdose	For patients with known or suspected opioid overdose who have a definite pulse but no normal breathing or only gasping (ie, a respiratory arrest), in addition to providing standard BLS care, it is reasonable for appropriately trained BLS healthcare providers to administer IM or IN naloxone (Class IIa, LOE C-LD).	new for 2015
2015	Cardiac or Respiratory Arrest Associated With Opioid Overdose	Standard resuscitative measures should take priority over naloxone administration (Class I, LOE C-EO), with a focus on high-quality CPR (compressions plus ventilation).	new for 2015
2015	Cardiac or Respiratory Arrest Associated With Opioid Overdose	It may be reasonable to administer IM or IN naloxone based on the possibility that the patient is not in cardiac arrest (Class IIb, LOE C-EO).	new for 2015
2015	Cardiac or Respiratory Arrest Associated With Opioid Overdose	Responders should not delay access to more-advanced medical services while awaiting the patient's response to naloxone or other interventions (Class I, LOE C-EO).	new for 2015
2015	Cardiac or Respiratory Arrest Associated With Opioid Overdose	Unless the patient refuses further care, victims who respond to naloxone administration should access advanced healthcare services (Class I, LOE C-EO).	new for 2015
2015	Cardiac or Respiratory Arrest Associated With Opioid Overdose	Bag-mask ventilation should be maintained until spontaneous breathing returns, and standard ACLS measures should continue if return of spontaneous breathing does not occur (Class I, LOE C-LD).	new for 2015
2015	Cardiac or Respiratory Arrest Associated With Opioid Overdose	After ROSC or return of spontaneous breathing, patients should be observed in a healthcare setting until the risk of recurrent opioid toxicity is low and the patient's level of consciousness and vital signs have normalized (Class I, LOE C-LD).	new for 2015
2015	Cardiac or Respiratory Arrest Associated With Opioid Overdose	If recurrent opioid toxicity develops, repeated small doses or an infusion of naloxone can be beneficial in healthcare settings (Class IIa, LOE C-LD).	new for 2015
2015	Cardiac or Respiratory Arrest Associated With Opioid Overdose	Naloxone administration in post–cardiac arrest care may be considered in order to achieve the specific therapeutic goals of reversing the effects of long-acting opioids (Class IIb, LOE C-EO).	new for 2015

(*Continued*)

2015 Guidelines Update: Part 10 Recommendations, *Continued*

Year Last Reviewed	Topic	Recommendation	Comments
2015	Role of Intravenous Lipid Emulsion Therapy in Management of Cardiac Arrest Due to Poisoning	It may be reasonable to administer ILE, concomitant with standard resuscitative care, to patients with local anesthetic systemic toxicity and particularly to patients who have premonitory neurotoxicity or cardiac arrest due to bupivacaine toxicity (Class IIb, LOE C-EO).	updated for 2015
2015	Role of Intravenous Lipid Emulsion Therapy in Management of Cardiac Arrest Due to Poisoning	It may be reasonable to administer ILE to patients with other forms of drug toxicity who are failing standard resuscitative measures (Class IIb, LOE C-EO).	new for 2015
2015	Cardiac Arrest During Percutaneous Coronary Intervention	It may be reasonable to use mechanical CPR devices to provide chest compressions to patients in cardiac arrest during PCI (Class IIb, LOE C-EO).	updated for 2015
2015	Cardiac Arrest During Percutaneous Coronary Intervention	It may be reasonable to use ECPR as a rescue treatment when initial therapy is failing for cardiac arrest that occurs during PCI (Class IIb, LOE C-LD).	new for 2015
2015	Cardiac Arrest During Percutaneous Coronary Intervention	Institutional guidelines should include the selection of appropriate candidates for use of mechanical support devices to ensure that these devices are used as a bridge to recovery, surgery or transplant, or other device (Class I, LOE C-EO).	new for 2015
The following recommendations were not reviewed in 2015. For more information, see the *2010 AHA Guidelines for CPR and ECC*, "Part 12: Cardiac Arrest in Special Situations."			
2010	Cardiac Arrest Associated With Asthma	Therefore, since the effects of auto-PEEP in an asthmatic patient with cardiac arrest are likely quite severe, a ventilation strategy of low respiratory rate and tidal volume is reasonable (Class IIa, LOE C).	not reviewed in 2015
2010	Cardiac Arrest Associated With Asthma	During arrest a brief disconnection from the bag mask or ventilator may be considered, and compression of the chest wall to relieve air-trapping can be effective (Class IIa, LOE C).	not reviewed in 2015
2010	Cardiac Arrest Associated With Asthma	For all asthmatic patients with cardiac arrest, and especially for patients in whom ventilation is difficult, the possible diagnosis of a tension pneumothorax should be considered and treated (Class I, LOE C).	not reviewed in 2015
2010	Cardiac Arrest Associated With Anaphylaxis	Given the potential for the rapid development of oropharyngeal or laryngeal edema, immediate referral to a health professional with expertise in advanced airway placement is recommended (Class I, LOE C).	not reviewed in 2015
2010	Cardiac Arrest Associated With Anaphylaxis	Epinephrine should be administered early by IM injection to all patients with signs of a systemic allergic reaction, especially hypotension, airway swelling, or difficulty breathing (Class I, LOE C).	not reviewed in 2015
2010	Cardiac Arrest Associated With Anaphylaxis	The recommended dose is 0.2 to 0.5 mg (1:1000) IM to be repeated every 5 to 15 minutes in the absence of clinical improvement (Class I, LOE C).	not reviewed in 2015
2010	Cardiac Arrest Associated With Anaphylaxis	In both anaphylaxis and cardiac arrest the immediate use of an epinephrine autoinjector is recommended if available (Class I, LOE C).	not reviewed in 2015
2010	Cardiac Arrest Associated With Anaphylaxis	Planning for advanced airway management, including a surgical airway, is recommended (Class I, LOE C).	not reviewed in 2015
2010	Cardiac Arrest Associated With Anaphylaxis	Vasogenic shock from anaphylaxis may require aggressive fluid resuscitation (Class IIa, LOE C).	not reviewed in 2015
2010	Cardiac Arrest Associated With Anaphylaxis	When an IV line is in place, it is reasonable to consider the IV route as an alternative to IM administration of epinephrine in anaphylactic shock (Class IIa, LOE C).	not reviewed in 2015
2010	Cardiac Arrest Associated With Anaphylaxis	Because fatal overdose of epinephrine has been reported, close hemodynamic monitoring is recommended (Class I, LOE B).	not reviewed in 2015
2010	Cardiac Arrest Associated With Anaphylaxis	IV infusion of epinephrine is a reasonable alternative to IV boluses for treatment of anaphylaxis in patients not in cardiac arrest (Class IIa, LOE C)	not reviewed in 2015
2010	Cardiac Arrest Associated With Anaphylaxis	Alternative vasoactive drugs (vasopressin, norepinephrine, methoxamine, and metaraminol) may be considered in cardiac arrest secondary to anaphylaxis that does not respond to epinephrine (Class IIb, LOE C).	not reviewed in 2015
2010	Cardiac Arrest Associated With Anaphylaxis	Adjuvant use of antihistamines (H1 and H2 antagonist), inhaled β-adrenergic agents, and IV corticosteroids has been successful in management of the patient with anaphylaxis and may be considered in cardiac arrest due to anaphylaxis (Class IIb, LOE C).	not reviewed in 2015
2010	Cardiac Arrest Associated With Anaphylaxis	Cardiopulmonary bypass has been successful in isolated case reports of anaphylaxis followed by cardiac arrest. Use of these advanced techniques may be considered in clinical situations where the required professional skills and equipment are immediately available (Class IIb, LOE C).	not reviewed in 2015

(*Continued*)

2015 Guidelines Update: Part 10 Recommendations, *Continued*

Year Last Reviewed	Topic	Recommendation	Comments
2010	Cardiac Arrest Associated With Pregnancy	Bag-mask ventilation with 100% oxygen before intubation is especially important in pregnancy (Class IIa, LOE B).	not reviewed in 2015
2010	Cardiac Arrest Associated With Pregnancy	If internal or external fetal monitors are attached during cardiac arrest in a pregnant woman, it is reasonable to remove them (Class IIb, LOE C).	not reviewed in 2015
2010	Cardiac Arrest Associated With Pregnancy	Team planning should be done in collaboration with the obstetric, neonatal, emergency, anesthesiology, intensive care, and cardiac arrest services (Class I, LOE C).	not reviewed in 2015
2010	Cardiac Arrest Associated With Pregnancy	During therapeutic hypothermia of the pregnant patient, it is recommended that the fetus be continuously monitored for bradycardia as a potential complication, and obstetric and neonatal consultation should be sought (Class I, LOE C).	not reviewed in 2015
2010	Cardiac Arrest Associated With Pulmonary Embolism	In patients with cardiac arrest and without known PE, routine fibrinolytic treatment given during CPR shows no benefit and is not recommended (Class III, LOE A).	not reviewed in 2015
2010	Cardiac Arrest Associated With Life-Threatening Electrolyte Disturbances	When cardiac arrest occurs secondary to hyperkalemia, it may be reasonable to administer adjuvant IV therapy as outlined above for cardiotoxicity in addition to standard ACLS (Class IIb, LOE C).	not reviewed in 2015
2010	Cardiac Arrest Associated With Life-Threatening Electrolyte Disturbances	The effect of bolus administration of potassium for cardiac arrest suspected to be secondary to hypokalemia is unknown and ill advised (Class III, LOE C).	not reviewed in 2015
2010	Cardiac Arrest Associated With Life-Threatening Electrolyte Disturbances	Administration of calcium (calcium chloride [10%] 5 to 10 mL or calcium gluconate [10%] 15 to 30 mL IV over 2 to 5 minutes) may be considered during cardiac arrest associated with hypermagnesemia (Class IIb, LOE C).	not reviewed in 2015
2010	Cardiac Arrest Associated With Life-Threatening Electrolyte Disturbances	For cardiotoxicity and cardiac arrest, IV magnesium 1 to 2 g of $MgSO_4$ bolus IV push is recommended (Class I, LOE C).	not reviewed in 2015
2010	Cardiac Arrest Associated With Life-Threatening Electrolyte Disturbances	Empirical use of calcium (calcium chloride [10%] 5 to 10 mL OR calcium gluconate [10%] 15 to 30 mL IV over 2 to 5 minutes) may be considered when hyperkalemia or hypermagnesemia is suspected as the cause of cardiac arrest (Class IIb, LOE C).	not reviewed in 2015
2010	Cardiac Arrest Associated With Toxic Ingestions	The administration of flumazenil to patients with undifferentiated coma confers risk and is not recommended (Class III, LOE B).	not reviewed in 2015
2010	Cardiac Arrest Associated With Toxic Ingestions	The recommended dose of glucagon is a bolus of 3 to 10 mg, administered slowly over 3 to 5 minutes, followed by an infusion of 3 to 5 mg/h (0.05 to 0.15 mg/kg followed by an infusion of 0.05 to 0.10 mg/kg per hour) (Class IIb, LOE C).	not reviewed in 2015
2010	Cardiac Arrest Associated With Toxic Ingestions	Administration of high-dose insulin in patients with shock refractory to other measures may be considered (Class IIb, LOE C).	not reviewed in 2015
2010	Cardiac Arrest Associated With Toxic Ingestions	Administration of calcium in patients with shock refractory to other measures may be considered (Class IIb, LOE C).	not reviewed in 2015
2010	Cardiac Arrest Associated With Toxic Ingestions	High-dose insulin, in the doses listed in the β-blocker section above, may be effective for restoring hemodynamic stability and improving survival in the setting of severe cardiovascular toxicity associated with toxicity from a calcium channel blocker overdose (Class IIb, LOE B).	not reviewed in 2015
2010	Cardiac Arrest Associated With Toxic Ingestions	Administration of calcium in patients with shock refractory to other measures may be considered (Class IIb, LOE C).	not reviewed in 2015
2010	Cardiac Arrest Associated With Toxic Ingestions	Antidigoxin Fab antibodies should be administered to patients with severe life-threatening cardiac glycoside toxicity (Class I, LOE B).	not reviewed in 2015
2010	Cardiac Arrest Associated With Toxic Ingestions	It may be reasonable to try agents that have shown efficacy in the management of acute coronary syndrome in patients with severe cardiovascular toxicity. β-Blockers (phentolamine), benzodiazepines (lorazepam, diazepam), calcium channel blockers (verapamil), morphine, and sublingual nitroglycerin may be used as needed to control hypertension, tachycardia, and agitation (Class IIb, LOE B).	not reviewed in 2015
2010	Cardiac Arrest Associated With Toxic Ingestions	The available data do not support the use of 1 agent over another in the treatment of cardiovascular toxicity due to cocaine (Class IIb, LOE B).	not reviewed in 2015
2010	Cardiac Arrest Associated With Toxic Ingestions	For cocaine-induced hypertension or chest discomfort, benzodiazepines, nitroglycerin, and/or morphine can be beneficial (Class IIa, LOE B).	not reviewed in 2015

(*Continued*)

2015 Guidelines Update: Part 10 Recommendations, *Continued*

Year Last Reviewed	Topic	Recommendation	Comments
2010	Cardiac Arrest Associated With Toxic Ingestions	Although contradictory evidence exists, current recommendations are that pure β-blocker medications in the setting of cocaine are not indicated (Class IIb, LOE C).	not reviewed in 2015
2010	Cardiac Arrest Associated With Toxic Ingestions	Administration of sodium bicarbonate for cardiac arrest due to cyclic antidepressant overdose may be considered (Class IIb, LOE C).	not reviewed in 2015
2010	Cardiac Arrest Associated With Toxic Ingestions	Sodium bicarbonate boluses of 1 mL/kg may be administered as needed to achieve hemodynamic stability (adequate mean arterial blood pressure and perfusion) and QRS narrowing (Class IIb, LOE C).	not reviewed in 2015
2010	Cardiac Arrest Associated With Toxic Ingestions	Because hyperbaric oxygen therapy appears to confer little risk, the available data suggest that hyperbaric oxygen therapy may be helpful in treatment of acute carbon monoxide poisoning in patients with severe toxicity (Class IIb, LOE C).	not reviewed in 2015
2010	Cardiac Arrest Associated With Toxic Ingestions	Based on the best evidence available, a treatment regimen of 100% oxygen and hydroxocobalamin, with or without sodium thiosulfate, is recommended (Class I, LOE B).	not reviewed in 2015
2010	Cardiac Arrest in Accidental Hypothermia	It may be reasonable to perform further defibrillation attempts according to the standard BLS algorithm concurrent with rewarming strategies (Class IIb, LOE C).	not reviewed in 2015
2010	Cardiac Arrest in Accidental Hypothermia	It may be reasonable to consider administration of a vasopressor during cardiac arrest according to the standard ACLS algorithm concurrent with rewarming strategies (Class IIb, LOE C).	not reviewed in 2015
2010	Cardiac Arrest in Avalanche Victims	Full resuscitative measures, including extracorporeal rewarming when available, are recommended for all avalanche victims without the characteristics outlined above that deem them unlikely to survive or with any obvious lethal traumatic injury (Class I, LOE C).	not reviewed in 2015
2010	Drowning	All victims of drowning who require any form of resuscitation (including rescue breathing alone) should be transported to the hospital for evaluation and monitoring, even if they appear to be alert and demonstrate effective cardiorespiratory function at the scene (Class I, LOE C).	not reviewed in 2015
2010	Drowning	Routine stabilization of the cervical spine in the absence of circumstances that suggest a spinal injury is not recommended (Class III, LOE B).	not reviewed in 2015
2010	Drowning	The routine use of abdominal thrusts or the Heimlich maneuver for drowning victims is not recommended (Class III, LOE C).	not reviewed in 2015
2010	Cardiac Arrest During Percutaneous Coronary Intervention	It is reasonable to use cough CPR during PCI (Class IIa, LOE C).	not reviewed in 2015
2010	Cardiac Arrest Caused by Cardiac Tamponade	In the arrest setting, in the absence of echocardiography, emergency pericardiocentesis without imaging guidance can be beneficial (Class IIa, LOE C).	not reviewed in 2015
2010	Cardiac Arrest Caused by Cardiac Tamponade	Emergency department thoracotomy may improve survival compared with pericardiocentesis in patients with pericardial tamponade secondary to trauma who are in cardiac arrest or who are prearrest, especially if gross blood causes clotting that blocks a pericardiocentesis needle (Class IIb, LOE C).	not reviewed in 2015
2010	Cardiac Arrest Following Cardiac Surgery	For patients with cardiac arrest following cardiac surgery, it is reasonable to perform resternotomy in an appropriately staffed and equipped intensive care unit (Class IIa, LOE B).	not reviewed in 2015
2010	Cardiac Arrest Following Cardiac Surgery	Despite rare case reports describing damage to the heart possibly due to external chest compressions, chest compressions should not be withheld if emergency resternotomy is not immediately available (Class IIa, LOE C).	not reviewed in 2015

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KEY WORDS: cardiac arrest ■ defibrillation ■ emergency

Part 11: Pediatric Basic Life Support and Cardiopulmonary Resuscitation Quality

2015 American Heart Association Guidelines Update for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care

Dianne L. Atkins, Chair; Stuart Berger; Jonathan P. Duff; John C. Gonzales; Elizabeth A. Hunt; Benny L. Joyner; Peter A. Meaney; Dana E. Niles; Ricardo A. Samson; Stephen M. Schexnayder

Introduction

This *2015 American Heart Association* (AHA) *Guidelines Update for Cardiopulmonary Resuscitation* (CPR) *and Emergency Cardiovascular Care* (ECC) section on pediatric basic life support (BLS) differs substantially from previous versions of the AHA Guidelines.[1] This publication updates the 2010 AHA Guidelines on pediatric BLS for several key questions related to pediatric CPR. The Pediatric ILCOR Task Force reviewed the topics covered in the *2010 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science With Treatment Recommendations* and the 2010 council-specific guidelines for CPR and ECC (including those published by the AHA) and formulated 3 priority questions to address for the 2015 systematic reviews. In the online version of this document, live links are provided so the reader can connect directly to those systematic reviews on the International Liaison Committee on Resuscitation (ILCOR) Scientific Evidence Evaluation and Review System (SEERS) website. These links are indicated by a superscript combination of letters and numbers (eg, Peds 709). We encourage readers to use the links and review the evidence and appendices.

A rigorous systematic review process was undertaken to review the relevant literature to answer those questions, resulting in the *2015 International Consensus on CPR and ECC Science With Treatment Recommendations,* "Part 6: Pediatric Basic Life Support and Pediatric Advanced Life Support."[2,3] This 2015 Guidelines Update covers only those topics reviewed as part of the 2015 systematic review process. Other recommendations published in the 2010 AHA Guidelines remain the official recommendations of the AHA ECC scientists (see Appendix). When making AHA treatment recommendations, we used the AHA Class of Recommendation and Level of Evidence (LOE) systems. This update uses the newest AHA Class of Recommendation and LOE classification system, which contains modifications of the Class III recommendation and introduces LOE B-R (randomized studies) and B-NR (nonrandomized studies) as well as LOE C-LD (limited data) and LOE C-EO (consensus of expert opinion).

Outcomes from pediatric in-hospital cardiac arrest (IHCA) have markedly improved over the past decade. From 2001 to 2009, rates of pediatric IHCA survival to hospital discharge improved from 24% to 39%.[4] Recent unpublished 2013 data from the AHA's Get With The Guidelines®-Resuscitation program observed 36% survival to hospital discharge for pediatric IHCA (Paul S. Chan, MD, personal communication, April 10, 2015). Prolonged CPR is not always futile, with 12% of patients who receive CPR for more than 35 minutes surviving to discharge and 60% of those survivors having a favorable neurologic outcome.[5]

Unlike IHCA, survival from out-of-hospital cardiac arrest (OHCA) remains poor. Data from 2005 to 2007 from the Resuscitation Outcomes Consortium, a registry of 11 US and Canadian emergency medical systems, showed age-dependent discharge survival rates of 3.3% for infants (younger than 1 year), 9.1% for children (1 to 11 years), and 8.9% for adolescents (12 to 19 years).[6] More recently published data from this network demonstrate 8.3% survival to hospital discharge across all age groups.[7]

For the purposes of these guidelines:

- Infant BLS guidelines apply to infants younger than approximately 1 year of age.
- Child BLS guidelines apply to children approximately 1 year of age until puberty. For teaching purposes, puberty is defined as breast development in females and the presence of axillary hair in males.
- Adult BLS guidelines apply at and beyond puberty (see "Part 5: Adult Basic Life Support and Cardiopulmonary Resuscitation Quality" in this supplement regarding the use of the automated external defibrillator (AED) and methods to achieve high-quality CPR).

The following subjects are addressed in this 2015 pediatric BLS guidelines update:

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- Pediatric BLS Healthcare Provider Pediatric Cardiac Arrest Algorithms for a single rescuer and for 2 or more rescuers
- The sequence of compressions, airway, breathing (C-A-B) versus airway, breathing, compressions (A-B-C)
- Chest compression rate and depth
- Compression-only (Hands-Only) CPR

Pediatric Advanced Life Support topics reviewed by the ILCOR Pediatric Task Force are covered in "Part 12: Pediatric Advanced Life Support."

Algorithms

Algorithms for 1- and 2-person healthcare provider CPR have been separated to better guide rescuers through the initial stages of resuscitation (Figures 1 and 2). In an era where cellular telephones with speakers are common, this technology can allow a single rescuer to activate the emergency response system while beginning CPR. These algorithms continue to emphasize the high priority for obtaining an AED quickly in a sudden, witnessed collapse, because such an event is likely to have a cardiac etiology.

Sequence of CPR

C-A-B Versus A-B-C[Peds 709]

Historically, the preferred sequence of CPR was A-B-C (Airway-Breathing-Compressions). The 2010 AHA Guidelines recommended a change to the C-A-B sequence (Compressions-Airway-Breathing) to decrease the time to initiation of chest compressions and reduce "no blood flow" time. The 2015 ILCOR systematic review addressed evidence to support this change.[2,3]

Pediatric cardiac arrest has inherent differences when compared with adult cardiac arrest. In infants and children, asphyxial cardiac arrest is more common than cardiac arrest from a primary cardiac event; therefore, ventilation may have greater importance during resuscitation of children. Data from animal studies[8,9] and 2 pediatric studies[10,11] suggest that resuscitation outcomes for asphyxial arrest are better with a combination of ventilation and chest compressions.

Manikin studies demonstrated that starting CPR with 30 chest compressions followed by 2 breaths delays the first ventilation by 18 seconds for a single rescuer and less (by about 9 seconds or less) for 2 rescuers. A universal CPR algorithm for victims of all ages minimizes the complexity of CPR and offers consistency in teaching CPR to rescuers who treat infants, children, or adults. Whether resuscitation beginning with ventilations (A-B-C) or with chest compressions (C-A-B) impacts survival is unknown. To increase bystander CPR rates as well as knowledge and skill retention, the use of the same sequence for infants and children as for adults has potential benefit.

2015 Evidence Summary

No human studies with clinical outcomes were identified that compared C-A-B and A-B-C approaches for initial management of cardiac arrest. The impact of time to first chest compression for C-A-B versus A-B-C sequence has been evaluated. Adult[12,13] and pediatric[14] manikin studies showed a significantly reduced time to first chest compression with the use of a C-A-B approach compared with an A-B-C approach. Data from 2 of these 3 studies demonstrated that time to first ventilation is delayed by only approximately 6 seconds when using a C-A-B sequence compared with an A-B-C sequence.[12,14]

2015 Recommendation—New

Because of the limited amount and quality of the data, it may be reasonable to maintain the sequence from the 2010 Guidelines by initiating CPR with C-A-B over A-B-C sequence (Class IIb, LOE C-EO). Knowledge gaps exist, and specific research is required to examine the best approach to initiating CPR in children.

Components of High-Quality CPR

The 5 components of high-quality CPR are

- Ensuring chest compressions of adequate rate
- Ensuring chest compressions of adequate depth
- Allowing full chest recoil between compressions
- Minimizing interruptions in chest compressions
- Avoiding excessive ventilation

The ILCOR Pediatric Task Force systematic review addressed the optimal depth of chest compressions in infants and children. Because there was insufficient evidence for a systemic review of chest compression rate in children, the ILCOR Pediatric Task Force and this writing group reviewed and accepted the recommendations of the ILCOR BLS Task Force regarding chest compression rate so that the recommended compression rate would be consistent for victims of all age groups.

Chest Compression Rate[BLS 343] and Depth[Peds 394]

2015 Evidence Summary

Insufficient data were available for a systematic review of chest compression rate in children. As noted above, the writing group reviewed the evidence and recommendations made for adult BLS and agreed to recommend the same compression rate during resuscitation of children. For the review of chest compression rate in adults, see "Part 5: Adult Basic Life Support and Cardiopulmonary Resuscitation Quality."

Limited pediatric evidence suggests that chest compression depth is a target for improving resuscitation. One observational study demonstrated that chest compression depth is often inadequate during pediatric cardiac arrest.[15] Adult data have demonstrated the importance of adequate chest compression depth to the outcome of resuscitation,[16] but such data in children are very limited. A case series of 6 infants with heart disease examined blood pressure during CPR in relation to chest compression depth and observed a higher systolic blood pressure during CPR in association with efforts to increase chest compression depth.[17] Another report of 87 pediatric resuscitation events, most involving children older than 8 years, found that compression depth greater than 51 mm for more than 60% of the compressions during 30-second epochs

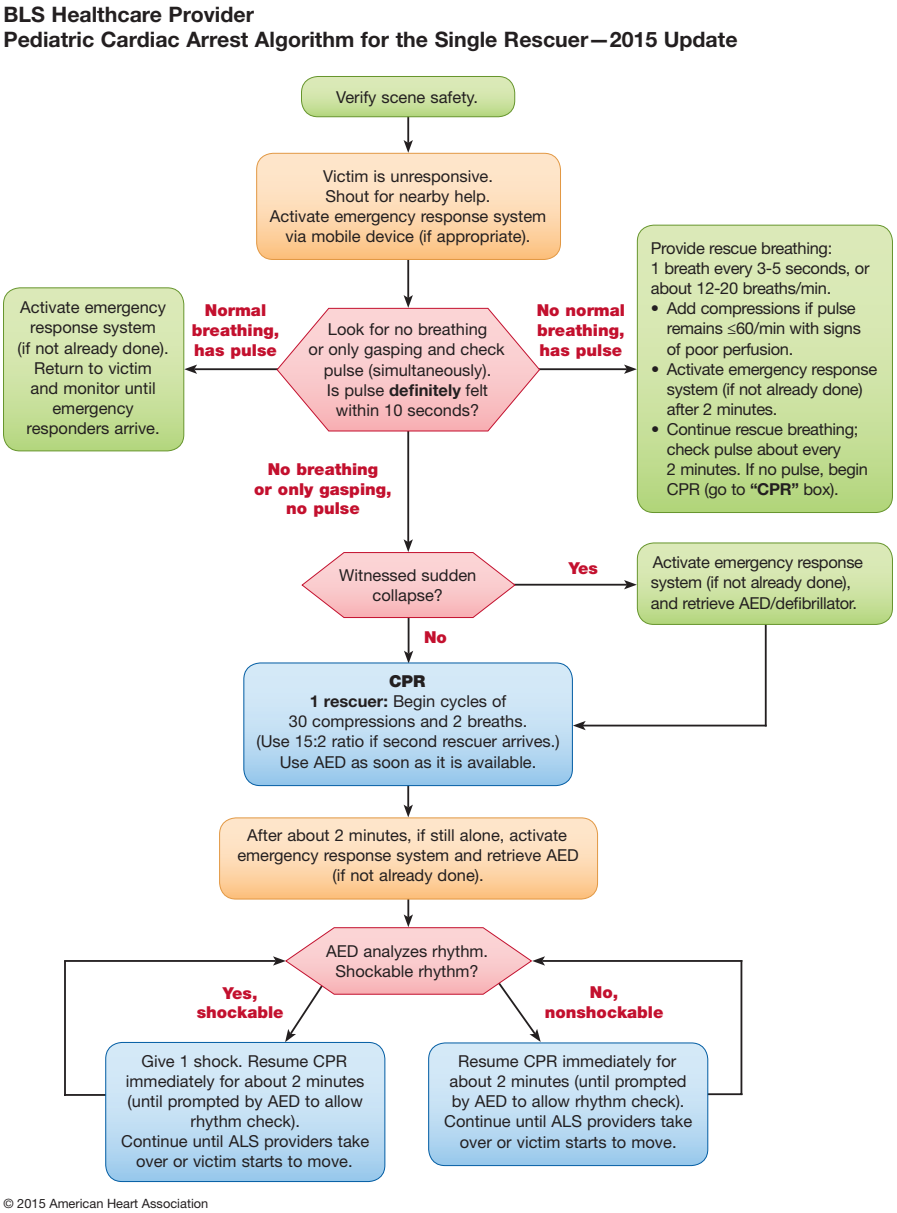

Figure 1. BLS Healthcare Provider Pediatric Cardiac Arrest Algorithm for the Single Rescuer—2015 Update.

within the first 5 minutes was associated with improved 24-hour survival.[18]

2015 Recommendations—New

For simplicity in CPR training, in the absence of sufficient pediatric evidence, it is reasonable to use the adult BLS-recommended chest compression rate of 100/min to 120/min for infants and children (Class IIa, LOE C-EO). Although the effectiveness of CPR feedback devices was not reviewed by this writing group, the consensus of the group is that the use of feedback devices likely helps the rescuer optimize adequate chest compression rate and depth, and we suggest their use when available (Class IIb, LOE C-EO; see also "Part 14: Education").

It is reasonable that for pediatric patients (birth to the onset of puberty) rescuers provide chest compressions that depress the chest at least one third the anterior-posterior diameter of the chest. This equates to approximately 1.5 inches (4 cm) in infants to 2 inches (5 cm) in children (Class IIa, LOE C-LD). Once children have reached puberty, the recommended adult compression depth of at least 5 cm, but no more than 6 cm, is used for the adolescent of average adult size (Class I, LOE C-LD).[16]

Compression-Only CPR[Peds 414]

The 2015 ILCOR pediatric systematic review addressed the use of compression-only CPR for cardiac arrest in infants and children. Compression-only CPR is an alternative for lay rescuer CPR in adults.

2015 Evidence Summary

In a large observational study examining data from a Japanese national registry of pediatric OHCA, the use of compression-only CPR, when compared with conventional CPR, was

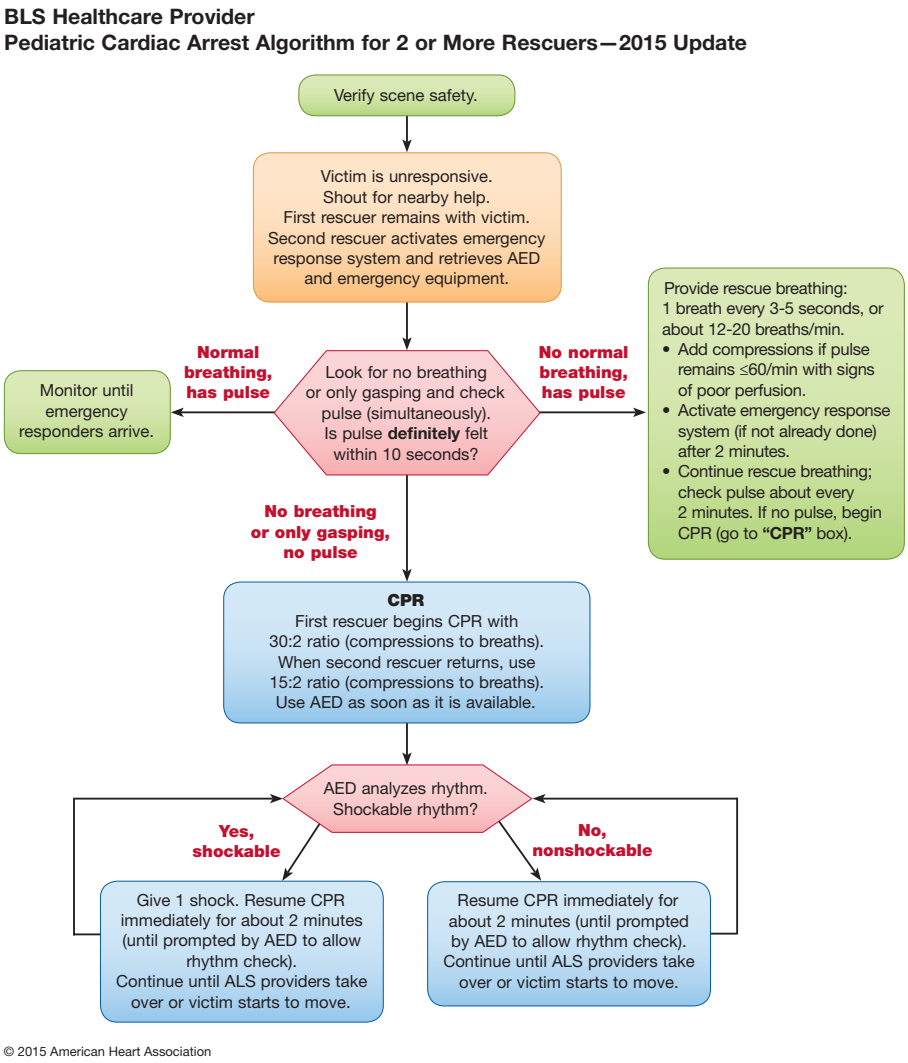

Figure 2. BLS Healthcare Provider Pediatric Cardiac Arrest Algorithm for 2 or More Rescuers—2015 Update.

associated with worse 30-day intact neurologic survival.[10] When analyzed by arrest etiology, although the numbers are small, in patients with presumed nonasphyxial arrest (ie, a presumed arrest of cardiac etiology), compression-only CPR was as effective as conventional CPR. However, in patients with presumed asphyxial cardiac arrest, outcomes after compression-only CPR were no better than those for patients receiving no bystander CPR.

A second large observational study using a more recent data set from the same Japanese registry examined the effect of dispatcher-assisted CPR in pediatric OHCA. In this study, the use of compression-only CPR was associated with worse 30-day intact neurologic survival compared with patients who received conventional CPR.[11] Although not stratified for etiology of arrest, outcomes after compression-only CPR were no better than for patients who received no bystander CPR.

2015 Recommendations—New

Conventional CPR (chest compressions and rescue breaths) should be provided for pediatric cardiac arrests (Class I, LOE B-NR). The asphyxial nature of the majority of pediatric cardiac arrests necessitates ventilation as part of effective CPR. However, because compression-only CPR is effective in patients with a primary cardiac event, if rescuers are unwilling or unable to deliver breaths, we recommend rescuers perform compression-only CPR for infants and children in cardiac arrest (Class I, LOE B-NR).

Disclosures

Part 11: Pediatric Basic Life Support and Cardiopulmonary Resuscitation Quality: 2015 Guidelines Update Writing Group Disclosures

Writing Group Member	Employment	Research Grant	Other Research Support	Speakers' Bureau/ Honoraria	Expert Witness	Ownership Interest	Consultant/ Advisory Board	Other
Dianne L. Atkins	University of Iowa	None	None	None	None	None	None	None
Stuart Berger	University of California	None	None	None	Entity: Defense and plaintiff expert testimony but none that have involved the subject of the AHA Scientific Statement in question. Relationship: Myself. Compensation: Compensated*	None	None	None
Jonathan P. Duff	University of Alberta and Stollery Children's Hospital	None	None	None	None	None	None	None
John C. Gonzales	Williamson County EMS	None	None	None	None	None	None	None
Elizabeth A. Hunt	Johns Hopkins University School of Medicine	None	Laerdal Foundation for Acute Care Medicine*	None	None	I have filed several patents on inventions related to simulators to be used in teaching and studying resuscitation*	None	None
Benny L. Joyner	University of North Carolina	None	None	None	None	None	None	None
Peter A. Meaney	The Children's Hospital of Philadelphia	None	None	None	None	None	None	None
Dana E. Niles	The Children's Hospital of Philadelphia	None	None	None	None	None	None	None
Consultants								
Ricardo A. Samson	University of Arizona	None	None	None	None	None	American Heart Association†	None
Stephen M. Schexnayder	University of Arkansas; Arkansas Children's Hospital	None	None	None	None	None	American Heart Association†	None

This table represents the relationships of writing group members that may be perceived as actual or reasonably perceived conflicts of interest as reported on the Disclosure Questionnaire, which all members of the writing group are required to complete and submit. A relationship is considered to be "significant" if (a) the person receives $10 000 or more during any 12-month period, or 5% or more of the person's gross income; or (b) the person owns 5% or more of the voting stock or share of the entity, or owns $10 000 or more of the fair market value of the entity. A relationship is considered to be "modest" if it is less than "significant" under the preceding definition.

*Modest.

†Significant.

Appendix

2015 Guidelines Update: Part 11 Recommendations

Year Last Reviewed	Topic	Recommendation	Comments
2015	Sequence of CPR	Because of the limited amount and quality of the data, it may be reasonable to maintain the sequence from the 2010 Guidelines by initiating CPR with C-A-B over A-B-C (Class IIb, LOE C-EO).	updated for 2015
2015	Components of High-Quality CPR: Chest Compression Rate and Depth	To maximize simplicity in CPR training, in the absence of sufficient pediatric evidence, it is reasonable to use the adult chest compression rate of 100/min to 120/min for infants and children (Class IIa, LOE C-EO).	updated for 2015
2015	Components of High-Quality CPR: Chest Compression Rate and Depth	Although the effectiveness of CPR feedback devices was not reviewed by this writing group, the consensus of the group is that the use of feedback devices likely helps the rescuer optimize adequate chest compression rate and depth, and we suggest their use when available (Class IIb, LOE C-EO).	updated for 2015
2015	Components of High-Quality CPR: Chest Compression Rate and Depth	It is reasonable that in pediatric patients (1 month to the onset of puberty) rescuers provide chest compressions that depress the chest at least one third the anterior-posterior diameter of the chest. This equates to approximately 1.5 inches (4 cm) in infants to 2 inches (5 cm) in children (Class IIa, LOE C-LD).	updated for 2015
2015	Components of High-Quality CPR: Compression-Only CPR	Conventional CPR (rescue breathing and chest compressions) should be provided for pediatric cardiac arrests (Class I, LOE B-NR).	updated for 2015
2015	Components of High-Quality CPR: Compression-Only CPR	The asphyxial nature of the majority of pediatric cardiac arrests necessitates ventilation as part of effective CPR. However, because compression-only CPR is effective in patients with a primary cardiac event, if rescuers are unwilling or unable to deliver breaths, we recommend rescuers perform compression-only CPR for infants and children in cardiac arrest (Class I, LOE B-NR).	updated for 2015
The following recommendations were not reviewed in 2015. For more information, see the *2010 AHA Guidelines for CPR and ECC*, "Part 13: Pediatric Basic Life Support."			
2010	Check for Breathing	Formal training as well as "just in time" training, such as that provided by an emergency response system dispatcher, should emphasize how to recognize the difference between gasping and normal breathing; rescuers should be instructed to provide CPR even when the unresponsive victim has occasional gasps (Class IIa, LOE C).	not reviewed in 2015
2010	Start Chest Compressions	For an infant, lone rescuers (whether lay rescuers or healthcare providers) should compress the sternum with 2 fingers placed just below the intermammary line (Class IIb, LOE C).	not reviewed in 2015
2010	Start Chest Compressions	There are no data to determine if the 1- or 2-hand method produces better compressions and better outcome (Class IIb, LOE C). Because children and rescuers come in all sizes, rescuers may use either 1 or 2 hands to compress the child's chest.	not reviewed in 2015
2010	Start Chest Compressions	After each compression, allow the chest to recoil completely (Class IIb, LOE B) because complete chest reexpansion improves the flow of blood returning to the heart and thereby blood flow to the body during CPR.	not reviewed in 2015
2010	Open the Airway and Give Ventilations	Open the airway using a head tilt–chin lift maneuver for both injured and noninjured victims (Class I, LOE B).	not reviewed in 2015
2010	Open the Airway and Give Ventilations	In an infant, if you have difficulty making an effective seal over the mouth and nose, try either mouth-to-mouth or mouth-to-nose ventilation (Class IIb, LOE C).	not reviewed in 2015
2010	Open the Airway and Give Ventilations	In either case make sure the chest rises when you give a breath. If you are the only rescuer, provide 2 effective ventilations using as short a pause in chest compressions as possible after each set of 30 compressions (Class IIa, LOE C).	not reviewed in 2015
2010	BLS Sequence for Healthcare Providers and Others Trained in 2-Rescuer CPR	It is reasonable for healthcare providers to tailor the sequence of rescue actions to the most likely cause of arrest. For example, if the arrest is witnessed and sudden (eg, sudden collapse in an adolescent or a child identified at high risk for arrhythmia or during an athletic event), the healthcare provider may assume that the victim has suffered a sudden VF–cardiac arrest and as soon as the rescuer verifies that the child is unresponsive and not breathing (or only gasping) the rescuer should immediately phone the emergency response system, get the AED and then begin CPR and use the AED. (Class IIa LOE C).	not reviewed in 2015
2010	Pulse Check	If, within 10 seconds, you don't feel a pulse or are not sure if you feel a pulse, begin chest compressions (Class IIa, LOE C).	not reviewed in 2015
2010	Inadequate Breathing With Pulse	Reassess the pulse about every 2 minutes (Class IIa, LOE B) but spend no more than 10 seconds doing so.	not reviewed in 2015
2010	Ventilations	For healthcare providers and others trained in 2-person CPR, if there is evidence of trauma that suggests spinal injury, use a jaw thrust without head tilt to open the airway (Class IIb LOE C).	not reviewed in 2015

(*Continued*)

2015 Guidelines Update: Part 11 Recommendations, *Continued*

Year Last Reviewed	Topic	Recommendation	Comments
2010	Coordinate Chest Compressions and Ventilations	Deliver ventilations with minimal interruptions in chest compressions (Class IIa, LOE C).	not reviewed in 2015
2010	Defibrillation	For infants a manual defibrillator is preferred when a shockable rhythm is identified by a trained healthcare provider (Class IIb, LOE C).	not reviewed in 2015
2010	Defibrillation	An AED with a pediatric attenuator is also preferred for children <8 years of age. If neither is available, an AED without a dose attenuator may be used (Class IIb, LOE C).	not reviewed in 2015
2010	Bag-Mask Ventilation (Healthcare Providers)	Avoid excessive ventilation (Class III, LOE C); use only the force and tidal volume necessary to just make the chest rise.	not reviewed in 2015

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KEY WORDS: automated external defibrillator ■ cardiopulmonary resuscitation ■ pediatrics

Part 12: Pediatric Advanced Life Support

2015 American Heart Association Guidelines Update for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care

Allan R. de Caen, Chair; Marc D. Berg; Leon Chameides; Cheryl K. Gooden; Robert W. Hickey; Halden F. Scott; Robert M. Sutton; Janice A. Tijssen; Alexis Topjian; Élise W. van der Jagt; Stephen M. Schexnayder; Ricardo A. Samson

Introduction

Over the past 13 years, survival to discharge from pediatric in-hospital cardiac arrest (IHCA) has markedly improved. From 2001 to 2013, rates of return of spontaneous circulation (ROSC) from IHCA increased significantly from 39% to 77%, and survival to hospital discharge improved from 24% to 36% to 43% (Girotra et al[1] and personal communication with Paul Chan, MD, MSc, April 3, 2015). In a single center, implementation of an intensive care unit (ICU)–based interdisciplinary debriefing program improved survival with favorable neurologic outcome from 29% to 50%.[2] Furthermore, new data show that prolonged cardiopulmonary resuscitation (CPR) is not futile: 12% of patients receiving CPR in IHCA for more than 35 minutes survived to discharge, and 60% of the survivors had a favorable neurologic outcome.[3] This improvement in survival rate from IHCA can be attributed to multiple factors, including emphasis on high-quality CPR and advances in post-resuscitation care. Over the past decade, the percent of cardiac arrests occurring in an ICU setting has increased (87% to 91% in 2000 to 2003 to 94% to 96% in 2004 to 2010).[4] While rates of survival from pulseless electrical activity and asystole have increased, there has been no change in survival rates from in-hospital ventricular fibrillation (VF) or pulseless ventricular tachycardia (pVT).

Conversely, survival from out-of-hospital cardiac arrest (OHCA) has not improved as dramatically over the past 5 years. Data from 11 US and Canadian hospital emergency medical service systems (the Resuscitation Outcomes Consortium) during 2005 to 2007 showed age-dependent discharge survival rates of 3.3% for infants (less than 1 year), 9.1% for children (1 to 11 years), and 8.9% for adolescents (12 to 19 years).[5] More recently published data (through 2012) from this network demonstrate 8.3% survival to hospital discharge across all age groups, with 10.5% survival for children aged 1 to 11 years and 15.8% survival for adolescents aged 12 to 18 years.[6]

Evidence Evaluation Process Informing This Guidelines Update

The American Heart Association (AHA) Emergency Cardiovascular Care (ECC) Committee uses a rigorous process to review and analyze the peer-reviewed published scientific evidence supporting the AHA Guidelines for CPR and ECC, including this update. In 2000, the AHA began collaborating with other resuscitation councils throughout the world, via the International Liaison Committee on Resuscitation (ILCOR), in a formal international process to evaluate resuscitation science. This process resulted in the publication of the International Consensus on CPR and ECC Science With Treatment Recommendations (CoSTR) in 2005 and 2010.[7,8] These publications provided the scientific support for AHA Guidelines revisions in those years.

In 2011, the AHA created an online evidence review process, the Scientific Evidence Evaluation and Review System (SEERS), to support ILCOR systematic reviews for 2015 and beyond. This new process includes the use of Grading of Recommendations Assessment, Development, and Evaluation (GRADE) software to create systematic reviews that will be available online and used by resuscitation councils to develop their guidelines for CPR and ECC. The drafts of the online reviews were posted for public comment, and ongoing reviews will be accessible to the public (https://volunteer.heart.org/apps/pico/Pages/default.aspx).

The AHA process for identification and management of potential conflicts of interest was used, and potential conflicts for writing group members are listed at the end of each Part of the *2015 AHA Guidelines Update for CPR and ECC*. For additional information about this systematic review or management of the potential conflicts of interest, see "Part 2: Evidence Evaluation and Management of Conflicts of Interest" in this supplement and the related article "Part 2: Evidence Evaluation and Management of Conflict of Interest" in the 2015 CoSTR publication.[9,10]

This update to the *2010 AHA Guidelines for CPR and ECC* for pediatric advanced life support (PALS) targets key questions related to pediatric resuscitation. Areas of update were selected by a group of international pediatric resuscitation experts from ILCOR, and the questions encompass resuscitation topics in prearrest care, intra-arrest care, and postresuscitation care. The ILCOR Pediatric Life Support Task Force experts reviewed the topics addressed in the 2010 Guidelines

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for PALS and, based on in-depth knowledge of new research developments, formulated 18 questions for further systematic evaluation.[11] Three questions that address pediatric basic life support appear in "Part 11: Pediatric Basic Life Support and Cardiopulmonary Resuscitation Quality."

Beginning with the publication of the 2015 CoSTR, the ILCOR evidence evaluation process will be continuous, rather than "batched" into 5-year cycles. The goal of this continuous evidence review is to improve survival from cardiac arrest by shortening the time between resuscitation science discoveries and their application in resuscitation practice. As additional resuscitation topics are prioritized and reviewed, these Guidelines may be updated again. When the evidence supports sufficient changes to the Guidelines or a change in sequence or treatments that must be woven throughout the Guidelines, then the Guidelines will be revised completely.

Because the *2015 AHA Guidelines Update for CPR and ECC* represents the first update to the previous Guidelines, recommendations from both this 2015 Guidelines Update and the 2010 Guidelines are contained in the Appendix. If the 2015 ILCOR review resulted in a new or significantly revised Guidelines recommendation, that recommendation will be labeled as *New* or *Updated*.

As with all AHA Guidelines, each 2015 recommendation is labeled with a Class of Recommendation (COR) and a Level of Evidence (LOE). This update uses the newest AHA COR and LOE classification system, which contains modifications of the Class III recommendation and introduces LOE B-R (randomized studies) and B-NR (nonrandomized studies) as well as LOE C-LD (limited data) and LOE C-EO (consensus of expert opinion).

These PALS recommendations are informed by the rigorous systematic review and consensus recommendations of the ILCOR Pediatric Task Force, and readers are referred to the complete consensus document in the 2015 CoSTR.[12,13] In the online version of this document, live links are provided so the reader can connect directly to the systematic reviews on the SEERS website. These links are indicated by a superscript combination of letters and numbers (eg, Peds 397). We encourage readers to use the links and review the evidence and appendixes, including the GRADE tables.

This 2015 Guidelines Update for PALS includes science review in the following subjects:

Prearrest Care

- Effectiveness of **medical emergency teams or rapid response teams** to improve outcomes
- Effectiveness of a **pediatric early warning score (PEWS)** to improve outcomes
- **Restrictive volume of isotonic crystalloid** for resuscitation from septic shock
- **Use of atropine as a premedication** in infants and children requiring emergency tracheal intubation
- Treatment for infants and children with **myocarditis or dilated cardiomyopathy and impending cardiac arrest**

Intra-arrest Care

- Effectiveness of **extracorporeal membrane oxygenation (ECMO) resuscitation** compared to standard resuscitation without ECMO
- Targeting a **specific end-tidal CO_2 ($ETCO_2$) threshold** to improve chest compression technique
- Reliability of **intra-arrest prognostic factors** to predict outcome
- Use of **invasive hemodynamic monitoring during CPR** to titrate to a specific systolic/diastolic blood pressure to improve outcomes
- Effectiveness of NO **vasopressor** compared with ANY vasopressors for resuscitation from cardiac arrest
- Use of **amiodarone** compared with **lidocaine** for **shock-refractory VF or pVT**
- Optimal **energy dose** for **defibrillation**

Postarrest Care

- Use of **targeted temperature management** to improve outcomes
- Use of a **targeted Pao_2 strategy** to improve outcomes
- Use of a **specific $Paco_2$ target** to improve outcomes
- Use of **parenteral fluids and inotropes and/or vasopressors** to maintain targeted measures of perfusion such as blood pressure to improve outcomes
- Use of **electroencephalograms (EEGs)** to accurately predict outcomes
- Use **of any specific post–cardiac arrest factors** to accurately predict outcomes

Prearrest Care Updates

Medical Emergency Team/Rapid Response Team[Peds 397]

Medical emergency team or rapid response team activation by caregivers or parents ideally occurs as a response to changes noted in a patient's condition and may prevent cardiac or respiratory arrest. Several variables, including the composition of the team, the type of patient, the hospital setting, and the confounder of a wider "system benefit," further complicate objective analyses.

2015 Evidence Summary

Observational data have been contradictory and have not consistently shown a decreased incidence of cardiac and/or respiratory arrest outside of the ICU setting.[14–16] The data addressing effects on hospital mortality were inconclusive.[16–21]

2015 Recommendation—Updated

Pediatric medical emergency team/rapid response team systems may be considered in facilities where children with high-risk illnesses are cared for on general in-patient units (Class IIb, LOE C-LD).

Pediatric Early Warning Scores[Peds 818]

In-hospital pediatric cardiac or respiratory arrest can potentially be averted by early recognition of and intervention for the deteriorating patient. The use of scoring systems might help to identify such patients sufficiently early so as to enable effective intervention.

2015 Evidence Summary

There is no evidence that the use of PEWS outside of the pediatric ICU setting reduces hospital mortality. In 1 observational study, PEWS use was associated with a reduction in cardiac

arrest rate when used in a single hospital with an established medical emergency team system.[22]

2015 Recommendation—New

The use of PEWS may be considered, but its effectiveness in the in-hospital setting is not well established (Class IIb, LOE C-LD).

Fluid Resuscitation in Septic Shock[Peds 545]

This update regarding intravenous fluid resuscitation in infants and children in septic shock in all settings addressed 2 specific therapeutic elements: (1) Withholding the use of bolus fluids was compared with the use of bolus fluids, and (2) noncrystalloid was compared with crystalloid fluids.

Early and rapid administration of intravenous fluid to reverse decompensated shock, and to prevent progression from compensated to decompensated shock, has been widely accepted based on limited observational studies.[23] Mortality from pediatric sepsis has declined in recent years, during which guidelines and publications have emphasized the role of early rapid fluid administration (along with early antibiotic and vasopressor therapy, and careful cardiovascular monitoring) in treating septic shock.[24,25] Since the 2010 Guidelines, a large randomized controlled trial of fluid resuscitation in pediatric severe febrile illness in a resource-limited setting found intravenous fluid boluses to be harmful.[26] This new information, contradicting long-held beliefs and practices, prompted careful analysis of the effect of fluid resuscitation on many outcomes in specific infectious illnesses.

2015 Evidence Summary

Specific infection-related shock states appear to behave differently with respect to fluid bolus therapy. Evidence was not considered to be specific to a particular setting, after determining that "resource-limited setting" is difficult to define and can vary greatly even within individual health systems and small geographic regions.

The evidence regarding the impact of restricting fluid boluses during resuscitation on outcomes in pediatric septic shock is summarized in Figure 1. There were no studies for many specific combinations of presenting illness and outcome. In the majority of scenarios, there was no benefit to restricting fluid boluses during resuscitation.

The most important exception is that in 1 large study, restriction of fluid boluses conveyed a benefit for survival to both 48 hours and 4 weeks after presentation. This study was conducted in sub-Saharan Africa, and inclusion criteria were severe febrile illness complicated by impaired consciousness (prostration or coma), respiratory distress (increased work of breathing), or both, and with impaired perfusion, as evidenced by 1 or more of the following: a capillary refill time of 3 or more seconds, lower limb temperature gradient, weak radial-pulse volume, or severe tachycardia. In this study, administration of 20 mL/kg or 40 mL/kg in the first hour was associated with decreased survival compared with the use of maintenance fluids alone.[26] Therefore, it appears that in this specific patient population, where critical care resources including inotropic and mechanical ventilator support were limited, bolus fluid therapy resulted in higher mortality.

The use of noncrystalloid fluid was compared with crystalloid fluid for the same diseases and outcomes listed in the preceding paragraph.[26–32] Evidence is summarized in Figure 2. In most scenarios, there was no benefit to noncrystalloids over crystalloids. In patients with Dengue shock, a benefit was conferred in using noncrystalloid compared with crystalloid fluid for the outcome of time to resolution of shock.[31]

2015 Recommendations—New

Administration of an initial fluid bolus of 20 mL/kg to infants and children with shock is reasonable, including those with conditions such as severe sepsis (Class IIa, LOE C-LD), severe malaria and Dengue (Class IIb, LOE B-R). When caring for children with severe febrile illness (such as those included in the FEAST trial[26]) in settings with limited access to critical care resources (ie, mechanical ventilation and inotropic support), administration of bolus intravenous fluids should be undertaken with extreme caution because it may be harmful (Class IIb, LOE B-R). Providers should reassess the patient after every fluid bolus (Class I, LOE C-EO).

Either isotonic crystalloids or colloids can be effective as the initial fluid choice for resuscitation (Class IIa, LOE B-R).

This recommendation takes into consideration the important work of Maitland et al,[26] which found that fluid boluses as part of resuscitation are not safe for all patients in all settings. This

	Studies	Survival to Hospital Discharge	Need for Transfusion or Diuretics	Need for Rescue Fluid	Mechanical Ventilation or Vasopressor	Time to Resolution of Shock	Total IV Fluids
Severe sepsis/ septic shock	Santhanam 2008; Carcillo 1991	No Benefit	No Benefit	No Studies Available	No Benefit	No Benefit	No Studies Available
Severe malaria	Maitland 2005; Maitland 2005	No Benefit	No Benefit	Harm	No Studies Available	No Benefit	No Benefit
Severe febrile illness with some but not all signs of shock	Maitland 2011; Maitland 2013	Benefit	No Benefit	No Studies Available	No Studies Available	Harm	No Benefit

Figure 1. Evidence for the use of restrictive volume of intravenous fluid resuscitation, compared with unrestrictive volume, by presenting illness and outcome. *Benefit* indicates that studies show a benefit to restricting fluid volume, *No Benefit* indicates that there is no benefit to restricting fluid volume, and *Harm* indicates that there is harm associated with restricting fluid volume. *No Studies Available* indicates no studies are available for a particular illness/outcome combination.

	Studies	Survival to Hospital Discharge	Need for Other Treatment	Need for Rescue Fluid	Mechanical Ventilation or Vasopressor	Time to Resolution of Shock	Total IV Fluids	Hospital Duration of Stay
Severe sepsis/ septic shock	Upadhyay 2005	No Benefit	No Benefit	No Studies Available	No Benefit	No Benefit	No Studies Available	No Studies Available
Severe malaria	Maitland 2003; Maitland 2005	No Studies Available	No Benefit	No Studies Available	No Studies Available	No Benefit	No Studies Available	No Studies Available
Dengue shock	Cifra 2003; Dung 1999; Ngo 2001; Wills 2005	No Benefit	No Benefit	No Benefit	No Studies Available	Benefit	No Benefit	No Benefit
Severe febrile illness with some but not all signs of shock	Maitland 2011	No Benefit	No Benefit	No Benefit	No Studies Available	No Benefit	No Benefit	No Studies Available

Figure 2. Evidence for the use of noncrystalloid intravenous fluid resuscitation, compared with crystalloid, by presenting illness and outcome. *Benefit* indicates that studies show a benefit to the use of noncrystalloid intravenous fluid resuscitation compared with crystalloid, and *No Benefit* indicates that there is no benefit to the use of noncrystalloid intravenous fluid resuscitation compared with crystalloid. *No Studies Available* indicates no studies are available for a particular illness/outcome combination.

study showed that the use of fluid boluses as part of resuscitation increased mortality in a specific population in a resource-limited setting, without access to some critical care interventions such as mechanical ventilation and inotrope support.

The spirit of this recommendation is a continued emphasis on fluid resuscitation for both compensated (detected by physical examination) and decompensated (hypotensive) septic shock. Moreover, emphasis is also placed on the use of individualized patient evaluation before the administration of intravenous fluid boluses, including physical examination by a clinician and frequent reassessment to determine the appropriate volume of fluid resuscitation. The clinician should also integrate clinical signs with patient and locality-specific information about prevalent diseases, vulnerabilities (such as severe anemia and malnutrition), and available critical care resources.

Atropine for Premedication During Emergency Intubation[Peds 821]

Bradycardia commonly occurs during emergency pediatric intubation, resulting from hypoxia/ischemia, as a vagal response to laryngoscopy, as a reflex response to positive pressure ventilation, or as a pharmacologic effect of some drugs (eg, succinylcholine or fentanyl). Practitioners have often tried to blunt this bradycardia with prophylactic premedication with atropine.

2015 Evidence Summary

The evidence regarding the use of atropine during emergency intubation has largely been observational, including extrapolation from experience with elective intubation in the operating suite. More recent in-hospital literature involves larger case series of critically ill neonates, infants, and children undergoing emergency intubation.[33–35]

There is no evidence that preintubation use of atropine improves survival or prevents cardiac arrest in infants and children. Observational data suggest that it increases the likelihood of survival to ICU discharge in children older than 28 days.[33] Evidence is conflicting as to whether preintubation atropine administration reduces the incidence of arrhythmias or postintubation shock.[34,35]

In past Guidelines, a minimum atropine dose of 0.1 mg IV was recommended after a report of paradoxical bradycardia observed in very small infants who received very low atropine doses.[36] However, in 2 of the most recent case series cited above, preintubation doses of 0.02 mg/kg, with no minimum dose, were shown to be effective.[33,34]

2015 Recommendations—New

The available evidence does not support the routine use of atropine preintubation of critically ill infants and children. It may be reasonable for practitioners to use atropine as a premedication in specific emergency intubations when there is higher risk of bradycardia (eg, when giving succinylcholine as a neuromuscular blocker to facilitate intubation) (Class IIb, LOE C-LD). A dose of 0.02 mg/kg of atropine with no minimum dose may be considered when atropine is used as a premedication for emergency intubation (Class IIb, LOE C-LD). This new recommendation applies only to the use of atropine as a premedication for infants and children during emergency intubation.

Prearrest Care of Infants and Children With Dilated Cardiomyopathy or Myocarditis[Peds 819]

Optimal care of a critically ill infant or child with dilated cardiomyopathy or myocarditis should avert cardiac arrest. While significant global experience exists with the care of these patients, the evidence base is limited. The ILCOR systematic review ultimately restricted its analysis to patients with myocarditis and did not include the use of ventricular assist devices.

2015 Evidence Summary

No literature was identified evaluating best prearrest management strategies (including anesthetic technique) for infants

and children with dilated cardiomyopathy or myocarditis. Limited observational data support the pre–cardiac arrest use of ECMO in children with acute fulminant myocarditis.[37]

2015 Recommendation—New

Venoarterial ECMO use may be considered in patients with acute fulminant myocarditis who are at high risk of imminent cardiac arrest (Class IIb, LOE C-EO). Optimal outcomes from ECMO are achieved in settings with existing ECMO protocols, expertise, and equipment.

Intra-arrest Care Updates

Extracorporeal CPR for In-Hospital Pediatric Cardiac Arrest[Peds 407]

The 2010 AHA PALS Guidelines suggested the use of ECMO when dealing with pediatric cardiac arrest refractory to conventional interventions and when managing a reversible underlying disease process. Pediatric OHCA was not considered for the 2015 ILCOR systematic review.

2015 Evidence Summary

Evidence from 4 observational studies of pediatric IHCA has shown no overall benefit to the use of CPR with ECMO (ECPR) compared to CPR without ECMO.[38–41] Observational data from a registry of pediatric IHCA showed improved survival to hospital discharge with the use of ECPR in patients with surgical cardiac diagnoses.[42] For children with underlying cardiac disease, when ECPR is initiated in a critical care setting, long-term survival has been reported even after more than 50 minutes of conventional CPR.[43] When ECPR is used during cardiac arrest, the outcome for children with underlying cardiac disease is better than for those with noncardiac disease.[44]

2015 Recommendation—New

ECPR may be considered for pediatric patients with cardiac diagnoses who have IHCA in settings with existing ECMO protocols, expertise, and equipment (Class IIb, LOE C-LD).

End-Tidal CO_2 Monitoring to Guide CPR Quality[Peds 827]

High-quality CPR is associated with improved outcomes after cardiac arrest. Animal data support a direct association between $ETCO_2$ and cardiac output. Capnography is used during pediatric cardiac arrest to monitor for ROSC as well as CPR quality. The 2010 Guidelines recommended that if the partial pressure of $ETCO_2$ is consistently less than 15 mm Hg, efforts should focus on improving CPR quality, particularly improving chest compressions and ensuring that the victim does not receive excessive ventilation.

2015 Evidence Summary

There is no pediatric evidence that $ETCO_2$ monitoring improves outcomes from cardiac arrest. One pediatric animal study showed that $ETCO_2$-guided chest compressions are as effective as standard chest compressions optimized by marker, video, and verbal feedback for achieving ROSC.[45] A recent study in adults found that $ETCO_2$ values generated during CPR were significantly associated with chest compression depth and ventilation rate.[46]

2015 Recommendation—New

$ETCO_2$ monitoring may be considered to evaluate the quality of chest compressions, but specific values to guide therapy have not been established in children (Class IIb, LOE C-LD).

Intra-arrest Prognostic Factors for Cardiac Arrest[Peds 814]

Accurate and reliable prognostication during pediatric cardiac arrest would allow termination of CPR in patients where CPR is futile, while encouraging continued CPR in patients with a potential for good recovery.

2015 Evidence Summary

For infants and children with OHCA, age less than 1 year,[5,47] longer durations of cardiac arrest[48–50] and presentation with a nonshockable as opposed to a shockable rhythm[5,47,49] are all predictors of poor patient outcome. For infants and children with IHCA, negative predictive factors include age greater than 1 year[3] and longer durations of cardiac arrest.[3,51–53] The evidence is contradictory as to whether a nonshockable (as opposed to shockable) initial cardiac arrest rhythm is a negative predictive factor in the in-hospital setting.[3,54,55]

2015 Recommendation—New

Multiple variables should be used when attempting to prognosticate outcomes during cardiac arrest (Class I, LOE C-LD). Although there are factors associated with better or worse outcomes, no single factor studied predicts outcome with sufficient accuracy to recommend termination or continuation of CPR.

Invasive Hemodynamic Monitoring During CPR[Peds 826]

Children often have cardiac arrests in settings where invasive hemodynamic monitoring already exists or is rapidly obtained. If a patient has an indwelling arterial catheter, the waveform can be used as feedback to evaluate chest compressions.

2015 Evidence Summary

Adjusting chest compression technique to a specific systolic blood pressure target has not been studied in humans. Two randomized controlled animal studies showed increased likelihood of ROSC and survival to completion of experiment with the use of invasive hemodynamic monitoring.[56,57]

2015 Recommendation—New

For patients with invasive hemodynamic monitoring in place at the time of cardiac arrest, it may be reasonable for rescuers to use blood pressure to guide CPR quality (Class IIb, LOE C-EO). Specific target values for blood pressure during CPR have not been established in children.

Vasopressors During Cardiac Arrest[Peds 424]

During cardiac arrest, vasopressors are used to restore spontaneous circulation by optimizing coronary perfusion and to help maintain cerebral perfusion. However, they also cause intense vasoconstriction and increase myocardial oxygen consumption, which might be detrimental.

2015 Evidence Summary

There are no pediatric studies that demonstrate the effectiveness of any vasopressors (epinephrine, or combination of vasopressors) in cardiac arrest. Two pediatric observational out-of-hospital studies[58,59] had too many confounders to determine if vasopressors were beneficial. One adult OHCA randomized controlled trial[60] showed epinephrine use was associated with increased ROSC and survival to hospital admission but no improvement in survival to hospital discharge.

2015 Recommendation—New

It is reasonable to administer epinephrine in pediatric cardiac arrest (Class IIa, LOE C-LD).

Amiodarone and Lidocaine for Shock-Refractory VF and pVT[Peds 825]

The 2005 and 2010 Guidelines recommended administering amiodarone in preference to lidocaine for the management of VF or pVT. This recommendation was based predominantly on pediatric case series or extrapolation from adult studies that used short-term outcomes.

2015 Evidence Summary

New pediatric observational data[61] showed improved ROSC with the use of lidocaine as compared with amiodarone. Use of lidocaine compared with no lidocaine was significantly associated with an increased likelihood of ROSC. The same study did not show an association between lidocaine or amiodarone use and survival to hospital discharge.

2015 Recommendation—New

For shock-refractory VF or pVT, either amiodarone or lidocaine may be used (Class IIb, LOE C-LD).

The Pediatric Cardiac Arrest Algorithm (Figure 3) reflects this change.

Energy Doses for Defibrillation[Peds 405]

The 2015 ILCOR systematic review addressed the dose of energy for pediatric manual defibrillation during cardiac arrest. Neither the energy dose specifically related to automated external defibrillators, nor the energy dose for cardioversion was evaluated in this evidence review.

2015 Evidence Summary

Two small case series demonstrated termination of VF/pVT with either 2 J/kg[62] or 2 to 4 J/kg.[63] In 1 observational study of IHCA,[64] a higher initial energy dose of more than 3 to 5 J/kg was less effective than 1 to 3 J/kg in achieving ROSC. One small observational study of IHCA[65] showed no benefit in achieving ROSC with a specific energy dose for initial defibrillation. Three small observational studies of IHCA and OHCA[63,65,66] showed no survival to discharge advantage of any energy dose compared with 2 to 4 J/kg for initial defibrillation.

2015 Recommendations—Updated

It is reasonable to use an initial dose of 2 to 4 J/kg of monophasic or biphasic energy for defibrillation (Class IIa, LOE C-LD), but for ease of teaching, an initial dose of 2 J/kg may be considered (Class IIb, LOE C-EO). For refractory VF, it is reasonable to increase the dose to 4 J/kg (Class IIa, LOE C-LD). For subsequent energy levels, a dose of 4 J/kg may be reasonable and higher energy levels may be considered, though not to exceed 10 J/kg or the adult maximum dose (Class IIb, LOE C-LD).

Postarrest Care Updates

Post–Cardiac Arrest Temperature Management[Peds 387]

Data suggest that fever after pediatric cardiac arrest is common and is associated with poor outcomes.[67] The 2010 AHA PALS Guidelines suggested a role for targeted temperature management after pediatric cardiac arrest (fever control for all patients, therapeutic hypothermia for some patients), but the recommendations were based predominantly on extrapolation from adult and asphyxiated newborn data.

2015 Evidence Summary

A large multi-institutional, prospective, randomized study of pediatric patients (aged 2 days to 18 years) with OHCA found no difference in survival with good functional outcome at 1 year and no additional complications in comatose patients who were treated with therapeutic hypothermia (32°C to 34°C), compared to those treated with normothermia (36°C to 37.5°C).[68] Observational data of pediatric patients resuscitated from IHCA or OHCA[69,70] have also shown that ICU duration of stay, neurologic outcomes, and mortality are unchanged with the use of therapeutic hypothermia. Only 1 small study of therapeutic hypothermia in survivors of pediatric asphyxial cardiac arrest[71] showed an improvement in mortality at hospital discharge, but with no difference in neurologic outcomes. Results are pending from a large multicenter randomized controlled trial of targeted temperature management for pediatric patients with IHCA (see Therapeutic Hypothermia After Cardiac Arrest website: www.THAPCA.org).

2015 Recommendations—New

For infants and children remaining comatose after OHCA, it is reasonable either to maintain 5 days of continuous normothermia (36°C to 37.5°C) or to maintain 2 days of initial continuous hypothermia (32°C to 34°C) followed by 3 days of continuous normothermia (Class IIa, LOE B-R). Continuous measurement of temperature during this time period is recommended (Class I, LOE B-NR).

For infants and children remaining comatose after IHCA, there is insufficient evidence to recommend cooling over normothermia.

Fever (temperature 38°C or higher) should be aggressively treated after ROSC (Class I, LOE B-NR).

Post–Cardiac Arrest Oxygenation[Peds 544]

Animal studies suggest that elevated levels of tissue Po_2 after ROSC (hyperoxia) contribute to oxidative stress that may potentiate the postresuscitation syndrome, while some adult studies show associations between hyperoxemia and increased mortality.[72,73]

2015 Evidence Summary

Three small observational studies of pediatric IHCA and OHCA survivors[74–76] did not show an association between elevated Pao_2 and outcome. In a larger observational study of 1427 pediatric IHCA and OHCA victims who survived to

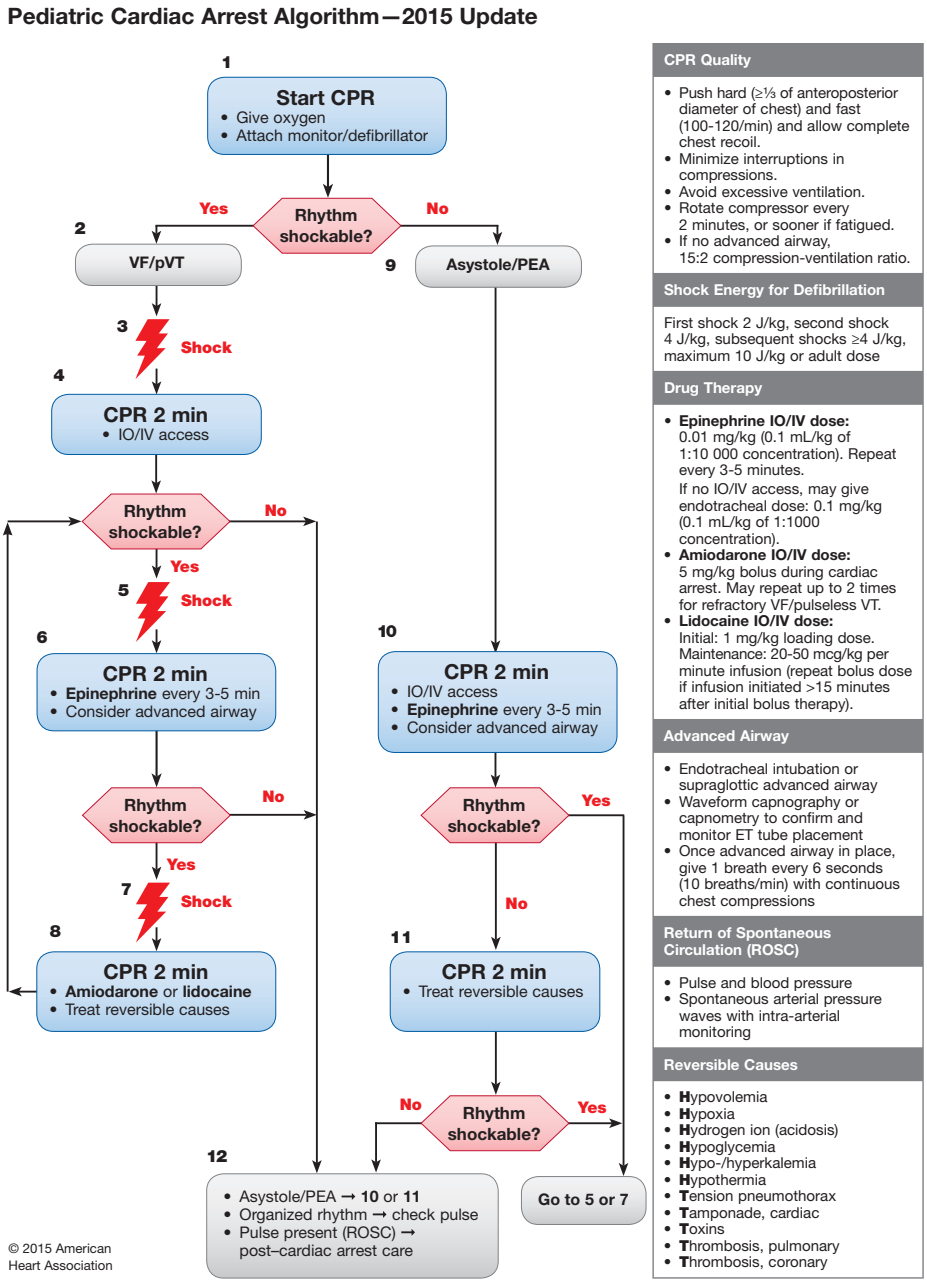

Figure 3. Pediatric Cardiac Arrest Algorithm—2015 Update.

pediatric ICU admission,[77] after adjustment of confounders, the presence of normoxemia (defined as a Pao_2 60 mm Hg or greater and less than 300 mm Hg) when compared with hyperoxemia (Pao_2 greater than 300 mm Hg) after ROSC was associated with improved survival to pediatric ICU discharge.

2015 Recommendations—New

It may be reasonable for rescuers to target normoxemia after ROSC (Class IIb, LOE B-NR). Because an arterial oxyhemoglobin saturation of 100% may correspond to a Pao_2 anywhere between 80 and approximately 500 mm Hg, it may be reasonable—when the necessary equipment is available—for rescuers to wean oxygen to target an oxyhemoglobin saturation of less than 100%, but 94% or greater. The goal of such an approach is to achieve normoxemia while ensuring that hypoxemia is strictly avoided. Ideally, oxygen is titrated to a value appropriate to the specific patient condition.

Post–Cardiac Arrest $Paco_2$ Peds 815

Cerebral vascular autoregulation may be abnormal after ROSC. Adult data show an association between post-ROSC hypocapnia and worse patient outcomes.[78,79] In other types of pediatric brain injury, hypocapnia is associated with worse clinical outcomes.[80–83]

2015 Evidence Summary

There were no studies in children after cardiac arrest specifically comparing ventilation with a predetermined $Paco_2$ target. One small observational study of both pediatric IHCA and OHCA[74] demonstrated no association between hypercapnia

($Paco_2$ greater than 50 mm Hg) or hypocapnia ($Paco_2$ less than 30 mm Hg) and outcome. However, in an observational study of pediatric IHCA,[76] hypercapnia ($Paco_2$ 50 mm Hg or greater) was associated with worse survival to hospital discharge.

2015 Recommendation—New

It is reasonable for practitioners to target a $Paco_2$ after ROSC that is appropriate to the specific patient condition, and limit exposure to severe hypercapnia or hypocapnia (Class IIb, LOE C-LD).

Post–Cardiac Arrest Fluids and Inotropes[Peds 820]

Myocardial dysfunction and vascular instability are common after resuscitation from cardiac arrest.[84–90]

2015 Evidence Summary

Three small observational studies involving pediatric IHCA and OHCA[91–93] demonstrated worse survival to hospital discharge when children were exposed to post-ROSC hypotension. One of these studies[91] associated post-ROSC hypotension (defined as a systolic blood pressure less than fifth percentile for age) after IHCA with lower likelihood of survival to discharge with favorable neurologic outcome. There are no studies evaluating the benefit of specific vasoactive agents after ROSC in infants and children.

2015 Recommendations—New

After ROSC, we recommend that parenteral fluids and/or inotropes or vasoactive drugs be used to maintain a systolic blood pressure greater than fifth percentile for age (Class I, LOE C-LD). When appropriate resources are available, continuous arterial pressure monitoring is recommended to identify and treat hypotension (Class I, LOE C-EO).

Postresuscitation Use of EEG for Prognosis[Peds 822]

Early and reliable prognostication of neurologic outcome in pediatric survivors of cardiac arrest is essential to enable effective planning and family support (whether it be to continue or discontinue life-sustaining therapy).

2015 Evidence Summary

Observational data from 2 small pediatric studies[94,95] showed that a continuous and reactive tracing on an EEG performed in the first 7 days after cardiac arrest was associated with a significantly higher likelihood of good neurologic outcome at hospital discharge, while an EEG demonstrating a discontinuous or isoelectric tracing was associated with a poorer neurologic outcome at hospital discharge. There are no data correlating EEG findings with neurologic outcome after hospital discharge.

2015 Recommendation—New

EEGs performed within the first 7 days after pediatric cardiac arrest may be considered in prognosticating neurologic outcome at the time of hospital discharge (Class IIb, LOE C-LD) but should not be used as the sole criterion.

Predictive Factors After Cardiac Arrest[Peds 813]

Several post-ROSC factors have been studied as possible predictors of survival and neurologic outcome after pediatric cardiac arrest. These include pupillary responses, the presence of hypotension, serum neurologic biomarkers, and serum lactate.

2015 Evidence Summary

Four observational studies supported the use of pupillary reactivity at 12 to 24 hours after cardiac arrest in predicting survival to discharge,[49,53,95,96] while 1 observational study found that reactive pupils 24 hours after cardiac arrest were associated with improved survival at 180 days with favorable neurologic outcome.[97]

Several serum biomarkers of neurologic injury have been considered for their prognostic value. Two small observational studies found that lower neuron-specific enolase and S100B serum levels after arrest were associated with improved survival to hospital discharge and with improved survival with favorable neurologic outcome.[97,98]

One observational study found that children with lower lactate levels in the first 12 hours after arrest had an improved survival to hospital discharge.[99]

2015 Recommendation—New

The reliability of any 1 variable for prognostication in children *after* cardiac arrest has not been established. Practitioners should consider multiple factors when predicting outcomes in infants and children who achieve ROSC after cardiac arrest (Class I, LOE C-LD).

Disclosures

Part 12: Pediatric Advanced Life Support: 2015 Guidelines Update Writing Group Disclosures

Writing Group Member	Employment	Research Grant	Other Research Support	Speakers' Bureau/Honoraria	Expert Witness	Ownership Interest	Consultant/ Advisory Board	Other
Allan R. de Caen	University of Alberta Stollery Children's Hospital	None	None	None	None	None	None	None
Marc D. Berg	University of Arizona	None	None	None	None	None	None	None
Leon Chameides	Connecticut Children's Medical Center	None	None	None	None	None	None	None
Cheryl K. Gooden	Mount Sinai Medical Center	None	None	None	None	None	None	None
Robert W. Hickey	Children's Hospital of Pittsburgh	None	None	None	None	None	None	None
Halden F. Scott	Children's Hospital Colorado	None	None	None	None	None	None	None
Robert M. Sutton	The Children's Hospital of Philadelphia; University of Pennsylvania School of Medicine	NIH†	None	Zoll Medical Sales Meeting Lecture (Speaking Honoraria)*	Webber and Gallagher*	None	None	None
Janice A. Tijssen	London Health Services Center	AMOSO Opportunities Fund*	None	None	None	None	None	None
Alexis Topjian	The Children's Hospital of Philadelphia; University of Pennsylvania School of Medicine	NIH*	None	None	Expert witness for defense and plantiff*	None	None	None
Élise W. van der Jagt	University of Rochester School of Medicine	NHLBI*	None	None	None	None	None	None
Consultants								
Ricardo A. Samson	The University of Arizona	None	None	None	None	None	American Heart Association†	None
Stephen M. Schexnayder	University of Arkansas; Arkansas Children's Hospital	None	None	None	Arkansas Dept. of Human Services*; Lewis Thomason*; University of Chicago*	None	American Heart Association†	None

This table represents the relationships of writing group members that may be perceived as actual or reasonably perceived conflicts of interest as reported on the Disclosure Questionnaire, which all members of the writing group are required to complete and submit. A relationship is considered to be "significant" if (a) the person receives $10 000 or more during any 12-month period, or 5% or more of the person's gross income; or (b) the person owns 5% or more of the voting stock or share of the entity, or owns $10 000 or more of the fair market value of the entity. A relationship is considered to be "modest" if it is less than "significant" under the preceding definition.

*Modest.

†Significant.

Appendix

2015 Guidelines Update: Part 12 Recommendations

Year Last Reviewed	Topic	Recommendation	Comments
2015	Prearrest Care Updates	Pediatric medical emergency team/rapid response team systems may be considered in facilities where children with high-risk illnesses are cared for on general in-patient units (Class IIb, LOE C-LD).	updated for 2015
2015	Prearrest Care Updates	The use of PEWS may be considered, but its effectiveness in the in-hospital setting is not well established (Class IIb, LOE C-LD).	new for 2015
2015	Prearrest Care Updates	Administration of an initial fluid bolus of 20 mL/kg to infants and children with shock is reasonable, including those with conditions such as severe sepsis (Class IIa, LOE C-LD), malaria and Dengue (Class IIb, LOE B-R).	new for 2015
2015	Prearrest Care Updates	When caring for children with severe febrile illness (such as those included in the FEAST trial), in settings with limited access to critical care resources (ie mechanical ventilation and inotropic support), administration of bolus intravenous fluids should be undertaken with extreme caution because it may be harmful (Class IIb, LOE B-R).	new for 2015
2015	Prearrest Care Updates	Providers should reassess the patient after every fluid bolus (Class I, LOE C-EO).	new for 2015
2015	Prearrest Care Updates	Either isotonic crystalloids or colloids can be effective as the initial fluid choice for resuscitation (Class IIa, LOE B-R).	new for 2015
2015	Prearrest Care Updates	The available evidence does not support the routine use of atropine preintubation of critically ill infants and children. It may be reasonable for practitioners to use atropine as a premedication in specific emergent intubations when there is higher risk of bradycardia (eg, when giving succinylcholine as a neuromuscular blocker to facilitate intubation) (Class IIb, LOE C-LD).	new for 2015
2015	Prearrest Care Updates	A dose of 0.02 mg/kg of atropine with no minimum dose may be considered when atropine is used as a premedication for emergency intubation (Class IIb, LOE C-LD).	new for 2015
2015	Prearrest Care Updates	Venoarterial ECMO use may be considered in patients with acute fulminant myocarditis who are at high risk of imminent cardiac arrest (Class IIb, LOE C-EO).	new for 2015
2015	Intra-arrest Care Updates	ECPR may be considered for pediatric patients with cardiac diagnoses who have IHCA in settings with existing ECMO protocols, expertise, and equipment (Class IIb, LOE C-LD).	new for 2015
2015	Intra-arrest Care Updates	$ETCO_2$ monitoring may be considered to evaluate the quality of chest compressions, but specific values to guide therapy have not been established in children (Class IIb, LOE C-LD).	new for 2015
2015	Intra-arrest Care Updates	Multiple variables should be used when attempting to prognosticate outcomes during cardiac arrest (Class I, LOE C-LD).	new for 2015
2015	Intra-arrest Care Updates	For patients with invasive hemodynamic monitoring in place at the time of cardiac arrest, it may be reasonable for rescuers to use blood pressure to guide CPR quality (Class IIb, LOE C-EO).	new for 2015
2015	Intra-arrest Care Updates	It is reasonable to administer epinephrine in pediatric cardiac arrest (Class IIa, LOE C-LD).	new for 2015
2015	Intra-arrest Care Updates	For shock-refractory VF or pVT, either amiodarone or lidocaine may be used (Class IIb, LOE C-LD).	new for 2015
2015	Intra-arrest Care Updates	It is reasonable to use an initial dose of 2 to 4 J/kg of monophasic or biphasic energy for defibrillation (Class IIa, LOE C-LD), but for ease of teaching, an initial dose of 2 J/kg may be considered (Class IIb, LOE C-EO).	updated for 2015
2015	Intra-arrest Care Updates	For refractory VF, it is reasonable to increase the dose to 4 J/kg (Class IIa, LOE C-LD).	updated for 2015
2015	Intra-arrest Care Updates	For subsequent energy levels, a dose of 4 J/kg may be reasonable and higher energy levels may be considered, though not to exceed 10 J/kg or the adult maximum dose (Class IIb, LOE C-LD).	updated for 2015
2015	Postarrest Care Updates	For infants and children remaining comatose after OHCA, it is reasonable either to maintain 5 days of continuous normothermia (36°C to 37.5°C) or to maintain 2 days of initial continuous hypothermia (32°C to 34°C) followed by 3 days of continuous normothermia (Class IIa, LOE B-R).	new for 2015
2015	Postarrest Care Updates	Continuous measurement of temperature during this time period is recommended (Class I, LOE B-NR).	new for 2015
2015	Postarrest Care Updates	Fever (temperature 38°C or higher) should be aggressively treated after ROSC (Class I, LOE B-NR).	new for 2015
2015	Postarrest Care Updates	It may be reasonable for rescuers to target normoxemia after ROSC (Class IIb, LOE B-NR).	new for 2015
2015	Postarrest Care Updates	It is reasonable for practitioners to target a Pa_{CO_2} after ROSC that is appropriate to the specific patient condition, and limit exposure to severe hypercapnia or hypocapnia (Class IIb, LOE C-LD).	new for 2015
2015	Postarrest Care Updates	After ROSC, we recommend that parenteral fluids and/or inotropes or vasoactive drugs be used to maintain a systolic blood pressure greater than fifth percentile for age (Class I, LOE C-LD).	new for 2015

(*Continued*)

2015 Guidelines Update: Part 12 Recommendations, *Continued*

Year Last Reviewed	Topic	Recommendation	Comments
2015	Postarrest Care Updates	When appropriate resources are available, continuous arterial pressure monitoring is recommended to identify and treat hypotension (Class I, LOE C-EO).	new for 2015
2015	Postarrest Care Updates	EEGs performed within the first 7 days after pediatric cardiac arrest may be considered in prognosticating neurologic outcome at the time of hospital discharge (Class IIb, LOE C-LD) but should not be used as the sole criterion.	new for 2015
2015	Postarrest Care Updates	The reliability of any one variable for prognostication in children after cardiac arrest has not been established. Practitioners should consider multiple factors when predicting outcomes in infants and children who achieve ROSC after cardiac arrest (Class I, LOE C-LD).	new for 2015
The following recommendations were not reviewed in 2015. For more information, see the *2010 AHA Guidelines for CPR and ECC*, "Part 14: Pediatric Advanced Life Support."			
2010	Family Presence During Resuscitation	Whenever possible, provide family members with the option of being present during resuscitation of an infant or child (Class I, LOE B).	not reviewed in 2015
2010	Laryngeal Mask Airway (LMA)	When bag-mask ventilation (see "Bag-Mask Ventilation," below) is unsuccessful and when endotracheal intubation is not possible, the LMA is acceptable when used by experienced providers to provide a patent airway and support ventilation (Class IIa, LOE C).	not reviewed in 2015
2010	Bag-Mask Ventilation	In the prehospital setting it is reasonable to ventilate and oxygenate infants and children with a bag-mask device, especially if transport time is short (Class IIa, LOE B).	not reviewed in 2015
2010	Precautions	Use only the force and tidal volume needed to just make the chest rise visibly (Class I, LOE C)	not reviewed in 2015
2010	Precautions	Avoid delivering excessive ventilation during cardiac arrest (Class III, LOE C).	not reviewed in 2015
2010	Precautions	If the infant or child is intubated, ventilate at a rate of about 1 breath every 6 to 8 seconds (8 to 10 times per minute) without interrupting chest compressions (Class I, LOE C).	not reviewed in 2015
2010	Precautions	It may be reasonable to do the same if an LMA is in place (Class IIb, LOE C).	not reviewed in 2015
2010	Precautions	In the victim with a perfusing rhythm but absent or inadequate respiratory effort, give 1 breath every 3 to 5 seconds (12 to 20 breaths per minute), using the higher rate for the younger child (Class I, LOE C).	not reviewed in 2015
2010	Two-Person Bag-Mask Ventilation	Apply cricoid pressure in an unresponsive victim to reduce air entry into the stomach (Class IIa, LOE B).	not reviewed in 2015
2010	Two-Person Bag-Mask Ventilation	Avoid excessive cricoid pressure so as not to obstruct the trachea (Class III, LOE B)	not reviewed in 2015
2010	Cricoid Pressure During Intubation	Do not continue cricoid pressure if it interferes with ventilation or the speed or ease of intubation (Class III, LOE C).	not reviewed in 2015
2010	Cuffed Versus Uncuffed Endotracheal Tubes	Both cuffed and uncuffed endotracheal tubes are acceptable for intubating infants and children (Class IIa, LOE C).	not reviewed in 2015
2010	Cuffed Versus Uncuffed Endotracheal Tubes	In certain circumstances (eg, poor lung compliance, high airway resistance, or a large glottic air leak) a cuffed endotracheal tube may be preferable to an uncuffed tube, provided that attention is paid to endotracheal tube size, position, and cuff inflation pressure (Class IIa, LOE B).	not reviewed in 2015
2010	Endotracheal Tube Size	For children between 1 and 2 years of age, it is reasonable to use a cuffed endotracheal tube with an internal diameter of 3.5 mm (Class IIa, LOE B).	not reviewed in 2015
2010	Endotracheal Tube Size	After age 2 it is reasonable to estimate tube size with the following formula (Class IIa, LOE B): Cuffed endotracheal tube ID (mm) 3.5+ (age/4).	not reviewed in 2015
2010	Esophageal Detector Device (EDD)	If capnography is not available, an esophageal detector device (EDD) may be considered to confirm endotracheal tube placement in children weighing >20 kg with a perfusing rhythm (Class IIb, LOE B), but the data are insufficient to make a recommendation for or against its use in children during cardiac arrest.	not reviewed in 2015
2010	Transtracheal Catheter Oxygenation and Ventilation	Attempt this procedure only after proper training and with appropriate equipment (Class IIb, LOE C).	not reviewed in 2015
2010	CPR Guidelines for Newborns With Cardiac Arrest of Cardiac Origin	It is reasonable to resuscitate newborns with a primary cardiac etiology of arrest, regardless of location, according to infant guidelines, with emphasis on chest compressions (Class IIa, LOE C).	not reviewed in 2015
2010	Echocardiography	When appropriately trained personnel are available, echocardiography may be considered to identify patients with potentially treatable causes of the arrest, particularly pericardial tamponade and inadequate ventricular filling (Class IIb, LOE C).	not reviewed in 2015
2010	Intraosseous (IO) Access	IO access is a rapid, safe, effective, and acceptable route for vascular access in children, and it is useful as the initial vascular access in cases of cardiac arrest (Class I, LOE C).	not reviewed in 2015
2010	Medication Dose Calculation	If the child's weight is unknown, it is reasonable to use a body length tape with precalculated doses (Class IIa, LOE C).	not reviewed in 2015

(*Continued*)

2015 Guidelines Update: Part 12 Recommendations, *Continued*

Year Last Reviewed	Topic	Recommendation	Comments
2010	Medication Dose Calculation	Regardless of the patient's habitus, use the actual body weight for calculating initial resuscitation drug doses or use a body length tape with precalculated doses (Class IIb, LOE C).	not reviewed in 2015
2010	Calcium	Calcium administration is not recommended for pediatric cardiopulmonary arrest in the absence of documented hypocalcemia, calcium channel blocker overdose, hypermagnesemia, or hyperkalemia (Class III, LOE B).	not reviewed in 2015
2010	Glucose	Check blood glucose concentration during the resuscitation and treat hypoglycemia promptly (Class I, LOE C).	not reviewed in 2015
2010	Sodium Bicarbonate	Routine administration of sodium bicarbonate is not recommended in cardiac arrest (Class III, LOE B).	not reviewed in 2015
2010	AEDs	If an AED with an attenuator is not available, use an AED with standard electrodes (Class IIa, LOE C).	not reviewed in 2015
2010	AEDs	An AED without a dose attenuator may be used if neither a manual defibrillator nor one with a dose attenuator is available (Class IIb, LOE C).	not reviewed in 2015
2010	Bradycardia	Continue to support airway, ventilation, oxygenation, and chest compressions (Class I, LOE B).	not reviewed in 2015
2010	Bradycardia	Emergency transcutaneous pacing may be lifesaving if the bradycardia is due to complete heart block or sinus node dysfunction unresponsive to ventilation, oxygenation, chest compressions, and medications, especially if it is associated with congenital or acquired heart disease (Class IIb, LOE C).	not reviewed in 2015
2010	Supraventricular Tachycardia	Attempt vagal stimulation first, unless the patient is hemodynamically unstable or the procedure will unduly delay chemical or electric cardioversion (Class IIa, LOE C).	not reviewed in 2015
2010	Supraventricular Tachycardia	An IV/IO dose of verapamil, 0.1 to 0.3 mg/kg is also effective in terminating SVT in older children, but it should not be used in infants without expert consultation (Class III, LOE C) because it may cause potential myocardial depression, hypotension, and cardiac arrest.	not reviewed in 2015
2010	Supraventricular Tachycardia	Use sedation, if possible. Start with a dose of 0.5 to 1 J/kg. If unsuccessful, increase the dose to 2 J/kg (Class IIb, LOE C).	not reviewed in 2015
2010	Supraventricular Tachycardia	Consider amiodarone 5 mg/kg IO/IV or procainamide 15 mg/kg IO/IV236 for a patient with SVT unresponsive to vagal maneuvers and adenosine and/or electric cardioversion; for hemodynamically stable patients, expert consultation is strongly recommended prior to administration (Class IIb, LOE C).	not reviewed in 2015
2010	Wide-Complex (>0.09 Second) Tachycardia	Consider electric cardioversion after sedation using a starting energy dose of 0.5 to 1 J/kg. If that fails, increase the dose to 2 J/kg (Class IIb, LOE C).	not reviewed in 2015
2010	Wide-Complex (>0.09 Second) Tachycardia	Electric cardioversion is recommended using a starting energy dose of 0.5 to 1 J/kg. If that fails, increase the dose to 2 J/kg (Class I, LOE C).	not reviewed in 2015
2010	Septic Shock	Early assisted ventilation may be considered as part of a protocol-driven strategy for septic shock (Class IIb, LOE C).	not reviewed in 2015
2010	Septic Shock	Etomidate has been shown to facilitate endotracheal intubation in infants and children with minimal hemodynamic effect, but do not use it routinely in pediatric patients with evidence of septic shock (Class III, LOE B).	not reviewed in 2015
2010	Trauma	Do not routinely hyperventilate even in case of head injury (Class III, LOE C).	not reviewed in 2015
2010	Trauma	If the patient has maxillofacial trauma or if you suspect a basilar skull fracture, insert an orogastric rather than a nasogastric tube (Class IIa, LOE C).	not reviewed in 2015
2010	Trauma	In the very select circumstances of children with cardiac arrest from penetrating trauma with short transport times, consider performing resuscitative thoracotomy (Class IIb, LOE C).	not reviewed in 2015
2010	Single Ventricle	Neonates in a prearrest state due to elevated pulmonary-to-systemic flow ratio prior to Stage I repair might benefit from a $Paco_2$ of 50 to 60 mm Hg, which can be achieved during mechanical ventilation by reducing minute ventilation, increasing the inspired fraction of CO_2, or administering opioids with or without chemical paralysis (Class IIb, LOE B).	not reviewed in 2015
2010	Single Ventricle	Neonates in a low cardiac output state following stage I repair may benefit from systemic vasodilators such as α-adrenergic antagonists (eg, phenoxybenzamine) to treat or ameliorate increased systemic vascular resistance, improve systemic oxygen delivery, and reduce the likelihood of cardiac arrest (Class IIa, LOE B).	not reviewed in 2015
2010	Single Ventricle	Other drugs that reduce systemic vascular resistance (eg, milrinone or nipride) may also be considered for patients with excessive Qp:Qs (Class IIa, LOE B).	not reviewed in 2015
2010	Single Ventricle	During cardiopulmonary arrest, it is reasonable to consider extracorporeal membrane oxygenation (ECMO) for patients with single ventricle anatomy who have undergone Stage I procedure (Class IIa, LOE B).	not reviewed in 2015

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2015 Guidelines Update: Part 12 Recommendations, *Continued*

Year Last Reviewed	Topic	Recommendation	Comments
2010	Single Ventricle	Hypoventilation may improve oxygen delivery in patients in a prearrest state with Fontan or hemi-Fontan/bidirectional Glenn (BDG) physiology (Class IIa, LOE B).	not reviewed in 2015
2010	Single Ventricle	Negative-pressure ventilation may improve cardiac output (Class IIa, LOE C).	not reviewed in 2015
2010	Single Ventricle	During cardiopulmonary arrest, it is reasonable to consider extracorporeal membrane oxygenation (ECMO) for patients with Fontan physiology (Class IIa, LOE C).	not reviewed in 2015
2010	Pulmonary Hypertension	If intravenous or inhaled therapy to decrease pulmonary hypertension has been interrupted, reinstitute it (Class IIa, LOE C).	not reviewed in 2015
2010	Pulmonary Hypertension	Consider administering inhaled nitric oxide (iNO) or aerosolized prostacyclin or analogue to reduce pulmonary vascular resistance (Class IIa, LOE C).	not reviewed in 2015
2010	Pulmonary Hypertension	If iNO is not available, consider giving an intravenous bolus of prostacyclin (Class IIa, LOE C).	not reviewed in 2015
2010	Pulmonary Hypertension	ECMO may be beneficial if instituted early in the resuscitation (Class IIa, LOE C).	not reviewed in 2015
2010	Cocaine	For coronary vasospasm consider nitroglycerin (Class IIa, LOE C), a benzodiazepine, and phentolamine (an α-adrenergic antagonist) (Class IIb, LOE C).	not reviewed in 2015
2010	Cocaine	Do not give β-adrenergic blockers (Class III, LOE C).	not reviewed in 2015
2010	Cocaine	For ventricular arrhythmia, consider sodium bicarbonate (1 to 2 mEq/kg) administration (Class IIb, LOE C) in addition to standard treatment.	not reviewed in 2015
2010	Cocaine	To prevent arrhythmias secondary to myocardial infarction, consider a lidocaine bolus followed by a lidocaine infusion (Class IIb, LOE C).	not reviewed in 2015
2010	Tricyclic Antidepressants and Other Sodium Channel Blockers	Do not administer Class IA (quinidine, procainamide), Class IC (flecainide, propafenone), or Class III (amiodarone and sotalol) antiarrhythmics, which may exacerbate cardiac toxicity (Class III, LOE C).	not reviewed in 2015
2010	Calcium Channel Blockers	The effectiveness of calcium administration is variable (Class IIb, LOE C).	not reviewed in 2015
2010	Calcium Channel Blockers	For bradycardia and hypotension, consider vasopressors and inotropes such as norepinephrine or epinephrine (Class IIb, LOE C).	not reviewed in 2015
2010	Beta-Adrenergic Blockers	High-dose epinephrine infusion may be effective (Class IIb, LOE C).	not reviewed in 2015
2010	Beta-Adrenergic Blockers	Consider glucagon (Class IIb, LOE C).	not reviewed in 2015
2010	Beta-Adrenergic Blockers	Consider an infusion of glucose and insulin (Class IIb, LOE C).	not reviewed in 2015
2010	Beta-Adrenergic Blockers	There are insufficient data to make a recommendation for or against using calcium (Class IIb, LOE C).	not reviewed in 2015
2010	Beta-Adrenergic Blockers	Calcium may be considered if glucagon and catecholamines are ineffective (Class IIb, LOE C).	not reviewed in 2015
2010	Opioids	Support of oxygenation and ventilation is the initial treatment for severe respiratory depression from any cause (Class I).	not reviewed in 2015
2010	Opioids	Naloxone reverses the respiratory depression of narcotic overdose (Class I, LOE B).	not reviewed in 2015
2010	Respiratory System	Monitor exhaled CO_2 (P_{ETCO_2}), especially during transport and diagnostic procedures (Class IIa, LOE B).	not reviewed in 2015
2010	Dopamine	Titrate dopamine to treat shock that is unresponsive to fluids and when systemic vascular resistance is low (Class IIb, LOE C).	not reviewed in 2015
2010	Inodilators	It is reasonable to use an inodilator in a highly monitored setting for treatment of myocardial dysfunction with increased systemic or pulmonary vascular resistance (Class IIa, LOE B).	not reviewed in 2015
2010	Neurologic System	It is reasonable for adolescents resuscitated from sudden, witnessed, out-of-hospital VF cardiac arrest (Class IIa, LOE C).	not reviewed in 2015
2010	Neurologic System	Monitor temperature continuously, if possible, and treat fever (>38°C) aggressively with antipyretics and cooling devices because fever adversely influences recovery from ischemic brain injury (Class IIa, LOE C).	not reviewed in 2015
2010	Interhospital Transport	Monitor exhaled CO_2 (qualitative colorimetric detector or capnography) during interhospital or intrahospital transport of intubated patients (Class IIa, LOE B).	not reviewed in 2015
2010	Family Presence During Resuscitation	Whenever possible, provide family members with the option of being present during resuscitation of an infant or child (Class I, LOE B).	not reviewed in 2015
2010	Family Presence During Resuscitation	If the presence of family members creates undue staff stress or is considered detrimental to the resuscitation, then family members should be respectfully asked to leave (Class IIa, LOE C).	not reviewed in 2015
2010	Sudden Unexplained Deaths	Refer families of patients that do not have a cause of death found on autopsy to a healthcare provider or center with expertise in arrhythmias (Class I, LOE C).	not reviewed in 2015

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Part 13: Neonatal Resuscitation

2015 American Heart Association Guidelines Update for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care

Myra H. Wyckoff, Chair; Khalid Aziz; Marilyn B. Escobedo; Vishal S. Kapadia; John Kattwinkel; Jeffrey M. Perlman; Wendy M. Simon; Gary M. Weiner; Jeanette G. Zaichkin

Introduction

The following guidelines are a summary of the evidence presented in the *2015 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science With Treatment Recommendations* (CoSTR).[1,2] Throughout the online version of this publication, live links are provided so the reader can connect directly to systematic reviews on the International Liaison Committee on Resuscitation (ILCOR) Scientific Evidence Evaluation and Review System (SEERS) website. These links are indicated by a combination of letters and numbers (eg, NRP 787). We encourage readers to use the links and review the evidence and appendices.

These guidelines apply primarily to newly born infants transitioning from intrauterine to extrauterine life. The recommendations are also applicable to neonates who have completed newborn transition and require resuscitation during the first weeks after birth.[3] Practitioners who resuscitate infants at birth or at any time during the initial hospitalization should consider following these guidelines. For purposes of these guidelines, the terms *newborn* and *neonate* apply to any infant during the initial hospitalization. The term *newly born* applies specifically to an infant at the time of birth.[3]

Immediately after birth, infants who are breathing and crying may undergo delayed cord clamping (see Umbilical Cord Management section). However, until more evidence is available, infants who are not breathing or crying should have the cord clamped (unless part of a delayed cord clamping research protocol), so that resuscitation measures can commence promptly.

Approximately 10% of newborns require some assistance to begin breathing at birth. Less than 1% require extensive resuscitation measures,[4] such as cardiac compressions and medications. Although most newly born infants successfully transition from intrauterine to extrauterine life without special help, because of the large total number of births, a significant number will require some degree of resuscitation.[3]

Newly born infants who do not require resuscitation can be generally identified upon delivery by rapidly assessing the answers to the following 3 questions:

- Term gestation?
- Good tone?
- Breathing or crying?

If the answer to all 3 questions is "yes," the newly born infant may stay with the mother for routine care. Routine care means the infant is dried, placed skin to skin with the mother, and covered with dry linen to maintain a normal temperature. Observation of breathing, activity, and color must be ongoing.

If the answer to any of these assessment questions is "no," the infant should be moved to a radiant warmer to receive 1 or more of the following 4 actions in sequence:

A. Initial steps in stabilization (warm and maintain normal temperature, position, clear secretions only if copious and/or obstructing the airway, dry, stimulate)
B. Ventilate and oxygenate
C. Initiate chest compressions
D. Administer epinephrine and/or volume

Approximately 60 seconds ("the Golden Minute") are allotted for completing the initial steps, reevaluating, and beginning ventilation if required (Figure 1). Although the 60-second mark is not precisely defined by science, it is important to avoid unnecessary delay in initiation of ventilation, because this is *the* most important step for successful resuscitation of the newly born who has not responded to the initial steps. The decision to progress beyond the initial steps is determined by simultaneous assessment of 2 vital characteristics: respirations (apnea, gasping, or labored or unlabored breathing) and heart rate (less than 100/min). Methods to accurately assess the heart rate will be discussed in detail in the section on Assessment of Heart Rate. Once positive-pressure ventilation (PPV) or supplementary oxygen administration is started, assessment should consist of simultaneous evaluation of 3 vital characteristics: heart rate, respirations, and oxygen saturation, as determined by pulse oximetry and discussed under Assessment of Oxygen Need and Administration of Oxygen. The most sensitive indicator of a successful response to each step is an increase in heart rate.[3]

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Anticipation of Resuscitation Need

Readiness for neonatal resuscitation requires assessment of perinatal risk, a system to assemble the appropriate personnel based on that risk, an organized method for ensuring immediate access to supplies and equipment, and standardization of behavioral skills that help assure effective teamwork and communication.

Every birth should be attended by at least 1 person who can perform the initial steps of newborn resuscitation and PPV, and whose only responsibility is care of the newborn. In the presence of significant perinatal risk factors that increase the likelihood of the need for resuscitation,[5,6] additional personnel with resuscitation skills, including chest compressions, endotracheal intubation, and umbilical vein catheter insertion, should be immediately available. Furthermore, because a newborn without apparent risk factors may unexpectedly require resuscitation, each institution should have a procedure in place for rapidly mobilizing a team with complete newborn resuscitation skills for any birth.

The neonatal resuscitation provider and/or team is at a major disadvantage if supplies are missing or equipment is not functioning. A standardized checklist to ensure that all necessary supplies and equipment are present and functioning may be helpful. A known perinatal risk factor, such as preterm birth, requires preparation of supplies specific to thermoregulation and respiratory support for this vulnerable population.

When perinatal risk factors are identified, a team should be mobilized and a team leader identified. As time permits,

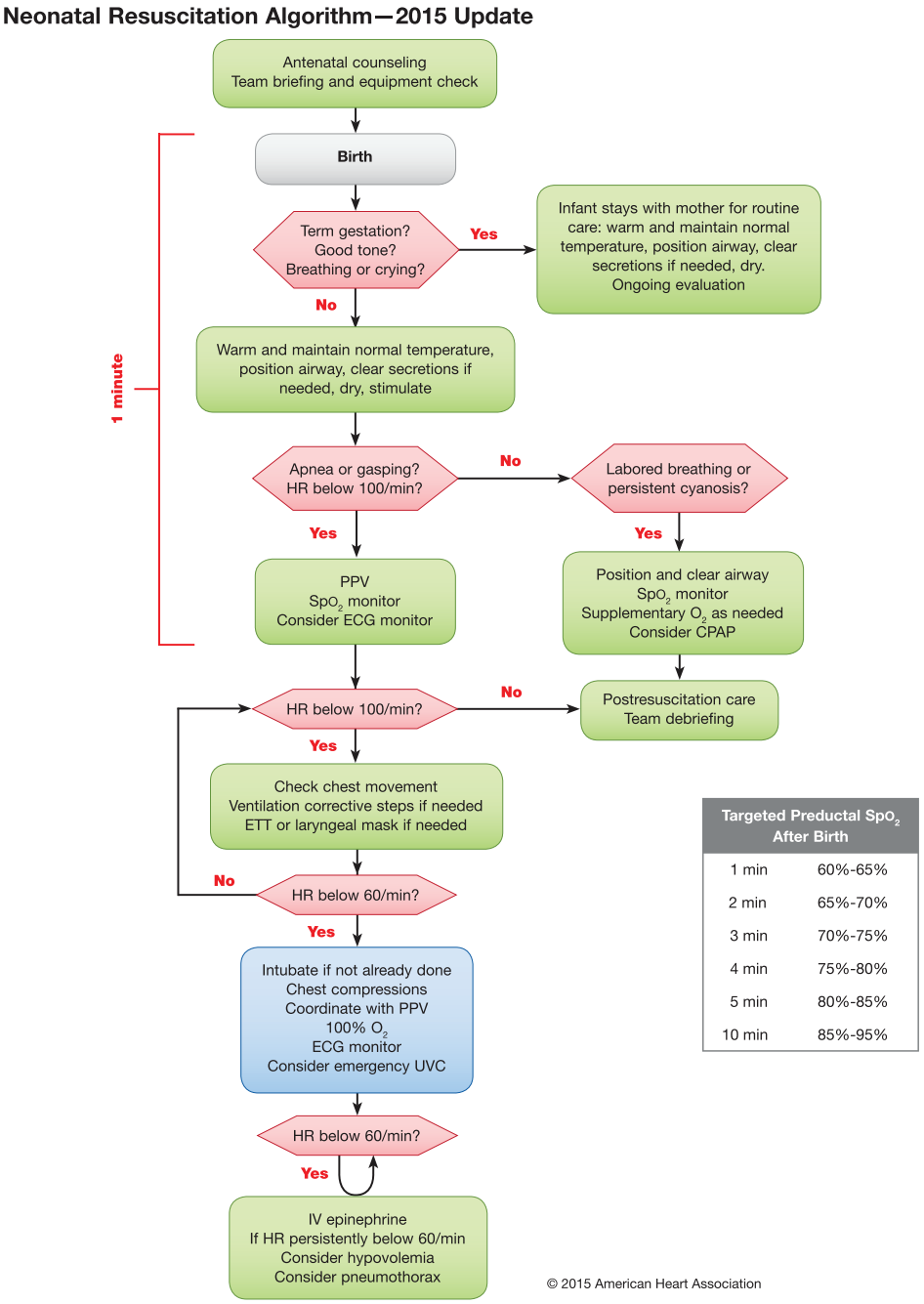

Figure 1. Neonatal Resuscitation Algorithm—2015 Update.

the leader should conduct a preresuscitation briefing, identify interventions that may be required, and assign roles and responsibilities to the team members.[7,8] During resuscitation, it is vital that the team demonstrates effective communication and teamwork skills to help ensure quality and patient safety.

Umbilical Cord Management[NRP 787, NRP 849]

Until recent years, a common practice has been to clamp the umbilical cord soon after birth to quickly transfer the infant to the neonatal team for stabilization. This immediate clamping was deemed particularly important for infants at high risk for difficulty with transition and those most likely to require resuscitation, such as infants born preterm. During the 2010 CoSTR review, evidence began to emerge suggesting that delayed cord clamping (DCC) might be beneficial for infants who did not need immediate resuscitation at birth.[7]

The 2015 ILCOR systematic review[NRP 787] confirms that DCC is associated with less intraventricular hemorrhage (IVH) of any grade, higher blood pressure and blood volume, less need for transfusion after birth, and less necrotizing enterocolitis. There was no evidence of decreased mortality or decreased incidence of severe IVH.[1,2] The studies were judged to be very low quality (downgraded for imprecision and very high risk of bias). The only negative consequence appears to be a slightly increased level of bilirubin, associated with more need for phototherapy. These findings have led to national recommendations that DCC be practiced when possible.[9,10] A major problem with essentially all of these studies has been that infants who were thought to require resuscitation were either withdrawn from the randomized controlled trials or electively were not enrolled. Therefore, there is no evidence regarding safety or utility of DCC for infants requiring resuscitation and some concern that the delay in establishing ventilation may be harmful. Some studies have suggested that cord "milking" might accomplish goals similar to DCC,[11–13] but there is insufficient evidence of either its safety or utility to suggest its routine use in the newly born, particularly in extremely preterm infants.

In summary, from the evidence reviewed in the 2010 CoSTR[7] and subsequent review of DCC and cord milking in preterm newborns in the 2015 ILCOR systematic review,[1,2] DCC for longer than 30 seconds is reasonable for both term and preterm infants who do not require resuscitation at birth (Class IIa, Level of Evidence [LOE] C-LD). There is insufficient evidence to recommend an approach to cord clamping for infants who require resuscitation at birth, and more randomized trials involving such infants are encouraged. In light of the limited information regarding the safety of rapid changes in blood volume for extremely preterm infants, we suggest against the routine use of cord milking for infants born at less than 29 weeks of gestation outside of a research setting. Further study is warranted because cord milking may improve initial mean blood pressure and hematologic indices and reduce intracranial hemorrhage, but thus far there is no evidence for improvement in long-term outcomes (Class IIb, LOE C-LD).

Initial Steps

The initial steps of newborn resuscitation are to maintain normal temperature of the infant, position the infant in a "sniffing" position to open the airway, clear secretions if needed with a bulb syringe or suction catheter, dry the infant (unless preterm and covered in plastic wrap), and stimulate the infant to breathe. Current examination of the evidence for these practices is summarized below.

Importance of Maintaining Normal Temperature in the Delivery Room[NRP 589]

It has long been recognized (since Budin's 1907 publication of *The Nursling*)[14] that the admission temperature of newly born nonasphyxiated infants is a strong predictor of mortality at all gestational ages.[15–49] Preterm infants are especially vulnerable. Hypothermia is also associated with serious morbidities, such as increased risk of IVH,[19,26,39,50–54] respiratory issues,[15,19,21,50,55–60] hypoglycemia,[15,44,60–64] and late-onset sepsis.[33,65] Because of this, admission temperature should be recorded as a predictor of outcomes as well as a quality indicator (Class I, LOE B-NR.) It is recommended that the temperature of newly born nonasphyxiated infants be maintained between 36.5°C and 37.5°C after birth through admission and stabilization (Class I, LOE C-LD).

Interventions to Maintain Newborn Temperature in the Delivery Room[NRP 599]

The use of radiant warmers and plastic wrap with a cap has improved but not eliminated the risk of hypothermia in preterm infants in the delivery room. Other strategies have been introduced, which include increased room temperature, thermal mattresses, and the use of warmed humidified resuscitation gases. Various combinations of these strategies may be reasonable to prevent hypothermia in infants born at less than 32 weeks of gestation (Class IIb, LOE B-R, B-NR, C-LD). Compared with plastic wrap and radiant warmer, the addition of a thermal mattress,[66–70] warmed humidified gases,[71,72] and increased room temperature plus cap plus thermal mattress[55,57,59,73] were all effective in reducing hypothermia. For all the studies, hyperthermia was a concern, but harm was not shown. Hyperthermia (greater than 38.0°C) should be avoided due to the potential associated risks (Class III: Harm, LOE C-EO).

Warming Hypothermic Newborns to Restore Normal Temperature[NRP 858]

The traditional recommendation for the method of rewarming neonates who are hypothermic after resuscitation has been that slower is preferable to faster rewarming to avoid complications such as apnea and arrhythmias. However, there is insufficient current evidence to recommend a preference for either rapid (0.5°C/h or greater) or slow rewarming (less than 0.5°C/h) of unintentionally hypothermic newborns (temperature less than 36°C) at hospital admission. Either approach to rewarming may be reasonable (Class IIb, LOE C-LD).

Effect of Maternal Hypothermia and Hyperthermia on the Neonate[NRP 804]

Maternal hyperthermia in labor is associated with adverse neonatal effects. These include increased mortality,[74,75] neonatal seizures,[74–80] and adverse neurologic states like encephalopathy.[81–84] Maternal hypothermia in labor has not been shown to be associated with clinically significant adverse neonatal outcomes at the time of birth.[85–89] Although maternal hyperthermia is associated with adverse neonatal outcomes, there is insufficient evidence to make a recommendation on the management of maternal hyperthermia.

Maintaining Normothermia in Resource-Limited Settings[NRP 793]

The ability to maintain temperature in resource-limited settings after birth is a significant problem,[40] with a dose-dependent increase in mortality for temperatures below 36.5°C. Premature newborns are at much higher risk than those born at term. Simple interventions to prevent hypothermia during transition (birth until 1 to 2 hours of life) reduce mortality. During transition, the use of plastic wraps[90–92] and the use of skin-to-skin contact[93–100] reduce hypothermia.

In resource-limited settings, to maintain body temperature or prevent hypothermia during transition (birth until 1 to 2 hours of life) in well newborn infants, it may be reasonable to put them in a clean food-grade plastic bag up to the level of the neck and swaddle them after drying (Class IIb, LOE C-LD). Another option that may be reasonable is to nurse such newborns with skin-to-skin contact or kangaroo mother care (Class IIb, LOE C-LD). There are no data examining the use of plastic wraps or skin-to-skin contact during resuscitation/stabilization in resource-limited settings.

Clearing the Airway

When Amniotic Fluid Is Clear

This topic was last reviewed in 2010.[3] Suctioning immediately after birth, whether with a bulb syringe or suction catheter, may be considered only if the airway appears obstructed or if PPV is required. Avoiding unnecessary suctioning helps prevent the risk of induced bradycardia due to suctioning of the nasopharynx.[101,102] Deterioration of pulmonary compliance, oxygenation, and cerebral blood flow velocity shown to accompany tracheal suction in intubated infants in the neonatal intensive care unit also suggests the need for caution in the use of suction immediately after birth.[103–105] This recommendation remains unchanged. Please refer to the 2010 CoSTR for the latest science review.[7,8]

When Meconium Is Present[NRP 865]

Since the mid-1970s, interventions to decrease the mortality and morbidity of meconium aspiration syndrome in infants who are born through meconium-stained amniotic fluid have been recommended. The practice of universal oropharyngeal suctioning of the fetus on the perineum followed by routine intubation and suctioning of the trachea at birth was generally practiced for many years. This practice was abandoned over a decade ago after a large multicenter, multinational randomized clinical trial provided evidence that newborns born through meconium-stained amniotic fluid who were vigorous at birth did not benefit from intervention and could avoid the risk of intubation.[106]

Because the presence of meconium-stained amniotic fluid may indicate fetal distress and increases the risk that the infant will require resuscitation after birth, a team that includes an individual skilled in tracheal intubation should be present at the time of birth. If the infant is vigorous with good respiratory effort and muscle tone, the infant may stay with the mother to receive the initial steps of newborn care. Gentle clearing of meconium from the mouth and nose with a bulb syringe may be done if necessary.

However, if the infant born through meconium-stained amniotic fluid presents with poor muscle tone and inadequate breathing efforts, the initial steps of resuscitation should be completed under the radiant warmer. PPV should be initiated if the infant is not breathing or the heart rate is less than 100/min after the initial steps are completed.

Routine intubation for tracheal suction in this setting is not suggested, because there is insufficient evidence to continue recommending this practice (Class IIb, LOE C-LD). In making this suggested change, greater value has been placed on harm avoidance (ie, delays in providing bag-mask ventilation, potential harm of the procedure) over the unknown benefit of the intervention of routine tracheal intubation and suctioning. Therefore, emphasis should be made on initiating ventilation within the first minute of life in nonbreathing or ineffectively breathing infants.

Although a definitive randomized clinical trial is still needed, current published human evidence does not support a recommendation for routine intervention of intubation and suction for the nonvigorous newborn with meconium-stained amniotic fluid.[107–116] Appropriate intervention to support ventilation and oxygenation should be initiated as indicated for each individual infant. This may include intubation and suction if the airway is obstructed.

Assessment of Heart Rate[NRP 898]

Immediately after birth, assessment of the newborn's heart rate is used to evaluate the effectiveness of spontaneous respiratory effort and determine the need for subsequent interventions. During resuscitation, an increase in the newborn's heart rate is considered the most sensitive indicator of a successful response to each intervention. Therefore, identifying a rapid, reliable, and accurate method to measure the newborn's heart rate is critically important. In previous treatment guidelines, auscultation of the precordium was recommended as the preferred physical examination method, and pulse oximetry was recommended as an adjunct to provide a noninvasive, rapid, and continuous assessment of heart rate during resuscitation.[3]

The 2015 ILCOR systematic review evaluated 1 study comparing clinical assessment with electrocardiography (ECG) in the delivery room[117] and 5 studies comparing simultaneous pulse oximetry and ECG.[118–122] Clinical assessment was found to be both unreliable and inaccurate. Among healthy newborns, providers frequently could not palpate the umbilical pulse and underestimated the newborn's heart rate by auscultation or palpation.[117] Four studies found that 3-lead ECG displayed a reliable heart rate faster than pulse oximetry.[118,120–122] In 2 studies, ECG was more likely to detect the newborn's heart rate during the first minute of life.[120,121] Although the mean differences between the series of heart rates measured by ECG and pulse oximetry were small, pulse oximetry tended to underestimate the newborn's heart rate and would have led to potentially unnecessary interventions.[118,119,122] During the first 2 minutes of life, pulse oximetry frequently displayed the newborn's heart rate below either 60/min or 100/min, while a simultaneous ECG showed the heart rate greater than 100/min.[122]

Many of the newborns included in the studies did not require resuscitation, and very few required chest compressions. The majority of the studies did not report any difficulties with applying the leads.[118–120]

During resuscitation of term and preterm newborns, the use of 3-lead ECG for the rapid and accurate measurement of the newborn's heart rate may be reasonable (Class IIb, LOE C-LD). The use of ECG does not replace the need for pulse oximetry to evaluate the newborn's oxygenation.

Assessment of Oxygen Need and Administration of Oxygen

Use of Pulse Oximetry

This topic was last reviewed in 2010.[3] It is recommended that oximetry be used when resuscitation can be anticipated, when PPV is administered, when central cyanosis persists beyond the first 5 to 10 minutes of life, or when supplementary oxygen is administered.

Administration of Oxygen

Term Infants

This topic was last reviewed in 2010.[3] It is reasonable to initiate resuscitation with air (21% oxygen at sea level). Supplementary oxygen may be administered and titrated to achieve a preductal oxygen saturation approximating the interquartile range measured in healthy term infants after vaginal birth at sea level.[7,8,123]

Preterm[NRP 864]

Meta-analysis of 7 randomized trials that compared initiating resuscitation of preterm newborns (less than 35 weeks of gestation) with high oxygen (65% or greater) and low oxygen (21% to 30%) showed no improvement in survival to hospital discharge with the use of high oxygen.[124–130] Similarly, in the subset of studies that evaluated these outcomes, no benefit was seen for the prevention of bronchopulmonary dysplasia,[125,127–130] IVH,[125,128–130] or retinopathy of prematurity.[125,128,129] When oxygen targeting was used as a cointervention, the oxygen concentration of resuscitation gas and the preductal oxygen saturation were similar between the high-oxygen and low-oxygen groups within the first 10 minutes of life.[125,128–130]

In all studies, irrespective of whether air or high oxygen (including 100%) was used to initiate resuscitation, most infants were in approximately 30% oxygen by the time of stabilization. Resuscitation of preterm newborns of less than 35 weeks of gestation should be initiated with low oxygen (21% to 30%), and the oxygen concentration should be titrated to achieve preductal oxygen saturation approximating the interquartile range measured in healthy term infants after vaginal birth at sea level[123] (Class I, LOE B-R). Initiating resuscitation of preterm newborns with high oxygen (65% or greater) is not recommended (Class III: No Benefit, LOE B-R). This recommendation reflects a preference for not exposing preterm newborns to additional oxygen without data demonstrating a proven benefit for important outcomes.

Positive Pressure Ventilation

Initial Breaths[NRP 809]

Several recent animal studies have suggested that a longer sustained inflation may be beneficial for establishing functional residual capacity during transition from fluid-filled to air-filled lungs after birth.[131,132] Some clinicians have suggested applying this technique for transition of human newborns. Review of the literature in 2015 identified 3 randomized controlled trials[133–135] and 2 cohort studies[136,137] that demonstrated a benefit of sustained inflation for reducing need for mechanical ventilation (very low quality of evidence, downgraded for variability of interventions). However, no benefit was found for reduction of mortality, bronchopulmonary dysplasia, or air leak. One cohort study[136] suggested that the need for intubation was less after sustained inflation.

There are insufficient data regarding short and long-term safety and the most appropriate duration and pressure of inflation to support routine application of sustained inflation of greater than 5 seconds' duration to the transitioning newborn (Class IIb, LOE B-R). Further studies using carefully designed protocols are needed.

End-Expiratory Pressure[NRP 897]

Administration of PPV is the standard recommended treatment for both preterm and term infants who are apneic. A flow-inflating or self-inflating resuscitation bag or T-piece resuscitator are appropriate devices to use for PPV. In the 2010 Guidelines[3] and based on experience with delivering PPV in the neonatal intensive care unit, the use of positive end-expiratory pressure (PEEP) was speculated to be beneficial when PPV is administered to the newly born, but no published evidence was available to support this recommendation. PEEP was evaluated again in 2015, and 2 randomized controlled trials[138,139] suggested that addition of PEEP during delivery room resuscitation of preterm newborns resulted in no improvement in mortality, no less need for cardiac drugs or chest compressions, no more rapid improvement in heart rate, no less need for intubation, no change in pulmonary air leaks, no less chronic lung disease, and no effect on Apgar scores, although the studies were underpowered to have sufficient confidence in a no-difference conclusion. However, 1 of the trials[139] provided low-quality evidence that the maximum amount of supplementary oxygen required to achieve target oxygen saturation may be slightly less when using PEEP. In 2015, the Neonatal Resuscitation ILCOR and Guidelines Task Forces repeated their 2010 recommendation that, when PPV is administered to preterm newborns, use of approximately 5 cm H_2O PEEP is suggested (Class IIb, LOE B-R). This will require the addition of a PEEP valve for self-inflating bags.

Assisted-Ventilation Devices and Advanced Airways[NRP 870, NRP 806]

PPV can be delivered effectively with a flow-inflating bag, self-inflating bag, or T-piece resuscitator[138,139] (Class IIa, LOE B-R). The most appropriate choice may be guided by available resources, local expertise, and preferences. The self-inflating bag remains the only device that can be used when a compressed gas source is not available. Unlike flow-inflating bags or T-piece resuscitators, self-inflating bags cannot deliver continuous positive airway pressure (CPAP) and may not be able to achieve PEEP reliably during PPV, even with a PEEP valve.[140–143] However, it may take more practice to use a flow-inflating bag effectively. In addition to ease of use, T-piece resuscitators can consistently provide target inflation pressures and longer inspiratory times in mechanical models,[144–146]

but there is insufficient evidence to suggest that these qualities result in improved clinical outcomes.[138,139]

Use of respiratory mechanics monitors have been reported to prevent excessive pressures and tidal volumes[147] and exhaled CO_2 monitors may help assess that actual gas exchange is occurring during face-mask PPV attempts.[148] Although use of such devices is feasible, thus far their effectiveness, particularly in changing important outcomes, has not been established (Class IIb, LOE C-LD).

Laryngeal Mask[NRP 618]

Laryngeal masks, which fit over the laryngeal inlet, can facilitate effective ventilation in term and preterm newborns at 34 weeks or more of gestation. Data are limited for their use in preterm infants delivered at less than 34 weeks of gestation or who weigh less than 2000 g. A laryngeal mask may be considered as an alternative to tracheal intubation if face-mask ventilation is unsuccessful in achieving effective ventilation[149] (Class IIb, LOE B-R). A laryngeal mask is recommended during resuscitation of term and preterm newborns at 34 weeks or more of gestation when tracheal intubation is unsuccessful or is not feasible (Class I, LOE C-EO). Use of the laryngeal mask has not been evaluated during chest compressions or for administration of emergency medications.

Endotracheal Tube Placement

During neonatal resuscitation, endotracheal intubation may be indicated when bag-mask ventilation is ineffective or prolonged, when chest compressions are performed, or for special circumstances such as congenital diaphragmatic hernia. When PPV is provided through an endotracheal tube, the best indicator of successful endotracheal intubation with successful inflation and aeration of the lungs is a prompt increase in heart rate. Although last reviewed in 2010,[3] exhaled CO_2 detection remains the most reliable method of confirmation of endotracheal tube placement.[7,8] Failure to detect exhaled CO_2 in neonates with adequate cardiac output strongly suggests esophageal intubation. Poor or absent pulmonary blood flow (eg, during cardiac arrest) may result in failure to detect exhaled CO_2 despite correct tube placement in the trachea and may result in unnecessary extubation and reintubation in these critically ill newborns.[3] Clinical assessment such as chest movement, presence of equal breath sounds bilaterally, and condensation in the endotracheal tube are additional indicators of correct endotracheal tube placement.

Continuous Positive Airway Pressure[NRP 590]

Three randomized controlled trials enrolling 2358 preterm infants born at less than 30 weeks of gestation demonstrated that starting newborns on CPAP may be beneficial when compared with endotracheal intubation and PPV.[150–152] Starting CPAP resulted in decreased rate of intubation in the delivery room, decreased duration of mechanical ventilation with potential benefit of reduction of death and/or bronchopulmonary dysplasia, and no significant increase in air leak or severe IVH. Based on this evidence, spontaneously breathing preterm infants with respiratory distress may be supported with CPAP initially rather than routine intubation for administering PPV (Class IIb, LOE B-R).

Chest Compressions[NRP 605, NRP 895, NRP 738, NRP 862]

If the heart rate is less than 60/min despite adequate ventilation (via endotracheal tube if possible), chest compressions are indicated. Because ventilation is the most effective action in neonatal resuscitation and because chest compressions are likely to compete with effective ventilation, rescuers should ensure that assisted ventilation is being delivered optimally before starting chest compressions.[3]

Compressions are delivered on the lower third of the sternum[153–156] to a depth of approximately one third of the anterior-posterior diameter of the chest (Class IIb, LOE C-LD).[157] Two techniques have been described: compression with 2 thumbs with the fingers encircling the chest and supporting the back (the 2-thumb technique) or compression with 2 fingers with a second hand supporting the back (the 2-finger technique). Because the 2-thumb technique generates higher blood pressure and coronary perfusion pressure with less rescuer fatigue, the 2 thumb–encircling hands technique is suggested as the preferred method[158–172] (Class IIb, LOE C-LD). Because the 2-thumb technique can be continued from the head of the bed while the umbilicus is accessed for insertion of an umbilical catheter, the 2-finger technique is no longer needed.

It is still suggested that compressions and ventilations be coordinated to avoid simultaneous delivery. The chest should be allowed to re-expand fully during relaxation, but the rescuer's thumbs should not leave the chest. The Neonatal Resuscitation ILCOR and Guidelines Task Forces continue to support use of a 3:1 ratio of compressions to ventilation, with 90 compressions and 30 breaths to achieve approximately 120 events per minute to maximize ventilation at an achievable rate[173–178] (Class IIa, LOE C-LD). Thus, each event will be allotted approximately a half of a second, with exhalation occurring during the first compression after each ventilation. A 3:1 compression-to-ventilation ratio is used for neonatal resuscitation where compromise of gas exchange is nearly always the primary cause of cardiovascular collapse, but rescuers may consider using higher ratios (eg, 15:2) if the arrest is believed to be of cardiac origin (Class IIb, LOE C-EO).

The Neonatal Guidelines Writing Group endorses increasing the oxygen concentration to 100% whenever chest compressions are provided (Class IIa, LOE C-EO). There are no available clinical studies regarding oxygen use during neonatal CPR. Animal evidence shows no advantage to 100% oxygen during CPR.[179–186] However, by the time resuscitation of a newborn infant has reached the stage of chest compressions, efforts to achieve return of spontaneous circulation using effective ventilation with low-concentration oxygen should have been attempted. Thus, it would appear sensible to try increasing the supplementary oxygen concentration. To reduce the risks of complications associated with hyperoxia, the supplementary oxygen concentration should be weaned as soon as the heart rate recovers (Class I, LOE C-LD).

The current measure for determining successful progress in neonatal resuscitation is to assess the heart rate response. Other devices, such as end-tidal CO_2 monitoring and pulse oximetry, may be useful techniques to determine when return of spontaneous circulation occurs.[187–191] However, in asystolic/bradycardic neonates, we suggest

against the routine use of any single feedback device such as $ETCO_2$ monitors or pulse oximeters for detection of return of spontaneous circulation, as their usefulness for this purpose in neonates has not been well established (Class IIb, LOE C-LD).

Medications

Drugs are rarely indicated in resuscitation of the newly born infant. Bradycardia in the newborn infant is usually the result of inadequate lung inflation or profound hypoxemia, and establishing adequate ventilation is the most important step to correct it. However, if the heart rate remains less than 60/min despite adequate ventilation with 100% oxygen (preferably through an endotracheal tube) and chest compressions, administration of epinephrine or volume, or both, is indicated.[3]

Epinephrine

This topic was last reviewed in 2010.[3] Dosing recommendations remain unchanged from 2010.[7,8] Intravenous administration of epinephrine may be considered at a dose of 0.01 to 0.03 mg/kg of 1:10 000 epinephrine. If endotracheal administration is attempted while intravenous access is being established, higher dosing at 0.05 to 0.1 mg/kg may be reasonable. Given the lack of supportive data for endotracheal epinephrine, it is reasonable to provide drugs by the intravenous route as soon as venous access is established.

Volume Expansion

This topic was last reviewed in 2010.[3] Dosing recommendations remain unchanged from 2010.[7,8] Volume expansion may be considered when blood loss is known or suspected (pale skin, poor perfusion, weak pulse) and the infant's heart rate has not responded adequately to other resuscitative measures. An isotonic crystalloid solution or blood may be considered for volume expansion in the delivery room. The recommended dose is 10 mL/kg, which may need to be repeated. When resuscitating premature infants, it is reasonable to avoid giving volume expanders rapidly, because rapid infusions of large volumes have been associated with IVH.[3]

Postresuscitation Care

Infants who require resuscitation are at risk of deterioration after their vital signs have returned to normal. Once effective ventilation and/or the circulation has been established, the infant should be maintained in or transferred to an environment where close monitoring and anticipatory care can be provided.

Glucose

In the 2010 Guidelines, the potential role of glucose in modulating neurologic outcome after hypoxia-ischemia was identified. Lower glucose levels were associated with an increased risk for brain injury, while increased glucose levels may be protective. However, it was not possible to recommend a specific protective target glucose concentration range. There are no new data to change this recommendation.[7,8]

Induced Therapeutic Hypothermia

Resource-Abundant Areas

Induced therapeutic hypothermia was last reviewed in 2010; at that time it was recommended that infants born at more than 36 weeks of gestation with evolving moderate-to-severe hypoxic-ischemic encephalopathy should be offered therapeutic hypothermia under clearly defined protocols similar to those used in published clinical trials and in facilities with the capabilities for multidisciplinary care and longitudinal follow-up (Class IIa, LOE A).[7,8] This recommendation remains unchanged.

Resource-Limited Areas[NRP 734]

Evidence suggests that use of therapeutic hypothermia in resource-limited settings (ie, lack of qualified staff, inadequate equipment, etc) may be considered and offered under clearly defined protocols similar to those used in published clinical trials and in facilities with the capabilities for multidisciplinary care and longitudinal follow-up[192–195] (Class IIb, LOE B-R).

Guidelines for Withholding and Discontinuing

Data reviewed for the 2010 Guidelines regarding management of neonates born at the margins of viability or those with conditions that predict a high risk of mortality or morbidity document wide variation in attitudes and practice by region and availability of resources. Additionally, parents desire a larger role in decisions related to initiation of resuscitation and continuation of support of severely compromised newborns. Noninitiation of resuscitation and discontinuation of life-sustaining treatment during or after resuscitation are considered ethically equivalent. The 2010 Guidelines provide suggestions for when resuscitation is not indicated, when it is nearly always indicated, and that under circumstances when outcome remains unclear, that the desires of the parents should be supported. No new data have been published that would justify a change to these guidelines as published in 2010.[7,8]

Antenatal assignment of prognosis for survival and/or disability of the neonate born extremely preterm has generally been made on the basis of gestational age alone. Scoring systems for including additional variables such as gender, use of maternal antenatal steroids, and multiplicity have been developed in an effort to improve prognostic accuracy. Indeed, it was suggested in the 2010 Guidelines that decisions regarding morbidity and risks of morbidity may be augmented by the use of published tools based on data from specific populations.

Withholding Resuscitation[NRP 805]

There is no evidence to support the prospective use of any particular delivery room prognostic score presently available over gestational age assessment alone, in preterm infants at less than 25 weeks of gestation. Importantly, no score has been shown to improve the clinician's ability to estimate likelihood of survival through the first 18 to 22 months after birth. However, in individual cases, when counseling a family

and constructing a prognosis for survival at gestations below 25 weeks, it is reasonable to consider variables such as perceived accuracy of gestational age assignment, the presence or absence of chorioamnionitis, and the level of care available for location of delivery. Decisions about appropriateness of resuscitation below 25 weeks of gestation will be influenced by region-specific guidelines. In making this statement, a higher value was placed on the lack of evidence for a generalized prospective approach to changing important outcomes over improved retrospective accuracy and locally validated counseling policies. The most useful data for antenatal counseling provides outcome figures for infants alive at the onset of labor, not only for those born alive or admitted to a neonatal intensive care unit[196–200] (Class IIb, LOE C-LD).

Discontinuing Resuscitative Efforts[NRP 896]

An Apgar score of 0 at 10 minutes is a strong predictor of mortality and morbidity in late preterm and term infants. We suggest that, in infants with an Apgar score of 0 after 10 minutes of resuscitation, if the heart rate remains undetectable, it may be reasonable to stop assisted ventilation; however, the decision to continue or discontinue resuscitative efforts must be individualized. Variables to be considered may include whether the resuscitation was considered optimal; availability of advanced neonatal care, such as therapeutic hypothermia; specific circumstances before delivery (eg, known timing of the insult); and wishes expressed by the family[201–206] (Class IIb, LOE C-LD).

Briefing/Debriefing

This topic was last reviewed in 2010.[3] It is still suggested that briefing and debriefing techniques be used whenever possible for neonatal resuscitation.

Structure of Educational Programs to Teach Neonatal Resuscitation

Instructors[NRP 867]

In studies that looked at the preparation of instructors for the training of healthcare providers, there was no association between the preparation provided and instructor or learner performance.[207–214] Until more research is available to clarify the optimal instructor training methodology, it is suggested that neonatal resuscitation instructors be trained using timely, objective, structured, and individually targeted verbal and/or written feedback (Class IIb, LOE C-EO).

Resuscitation Providers[NRP 859]

The 2010 Guidelines suggested that simulation should become a standard component in neonatal resuscitation training.[3,6,215] Studies that explored how frequently healthcare providers or healthcare students should train showed no differences in patient outcomes (LOE C-EO) but were able to show some advantages in psychomotor performance (LOE B-R) and knowledge and confidence (LOE C-LD) when focused training occurred every 6 months or more frequently.[216–231] It is therefore suggested that neonatal resuscitation task training occur more frequently than the current 2-year interval (Class IIb, LOE B-R).

Disclosures

Part 13: Neonatal Resuscitation: 2015 Guidelines Update Writing Group Disclosures

Writing Group Member	Employment	Research Grant	Other Research Support	Speakers' Bureau/ Honoraria	Expert Witness	Ownership Interest	Consultant/ Advisory Board	Other
Myra H. Wyckoff	UT Southwestern Medical School	None	None	None	None	None	None	None
Khalid Aziz	Royal Alexandra Hospital	None	None	None	None	None	None	None
Marilyn B. Escobedo	University of Oklahoma Medical School	None	None	None	None	None	None	None
Vishal S. Kapadia	UT Southwestern	None	Neonatal Resuscitation Program*; NIH/NCATS KL2TR001103†	None	None	None	None	None
John Kattwinkel	University of Virginia Health System	None	None	None	None	None	None	None
Jeffrey M. Perlman	Weill Cornell Medical College	None	Laerdal Foundation for Global Health*	None	None	None	None	None
Wendy M. Simon	American Academy of Pediatrics	None	None	None	None	None	None	None
Gary M. Weiner	University of Michigan	None	None	None	None	None	American Academy of Pediatrics†	None
Jeanette G. Zaichkin	Self-employed	None	None	None	None	None	American Academy of Pediatrics†	None

This table represents the relationships of writing group members that may be perceived as actual or reasonably perceived conflicts of interest as reported on the Disclosure Questionnaire, which all members of the writing group are required to complete and submit. A relationship is considered to be "significant" if (a) the person receives $10 000 or more during any 12-month period, or 5% or more of the person's gross income; or (b) the person owns 5% or more of the voting stock or share of the entity, or owns $10 000 or more of the fair market value of the entity. A relationship is considered to be "modest" if it is less than "significant" under the preceding definition.

*Modest.

†Significant.

Appendix

2015 Guidelines Update: Part 13 Recommendations

Year Last Reviewed	Topic	Recommendation	Comments
2015	Umbilical Cord Management	In summary, from the evidence reviewed in the 2010 CoSTR and subsequent review of DCC and cord milking in preterm newborns in the 2015 ILCOR systematic review, DCC for longer than 30 seconds is reasonable for both term and preterm infants who do not require resuscitation at birth (Class IIa, LOE C-LD).	new for 2015
2015	Umbilical Cord Management	There is insufficient evidence to recommend an approach to cord clamping for infants who require resuscitation at birth and more randomized trials involving such infants are encouraged. In light of the limited information regarding the safety of rapid changes in blood volume for extremely preterm infants, we suggest against the routine use of cord milking for infants born at less than 29 weeks of gestation outside of a research setting. Further study is warranted because cord milking may improve initial mean blood pressure, hematologic indices, and reduce intracranial hemorrhage, but thus far there is no evidence for improvement in long-term outcomes (Class IIb, LOE C-LD).	new for 2015
2015	Importance of Maintaining Normal Temperature in the Delivery Room	Preterm infants are especially vulnerable. Hypothermia is also associated with serious morbidities, such as increased respiratory issues, hypoglycemia, and late-onset sepsis. Because of this, admission temperature should be recorded as a predictor of outcomes as well as a quality indicator (Class I, LOE B-NR).	new for 2015
2015	Importance of Maintaining Normal Temperature in the Delivery Room	It is recommended that the temperature of newly born nonasphyxiated infants be maintained between 36.5°C and 37.5°C after birth through admission and stabilization (Class I, LOE C-LD).	new for 2015
2015	Interventions to Maintain Newborn Temperature in the Delivery Room	The use of radiant warmers and plastic wrap with a cap has improved but not eliminated the risk of hypothermia in preterms in the delivery room. Other strategies have been introduced, which include increased room temperature, thermal mattresses, and the use of warmed humidified resuscitation gases. Various combinations of these strategies may be reasonable to prevent hypothermia in infants born at less than 32 weeks of gestation (Class IIb, LOE B-R, B-NR, C-LD).	updated for 2015
2015	Interventions to Maintain Newborn Temperature in the Delivery Room	Compared with plastic wrap and radiant warmer, the addition of a thermal mattress, warmed humidified gases and increased room temperature plus cap plus thermal mattress were all effective in reducing hypothermia. For all the studies, hyperthermia was a concern, but harm was not shown. Hyperthermia (greater than 38.0°C) should be avoided due to the potential associated risks (Class III: Harm, LOE C-EO).	updated for 2015
2015	Warming Hypothermic Newborns to Restore Normal Temperature	The traditional recommendation for the method of rewarming neonates who are hypothermic after resuscitation has been that slower is preferable to faster rewarming to avoid complications such as apnea and arrhythmias. However, there is insufficient current evidence to recommend a preference for either rapid (0.5°C/h or greater) or slow rewarming (less than 0.5°C/h) of unintentionally hypothermic newborns (temperature less than 36°C) at hospital admission. Either approach to rewarming may be reasonable (Class IIb, LOE C-LD).	new for 2015
2015	Maintaining Normothermia in Resource-Limited Settings	In resource-limited settings, to maintain body temperature or prevent hypothermia during transition (birth until 1 to 2 hours of life) in well newborn infants, it may be reasonable to put them in a clean food-grade plastic bag up to the level of the neck and swaddle them after drying (Class IIb, LOE C-LD).	new for 2015
2015	Maintaining Normothermia in Resource-Limited Settings	Another option that may be reasonable is to nurse such newborns with skin-to-skin contact or kangaroo mother care (Class IIb, LOE C-LD).	new for 2015
2015	Clearing the Airway When Meconium Is Present	However, if the infant born through meconium-stained amniotic fluid presents with poor muscle tone and inadequate breathing efforts, the initial steps of resuscitation should be completed under the radiant warmer. PPV should be initiated if the infant is not breathing or the heart rate is less than 100/min after the initial steps are completed. Routine intubation for tracheal suction in this setting is not suggested, because there is insufficient evidence to continue recommending this practice (Class IIb, LOE C-LD).	updated for 2015
2015	Assessment of Heart Rate	During resuscitation of term and preterm newborns, the use of 3-lead ECG for the rapid and accurate measurement of the newborn's heart rate may be reasonable (Class IIb, LOE C-LD).	new for 2015
2015	Administration of Oxygen in Preterm Infants	In all studies, irrespective of whether air or high oxygen (including 100%) was used to initiate resuscitation, most infants were in approximately 30% oxygen by the time of stabilization. Resuscitation of preterm newborns of less than 35 weeks of gestation should be initiated with low oxygen (21% to 30%), and the oxygen concentration should be titrated to achieve preductal oxygen saturation approximating the interquartile range measured in healthy term infants after vaginal birth at sea level (Class I, LOE B-R).	new for 2015

(*Continued*)

2015 Guidelines Update: Part 13 Recommendations, *Continued*

Year Last Reviewed	Topic	Recommendation	Comments
2015	Administration of Oxygen	Initiating resuscitation of preterm newborns with high oxygen (65% or greater) is not recommended (Class III: No Benefit, LOE B-R).	new for 2015
2015	Positive Pressure Ventilation (PPV)	There is insufficient data regarding short and long-term safety and the most appropriate duration and pressure of inflation to support routine application of sustained inflation of greater than 5 seconds' duration to the transitioning newborn (Class IIb, LOE B-R).	new for 2015
2015	Positive Pressure Ventilation (PPV)	In 2015, the Neonatal Resuscitation ILCOR and Guidelines Task Forces repeated their 2010 recommendation that, when PPV is administered to preterm newborns, approximately 5 cm H_2O PEEP is suggested (Class IIb, LOE B-R).	updated for 2015
2015	Positive Pressure Ventilation (PPV)	PPV can be delivered effectively with a flow-inflating bag, self-inflating bag, or T-piece resuscitator (Class IIa, LOE B-R).	updated for 2015
2015	Positive Pressure Ventilation (PPV)	Use of respiratory mechanics monitors have been reported to prevent excessive pressures and tidal volumes and exhaled CO_2 monitors may help assess that actual gas exchange is occurring during face-mask PPV attempts. Although use of such devices is feasible, thus far their effectiveness, particularly in changing important outcomes, has not been established (Class IIb, LOE C-LD).	new for 2015
2015	Positive Pressure Ventilation (PPV)	Laryngeal masks, which fit over the laryngeal inlet, can achieve effective ventilation in term and preterm newborns at 34 weeks or more of gestation. Data are limited for their use in preterm infants delivered at less than 34 weeks of gestation or who weigh less than 2000 g. A laryngeal mask may be considered as an alternative to tracheal intubation if face-mask ventilation is unsuccessful in achieving effective ventilation (Class IIb, LOE B-R).	updated for 2015
2015	Positive Pressure Ventilation (PPV)	A laryngeal mask is recommended during resuscitation of term and preterm newborns at 34 weeks or more of gestation when tracheal intubation is unsuccessful or is not feasible (Class I, LOE C-EO).	updated for 2015
2015	CPAP	Based on this evidence, spontaneously breathing preterm infants with respiratory distress may be supported with CPAP initially rather than routine intubation for administering PPV (Class IIb, LOE B-R).	updated for 2015
2015	Chest Compressions	Compressions are delivered on the lower third of the sternum to a depth of approximately one third of the anterior-posterior diameter of the chest (Class IIb, LOE C-LD).	updated for 2015
2015	Chest Compressions	Because the 2-thumb technique generates higher blood pressures and coronary perfusion pressure with less rescuer fatigue, the 2 thumb–encircling hands technique is suggested as the preferred method (Class IIb, LOE C-LD).	updated for 2015
2015	Chest Compressions	It is still suggested that compressions and ventilations be coordinated to avoid simultaneous delivery. The chest should be allowed to re-expand fully during relaxation, but the rescuer's thumbs should not leave the chest. The Neonatal Resuscitation ILCOR and Guidelines Task Forces continue to support use of a 3:1 ratio of compressions to ventilation, with 90 compressions and 30 breaths to achieve approximately 120 events per minute to maximize ventilation at an achievable rate (Class IIa, LOE C-LD).	updated for 2015
2015	Chest Compressions	A 3:1 compression-to-ventilation ratio is used for neonatal resuscitation where compromise of gas exchange is nearly always the primary cause of cardiovascular collapse, but rescuers may consider using higher ratios (eg, 15:2) if the arrest is believed to be of cardiac origin (Class IIb, LOE C-EO).	updated for 2015
2015	Chest Compressions	The Neonatal Guidelines Writing Group endorses increasing the oxygen concentration to 100% whenever chest compressions are provided (Class IIa, LOE C-EO).	new for 2015
2015	Chest Compressions	To reduce the risks of complications associated with hyperoxia the supplementary oxygen concentration should be weaned as soon as the heart rate recovers (Class I, LOE C-LD).	new for 2015
2015	Chest Compressions	The current measure for determining successful progress in neonatal resuscitation is to assess the heart rate response. Other devices, such as end-tidal CO_2 monitoring and pulse oximetry, may be useful techniques to determine when return of spontaneous circulation occurs. However, in asystolic/bradycardic neonates, we suggest against the routine use of any single feedback device such as $ETCO_2$ monitors or pulse oximeters for detection of return of spontaneous circulation, as their usefulness for this purpose in neonates has not been well established (Class IIb, LOE C-LD).	new for 2015
2015	Induced Therapeutic Hypothermia Resource-Limited Areas	Evidence suggests that use of therapeutic hypothermia in resource-limited settings (ie, lack of qualified staff, inadequate equipment, etc) may be considered and offered under clearly defined protocols similar to those used in published clinical trials and in facilities with the capabilities for multidisciplinary care and longitudinal follow-up (Class IIb, LOE-B-R).	new for 2015

(*Continued*)

2015 Guidelines Update: Part 13 Recommendations, *Continued*

Year Last Reviewed	Topic	Recommendation	Comments
2015	Guidelines for Withholding and Discontinuing	However, in individual cases, when counseling a family and constructing a prognosis for survival at gestations below 25 weeks, it is reasonable to consider variables such as perceived accuracy of gestational age assignment, the presence or absence of chorioamnionitis, and the level of care available for location of delivery. It is also recognized that decisions about appropriateness of resuscitation below 25 weeks of gestation will be influenced by region-specific guidelines. In making this statement, a higher value was placed on the lack of evidence for a generalized prospective approach to changing important outcomes over improved retrospective accuracy and locally validated counseling policies. The most useful data for antenatal counseling provides outcome figures for infants alive at the onset of labor, not only for those born alive or admitted to a neonatal intensive care unit (Class IIb, LOE C-LD).	new for 2015
2015	Guidelines for Withholding and Discontinuing	We suggest that, in infants with an Apgar score of 0 after 10 minutes of resuscitation, if the heart rate remain undetectable, it may be reasonable to stop assisted ventilations; however, the decision to continue or discontinue resuscitative efforts must be individualized. Variables to be considered may include whether the resuscitation was considered optimal; availability of advanced neonatal care, such as therapeutic hypothermia; specific circumstances before delivery (eg, known timing of the insult); and wishes expressed by the family (Class IIb, LOE C-LD).	updated for 2015
2015	Structure of Educational Programs to Teach Neonatal Resuscitation: Instructors	Until more research is available to clarify the optimal instructor training methodology, it is suggested that neonatal resuscitation instructors be trained using timely, objective, structured, and individually targeted verbal and/or written feedback (Class IIb, LOE C-EO).	new for 2015
2015	Structure of Educational Programs to Teach Neonatal Resuscitation: Providers	Studies that explored how frequently healthcare providers or healthcare students should train showed no differences in patient outcomes (LOE C-EO) but were able to show some advantages in psychomotor performance (LOE B-R) and knowledge and confidence (LOE C-LD) when focused training occurred every 6 months or more frequently. It is therefore suggested that neonatal resuscitation task training occur more frequently than the current 2-year interval (Class IIb, LOE B-R, LOE C-EO, LOE C-LD).	new for 2015
The following recommendations were not reviewed in 2015. For more information, see the *2010 AHA Guidelines for CPR and ECC*, "Part 15: Neonatal Resuscitation."			
2010	Temperature Control	All resuscitation procedures, including endotracheal intubation, chest compression, and insertion of intravenous lines, can be performed with these temperature-controlling interventions in place (Class IIb, LOE C).	not reviewed in 2015
2010	Clearing the Airway When Amniotic Fluid Is Clear	Suctioning immediately after birth, whether with a bulb syringe or suction catheter, may be considered only if the airway appears obstructed or if PPV is required (Class IIb, LOE C).	not reviewed in 2015
2010	Assessment of Oxygen Need and Administration of Oxygen	It is recommended that oximetry be used when resuscitation can be anticipated, when PPV is administered, when central cyanosis persists beyond the first 5 to 10 minutes of life, or when supplementary oxygen is administered (Class I, LOE B).	not reviewed in 2015
2010	Administration of Oxygen in Term Infants	It is reasonable to initiate resuscitation with air (21% oxygen at sea level; Class IIb, LOE C).	not reviewed in 2015
2010	Administration of Oxygen in Term Infants	Supplementary oxygen may be administered and titrated to achieve a preductal oxygen saturation approximating the interquartile range measured in healthy term infants after vaginal birth at sea level (Class IIb, LOE B).	not reviewed in 2015
2010	Initial Breaths and Assisted Ventilation	Inflation pressure should be monitored; an initial inflation pressure of 20 cm H_2O may be effective, but ≥30 to 40 cm H_2O may be required in some term babies without spontaneous ventilation (Class IIb, LOE C).	not reviewed in 2015
2010	Initial Breaths and Assisted Ventilation	In summary, assisted ventilation should be delivered at a rate of 40 to 60 breaths per minute to promptly achieve or maintain a heart rate of 100 per minute (Class IIb, LOE C).	not reviewed in 2015
2010	Assisted-Ventilation Devices	Target inflation pressures and long inspiratory times are more consistently achieved in mechanical models when T-piece devices are used rather than bags, although the clinical implications of these findings are not clear (Class IIb, LOE C).	not reviewed in 2015
2010	Assisted-Ventilation Devices	Resuscitators are insensitive to changes in lung compliance, regardless of the device being used (Class IIb, LOE C).	not reviewed in 2015
2010	Endotracheal Tube Placement	Although last reviewed in 2010, exhaled CO_2 detection remains the most reliable method of confirmation of endotracheal tube placement (Class IIa, LOE B).	not reviewed in 2015
2010	Chest Compressions	Respirations, heart rate, and oxygenation should be reassessed periodically, and coordinated chest compressions and ventilations should continue until the spontaneous heart rate is <60 per minute (Class IIb, LOE C).	not reviewed in 2015

(*Continued*)

2015 Guidelines Update: Part 13 Recommendations, *Continued*

Year Last Reviewed	Topic	Recommendation	Comments
2010	Epinephrine	Dosing recommendations remain unchanged from 2010. Intravenous administration of epinephrine may be considered at a dose of 0.01 to 0.03 mg/kg of 1:10 000 epinephrine. If an endotracheal administration route is attempted while intravenous access is being established, higher dosing will be needed at 0.05 to 0.1 mg/kg (Class IIb, LOE C).	not reviewed in 2015
2010	Epinephrine	Given the lack of supportive data for endotracheal epinephrine, it is reasonable to provide drugs by the intravenous route as soon as venous access is established (Class IIb, LOE C).	not reviewed in 2015
2010	Volume Expansion	Volume expansion may be considered when blood loss is known or suspected (pale skin, poor perfusion, weak pulse) and the infant's heart rate has not responded adequately to other resuscitative measures (Class IIb, LOE C).	not reviewed in 2015
2010	Volume Expansion	An isotonic crystalloid solution or blood may be useful for volume expansion in the delivery room (Class IIb, LOE C).	not reviewed in 2015
2010	Volume Expansion	The recommended dose is 10 mL/kg, which may need to be repeated. When resuscitating premature infants, care should be taken to avoid giving volume expanders rapidly, because rapid infusions of large volumes have been associated with IVH (Class IIb, LOE C).	not reviewed in 2015
2010	Induced Therapeutic Hypothermia Resource-Abundant Areas	Induced therapeutic hypothermia was last reviewed in 2010; at that time it was recommended that infants born at more than 36 weeks of gestation with evolving moderate-to-severe hypoxic-ischemic encephalopathy should be offered therapeutic hypothermia under clearly defined protocols similar to those used in published clinical trials and in facilities with the capabilities for multidisciplinary care and longitudinal follow-up (Class IIa, LOE A).	not reviewed in 2015
2010	Guidelines for Withholding and Discontinuing	The 2010 Guidelines provide suggestions for when resuscitation is not indicated, when it is nearly always indicated, and that under circumstances when outcome remains unclear, that the desires of the parents should be supported (Class IIb, LOE C).	not reviewed in 2015
2010	Briefing/Debriefing	It is still suggested that briefing and debriefing techniques be used whenever possible for neonatal resuscitation (Class IIb, LOE C).	not reviewed in 2015

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KEY WORDS: cardiopulmonary resuscitation

Part 14: Education

2015 American Heart Association Guidelines Update for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care

Farhan Bhanji, Chair; Aaron J. Donoghue; Margaret S. Wolff; Gustavo E. Flores; Louis P. Halamek; Jeffrey M. Berman; Elizabeth H. Sinz; Adam Cheng

Introduction

Cardiac arrest is a major public health issue, with more than 500 000 deaths of children and adults per year in the United States.[1–3] Despite significant scientific advances in the care of cardiac arrest victims, there remain striking disparities in survival rates for both out-of-hospital and in-hospital cardiac arrest. Survival can vary among geographic regions by as much as 6-fold for victims in the prehospital setting.[4,5] Significant variability in survival outcomes also exists for cardiac arrest victims in the hospital setting, particularly when the time of day or the location of the cardiac arrest is considered.[6] Inconsistencies in performance of both healthcare professionals and the systems in which they work likely contribute to these differences in outcome.[7]

For out-of-hospital cardiac arrest victims, the key determinants of survival are the timely performance of bystander cardiopulmonary resuscitation (CPR) and defibrillation for those in ventricular fibrillation or pulseless ventricular tachycardia. Only a minority of cardiac arrest victims receive potentially lifesaving bystander CPR, thus indicating room for improvement from a systems and educational point of view. For in-hospital cardiac arrest, the important provider-dependent determinants of survival are early defibrillation for shockable rhythms and high-quality CPR, along with recognition and response to deteriorating patients before an arrest.

Defining the optimal means of delivering resuscitation education to address these critical determinants of survival may help to improve outcomes from cardiac arrest.

Resuscitation education is primarily focused on ensuring widespread and uniform implementation of the science of resuscitation (eg, the Scientific Statements and Guidelines) into practice by lay and healthcare CPR providers. It aims to close the gap between actual and desired performance by providing lay providers with CPR skills and the self-efficacy to use them; supplementing training with in-the-moment support, such as dispatch-assisted CPR; improving healthcare professionals' ability to recognize and respond to patients at risk of cardiac arrest; improving resuscitation performance (including CPR); and ensuring continuous quality improvement activities to optimize future performance through targeted education. Simply ensuring that cardiac arrest victims receive care consistent with the current state of scientific knowledge has the potential to save thousands of lives every year in the United States.

Development of Evidence-Based Education Guidelines

The American Heart Association (AHA) Emergency Cardiovascular Care (ECC) Committee uses a rigorous process to review and analyze the peer-reviewed published scientific evidence supporting the AHA Guidelines for CPR and ECC, including this update. In 2000, the AHA began collaborating with other resuscitation councils throughout the world, via the International Liaison Committee on Resuscitation (ILCOR), in a formal international process to evaluate resuscitation science. This process resulted in the publication of the International Consensus on CPR and ECC Science With Treatment Recommendations in 2005 and in 2010.[8] These publications provided the scientific support for AHA Guidelines revisions in those years.[9,10]

In 2011, the AHA created an online evidence review process, the Scientific Evidence Evaluation and Review System (SEERS), to support ILCOR systematic reviews for 2015 and beyond. This new process includes the use of Grading of Recommendations Assessment, Development, and Evaluation (GRADE) software to create systematic reviews that will be available online and used by resuscitation councils to develop their guidelines for CPR and ECC. The drafts of the online reviews were posted for public comment, and ongoing reviews will be accessible to the public.[11] Throughout the online version of this publication, live links are provided so the reader can connect directly to the systematic reviews on the SEERS website. These links are indicated by a combination of letters and numbers (eg, EIT 647). We encourage readers to use the links and review the evidence and appendixes, such as the GRADE tables.

For this 2015 international evidence review, members of the ILCOR Education, Implementation, and Teams Task Force[12,13] identified topics through consensus, based on their perceived relevance, potential impact on saving lives, and

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the likelihood for new evidence since the 2010 Guidelines. They also sought recommendations about topics from ILCOR member resuscitation councils through their council chairs and individual task force members. The systematic reviews of these high-priority topics provided the evidence base for these 2015 education guidelines.

Each review seeks to determine the answer to a question regarding the effect in a population of an intervention (evaluated against a control or other comparison group) on an outcome. The Education, Implementation, and Teams Task Force identified patient-related outcomes and actual performance in the clinical setting as the critical outcomes, with learning-related outcomes (immediate and longer retention) considered to be important outcomes. This approach is consistent with other recognized program evaluation paradigms, such as Kirkpatrick's model,[14] where "results" (or patient outcome) are considered more important than "transfer" of learning to the clinical setting, which is in turn more important than evidence of "learning." McGaghie's model describing translational outcomes for medical education research follows a similar logic.[15] The implication is that treatment recommendations based strictly on studies demonstrating improved learning will be weaker than if differences in critical patient related outcomes are demonstrated.

Because this *2015 AHA Guidelines Update for CPR and ECC* represents the first update to the previous Guidelines, recommendations from both this 2015 Guidelines Update and the 2010 Guidelines are in the Appendix.

As with all AHA Guidelines, each 2015 recommendation is labeled with a Class of Recommendation (COR) and a Level of Evidence (LOE). This 2015 update uses the newest AHA COR and LOE classification system, which contains modifications of the Class III recommendation and introduces LOE B-R (randomized studies) and B-NR (nonrandomized studies) as well as LOE C-LD (limited data) and C-EO (expert opinion/consensus). For further information, please see "Part 2: Evidence Evaluation and Management of Conflicts of Interest."

These 2015 AHA education guidelines differ from the 2010 AHA Guidelines on education, implementation, and teams because the focus of this publication is strictly on training, with important related topics covered in other Parts (eg, dispatch-guided CPR in "Part 5: Adult Basic Life Support and Cardiopulmonary Resuscitation Quality" and continuous quality improvement in "Part 4: Systems of Care and Continuous Quality Improvement").

Key recommendations in this 2015 update to the 2010 Guidelines include the following:

- Use of high-fidelity manikins is encouraged at training centers and organizations that have the infrastructure, trained personnel, and resources to maintain the program.
- Use of CPR feedback devices can help to learn the psychomotor skill of CPR.
- Two-year retraining cycles are not optimal. More frequent training in basic life support (BLS) and retraining in advanced life support (ALS) may be helpful for providers who are likely to encounter a cardiac arrest.

Educational Design

Evidence-based instructional design is essential to improve training of providers and ultimately improve resuscitation performance and patient outcomes. The quality of rescuer performance depends on learners integrating, retaining, and applying the cognitive, behavioral, and psychomotor skills required to perform resuscitation successfully. Learners need to develop the self-efficacy to use the skills they learned when faced with a resuscitation scenario.[16,17] Well-designed resuscitation education informed by adult learning theories and educational science increases the likelihood that this will occur. The appropriate application of learning theories combined with research into program effectiveness has resulted in substantial changes to AHA ECC courses over the past quarter century.[18] In 2013, the AHA established the ECC Educational Sciences and Programs Subcommittee to help inform the creation of courses by using the best available evidence in education science. The development of the AHA courses are guided by core educational principles (Table 1), including deliberate, hands-on practice, where feedback and debriefing should support participants' development toward mastery.[18–20]

An essential component of resuscitation education is the experiential learning that occurs through simulation and the associated debriefing. Kolb's experiential learning cycle provides a framework of 4 stages that are required to consolidate learning (Figure 1).[44] For most individuals participating in resuscitation courses, clinical resuscitations are rare events, emphasizing the importance of learning from simulated scenarios so that they are able to act when the real-life events occur.[45] By engaging learners in scenarios and guiding them through a constructive debriefing, instructors can maximize knowledge transfer to real-life events. Critical to this learning process is the notion that the experience is not enough to promote practice change. Experience needs to be coupled with a constructive debriefing, allowing for guided reflection that can promote change in performance.[9,20,46] AHA courses promote the use of structured and supported debriefing by using the GAS (gather-analyze-summarize) model of debriefing paired with evidence-based scripted debriefing tools.[18,47]

As a part of this educational process, attention to functional task alignment is necessary to ensure that learners take away the appropriate skills.[48] By aligning the nature and degree of realism with the predetermined learning objectives and/or tasks, the instructor is deliberately targeting realism to the learning need. Taking shortcuts within the educational design of these courses can result in significant unintended consequences. As an example, a study by Krogh et al demonstrated poor adherence to the recommended 2-minute CPR time cycles when learners practiced CPR with abbreviated cycles.[49] Greater attention to promoting realism of the simulation scenario with respect to timing, duration, and integration of tasks with accompanying feedback creates a learning environment best suited to improving learning outcomes.[50] To quote the legendary coach Vince Lombardi, "Practice doesn't make perfect. Only perfect practice makes perfect."

There is substantial evidence to suggest that mastery learning is the key to skill retention and the prevention of rapid decay in skills and knowledge after simulation-based learning.[45,51–53] The goal of mastery learning is to have learners

Table 1. Core AHA Emergency Cardiovascular Care Educational Concepts

Simplification	Course content should be simplified in both the presentation of the content and the breadth of content to facilitate accomplishment of course objectives.[21,22]
Consistency	Course content and skill demonstrations should be presented in a consistent manner. Video-mediated, practice-while-watching instruction is the preferred method for basic psychomotor skill training because it reduces instructor variability that deviates from the intended course agenda.[22–25]
Contextual	Adult learning principles[26] should be applied to all ECC courses, with emphasis on creating relevant training scenarios that can be applied practically to the learners' real-world setting, such as having hospital-based learners practice CPR on a bed instead of the floor.
Hands-on practice	Substantial hands-on practice is needed to meet psychomotor and nontechnical/leadership skill performance objectives.[22,23,27–29]
Practice to mastery	Learners should have opportunities for repetitive performance of key skills coupled with rigorous assessment and informative feedback in a controlled setting.[30–33] This deliberate practice should be based on clearly defined objectives[34–36] and not time spent, to promote student development toward mastery.[37–41]
Debriefing	The provision of feedback and/or debriefing is a critical component of experiential learning.[20] Feedback and debriefing after skills practice and simulations allow learners (and groups of learners) the opportunity to reflect on their performance and to receive structured feedback on how to improve their performance in the future.[18]
Assessment	Assessment of learning in resuscitation courses serves to both ensure achievement of competence and provide the benchmarks that students will strive toward. Assessment also provides the basis for student feedback (assessment *for* learning). Assessment strategies should evaluate competence and promote learning. Learning objectives[42] must be clear and measurable and serve as the basis of evaluation.
Course/program evaluation	This is an integral component of resuscitation education, with the appraisal of resuscitation courses including learner, individual instructor, course, and program performance.[43] Training organizations should use this information to drive the continuous quality improvement process.

AHA indicates American Heart Association; CPR, cardiopulmonary resuscitation; and ECC, emergency cardiovascular care.

achieve the highest standards for all educational outcomes instead of simply meeting the minimum standard.[54] Although this is not a new educational concept, this represents a shift in the way resuscitation courses are taught. Flexibility is necessary for mastery learning to occur because the time required for learners to meet this mastery standard may vary.[53]

Assessment within AHA courses needs to play an important dual role. Summative assessment (ie, assessment conducted at the end of training that is compared with a standard or benchmark) is required to ensure that intended learning outcomes are met. Formative assessment (ie, low stakes assessment with little to no "point" value in the course) provides clarity to learners about what the important desired outcomes are and provides practical advice to learners on where they can improve and how to do it (so-called assessment *for* learning). Assessment is deliberately aligned to the learning objectives and instructional programs within the AHA courses. In recognizing that successful resuscitation requires the integration of cognitive, psychomotor, and behavioral skills, there is an increasing emphasis on focusing learner evaluation on the higher levels of Miller's classic description of assessment (ie, above the level of knowledge). The simulated setting readily allows such an approach.[55] Optimal learning depends heavily on the assessment skills of the instructor; therefore, early and ongoing faculty development is a priority, as are the development and implementation of appropriate assessment tools with evidence of validity and reliability.

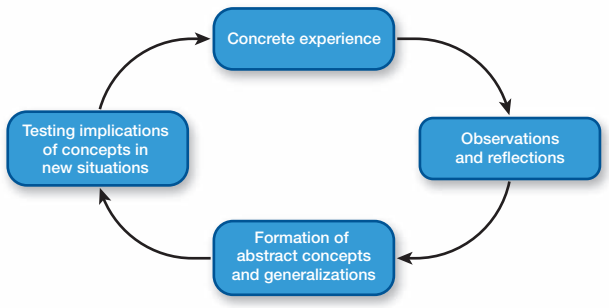

Figure 1. Experiential learning cycle. Kolb, David A., Experiential Learning: Experience as a Source of Learning & Development, 1st, ©1984, 21. Reprinted by permission of Pearson Education, Inc., New York, New York.[44]

The degree to which a learner masters the material depends on the instructor's expertise and the debriefing process.[20,56] Helping learners understand *why* the course is important (ie, the relevance) and how it applies to their situation is critical in motivating adult learners. Respecting their prior experience and defining how their learning in the course can help them care for loved ones or their patients can be particularly useful. During debriefing, learners reflect on their performance during the simulation, performance gaps are identified and corrected, and "take-home" messages are generalized to maximize learning.[57] Without this step, learners are unlikely to improve nontechnical skills, decision-making abilities, situational awareness, and team coordination.[46] Future work should aim to establish competency and performance standards for resuscitation instructors that will help to standardize quality of instruction across training programs.[58]

Basic Life Support Training

CPR Instruction Methods[EIT 647]—Updated

Studies on CPR instruction methods (video- and/or computer-based with hands-on practice versus instructor-led courses) are heterogeneous with regard to instruction delivery and learner outcomes. Although instructor-led courses have been considered the gold-standard, multiple studies have demonstrated no difference in learning outcomes (cognitive performance,

skill performance at course conclusion, and skill decay) when courses with self-instruction are compared with traditional instructor-led courses.[22–25,41,59–66] CPR self-instruction through video- and/or computer-based modules paired with hands-on practice may be a reasonable alternative to instructor-led courses (Class IIb, LOE C-LD). This recommendation is based on the absence of differences in learner outcomes, the benefits of increased standardization, plus the likely reduction of time and resources required for training.

Automated External Defibrillator Training Methods[EIT 651]—New

Allowing the use of automated external defibrillators (AEDs) by untrained bystanders can potentially be lifesaving and should be encouraged when trained individuals are not immediately available. Although AEDs can be used effectively without prior training, even brief training increases the willingness of a bystander to use an AED and improves individual performance,[67–69] although the most effective method of instruction is not known. None of the studies identified in the literature review addressed patient-related outcomes (ie, they were manikin-based with learning outcomes assessed within 6 months of training).

In lay providers, 4 studies examined self-instruction without instructor involvement versus a traditional instructor-led course.[27,41,70,71] There was no significant difference between these methods.[27,41,70,71] Two studies evaluated self-instruction combined with instructor-led training versus traditional courses; one study showed equivalent results,[70] whereas the other demonstrated that self-instruction combined with instructor-led AED training was inferior to traditional methods.[27]

A combination of self-instruction and instructor-led teaching with hands-on training can be considered as an alternative to traditional instructor-led courses for lay providers. If instructor-led training is not available, self-directed training may be considered for lay providers learning AED skills (Class IIb, LOE C-EO). Potential to increase the numbers of lay providers trained and cost implications were important considerations in the development of this recommendation.

In healthcare providers, 3 studies compared self-instruction without instructor involvement[25,72,73] versus an instructor-led course and demonstrated either no difference in performance[25,72] or inferior performance in the self-instruction group.[73] When compared with instructor-led training alone, self-instruction combined with instructor-led AED training led to slight reductions in performance but significant reductions in training time.[25,72] Self-directed methods can be considered for healthcare professionals learning AED skills (Class IIb, LOE C-EO).

CPR Feedback/Prompt Devices in Training[EIT 648]—New and Updated

Mastery learning requires accurate assessment of CPR skills and feedback to help learners improve subsequent performance. Unfortunately, inadequate performance of CPR is common yet challenging for providers and instructors to detect,[74,75] thereby making it difficult to appropriately focus feedback and improve future performance. Technology could theoretically help address this problem by assessing CPR performance and providing feedback. In conducting this analysis, we separated CPR feedback devices that provide corrective feedback to the learner from prompt devices that provide only a tone or rate for the rescuer to follow (with no feedback on how the learner is actually performing).

Learners who used devices that provided corrective feedback during CPR training had improved compression rate, depth, and recoil compared with learners performing CPR without feedback devices.[50,76–96] Evidence on the effect of feedback devices on CPR skill retention is limited, with 1 of 3 studies demonstrating improved retention.[82,85,86] Use of feedback devices can be effective in improving CPR performance during training (Class IIa, LOE A).

Three randomized trials examined the use of auditory guidance (ie, use of a metronome or music) to guide CPR performance. All 3 studies found that compression rate was more appropriate when auditory guidance was used, although there was a negative impact on compression depth in 1 study.[94–96] If feedback devices are not available, auditory guidance (eg, metronome, music) may be considered to improve adherence to recommendations for chest compression rate only (Class IIb, LOE B-R). These recommendations are made, balancing the potential benefit of improved CPR performance with the cost of the use of such devices during training.

Retraining Intervals for BLS[EIT 628]—Updated

The standard retraining period for BLS is every 2 years, despite growing evidence that BLS knowledge and skills decay rapidly after initial training. Studies have demonstrated the deterioration of BLS skills in as little as 3 months after initial training.[9,97,98]

Three studies evaluated the impact of 1 additional episode of BLS retraining 6 to 9 months after BLS certification and found no difference in chest compression performance or time to defibrillation.[99–101] Two studies examined the effect of brief, more frequent training sessions; both studies demonstrated slight improvement in chest compression performance, and 1 study found a shorter time to defibrillation.[86,102] These same studies also found that students reported improved confidence and willingness to perform CPR after additional or high-frequency training.

There is insufficient evidence to determine the optimal method and timing of BLS recertification. Given the rapidity with which BLS skills decay after training, coupled with the observed improvement in skill and confidence among students who train more frequently, it may be reasonable for BLS retraining to be completed more often by individuals who are likely to encounter cardiac arrest (Class IIb, LOE C-LD). It should be emphasized that BLS skill maintenance needs to be appropriately tailored for potential provider groups on the basis of their setting and the feasibility of more frequent training.

Advanced Life Support Training

Precourse Preparation[EIT 637]—Updated

To maximize learning from an ALS training program, an adult learner should be well prepared before attending such a

program. Similarly, instructors have the responsibility of providing an optimal learning environment that will facilitate the acquisition and refinement of skills in motivated trainees. In view of the resources (time, equipment, supplies, money, etc) required and the potential impact (life or death) on patients, this duty is paramount. During the past decade, many life support programs have mandated independent review of content knowledge, via study of the pertinent provider manual, and successful completion of an online examination before attendance at the program. Unfortunately, trainee preparation has not been extensively studied. A single multicenter randomized controlled trial[103] compared extensive precourse preparation using an interactive compact disc and additional course materials (intervention group) with the use of course materials alone (control group). Subjects exhibited no differences in performance during a simulated cardiac arrest, and no differences were noted in knowledge acquisition or performance of the technical skills required during resuscitation. Although this study revealed no benefit of trainee preparation, it is important to acknowledge that the type of skill(s) practiced during preprogram preparation and the skill(s) assessed during the program may not have been directly aligned and thus may have confounded the results. Therefore, any conclusions from this study must be tempered by its limitations. Precourse preparation is consistent with theories of learning and current practices in other professional education. It has the potential to improve learning and improve the care delivered to patients.

Precourse preparation, including review of appropriate content information, online/precourse testing, and practice of pertinent technical skills is reasonable before attending ALS training programs (Class IIa, LOE C-EO).

Team and Leadership Training[EIT 631]—Updated

Effective management of a cardiac arrest patient requires a team-based approach with providers who have the knowledge, clinical skills, interpersonal communication skills, and leadership skills to perform effectively in a high-stakes environment. This also requires a team leader who has the ability to provide oversight of the team, provide guidance for specific tasks, and maintain a heightened level of situational awareness to avoid fixation on certain aspects of care. Given that team-based skills are different from clinical care skills, specific team and leadership training may have a role in the effective performance of resuscitation teams and patient outcomes after cardiac arrest.

A systematic review of the resuscitation education literature identified several studies assessing the impact of team training for healthcare professionals in a cardiac arrest setting. In 1 observational study, the implementation of a hospital-wide mock code program with team training resulted in a survival increase for pediatric cardiac arrest during the study period.[104]

In another observational study, the implementation of surgical team training resulted in a decrease in surgical patient mortality in hospitals that implemented the program when compared with those that did not.[105]

A number of additional studies demonstrated better performance of patient tasks, teamwork, and/or leadership behaviors in the immediate postcourse time period up to 1 year after training.[95–106]

Given very small risk for harm and the potential benefit of team and leadership training, the inclusion of team and leadership training as part of ALS training is reasonable (Class IIa, LOE C-LD).

Manikin Fidelity[EIT 623]—Updated

Many training programs use high-fidelity manikins for adult and pediatric ALS training.[106–108] The use of high-fidelity manikins can encourage learners to engage physically and emotionally with the manikin and the environment, thus helping to promote teamwork, clinical decision making, and full participant immersion within the experiential learning environment. High-fidelity manikins have a wide range of functionality depending on make and model type, but generally they are defined as manikins that provide physical findings (such as heart and breath sounds, pulses, chest rise and fall, and blinking eyes), display vital signs that correlate with physical findings, and "physiologically" respond to medical intervention through an operator-controlled computer interface.[107] Many of these manikins also allow participants to actually perform some critical care procedures, including bag-mask ventilation, intubation, intraosseous needle insertion, and/or chest tube insertion.

A meta-analysis of 12 randomized controlled trials showed improvement of skills at course conclusion with the use of high-fidelity manikins.[47,109–119] A meta-analysis of 8 randomized controlled trials assessing knowledge at course conclusion demonstrated no significant benefit of training with high-fidelity manikins compared with low-fidelity manikins.[47,110,111,116–118,120,121] This is supported by 1 additional nonrandomized trial demonstrating no substantial benefit of high-fidelity training on knowledge acquisition.[122] With regard to skill retention, 1 study showed no benefit of high-fidelity training on skills performance (in the simulated environment) at 1 year after training,[109] and another demonstrated similar results for skills performance between course conclusion and 1 year.[118]

The use of high-fidelity manikins for ALS training can be beneficial for improving skills performance at course conclusion (Class IIa, LOE B-R). The usefulness of high-fidelity manikins for improving knowledge at course conclusion and skills performance beyond course conclusion is uncertain. Given the increased cost associated with high-fidelity training, the use of high-fidelity manikins is particularly appropriate in programs where existing resources (ie, human and financial resources) are already in place.

Training Intervals[EIT 633]—Updated

Retraining intervals for AHA basic and advanced life support programs have traditionally been time-specific, with a maximum 2-year interval recommended, despite evidence that core skills and knowledge decay within 3 to 12 months after initial training.[9,97] Unfortunately, the literature directly assessing the question of the retraining intervals is limited. In 1 pediatric ALS study,[123] frequent refreshers with manikin-based simulation showed better clinical performance scores and equivalent behavioral performance scores, using less total time of retraining, when compared with standard retraining intervals.

Recent literature in resuscitation education also demonstrates improved learning from "frequent, low-dose" versus "comprehensive, all-at-once" instruction and a learner preference for this format.[124]

Given the potential educational benefits of short, frequent retraining sessions coupled with the potential for cost savings from reduced training time and removal of staff from the clinical environment for standard refresher training, it is reasonable that individuals who are likely to encounter a cardiac arrest victim perform more frequent manikin-based retraining (Class IIa, LOE C-LD). There is insufficient evidence to recommend the optimum time interval.

Special Considerations

Compression-Only CPR Training in Communities[EIT 881]—New

Compression-only (Hands-Only™) CPR has been advocated as a method of training laypeople that is simpler to learn and may increase bystander willingness to provide CPR. Most published studies on bystander compression-only CPR have involved dispatcher-guided CPR by lay rescuers. Life support course students, when surveyed, have reported a greater willingness to provide compression-only CPR than conventional CPR with assisted ventilations.[125–129] Two studies published after a state-wide educational campaign for bystander compression-only CPR showed that the prevalence of both overall bystander CPR and compression-only CPR by bystanders increased over time, but no effect on patient survival was demonstrated.[130,131]

Communities may consider training bystanders in compression-only CPR for adult out-of-hospital cardiac arrest as an alternative to training in conventional CPR (Class IIb, LOE C-LD). Communities should consider existing bystander CPR rates and other factors, such as local epidemiology of out-of-hospital cardiac arrest and cultural preferences, when deciding on the optimal community CPR training strategy.

CPR Training in Resource-Limited Environments[EIT 634]—New

Studies examining CPR training in resource-limited environments are heterogeneous in design and training outcomes. Studies comparing traditional course format with training using computer-based instruction, self-directed learning, video-based instruction, and varied instructor-to-student ratios showed mixed results with regard to knowledge and skill at course completion and at reassessment up to 6 months after course completion.[132–138] These studies varied in course composition (paramedic students, medical students at various levels, nursing students, and credentialed healthcare providers), type of course (BLS or ALS), and instructional methods.

It may be reasonable to use alternative instructional modalities for BLS and/or ALS teaching in resource-limited environments (Class IIb, LOE C-LD). In making this recommendation, we considered the cost of and access to training as major impediments to training BLS and ALS for healthcare workers in resource-limited areas. Additionally, the intent is to promote research and initiatives around creative teaching strategies that lower both cost and human resources needed to achieve more widespread BLS and ALS training that meets the desired learning objectives in resource-limited environments.

CPR for High-Risk Populations[EIT 649]—New

There are many studies evaluating the effectiveness of BLS training in family members and/or caregivers of high-risk cardiac patients, including some that measure the frequency at which CPR is performed by family members[125,139–147]; their retention of knowledge, skills, and adequacy of performance[125,139,140,142,148,149]; and the survival rates of cardiac arrest victims receiving CPR from family members.[66,139,140,142,150–153] Despite the heterogeneity and generally low quality, these studies consistently showed high scores for CPR performance in those who were trained compared with those who were untrained. Most studies examining retention of skills showed a decline in CPR performance over time without retraining. Training primary caregivers and/or family members of high-risk patients may be reasonable (Class IIb, LOE C-LD), although further work needs to help define which groups to preferentially target. This recommendation is predicated on the significant potential benefit and low potential for harm in patients receiving bystander CPR by a trained family member or caregiver.

Knowledge Gaps

Implementing resuscitation science into clinical practice requires educational practice based on high-quality educational research. To date, the resuscitation education literature has been limited by outcomes that focus on short-term learning rather than patient outcome or transfer of provider performance into the clinical environment (or even long-term retention of critical skills), variable quality of research design, and the use of assessment tools that lack validity and reliability evidence. With that in mind, the writing group for the AHA education guidelines suggests the following general concepts to advance educational research and educational practice, along with a series of specific themes of research that warrant further exploration (Table 2).

General Concepts

Research on resuscitation education needs higher-quality studies that are adequately powered and that address important educational questions. Multicenter collaborative studies may be of benefit to support both quality in study design and enrolling adequate numbers of participants. Ideally, the outcomes from educational studies should focus on patient outcomes (where feasible), transfer of learning into performance in the clinical environment, or at least long-term retention of psychomotor and behavioral skills in the simulated resuscitation environment. Too much of the current focus of educational research is exclusively on the immediate end-of-course performance, which may not be representative of participants' performance when they are faced with a resuscitation event months to years later. Because much of the training for resuscitation events uses manikin-based simulation, research is needed to reflect important patient characteristics in training devices, such as chest compliance and clinical signs of distress. Assessment tools that have been empirically studied for

Table 2. Specific Themes for Future Resuscitation Education Research

Topic	Research Needs/Questions
Basic Life Support Training	
CPR instruction methods	• Determine the impact of short, video-based practice on long-term CPR performance as well as patient outcomes • Determine the optimal design of these short courses
AED training methods	• Define the optimal instructional strategies and retraining intervals, including the methods of retraining, to improve performance and self-efficacy
CPR feedback/prompt devices in training	• Determine the impact of CPR feedback devices on future (long-term) performance of CPR • Explore the additional or reduced costs of training with feedback devices
Retraining intervals for basic life support	• Determine the ideal frequency of retraining required to enhance retention of skills and performance in simulated and real resuscitations • Assess if real resuscitation events, coupled with appropriate feedback and/or assessment, can serve as an adjunct or replacement for more frequent retraining
Compression-only CPR training in communities	• Define the optimal community bystander CPR training strategy based on cultural and local variables
CPR training in resource-limited environments	• Determine the optimal method of low-cost instruction while enhancing learning and patient outcomes
CPR for high-risk populations	• Determine which populations are best suited for targeted training, including the cost-effectiveness of this intervention
Advanced Life Support Training	
Precourse preparation	• Determine the content, timing, and importance of precourse preparation for various life support courses on learning outcomes
Team and leadership training	• Determine the optimal methodology (ie, instructional design), frequency, and context of team and leadership training for acquisition and retention of key resuscitation skills • Define how individual leadership and team skills influence and/or relate to specific clinical performance metrics during resuscitation
Manikin fidelity	• Determine the relative impact of different types of manikin fidelity (physical, emotional, conceptual) on learning, performance, and real clinical outcomes • Determine which aspects of manikin fidelity are important for achieving improved learning outcomes for specific objectives (eg, technical versus cognitive versus behavioral)
Training intervals	• Determine the ideal methodology (ie, instructional design) and frequency of retraining required to enhance retention of skills and performance in simulated and real resuscitations • Assess if real resuscitation events, coupled with appropriate feedback and/or assessment, can serve as an adjunct or replacement for more frequent retraining
Other Topics	
Repetitive practice/mastery learning	• Determine how repetitive practice and mastery learning can be applied to enhance the acquisition and retention of the various critical resuscitation competencies
Briefing/debriefing	• Determine how the various aspects of briefing (eg, content, duration) influence learning outcomes from simulation-based resuscitation education • Determine how various aspects of debriefing (eg, duration, method, framework, facilitator, use of video) can be tailored to improve the quality of simulation-based resuscitation education
Data-informed feedback	• Determine the value of data-informed feedback (eg, quantitative CPR data, video review) during advanced life support courses
Blended learning	• Determine how different learning methods and models (eg, screen-based learning, mastery learning, high-fidelity simulation) can be blended to enhance learning and patient outcomes
Instructor training and competencies	• Determine the key instructor competencies that influence positive learning outcomes • Determine the optimal means of coaching, training, and assessing instructors

AED indicates automated external defibrillator; and CPR, cardiopulmonary resuscitation.

evidence of validity and reliability are foundational to high-quality research. Standardizing the use of such tools across studies could potentially allow for meaningful comparisons when evidence is synthesized in systematic reviews to more precisely determine the impact of certain interventions. Finally, there is a clear need for cost-effectiveness research because many of the AHA education guidelines are developed in the absence of this information.

Disclosures

Part 14: Education: 2015 Guidelines Update Writing Group Disclosures

Writing Group Member	Employment	Research Grant	Other Research Support	Speakers' Bureau/ Honoraria	Expert Witness	Ownership Interest	Consultant/ Advisory Board	Other
Farhan Bhanji	McGill University	None	None	None	None	None	None	None
Jeffrey M. Berman	UNC Hospitals	None	None	None	None	None	None	None
Adam Cheng	Alberta Children's Hospital	Heart and Stroke Foundation of Canada*	None	None	None	None	None	None
Aaron J. Donoghue	The Children's Hospital of Philadelphia, University of Pennsylvania School of Medicine	Zoll Foundation*	None	None	None	None	None	None
Gustavo E. Flores	Emergency & Critical Care Trainings, LLC	None	None	None	None	None	None	None
Louis P. Halamek	Stanford University School of Medicine	None	None	None	None	None	None	None
Margaret S. Wolff	University of Michigan	None	None	None	None	None	None	None
Consultant								
Elizabeth H. Sinz	Pennsylvania State University College of Medicine	AHRQ*	None	None	None	None	American Heart Association†	None

This table represents the relationships of writing group members that may be perceived as actual or reasonably perceived conflicts of interest as reported on the Disclosure Questionnaire, which all members of the writing group are required to complete and submit. A relationship is considered to be "significant" if (a) the person receives $10 000 or more during any 12-month period, or 5% or more of the person's gross income; or (b) the person owns 5% or more of the voting stock or share of the entity, or owns $10 000 or more of the fair market value of the entity. A relationship is considered to be "modest" if it is less than "significant" under the preceding definition.

*Modest.

†Significant.

Appendix

2015 Guidelines Update: Part 14 Recommendations

Year Last Reviewed	Topic	Correct Recommendation	Comments
2015	Basic Life Support Training	CPR self-instruction through video- and/or computer-based modules paired with hands-on practice may be a reasonable alternative to instructor-led courses (Class IIb, LOE C-LD).	updated for 2015
2015	Basic Life Support Training	A combination of self-instruction and instructor-led teaching with hands-on training can be considered as an alternative to traditional instructor-led courses for lay providers. If instructor-led training is not available, self-directed training may be considered for lay providers learning AED skills (Class IIb, LOE C-EO).	new for 2015
2015	Basic Life Support Training	Self-directed methods can be considered for healthcare professionals learning AED skills (Class IIb, LOE C-EO).	new for 2015
2015	Basic Life Support Training	Use of feedback devices can be effective in improving CPR performance during training (Class IIa, LOE A).	updated for 2015
2015	Basic Life Support Training	If feedback devices are not available, auditory guidance (eg, metronome, music) may be considered to improve adherence to recommendations for chest compression rate only (Class IIb, LOE B-R).	updated for 2015
2015	Basic Life Support Training	Given the rapidity with which BLS skills decay after training, coupled with the observed improvement in skill and confidence among students who train more frequently, it may be reasonable for BLS retraining to be completed more often by individuals who are likely to encounter cardiac arrest (Class IIb, LOE C-LD).	updated for 2015

(*Continued*)

2015 Guidelines Update: Part 14 Recommendations, *Continued*

Year Last Reviewed	Topic	Correct Recommendation	Comments
2015	Advanced Life Support Training	Precourse preparation, including review of appropriate content information, online/precourse testing, and practice of pertinent technical skills are reasonable before attending ALS training programs (Class IIa, LOE C-EO).	updated for 2015
2015	Advanced Life Support Training	Given very small risk for harm and the potential benefit of team and leadership training, the inclusion of team and leadership training as part of ALS training is reasonable (Class IIa, LOE C-LD).	updated for 2015
2015	Advanced Life Support Training	The use of high-fidelity manikins for ALS training can be beneficial for improving skills performance at course conclusion (Class IIa, LOE B-R).	updated for 2015
2015	Advanced Life Support Training	Given the potential educational benefits of short, frequent retraining sessions coupled with the potential for cost savings from reduced training time and removal of staff from the clinical environment for standard refresher training, it is reasonable that individuals who are likely to encounter a cardiac arrest victim perform more frequent manikin-based retraining (Class IIa, LOE C-LD).	updated for 2015
2015	Special Considerations	Communities may consider training bystanders in compression-only CPR for adult out-of-hospital cardiac arrest as an alternative to training in conventional CPR (Class IIb, LOE C-LD).	new for 2015
2015	Special Considerations	It may be reasonable to use alternative instructional modalities for BLS and/or ALS teaching in resource-limited environments (Class IIb, LOE C-LD).	new for 2015
2015	Special Considerations	Training primary caregivers and/or family members of high-risk patients may be reasonable (Class IIb, LOE C-LD), although further work needs to help define which groups to preferentially target.	new for 2015
The following recommendations were not reviewed in 2015. For more information, see the *2010 AHA Guidelines for CPR and ECC*, "Part 16: Education, Implementation, and Teams."			
2010	Barriers to Recognition of Cardiac Arrest	Rescuers should be taught to initiate CPR if the adult victim is unresponsive and is not breathing or not breathing normally (eg, only gasping) (Class I, LOE B).	not reviewed in 2015
2010	Physical and Psychological Concerns for Rescuers	It is reasonable that participants undertaking CPR training be advised of the vigorous physical activity required during the skills portion of the training program (Class IIa, LOE B).	not reviewed in 2015
2010	Barriers to AED Use	To maximize willingness to use an AED, public access defibrillation training should continue to be encouraged for the lay public (Class I, LOE B).	not reviewed in 2015
2010	Course Design	Consistent with established methodologies for program evaluation, the effectiveness of resuscitation courses should be evaluated (Class I, LOE C).	not reviewed in 2015
2010	AED Training Requirement	Allowing the use of AEDs by untrained bystanders can be beneficial and may be lifesaving (Class IIa, LOE B).	not reviewed in 2015
2010	AED Training Requirement	Because even minimal training has been shown to improve performance in simulated cardiac arrests, training opportunities should be made available and promoted for the lay rescuer (Class I, LOE B).	not reviewed in 2015
2010	Course Delivery Formats	It is reasonable to consider alternative course scheduling formats for advanced life support courses (eg, ACLS or PALS), provided acceptable programmatic evaluation is conducted and learners meet course objectives (Class IIa, LOE B).	not reviewed in 2015
2010	Checklists/Cognitive Aids	Checklists or cognitive aids, such as the AHA algorithms, may be considered for use during actual resuscitation (Class IIb, LOE C).	not reviewed in 2015
2010	Debriefing	Debriefing as a technique to facilitate learning should be included in all advanced life support courses (Class I, LOE B).	not reviewed in 2015
2010	Regional Systems of (Emergency) Cardiovascular Care	It is reasonable that regional systems of care be considered as part of an overall approach to improve survival from cardiac arrest (Class IIa, LOE C).	not reviewed in 2015
2010	Barriers to Bystander CPR	Because panic can significantly impair a bystander's ability to perform in an emergency, it may be reasonable for CPR training to address the possibility of panic and encourage learners to consider how they will overcome it (Class IIb LOE C).	not reviewed in 2015
2010	Barriers to Bystander CPR	Despite the low risk of infections, it is reasonable to teach rescuers about the use of barrier devices emphasizing that CPR should not be delayed for their use (Class IIa, LOE C).	not reviewed in 2015
2010	Post-Course Assessment	A written test should not be used exclusively to assess learner competence following an advanced life support course (Class I, LOE B).	not reviewed in 2015
2010	Post-Course Assessment	End-of-course assessment may be useful in helping learners retain skills (Class IIb, LOE C).	not reviewed in 2015

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KEY WORDS: cardiopulmonary resuscitation

Part 15: First Aid

2015 American Heart Association and American Red Cross Guidelines Update for First Aid

Eunice M. Singletary, Chair; Nathan P. Charlton; Jonathan L. Epstein; Jeffrey D. Ferguson; Jan L. Jensen; Andrew I. MacPherson; Jeffrey L. Pellegrino; William "Will" R. Smith; Janel M. Swain; Luis F. Lojero-Wheatley; David A. Zideman

Introduction

The International Liaison Committee on Resuscitation (ILCOR) First Aid Task Force was formed in 2013 to review and evaluate the scientific literature on first aid in preparation for development of international first aid guidelines, including the *2015 American Heart Association* (AHA) *and American Red Cross Guidelines Update for First Aid*. The 14 members of the task force represent 6 of the international member organizations of ILCOR. Before 2015, evidence evaluation for first aid was conducted by the International First Aid Science Advisory Board and the National First Aid Advisory Board. Although the group responsible for evidence evaluation has changed, the goals remain the same: to reduce morbidity and mortality due to emergency events by making recommendations based on an analysis of the scientific evidence.

A critical review of the scientific literature by appointed ILCOR First Aid Task Force members and evidence evaluators resulted in consensus on science statements with treatment recommendations for 22 selected questions addressing first aid interventions. These findings are presented in "Part 9: First Aid" of the *2015 ILCOR International Consensus on First Aid Science With Treatment Recommendations*,[1,2] and they include a list of identified knowledge gaps that may be filled through future research. The ILCOR treatment recommendations are intended for the international first aid community, with the understanding that local, state, or provincial regulatory requirements may limit the ability to implement recommended first aid interventions. The current AHA/American Red Cross First Aid guidelines are derived from this work. New topics found in the 2015 First Aid Guidelines Update include first aid education, recognition of stroke, recognition of concussion, treatment of mild symptomatic hypoglycemia, and management of open chest wounds. Other topics have been updated based on findings from the corresponding ILCOR reviews.

Background

The roots of first aid have been recorded throughout history, particularly as related to warfare or battlefield care. Images on classical Greek pottery from circa 500 BC depict bandaging of battle wounds.[3] A system of first aid existed in the Roman army, with *capsarii* responsible for first aid, including bandaging, and resembling modern day combat medics.[4] In the 1870s, Johannes Friedrich August von Esmarch, a Prussian military surgeon, was the first to use the term *Erste Hilfe* ("first aid") and taught soldiers to use a standard set of bandaging and splinting skills to care for their wounded comrades on the battlefield.[3] During that same decade, the English Priory of the Order of St John was changed from a religious and fraternal body to a charitable organization with the goal of alleviating human suffering. They later established Britain's first ambulance service and the wheeled transport litter (the St John Ambulance) followed by the St John Ambulance Association "to train men and women for the benefit of the sick and wounded."[5] In the United States, organized training in first aid started in 1903, when Clara Barton, president of the Red Cross, formed a committee to establish instruction in first aid among industrial workers, who were frequently subject to dangerous conditions, accidents, and deaths.[6]

The Evidence Evaluation Process

The recommendations in this 2015 Guidelines Update are based on an extensive evidence review process that was begun by ILCOR after the publication of the *2010 American Heart Association and American Red Cross International Consensus on First Aid Science With Treatment Recommendations*[7] and was completed in February 2015.[1,2]

In this in-depth evidence review process, ILCOR examined topics and then generated a prioritized list of questions for systematic review. Questions were first formulated in PICO (population, intervention, comparator, outcome) format,[8] search strategies and inclusion and exclusion criteria were defined, and then a search for relevant articles was performed. The evidence was evaluated by the ILCOR task forces by using the standardized methodological approach proposed by the Grading of Recommendations Assessment, Development and Evaluation (GRADE) Working Group.[9]

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The quality of the evidence was categorized based on the study methodologies and the 5 core GRADE domains of risk of bias, inconsistency, indirectness, imprecision, and other considerations (including publication bias). Where possible, consensus-based treatment recommendations were created.

To create this 2015 First Aid Guidelines Update, the AHA and the American Red Cross formed a joint writing group, with careful attention to avoiding conflicts of interest, to assessing the ILCOR treatment recommendations, and to writing AHA and American Red Cross treatment recommendations by using the AHA Class of Recommendation and Level of Evidence (LOE) system. The recommendations made in the 2015 Guidelines Update are informed by the ILCOR recommendations and GRADE classification, in the context of the delivery of medical care in North America. Throughout the online version of this document, live links are provided so the reader can connect directly to the systematic review on the ILCOR website, the Scientific Evidence Evaluation and Review System (SEERS) site. These links are indicated by a superscript combination of letters and numbers (eg, FA 517). We encourage readers to review the evidence and appendixes, such as the GRADE tables. For further information, please see "Part 2: Evidence Evaluation and Management of Conflicts of Interest."

A paucity of research in the field of first aid is present, although certain topics have received recent attention (eg, tourniquets for traumatic amputations, hemostatic dressings, identification of stroke symptoms). Without research into first aid interventions, all recommendations must be derived indirectly from hospital-based, animal, or, at best, emergency medical services (EMS) studies.

Definition of First Aid

We define *first aid* as helping behaviors and initial care provided for an acute illness or injury. The goals of a first aid provider include preserving life, alleviating suffering, preventing further illness or injury, and promoting recovery. First aid can be initiated by anyone in any situation and includes self-care. First aid assessments and interventions should be medically sound and based on scientific evidence or, in the absence of such evidence, on expert consensus. First aid competencies include, at any level of training,

- Recognizing, assessing, and prioritizing the need for first aid
- Providing care by using appropriate knowledge, skills, and behaviors
- Recognizing limitations and seeking additional care when needed

The scope of first aid is not purely scientific; it is influenced by both training and regulatory constraints. The definition of scope is therefore variable and should be defined according to circumstances, need, and regulatory requirements.

First Aid Education[FA 773]—New

First aid education can be accomplished through a variety of means, including online courses, classes, and public health campaigns. First aid education can increase survival rates, reduce injury severity, and resolve symptoms over a spectrum of approaches, including public health campaigns,[10,11] focused health topics, or courses that result in certification.[12] Education and training in first aid can be useful to improve morbidity and mortality from injury and illness (Class IIa, LOE C-LD). We recommend that first aid education be universally available (Class I, LOE C-EO).

Calling for Help

The goal of first aid intervention is to recognize when help is needed and how to get it. This goal includes learning how and when to access the EMS system (9-1-1), how to activate the on-site emergency response plan, and how to contact the Poison Control Center (1-800-222-1222).

Providing care for someone who is ill or injured should not usually delay calling for more advanced care if needed. However, if the first aid provider is alone with an injured or ill person and there are imminent threats to life involving the ABCs (airway, breathing, circulation), then basic care—such as opening an airway or applying pressure to the site of severe bleeding—should be provided before leaving the victim to activate the emergency response system or phone for help (EMS or 9-1-1).

Positioning the Ill or Injured Person[FA 517]—Updated

Generally, an ill or injured person should not need to be moved. This is especially important if you suspect, from the person's position or the nature of the injury, that the person may have a pelvic or spine injury. There are times, however, when the person should be moved:

- If the area is unsafe for the first aid provider or the person, move to a safe location if possible (Class I, LOE C-EO).
- If a person is unresponsive and breathing normally, it may be reasonable to place him or her in a lateral side-lying recovery position (Class IIb, LOE C-LD). There is evidence that this position will help increase total airway volume[13] and decrease stridor severity.[14] Extend one of the person's arms above the head and roll the body to the side so that the person's head rests on the extended arm. Once the person is on his or her side, bend both legs to stabilize the body. There is little evidence to suggest an alternative optimal recovery position.[1] If a person is unresponsive and not breathing normally, proceed with basic life support guidelines (see "Part 5: Adult Basic Life Support and Cardiopulmonary Resuscitation Quality").
- If a person has been injured and the nature of the injury suggests a neck, back, hip, or pelvic injury, the person should not be rolled onto his or her side and instead should be left in the position in which they were found, to avoid potential further injury (Class I, LOE C-EO). If leaving the person in the position found is causing the person's airway to be blocked, or if the area is unsafe, move the person only as needed to open the airway and to reach a safe location (Class I, LOE C-EO).

Position for Shock[FA 520]—Updated

The ILCOR 2015 International Consensus on CPR and ECC Science With Treatment Recommendations (C2015) reviewed the published evidence in support of various body positions that might be used by a first aid provider for a person in shock. Studies included normotensive volunteers; healthy individuals who underwent phlebotomy; and patients with septic, cardiogenic, or hypovolemic shock. Study results were sometimes conflicting.[15–20] One observational study found a lower cardiac index and higher heart rate for individuals following phlebotomy when placed in a standing position compared with the supine position.[20] Other studies found that the addition of passive leg raising alone compared to the supine position in hypotensive patients resulted in an improvement in various vital signs and indicators of cardiac output, but this effect was temporary, lasting no more than 7 minutes.[16,17,20] There were no reported adverse effects due to raising the feet.

If a person shows evidence of shock and is responsive and breathing normally, it is reasonable to place or maintain the person in a supine position (Class IIa, LOE C-LD). If there is no evidence of trauma or injury (eg, simple fainting, shock from nontraumatic bleeding, sepsis, dehydration), raising the feet about 6 to 12 inches (about 30° to 60°) from the supine position is an option that may be considered while awaiting arrival of EMS (Class IIb, LOE C-LD). Do not raise the feet of a person in shock if the movement or the position causes pain (Class III: Harm, LOE C-EO).

Oxygen Use in First Aid[FA 519]—Updated

Despite the common use of supplementary oxygen in various medical conditions, there is little evidence to support its use in the first aid setting. Administration of oxygen is not considered a standard first aid skill. However, oxygen may be available in some first aid environments and requires specific training in its use.

The 2015 ILCOR evidence review of oxygen in the first aid setting sought to determine the impact of oxygen supplementation, as compared with no oxygen supplementation, on outcomes of patients with shortness of breath, difficulty breathing, or hypoxia. The review attempted to identify specific medical conditions, other than chest pain, that may benefit from supplementary oxygen administration by first aid providers. Supplementary oxygen for adults with chest pain, during CPR and after return of spontaneous circulation, is addressed in "Part 5: Adult Basic Life Support and Cardiopulmonary Resuscitation Quality," "Part 7: Adult Advanced Cardiovascular Life Support," "Part 8: Post–Cardiac Arrest Care," and "Part 9: Acute Coronary Syndromes." No evidence was found in the C2015 review for or against the routine administration of supplementary oxygen by first aid providers.[1]

Evidence was identified showing a beneficial effect with the use of supplementary oxygen for the relief of decompression sickness.[21] The use of supplementary oxygen by first aid providers with specific training is reasonable for cases of decompression sickness (Class IIa, LOE C-LD).

Patients with advanced cancer may use oxygen at home. One meta-analysis[22] found that the use of oxygen for patients with advanced cancer who had normoxia and dyspnea was not of benefit in relieving dyspnea. Two small, randomized controlled trials demonstrated relief of dyspnea in patients with advanced cancer who had hypoxemia and dyspnea.[23,24] For first aid providers with specific training in the use of oxygen, the administration of supplementary oxygen to persons with known advanced cancer with dyspnea *and* hypoxemia may be reasonable (Class IIb, LOE B-R).

Although no evidence was identified to support the use of oxygen, it might be reasonable to provide oxygen to spontaneously breathing persons who are exposed to carbon monoxide while waiting for advanced medical care (Class IIb, LOE C-EO).

Oxygen delivery mechanisms and amounts will vary with the individual's underlying health problems. Specialized courses are available for persons who may potentially need to use oxygen in the settings described above.

Medical Emergencies

Bronchodilators for Asthma With Shortness of Breath[FA 534]

There are many causes of shortness of breath. Some people carry inhaled medications to relieve certain causes of shortness of breath and wheezing, such as bronchitis, asthma, reactive airway disease or chronic obstructive pulmonary disease. The incidence of severe asthma and deaths from asthma are increasing.[25] First aid providers will likely encounter persons with a previous diagnosis of asthma and prescribed inhaled medication who have acute difficulty breathing and/or wheezing.

Inhaled bronchodilators have been shown to be effective in patients with asthma and acute shortness of breath.[26–36] Evidence from included studies was extrapolated from the prehospital and emergency department settings.

The incidence of adverse events related to the use of inhaled bronchodilators is low: multiple studies show that treatment with albuterol/salbutamol causes no significant change in heart rate,[26,31–33] blood pressure,[33] serum potassium, tremor, headache, nervousness, weakness, palpitation, or dry mouth.[26] However, a single study showed a statistically significant difference in heart rate with different treatment regimens of salbutamol/albuterol.[26]

It is reasonable for first aid providers to be familiar with the available inhaled bronchodilator devices and to assist as needed with the administration of prescribed bronchodilators when a person with asthma is having difficulty breathing (Class IIa, LOE B-R).

Stroke Recognition[FA 801]—New

Worldwide, 15 million individuals are estimated to have a stroke each year. Some areas have achieved great success in decreasing the incidence and long-term effects of stroke through prevention, recognition, treatment, and rehabilitation programs. Early stroke recognition through the use of stroke-assessment systems decreases the interval between the time of stroke onset and arrival at the hospital and definitive treatment.[37–42] This is associated with better outcomes, such as improved neurologic function. From a first aid education

perspective, it has been shown that 94.4% of lay providers trained in a stroke-assessment system are able to recognize signs and symptoms of a stroke, compared with 76.4% of those without training. The ability to recognize stroke with a stroke-assessment system persists at 3 months after training.[43]

The Face, Arm, Speech, Time (FAST) and Cincinnati Prehospital Stroke Scale (CPSS) stroke assessment systems are the simplest of these tools, with high sensitivity for the identification of stroke.[1] If glucose measurement is available to the first aid provider, stroke assessment systems such as the Los Angeles Prehospital Stroke Screen (LAPSS), Ontario Prehospital Stroke Scale (OPSS), Recognition of Stroke in the Emergency Room (ROSIER), and Kurashiki Prehospital Stroke Scale (KPSS) show increased specificity.[1,37–42,44–60]

The use of a stroke assessment system by first aid providers is recommended (Class I, LOE B-NR).

Chest Pain[FA 871, FA 586]

Chest pain is a common health problem with a myriad of causes, ranging from minor chest wall strains to pneumonia, angina, or myocardial infarction. It can be very difficult to differentiate chest pain of cardiac origin, such as a heart attack or myocardial infarction, from other origins. Common signs and symptoms associated with chest pain or discomfort of cardiac origin include shortness of breath, nausea, sweating, or pain in the arm(s) or back.

Aspirin has been found to significantly decrease mortality due to myocardial infarction in several large studies[61–63] and is therefore recommended for persons with chest pain due to suspected myocardial infarction (Class I, LOE B-R). There was no evidence of allergic reactions in 1 small study,[64] but there was an increased risk of bleeding among recipients of aspirin in 1 large study.[61]

The 2015 ILCOR systematic review for the use of aspirin in chest pain did not find any evidence to support the use of aspirin for undifferentiated chest pain.[1] When early aspirin administration (ie, in the first few hours after onset of symptoms) is compared with late aspirin administration (eg, after hospital arrival) for chest pain due to myocardial infarction, a reduction of mortality is found.[61,65,66]

Call EMS immediately for anyone with chest pain or other signs of heart attack, rather than trying to transport the person to a healthcare facility yourself (Class I, LOE C-EO).

While waiting for EMS to arrive, the first aid provider may encourage a person with chest pain to take aspirin if the signs and symptoms suggest that the person is having a heart attack and the person has no allergy or contraindication to aspirin, such as recent bleeding (Class IIa, LOE B-NR). The suggested dose of aspirin is 1 adult 325-mg tablet, or 2 to 4 low-dose "baby" aspirins (81 mg each), chewed and swallowed. If a person has chest pain that does not suggest that the cause is cardiac in origin, or if the first aid provider is uncertain or uncomfortable with administration of aspirin, then the first aid provider should not encourage the person to take aspirin (Class III: Harm, LOE C-EO). The decision to administer aspirin in these cases may be deferred to an EMS provider with physician oversight.

Anaphylaxis[FA 500]—Updated

Allergic reactions do not require epinephrine, but a small portion of reactions can progress to anaphylaxis. Epinephrine is recommended for anaphylaxis, and persons at risk are typically prescribed and carry an epinephrine autoinjector. An anaphylactic reaction involves 2 or more body systems and can be life-threatening. Symptoms may include respiratory difficulty (such as wheezing), cutaneous manifestations (such as hives or swelling of the lips and eyes), cardiovascular effects (such as hypotension, cardiovascular collapse, or shock), or gastrointestinal cramping and diarrhea. This update does not change the 2010 Guidelines recommendation that first aid providers assist with or administer to persons with symptoms of anaphylaxis their own epinephrine when they are having a reaction.[6] The recommended dose of epinephrine is 0.3 mg intramuscularly for adults and children greater than 30 kg, 0.15 mg intramuscularly for children 15 to 30 kg, or as prescribed by the person's physician. First aid providers should call 9-1-1 immediately when caring for a person with suspected anaphylaxis or a severe allergic reaction (Class I, LOE C-EO).

A second dose of epinephrine has been found to be beneficial for persons not responding to a first dose.[67–75] When a person with anaphylaxis does not respond to the initial dose, and arrival of advanced care will exceed 5 to 10 minutes, a repeat dose may be considered (Class IIb, LOE C-LD).

Hypoglycemia[FA 795]—New

Hypoglycemia can manifest as a variety of symptoms, including confusion, altered behavior, diaphoresis, or tremulousness. Diabetics who display these symptoms should be assumed by the first aid provider to have hypoglycemia. If the person is unconscious, exhibits seizures, or is unable to follow simple commands or swallow safely, the first aid provider should call for EMS immediately (Class I, LOE C-EO).

Evidence from the 2015 ILCOR systematic review demonstrates more rapid clinical relief of symptomatic hypoglycemia with glucose tablets compared with various evaluated dietary sugars, such as sucrose- or fructose-containing candies or foods, orange juice, or milk (Table 1).[76–78] If a person with diabetes reports low blood sugar or exhibits signs or symptoms of mild hypoglycemia and is able to follow simple commands and swallow, oral glucose should be given to attempt to resolve the hypoglycemia. Glucose tablets, if available, should be used to reverse hypoglycemia in a person who is able to take these orally (Class I, LOE B-R).

If glucose tablets are not available, other forms of dietary sugars, as depicted in Table 1, have been found to be effective as a substitute for glucose tablets to reverse hypoglycemia.[76–79] It is reasonable to use these dietary sugars as an alternative to glucose tablets (when not available) for reversal of mild symptomatic hypoglycemia (Class IIa, LOE B-R).

For diabetics with symptoms of hypoglycemia, symptoms may not resolve until 10 to 15 minutes after ingesting glucose tablets or dietary sugars (Table 1).[76–79] First aid providers should therefore wait at least 10 to 15 minutes before calling EMS and re-treating a diabetic with mild symptomatic hypoglycemia with additional oral sugars (Class I, LOE

Table 1. Types of Food Representing 20 g of Carbohydrates and Number of People With Improvement in Hypoglycemia Within 15 Minutes (Based on Included Evidence)[1]

Type of Food or Fluid	Carbohydrates/Serving	Measure Representing 20 g Carbohydrates*	Clinical Relief 15 min or Less After Ingestion
Glucose tablets	Varies	Varies	194/223 (87.0%)
Glucose 71%/oligosaccharides 29% candy (Mentos)	2.8 g/mint	5–10 mints	44/48 (91.7%)
Sucrose candy (Skittles)	0.9 g/candy	20–25 candies	150/177 (84.7%)
Jelly beans	1.1 g/jelly bean	15–20 jelly beans	33/45 (73.3%)
Orange juice (unsweetened, from concentrate)	1 g/10 mL	200 mL	35/50 (70.0%)
Fructose (fruit leather, such as Stretch Island)	10 g/strip	2 strips	111/165 (67.3%)
Whole milk	21.75 g/mL	435 mL	Not reported

*These measurements may differ from those in the evaluated studies, as the amount was not standardized across studies.

B-R). If the person's status deteriorates during that time or does not improve, the first aid provider should call EMS (Class I, LOE C-EO).

Exertional Dehydration[FA 584]—Updated

First aid providers are often called upon to assist at "hydration stations" at sporting events. Vigorous exercise, particularly in hot and humid environments, can lead to significant dehydration with loss of water and electrolytes through sweat.

Evidence from the 2015 ILCOR systematic review shows that ingestion of 5% to 8% carbohydrate-electrolyte (CE) solutions facilitates rehydration after exercise-induced dehydration and is generally well tolerated.[80,81] Studies in this review looked at the specific percentage CE solutions described and did not evaluate oral rehydration therapy or salts that are sometimes used for diarrheal illness. In the absence of shock, confusion, or inability to swallow, it is reasonable for first aid providers to assist or encourage individuals with exertional dehydration to orally rehydrate with CE drinks (Class IIa, LOE B-R). For individuals with severe dehydration with shock, confusion or symptoms of heat stroke, or symptoms of heat exhaustion or cramps, refer to the 2010 First Aid Guidelines.[6] Lemon tea-based CE drinks and Chinese tea with caffeine have been found to be similar to water for rehydration.[82] Other beverages, such as coconut water and 2% milk, have also been found to promote rehydration after exercise-associated dehydration, but they may not be as readily available.[80,82,83] If these alternative beverages are not available, potable water may be used (Class IIb, LOE B-R).

Toxic Eye Injury[FA 540]

Chemical injury to the eye occurs most commonly from chemicals in powder and liquid form. Evidence limited to a single study of eye exposure to an alkali showed improvement in ocular pH following irrigation with tap water compared with normal saline. In this study, irrigation with 1.5 L of solution occurred over 15 minutes.[84] It can be beneficial to rinse eyes exposed to toxic chemicals immediately and with a copious amount of tap water for at least 15 minutes or until advanced medical care arrives (Class IIa, LOE C-LD). If tap water is not available, normal saline or another commercially available eye irrigation solution may be reasonable (Class IIb, LOE C-LD). First aid providers caring for individuals with chemical eye injury should contact their local poison control center or, if a poison control center is not available, seek help from a medical provider or 9-1-1 (Class I, LOE C-EO).

Trauma Emergencies

Bleeding[FA 530]

Control of bleeding is an important first aid skill. Standard first aid bleeding control includes applying direct pressure with or without gauze. The 2015 ILCOR systematic review evaluated the use of pressure points, elevation, local application of ice, tourniquets, and hemostatic dressings for the control of bleeding compared with direct pressure.

Direct Pressure, Pressure Points, and Elevation

There continues to be no evidence to support the use of pressure points or elevation of an injury to control external bleeding. The use of pressure points or elevation of an extremity to control external bleeding is not indicated (Class III: No Benefit, LOE C-EO). The standard method for first aid providers to control open bleeding is to apply direct pressure to the bleeding site until it stops. Control open bleeding by applying direct pressure to the bleeding site (Class I, LOE B-NR).

Localized Cold Therapy

There are limited data from the hospital setting demonstrating a benefit from application of localized cold therapy compared to direct pressure alone to closed bleeding, such as a bruise or hematoma.[85,86] Local cold therapy, such as an instant cold pack, can be useful for these types of injuries to the extremity or scalp (Class IIa, LOE C-LD). Cold therapy should be used with caution in children because of the risk of hypothermia in this population (Class I, LOE C-EO).

Tourniquets[FA 768]

Tourniquets can be effective for severe external limb bleeding. The use of tourniquets in the prehospital setting for severe external limb bleeding has been studied in the military setting[87–94] and civilian EMS setting.[95,96] The effectiveness and complications of different types of tourniquets, such as military tourniquets compared with commercial or improvised tourniquets, was not reviewed for 2015. However, tourniquets have been found to control bleeding effectively in most cases.[87,89,93,95] Potential complications include compartment syndrome,[88] nerve damage,[88,90,93,95] damage to blood vessels,[95]

and amputation or limb shortening.[87,88,90,93] Complications may be related to tourniquet pressure and duration of occlusion, but there is insufficient evidence to determine a minimal critical time beyond which irreversible complications may occur. Because the rate of complications is low and the rate of hemostasis is high, first aid providers may consider the use of a tourniquet when standard first aid hemorrhage control does not control severe external limb bleeding (Class IIb, LOE C-LD).

A tourniquet may be considered for initial care when a first aid provider is unable to use standard first aid hemorrhage control, such as during a mass casualty incident, with a person who has multisystem trauma, in an unsafe environment, or with a wound that cannot be accessed (Class IIb, LOE C-EO). Although maximum time for tourniquet use was not reviewed by a 2015 ILCOR systematic review, it has been recommended that the first aid provider note the time that a tourniquet is first applied and communicate this information with EMS providers.[6] It is reasonable for first aid providers to be trained in the proper application of tourniquets, both manufactured and improvised (Class IIa, LOE C-EO).

Hemostatic Dressings[FA 769]—Updated

Hemostatic dressings are becoming more commonly used to control bleeding, especially in the military setting.[97–99] Early-generation powder or granular hemostatic agents were poured directly into the wound and were associated with exothermic reactions that could worsen tissue injury. Because of the potential for adverse effects and the variability of effectiveness of early hemostatic agents and dressings, routine use has not previously been advised. Newer-generation hemostatic agent–impregnated dressings are safer and effective in providing hemostasis in up to 90% of participants in case series.[97–100] Both complications and adverse effects are now uncommon but may include wound infection and exothermic burns.[97] Use of newer-generation hemostatic dressings is increasing in the civilian setting.[100]

Hemostatic dressings may be considered by first aid providers when standard bleeding control (direct pressure with or without gauze or cloth dressing) is not effective for severe or life-threatening bleeding (Class IIb, LOE C-LD). Hemostatic dressings are likely of greatest use for severe external bleeding in locations where standard hemorrhage control is not effective, when a tourniquet cannot be applied (trunk or junctional areas such as the abdomen or axilla/groin), when a tourniquet is not available, or when a tourniquet is not effective to stop bleeding. Proper application of hemostatic dressings requires training (Class I, LOE C-EO).

Open Chest Wounds[FA 525]—New

Management of an open chest wound in out-of-hospital settings is challenging and requires immediate activation of EMS. The greatest concern is the improper use of a dressing or device that could lead to fatal tension pneumothorax. There are no human studies comparing the application of an occlusive device versus a nonocclusive device.[1] We recommend against the application of an occlusive dressing or device by first aid providers for individuals with an open chest wound (Class III: Harm, LOE C-EO). In the first aid situation, it is reasonable to leave an open chest wound exposed to ambient air without a dressing or seal (Class IIa, LOE C-EO). If a nonocclusive dressing, such as a dry gauze dressing, is applied for active bleeding, care must be taken to ensure that saturation of the dressing does not lead to partial or complete occlusion.

Concussion[FA 799]—New

The signs and symptoms of concussion (mild traumatic brain injury) are complex. The classic signs of concussion after head trauma include feeling stunned or dazed, or experiencing headache, nausea, dizziness and unsteadiness (difficulty in balance), visual disturbance, confusion, or loss of memory (from either before or after the injury).[101] The various grades and combinations of these symptoms make the recognition of concussion difficult.[102] Furthermore, changes may be subtle and yet progressive.

First aid providers are often faced with the decision as to what advice to give to a person after minor head trauma, and it is now widely recognized that an incorrect decision can have long-term serious or even fatal consequences.[103]

There are no clinical studies to support the use of a simple concussion scoring system by first aid providers. Any person with a head injury that has resulted in a change in level of consciousness, has progressive development of signs or symptoms as described above, or is otherwise a cause for concern should be evaluated by a healthcare provider or EMS personnel as soon as possible (Class I, LOE C-EO). Using any mechanical machinery, driving, cycling, or continuing to participate in sports after a head injury should be deferred by these individuals until they are assessed by a healthcare provider and cleared to participate in those activities (Class I, LOE C-EO).

Spinal Motion Restriction[FA 772]

The terms *spinal immobilization* and *spinal motion restriction* have been used synonymously in the past. Because true spinal immobilization is not possible, the term *spinal motion restriction* is now being used to describe the practice of attempting to maintain the spine in anatomical alignment and minimize gross movement, with or without the use of specific adjuncts such as collars.

In the 2010 review, no published studies were identified to support or refute the benefit of spinal immobilization and/or the method by which to apply spinal motion restriction (SMR) by first aid providers.[7] For the 2015 ILCOR systematic review, cervical SMR in injured persons without penetrating trauma, as a component of total SMR, was the specific focus for evidence review. Thus, the evidence evaluation was limited to the use of cervical collars. Potential adverse effects from the use of a cervical collar include increased intracranial pressure[104–109] and potential airway compromise.[110] Once again, no studies were found that demonstrated a decrease in neurologic injury with the use of a cervical collar.[111]

While complete SMR may be indicated for individuals who have blunt mechanism of injury and who meet high-risk criteria as recommended in the 2010 Guidelines,[6] the proper technique for SMR requires extensive training and practice to be performed properly and is thus not considered a skill for first aid providers.

With a growing body of evidence showing more actual harm and no good evidence showing clear benefit, we

recommend against routine application of cervical collars by first aid providers (Class III: Harm, LOE C-LD). If a first aid provider suspects a spinal injury, he or she should have the person remain as still as possible and await the arrival of EMS providers (Class I, LOE C-EO).

Musculoskeletal Trauma

Suspected Long Bone Fractures[FA 503]

Long bone fractures may at times be severely angulated. The 2015 ILCOR systematic review attempted to compare straightening of angulated long bone fractures before splinting with splinting in the position found. No studies were identified that evaluate straightening of angulated long bone fractures before splinting. Thus, there is no evidence in the first aid setting for or against the straightening or gentle realignment of a suspected angulated long bone fracture before splinting, including in the presence of neurovascular compromise, for outcomes of incidence of neurologic or vascular injury, ability to splint, pain experienced, or time to medical transportation.[1]

In general, first aid providers should not move or try to straighten an injured extremity (Class III: Harm, LOE C-EO). Based on training and circumstance (such as remote distance from EMS or wilderness settings, presence of vascular compromise), some first aid providers may need to move an injured limb or person. In such situations, providers should protect the injured person, including splinting in a way that limits pain, reduces the chance for further injury, and facilitates safe and prompt transport (Class I, LOE C-EO).

If an injured extremity is blue or extremely pale, activate EMS immediately (Class I, LOE C-EO).

Burns

Thermal Burns: Cooling[FA 770]

Burns can come from a variety of sources such as hot water (scalds) and fire. It is known that applying ice directly to a burn can cause tissue ischemia.[6,7] The 2015 ILCOR systematic review of the evidence for cooling of burns evaluated agents that were cool or cold, but not frozen. Cooling was found to reduce risk of injury and depth of injury.[11,112,113] Cool thermal burns with cool or cold potable water as soon as possible and for at least 10 minutes (Class I, LOE B-NR). If cool or cold water is not available, a clean cool or cold, but not freezing, compress can be useful as a substitute for cooling thermal burns (Class IIa, LOE B-NR). Care should be taken to monitor for hypothermia when cooling large burns (Class I, LOE C-EO). This is particularly important in children, who have a larger body surface area for their weight than adults have.

Burn Dressings[FA 771]

It is common for first aid providers to cover a burn with a dressing after it has been cooled; however, based on limited data, there is no evidence that a wet dressing compared with a dry dressing is beneficial for care of a burn.[1] One study showed no benefit for a topical penetrating antibacterial versus petrolatum gauze or for a topical nonpenetrating antibacterial versus dry dressing.[114] After cooling of a burn, it may be reasonable to loosely cover the burn with a sterile, dry dressing (Class IIb, LOE C-LD).

Honey, when used as a dressing, has been shown in 2 randomized controlled trials to decrease the risk of infection and mean duration of time to healing when compared with an antibiotic–impregnated gauze dressings.[115,116] Both of these studies were downgraded for risk of bias, imprecision, and indirectness. In general, it may be reasonable to avoid natural remedies, such as honey or potato peel dressings (Class IIb, LOE C-LD). However, in remote or wilderness settings where commercially made topical antibiotics are not available, it may be reasonable to consider applying honey topically as an antimicrobial agent (Class IIb, LOE C-LD).

Burns: When Advanced Care Is Needed

Burns associated with or involving (1) blistering or broken skin; (2) difficulty breathing; (3) the face, neck, hands, or genitals; (4) a larger surface area, such as trunk or extremities; or (5) other cause for concern should be evaluated by a healthcare provider (Class I, LOE C-EO).

Dental Avulsion[FA 794] —Updated

Dental avulsion injury can damage both the tooth and the supporting soft tissue and bone, resulting in permanent loss of the tooth. Immediate reimplantation of an avulsed tooth is believed by the dental community to result in the greatest chance of tooth survival.[117] In situations that do not allow for immediate reimplantation, it can be beneficial to temporarily store an avulsed tooth in a variety of solutions shown to prolong viability of dental cells (Class IIa, LOE C-LD). The following solutions have demonstrated efficacy at prolonging dental cell viability from 30 to 120 minutes, and they may be available to first aid providers (listed in order of preference based on the C2015 evidence review): Hank's Balanced Salt Solution (containing calcium, potassium chloride and phosphate, magnesium chloride and sulfate, sodium chloride, sodium bicarbonate, sodium phosphate dibasic and glucose), propolis, egg white, coconut water, Ricetral, or whole milk.[118–128]

If none of these solutions are available, it may be reasonable to store an avulsed tooth in the injured persons saliva (not in the mouth) pending reimplantation (Class IIb, LOE C-LD). Viability of an avulsed tooth stored in any of the above solutions is limited. Reimplantation of the tooth within an hour after avulsion affords the greatest chance for tooth survival. Following dental avulsion, it is essential to seek rapid assistance with reimplantation (Class I, LOE C-EO).

Disclosures

Part 15: First Aid: 2015 Guidelines Update Writing Group Disclosures

Writing Group Member	Employment	Research Grant	Other Research Support	Speakers' Bureau/ Honoraria	Expert Witness	Ownership Interest	Consultant/ Advisory Board	Other
Eunice M. Singletary	University of Virginia; University Physicians Group	None	None	None	None	None	None	None
Nathan P. Charlton	University of Virginia	None	None	None	None	None	None	None
Jonathan L. Epstein	American Red Cross	None	None	None	None	None	None	None
Jeffrey D. Ferguson	Virginia Commonwealth University	None	None	None	None	None	None	None
Jan L. Jenson	Emergency Health Services, Dalhousie University	None	Nova Scotia Health Research Foundation*; Canadian Institutes of Health Research*	None	None	None	None	None
Luis F. Lojero-Wheatley	Swiss Hospital	None	None	None	None	None	None	None
Andrew I. MacPherson	Canadian Red Cross	None	None	None	None	None	None	None
Jeffrey L. Pellegrino	Kent State University	None	None	None	None	None	None	None
William "Will" R. Smith	Wilderness and Emergency Medicine Consulting (WEMC), LLC	None	None	None	Medicolegal consulting†	None	Chinook Medical Gear*	National Park Service*
Janel M. Swain	Emergency Health Services	None	Capital District Health Authority*	None	None	None	None	Emergency Health Services/ Emergency Medical Care Inc.†
David A. Zideman	Imperial College Healthcare NHS	None	None	None	None	None	None	None

This table represents the relationships of writing group members that may be perceived as actual or reasonably perceived conflicts of interest as reported on the Disclosure Questionnaire, which all members of the writing group are required to complete and submit. A relationship is considered to be "significant" if (a) the person receives $10 000 or more during any 12-month period, or 5% or more of the person's gross income; or (b) the person owns 5% or more of the voting stock or share of the entity, or owns $10 000 or more of the fair market value of the entity. A relationship is considered to be "modest" if it is less than "significant" under the preceding definition.

*Modest.

†Significant.

Appendix

2015 Guidelines Update: Part 15 Recommendations

Year Last Reviewed	Topic	Recommendation	Comments
2015	First Aid Education	Education and training in first aid can be useful to improve morbidity and mortality from injury and illness (Class IIa, LOE C-LD).	new for 2015
2015	First Aid Education	We recommend that first aid education be universally available (Class I, LOE C-EO).	new for 2015
2015	Positioning the Ill or Injured Person	If the area is unsafe for the first aid provider or the person, move to a safe location if possible (Class I, LOE C-EO).	updated for 2015
2015	Positioning the Ill or Injured Person	If a person is unresponsive and breathing normally, it may be reasonable to place him or her in a lateral side-lying recovery position (Class IIb, LOE C-LD).	updated for 2015
2015	Positioning the Ill or Injured Person	If a person has been injured and the nature of the injury suggests a neck, back, hip, or pelvic injury, the person should not be rolled onto his or her side and instead should be left in the position in which they were found, to avoid potential further injury (Class I, LOE C-EO).	updated for 2015
2015	Positioning the Ill or Injured Person	If leaving the person in the position found is causing the person's airway to be blocked, or if the area is unsafe, move the person only as needed to open the airway and to reach a safe location (Class I, LOE C-EO).	updated for 2015
2015	Position for Shock	If a person shows evidence of shock and is responsive and breathing normally, it is reasonable to place or maintain the person in a supine position (Class IIa, LOE C-LD)	updated for 2015
2015	Position for Shock	If there is no evidence of trauma or injury (eg, simple fainting, shock from nontraumatic bleeding, sepsis, dehydration), raising the feet about 6 to 12 inches (about 30° to 60°) from the supine position is an option that may be considered while awaiting arrival of EMS (Class IIb, LOE C-LD)	updated for 2015
2015	Position for Shock	Do not raise the feet of a person in shock if the movement or the position causes pain (Class III: Harm, LOE C-EO).	new for 2015
2015	Oxygen Use in First Aid	The use of supplementary oxygen by first aid providers with specific training is reasonable for cases of decompression sickness (Class IIa, LOE C-LD)	updated for 2015
2015	Oxygen Use in First Aid	For first aid providers with specific training in the use of oxygen, the administration of supplementary oxygen to persons with known advanced cancer with dyspnea and hypoxemia may be reasonable (Class IIb, LOE B-R).	new for 2015
2015	Oxygen Use in First Aid	Although no evidence was identified to support the use of oxygen, it might be reasonable to provide oxygen to spontaneously breathing persons who are exposed to carbon monoxide while waiting for advanced medical care (Class IIb, LOE C-EO).	new for 2015
2015	Medical Emergencies: Asthma	It is reasonable for first aid providers to be familiar with the available inhaled bronchodilator devices and to assist as needed with the administration of prescribed bronchodilators when a person with asthma is having difficulty breathing (Class IIa, LOE B-R).	updated for 2015
2015	Medical Emergencies: Stroke	The use of a stroke assessment system by first aid providers is recommended (Class I, LOE B-NR).	new for 2015
2015	Medical Emergencies: Chest Pain	Aspirin has been found to significantly decrease mortality due to myocardial infarction in several large studies and is therefore recommended for persons with chest pain due to suspected myocardial infarction (Class I, LOE B-R).	updated for 2015
2015	Medical Emergencies: Chest Pain	Call EMS immediately for anyone with chest pain or other signs of heart attack, rather than trying to transport the person to a healthcare facility yourself (Class I, LOE C-EO).	new for 2015
2015	Medical Emergencies: Chest Pain	While waiting for EMS to arrive, the first aid provider may encourage a person with chest pain to take aspirin if the signs and symptoms suggest that the person is having a heart attack and the person has no allergy or contraindication to aspirin, such as recent bleeding (Class IIa, LOE B-NR).	updated for 2015
2015	Medical Emergencies: Chest Pain	If a person has chest pain that does not suggest that the cause is cardiac in origin, or if the first aid provider is uncertain or uncomfortable with administration of aspirin, then the first aid provider should not encourage the person to take aspirin (Class III: Harm, LOE C-EO).	new for 2015
2015	Medical Emergencies: Anaphylaxis	The recommended dose of epinephrine is 0.3 mg intramuscularly for adults and children greater than 30 kg, 0.15 mg intramuscularly for children 15 to 30 kg, or as prescribed by the person's physician. First aid providers should call 9-1-1 immediately when caring for a person with suspected anaphylaxis or a severe allergic reaction (Class I, LOE C-EO).	new for 2015
2015	Medical Emergencies: Anaphylaxis	When a person with anaphylaxis does not respond to the initial dose, and arrival of advanced care will exceed 5 to 10 minutes, a repeat dose may be considered (Class IIb, LOE C-LD).	updated for 2015

(*Continued*)

2015 Guidelines Update: Part 15 Recommendations, *Continued*

Year Last Reviewed	Topic	Recommendation	Comments
2015	Medical Emergencies: Hypoglycemia	If the person is unconscious, exhibits seizures, or is unable to follow simple commands or swallow safely, the first aid provider should call for EMS immediately (Class I, LOE C-EO).	new for 2015
2015	Medical Emergencies: Hypoglycemia	If a person with diabetes reports low blood sugar or exhibits signs or symptoms of mild hypoglycemia and is able to follow simple commands and swallow, oral glucose should be given to attempt to resolve the hypoglycemia. Glucose tablets, if available, should be used to reverse hypoglycemia in a person who is able to take these orally (Class I, LOE B-R).	new for 2015
2015	Medical Emergencies: Hypoglycemia	It is reasonable to use these dietary sugars as an alternative to glucose tablets (when not available) for reversal of mild symptomatic hypoglycemia (Class IIa, LOE B-R).	new for 2015
2015	Medical Emergencies: Hypoglycemia	First aid providers should therefore wait at least 10 to 15 minutes before calling EMS and re-treating a diabetic with mild symptomatic hypoglycemia with additional oral sugars (Class I, LOE B-R).	new for 2015
2015	Medical Emergencies: Hypoglycemia	If the person's status deteriorates during that time or does not improve, the first aid provider should call EMS (Class I, LOE C-EO).	new for 2015
2015	Medical Emergencies: Dehydration	In the absence of shock, confusion, or inability to swallow, it is reasonable for first aid providers to assist or encourage individuals with exertional dehydration to orally rehydrate with CE drinks (Class IIa, LOE B-R).	new for 2015
2015	Medical Emergencies: Dehydration	If these alternative beverages are not available, potable water may be used (Class IIb, LOE B-R).	new for 2015
2015	Medical Emergencies: Toxic Eye Injury	It can be beneficial to rinse eyes exposed to toxic chemicals immediately and with a copious amount of tap water for at least 15 minutes or until advanced medical care arrives (Class IIa, LOE C-LD).	updated for 2015
2015	Medical Emergencies: Toxic Eye Injury	If tap water is not available, normal saline or another commercially available eye irrigation solution may be reasonable (Class IIb, LOE C-LD).	new for 2015
2015	Medical Emergencies: Chemical Eye Injury	First aid providers caring for individuals with chemical eye injury should contact their local poison control center or, if a poison control center is not available, seek help from a medical provider or 9-1-1 (Class I, LOE C-EO).	new for 2015
2015	Trauma Emergencies: Control of Bleeding	There continues to be no evidence to support the use of pressure points or elevation of an injury to control external bleeding. The use of pressure points or elevation of an extremity to control external bleeding is not indicated (Class III: No Benefit, LOE C-EO).	updated for 2015
2015	Trauma Emergencies: Control of Bleeding	The standard method for first aid providers to control open bleeding is to apply direct pressure to the bleeding site until it stops. Control open bleeding by applying direct pressure to the bleeding site (Class I, LOE B-NR).	updated for 2015
2015	Trauma Emergencies: Control of Bleeding	Local cold therapy, such as an instant cold pack, can be useful for these types of injuries to the extremity or scalp (Class IIa, LOE C-LD).	new for 2015
2015	Trauma Emergencies: Control of Bleeding	Cold therapy should be used with caution in children because of the risk of hypothermia in this population (Class I, LOE C-EO).	new for 2015
2015	Trauma Emergencies: Control of Bleeding	Because the rate of complications is low and the rate of hemostasis is high, first aid providers may consider the use of a tourniquet when standard first aid hemorrhage control does not control severe external limb bleeding (Class IIb, LOE C-LD).	updated for 2015
2015	Trauma Emergencies: Control of Bleeding	A tourniquet may be considered for initial care when a first aid provider is unable to use standard first aid hemorrhage control, such as during a mass casualty incident, with a person who has multisystem trauma, in an unsafe environment, or with a wound that cannot be accessed (Class IIb, LOE C-EO).	new for 2015
2015	Trauma Emergencies: Control of Bleeding	Although maximum time for tourniquet use was not reviewed by a 2015 ILCOR systematic review, it has been recommended that the first aid provider note the time that a tourniquet is first applied and communicate this information with EMS providers. It is reasonable for first aid providers to be trained in the proper application of tourniquets, both manufactured and improvised (Class IIa, LOE C-EO).	new for 2015
2015	Trauma Emergencies: Control of Bleeding	Hemostatic dressings may be considered by first aid providers when standard bleeding control (direct pressure with or without gauze or cloth dressing) is not effective for severe or life-threatening bleeding (Class IIb, LOE C-LD).	updated for 2015
2015	Trauma Emergencies: Control of Bleeding	Proper application of hemostatic dressings requires training (Class I, LOE C-EO).	updated for 2015
2015	Trauma Emergencies: Open Chest Wounds	We recommend against the application of an occlusive dressing or device by first aid providers for individuals with an open chest wound (Class III: Harm, LOE C-EO).	new for 2015

(*Continued*)

2015 Guidelines Update: Part 15 Recommendations, *Continued*

Year Last Reviewed	Topic	Recommendation	Comments
2015	Trauma Emergencies: Open Chest Wounds	In the first aid situation, it is reasonable to leave an open chest wound exposed to ambient air without a dressing or seal (Class IIa, LOE C-EO).	new for 2015
2015	Trauma Emergencies: Concussion	Any person with a head injury that has resulted in a change in level of consciousness, has progressive development of signs or symptoms as described above, or is otherwise a cause for concern should be evaluated by a healthcare provider or EMS personnel as soon as possible (Class I, LOE C-EO).	new for 2015
2015	Trauma Emergencies: Concussion	Using any mechanical machinery, driving, cycling, or continuing to participate in sports after a head injury should be deferred by these individuals until they are assessed by a healthcare provider and cleared to participate in those activities (Class I, LOE C-EO).	new for 2015
2015	Trauma Emergencies: Spinal Motion Restriction	With a growing body of evidence showing more actual harm and no good evidence showing clear benefit, we recommend against routine application of cervical collars by first aid providers (Class III: Harm, LOE C-LD).	updated for 2015
2015	Trauma Emergencies: Spinal Motion Restriction	If a first aid provider suspects a spinal injury, he or she should have the person remain as still as possible and await the arrival of EMS providers (Class I, LOE C-EO).	new for 2015
2015	Musculoskeletal Trauma	In general, first aid providers should not move or try to straighten an injured extremity (Class III: Harm, LOE C-EO).	updated for 2015
2015	Musculoskeletal Trauma	In such situations, providers should protect the injured person, including splinting in a way that limits pain, reduces the chance for further injury, and facilitates safe and prompt transport (Class I, LOE C-EO).	updated for 2015
2015	Musculoskeletal Trauma	If an injured extremity is blue or extremely pale, activate EMS immediately (Class I, LOE C-EO).	new for 2015
2015	Burns	Cool thermal burns with cool or cold potable water as soon as possible and for at least 10 minutes (Class I, LOE B-NR).	updated for 2015
2015	Burns	If cool or cold water is not available, a clean cool or cold, but not freezing, compress can be useful as a substitute for cooling thermal burns (Class IIa, LOE B-NR).	new for 2015
2015	Burns	Care should be taken to monitor for hypothermia when cooling large burns (Class I, LOE C-EO).	new for 2015
2015	Burns	After cooling of a burn, it may be reasonable to loosely cover the burn with a sterile, dry dressing (Class IIb, LOE C-LD).	updated for 2015
2015	Burns	In general, it may be reasonable to avoid natural remedies, such as honey or potato peel dressings (Class IIb, LOE C-LD).	new for 2015
2015	Burns	However, in remote or wilderness settings where commercially made topical antibiotics are not available, it may be reasonable to consider applying honey topically as an antimicrobial agent (Class IIb, LOE C-LD).	new for 2015
2015	Burns	Burns associated with or involving (1) blistering or broken skin; (2) difficulty breathing; (3) the face, neck, hands, or genitals; (4) a larger surface area, such as trunk or extremities; or (5) other cause for concern should be evaluated by a healthcare provider (Class I, LOE C-EO).	new for 2015
2015	Dental Injury	In situations that do not allow for immediate reimplantation, it can be beneficial to temporarily store an avulsed tooth in a variety of solutions shown to prolong viability of dental cells (Class IIa, LOE C-LD).	updated for 2015
2015	Dental Injury	If none of these solutions are available, it may be reasonable to store an avulsed tooth in the injured persons saliva (not in the mouth) pending reimplantation (Class IIb, LOE C-LD).	new for 2015
2015	Dental Injury	Following dental avulsion, it is essential to seek rapid assistance with reimplantation (Class I, LOE C-EO).	new for 2015
The following recommendations were not reviewed in 2015. For more information, see the *2010 AHA and American Red Cross Guidelines for First Aid*, "Part 17: First Aid."			
2010	Oxygen	There is insufficient evidence to recommend routine use of supplementary oxygen by a first aid provider for victims complaining of chest discomfort or shortness of breath (Class IIb, LOE C).	not reviewed in 2015
2010	Anaphylaxis	First aid providers should also know how to administer the auto-injector if the victim is unable to do so, provided that the medication has been prescribed by a physician and state law permits it (Class IIb, LOE B).	not reviewed in 2015
2010	Tourniquets	Specifically designed tourniquets appear to be better than ones that are improvised, but tourniquets should only be used with proper training (Class IIa, LOE B).	not reviewed in 2015
2010	Thermal Burns	Don't apply ice directly to a burn; it can produce tissue ischemia (Class III, LOE B).	not reviewed in 2015
2010	Spine Stabilization	Because of the dire consequences if secondary injury does occur, maintain spinal motion restriction by manually stabilizing the head so that the motion of head, neck, and spine is minimized (Class IIb, LOE C).	not reviewed in 2015

(*Continued*)

2015 Guidelines Update: Part 15 Recommendations, *Continued*

Year Last Reviewed	Topic	Recommendation	Comments
2010	Sprains and Strains	Place a barrier, such as a thin towel, between the cold container and the skin (Class IIb, LOE C).	not reviewed in 2015
2010	Hypothermia	If the hypothermia victim is far from definitive health care, begin active rewarming (Class IIa, LOE B) although the effectiveness of active rewarming has not been evaluated.	not reviewed in 2015
2010	Seizures	Placing an object in the victim's mouth may cause dental damage or aspiration (Class IIa, LOE C).	not reviewed in 2015
2010	Wounds and Abrasions	Superficial wounds and abrasions should be thoroughly irrigated with a large volume of warm or room temperature potable water with or without soap until there is no foreign matter in the wound (Class I, LOE A).	not reviewed in 2015
2010	Wounds and Abrasions	Wounds heal better with less infection if they are covered with an antibiotic ointment or cream and a clean occlusive dressing (Class IIa, LOE A).	not reviewed in 2015
2010	Burn Blisters	Loosely cover burn blisters with a sterile dressing but leave blisters intact because this improves healing and reduces pain (Class IIa, LOE B).	not reviewed in 2015
2010	Electric Injuries	Do not place yourself in danger by touching an electrocuted victim while the power is on (Class III, LOE C).	not reviewed in 2015
2010	Human and Animal Bites	Irrigate human and animal bites with copious amounts of water (Class I, LOE B).	not reviewed in 2015
2010	Snakebites	Do not apply suction as first aid for snakebites (Class III, LOE C).	not reviewed in 2015
2010	Snakebites	Applying a pressure immobilization bandage with a pressure between 40 and 70 mm Hg in the upper extremity and between 55 and 70 mm Hg in the lower extremity around the entire length of the bitten extremity is an effective and safe way to slow the dissemination of venom by slowing lymph flow (Class IIa, LOE C).	not reviewed in 2015
2010	Jellyfish Stings	To inactivate venom load and prevent further envenomation, jellyfish stings should be liberally washed with vinegar (4% to 6% acetic acid solution) as soon as possible for at least 30 seconds (Class IIa, LOE B).	not reviewed in 2015
2010	Jellyfish Stings	For the treatment of pain, after the nematocysts are removed or deactivated, jellyfish stings should be treated with hot-water immersion when possible (Class IIa, LOE B).	not reviewed in 2015
2010	Jellyfish Stings	If hot water is not available, dry hot packs or, as a second choice, dry cold packs may be helpful in decreasing pain but these are not as effective as hot water (Class IIb, LOE B).	not reviewed in 2015
2010	Jellyfish Stings	Topical application of aluminum sulfate or meat tenderizer, commercially available aerosol products, fresh water wash, and papain, an enzyme derived from papaya used as a local medicine, are even less effective in relieving pain (Class IIb, LOE B).	not reviewed in 2015
2010	Jellyfish Stings	Pressure immobilization bandages are not recommended for the treatment of jellyfish stings because animal studies show that pressure with an immobilization bandage causes further release of venom, even from already fired nematocysts (Class III, LOE C).	not reviewed in 2015
2010	Frostbite	Do not try to rewarm the frostbite if there is any chance that it might refreeze or if you are close to a medical facility (Class III, LOE C).	not reviewed in 2015
2010	Frostbite	Severe or deep frostbite should be rewarmed within 24 hours of injury and this is best accomplished by immersing the frostbitten part in warm (37° to 40°C or approximately body temperature) water for 20 to 30 minutes (Class IIb, LOE C).	not reviewed in 2015
2010	Frostbite	Chemical warmers should not be placed directly on frostbitten tissue because they can reach temperatures that can cause burns (Class III, LOE C).	not reviewed in 2015
2010	Chemical Burns	In case of exposure to an acid or alkali on the skin or eye, immediately irrigate the affected area with copious amounts of water (Class I, LOE B).	not reviewed in 2015
2010	Treatment With Milk or Water	Do not administer anything by mouth for any poison ingestion unless advised to do so by a poison control center or emergency medical personnel because it may be harmful (Class III, LOE C).	not reviewed in 2015
2010	Activated Charcoal	Do not administer activated charcoal to a victim who has ingested a poisonous substance unless you are advised to do so by poison control center or emergency medical personnel (Class IIb, LOE C).	not reviewed in 2015
2010	Ipecac	Do not administer syrup of ipecac for ingestions of toxins (Class III, LOE B).	not reviewed in 2015

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