

Part 11: Pediatric Basic Life Support and Cardiopulmonary Resuscitation Quality

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

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Introduction

This 2015 American Heart Association (AHA) Guidelines Update for Cardiopulmonary Resuscitation (CPR) and Emergency Cardiovascular Care (ECC) section on pediatric basic life support (BLS) differs substantially from previous versions of the AHA Guidelines.¹ This publication updates the 2010 AHA Guidelines on pediatric BLS for several key questions related to pediatric CPR. The Pediatric ILCOR Task Force reviewed the topics covered in the 2010 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science With Treatment Recommendations and the 2010 council-specific guidelines for CPR and ECC (including those published by the AHA) and formulated 3 priority questions to address for the 2015 systematic reviews. In the online version of this document, live links are provided so the reader can connect directly to those systematic reviews on the International Liaison Committee on Resuscitation (ILCOR) Scientific Evidence Evaluation and Review System (SEERS) website. These links are indicated by a superscript combination of letters and numbers (eg, Peds 709). We encourage readers to use the links and review the evidence and appendices.

A rigorous systematic review process was undertaken to review the relevant literature to answer those questions, resulting in the 2015 International Consensus on CPR and ECC Science With Treatment Recommendations, "Part 6: Pediatric Basic Life Support and Pediatric Advanced Life Support."^{2,3} This 2015 Guidelines Update covers only those topics reviewed as part of the 2015 systematic review process. Other recommendations published in the 2010 AHA Guidelines remain the official recommendations of the AHA ECC scientists (see Appendix). When making AHA treatment recommendations, we used the AHA Class of Recommendation and Level of Evidence (LOE) systems. This update uses the newest AHA Class of Recommendation and LOE classification system, which contains modifications of the Class III recommendation and introduces LOE B-R (randomized studies) and

B-NR (nonrandomized studies) as well as LOE C-LD (limited data) and LOE C-EO (consensus of expert opinion).

Outcomes from pediatric in-hospital cardiac arrest (IHCA) have markedly improved over the past decade. From 2001 to 2009, rates of pediatric IHCA survival to hospital discharge improved from 24% to 39%.⁴ Recent unpublished 2013 data from the AHA's Get With The Guidelines[®]-Resuscitation program observed 36% survival to hospital discharge for pediatric IHCA (Paul S. Chan, MD, personal communication, April 10, 2015). Prolonged CPR is not always futile, with 12% of patients who receive CPR for more than 35 minutes surviving to discharge and 60% of those survivors having a favorable neurologic outcome.⁵

Unlike IHCA, survival from out-of-hospital cardiac arrest (OHCA) remains poor. Data from 2005 to 2007 from the Resuscitation Outcomes Consortium, a registry of 11 US and Canadian emergency medical systems, showed age-dependent discharge survival rates of 3.3% for infants (younger than 1 year), 9.1% for children (1 to 11 years), and 8.9% for adolescents (12 to 19 years).⁶ More recently published data from this network demonstrate 8.3% survival to hospital discharge across all age groups.⁷

For the purposes of these guidelines:

- Infant BLS guidelines apply to infants younger than approximately 1 year of age.
- Child BLS guidelines apply to children approximately 1 year of age until puberty. For teaching purposes, puberty is defined as breast development in females and the presence of axillary hair in males.
- Adult BLS guidelines apply at and beyond puberty (see "Part 5: Adult Basic Life Support and Cardiopulmonary Resuscitation Quality" in this supplement regarding the use of the automated external defibrillator (AED) and methods to achieve high-quality CPR).

The following subjects are addressed in this 2015 pediatric BLS guidelines update:

The American Heart Association requests that this document be cited as follows: Atkins DL, Berger S, Duff JP, Gonzales JC, Hunt EA, Joyner BL, Meaney PA, Niles DE, Samson RA, Schexnayder SM. Part 11: pediatric basic life support and cardiopulmonary resuscitation quality: 2015 American Heart Association Guidelines Update for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care. *Circulation*. 2015;132(suppl 2):S519–S525.

This article has been reprinted in *Pediatrics*.

(*Circulation*. 2015;132[suppl 2]:S519–S525. DOI: 10.1161/CIR.0000000000000265.)

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Circulation is available at <http://circ.ahajournals.org>

DOI: 10.1161/CIR.0000000000000265

- Pediatric BLS Healthcare Provider Pediatric Cardiac Arrest Algorithms for a single rescuer and for 2 or more rescuers
- The sequence of compressions, airway, breathing (C-A-B) versus airway, breathing, compressions (A-B-C)
- Chest compression rate and depth
- Compression-only (Hands-Only) CPR

Pediatric Advanced Life Support topics reviewed by the ILCOR Pediatric Task Force are covered in “Part 12: Pediatric Advanced Life Support.”

Algorithms

Algorithms for 1- and 2-person healthcare provider CPR have been separated to better guide rescuers through the initial stages of resuscitation (Figures 1 and 2). In an era where cellular telephones with speakers are common, this technology can allow a single rescuer to activate the emergency response system while beginning CPR. These algorithms continue to emphasize the high priority for obtaining an AED quickly in a sudden, witnessed collapse, because such an event is likely to have a cardiac etiology.

Sequence of CPR

C-A-B Versus A-B-C^{Peds 709}

Historically, the preferred sequence of CPR was A-B-C (Airway-Breathing-Compressions). The 2010 AHA Guidelines recommended a change to the C-A-B sequence (Compressions-Airway-Breathing) to decrease the time to initiation of chest compressions and reduce “no blood flow” time. The 2015 ILCOR systematic review addressed evidence to support this change.^{2,3}

Pediatric cardiac arrest has inherent differences when compared with adult cardiac arrest. In infants and children, asphyxial cardiac arrest is more common than cardiac arrest from a primary cardiac event; therefore, ventilation may have greater importance during resuscitation of children. Data from animal studies^{8,9} and 2 pediatric studies^{10,11} suggest that resuscitation outcomes for asphyxial arrest are better with a combination of ventilation and chest compressions.

Manikin studies demonstrated that starting CPR with 30 chest compressions followed by 2 breaths delays the first ventilation by 18 seconds for a single rescuer and less (by about 9 seconds or less) for 2 rescuers. A universal CPR algorithm for victims of all ages minimizes the complexity of CPR and offers consistency in teaching CPR to rescuers who treat infants, children, or adults. Whether resuscitation beginning with ventilations (A-B-C) or with chest compressions (C-A-B) impacts survival is unknown. To increase bystander CPR rates as well as knowledge and skill retention, the use of the same sequence for infants and children as for adults has potential benefit.

2015 Evidence Summary

No human studies with clinical outcomes were identified that compared C-A-B and A-B-C approaches for initial management of cardiac arrest. The impact of time to first chest compression for C-A-B versus A-B-C sequence has been

evaluated. Adult^{12,13} and pediatric¹⁴ manikin studies showed a significantly reduced time to first chest compression with the use of a C-A-B approach compared with an A-B-C approach. Data from 2 of these 3 studies demonstrated that time to first ventilation is delayed by only approximately 6 seconds when using a C-A-B sequence compared with an A-B-C sequence.^{12,14}

2015 Recommendation—New

Because of the limited amount and quality of the data, it may be reasonable to maintain the sequence from the 2010 Guidelines by initiating CPR with C-A-B over A-B-C sequence (Class IIb, LOE C-EO). Knowledge gaps exist, and specific research is required to examine the best approach to initiating CPR in children.

Components of High-Quality CPR

The 5 components of high-quality CPR are

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

The ILCOR Pediatric Task Force systematic review addressed the optimal depth of chest compressions in infants and children. Because there was insufficient evidence for a systemic review of chest compression rate in children, the ILCOR Pediatric Task Force and this writing group reviewed and accepted the recommendations of the ILCOR BLS Task Force regarding chest compression rate so that the recommended compression rate would be consistent for victims of all age groups.

Chest Compression Rate^{BLS 343} and Depth^{Peds 394}

2015 Evidence Summary

Insufficient data were available for a systematic review of chest compression rate in children. As noted above, the writing group reviewed the evidence and recommendations made for adult BLS and agreed to recommend the same compression rate during resuscitation of children. For the review of chest compression rate in adults, see “Part 5: Adult Basic Life Support and Cardiopulmonary Resuscitation Quality.”

Limited pediatric evidence suggests that chest compression depth is a target for improving resuscitation. One observational study demonstrated that chest compression depth is often inadequate during pediatric cardiac arrest.¹⁵ Adult data have demonstrated the importance of adequate chest compression depth to the outcome of resuscitation,¹⁶ but such data in children are very limited. A case series of 6 infants with heart disease examined blood pressure during CPR in relation to chest compression depth and observed a higher systolic blood pressure during CPR in association with efforts to increase chest compression depth.¹⁷ Another report of 87 pediatric resuscitation events, most involving children older than 8 years, found that compression depth greater than 51 mm for more than 60% of the compressions during 30-second epochs

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

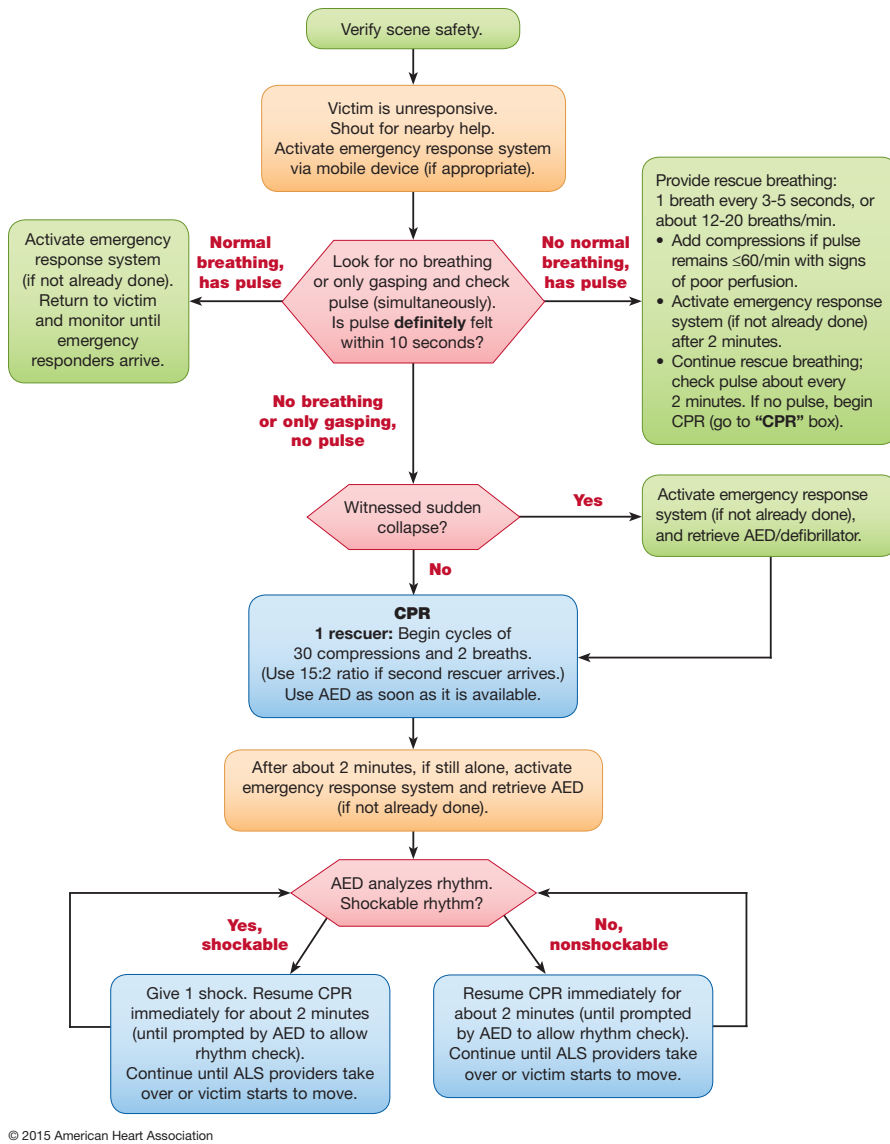


Figure 1. BLS Healthcare Provider Pediatric Cardiac Arrest Algorithm for the Single Rescuer—2015 Update.

within the first 5 minutes was associated with improved 24-hour survival.¹⁸

2015 Recommendations—New

For simplicity in CPR training, in the absence of sufficient pediatric evidence, it is reasonable to use the adult BLS-recommended chest compression rate of 100/min to 120/min for infants and children (Class IIa, LOE C-EO). Although the effectiveness of CPR feedback devices was not reviewed by this writing group, the consensus of the group is that the use of feedback devices likely helps the rescuer optimize adequate chest compression rate and depth, and we suggest their use when available (Class IIb, LOE C-EO; see also “Part 14: Education”).

It is reasonable that for pediatric patients (birth to the onset of puberty) rescuers provide chest compressions that depress the chest at least one third the anterior-posterior

diameter of the chest. This equates to approximately 1.5 inches (4 cm) in infants to 2 inches (5 cm) in children (Class IIa, LOE C-LD). Once children have reached puberty, the recommended adult compression depth of at least 5 cm, but no more than 6 cm, is used for the adolescent of average adult size (Class I, LOE C-LD).¹⁶

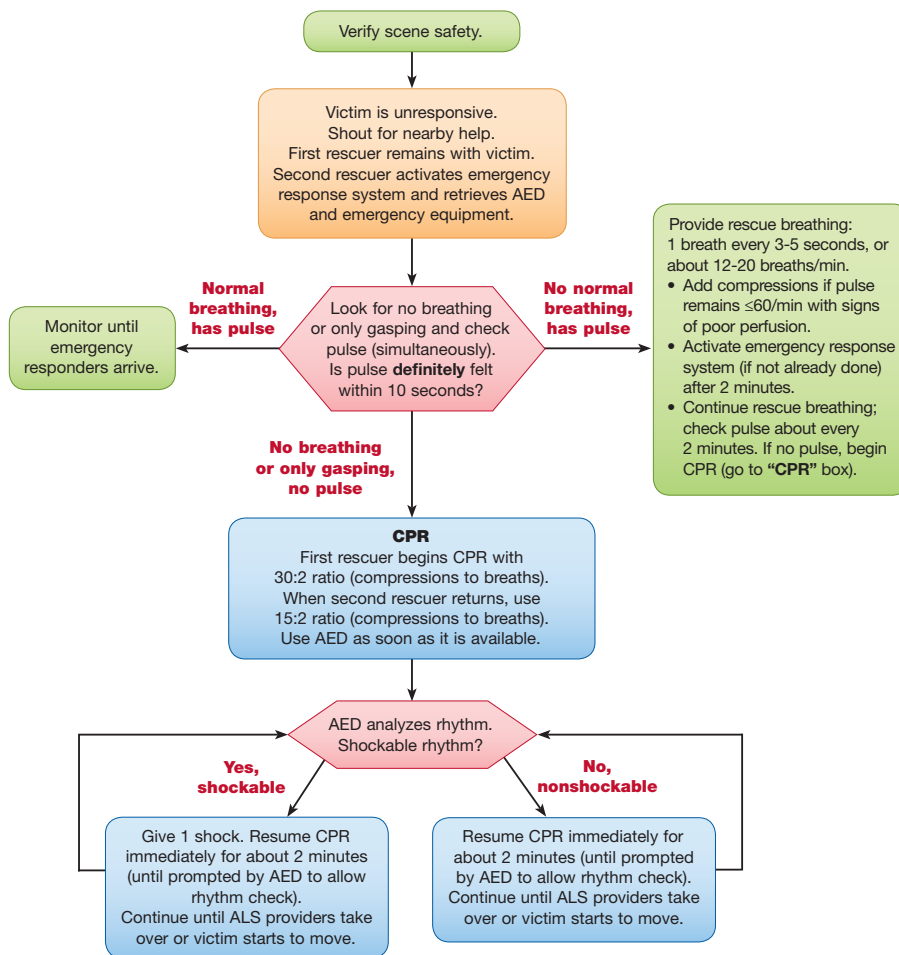
Compression-Only CPR^{Peds 414}

The 2015 ILCOR pediatric systematic review addressed the use of compression-only CPR for cardiac arrest in infants and children. Compression-only CPR is an alternative for lay rescuer CPR in adults.

2015 Evidence Summary

In a large observational study examining data from a Japanese national registry of pediatric OHCA, the use of compression-only CPR, when compared with conventional CPR, was

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



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

associated with worse 30-day intact neurologic survival.¹⁰ When analyzed by arrest etiology, although the numbers are small, in patients with presumed nonasphyxial arrest (ie, a presumed arrest of cardiac etiology), compression-only CPR was as effective as conventional CPR. However, in patients with presumed asphyxial cardiac arrest, outcomes after compression-only CPR were no better than those for patients receiving no bystander CPR.

A second large observational study using a more recent data set from the same Japanese registry examined the effect of dispatcher-assisted CPR in pediatric OHCA. In this study, the use of compression-only CPR was associated with worse 30-day intact neurologic survival compared

with patients who received conventional CPR.¹¹ Although not stratified for etiology of arrest, outcomes after compression-only CPR were no better than for patients who received no bystander CPR.

2015 Recommendations—New

Conventional CPR (chest compressions and rescue breaths) should be provided for pediatric cardiac arrests (Class I, LOE B-NR). The asphyxial nature of the majority of pediatric cardiac arrests necessitates ventilation as part of effective CPR. However, because compression-only CPR is effective in patients with a primary cardiac event, if rescuers are unwilling or unable to deliver breaths, we recommend rescuers perform compression-only CPR for infants and children in cardiac arrest (Class I, LOE B-NR).

Disclosures

Part 11: Pediatric Basic Life Support and Cardiopulmonary Resuscitation Quality: 2015 Guidelines Update Writing Group Disclosures

Writing Group Member	Employment	Research Grant	Other Research Support	Speakers' Bureau/Honoraria	Expert Witness	Ownership Interest	Consultant/Advisory Board	Other
Dianne L. Atkins	University of Iowa	None	None	None	None	None	None	None
Stuart Berger	University of California	None	None	None	Entity: Defense and plaintiff expert testimony but none that have involved the subject of the AHA Scientific Statement in question. Relationship: Myself. Compensation: Compensated*	None	None	None
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This table represents the relationships of writing group members that may be perceived as actual or reasonably perceived conflicts of interest as reported on the Disclosure Questionnaire, which all members of the writing group are required to complete and submit. A relationship is considered to be "significant" if (a) the person receives \$10 000 or more during any 12-month period, or 5% or more of the person's gross income; or (b) the person owns 5% or more of the voting stock or share of the entity, or owns \$10 000 or more of the fair market value of the entity. A relationship is considered to be "modest" if it is less than "significant" under the preceding definition.

*Modest.

†Significant.

Appendix

2015 Guidelines Update: Part 11 Recommendations

Year Last Reviewed	Topic	Recommendation	Comments
2015	Sequence of CPR	Because of the limited amount and quality of the data, it may be reasonable to maintain the sequence from the 2010 Guidelines by initiating CPR with C-A-B over A-B-C (Class IIb, LOE C-E0).	updated for 2015
2015	Components of High-Quality CPR: Chest Compression Rate and Depth	To maximize simplicity in CPR training, in the absence of sufficient pediatric evidence, it is reasonable to use the adult chest compression rate of 100/min to 120/min for infants and children (Class IIa, LOE C-E0).	updated for 2015
2015	Components of High-Quality CPR: Chest Compression Rate and Depth	Although the effectiveness of CPR feedback devices was not reviewed by this writing group, the consensus of the group is that the use of feedback devices likely helps the rescuer optimize adequate chest compression rate and depth, and we suggest their use when available (Class IIb, LOE C-E0).	updated for 2015
2015	Components of High-Quality CPR: Chest Compression Rate and Depth	It is reasonable that in pediatric patients (1 month to the onset of puberty) rescuers provide chest compressions that depress the chest at least one third the anterior-posterior diameter of the chest. This equates to approximately 1.5 inches (4 cm) in infants to 2 inches (5 cm) in children (Class IIa, LOE C-LD).	updated for 2015
2015	Components of High-Quality CPR: Compression-Only CPR	Conventional CPR (rescue breathing and chest compressions) should be provided for pediatric cardiac arrests (Class I, LOE B-NR).	updated for 2015
2015	Components of High-Quality CPR: Compression-Only CPR	The asphyxial nature of the majority of pediatric cardiac arrests necessitates ventilation as part of effective CPR. However, because compression-only CPR is effective in patients with a primary cardiac event, if rescuers are unwilling or unable to deliver breaths, we recommend rescuers perform compression-only CPR for infants and children in cardiac arrest (Class I, LOE B-NR).	updated for 2015
The following recommendations were not reviewed in 2015. For more information, see the <i>2010 AHA Guidelines for CPR and ECC</i> , "Part 13: Pediatric Basic Life Support."			
2010	Check for Breathing	Formal training as well as "just in time" training, such as that provided by an emergency response system dispatcher, should emphasize how to recognize the difference between gasping and normal breathing; rescuers should be instructed to provide CPR even when the unresponsive victim has occasional gasps (Class IIa, LOE C).	not reviewed in 2015
2010	Start Chest Compressions	For an infant, lone rescuers (whether lay rescuers or healthcare providers) should compress the sternum with 2 fingers placed just below the intermammary line (Class IIb, LOE C).	not reviewed in 2015
2010	Start Chest Compressions	There are no data to determine if the 1- or 2-hand method produces better compressions and better outcome (Class IIb, LOE C). Because children and rescuers come in all sizes, rescuers may use either 1 or 2 hands to compress the child's chest.	not reviewed in 2015
2010	Start Chest Compressions	After each compression, allow the chest to recoil completely (Class IIb, LOE B) because complete chest reexpansion improves the flow of blood returning to the heart and thereby blood flow to the body during CPR.	not reviewed in 2015
2010	Open the Airway and Give Ventilations	Open the airway using a head tilt–chin lift maneuver for both injured and noninjured victims (Class I, LOE B).	not reviewed in 2015
2010	Open the Airway and Give Ventilations	In an infant, if you have difficulty making an effective seal over the mouth and nose, try either mouth-to-mouth or mouth-to-nose ventilation (Class IIb, LOE C).	not reviewed in 2015
2010	Open the Airway and Give Ventilations	In either case make sure the chest rises when you give a breath. If you are the only rescuer, provide 2 effective ventilations using as short a pause in chest compressions as possible after each set of 30 compressions (Class IIa, LOE C).	not reviewed in 2015
2010	BLS Sequence for Healthcare Providers and Others Trained in 2-Rescuer CPR	It is reasonable for healthcare providers to tailor the sequence of rescue actions to the most likely cause of arrest. For example, if the arrest is witnessed and sudden (eg, sudden collapse in an adolescent or a child identified at high risk for arrhythmia or during an athletic event), the healthcare provider may assume that the victim has suffered a sudden VF–cardiac arrest and as soon as the rescuer verifies that the child is unresponsive and not breathing (or only gasping) the rescuer should immediately phone the emergency response system, get the AED and then begin CPR and use the AED. (Class IIa LOE C).	not reviewed in 2015
2010	Pulse Check	If, within 10 seconds, you don't feel a pulse or are not sure if you feel a pulse, begin chest compressions (Class IIa, LOE C).	not reviewed in 2015
2010	Inadequate Breathing With Pulse	Reassess the pulse about every 2 minutes (Class IIa, LOE B) but spend no more than 10 seconds doing so.	not reviewed in 2015
2010	Ventilations	For healthcare providers and others trained in 2-person CPR, if there is evidence of trauma that suggests spinal injury, use a jaw thrust without head tilt to open the airway (Class IIb LOE C).	not reviewed in 2015

(Continued)

2015 Guidelines Update: Part 11 Recommendations, *Continued*

Year Last Reviewed	Topic	Recommendation	Comments
2010	Coordinate Chest Compressions and Ventilations	Deliver ventilations with minimal interruptions in chest compressions (Class IIa, LOE C).	not reviewed in 2015
2010	Defibrillation	For infants a manual defibrillator is preferred when a shockable rhythm is identified by a trained healthcare provider (Class IIb, LOE C).	not reviewed in 2015
2010	Defibrillation	An AED with a pediatric attenuator is also preferred for children <8 years of age. If neither is available, an AED without a dose attenuator may be used (Class IIb, LOE C).	not reviewed in 2015
2010	Bag-Mask Ventilation (Healthcare Providers)	Avoid excessive ventilation (Class III, LOE C); use only the force and tidal volume necessary to just make the chest rise.	not reviewed in 2015

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KEY WORDS: automated external defibrillator ■ cardiopulmonary resuscitation ■ pediatrics