American
Heart
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GUIDELINES
2015 CPR & ECC
HIGHLIGHTS
of the 2015 American Heart Association
Guidelines Update for CPR and ECC
2015

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Introduction

This "Guidelines Highlights" publication summarizes the key issues and changes in the *2015 American Heart Association* (AHA) *Guidelines Update for Cardiopulmonary Resuscitation* (CPR) *and Emergency Cardiovascular Care* (ECC). It has been developed for resuscitation providers and for AHA instructors to focus on the resuscitation science and guidelines recommendations that are most significant or controversial or those that will result in changes in resuscitation practice or resuscitation training. In addition, it provides the rationale for the recommendations.

Because this publication is designed as a summary, it does not reference the supporting published studies and does not list Classes of Recommendation or Levels of Evidence.

For more detailed information and references, readers are encouraged to read the *2015 AHA Guidelines Update for CPR and ECC*, including the Executive Summary,[1] published in *Circulation* in October 2015, and to consult the detailed summary of resuscitation science in the *2015 International Consensus on CPR and ECC Science With Treatment Recommendations*, published simultaneously in *Circulation*[2] and *Resuscitation*.[3]

The *2015 AHA Guidelines Update for CPR and ECC* is based on an international evidence evaluation process that involved 250 evidence reviewers from 39 countries. The process for the 2015 International Liaison Committee on Resuscitation (ILCOR) systematic review was quite different when compared with the process used in 2010. For the 2015 systematic review process, the ILCOR task forces prioritized topics for review, selecting those where there was

Figure 1

New AHA Classification System for Classes of Recommendation and Levels of Evidence*

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) — **Benefit = Risk**
(Generally, LOE A or B use only)

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.

sufficient new science or controversy to prompt a systematic review. As a result of this prioritization, there were fewer reviews completed in 2015 (166) than in 2010 (274).

Once the topics were selected, there were 2 important additions to the 2015 process of review itself. First, reviewers used Grading of Recommendations Assessment, Development, and Evaluation (GRADE; www.gradeworkinggroup.org), a highly structured and reproducible evidence review system, to improve the consistency and quality of the 2015 systematic reviews. Second, reviewers from around the world were able to work together virtually to complete the systematic reviews through the use of a purpose-built AHA Web-based platform, the Systematic Evidence Evaluation and Review System (SEERS), designed to support the many steps of the evaluation process. This SEERS site was used to provide public disclosure of drafts of the ILCOR *2015 International Consensus on CPR and ECC Science With Treatment Recommendations* and to receive public comment. To learn more about SEERS and to see a comprehensive list of all systematic reviews conducted by ILCOR, visit www.ilcor.org/seers.

The *2015 AHA Guidelines Update for CPR and ECC* is very different from previous editions of the AHA Guidelines for CPR and ECC. The ECC Committee determined that this 2015 version would be an *update*, addressing *only* those topics addressed by the 2015 ILCOR evidence review or those requested by the training network. This decision ensures that we have only one standard for evidence evaluation, and that is the process created by ILCOR. As a result, the *2015 AHA Guidelines Update for CPR and ECC* is not a comprehensive revision of the *2010 AHA Guidelines for CPR and ECC*. Such an integrated version is available online at ECCguidelines.heart.org.

The publication of the *2015 International Consensus on CPR and ECC Science With Treatment Recommendations* begins a process of ongoing review of resuscitation science. The topics reviewed in 2015 will be updated as needed and new topics will be added. Readers will want to monitor the SEERS site to keep up-to-date on the newest resuscitation science and the ILCOR evaluation of that science. When sufficient evidence emerges that indicates the need to change the AHA Guidelines for CPR and ECC, such changes will be made and communicated to clinicians and to the training network.

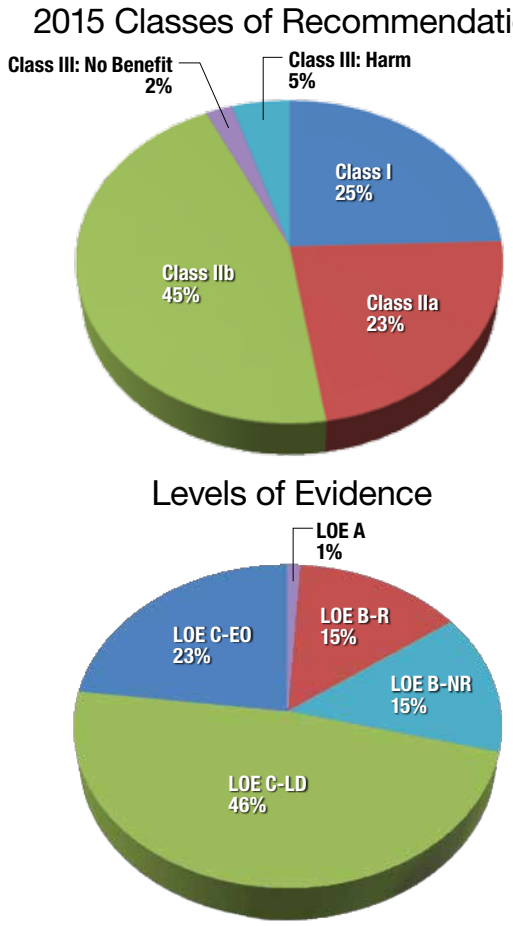
The 2015 Guidelines Update used the most recent version of the AHA definitions for the Classes of Recommendation and Levels of Evidence (Figure 1). Readers will note that this version contains a modified Class III recommendation, Class III: No Benefit, to be used infrequently when evidence suggests a strategy is demonstrated by a high- or moderate-quality study (Level of Evidence [LOE] A or B, respectively) to be no better than the control. The Levels of Evidence have also been modified. LOE B is now divided into LOE B-R (randomized studies) and LOE B-NR (nonrandomized studies). LOE C is now divided into LOE C-LD (limited data) and C-EO (expert opinion).

As outlined in the recently published Institute of Medicine report[4] and the AHA ECC consensus response to this report,[5] more needs to be done to advance the science and practice of resuscitation. There must be a concerted effort to fund cardiac arrest resuscitation research similar to what has driven cancer and stroke research over the past 2 decades. The gaps in the science are clear when the recommendations contained within the 2015 Guidelines Update are scrutinized (Figure 2). Collectively, the Levels of Evidence and the Classes of Recommendation in resuscitation are low, with only 1% of the total recommendations in 2015 (3 of 315) based on the highest Level of Evidence (LOE A) and only 25% of the recommendations (78 of 315) designated as Class I (strong recommendation). Most (69%) of the 2015 Guidelines Update recommendations are supported by the lowest Levels of Evidence (LOE C-LD or C-EO), and nearly half (144 of 315; 45%) are categorized as Class IIb (weak recommendation).

Throughout the ILCOR evidence evaluation process and the 2015 Guidelines Update development, participants adhered strictly to the AHA conflict of interest disclosure requirements. The AHA staff processed more than 1000 conflict of interest disclosures, and all Guidelines writing group chairs and at least 50% of Guidelines writing group members were required to be free of relevant conflicts of interest.

Figure 2

Distribution of Classes of Recommendation and Levels of Evidence as Percent of 315 Total Recommendations in 2015 AHA Guidelines Update



Percent of 315 recommendations.

Ethical Issues

As resuscitation practice evolves, ethical considerations must also evolve. Managing the multiple decisions associated with resuscitation is challenging from many perspectives, no more so than when healthcare providers (HCPs) are dealing with the ethics surrounding decisions to provide or withhold emergency cardiovascular interventions.

Ethical issues surrounding whether to start or when to terminate CPR are complex and may vary across settings (in- or out-of-hospital), providers (basic or advanced), and patient population (neonatal, pediatrics, adult). Although ethical principles have not changed 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 AHA Guidelines Update include several science updates that have implications for ethical decision making for periarrest, arrest, and postarrest patients.

Significant New and Updated Recommendations That May Inform Ethical Decisions

- The use of extracorporeal CPR (ECPR) for cardiac arrest
- Intra-arrest prognostic factors
- Review of evidence about prognostic scores for preterm infants
- Prognostication for children and adults after cardiac arrest
- Function of transplanted organs recovered after cardiac arrest

New resuscitation strategies such as ECPR have made decisions to discontinue resuscitation measures more complicated (see the Adult Advanced Cardiovascular Life Support section in this publication). Understanding the appropriate use, implications, and likely benefits related to such new treatments will have an impact on decision making. There is new information about prognostication for neonates, children, and adults in cardiac arrest and after cardiac arrest (see Neonatal Resuscitation, Pediatric Advanced Life Support, and Post–Cardiac Arrest Care). The increased use of targeted temperature management (TTM) has led to new challenges for predicting neurologic outcomes in comatose post–cardiac arrest patients, and the latest data about the usefulness of particular tests and studies should inform decisions about goals of care and limiting interventions.

There is greater 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 each patient's level of development. In addition, 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 with specific limits on interventions at the end of life, both in and out of healthcare facilities. Even with new information that the success of kidney and liver transplants from adult donors is unrelated to whether the donor receives CPR, the donation of organs after resuscitation remains controversial. Viewpoints on several important ethical concerns that are the topics of ongoing debate around organ donation in an emergency setting are summarized in "Part 3: Ethical Issues" of the 2015 Guidelines Update.

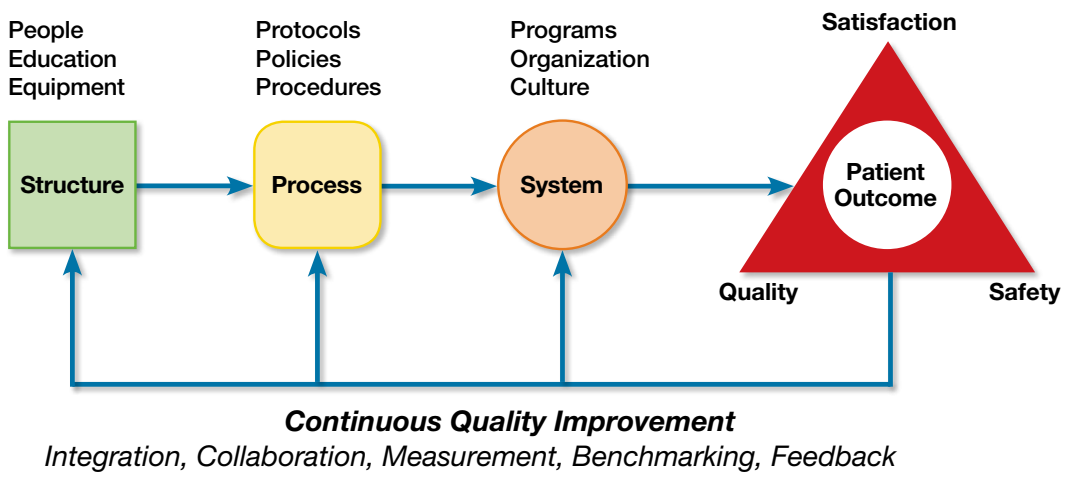
Systems of Care and Continuous Quality Improvement

The 2015 Guidelines Update provides stakeholders with a new perspective on systems of care, differentiating in-hospital cardiac arrests (IHCAs) from out-of-hospital cardiac arrests (OHCAs). Major highlights include

- A universal taxonomy of systems of care
- Separation of the AHA adult Chain of Survival into 2 chains: one for in-hospital and one for out-of-hospital systems of care
- Review of best evidence on how these cardiac arrest systems of care are reviewed, with a focus on cardiac arrest, ST-segment elevation myocardial infarction (STEMI), and stroke

Figure 3

Taxonomy of Systems of Care: SPSO



Components of a System of Care

2015 (New): Universal elements of a system of care have been identified to provide stakeholders with a common framework with which to assemble an integrated resuscitation system (Figure 3).

Why: Healthcare delivery requires structure (eg, people, equipment, education) and process (eg, policies, protocols, procedures) that, when integrated, produce a system (eg, programs, organizations, cultures) that leads to optimal outcomes (eg, patient survival and safety, quality, satisfaction). An effective system of care comprises all of these elements—structure, process, system, and patient outcomes—in a framework of continuous quality improvement.

Chains of Survival

2015 (New): Separate Chains of Survival (Figure 4) have been recommended that identify the different pathways of care for patients who experience cardiac arrest in the hospital as distinct from out-of-hospital settings.

Why: The care for all post–cardiac arrest patients, regardless of where their arrests occur, converges in the hospital, generally in an intensive care unit where post–cardiac arrest care is provided. The elements of structure and process that are required before that convergence are very different for the 2 settings. Patients who have an OHCA depend on their community for support. Lay rescuers must recognize the arrest, call for help, and initiate CPR and provide defibrillation (ie, public-access defibrillation [PAD]) until a team of professionally trained emergency medical service (EMS) providers assumes responsibility and then transports the patient to an emergency department and/or cardiac catheterization lab. The patient is ultimately transferred to a critical care unit for continued care. In contrast, patients who have an IHCA depend on a system of appropriate surveillance (eg, rapid response or early warning system) to prevent cardiac arrest. If cardiac arrest occurs, patients depend on the smooth interaction of the institution's various departments and services and on a multidisciplinary team of professional providers, including physicians, nurses, respiratory therapists, and others.

Use of Social Media to Summon Rescuers

2015 (New): It may be reasonable for communities to incorporate social media technologies that summon rescuers who are in close proximity to a victim of suspected OHCA and are willing and able to perform CPR.

Why: There is limited evidence to support the use of social media by dispatchers to notify potential rescuers of a possible

Figure 4

IHCA and OHCA Chains of Survival

cardiac arrest nearby, and activation of social media has not been shown to improve survival from OHCA. However, in a recent study in Sweden, there was a significant increase in the rate of bystander-initiated CPR when a mobile-phone dispatch system was used.[6] Given the low harm and the potential benefit, as well as the ubiquitous presence of digital devices, municipalities could consider incorporating these technologies into their OHCA systems of care.

Team Resuscitation: Early Warning Sign Systems, Rapid Response Teams, and Medical Emergency Team Systems

2015 (Updated): For adult patients, rapid response team (RRT) or medical emergency team (MET) systems can be effective in reducing the incidence of cardiac arrest, particularly in the general care wards. Pediatric MET/RRT systems may be considered in facilities where children with high-risk illnesses are cared for in general in-patient units. The use of early warning sign systems may be considered for adults and children.

2010 (Old): Although conflicting evidence exists, expert consensus recommended the systematic identification of patients at risk of cardiac arrest, an organized response to such patients, and an evaluation of outcomes to foster continuous quality improvement.

Why: RRTs or METs were established to provide early intervention for patients with clinical deterioration, with the goal of preventing IHCA. Teams can be composed of varying combinations of physicians, nurses, and respiratory therapists. These teams are usually summoned to a patient bedside when acute deterioration is identified by hospital staff. The team typically brings emergency monitoring and resuscitation equipment and drugs. Although the evidence is still evolving, there is face validity in the concept of having teams trained in the complex choreography of resuscitation.

Continuous Quality Improvement for Resuscitation Programs

2015 (Reaffirmation of 2010): Resuscitation systems should establish ongoing assessment and improvement of systems of care.

Why: There is evidence of considerable regional variation in the reported incidence and outcome of cardiac arrest in the United States. This variation underscores the need for communities and systems to accurately identify each occurrence of treated cardiac arrest and to record outcomes. There are likely to be opportunities to improve survival rates in many communities.

Community- and hospital-based resuscitation programs should systematically monitor cardiac arrests, the level of resuscitation care provided, and outcome. Continuous quality improvement includes systematic evaluation and feedback, measurement or benchmarking, and analysis. Continuous efforts are needed to optimize resuscitation care so that the gaps between ideal and actual resuscitation performance can be narrowed.

Regionalization of Care

2015 (Reaffirmation of 2010): A regionalized approach to OHCA resuscitation that includes the use of cardiac resuscitation centers may be considered.

Why: A cardiac resuscitation center is a hospital that provides evidence-based care in resuscitation and post–cardiac arrest care, including 24-hour, 7-day percutaneous coronary intervention (PCI) capability, TTM with an adequate annual volume of cases, and commitment to ongoing performance improvement that includes measurement, benchmarking, and both feedback and process change. It is hoped that resuscitation systems of care will achieve the improved survival rates that followed establishment of other systems of care, such as trauma.

Adult Basic Life Support and CPR Quality: Lay Rescuer CPR

Summary of Key Issues and Major Changes

Key issues and major changes in the 2015 Guidelines Update recommendations for adult CPR by lay rescuers include the following:

- The crucial links in the out-of-hospital adult Chain of Survival are unchanged from 2010, with continued emphasis on the simplified universal Adult Basic Life Support (BLS) Algorithm.
- The Adult BLS Algorithm has been modified to reflect the fact that rescuers can activate an emergency response (ie, through use of a mobile telephone) without leaving the victim's side.
- It is recommended that communities with people at risk for cardiac arrest implement PAD programs.
- Recommendations have been strengthened to encourage immediate recognition of unresponsiveness, activation of the emergency response system, and initiation of CPR if the lay rescuer finds an unresponsive victim is not breathing or not breathing normally (eg, gasping).
- Emphasis has been increased about the rapid identification of potential cardiac arrest by dispatchers, with immediate provision of CPR instructions to the caller (ie, dispatch-guided CPR).
- The recommended sequence for a single rescuer has been confirmed: the single rescuer is to initiate chest compressions before giving rescue breaths (C-A-B rather than A-B-C) to reduce delay to first compression. The single rescuer should begin CPR with 30 chest compressions followed by 2 breaths.
- There is continued emphasis on the characteristics of high-quality CPR: compressing the chest at an adequate rate and depth, allowing complete chest recoil after each compression, minimizing interruptions in compressions, and avoiding excessive ventilation.
- The recommended chest compression rate is 100 to 120/min (updated from *at least* 100/min).
- The clarified recommendation for chest compression depth for adults is at least 2 inches (5 cm) but not greater than 2.4 inches (6 cm).
- Bystander-administered naloxone may be considered for suspected life-threatening opioid-associated emergencies.

These changes are designed to simplify lay rescuer training and to emphasize the need for early chest compressions for victims of sudden cardiac arrest. More information about these changes appears below.

> In the following topics, changes or points of emphasis that are similar for lay rescuers and HCPs are noted with an asterisk (*).

Community Lay Rescuer AED Programs

2015 (Updated): It is recommended that PAD programs for patients with OHCA be implemented in public locations where there is a relatively high likelihood of witnessed cardiac arrest (eg, airports, casinos, sports facilities).

2010 (Old): CPR and the use of automated external defibrillators (AEDs) by public safety first responders were recommended to increase survival rates for out-of-hospital sudden cardiac arrest. The 2010 Guidelines recommended the establishment of AED programs in public locations where there is a relatively high likelihood of witnessed cardiac arrest (eg, airports, casinos, sports facilities).

Why: There is clear and consistent evidence of improved survival from cardiac arrest when a bystander performs CPR and rapidly uses an AED. Thus, immediate access to a defibrillator is a primary component of the system of care. The implementation of a PAD program requires 4 essential components: (1) a planned and practiced response, which ideally includes identification of locations and neighborhoods where there is high risk of cardiac arrest, placement of AEDs in those areas and ensuring that bystanders are aware of the location of the AEDs, and, typically, oversight by an HCP; (2) training of anticipated rescuers in CPR and use of the AED; (3) an integrated link with the local EMS system; and (4) a program of ongoing quality improvement.

A system-of-care approach for OHCA might include public policy that encourages reporting of public AED locations to public service access points (PSAPs; the term *public service access point* has replaced the less-precise *EMS dispatch center*). 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 areas, these community programs represent an important link in the Chain of Survival between recognition and activation of the PSAPs. This information is expanded in “Part 4: Systems of Care and Continuous Quality Improvement” in the 2015 Guidelines Update.

There is insufficient evidence to recommend for or against the deployment of AEDs in homes. Victims of OHCAs that occur in private residences are much less likely to receive chest compressions than are patients who experience cardiac arrest in public settings. Real-time instructions provided by emergency dispatchers may help potential in-home rescuers to initiate action. Robust community CPR training programs for cardiac arrest, along with effective, prearrival dispatch protocols, can improve outcomes.

Dispatcher Identification of Agonal Gasps

Cardiac arrest victims sometimes present with seizure-like activity or agonal gasps that can confuse potential rescuers. Dispatchers should be specifically trained to identify these presentations of cardiac arrest to enable prompt recognition and immediate dispatcher-guided CPR.

2015 (Updated): To help bystanders recognize cardiac arrest, dispatchers should inquire about a victim’s absence of responsiveness and quality of breathing (normal versus not normal). If the victim is unresponsive with absent or abnormal breathing, the rescuer and the dispatcher should assume that the victim is in cardiac arrest. Dispatchers should be educated to identify unresponsiveness with abnormal and agonal gasps across a range of clinical presentations and descriptions.

2010 (Old): To help bystanders recognize cardiac arrest, dispatchers should ask about an adult victim’s responsiveness, if the victim is breathing, and if the breathing is normal, in an attempt to distinguish victims with agonal gasps (ie, in those who need CPR) from victims who are breathing normally and do not need CPR.

Why: This change from the 2010 Guidelines emphasizes the role that emergency dispatchers can play in helping the lay rescuer recognize absent or abnormal breathing.

Dispatchers should be specifically educated to help bystanders recognize that agonal gasps are a sign of cardiac arrest. Dispatchers should also be aware that brief generalized seizures may be the first manifestation of cardiac arrest. In summary, in addition to activating professional emergency responders, the dispatcher should ask straightforward questions about whether the patient is unresponsive and if breathing is normal or abnormal in order to identify patients with possible cardiac arrest and enable dispatcher-guided CPR.

Emphasis on Chest Compressions*

2015 (Updated): Untrained lay rescuers should provide compression-only (Hands-Only) CPR, with or without dispatcher guidance, for adult victims of cardiac arrest. The rescuer should continue compression-only CPR until the arrival of an AED or rescuers with additional training. All lay rescuers should, at a minimum, provide chest compressions for victims of cardiac arrest. 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, EMS providers take over care of the victim, or the victim starts to move.

2010 (Old): If a bystander is not trained in CPR, the bystander should provide compression-only CPR for the adult victim who suddenly collapses, with an emphasis to “push hard and fast” on the center of the chest, or follow the directions of the EMS dispatcher. The rescuer should continue compression-only CPR until an AED arrives and is ready for use or EMS providers take over care of the victim. All trained lay rescuers should, at a minimum,

provide chest compressions for victims of cardiac arrest. In addition, if the trained lay rescuer is able to perform rescue breaths, compressions and breaths should be provided 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.

Why: Compression-only CPR is easy for an untrained rescuer to perform and can be more effectively guided by dispatchers over the telephone. Moreover, survival rates from adult cardiac arrests of cardiac etiology are similar with either compression-only CPR or CPR with both compressions and rescue breaths when provided before EMS arrival. However, for the trained lay rescuer who is able, the recommendation remains for the rescuer to perform both compressions and breaths.

Chest Compression Rate*

2015 (Updated): In adult victims of cardiac arrest, it is reasonable for rescuers to perform chest compressions at a rate of 100 to 120/min.

2010 (Old): It is reasonable for lay rescuers and HCPs to perform chest compressions at a rate of at least 100/min.

Why: The number of chest compressions delivered per minute during CPR is an important determinant of return of spontaneous circulation (ROSC) and survival with good neurologic function. The actual number of chest compressions delivered per minute is determined by the rate of chest compressions and the number and duration of interruptions in compressions (eg, to open the airway, deliver rescue breaths, allow AED analysis). In most studies, more compressions are associated with higher survival rates, and fewer compressions are associated with lower survival rates. Provision of adequate chest compressions requires an emphasis not only on an adequate compression rate but also on minimizing interruptions to this critical component of CPR. An inadequate compression rate or frequent interruptions (or both) will reduce the total number of compressions delivered per minute. New to the 2015 Guidelines Update are upper limits of recommended compression rate and compression depth, based on preliminary data suggesting that excessive compression rate and depth adversely affect outcomes. The addition of an upper limit of compression rate is based on 1 large registry study analysis associating extremely rapid compression rates (greater than 140/min) with inadequate compression depth. Box 1 uses the analogy of automobile travel to explain the effect of compression rate and interruptions on total number of compressions delivered during resuscitation.

Box 1

Number of Compressions Delivered Affected by Compression Rate and by Interruptions

The total number of compressions delivered during resuscitation is an important determinant of survival from cardiac arrest.

- The number of compressions delivered is affected by the compression *rate* (the frequency of chest compressions per minute) and by the compression *fraction* (the portion of total CPR time during which compressions are performed). Increases in compression rate and fraction increase the total number of compressions delivered. Compression fraction is improved by reducing the number and duration of any interruptions in compressions.
- An analogy can be found in automobile travel. When traveling in an automobile, the number of miles traveled in a day is affected not only by the speed (rate of travel) but also by the number and duration of any stops (interruptions in travel). Traveling 60 mph without interruptions translates to an actual travel distance of 60 miles in an hour. Traveling 60 mph except for a 10-minute stop translates to an actual travel of 50 miles in that hour. The more frequent and the more prolonged the stops, the lower the actual miles traveled.
- During CPR, rescuers should deliver effective compressions at an appropriate rate (100 to 120/min) and depth while minimizing the number and duration of interruptions in chest compressions. Additional components of high-quality CPR include allowing complete chest recoil after each compression and avoiding excessive ventilation.

Chest Compression Depth*

2015 (Updated): During manual CPR, rescuers should perform chest compressions to a depth of at least 2 inches (5 cm) for an average adult, while avoiding excessive chest compression depths (greater than 2.4 inches [6 cm]).

2010 (Old): The adult sternum should be depressed at least 2 inches (5 cm).

Why: Compressions create blood flow primarily by increasing intrathoracic pressure and directly compressing the heart, which in turn results in critical blood flow and oxygen delivery to the heart and brain. Rescuers often do not compress the chest deeply enough despite the recommendation to "push hard." While a compression depth of at least 2 inches (5 cm) is recommended, the 2015 Guidelines Update incorporates new evidence about the potential for an upper threshold of compression depth (greater than 2.4 inches [6 cm]), beyond which complications may occur. Compression depth may be difficult to judge without use of feedback devices, and identification of upper limits of compression depth may be challenging. It is important for rescuers to know that the recommendation about the upper limit of compression depth is based on 1 very small study that reported an association between excessive compression depth and injuries that were not life-threatening. Most monitoring via CPR feedback devices suggests that compressions are more often too shallow than they are too deep.

Bystander Naloxone in Opioid-Associated Life-Threatening Emergencies*

2015 (New): For patients with known or suspected opioid addiction who are unresponsive with no normal breathing but a pulse, it is reasonable for appropriately trained lay rescuers and BLS providers, in addition to providing standard BLS care, to administer intramuscular (IM) or intranasal (IN) naloxone. Opioid overdose response education with or without naloxone distribution to persons at risk for opioid overdose in any setting may be considered. This topic is also addressed in the Special Circumstances of Resuscitation section.

Why: There is substantial epidemiologic data demonstrating the large burden of disease from lethal opioid overdoses, as well as some documented success in targeted national strategies for bystander-administered naloxone for people at risk. In 2014, the naloxone autoinjector was approved by the US Food and Drug Administration for use by lay rescuers and HCPs.[7] The resuscitation training network has requested information about the best way to incorporate such a device into the adult BLS guidelines and training. This recommendation incorporates the newly approved treatment.

Adult Basic Life Support and CPR Quality: HCP BLS

Summary of Key Issues and Major Changes

Key issues and major changes in the 2015 Guidelines Update recommendations for HCPs include the following:

- These recommendations allow flexibility for activation of the emergency response system to better match the HCP's clinical setting.
- 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 chest compression.
- Integrated teams of highly trained rescuers may use a choreographed approach that accomplishes multiple steps and assessments simultaneously rather than 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).
- Increased emphasis has been placed on high-quality CPR using performance targets (compressions of adequate rate and depth, allowing complete chest recoil between compressions, minimizing interruptions in compressions, and avoiding excessive ventilation). See Table 1.
- Compression **rate** is modified to a range of 100 to 120/min.
- Compression **depth** for adults is modified to at least 2 inches (5 cm) but should not exceed 2.4 inches (6 cm).
- To allow full chest wall **recoil** after each compression, rescuers must avoid leaning on the chest between compressions.
- Criteria for **minimizing interruptions** is clarified with a goal of chest compression fraction as high as possible, with a target of at least 60%.
- Where EMS systems have adopted bundles of care involving continuous chest compressions, the use of passive ventilation techniques may be considered as part of that bundle for victims of OHCA.
- For patients with ongoing CPR and an advanced airway in place, a simplified ventilation rate of 1 breath every 6 seconds (10 breaths per minute) is recommended.

These changes are designed to simplify training for HCPs and to continue to emphasize the need to provide early and high-quality CPR for victims of cardiac arrest. More information about these changes follows.

> In the following topics for HCPs, an asterisk (*) marks those that are similar for HCPs and lay rescuers.

Immediate Recognition and Activation of Emergency Response System

2015 (Updated): HCPs must call for nearby help upon finding the victim unresponsive, but it would be practical for an HCP to continue to assess the breathing and pulse simultaneously before fully activating the emergency response system (or calling for backup).

2010 (Old): The HCP should check for response while looking at the patient to determine if breathing is absent or not normal.

Why: The intent of the recommendation change is to minimize delay and to encourage fast, efficient simultaneous assessment and response, rather than a slow, methodical, step-by-step approach.

Emphasis on Chest Compressions*

2015 (Updated): It is reasonable for HCPs to provide chest compressions and ventilation for all adult patients in cardiac arrest, whether from a cardiac or noncardiac cause. Moreover, it is realistic for HCPs to tailor the sequence of rescue actions to the most likely cause of arrest.

2010 (Old): It is reasonable for both EMS and in-hospital professional rescuers to provide chest compressions and rescue breaths for cardiac arrest victims.

Table 1 BLS Dos and Don'ts of Adult High-Quality CPR

Rescuers Should	Rescuers Should *Not*
Perform chest compressions at a rate of 100-120/min	Compress at a rate slower than 100/min or faster than 120/min
Compress to a depth of at least 2 inches (5 cm)	Compress to a depth of less than 2 inches (5 cm) or greater than 2.4 inches (6 cm)
Allow full recoil after each compression	Lean on the chest between compressions
Minimize pauses in compressions	Interrupt compressions for greater than 10 seconds
Ventilate adequately (2 breaths after 30 compressions, each breath delivered over 1 second, each causing chest rise)	Provide excessive ventilation (ie, too many breaths or breaths with excessive force)

Why: Compression-only CPR is recommended for untrained rescuers because it is relatively easy for dispatchers to guide with telephone instructions. It is expected that HCPs are trained in CPR and can effectively perform both compressions and ventilation. However, the priority for the provider, especially if acting alone, should still be to activate the emergency response system and to provide chest compressions. There may be circumstances that warrant a change of sequence, such as the availability of an AED that the provider can quickly retrieve and use.

Shock First vs CPR First

2015 (Updated): For witnessed adult cardiac arrest when an AED is immediately available, it is reasonable that the defibrillator be used as soon as possible. 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.

2010 (Old): When any rescuer witnesses an out-of-hospital arrest and an AED is immediately available on-site, the rescuer should start CPR with chest compressions and use the AED as soon as possible. HCPs who treat cardiac arrest in hospitals and other facilities with on-site AEDs or defibrillators should provide immediate CPR and should use the AED/defibrillator as soon as it is available. These recommendations are designed to support early CPR and early defibrillation, particularly when an AED or defibrillator is available within moments of the onset of sudden cardiac arrest. When an OHCA is not witnessed by EMS personnel, EMS may initiate CPR while checking the rhythm with the AED or on the electrocardiogram (ECG) and preparing for defibrillation. In such instances, 1½ to 3 minutes of CPR may be considered before attempted defibrillation. Whenever 2 or more rescuers are present, CPR should be provided while the defibrillator is retrieved.

With in-hospital sudden cardiac arrest, there is insufficient evidence to support or refute CPR before defibrillation. However, in monitored patients, the time from ventricular fibrillation (VF) to shock delivery should be under 3 minutes, and CPR should be performed while the defibrillator is readied.

Why: While numerous studies have addressed the question of whether a benefit is conferred by providing a specified period (typically 1½ to 3 minutes) of chest compressions before shock delivery, as compared with delivering a shock as soon as the AED can be readied, no difference in outcome has been shown. CPR should be provided while the AED pads are applied and until the AED is ready to analyze the rhythm.

Chest Compression Rate: 100 to 120/min*

2015 (Updated): In adult victims of cardiac arrest, it is reasonable for rescuers to perform chest compressions at a rate of 100 to 120/min.

2010 (Old): It is reasonable for lay rescuers and HCPs to perform chest compressions at a rate of at least 100/min.

Why: The minimum recommended compression rate remains 100/min. The upper limit rate of 120/min has been added because 1 large registry series suggested that as the compression rate increases to more than 120/min, compression depth decreases in a dose-dependent manner. For example, the proportion of compressions of inadequate depth was about 35% for a compression rate of 100 to 119/min but increased to inadequate depth in 50% of compressions when the compression rate was 120 to 139/min and to inadequate depth in 70% of compressions when compression rate was more than 140/min.

Chest Compression Depth*

2015 (Updated): During manual CPR, rescuers should perform chest compressions to a depth of at least 2 inches (5 cm) for an average adult while avoiding excessive chest compression depths (greater than 2.4 inches [6 cm]).

2010 (Old): The adult sternum should be depressed at least 2 inches (5 cm).

Why: A compression depth of approximately 5 cm is associated with greater likelihood of favorable outcomes compared with shallower compressions. While there is less evidence about whether there is an upper threshold beyond which compressions may be too deep, a recent very small study suggests potential injuries (none life-threatening) from excessive chest compression depth (greater than 2.4 inches [6 cm]). Compression depth may be difficult to judge without use of feedback devices, and identification of upper limits of compression depth may be challenging. It is important for rescuers to know that chest compression depth is more often too shallow than too deep.

Chest Recoil*

2015 (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.

2010 (Old): Rescuers should allow complete recoil of the chest after each compression, to allow the heart to fill completely before the next compression.

Why: 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 raises intrathoracic pressure and reduces venous return, coronary perfusion pressure, and myocardial blood flow and can influence resuscitation outcomes.

Minimizing Interruptions in Chest Compressions*

2015 (Reaffirmation of 2010): Rescuers should attempt to minimize the frequency and duration of interruptions in compressions to maximize the number of compressions delivered per minute.

Table 2 **Summary of High-Quality CPR Components for BLS Providers**

Component	Adults and Adolescents	Children (Age 1 Year to Puberty)	Infants (Age Less Than 1 Year, Excluding Newborns)
Scene safety	Make sure the environment is safe for rescuers and victim		
Recognition of cardiac arrest	Check for responsiveness No breathing or only gasping (ie, no normal breathing) No definite pulse felt within 10 seconds (Breathing and pulse check can be performed simultaneously in less than 10 seconds)		
Activation of emergency response system	If you are alone with no mobile phone, leave the victim to activate the emergency response system and get the AED before beginning CPR Otherwise, send someone and begin CPR immediately; use the AED as soon as it is available	***Witnessed collapse*** Follow steps for adults and adolescents on the left ***Unwitnessed collapse*** Give 2 minutes of CPR Leave the victim to activate the emergency response system and get the AED Return to the child or infant and resume CPR; use the AED as soon as it is available	
Compression-ventilation ratio *without advanced airway*	***1 or 2 rescuers*** 30:2	***1 rescuer*** 30:2 ***2 or more rescuers*** 15:2	
Compression-ventilation ratio *with advanced airway*	Continuous compressions at a rate of 100-120/min Give 1 breath every 6 seconds (10 breaths/min)		
Compression rate	100-120/min		
Compression depth	At least 2 inches (5 cm)*	At least one third AP diameter of chest About 2 inches (5 cm)	At least one third AP diameter of chest About 1½ inches (4 cm)
Hand placement	2 hands on the lower half of the breastbone (sternum)	2 hands or 1 hand (optional for very small child) on the lower half of the breastbone (sternum)	***1 rescuer*** 2 fingers in the center of the chest, just below the nipple line ***2 or more rescuers*** 2 thumb–encircling hands in the center of the chest, just below the nipple line
Chest recoil	Allow full recoil of chest after each compression; do not lean on the chest after each compression		
Minimizing interruptions	Limit interruptions in chest compressions to less than 10 seconds		

*Compression depth should be no more than 2.4 inches (6 cm).

Abbreviations: AED, automated external defibrillator; AP, anteroposterior; CPR, cardiopulmonary resuscitation.

2015 (New): For adults in cardiac arrest who receive CPR without an advanced 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%.

Why: 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 total resuscitation time that compressions are performed. 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 addition of a target compression fraction is intended to limit interruptions in compressions and to maximize coronary perfusion and blood flow during CPR.

Comparison of Key Elements of Adult, Child, and Infant BLS

Table 2 lists the 2015 key elements of adult, child, and infant BLS (excluding CPR for newly born infants).

Chest Compression Feedback

2015 (Updated): It may be reasonable to use audiovisual feedback devices during CPR for real-time optimization of CPR performance.

2010 (Old): New CPR prompt and feedback devices may be useful for training rescuers and as part of an overall strategy to improve the quality of CPR in actual resuscitations. Training for the complex combination of skills required to perform adequate chest compressions should focus on demonstrating mastery.

Why: Technology allows for real-time monitoring, recording, and feedback about CPR quality, including both physiologic patient parameters and rescuer performance metrics. These important data can be used in real time during resuscitation, for debriefing after resuscitation, and for system-wide quality improvement programs. Maintaining focus during CPR on the characteristics of compression rate and depth and chest recoil while minimizing interruptions is a complex challenge even for highly trained professionals. There is some evidence that the use of CPR feedback may be effective in modifying chest compression rates that are too fast, and there is separate evidence that CPR feedback decreases the leaning force during chest compressions. However, studies to date have not demonstrated a significant improvement in favorable neurologic outcome or survival to hospital discharge with the use of CPR feedback devices during actual cardiac arrest events.

Delayed Ventilation

2015 (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 (PPV) by using a strategy of up to 3 cycles of 200 continuous compressions with passive oxygen insufflation and airway adjuncts.

Why: Several EMS systems have tested a strategy of providing initial continuous chest compressions with delayed PPV for adult victims of OHCA. In all of these EMS systems, the providers received additional training with emphasis on provision of high-quality chest compressions. Three studies in systems that use priority-based, multitiered response in both urban and rural communities, and provide a bundled package of care that includes up to 3 cycles of passive oxygen insufflation, airway adjunct insertion, and 200 continuous chest compressions with interposed shocks, showed improved survival with favorable neurologic status for victims with witnessed arrest or shockable rhythm.

Ventilation During CPR With an Advanced Airway

2015 (Updated): 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 (ie, during CPR with an advanced airway).

2010 (Old): When an advanced airway (ie, endotracheal tube, Combitube, or laryngeal mask airway) is in place during 2-person CPR, give 1 breath every 6 to 8 seconds without attempting to synchronize breaths between compressions (this will result in delivery of 8 to 10 breaths per minute).

Why: This simple single rate for adults, children, and infants—rather than a range of breaths per minute—should be easier to learn, remember, and perform.

Team Resuscitation: Basic Principles

2015 (New): For HCPs, the 2015 Guidelines Update allows flexibility for activation of the emergency response and subsequent management in order to better match the provider's clinical setting (Figure 5).

Why: The steps in the BLS algorithms have traditionally been presented as a sequence in order to help a single rescuer prioritize actions. However, there are several factors in any resuscitation (eg, type of arrest, location, whether trained providers are nearby, whether the rescuer must leave a victim to activate the emergency response system) that may require modifications in the BLS sequence. The updated BLS HCP algorithms aim to communicate when and where flexibility in sequence is appropriate.

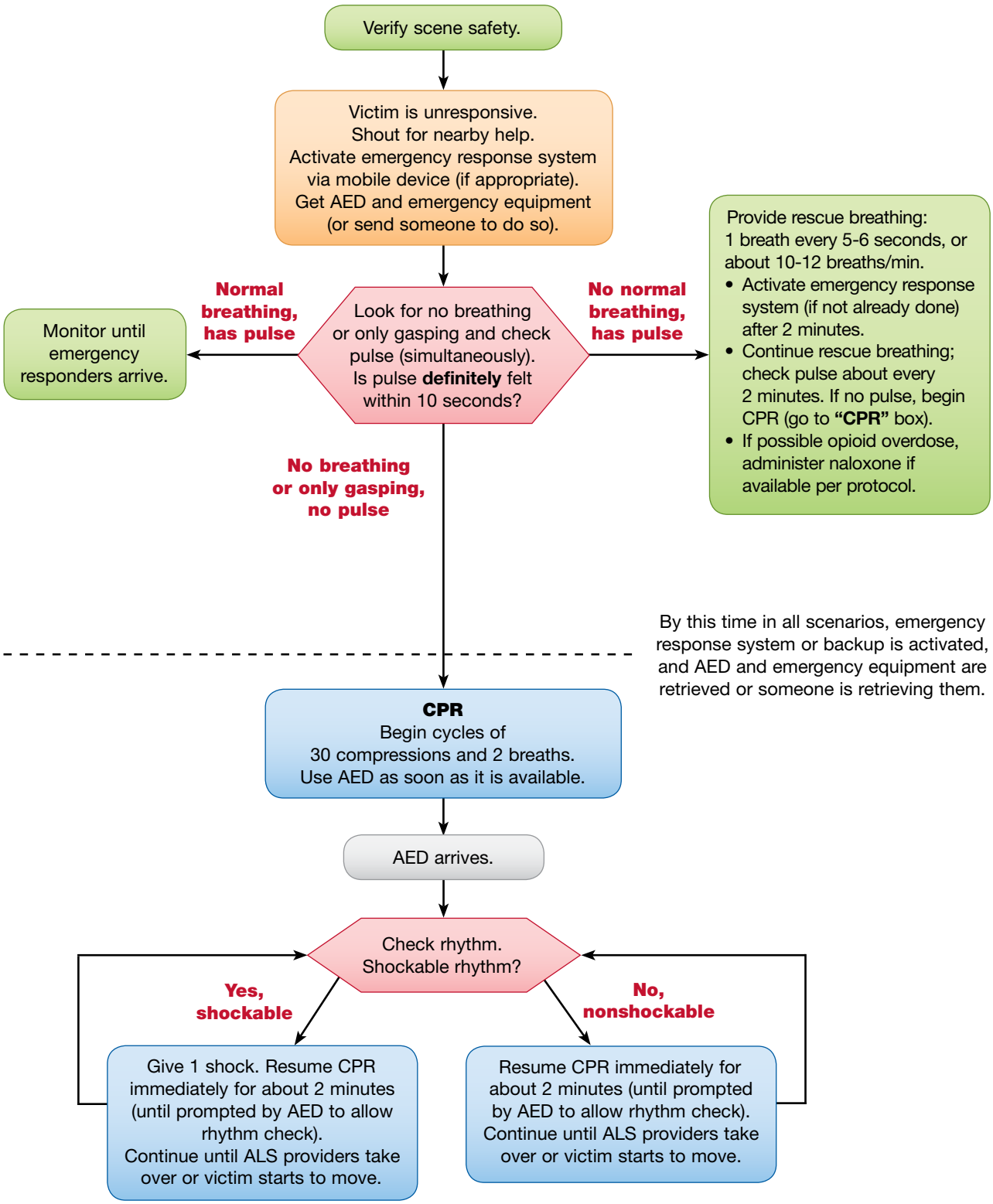
Alternative Techniques and Ancillary Devices for CPR

Summary of Key Issues and Major Changes

Conventional CPR consisting of manual chest compressions interspersed with rescue breaths is inherently inefficient with respect to generating significant cardiac output. A variety of alternatives and adjuncts to conventional CPR have been developed with the aim of enhancing cardiac output during resuscitation from cardiac arrest. Since the 2010 Guidelines were published, a number of clinical trials have provided new data on the effectiveness of these alternatives.

Figure 5

BLS Healthcare Provider Adult Cardiac Arrest Algorithm—2015 Update



Compared with conventional CPR, many of these techniques and devices require specialized equipment and training. When rescuers or healthcare systems are considering implementation, it must be noted that some techniques and devices have been tested only in highly selected subgroups of cardiac arrest patients.

- The routine use of the impedance threshold device (ITD) as an adjunct to conventional CPR is not recommended.
- A recent randomized controlled trial suggests that the use of the ITD plus active compression-decompression CPR is associated with improved neurologically intact survival for patients with OHCA.
- The routine use of mechanical chest compression devices is not recommended, but special settings where this technology may be useful are identified.
- The use of ECPR may be considered for selected patients in settings where a reversible cause of cardiac arrest is suspected.

Impedance Threshold Devices

2015 (Updated): The routine use of the ITD as an adjunct during conventional CPR is not recommended. The combination of ITD with active compression-decompression CPR may be a reasonable alternative to conventional CPR in settings with available equipment and properly trained personnel.

2010 (Old): The use of the ITD may be considered by trained personnel as a CPR adjunct in adult cardiac arrest.

Why: Two large randomized controlled trials have provided new information about the use of the ITD in OHCA. One large multicenter randomized clinical trial failed to demonstrate any improvement associated with the use of an ITD (compared with a sham device) as an adjunct to conventional CPR. Another clinical trial demonstrated a benefit with the use of active compression-decompression CPR plus an ITD when compared with conventional CPR and no ITD. However, confidence intervals around the primary outcome point estimate were very broad, and there is a high risk of bias on the basis of co-intervention (the group receiving active compression-decompression CPR plus the ITD also had CPR delivered using CPR quality feedback devices, while the control arm did not have the use of such feedback devices).

Mechanical Chest Compression Devices

2015 (Updated): 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. However, such a device may be a reasonable alternative to conventional CPR 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, CPR during hypothermic cardiac arrest, CPR in a moving ambulance, CPR in the angiography suite, CPR during preparation for ECPR).

2010 (Old): Mechanical piston devices may be considered for use by properly trained personnel in specific settings for the treatment of adult cardiac arrest in circumstances (eg, during diagnostic and interventional procedures) that make manual resuscitation difficult. The load-distributing band may be considered for use by properly trained personnel in specific settings for the treatment of cardiac arrest.

Why: Three large randomized controlled trials comparing mechanical chest compression devices have not demonstrated improved outcomes for patients with OHCA when compared with manual chest compressions. For this reason, manual chest compressions remain the standard of care.

Extracorporeal Techniques and Invasive Perfusion Devices

2015 (Updated): ECPR may be considered an alternative to conventional CPR for select patients who have a cardiac arrest and for whom the suspected etiology of the cardiac arrest is potentially reversible.

2010 (Old): There was insufficient evidence to recommend the routine use of ECPR for patients in cardiac arrest. However, in settings where ECPR is readily available, it may be considered when the time without blood flow is brief and the condition leading to the cardiac arrest is reversible (eg, accidental hypothermia, drug intoxication) or amenable to heart transplantation (eg, myocarditis) or revascularization (eg, acute myocardial infarction).

Why: The term *extracorporeal CPR* is used to describe the initiation of extracorporeal circulation and oxygenation during the resuscitation of a patient in cardiac arrest. ECPR involves the emergency cannulation of a large vein and artery (eg, femoral vessels). The goal of ECPR is to support patients in cardiac arrest while potentially reversible conditions are treated. ECPR is a complex process that requires a highly trained team, specialized equipment, and multidisciplinary support within the local healthcare system. There are no clinical trials on ECPR, and available 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 limited comorbidities, with arrest of cardiac origin, after conventional CPR for more than 10 minutes without ROSC. These inclusion criteria should be considered in a provider's selection of potential candidates for ECPR.

Adult Advanced Cardiovascular Life Support

Summary of Key Issues and Major Changes

Key issues and major changes in the 2015 Guidelines Update recommendations for advanced cardiac life support include the following:

- The combined use of vasopressin and epinephrine offers no advantage to using standard-dose epinephrine in cardiac arrest. Also, vasopressin does not offer an advantage over the use of epinephrine alone. Therefore, to simplify the algorithm, vasopressin has been removed from the Adult Cardiac Arrest Algorithm–2015 Update.

- Low end-tidal carbon dioxide ($ETCO_2$) in intubated patients after 20 minutes of CPR is associated with a very low likelihood of resuscitation. While this parameter should not be used in isolation for decision making, providers may consider low $ETCO_2$ after 20 minutes of CPR in combination with other factors to help determine when to terminate resuscitation.
- Steroids may provide some benefit when bundled with vasopressin and epinephrine in treating IHCA. While routine use is not recommended pending follow-up studies, it would be reasonable for a provider to administer the bundle for IHCA.
- When rapidly implemented, ECPR can prolong viability, as it may provide time to treat potentially reversible conditions or arrange for cardiac transplantation for patients who are not resuscitated by conventional CPR.
- In cardiac arrest patients with nonshockable rhythm and who are otherwise receiving epinephrine, the early provision of epinephrine is suggested.
- Studies about the use of lidocaine after ROSC are conflicting, and routine lidocaine use is not recommended. However, the initiation or continuation of lidocaine may be considered immediately after ROSC from VF/pulseless ventricular tachycardia (pVT) cardiac arrest.
- One observational study suggests that β-blocker use after cardiac arrest may be associated with better outcomes than when β-blockers are not used. Although this observational study is not strong-enough evidence to recommend routine use, the initiation or continuation of an oral or intravenous (IV) β-blocker may be considered early after hospitalization from cardiac arrest due to VF/pVT.

Vasopressors for Resuscitation: Vasopressin

2015 (Updated): Vasopressin in combination with epinephrine offers no advantage as a substitute for standard-dose epinephrine in cardiac arrest.

2010 (Old): One dose of vasopressin 40 units IV/intraosseously may replace either the first or second dose of epinephrine in the treatment of cardiac arrest.

Why: Both epinephrine and vasopressin administration during cardiac arrest have been shown to improve ROSC. Review of the available evidence shows that efficacy of the 2 drugs is similar and that there is no demonstrable benefit from administering both epinephrine and vasopressin as compared with epinephrine alone. In the interest of simplicity, vasopressin has been removed from the Adult Cardiac Arrest Algorithm.

Vasopressors for Resuscitation: Epinephrine

2015 (New): It may be reasonable to administer epinephrine as soon as feasible after the onset of cardiac arrest due to an initial nonshockable rhythm.

Why: A very large observational study of cardiac arrest with nonshockable rhythm compared epinephrine given at 1 to 3 minutes with epinephrine given at 3 later time intervals (4 to 6, 7 to 9, and greater than 9 minutes). The study found an association between early administration of epinephrine and increased ROSC, survival to hospital discharge, and neurologically intact survival.

$ETCO_2$ for Prediction of Failed Resuscitation

2015 (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.

Why: Failure to achieve an $ETCO_2$ of 10 mm Hg by waveform capnography after 20 minutes of resuscitation has been associated with an extremely poor chance of ROSC and survival. However, the studies to date are limited in that they have potential confounders and have included relatively small numbers of patients, so it is inadvisable to rely solely on $ETCO_2$ in determining when to terminate resuscitation.

Extracorporeal CPR

2015 (New): ECPR may be considered among select cardiac arrest patients who have not responded to initial conventional CPR, in settings where it can be rapidly implemented.

Why: Although no high-quality studies have compared ECPR to conventional CPR, a number of lower-quality studies suggest improved survival with good neurologic outcome for select patient populations. Because ECPR is resource intensive and costly, it should be considered only when the patient has a reasonably high likelihood of benefit—in cases where the patient has a potentially reversible illness or to support a patient while waiting for a cardiac transplant.

Post–Cardiac Arrest Drug Therapy: Lidocaine

2015 (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.

Why: While earlier studies showed an association between giving lidocaine after myocardial infarction and increased mortality, a recent study of lidocaine in cardiac arrest survivors showed a decrease in the incidence of recurrent VF/pVT but did not show either long-term benefit or harm.

Post–Cardiac Arrest Drug Therapy: β-Blockers

2015 (New): 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 IV β-blocker may be considered early after hospitalization from cardiac arrest due to VF/pVT.

Why: In an observational study of patients who had ROSC after VF/pVT cardiac arrest, β-blocker administration was associated with higher survival rates. However, this finding is only an associative relationship, and the routine use of β-blockers after cardiac arrest is potentially hazardous because β-blockers can cause or worsen hemodynamic instability, exacerbate heart failure, and cause bradyarrhythmias. Therefore, providers should evaluate patients individually for their suitability for β-blockers.

Post–Cardiac Arrest Care

Summary of Key Issues and Major Changes

Key issues and major changes in the 2015 Guidelines Update recommendations for post–cardiac arrest care include the following:

- Emergency coronary angiography is recommended for all patients with ST elevation and for hemodynamically or electrically unstable patients without ST elevation for whom a cardiovascular lesion is suspected.
- TTM recommendations have been updated with new evidence suggesting that a range of temperatures may be acceptable to target in the post–cardiac arrest period.
- After TTM is complete, fever may develop. While there are conflicting observational data about the harm of fever after TTM, the prevention of fever is considered benign and therefore is reasonable to pursue.
- Identification and correction of hypotension is recommended in the immediate post–cardiac arrest period.
- Prognostication is now recommended no sooner than 72 hours after the completion of TTM; for those who do not have TTM, prognostication is not recommended any sooner than 72 hours after ROSC.
- All patients who progress to brain death or circulatory death after initial cardiac arrest should be considered potential organ donors.

Coronary Angiography

2015 (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. 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. Coronary angiography is reasonable in post–cardiac arrest patients for whom coronary angiography is indicated, regardless of whether the patient is comatose or awake.

2010 (Old): Primary PCI (PPCI) after ROSC in subjects with arrest of presumed ischemic cardiac etiology may be reasonable, even in the absence of a clearly defined STEMI. Appropriate treatment of acute coronary syndromes (ACS) or STEMI, including PCI or fibrinolysis, should be initiated regardless of coma.

Why: Multiple observational studies found positive associations between emergency coronary revascularization and both survival and favorable functional outcome. In the absence of cardiac arrest, guidelines already recommend emergency treatment of STEMI and emergency treatment of non–ST-segment elevation ACS with electrical or hemodynamic instability. Because the outcome of coma may be improved by correction of cardiac instability, and the prognosis of coma cannot be reliably determined in the first few hours after cardiac arrest, emergency treatment of post–cardiac arrest patients should follow identical guidelines.

Targeted Temperature Management

2015 (Updated): All comatose (ie, lacking meaningful response to verbal commands) adult patients with ROSC after cardiac arrest should have TTM, with a target temperature between 32°C and 36°C selected and achieved, then maintained constantly for at least 24 hours.

2010 (Old): Comatose (ie, lacking of meaningful response to verbal commands) adult patients with ROSC after out-of-hospital VF cardiac arrest should be cooled to 32°C to 34°C for 12 to 24 hours. Induced hypothermia also may be considered for comatose adult patients with ROSC after IHCA of any initial rhythm or after OHCA with an initial rhythm of pulseless electrical activity or asystole.

Why: Initial studies of TTM examined cooling to temperatures between 32°C and 34°C compared with no well-defined TTM and found improvement in neurologic outcome for those in whom hypothermia was induced. A recent high-quality study compared temperature management at 36°C and at 33°C and found outcomes to be similar for both. Taken together, the initial studies suggest that TTM is beneficial, so the recommendation remains to select a single target temperature and perform TTM. Given that 33°C is no better than 36°C, clinicians can select from a wider range of target temperatures. The selected temperature may be determined by clinician preference or clinical factors.

Continuing Temperature Management Beyond 24 Hours

2015 (New): Actively preventing fever in comatose patients after TTM is reasonable.

Why: In some observational studies, fever after rewarming from TTM is associated with worsened neurologic injury, although studies are conflicting. Because preventing fever after TTM is relatively benign and fever may be associated with harm, preventing fever is suggested.

Out-of-Hospital Cooling

2015 (New): The routine prehospital cooling of patients with rapid infusion of cold IV fluids after ROSC is not recommended.

Why: Before 2010, cooling patients in the prehospital setting had not been extensively evaluated. It had been assumed that earlier initiation of cooling might provide added benefits and also that prehospital initiation might facilitate and encourage continued in-hospital cooling. Recently published high-quality studies demonstrated no benefit to prehospital cooling and also identified potential complications when using cold IV fluids for prehospital cooling.

Hemodynamic Goals After Resuscitation

2015 (New): It may be reasonable to avoid and immediately correct hypotension (systolic blood pressure less than 90 mm Hg, mean arterial pressure less than 65 mm Hg) during post–cardiac arrest care.

Why: Studies of patients after cardiac arrest have found that a systolic blood pressure less than 90 mm Hg or a mean arterial pressure of less than 65 mm Hg is associated with higher mortality and diminished functional recovery, while systolic arterial pressures of greater than 100 mm Hg are associated with better recovery. While higher pressures appear superior, specific systolic or mean arterial pressure targets could not be identified, because trials typically studied a bundle of many interventions, including hemodynamic control. Also, because baseline blood pressure varies from patient to patient, different patients may have different requirements to maintain optimal organ perfusion.

Prognostication After Cardiac Arrest

2015 (New): The earliest time to prognosticate a poor neurologic outcome using clinical examination in patients *not* treated with TTM is 72 hours after cardiac arrest, 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.

2015 (Updated): In patients treated *with* TTM, where sedation or paralysis could confound clinical examination, it is reasonable to wait until 72 hours after return to normothermia before predicting outcome.

2010 (Old): While times for usefulness of specific tests were identified, no specific overall recommendation was made about time to prognostication.

Why: Clinical findings, electrophysiologic modalities, imaging modalities, and blood markers are all useful for predicting neurologic outcome in comatose patients, but each finding, test, and marker is affected differently by sedation and neuromuscular blockade. In addition, the comatose brain may be more sensitive to medications, and medications may take longer to metabolize after cardiac arrest.

No single physical finding or test can predict neurologic recovery after cardiac arrest with 100% certainty. Multiple modalities of testing and examination used together to predict outcome after the effects of hypothermia and medications have been allowed to resolve, are most likely to provide accurate prediction of outcome (Box 2).

Box 2

Useful Clinical Findings That Are Associated With Poor Neurologic Outcome*

- Absence of pupillary reflex to light at 72 hours or more after cardiac arrest
- Presence of status myoclonus (different from isolated myoclonic jerks) during the first 72 hours after cardiac arrest
- Absence of the N20 somatosensory evoked potential cortical wave 24 to 72 hours after cardiac arrest or after rewarming
- Presence of a marked reduction of the gray-white ratio on brain CT obtained within 2 hours after cardiac arrest
- Extensive restriction of diffusion on brain MRI at 2 to 6 days after cardiac arrest
- Persistent absence of EEG reactivity to external stimuli at 72 hours after cardiac arrest
- Persistent burst suppression or intractable status epilepticus on EEG after rewarming

Absent motor movements, extensor posturing, or myoclonus should not be used alone for predicting outcome.

*Shock, temperature, metabolic derangement, prior sedatives or neuromuscular blockers, and other clinical factors should be considered carefully because they may affect results or interpretation of some tests.

Abbreviations: CT, computed tomography; EEG, electroencephalogram; MRI, magnetic resonance imaging.

Organ Donation

2015 (Updated): 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 achieve ROSC and who would otherwise have resuscitation terminated may be considered as potential kidney or liver donors in settings where rapid organ recovery programs exist.

2010 (Old): Adult patients who progress to brain death after resuscitation from cardiac arrest should be considered for organ donation.

Why: There has been no difference reported 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. Organs transplanted from these donors have success rates comparable to organs recovered from similar donors with other conditions.

Acute Coronary Syndromes

The 2015 Guidelines Update marks a change in the scope of the AHA guidelines for the evaluation and management of ACS. Starting with this update, recommendations will be limited to the prehospital and emergency department phases of care. In-hospital care is addressed by guidelines for the management of myocardial infarction published jointly by the AHA and the American College of Cardiology Foundation.

Summary of Key Issues and Major Changes

Key issues with major changes in the 2015 Guidelines Update recommendations for ACS include the following:

- Prehospital ECG acquisition and interpretation
- Choosing a reperfusion strategy when prehospital fibrinolysis is available
- Choosing a reperfusion strategy at a non–PCI-capable hospital
- Troponin to identify patients who can be safely discharged from the emergency department
- Interventions that may or may not be of benefit if given before hospital arrival

Prehospital ECG Acquisition and Interpretation

2015 (New): Prehospital 12-lead ECG should be acquired early for patients with possible ACS.

2015 (New): Trained nonphysicians may perform ECG interpretation to determine whether or not the tracing shows evidence of STEMI.

2015 (Updated): Computer-assisted ECG interpretation may be used in conjunction with interpretation by a physician or trained provider to recognize STEMI.

2015 (Updated): Prehospital notification of the receiving hospital and/or prehospital activation of the catheterization laboratory should occur for all patients with a STEMI identified on prehospital ECG.

2010 (Old): If providers are not trained to interpret the 12-lead ECG, field transmission of the ECG or a computer report to the receiving hospital was recommended.

2010 (Old): Advance notification should be provided to the receiving hospital for patients identified as having STEMI.

Why: A 12-lead ECG is inexpensive, is easy to perform, and can rapidly provide evidence of acute ST elevation. Concern that nonphysician interpretation of ECGs could lead to either overdiagnosis with a resulting overuse of resources or, alternately, underdiagnosis, which could result in a delay to treatment, has inhibited expansion of ECG programs to EMS systems. Similar concerns existed with computer interpretation of ECGs. A review of the literature shows that when fibrinolysis is not given in the prehospital setting, early hospital notification of the impending arrival of a patient with ST elevation or prehospital activation of the catheterization laboratory reduces time to reperfusion and reduces morbidity and mortality. Because it may take time for the inexperienced provider to develop skill with 12-lead ECG interpretation, computer interpretation can be expected to increase the accuracy of interpretation when used in conjunction with trained nonphysician interpretation.

Reperfusion

2015 (New): 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 it results in a small relative decrease in the incidence of intracranial hemorrhage. There is, however, no evidence of mortality benefit of one therapy over the other.

2015 (New): In adult patients presenting with STEMI in the emergency department 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.

2015 (New): When STEMI patients cannot be transferred to a PCI-capable hospital in a timely manner, fibrinolytic therapy with routine transfer for angiography (see below) may be an acceptable alternative to immediate transfer to primary PCI.

2015 (New): 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.

2010 (Old): Transfer of high-risk patients who have received primary reperfusion with fibrinolytic therapy is reasonable.

Why: Fibrinolysis has been the standard of care for STEMI for more than 30 years. In the past 15 years, PPCI has become more readily available in most parts of North America and has been shown to modestly improve outcomes, compared with fibrinolysis, when PPCI can be provided in a timely manner by experienced practitioners. However, when there is a delay to PPCI, depending on the length of that delay, immediate fibrinolysis may overcome any additional benefits of PCI. Direct transfer to a PCI-capable hospital compared with prehospital fibrinolysis does not produce any difference in mortality, but transfer for PPCI does result in a small relative decrease in the incidence of intracranial hemorrhage. A fresh look at the evidence has allowed stratification of treatment recommendations according to time from *symptom onset* and anticipated delay to PPCI, and has enabled recommendations specifically for clinicians at non–PCI-capable hospitals. Immediate PCI after treating with fibrinolysis provides no added benefit, but routine angiography within the first 24 hours after giving fibrinolysis does reduce the incidence of reinfarction.

Troponin to Identify Patients Who Can Be Safely Discharged From the Emergency Department

2015 (New): High-sensitivity troponin T and troponin I alone measured at 0 and 2 hours (without performing clinical risk stratification) should not be used to exclude the diagnosis of ACS, but high-sensitivity troponin I 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, or low risk per Vancouver rule) to predict a less than 1% chance of 30-day major adverse cardiac event (MACE). Also, negative troponin I or troponin T 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.

2010 (Old): If biomarkers are initially negative within 6 hours of symptom onset, it was recommended that biomarkers should be remeasured between 6 to 12 hours after symptom onset.

Why: Relying on a negative troponin test result, either alone or in combination with *unstructured* risk assessment, results in an unacceptably high rate of MACE at 30 days. However, predictions based on negative troponin test results, combined with *structured* risk assessment, carry a risk of less than 1% of MACE at 30 days.

Other Interventions

When a medication reduces morbidity or mortality, prehospital compared with hospital administration of that medication allows the drug to begin its work sooner and may further decrease morbidity or mortality. However, when urban EMS response and transport times are short,

the opportunity for beneficial drug effect may not be great. Moreover, adding medications increases the complexity of prehospital care, which may in turn produce negative effects.

- Adenosine diphosphate inhibition for hospital patients with suspected STEMI has been recommended for many years. Administration of an adenosine diphosphate inhibitor in the prehospital setting provides neither additional benefit nor harm compared with waiting to administer it in the hospital.
- Unfractionated heparin (UFH) administered to patients with STEMI in the prehospital setting has not been shown to provide additional benefits to giving it in the hospital. In systems where prehospital administration of UFH already occurs, it is reasonable to continue to use it. Where it is not already used in the prehospital setting, it is just as reasonable to wait to give UFH until hospital arrival.
- Before the 2010 recommendations, oxygen was routinely administered to all patients with suspected ACS regardless of oxygen saturation or respiratory condition. In 2010, weak evidence of no benefit and possible harm prompted a recommendation that supplementary oxygen was not needed for patients with ACS who had an oxyhemoglobin saturation of 94% or greater (ie, no hypoxemia) and no evidence of respiratory distress. Further evidence that the routine administration of supplementary oxygen may be harmful, supported by a multicenter randomized controlled trial published since the 2015 systematic review,[8] strengthens the recommendation that oxygen be withheld from patients with possible ACS who have a normal oxygen saturation (ie, who are without hypoxemia).
- For STEMI patients, prehospital administration of UFH or bivalirudin is reasonable.
- For suspected STEMI patients who are being transferred for PPCI, enoxaparin is a reasonable alternative to UFH.

Special Circumstances of Resuscitation

Summary of Key Issues and Major Changes

- Experience with treatment of patients with known or suspected opioid overdose has demonstrated that naloxone can be administered with apparent safety and effectiveness in the first aid and BLS settings. For this reason, naloxone administration by lay rescuers and HCPs is now recommended, and simplified training is being offered. In addition, a new algorithm for management of unresponsive victims with suspected opioid overdose is provided.
- Intravenous lipid emulsion (ILE) may be considered for treatment of local anesthetic systemic toxicity. In addition, a new recommendation is provided, supporting a possible role for ILE in patients who have cardiac arrest and are failing standard resuscitative measures as the result of drug toxicity other than local anesthetic systemic toxicity.
- The importance of high-quality CPR during any cardiac arrest has led to a reassessment of the recommendations about relief of aortocaval compression during cardiac arrest in pregnancy. This reassessment has resulted in refined recommendations about strategies for uterine displacement.

Opioid Overdose Education and Naloxone Training and Distribution

2015 (New): 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 (or those living with or in frequent contact with such persons). It is reasonable to base this training on first aid and non-HCP BLS recommendations rather than on more advanced practices intended for HCPs.

Opioid Overdose Treatment

2015 (New): Empiric administration of IM or IN naloxone to all unresponsive victims of possible opioid-associated life-threatening emergency may be reasonable as an adjunct to standard first aid and non-HCP BLS protocols. 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 care, it is reasonable for appropriately trained rescuers to administer IM or IN naloxone to patients with an opioid-associated respiratory emergency (Figure 6). Responders should not delay access to more advanced medical services while awaiting the patient's response to naloxone or other interventions.

Empiric administration of IM or IN naloxone to all unresponsive opioid-associated resuscitative emergency patients may be reasonable as an adjunct to standard first aid and non-HCP BLS protocols. Standard resuscitation procedures, including EMS activation, should not be delayed for naloxone administration.

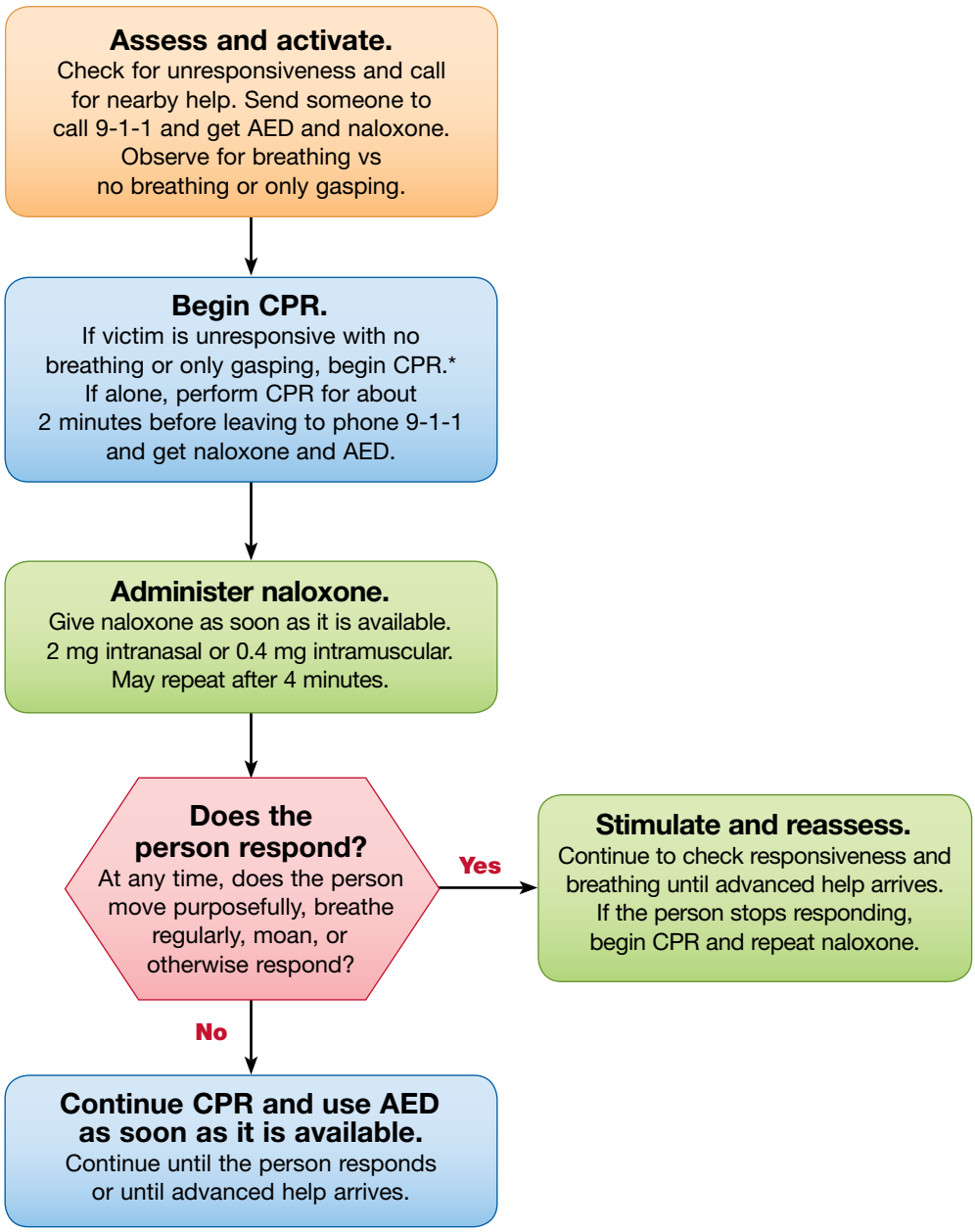
Cardiac Arrest in Patients With Known or Suspected Opioid Overdose

2015 (New): 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, 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 in respiratory arrest, not in cardiac arrest. Responders should not delay access to more-advanced medical services while awaiting the patient's response to naloxone or other interventions.

Why: Naloxone administration has not previously been recommended for first aid providers, non-HCPs, or BLS providers. However, naloxone administration devices intended for use by lay rescuers are now approved and available for use in the United States, and the successful implementation of lay rescuer naloxone programs has been highlighted by the Centers for Disease Control.[9] While it is not expected that naloxone is beneficial in cardiac arrest, whether or not the cause is opioid overdose, it is recognized that it may be difficult to distinguish cardiac arrest from severe respiratory depression in victims of opioid overdose. While there is no evidence that administration of naloxone will help a patient in cardiac

Figure 6

Opioid-Associated Life-Threatening Emergency (Adult) Algorithm—New 2015



*CPR technique based on rescuer's level of training.

arrest, the provision of naloxone may help an unresponsive patient with severe respiratory depression who only appears to be in cardiac arrest (ie, it is difficult to determine if a pulse is present).

Intravenous Lipid Emulsion

2015 (Updated): It may be reasonable to administer ILE, concomitant with standard resuscitative care, to patients who have premonitory neurotoxicity or cardiac arrest due to local anesthetic toxicity. It may be reasonable to administer ILE to patients with other forms of drug toxicity who are failing standard resuscitative measures.

2010 (Old): It may be reasonable to consider ILE for local anesthetic toxicity.

Why: Since 2010, published animal studies and human case reports have examined the use of ILE for patients with drug toxicity that is not the result of local anesthetic infusion. Although the results of these studies and reports

are mixed, there may be clinical improvement after ILE administration. As the prognosis of patients who are failing standard resuscitative measures is very poor, empiric administration of ILE in this situation may be reasonable despite the very weak and conflicting evidence.

Cardiac Arrest in Pregnancy: Provision of CPR

2015 (Updated): Priorities for the pregnant woman in cardiac arrest are provision of high-quality CPR and relief of aortocaval compression. 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.

2010 (Old): To relieve aortocaval compression during chest compressions and optimize the quality of CPR, it is reasonable to perform manual left uterine displacement in the supine position first. If this technique is unsuccessful, and an appropriate wedge is readily available, then providers may consider placing the patient in a left lateral tilt of 27° to 30°, using a firm wedge to support the pelvis and thorax.

Why: Recognition of the critical importance of high-quality CPR and the incompatibility of the lateral tilt with high-quality CPR has prompted the elimination of the recommendation for using the lateral tilt and the strengthening of the recommendation for lateral uterine displacement.

Cardiac Arrest in Pregnancy: Emergency Cesarean Delivery

2015 (Updated): 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 perimortem cesarean delivery (PMCD). PMCD should be considered at 4 minutes after onset of maternal cardiac arrest or resuscitative efforts (for the unwitnessed arrest) if there is no maternal ROSC. 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 of the fetus), and system resources.

2010 (Old): Emergency cesarean delivery may be considered at 4 minutes after onset of maternal cardiac arrest if there is no ROSC.

Why: PMCD provides the opportunity for separate resuscitation of the potentially viable fetus and the ultimate relief of aortocaval compression, which may improve maternal resuscitation outcomes. The clinical scenario and circumstances of the arrest should inform the ultimate decision around the timing of emergency cesarean delivery.

Pediatric Basic Life Support and CPR Quality

Summary of Key Issues and Major Changes

The changes for pediatric BLS parallel changes in adult BLS. The topics reviewed here include the following:

- Reaffirming the C-A-B sequence as the preferred sequence for pediatric CPR
- New algorithms for 1-rescuer and multiple-rescuer pediatric HCP CPR in the cell phone era
- Establishing an upper limit of 6 cm for chest compression depth in an adolescent
- Mirroring the adult BLS recommended chest compression rate of 100 to 120/min
- Strongly reaffirming that compressions and ventilation are needed for pediatric BLS

C-A-B Sequence

2015 (Updated): Although the amount and quality of supporting data are limited, it may be reasonable to maintain the sequence from the 2010 Guidelines by initiating CPR with C-A-B over A-B-C. Knowledge gaps exist, and specific research is required to examine the best sequence for CPR in children.

2010 (Old): Initiate CPR for infants and children with chest compressions rather than rescue breaths (C-A-B rather than A-B-C). CPR should begin with 30 compressions (by a single rescuer) or 15 compressions (for resuscitation of infants and children by 2 HCPs) rather than with 2 ventilations.

Why: In the absence of new data, the 2010 sequence has not been changed. Consistency in the order of compressions, airway, and breathing for CPR in victims of all ages may be easiest for rescuers who treat people of all ages to remember and perform. Maintaining the same sequence for adults and children offers consistency in teaching.

New Algorithms for 1-Rescuer and Multiple-Rescuer HCP CPR

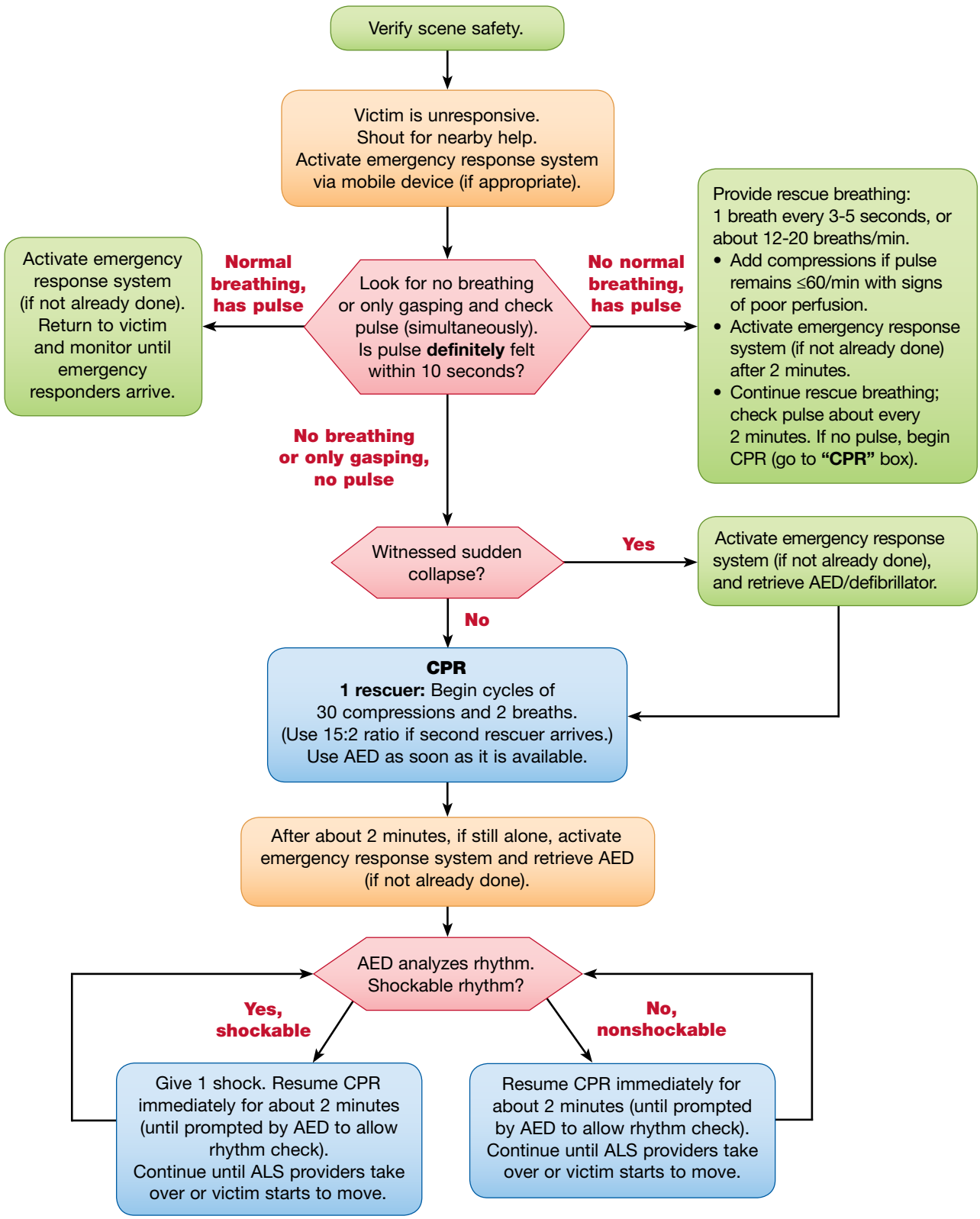
Algorithms for 1-rescuer and multiple-rescuer HCP pediatric CPR have been separated (Figures 7 and 8) to better guide rescuers through the initial stages of resuscitation in an era in which handheld cellular telephones with speakers are common. These devices can enable a single rescuer to activate an emergency response while beginning CPR; the rescuer can continue conversation with a dispatcher during CPR. These algorithms continue to emphasize the high priority for high-quality CPR and, in the case of sudden, witnessed collapse, for obtaining an AED quickly because such an event is likely to have a cardiac etiology.

Chest Compression Depth

2015 (Updated): It is reasonable that rescuers provide chest compressions that depress the chest at least one third the

Figure 7

BLS Healthcare Provider Pediatric Cardiac Arrest Algorithm for the Single Rescuer—2015 Update



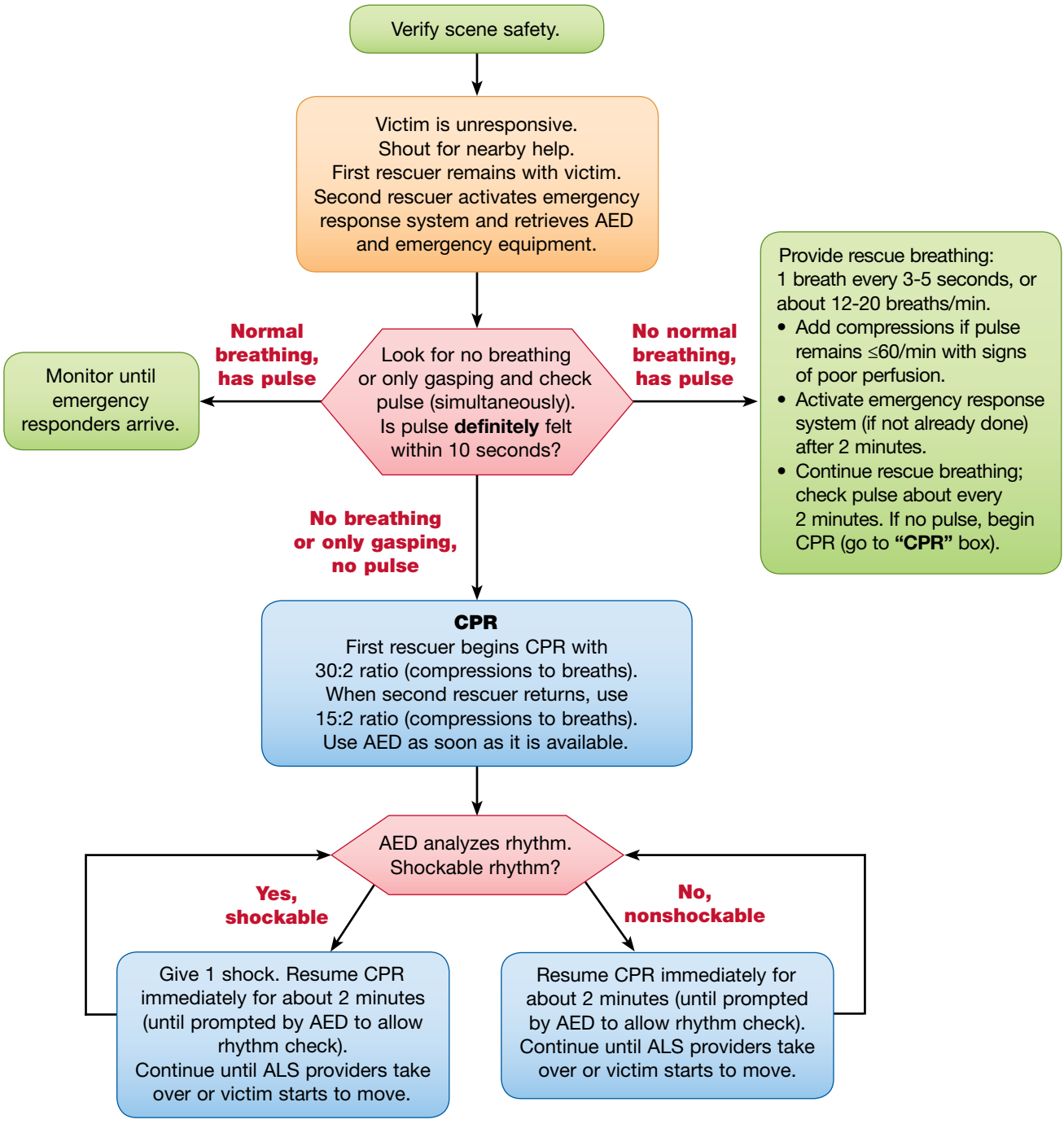
anteroposterior diameter of the chest in pediatric patients (infants [younger than 1 year] to children up to the onset of puberty). This equates to approximately 1.5 inches (4 cm) in infants to 2 inches (5 cm) in children. Once children have reached puberty (ie, adolescents), the recommended adult compression depth of at least 2 inches (5 cm) but no greater than 2.4 inches (6 cm) is used.

2010 (Old): To achieve effective chest compressions, rescuers should compress at least one third of the anteroposterior diameter of the chest. This corresponds to approximately 1.5 inches (about 4 cm) in most infants and about 2 inches (5 cm) in most children.

Why: One adult study suggested harm with chest compressions deeper than 2.4 inches (6 cm). This resulted in a change in the adult BLS recommendation to include an upper limit for chest compression depth; the pediatric experts accepted this recommendation for adolescents beyond puberty. A pediatric study observed improved

Figure 8

BLS Healthcare Provider Pediatric Cardiac Arrest Algorithm for 2 or More Rescuers—2015 Update



24-hour survival when compression depth was greater than 2 inches (51 mm). Judgment of compression depth is difficult at the bedside, and the use of a feedback device that provides such information may be useful if available.

Chest Compression Rate

2015 (Updated): To maximize simplicity in CPR training, in the absence of sufficient pediatric evidence, it is reasonable to use the recommended adult chest compression rate of 100 to 120/min for infants and children.

2010 (Old): "Push fast": Push at a rate of at least 100 compressions per minute.

Why: One adult registry study demonstrated inadequate chest compression depth with extremely rapid compression rates. To maximize educational consistency and retention, in the absence of pediatric data, pediatric experts adopted the same recommendation for compression rate as is made for adult BLS. See the Adult BLS and CPR Quality section of this publication for more detail.

Compression-Only CPR

2015 (Updated): Conventional CPR (rescue breaths and chest compressions) should be provided for infants and children in cardiac arrest. The asphyxial nature of most pediatric cardiac arrests necessitates ventilation as part of effective CPR. However, because compression-only CPR can be effective in patients with a primary cardiac arrest, if rescuers are unwilling or unable to deliver breaths, we recommend rescuers perform compression-only CPR for infants and children in cardiac arrest.

2010 (Old): Optimal CPR in infants and children includes both compressions and ventilations, but compressions alone are preferable to no CPR.

Why: Large registry studies have demonstrated worse outcomes for presumed asphyxial pediatric cardiac arrests (which compose the vast majority of out-of-hospital pediatric cardiac arrests) treated with compression-only CPR. In 2 studies, when conventional CPR (compressions plus breaths) was not given in presumed asphyxial arrest, outcomes were no different from when victims did not receive any bystander CPR. When a presumed cardiac etiology was present, outcomes were similar whether conventional or compression-only CPR was provided.

Pediatric Advanced Life Support

Summary of Key Issues and Major Changes

Many key issues in the review of the pediatric advanced life support literature resulted in refinement of existing recommendations rather than in new recommendations. New information or updates are provided about fluid resuscitation in febrile illness, atropine use before tracheal intubation, use of amiodarone and lidocaine in shock-refractory VF/pVT, TTM after resuscitation from cardiac arrest in infants and children, and post–cardiac arrest management of blood pressure.

- In specific settings, when treating pediatric patients with febrile illnesses, the use of restrictive volumes of isotonic crystalloid leads to improved survival. This contrasts with traditional thinking that routine aggressive volume resuscitation is beneficial.
- Routine use of atropine as a premedication for emergency tracheal intubation in non-neonates, specifically to prevent arrhythmias, is controversial. Also, there are data to suggest that there is no minimum dose required for atropine for this indication.
- If invasive arterial blood pressure monitoring is already in place, it may be used to adjust CPR to achieve specific blood pressure targets for children in cardiac arrest.
- Amiodarone *or* lidocaine is an acceptable antiarrhythmic agent for shock-refractory pediatric VF and pVT in children.
- Epinephrine continues to be recommended as a vasopressor in pediatric cardiac arrest.
- For pediatric patients with cardiac diagnoses and IHCA in settings with existing extracorporeal membrane oxygenation protocols, ECPR may be considered.
- Fever should be avoided when caring for comatose children with ROSC after OHCA. A large randomized trial of therapeutic hypothermia for children with OHCA showed no difference in outcomes whether a period of moderate therapeutic hypothermia (with temperature maintained at 32°C to 34°C) or the strict maintenance of normothermia (with temperature maintained 36°C to 37.5°C) was provided.
- Several intra-arrest and post–cardiac arrest clinical variables were examined for prognostic significance. No single variable was identified to be sufficiently reliable to predict outcomes. Therefore, caretakers should consider multiple factors in trying to predict outcomes during cardiac arrest and in the post-ROSC setting.
- After ROSC, fluids and vasoactive infusions should be used to maintain a systolic blood pressure above the fifth percentile for age.
- After ROSC, normoxemia should be targeted. When the necessary equipment is available, oxygen administration should be weaned to target an oxyhemoglobin saturation of 94% to 99%. Hypoxemia should be strictly avoided. Ideally, oxygen should be titrated to a value appropriate to the specific patient condition. Likewise, after ROSC, the child's $Paco_2$ should be targeted to a level appropriate to each patient's condition. Exposure to severe hypercapnia or hypocapnia should be avoided.

Recommendations for Fluid Resuscitation

2015 (New): Early, rapid IV administration of isotonic fluids is widely accepted as a cornerstone of therapy for septic shock. Recently, a large randomized controlled trial of fluid resuscitation conducted in children with severe febrile illnesses in a resource-limited setting found worse outcomes to be associated with IV fluid boluses. For children in shock, an initial fluid bolus of 20 mL/kg is reasonable. However, for children with febrile illness in settings with limited access to critical care resources (ie, mechanical ventilation and inotropic support), administration of bolus IV fluids should be undertaken with extreme caution, as it may be harmful. Individualized treatment and frequent clinical reassessment are emphasized.

Why: This recommendation continues to emphasize the administration of IV fluid for children with septic shock.

Additionally, it emphasizes individualized treatment plans for each patient, based on frequent clinical assessment before, during, and after fluid therapy is given, and it presumes the availability of other critical care therapies. In certain resource-limited settings, excessive fluid boluses given to febrile children may lead to complications where the appropriate equipment and expertise might not be present to effectively address them.

Atropine for Endotracheal Intubation

2015 (Updated): There is no evidence to support the *routine* use of atropine as a premedication to prevent bradycardia in emergency pediatric intubations. It may be considered in situations where there is an increased risk of bradycardia. There is no evidence to support a minimum dose of atropine when used as a premedication for emergency intubation.

2010 (Old): A minimum atropine dose of 0.1 mg IV was recommended because of reports of paradoxical bradycardia occurring in very small infants who received low doses of atropine.

Why: Recent evidence is conflicting as to whether atropine prevents bradycardia and other arrhythmias during emergency intubation in children. However, these recent studies did use atropine doses less than 0.1 mg without an increase in the likelihood of arrhythmias.

Invasive Hemodynamic Monitoring During CPR

2015 (Updated): If invasive hemodynamic monitoring is in place at the time of a cardiac arrest in a child, it may be reasonable to use it to guide CPR quality.

2010 (Old): If the patient has an indwelling arterial catheter, the waveform can be used as feedback to evaluate hand position and chest compression depth. Compressing to a specific systolic blood pressure target has not been studied in humans but may improve outcomes in animals.

Why: Two randomized controlled trials in animals found improvements in ROSC and survival to completion of the experiment when CPR technique was adjusted on the basis of invasive hemodynamic monitoring. This has yet to be studied in humans.

Antiarrhythmic Medications for Shock-Refractory VF or Pulseless VT

2015 (Updated): Amiodarone or lidocaine is equally acceptable for the treatment of shock-refractory VF or pVT in children.

2010 (Old): Amiodarone was recommended for shock-refractory VF or pVT. Lidocaine can be given if amiodarone is not available.

Why: A recent, retrospective, multi-institution registry of in-patient pediatric cardiac arrest showed that, compared with amiodarone, lidocaine was associated with higher rates of ROSC and 24-hour survival. However, neither lidocaine nor amiodarone administration was associated with improved survival to hospital discharge.

Vasopressors for Resuscitation

2015 (Updated): It is reasonable to give epinephrine during cardiac arrest.

2010 (Old): Epinephrine should be given for pulseless cardiac arrest.

Why: The recommendation about epinephrine administration during cardiac arrest was downgraded slightly in Class of Recommendation. There are no high-quality pediatric studies showing the effectiveness of any vasopressors in cardiac arrest. Two pediatric observational studies were inconclusive, and 1 randomized, out-of-hospital adult study found that epinephrine was associated with improved ROSC and survival to hospital admission but not to hospital discharge.

ECPR Compared With Standard Resuscitation

2015 (Updated): ECPR may be considered for children with underlying cardiac conditions who have an IHCA, provided appropriate protocols, expertise, and equipment are available.

2010 (Old): Consider early activation of extracorporeal life support for a cardiac arrest that occurs in a highly supervised environment, such as an intensive care unit, with the clinical protocols in place and the expertise and equipment available to initiate it rapidly. Extracorporeal life support should be considered only for children in cardiac arrest refractory to standard resuscitation attempts, with a potentially reversible cause of arrest.

Why: OHCA in children was not considered. For pediatric IHCA, there was no difference in overall survival comparing ECPR to CPR without extracorporeal membrane oxygenation. One retrospective registry review showed better outcome with ECPR for patients with cardiac disease than for those with noncardiac disease.

Targeted Temperature Management

2015 (Updated): For children who are comatose in the first several days after cardiac arrest (in-hospital or out-of-hospital), temperature should be monitored continuously and fever should be treated aggressively.

For comatose children resuscitated from OHCA, it is reasonable for caretakers to maintain either 5 days of normothermia (36°C to 37.5°C) or 2 days of initial continuous hypothermia (32°C to 34°C) followed by 3 days of normothermia.

For children remaining comatose after IHCA, there are insufficient data to recommend hypothermia over normothermia.

2010 (Old): Therapeutic hypothermia (32°C to 34°C) may be considered for children who remain comatose after resuscitation from cardiac arrest. It is reasonable for adolescents resuscitated from witnessed out-of-hospital VF arrest.

Why: A prospective, multicenter study of pediatric OHCA victims randomized to receive either therapeutic hypothermia (32°C to 34°C) or normothermia (36°C to 37.5°C) showed

no difference in functional outcome at 1 year between the 2 groups. This and other observational studies demonstrated no additional complications in the group treated with therapeutic hypothermia. Results are currently pending from a large, multicenter, randomized controlled trial of therapeutic hypothermia for patients who are comatose after ROSC following pediatric IHCA (see Therapeutic Hypothermia After Pediatric Cardiac Arrest website: www.THAPCA.org).

Intra-arrest and Postarrest Prognostic Factors

2015 (Updated): Multiple factors should be considered when trying to predict outcomes of cardiac arrest. Multiple factors play a role in the decision to continue or terminate resuscitative efforts during cardiac arrest and in the estimation of potential for recovery after cardiac arrest.

2010 (Old): Practitioners should consider multiple variables to prognosticate outcomes and use judgment to titrate efforts appropriately.

Why: No single intra-arrest or post–cardiac arrest variable has been found that reliably predicts favorable or poor outcomes.

Post–Cardiac Arrest Fluids and Inotropes

2015 (New): After ROSC, fluids and inotropes/vasopressors should be used to maintain a systolic blood pressure above the fifth percentile for age. Intra-arterial pressure monitoring should be used to continuously monitor blood pressure and identify and treat hypotension.

Why: No studies were identified that evaluated specific vasoactive agents in post-ROSC pediatric patients. Recent observational studies found that children who had post-ROSC hypotension had worse survival to hospital discharge and worse neurologic outcome.

Post–Cardiac Arrest Pao_2 and $Paco_2$

2015 (Updated): After ROSC in children, it may be reasonable for rescuers to titrate oxygen administration to achieve normoxemia (oxyhemoglobin saturation of 94% or above). When the requisite equipment is available, oxygen should be weaned to target an oxyhemoglobin saturation within the range of 94% to 99%. The goal should be to strictly avoid hypoxemia while maintaining normoxemia. Likewise, post-ROSC ventilation strategies in children should target a $Paco_2$ that is appropriate for each patient while avoiding extremes of hypercapnia or hypocapnia.

2010 (Old): Once circulation is restored, if appropriate equipment is in place, it may be reasonable to wean the fraction of inspired oxygen to maintain an oxyhemoglobin saturation of 94% or greater. No recommendations were made about $Paco_2$.

Why: A large observational pediatric study of IHCA and OHCA found that normoxemia (defined as Pao_2 60 to 300 mm Hg) was associated with improved survival to pediatric intensive care unit discharge, compared with hyperoxemia (Pao_2 greater than 300 mm Hg). Adult and animal studies show increased mortality associated with hyperoxemia. Likewise, adult studies after ROSC demonstrate worse patient outcomes associated with hypocapnia.

Neonatal Resuscitation

Summary of Key Issues and Major Changes

Neonatal cardiac arrest is predominantly asphyxial, so initiation of ventilation remains the focus of initial resuscitation. The following were the major neonatal topics in 2015:

- The order of the 3 assessment questions has changed to (1) Term gestation? (2) Good tone? and (3) Breathing or crying?
- The Golden Minute (60-second) mark for completing the initial steps, reevaluating, and beginning ventilation (if required) is retained to emphasize the importance of avoiding unnecessary delay in initiation of ventilation, the most important step for successful resuscitation of the newly born who has not responded to the initial steps.
- There is a new recommendation that delayed cord clamping for longer than 30 seconds is reasonable for both term and preterm infants who do not require resuscitation at birth, but there is insufficient evidence to recommend an approach to cord clamping for infants who require resuscitation at birth, and a suggestion against the routine use of cord milking (outside of a research setting) for infants born at less than 29 weeks of gestation, until more is known of benefits and complications.
- Temperature should be recorded as a predictor of outcomes and as a quality indicator.
- Temperature of newly born nonasphyxiated infants should be maintained between 36.5°C and 37.5°C after birth through admission and stabilization.
- A variety of strategies (radiant warmers, plastic wrap with a cap, thermal mattress, warmed humidified gases, and increased room temperature plus cap plus thermal mattress) may be reasonable to prevent hypothermia in preterm infants. Hyperthermia (temperature greater than 38°C) should be avoided because it introduces potential associated risks.
- In resource-limited settings, simple measures to prevent hypothermia in the first hours of life (use of plastic wraps, skin-to-skin contact, and even placing the infant after drying in a clean food-grade plastic bag up to the neck) may reduce mortality.
- If an infant is born through meconium-stained amniotic fluid and presents with poor muscle tone and inadequate breathing efforts, the infant should be placed under a radiant warmer and PPV should be initiated if needed. Routine intubation for tracheal suction is no longer suggested because there is insufficient evidence to continue this recommendation. 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 remains critical during the first minute of resuscitation and the use of a 3-lead ECG may be reasonable, because providers may not assess heart rate accurately by auscultation or palpation, and pulse oximetry may underestimate heart rate. Use of the ECG does not replace the need for pulse oximetry to evaluate the newborn's oxygenation.
- Resuscitation of *preterm* newborns of less than 35 weeks of gestation should be initiated with low oxygen (21% to 30%) and the oxygen titrated to achieve preductal oxygen saturation approximating the range achieved in healthy term infants.

- There are insufficient data about the safety and the method of application of sustained inflation of greater than 5 seconds' duration for the transitioning newborn.
- A laryngeal mask may be considered as an alternative to tracheal intubation if face-mask ventilation is unsuccessful, and a laryngeal mask is recommended during resuscitation of newborns 34 weeks or more of gestation when tracheal intubation is unsuccessful or not feasible.
- Spontaneously breathing preterm infants with respiratory distress may be supported with continuous positive airway pressure initially rather than with routine intubation for administering PPV.
- Recommendations about chest compression technique (2 thumb–encircling hands) and compression-to-ventilation ratio (3:1 with 90 compressions and 30 breaths per minute) remain unchanged. As in the 2010 recommendations, rescuers may consider using higher ratios (eg, 15:2) if the arrest is believed to be of cardiac origin.
- Although there are no available clinical studies about oxygen use during CPR, the Neonatal Guidelines Writing Group continues to endorse the use of 100% oxygen whenever chest compressions are provided. It is reasonable to wean the oxygen concentration as soon as the heart rate recovers.
- Recommendations about use of epinephrine during CPR and volume administration were not reviewed in 2015, so the 2010 recommendations remain in effect.
- Induced therapeutic hypothermia in resource-abundant areas, for infants born at more than 36 weeks of gestation with evolving moderate to severe hypoxic-ischemic encephalopathy, was not reviewed in 2015, so the 2010 recommendations remain in effect.
- In resource-limited settings, use of therapeutic hypothermia may be considered under clearly defined protocols similar to those used in clinical trials and in facilities with the capabilities for multidisciplinary care and follow-up.
- In general, no new data have been published to justify a change in the 2010 recommendations about withholding or withdrawing resuscitation. An Apgar score of 0 at 10 minutes is a strong predictor of mortality and morbidity in late preterm and term infants, but decisions to continue or discontinue resuscitation efforts must be individualized.
- It is suggested that neonatal resuscitation task training occur more frequently than the current 2-year interval.

Umbilical Cord Management: Delayed Cord Clamping

2015 (Updated): Delayed cord clamping after 30 seconds is suggested for both term and preterm infants who do not require resuscitation at birth. There is insufficient evidence to recommend an approach to cord clamping for infants who require resuscitation at birth.

2010 (Old): There is increasing evidence of benefit of delaying cord clamping for at least 1 minute in term and preterm infants not requiring resuscitation. There is insufficient evidence to support or refute a recommendation to delay cord clamping in infants requiring resuscitation.

Why: In infants who do not require resuscitation, 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. The only adverse consequence found was a slightly increased level of bilirubin, associated with more need for phototherapy.

Suctioning Nonvigorous Infants Through Meconium-Stained Amniotic Fluid

2015 (Updated): If an 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. However, a team that includes someone skilled in intubation of the newborn should still be present in the delivery room.

2010 (Old): There was insufficient evidence to recommend a change in the current practice of performing endotracheal suctioning of nonvigorous infants with meconium-stained amniotic fluid.

Why: Review of the evidence suggests that resuscitation should follow the same principles for infants with meconium-stained fluid as for those with clear fluid; that is, if poor muscle tone and inadequate breathing effort are present, the initial steps of resuscitation (warming and maintaining temperature, positioning the infant, clearing the airway of secretions if needed, drying, and stimulating the infant) should be completed under an overbed 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. Experts placed greater value 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. 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: Use of 3-Lead ECG

2015 (Updated): 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 useful. The use of ECG does not replace the need for pulse oximetry to evaluate the newborn's oxygenation.

2010 (Old): Although use of ECG was not mentioned in 2010, the issue of how to assess the heart rate was addressed: Assessment of heart rate should be done by intermittently auscultating the precordial pulse. When a pulse is detectable, palpation of the umbilical pulse can also provide a rapid estimate of the pulse and is more accurate than palpation at other sites. A pulse oximeter can provide a continuous assessment of the pulse without interruption of other resuscitation measures, but the device takes 1 to 2 minutes to apply and may not function during states of very poor cardiac output or perfusion.

Why: Clinical assessment of heart rate in the delivery room has been found to be both unreliable and inaccurate. Underestimation of the heart rate may lead to unnecessary resuscitation. The ECG has been found to display an accurate heart rate faster than pulse oximetry. Pulse oximetry more often displayed a lower rate in the first 2 minutes of life, often at levels that suggest the need for intervention.

Administration of Oxygen to Preterm Newborns

2015 (Updated): 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 a preductal oxygen saturation approximating the interquartile range measured in healthy term infants after vaginal birth at sea level. Initiating resuscitation of preterm newborns with high oxygen (65% or greater) is not recommended. This recommendation reflects a preference for not exposing preterm newborns to additional oxygen without data demonstrating a proven benefit for important outcomes.

2010 (Old): 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. Most data were from term infants not during resuscitation, with a single study of preterm infants during resuscitation.

Why: Data are now available from a meta-analysis of 7 randomized studies demonstrating no benefit in survival to hospital discharge, prevention of bronchopulmonary dysplasia, intraventricular hemorrhage, or retinopathy of prematurity when preterm newborns (less than 35 weeks of gestation) were resuscitated with high (65% or greater) compared with low (21% to 30%) oxygen concentration.

Postresuscitation Therapeutic Hypothermia: Resource-Limited Settings

2015 (Updated): It is suggested that the 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.

2010 (Old): It is recommended that infants born at 36 weeks or more of gestation with evolving moderate to severe hypoxic-ischemic encephalopathy should be offered therapeutic hypothermia. Therapeutic hypothermia should be administered 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.

Why: While the recommendation for therapeutic hypothermia in the treatment of moderate to severe hypoxic-ischemic encephalopathy in resource-abundant settings remains unchanged, a recommendation was added to guide the use of this modality in settings where resources may limit options for some therapies.

Education

Despite significant scientific advances in the care of cardiac arrest victims, there remains considerable variability in survival rates that cannot be attributed to patient characteristics alone. To optimize the likelihood that cardiac arrest victims receive the highest-quality evidence-based care, resuscitation education must use sound educational principles supported by empirical educational research to translate scientific knowledge into practice. While the 2010 AHA education guidelines included implementation and teams in its recommendations, the 2015 AHA education guidelines now focus strictly on education, with implementation and teams being included in other parts of the 2015 Guidelines Update.

Summary of Key Issues and Major Changes

Key recommendations and points of emphasis include the following:

- Use of a CPR feedback device is recommended to assist in learning the psychomotor skill of CPR. Devices that provide corrective feedback on performance are preferred over devices that provide only prompts (such as a metronome).
- The use of high-fidelity manikins is encouraged for 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.
- BLS skills seem to be learned as easily through self-instruction (video or computer based) with hands-on practice as through traditional instructor-led courses.
- Although prior CPR training is not essential for potential rescuers to initiate CPR, training helps people to learn the skills and develop the confidence to provide CPR when encountering a cardiac arrest victim.
- To minimize the time to defibrillation for cardiac arrest victims, the deployment of an AED should not be limited to trained individuals (although training is still recommended).
- A combination of self-instruction and instructor-led courses with hands-on training can be considered as an alternative to traditional instructor-led courses for lay providers.
- Precourse preparation that includes review of appropriate content information, online/precourse testing, and/or practice of pertinent technical skills may optimize learning from adult and pediatric advanced life support courses.
- Given the importance of team dynamics in resuscitation, training with a focus on leadership and teamwork principles should be incorporated into advanced life support courses.
- Communities may consider training bystanders in compression-only CPR for adult OHCA as an alternative to training in conventional CPR.
- Two-year retraining cycles are not optimal. More-frequent training of basic and advanced life support skills may be helpful for providers who are likely to encounter a cardiac arrest.

The 2015 AHA ECC Education Guidelines Writing Group agreed on several core concepts to guide the development of courses and course materials (Table 3).

Table 3 Core AHA ECC 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.[10,11]
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.[11-14]
Contextual	Adult learning principles[15] 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.[11,12,16-18]
Practice to mastery	Learners should have opportunities for repetitive performance of key skills coupled with rigorous assessment and informative feedback in a controlled setting.[19-22] This deliberate practice should be based on clearly defined objectives[23-25] and not time spent, to promote student development toward mastery.[26-30]
Debriefing	The provision of feedback and/or debriefing is a critical component of experiential learning.[31] 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.[32]
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[33] 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.[34] Training organizations should use this information to drive the continuous quality improvement process.

Abbreviations: AHA, American Heart Association; CPR, cardiopulmonary resuscitation; ECC, emergency cardiovascular care.

CPR Feedback Devices

2015 (Updated): Use of feedback devices can be effective in improving CPR performance during training.

2015 (New): If feedback devices are not available, auditory guidance (eg, metronome, music) may be considered to improve adherence to recommendations for chest compression rate.

2010 (Old): The use of a CPR feedback device can be effective for training.

Why: New evidence differentiates the benefit of different types of feedback for training, with a slight advantage given to feedback that is more comprehensive.

Use of High-Fidelity Manikins

2015 (Updated): The use of high-fidelity manikins for advanced life support training can be beneficial for improving skills performance at course conclusion.

2010 (Old): Realistic manikins may be useful for integrating the knowledge, skills, and behaviors in advanced life support training.

Why: In the 2010 evidence review, there was insufficient evidence to recommend the routine use of more realistic manikins to improve skills performance in actual resuscitations, particularly given the additional costs and resources required. Considering both the potential benefit of having more realistic manikins as well as the increased costs and resources involved, newly published literature supports the use of high-fidelity manikins, particularly in programs where resources (eg, human and financial resources) are already in place.

Blended Learning Formats

2015 (Updated): CPR self-instruction through video and/or computer-based modules with hands-on practice may be a reasonable alternative to instructor-led courses.

2015 (New): It may be reasonable to use alternative instructional modalities for basic and advanced life support teaching in resource-limited environments.

2010 (Old): Short video instruction combined with synchronous hands-on practice is an effective alternative to instructor-led BLS courses.

Why: Learner outcomes are more important than course formats. Knowledge and skill acquisition and retention and, ultimately, clinical performance and patient outcome should guide resuscitation education. There is new evidence that specific formats, such as CPR self-instruction using

video or computer-based modules, can provide similar outcomes to instructor-led courses. The ability to effectively use alternative course formats is particularly important in resource-limited environments where instructor-led courses may be cost prohibitive. Self-instruction courses offer the opportunity to train many more individuals to provide CPR while reducing the cost and resources required for training—important factors when considering the vast population of potential rescuers that should be trained.

Targeted Training

2015 (New): Training primary caregivers and/or family members of high-risk patients may be reasonable.

Why: Studies consistently show high scores for CPR performance by trained family members and/or caregivers of high-risk cardiac patients as compared with those who were untrained.

Expanded Training for AEDs

2015 (Updated): 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.

2015 (New): Self-directed methods can be considered for healthcare professionals learning AED skills.

2010 (Old): Because even minimal training in AED use has been shown to improve performance in simulated cardiac arrests, training opportunities should be made available and promoted for lay rescuers.

Why: AEDs can be correctly operated without any prior training: There is no need for a requirement for training to be placed on the use of AEDs by the public. Nevertheless, even minimal training improves performance, timeliness, and efficacy. Self-directed training broadens the opportunities for training for both lay providers and healthcare professionals.

Teamwork and Leadership

2015 (Updated): Given the very small risk for harm and the potential benefit of team and leadership training, the inclusion of team and leadership training as part of advanced life support training is reasonable.

2010 (Old): Teamwork and leadership skills training should be included in advanced life support courses.

Why: Resuscitation is a complex process that often involves the cooperation of many individuals. Teamwork and leadership are important components of effective resuscitation. Despite the importance of these factors, there is limited evidence that teamwork and leadership training affects patient outcomes.

Compression-Only CPR

2015 (New): Communities may consider training bystanders in compression-only CPR for adult OHCA as an alternative to training in conventional CPR.

Why: Compression-only CPR is simpler for lay providers to learn than conventional CPR (compressions with breaths) and can even be coached by a dispatcher during an emergency. Studies performed after a statewide educational campaign for bystander compression-only CPR showed that the prevalence of both overall CPR and compression-only CPR by bystanders increased.

BLS Retraining Intervals

2015 (Updated): 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 frequently by individuals who are likely to encounter cardiac arrest.

2015 (New): 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 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. There is insufficient evidence to recommend the optimal time interval.

2010 (Old): Skill performance should be assessed during the 2-year certification with reinforcement provided as needed.

Why: While growing evidence continues to show that recertification in basic and advanced life support every 2 years is inadequate for most people, the optimal timing of retraining has not been determined. Factors that affect the optimal retraining interval include the quality of initial training, the fact that some skills may be more likely to decay than others, and the frequency with which skills are used in clinical practice. Although data are limited, there is an observed improvement in skills and confidence among students who train more frequently. Also, frequent refreshers with manikin-based simulation may provide cost savings by using less total retraining time as compared with standard retraining intervals.

First Aid

The *2015 AHA and American Red Cross Guidelines Update for First Aid* reaffirms the goals of first aid: to reduce morbidity and mortality by alleviating suffering, preventing further illness or injury, and promoting recovery. The scope of first aid has been expanded. First aid can be initiated by anyone, in any situation, and includes self-care.

Summary of Key Issues and Major Changes

- The use of stroke assessment systems can assist first aid providers with identifying signs and symptoms of stroke.
- While glucose tablets are preferred for care of mild hypoglycemia, they may not be readily available. In these cases, other forms of sugar found in common dietary products have been found to be acceptable alternatives to glucose tablets for diabetics with mild symptomatic hypoglycemia who are conscious and are able to swallow and to follow commands.

- It is acceptable for a first aid provider to leave an open chest wound open and uncovered. If a dressing and direct pressure are needed to control bleeding, care should be taken to ensure the dressing does not inadvertently convert to an occlusive dressing.
- There are no single-stage concussion assessment systems to aid first aid providers in the recognition of concussion.
- When reimplantation of an avulsed tooth will be delayed, temporary storage of the tooth in an appropriate solution may help prolong viability of the tooth.
- First aid education delivered through public health campaigns, focused topics, or courses resulting in certification can increase survival rates, can decrease severity of injury and time in the hospital, and can resolve symptoms of injured and ill persons.
- When caring for an unresponsive person who is breathing normally, and in the absence of major trauma such as to the spine or pelvis, placing the person into a lateral, side-lying position may improve airway mechanics. The modified High Arm in Endangered Spine (HAINES) recovery position is no longer recommended.
- There continues to be no indication for the routine administration of supplementary oxygen by first aid providers. For those first aid providers with specialized training in the use of supplementary oxygen, administration of oxygen can be beneficial for persons with decompression injury. Other situations when administration may be considered include suspected carbon monoxide poisoning and for lung cancer patients with dyspnea coupled with hypoxemia.
- The recommendations still state that while awaiting the arrival of EMS providers, the first aid provider may encourage a person with chest pain to chew 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. However, the update of this recommendation notes that 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 about the cause of the chest pain or uncomfortable with administration of aspirin, a first aid provider should not encourage the person to take the aspirin.
- Epinephrine is recommended for the life-threatening condition of anaphylaxis, and those at risk typically carry epinephrine auto-injectors, often as a 2-dose package. When symptoms of anaphylaxis do not resolve with an initial dose of epinephrine, and EMS arrival will exceed 5 to 10 minutes, a second dose of epinephrine may be considered.
- The primary method to control bleeding is through the application of firm, direct pressure. When direct pressure is not effective for severe or life-threatening bleeding, the use of a hemostatic dressing combined with direct pressure may be considered but requires training in proper application and indications for use.
- Use of cervical collars by first aid providers is not recommended. For injured persons who meet high-risk criteria for spinal injury, the ideal method for a first aid provider to help prevent movement of the spine requires further study but may include verbal prompts or manual stabilization while awaiting arrival of advanced care providers.
- Topics covered in the 2015 Guidelines Update that have no new recommendations since 2010 include the use of bronchodilators for asthma with shortness of breath, toxic eye injury, control of bleeding, use of tourniquets, treatment of suspected long bone fractures, cooling of thermal burns, burn dressings, and spinal motion restriction.

Stroke Recognition

2015 (New): The use of a stroke assessment system by first aid providers is recommended. Compared with stroke assessment systems that do not require glucose measurement, assessment systems that include glucose measurement have similar sensitivity but higher specificity for recognition of stroke. The Face, Arm, Speech, Time (FAST) or Cincinnati Prehospital Stroke Scale (CPSS) stroke assessment systems are the simplest of these tools for use by first aid providers, with high sensitivity for the identification of stroke.

Why: Evidence shows that the early recognition of stroke with the use of a stroke assessment system decreases the interval between the time of stroke onset and arrival at a hospital and definitive treatment. In 1 study, more than 94% of lay providers trained in a stroke assessment system were able to recognize signs and symptoms of a stroke, and this ability persisted at 3 months after training.[35,36]

Hypoglycemia

2015 (New): For diabetics with mild symptomatic hypoglycemia who are able to follow commands and swallow safely, the use of oral glucose in the form of glucose tablets provides more rapid clinical relief compared with other forms of sugar found in common dietary products. Glucose tablets, if available, should be used to resolve hypoglycemia in these individuals. If glucose tablets are not available, other specifically evaluated forms of foods and liquids containing sugars such as sucrose, fructose, and oligosaccharides can be effective alternatives for reversal of mild symptomatic hypoglycemia.

Why: Hypoglycemia is a condition that first aid providers commonly encounter. Early treatment of mild hypoglycemia may prevent progression to severe hypoglycemia. Severe hypoglycemia can result in loss of consciousness or seizures and typically requires management by EMS.

Treatment of Open Chest Wounds

2015 (New): A first aid provider caring for an individual with an open chest wound may leave the wound open. If a dressing and direct pressure are required to stop bleeding, care must be taken to ensure that a blood-saturated dressing does not inadvertently become occlusive.

Why: The improper use of an occlusive dressing or device for open chest wounds may lead to development of an unrecognized life-threatening tension pneumothorax. There are no human studies comparing the application of an occlusive dressing or device to a nonocclusive dressing or device, and only a single animal study showed benefit to use of a nonocclusive device. As a result of the lack of evidence for use of an occlusive device, and considering the risk of unrecognized tension pneumothorax, the application of an occlusive dressing or device by first aid providers for individuals with an open chest wound is not recommended.

Concussion

2015 (New): An HCP should evaluate any person with a head injury that has resulted in a change in level of consciousness, progressive development of signs or symptoms of concussion, or other causes for concern to the first aid provider. The evaluation should occur as soon as possible.

Why: First aid providers often encounter individuals with minor head injury and possible concussion (mild traumatic brain injury). The myriad of signs and symptoms of concussion can make recognition of this injury a challenge. In addition, the long-term consequences of unrecognized concussion can be significant. Although a simple validated single-stage concussion scoring system could possibly help first aid providers with the recognition of concussion, no such assessment system has been identified. Sport concussion assessment tools used by healthcare professionals that require a 2-stage assessment (before competition and after concussion) are not appropriate as a single assessment tool for first aid providers.

Dental Avulsion

2015 (Updated): First aid providers may be unable to reimplant an avulsed tooth due to lack of protective medical gloves, training and skill, or fear of causing pain. When immediate reimplantation is not possible, it may be beneficial to temporarily store an avulsed tooth in a solution shown to prolong viability of dental cells (compared with saliva). Solutions with demonstrated efficacy at prolonging dental cell viability from 30 to 120 minutes include 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.

2010 (Old): Place the tooth in milk—or clean water if milk is not available.

Why: Dental avulsion can result in permanent loss of a tooth. The dental community agrees that immediate reimplantation of the avulsed tooth affords the greatest chance of tooth survival, but it may not be an option. In the event of delayed reimplantation, temporary storage of an avulsed tooth in an appropriate solution may improve chances of tooth survival.

First Aid Education

2015 (New): Education and training in first aid can be useful to improve morbidity and mortality from injury and illness, and we recommend that it be universally available.

Why: Evidence shows that education in first aid can increase survival rates, improve recognition of acute illness, and aid symptom resolution.

Positioning an Ill or Injured Person

2015 (Updated): The recommended recovery position has changed from supine to a lateral side-lying position for patients without suspected spine, hip, or pelvis injury. There is little evidence to suggest that any alternative recovery position is of greater benefit for an individual who is unresponsive and breathing normally.

2010 (Old): If the victim is facedown and is unresponsive, turn the victim faceup. If the victim has difficulty breathing because of copious secretions or vomiting, or if you are alone and have to leave an unresponsive victim to get help, place the victim in a modified HAINES recovery position.

Why: Studies showing some improvement to respiratory indices when the victim is in a lateral position compared with a supine position has led to a change in the recommendation for patients without suspected spine, hip, or pelvis injury. The HAINES position is no longer recommended, due to the paucity and very low quality of evidence to support this position.

Oxygen Use in First Aid

2015 (Updated): There is no evidence supporting the routine administration of supplementary oxygen by first aid providers. Supplementary oxygen may be of benefit in only a few specific situations such as decompression injury and when administered by providers with training in its use.

2010 (Old): There is no evidence for or against the routine use of oxygen as a first aid measure for victims experiencing shortness of breath or chest pain. Oxygen may be beneficial for first aid in divers with a decompression injury.

Why: Evidence shows a benefit from use of oxygen for decompression sickness by first aid providers who have taken a diving first aid oxygen course. Limited evidence also shows supplementary oxygen to be effective for relief of dyspnea in advanced lung cancer patients with dyspnea and associated hypoxemia but not for similar patients without hypoxemia. Although no evidence was identified to support the use of oxygen, when patients exposed to carbon monoxide are breathing spontaneously, it might be reasonable to provide oxygen while waiting for advanced medical care.

Chest Pain

2015 (Updated): While waiting for EMS to arrive, the first aid provider may encourage a person with chest pain to chew 1 adult or 2 low-dose aspirins if the signs and symptoms suggest that the person is having a myocardial infarction, and if the person has no allergy or other contraindication to aspirin. If a person has chest pain that does not suggest a cardiac source, or if the first aid provider is uncertain of the cause of chest pain or uncomfortable with administration of aspirin, then the first aid provider should not encourage the person to take aspirin and the decision to administer aspirin can be deferred to an EMS provider.

2010 (Old): While waiting for EMS to arrive, the first aid provider may encourage the victim to chew and swallow 1 adult (non–enteric-coated) or 2 low-dose "baby" aspirins if the patient has no allergy to aspirin or other contraindication to aspirin, such as evidence of a stroke or recent bleeding.

Why: The administration of aspirin significantly decreases mortality due to myocardial infarction, but there is no evidence to support the use of aspirin for undifferentiated chest pain. A reduction in mortality is also found when "early" administration of aspirin (ie, in the first few hours after onset of symptoms from myocardial infarction) is compared with "later" (ie, after hospital arrival) administration of aspirin for chest pain due to acute myocardial infarction. It remains unclear, however, whether first aid providers can recognize the signs and symptoms of myocardial infarction, and it is possible that use of aspirin for noncardiac causes of chest pain could cause harm. Although the dose and form of aspirin used for chest pain was not specifically reviewed by the ILCOR First Aid Task Force, the bioavailability of enteric-coated aspirin is similar to non–enteric-coated when chewed and swallowed.[36] Thus, there is no longer the restriction to use non–enteric-coated aspirin, as long as the aspirin is chewed before swallowing.

Anaphylaxis

2015 (Updated): When a person with anaphylaxis does not respond to an initial dose of epinephrine, and arrival of advanced care will exceed 5 to 10 minutes, a repeat dose may be considered.

2010 (Old): In unusual circumstances, when advanced medical assistance is not available, a second dose of epinephrine may be given if symptoms of anaphylaxis persist.

Why: The 2010 Guidelines recommended that first aid providers assist with or administer (the victim's own) epinephrine to persons with symptoms of anaphylaxis. Evidence supports the need for a second dose of epinephrine for acute anaphylaxis in persons not responding to a first dose; the guidelines revision provides clarification as to the time frame for considering a second dose of epinephrine.

Hemostatic Dressings

2015 (Updated): First aid providers may consider use of hemostatic dressings when standard bleeding control measures (with direct pressure with or without gauze or cloth dressing) are not effective for severe or life-threatening bleeding.

2010 (Old): Routine use (of hemostatic agents) in first aid cannot be recommended at this time because of significant variation in effectiveness by different agents and their potential for adverse effects, including tissue destruction with induction of a proembolic state and potential thermal injury.

Why: The application of firm, direct pressure to a wound is still considered the primary means for control of bleeding. When direct pressure fails to control severe or life-threatening bleeding, first aid providers who have specific training in their indications and use may consider a hemostatic dressing. Newer-generation hemostatic agent-impregnated dressings have been shown to cause fewer complications and adverse effects than older hemostatic agents, and are effective in providing hemostasis in up to 90% of subjects.

Spinal Motion Restriction

2015 (Updated): With a growing body of evidence showing harm and no good evidence showing clear benefit, routine application of cervical collars by first aid providers is not recommended. A first aid provider who suspects a spinal injury should have the injured person remain as still as possible while awaiting arrival of EMS providers.

2010 (Old): First aid providers should not use immobilization devices because their benefit in first aid has not been proven and they may be harmful. Maintain spinal motion restriction by manually stabilizing the head so that motion of the head, neck, and spine is minimized.

Why: In the 2015 ILCOR systematic review of the use of cervical collars as a component of spinal motion restriction for blunt trauma, there was no evidence found to show a decrease in neurologic injury with the use of cervical collars. In fact, studies demonstrated actual or potential adverse effects such as increased intracranial pressure and airway compromise with use of a cervical collar. Proper technique for application of a cervical collar in high-risk individuals requires significant training and practice to be performed correctly. Application of cervical collars is not a first aid skill. The revision of this guideline reflects a change in recommendation class to Class III: Harm due to potential for adverse effects.

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