

Part 11: Pediatric Basic Life Support and Cardiopulmonary Resuscitation Quality

Key Words: automatic external defibrillator | cardiopulmonary resuscitation | pediatrics

1 Highlights

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 (Figure 1 and Figure 2) 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.

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

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

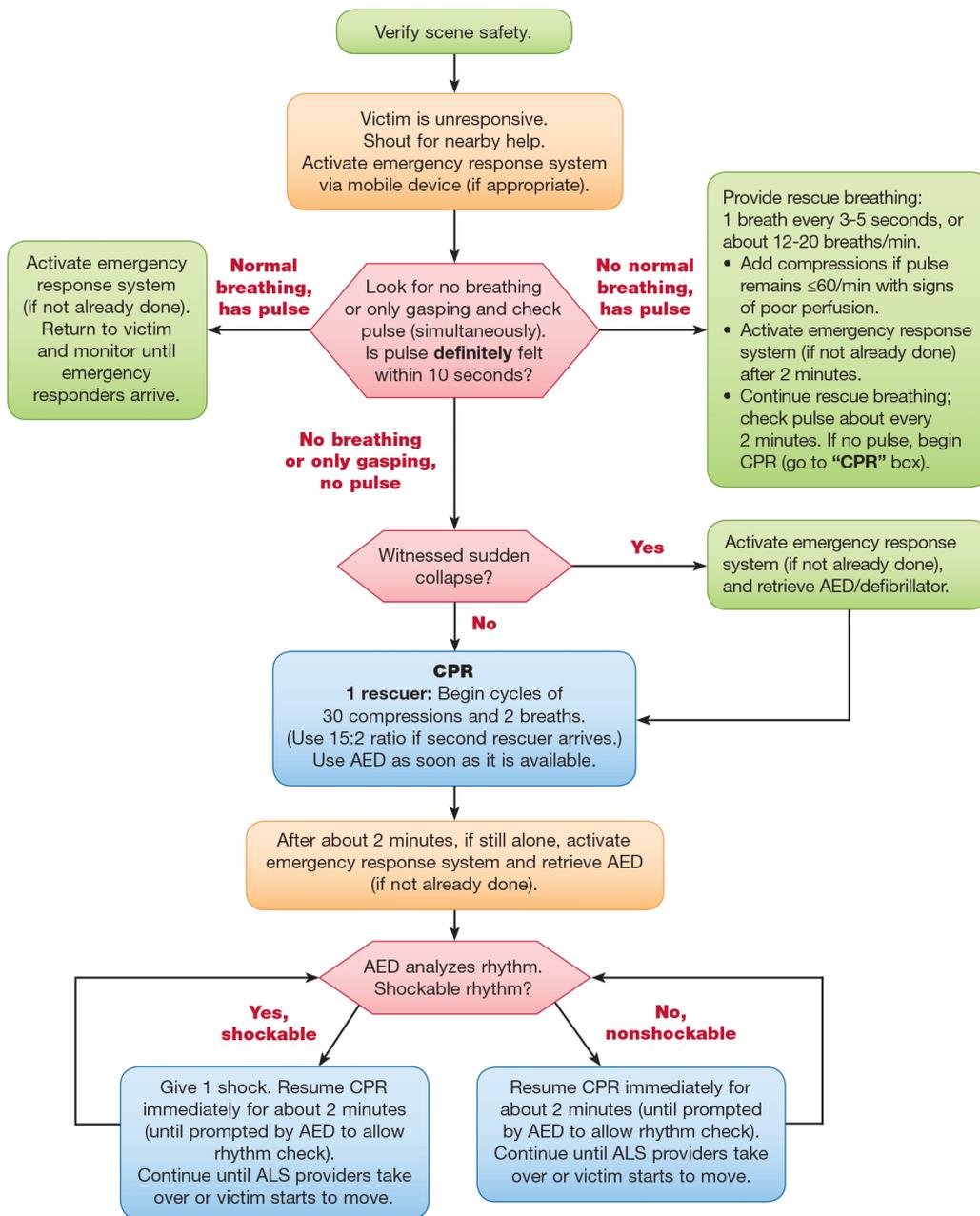
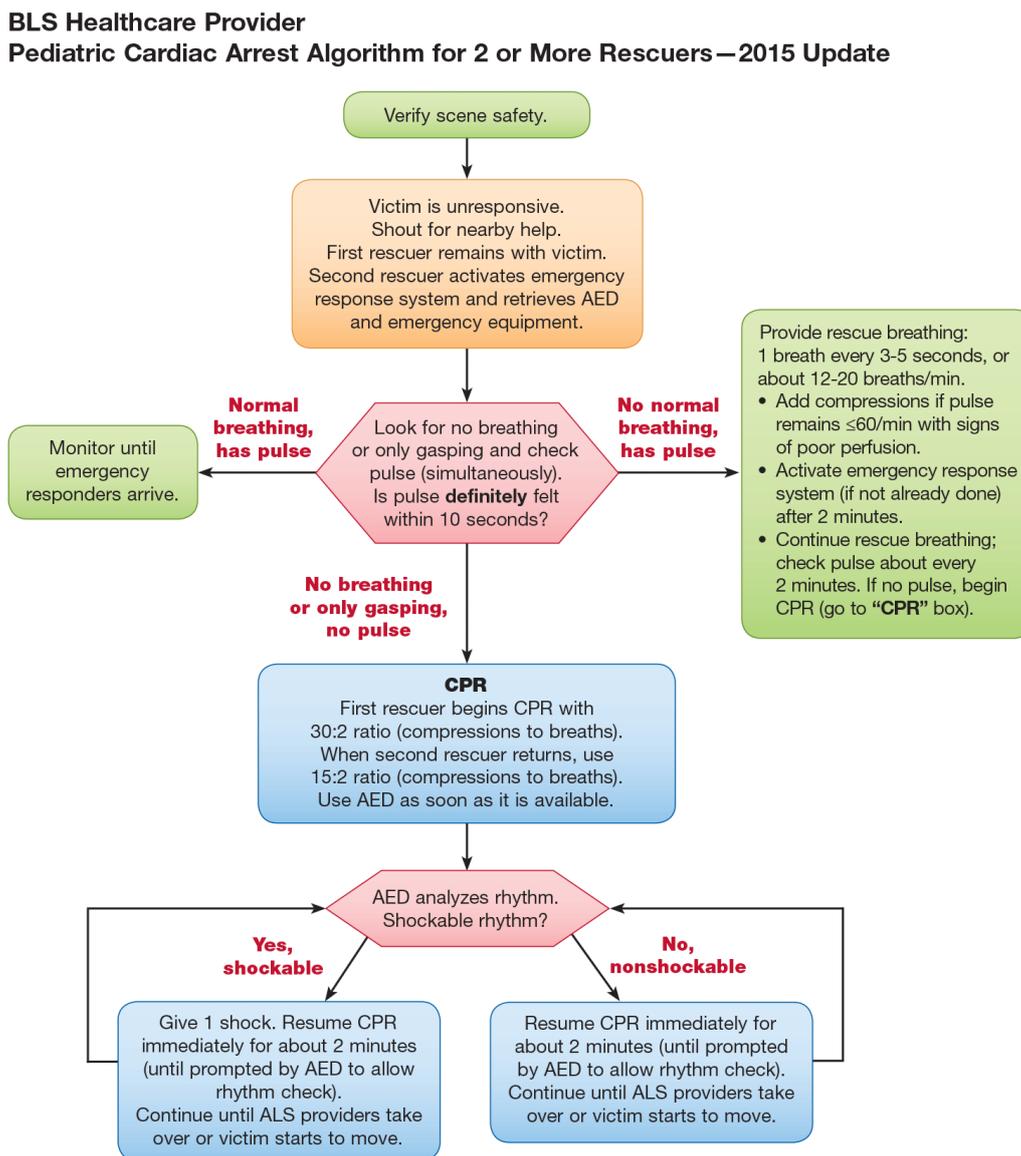


Figure 2: BLS Healthcare Provider Pediatric Cardiac Arrest Algorithm for 2 or More Rescuers—2015 Update



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Chest Compression Depth

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

2 Introduction - Updated

These Web-based Integrated Guidelines incorporate the relevant recommendations from 2010 and the new or updated recommendations from 2015.

The 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. 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.”^{1,2} 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. As stated above, this Web-based Integrated Guideline document includes relevant 2010 recommendations as well as the new or updated recommendations from 2015. When making AHA treatment recommendations, we used the AHA Class of Recommendation and Level of Evidence (LOE) systems. New or updated recommendations use the newest AHA COR and LOE classification system, which contains modifications of the Class III recommendation and introduces LOE B-R (randomized studies) and B-NR (nonrandomized studies) as well as LOE C-LD (limited data) and LOE C-EO (consensus of expert opinion).

Recommendations from 2010 display the original classification system from 2010.

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%.³ 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.⁴

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).⁵ More recently published data from this network demonstrate 8.3% survival to hospital discharge across all age groups.⁶

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 *Web-based Integrated Guidelines* regarding the use of the AED and methods to achieve high-quality CPR).

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

- 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](#)."

3 Prevention of Cardiopulmonary Arrest

In infants, the leading causes of death are congenital malformations, complications of prematurity, and SIDS. In children over 1 year of age, injury is the leading cause of death. Survival from traumatic cardiac arrest is rare, emphasizing the importance of injury prevention in reducing deaths.^{7,8} Motor vehicle crashes are the most common cause of fatal childhood injuries; targeted interventions, such as the use of child passenger safety seats, can reduce the risk of death. Resources for the prevention of motor vehicle-related injuries are detailed on the US National Highway Traffic Safety Administration's website at www.nhtsa.gov. The World Health Organization provides information on the prevention of violence and injuries at www.who.int/violence_injury_prevention/en/.

4 Algorithms - Updated

Algorithms for 1- and 2-person healthcare provider CPR have been separated to better guide rescuers through the initial stages of resuscitation (Figure 1 and Figure 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.

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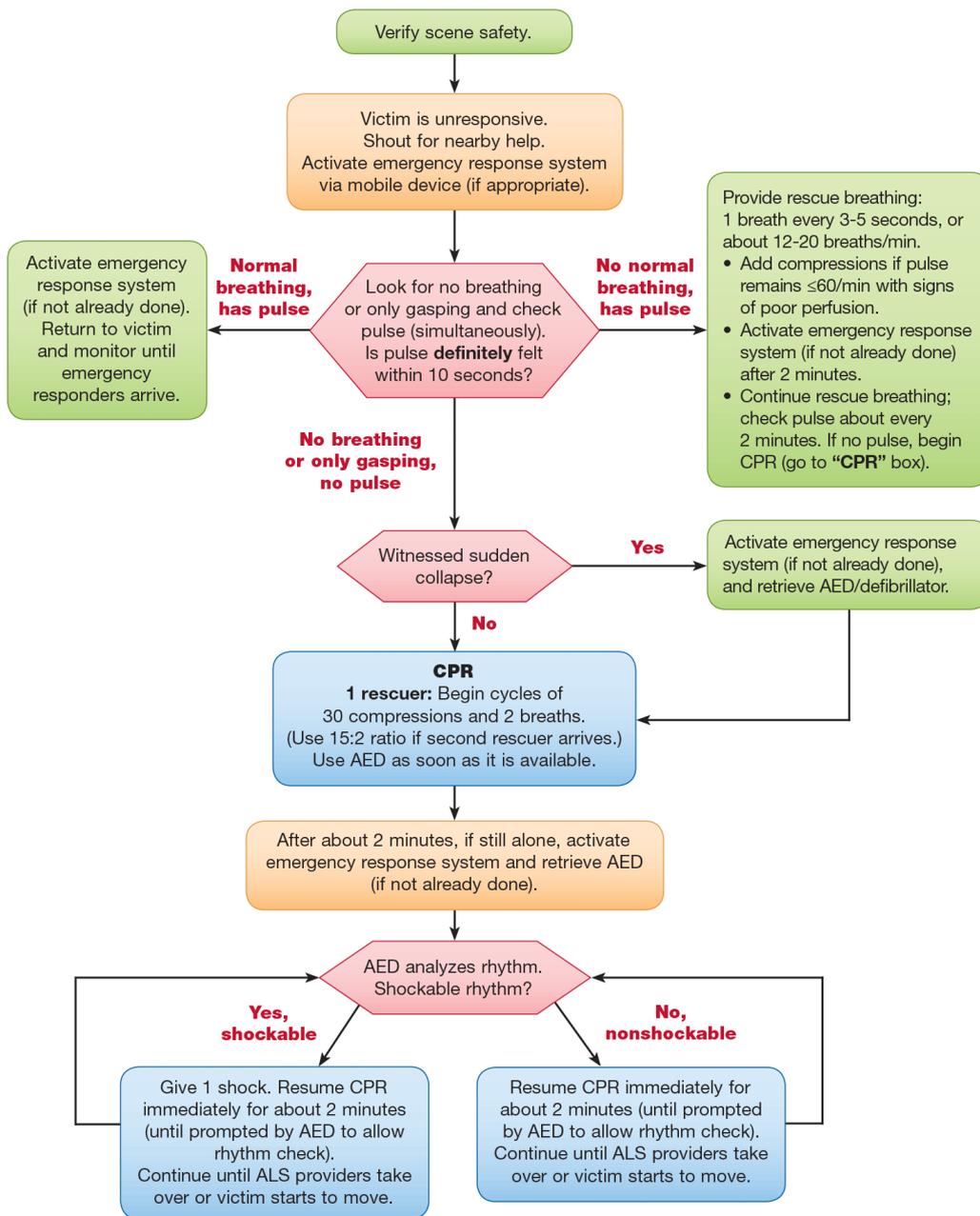
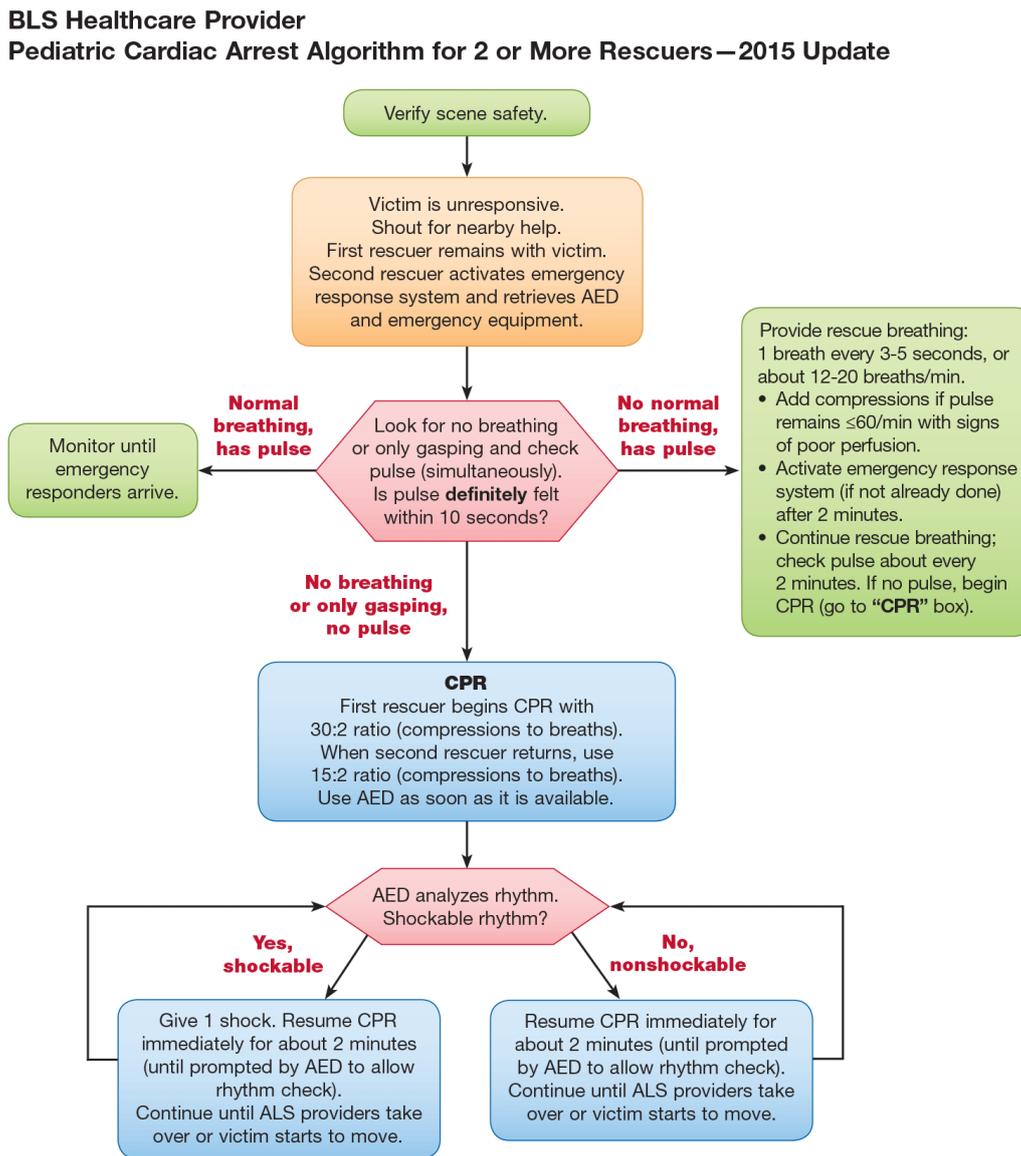


Figure 2: BLS Healthcare Provider Pediatric Cardiac Arrest Algorithm for 2 or More Rescuers—2015 Update



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5 BLS Sequence for Lay Rescuers

5.1 Safety of Rescuer and Victim

Always make sure that the area is safe for you and the victim. Although provision of CPR carries a theoretical risk of transmitting infectious disease, the risk to the rescuer is very low.⁹

5.2 Assess Need for CPR

To assess the need for CPR, the lay rescuer should assume that cardiac arrest is present if the victim is unresponsive and not breathing or only gasping.

5.3 Check for Response

Gently tap the victim and ask loudly, "Are you okay?" Call the child's name if you know it. If the child is responsive, he or she will answer, move, or moan. Quickly check to see if the child has any injuries or needs medical assistance. If you are alone and the child is breathing, leave the child to phone the emergency response system, but return quickly and recheck the child's condition frequently. Children with respiratory distress often

assume a position that maintains airway patency and optimizes ventilation. Allow the child with respiratory distress to remain in a position that is most comfortable. If the child is unresponsive, shout for help.

5.4 Check for Breathing

If you see regular breathing, the victim does not need CPR. If there is no evidence of trauma, turn the child onto the side (recovery position), which helps maintain a patent airway and decreases risk of aspiration.

If the victim is unresponsive and not breathing (or only gasping), begin CPR. Sometimes victims who require CPR will gasp, which may be misinterpreted as breathing. Treat the victim with gasps as though there is no breathing and begin CPR.

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)

5.5 Start Chest Compressions

During cardiac arrest, high-quality chest compressions generate blood flow to vital organs and increase the likelihood of ROSC. For details on chest compression see the section in this document entitled: “Components of High-Quality CPR.”

5.6 Open the Airway and Give Ventilations

For the lone rescuer a compression-to-ventilation ratio of 30:2 is recommended. After the initial set of 30 compressions, open the airway and give 2 breaths. In an unresponsive infant or child, the tongue may obstruct the airway and interfere with ventilations.¹⁰⁻¹²

Open the airway using a head tilt–chin lift maneuver for both injured and noninjured victims. (Class I, LOE B)

To give breaths to an infant, use a mouth-to-mouth-and-nose technique; to give breaths to a child, use a mouth-to-mouth technique.¹³ Make sure the breaths are effective (ie, the chest rises). Each breath should take about 1 second. If the chest does not rise, reposition the head, make a better seal, and try again.¹³ It may be necessary to move the child’s head through a range of positions to provide optimal airway patency and effective rescue breathing.

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.¹⁴⁻¹⁶ (Class IIb, LOE C)

If you use the mouth-to-mouth technique, pinch the nose closed. If you use the mouth-to-nose technique, close the mouth.

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)

5.7 Coordinate Chest Compressions and Breathing

After giving 2 breaths, immediately give 30 compressions. The lone rescuer should continue this cycle of 30 compressions and 2 breaths for approximately 2 minutes (about 5 cycles) before leaving the victim to activate the emergency response system and obtain an automated external defibrillator (AED) if one is nearby.

The ideal compression-to-ventilation ratio in infants and children is unknown. The following have been considered in recommending a compression-to-ventilation ratio of 30:2 for single rescuers:

Evidence from manikin studies shows that lone rescuers cannot deliver the desired number of compressions per minute with the compression-to-ventilation ratio of 5:1 that was previously recommended (2000 and earlier).¹⁷⁻²⁰ For the lone rescuer, manikin studies show that a ratio of 30:2 yields more chest compressions than a 15:2 ratio with no, or minimal, increase in rescuer fatigue.²¹⁻²⁵

Volunteers recruited at an airport to perform single-rescuer layperson CPR on an adult manikin had less “no flow time” (ie, arrest time without chest compressions, when no blood flow is generated) with 30:2 compared with a 15:2 ratio.²⁶

An observational human study²⁷ comparing resuscitations by firefighters prior to and following the change from 15:2 to 30:2 compression-to-ventilation ratio reported more chest compressions per minute with a 30:2 ratio; ROSC was unchanged.

Animal studies²⁸⁻³⁰ show that coronary perfusion pressure, a major determinant of success in resuscitation, rapidly declines when chest compressions are interrupted; once compressions are resumed, several chest compressions are needed to restore coronary perfusion pressure. Thus, frequent interruptions of chest compressions prolong the duration of low coronary perfusion pressure and flow.

Manikin studies,^{31,26,32} as well as in- and out-of-hospital adult human studies,^{33,34,35} have documented long interruptions in chest compressions. Adult studies³⁶⁻³⁸ have also demonstrated that these interruptions reduce the likelihood of ROSC.

5.8 Activate Emergency Response System

If there are 2 rescuers, one should start CPR immediately and the other should activate the emergency response system (in most locales by phoning 911) and obtain an AED, if one is available. Most infants and children with cardiac arrest have an asphyxial rather than a VF arrest^{39,40,41}; therefore 2 minutes of CPR are recommended before the lone rescuer activates the emergency response system and gets an AED if one is nearby. The lone rescuer should then return to the victim as soon as possible and use the AED (if available) or resume CPR, starting with chest compressions. Continue with cycles of 30 compressions to 2 ventilations until emergency response rescuers arrive or the victim starts breathing spontaneously.

6 BLS Sequence for Healthcare Providers and Others Trained in 2-Rescuer CPR

As stated previously, in 2015 the algorithms for 1- and 2-person pediatric HCP CPR have been separated to better guide rescuers through the initial stages of resuscitation (Figure 1 and Figure 2).

For the most part the sequence of BLS for healthcare providers is similar to that for laypeople with some variation as indicated (Figure 1 and Figure 2). Healthcare providers are more likely to work in teams and less likely to be lone rescuers. Activities described as a series of individual sequences are often performed simultaneously (eg, chest compressions and preparing for rescue breathing) so there is less significance regarding which is performed first.

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.^{42, 43, 44} (Class IIa LOE C)

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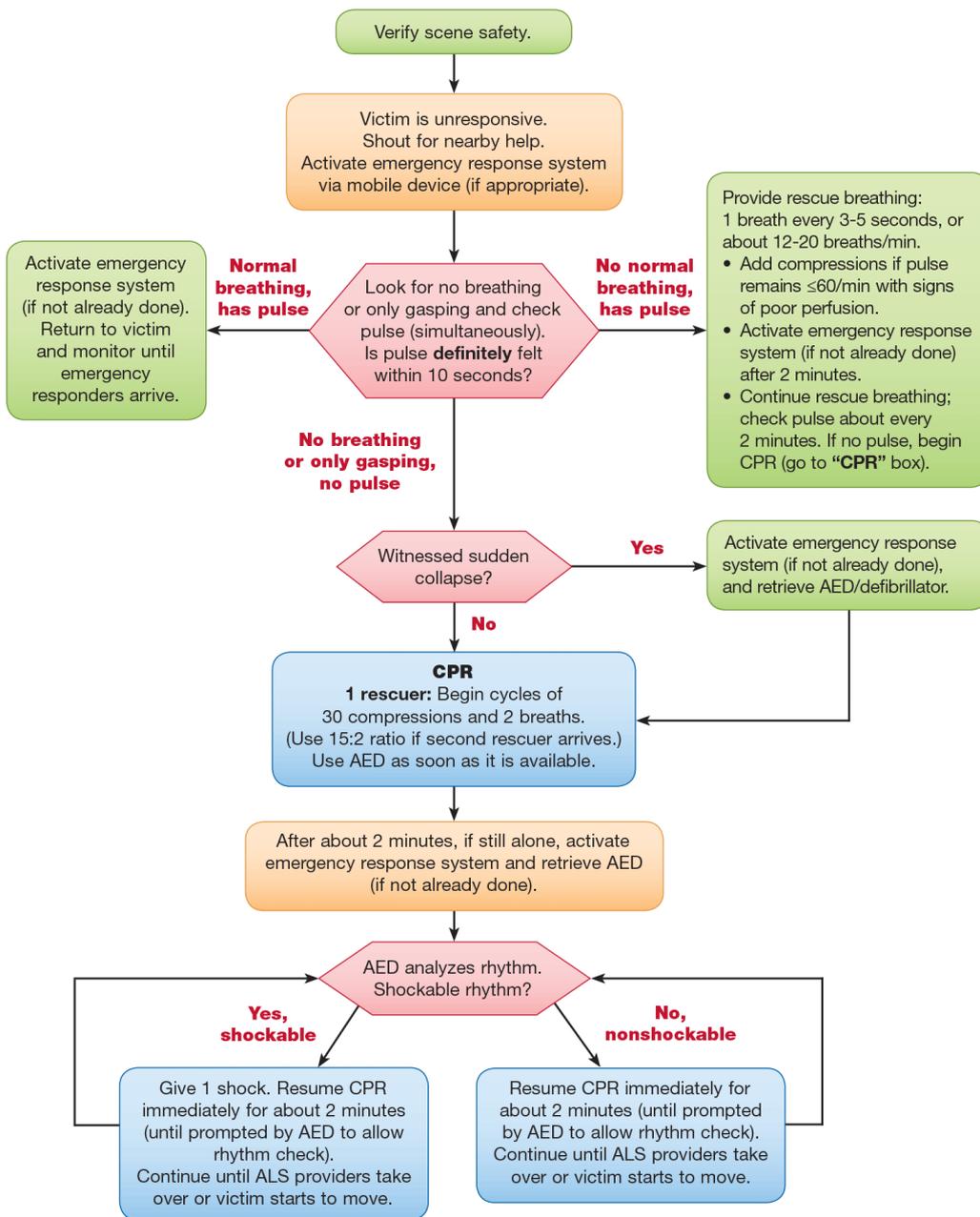
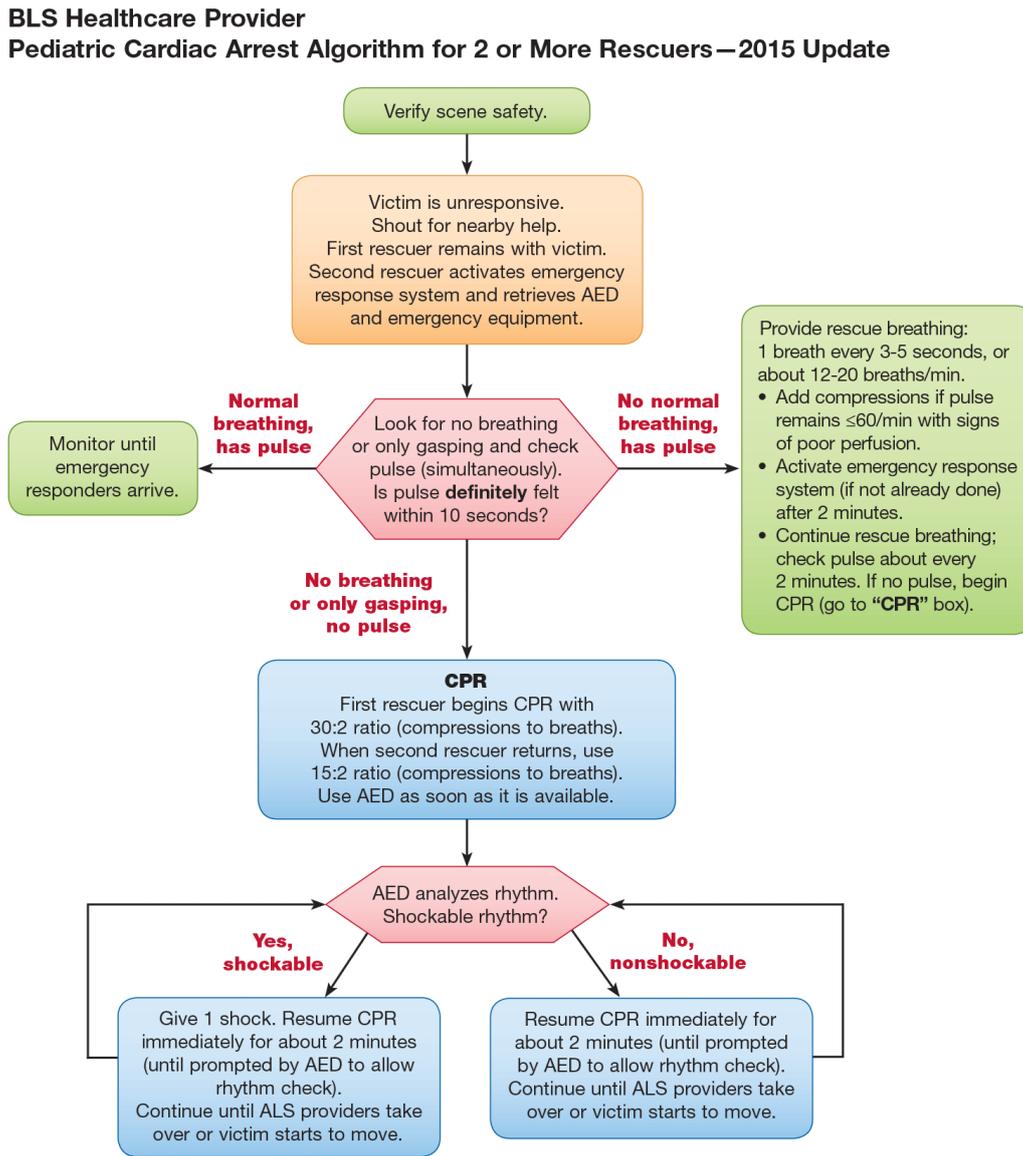


Figure 2: BLS Healthcare Provider Pediatric Cardiac Arrest Algorithm for 2 or More Rescuers—2015 Update



6.1 Assess the Need for CPR

If the victim is unresponsive and is not breathing (or only gasping), send someone to activate the emergency response system.

6.2 Pulse Check

If the infant or child is unresponsive and not breathing (gasps do not count as breathing), healthcare providers may take up to 10 seconds to attempt to feel for a pulse (brachial in an infant and carotid or femoral in a child).

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)

It can be difficult to feel a pulse, especially in the heat of an emergency, and studies show that healthcare providers,⁴⁵ as well as lay rescuers, are unable to reliably detect a pulse.⁴⁶⁻⁶⁰

6.3 Inadequate Breathing With Pulse

If there is a palpable pulse ≥ 60 per minute but there is inadequate breathing, give rescue breaths at a rate of about 12 to 20 breaths per minute (1 breath every 3 to 5 seconds) until spontaneous breathing resumes.

Reassess the pulse about every 2 minutes but spend no more than 10 seconds doing so.
(Class IIa, LOE B)

6.4 Bradycardia With Poor Perfusion

If the pulse is <60 per minute and there are signs of poor perfusion (ie, pallor, mottling, cyanosis) despite support of oxygenation and ventilation, begin chest compressions. Because cardiac output in infancy and childhood largely depends on heart rate, profound bradycardia with poor perfusion is an indication for chest compressions because cardiac arrest is imminent and beginning CPR prior to full cardiac arrest results in improved survival.⁶¹

The absolute heart rate at which chest compressions should be initiated is unknown; the recommendation to provide chest compressions for a heart rate <60 per minute with signs of poor perfusion is based on ease of teaching and retention of skills. For additional information see Bradycardia in [Part 12: Pediatric Advanced Life Support](#).

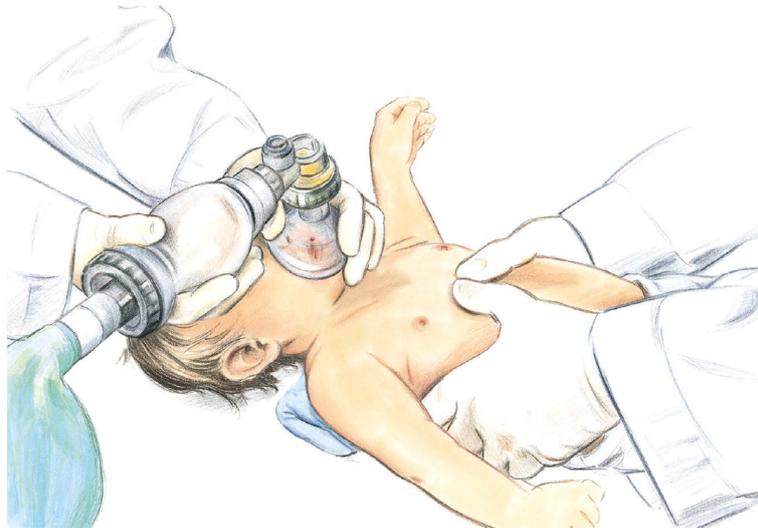
6.5 Chest Compressions

If the infant or child is unresponsive, not breathing, and has no pulse (or you are unsure whether there is a pulse), start chest compressions (see the section in this document entitled: “Components of High-Quality CPR.”). The only difference in chest compressions for the healthcare provider is in chest compression for infants.

The lone healthcare provider should use the 2-finger chest compression technique for infants. The 2-thumb–encircling hands technique (Figure 3) is recommended when CPR is provided by 2 rescuers. Encircle the infant’s chest with both hands; spread your fingers around the thorax, and place your thumbs together over the lower third of the sternum.^{62-66,67-73} Forcefully compress the sternum with your thumbs. In the past, it has been recommended that the thorax be squeezed at the time of chest compression, but there is no data that show benefit from a circumferential squeeze. The 2-thumb–encircling hands technique is preferred over the 2-finger technique because it produces higher coronary artery perfusion pressure, results more consistently in appropriate depth or force of compression,⁶⁹⁻⁷² and may generate higher systolic and diastolic pressures.^{67,68,73,74} If you cannot physically encircle the victim’s chest, compress the chest with 2 fingers, see the section in this document entitled: “Components of High-Quality CPR.”

Figure 3: Two thumb-encircling hands chest compression in infant (2 rescuers)

Two thumb-encircling hands chest compression in infant (2 rescuers).



6.6 Ventilations

After 30 compressions (15 compressions if 2 rescuers), open the airway with a head tilt–chin lift and give 2 breaths.

Ventilations

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)

Because maintaining a patent airway and providing adequate ventilation is important in pediatric CPR, use a head tilt–chin lift maneuver if the jaw thrust does not open the airway.

6.7 Coordinate Chest Compressions and Ventilations

A lone rescuer uses a compression-to-ventilation ratio of 30:2. For 2-rescuer infant and child CPR, one provider should perform chest compressions while the other keeps the airway open and performs ventilations at a ratio of 15:2.

Deliver ventilations with minimal interruptions in chest compressions. (Class IIa, LOE C)

If an advanced airway is in place, cycles of compressions and ventilations are no longer delivered. Instead the compressing rescuer should deliver at least 100 compressions per minute continuously without pauses for ventilation. The ventilation rescuer delivers 8 to 10 breaths per minute (a breath every 6 to 8 seconds), being careful to avoid excessive ventilation in the stressful environment of a pediatric arrest.

6.8 Defibrillation

VF can be the cause of sudden collapse^{43,75} or may develop during resuscitation attempts.^{76,77} Children with sudden witnessed collapse (eg, a child collapsing during an athletic event) are likely to have VF or pulseless VT

and need immediate CPR and rapid defibrillation. VF and pulseless VT are referred to as “shockable rhythms” because they respond to electric shocks (defibrillation).

Many AEDs have high specificity in recognizing pediatric shockable rhythms, and some are equipped to decrease (or attenuate) the delivered energy to make them suitable for infants and children <8 years of age.⁷⁸⁻⁸⁰

For infants a manual defibrillator is preferred when a shockable rhythm is identified by a trained healthcare provider. (Class IIb, LOE C)

The recommended first energy dose for defibrillation is 2 J/kg. If a second dose is required, it should be doubled to 4 J/kg. If a manual defibrillator is not available, an AED equipped with a pediatric attenuator is preferred for infants.

An AED with a pediatric attenuator is also preferred for children (Class IIb, LOE C)

AEDs that deliver relatively high energy doses have been successfully used in infants with minimal myocardial damage and good neurological outcomes.^{81,82}

Rescuers should coordinate chest compressions and shock delivery to minimize the time between compressions and shock delivery and to resume CPR, beginning with compressions, immediately after shock delivery. The AED will prompt the rescuer to re-analyze the rhythm about every 2 minutes. Shock delivery should ideally occur as soon as possible after compressions.

6.9 Defibrillation Sequence Using an AED

Turn the AED on.

Follow the AED prompts.

End CPR cycle (for analysis and shock) with compressions, if possible

Resume chest compressions immediately after the shock. Minimize interruptions in chest compressions.

6.10 Breathing Adjuncts

6.10.1 Barrier Devices

Despite its safety,⁹ some healthcare providers⁸³⁻⁸⁵ and lay rescuers^{40,86,87} may hesitate to give mouth-to-mouth rescue breathing without a barrier device. Barrier devices have not reduced the low risk of transmission of infection,⁹ and some may increase resistance to air flow.^{88,89} If you use a barrier device, do not delay rescue breathing. If there is any delay in obtaining a barrier device or ventilation equipment, give mouth-to-mouth ventilation (if willing and able) or continue chest compressions alone.

6.10.2 Bag-Mask Ventilation (Healthcare Providers)

Bag-mask ventilation is an essential CPR technique for healthcare providers. Bag-mask ventilation requires training and periodic retraining in the following skills: selecting the correct mask size, opening the airway, making a tight seal between the mask and face, delivering effective ventilation, and assessing the effectiveness of that ventilation.

Use a self-inflating bag with a volume of at least 450 to 500 mL⁹⁰ for infants and young children, as smaller bags may not deliver an effective tidal volume or the longer inspiratory times required by full-term neonates and infants.⁹¹ In older children or adolescents, an adult self-inflating bag (1000 mL) may be needed to reliably achieve chest rise.

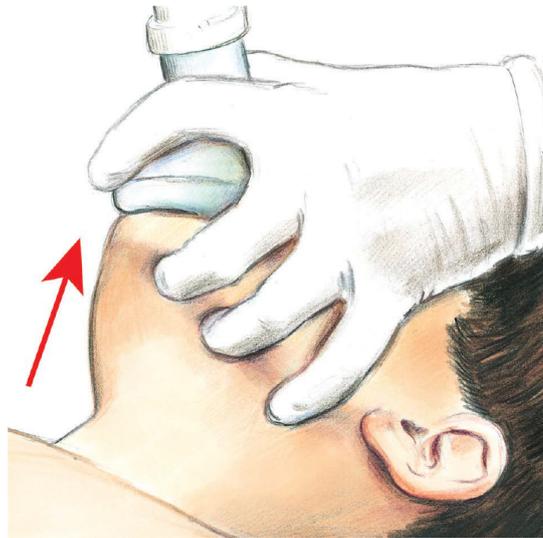
A self-inflating bag delivers only room air unless supplementary oxygen is attached, but even with an oxygen inflow of 10 L/min, the concentration of delivered oxygen varies from 30% to 80% and is affected by the tidal volume and peak inspiratory flow rate.⁹² To deliver a high oxygen concentration (60% to 95%), attach an oxygen reservoir to the self-inflating bag. Maintain an oxygen flow of 10 to 15 L/min into a reservoir attached to a pediatric bag⁹² and a flow of at least 15 L/min into an adult bag.

Effective bag-mask ventilation requires a tight seal between the mask and the victim's face. Open the airway by lifting the jaw toward the mask making a tight seal and squeeze the bag until the chest rises (Figure 4). Because effective bag-mask ventilation requires complex steps, bag-mask ventilation is not recommended for a lone rescuer during CPR. During CPR the lone rescuer should use mouth-to-barrier device techniques for ventilation. Bag-mask ventilation can be provided effectively during 2-person CPR.

Three fingers of one hand lift the jaw (they form the "E") while the thumb and index finger hold the mask to the face (making a "C").

Figure 4: The EC clamp technique of bag-mask ventilations.

The EC clamp technique of bag-mask ventilations



Three fingers of one hand lift the jaw (they form the “E”) while the thumb and index finger hold the mask to the face (making a “C”).

6.10.3 Precautions

Healthcare providers often deliver excessive ventilation during CPR,^{34,93,94} particularly when an advanced airway is in place. Excessive ventilation is harmful because it

Increases intrathoracic pressure and impedes venous return and therefore decreases cardiac output, cerebral blood flow, and coronary perfusion.⁹⁴

Causes air trapping and barotrauma in patients with small-airway obstruction.

Increases the risk of regurgitation and aspiration in patients without an advanced airway.

Avoid excessive ventilation; use only the force and tidal volume necessary to just make the chest rise. (Class III, LOE C)

Give each breath slowly, over approximately 1 second, and watch for chest rise. If the chest does not rise, reopen the airway, verify that there is a tight seal between the mask and the face (or between the bag and the advanced airway), and reattempt ventilation.

Because effective bag-mask ventilation requires complex steps, bag-mask ventilation is not recommended for ventilation by a lone rescuer during CPR.

Patients with airway obstruction or poor lung compliance may require high inspiratory pressures to be properly ventilated (sufficient to produce chest rise). A pressure-relief valve may prevent the delivery of a sufficient tidal volume in these patients.⁹² Make sure that the bag-mask device allows you to bypass the pressure-relief valve and use high pressures, if necessary, to achieve visible chest expansion.⁹⁵

6.10.4 Two-Person Bag-Mask Ventilation

If skilled rescuers are available, a 2-person technique may provide more effective bag-mask-ventilation than a single-person technique.⁹⁶

A 2-person technique may be required to provide effective bag-mask ventilation when there is significant airway obstruction, poor lung compliance,⁹⁵ or difficulty in creating a tight seal between the mask and the face. One rescuer uses both hands to open the airway and maintain a tight mask-to-face seal while the other compresses the ventilation bag. Both rescuers should observe the chest to ensure chest rise. Because the 2-person technique may be more effective, be careful to avoid delivering too high a tidal volume that may contribute to excessive ventilation.

6.10.5 Gastric Inflation and Cricoid Pressure

Gastric inflation may interfere with effective ventilation⁹⁷ and cause regurgitation. To minimize gastric inflation avoid creation of excessive peak inspiratory pressures by delivering each breath over approximately 1 second.⁹⁸

Cricoid pressure may be considered, but only in an unresponsive victim if there is an additional healthcare provider.⁹⁹⁻¹⁰¹ Avoid excessive cricoid pressure so as not to obstruct the trachea.¹⁰²

6.10.6 Oxygen

Animal and theoretical data suggest possible adverse effects of 100% oxygen,¹⁰³⁻¹⁰⁶ but studies comparing various concentrations of oxygen during resuscitation have been performed only in the newborn period.^{104,106-112} Until additional information becomes available, it is reasonable for healthcare providers to use 100% oxygen during resuscitation. Once circulation is restored, monitor systemic oxygen saturation. It may be reasonable, when appropriate equipment is available, to titrate oxygen administration to maintain the oxyhemoglobin saturation $\geq 94\%$. Provided appropriate equipment is available, once ROSC is achieved, adjust the FIO₂ to the minimum concentration needed to achieve transcutaneous or arterial oxygen saturation of at least 94% with the goal of avoiding hyperoxia while ensuring adequate oxygen delivery.

Since an oxygen saturation of 100% may correspond to a PaO₂ anywhere between ≥ 80 and 500 mm Hg, in general it is appropriate to wean the FIO₂ for a saturation of 100%, provided the oxyhemoglobin saturation can be maintained $\geq 94\%$. (Class IIb, LOE C)

Whenever possible, humidify oxygen to prevent mucosal drying and thickening of pulmonary secretions.

6.10.7 Oxygen Masks

Simple oxygen masks can provide an oxygen concentration of 30% to 50% to a victim who is breathing spontaneously. To deliver a higher concentration of oxygen, use a tight-fitting nonbreathing mask with an oxygen inflow rate of approximately 15 L/min to maintain inflation of the reservoir bag.

6.10.8 Nasal Cannulas

Infant- and pediatric-size nasal cannulas are suitable for children with spontaneous breathing. The concentration of delivered oxygen depends on the child's size, respiratory rate, and respiratory effort,¹¹³ but the concentration of inspired oxygen is limited unless a high-flow device is used.

6.11 Other CPR Techniques and Adjuncts

There is insufficient data in infants and children to recommend for or against the use of the following: mechanical devices to compress the chest, active compression-decompression CPR, interposed abdominal compression CPR (IAC-CPR), the impedance threshold device, or pressure sensor accelerometer (feedback) devices. For further information, see [Part 6: Alternative Techniques and Ancillary Devices for Cardiopulmonary Resuscitation](#) for adjuncts in adults.

6.12 Foreign-Body Airway Obstruction (Choking) (FBAO)

6.12.1 Epidemiology and Recognition

More than 90% of childhood deaths from foreign-body aspiration occur in children <5 years of age; 65% of the victims are infants. Liquids are the most common cause of choking in infants,¹¹⁴ whereas balloons, small objects, and foods (eg, hot dogs, round candies, nuts, and grapes) are the most common causes of foreign-body airway obstruction (FBAO) in children.¹¹⁵⁻¹¹⁸

Signs of FBAO include a *sudden* onset of respiratory distress with coughing, gagging, stridor, or wheezing. Sudden onset of respiratory distress in the absence of fever or other respiratory symptoms (eg, antecedent cough, congestion) suggests FBAO rather than an infectious cause of respiratory distress, such as croup.

6.12.2 Relief of FBAO

FBAO may cause mild or severe airway obstruction. When the airway obstruction is mild, the child can cough and make some sounds. When the airway obstruction is severe, the victim cannot cough or make any sound.

If FBAO is mild, do not interfere. Allow the victim to clear the airway by coughing while you observe for signs of severe FBAO.

If the FBAO is severe (ie, the victim is unable to make a sound) you must act to relieve the obstruction.

For a child perform subdiaphragmatic abdominal thrusts (Heimlich maneuver)^{119,120} until the object is expelled or the victim becomes unresponsive. For an infant, deliver repeated cycles of 5 back blows (slaps) followed by 5 chest compressions¹²¹⁻¹²³ until the object is expelled or the victim becomes unresponsive. Abdominal thrusts are not recommended for infants because they may damage the infant's relatively large and unprotected liver.

If the victim becomes unresponsive, start CPR with chest compressions (do not perform a pulse check). After 30 chest compressions, open the airway. If you see a foreign body, remove it but do not perform blind finger sweeps because they may push obstructing objects farther into the pharynx and may damage the oropharynx.¹²⁴⁻¹²⁶

Attempt to give 2 breaths and continue with cycles of chest compressions and ventilations until the object is expelled. After 2 minutes, if no one has already done so, activate the emergency response system.

6.13 Special Resuscitation Situations

6.13.1 Children With Special Healthcare Needs

Children with special healthcare needs may require emergency care for complications of chronic conditions (eg, obstruction of a tracheostomy), failure of support technology (eg, ventilator malfunction), progression of underlying disease, or events unrelated to those special needs.¹²⁷ Care is often complicated by a lack of medical information, a comprehensive plan of medical care, a list of current medications, and lack of clarity in limitation of resuscitation orders such as "Do Not Attempt Resuscitation (DNAR)" or "Allow Natural Death (AND)." Parents and child-care providers of children with special healthcare needs are encouraged to keep copies of medical information at home, with the child, and at the child's school or child-care facility. School nurses should have copies and should maintain a readily available list of children with DNAR/AND orders.^{127,128} An Emergency Information Form (EIF) developed by the American Academy of Pediatrics and the American College of Emergency Physicians¹²⁹ is available online (www2.aap.org/advocacy/blankform.pdf).

6.13.2 Advanced Directives

If a decision to limit or withhold resuscitative efforts is made, the physician must write an order clearly detailing the limits of any attempted resuscitation. A separate order must be written for the out-of-hospital setting. Regulations regarding out-of-hospital DNAR or AND directives vary from state to state.

When a child with a chronic or potentially life-threatening condition is discharged from the hospital, parents, school nurses, and home healthcare providers should be informed about the reason for hospitalization, a summary of the hospital course, and how to recognize signs of deterioration. They should receive specific instructions about CPR and whom to contact.¹²⁸

6.13.3 Ventilation With a Tracheostomy or Stoma

Everyone involved with the care of a child with a tracheostomy (parents, school nurses, and home healthcare providers) should know how to assess patency of the airway, clear the airway, change the tracheostomy tube, and perform CPR using the artificial airway.

Use the tracheostomy tube for ventilation and verify adequacy of airway and ventilation by watching for chest expansion. If the tracheostomy tube does not allow effective ventilation even after suctioning, replace it. If you are still unable to achieve chest rise, remove the tracheostomy tube and attempt alternative ventilation methods, such as mouth-to-stoma ventilation or bag-mask ventilation through the nose and mouth (while you or someone else occludes the tracheal stoma).

6.13.4 Trauma

The principles of BLS resuscitation for the injured child are the same as those for the ill child, but some aspects require emphasis.

The following are important aspects of resuscitation of pediatric victims of trauma:

Anticipate airway obstruction by dental fragments, blood, or other debris. Use a suction device if necessary.

Stop all external bleeding with direct pressure.

When the mechanism of injury is compatible with spinal injury, minimize motion of the cervical spine and movement of the head and neck.

Professional rescuers should open and maintain the airway with a jaw thrust and try not to tilt the head. If a jaw thrust does not open the airway, use a head tilt–chin lift, because a patent airway is necessary. If there are 2 rescuers, 1 can manually restrict cervical spine motion while the other rescuer opens the airway.

To limit spine motion, secure at least the thighs, pelvis, and shoulders to the immobilization board. Because of the disproportionately large size of the head in infants and young children, optimal positioning may require recessing the occiput¹³⁰ or elevating the torso to avoid undesirable backboard-induced cervical flexion.^{130,131}

If possible, transport children with potential for serious trauma to a trauma center with pediatric expertise.

6.13.5 Drowning

Outcome after drowning is determined by the duration of submersion, the water temperature, and how promptly and effectively CPR is provided.^{132,133,134} Neurologically intact survival has been reported after prolonged submersion in icy waters.^{135,136} Start resuscitation by safely removing the victim from the water as rapidly as possible. If you have special training, start rescue breathing while the victim is still in the water¹³⁷ if doing so will not delay removing the victim from the water. Do not attempt chest compressions in the water.

After removing the victim from the water start CPR if the victim is unresponsive and is not breathing. If you are alone, continue with 5 cycles (about 2 minutes) of compressions and ventilations before activating the emergency response system and getting an AED. If 2 rescuers are present, send the second rescuer to activate the emergency response system immediately and get the AED while you continue CPR.

7 Sequence of CPR - Updated

7.1 C-A-B Versus A-B-C - Updated [PEDI 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.^{1,2}

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^{138,139} and 2 pediatric studies^{140,141} 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-AB) 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.

7.1.1 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^{142,143} and pediatric¹⁴⁴ 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.^{142,144}

7.1.2 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.

8 Components of High-Quality CPR - Updated

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.

8.1 Chest Compression Rate and Depth - Updated BLS 343 PEDS 394

8.1.1 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.¹⁴⁵ Adult data have demonstrated the importance of adequate chest compression depth to the outcome of resuscitation,¹⁴⁶ 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.¹⁴⁷ 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 within the first 5 minutes was associated with improved 24-hour survival.¹⁴⁸

8.1.2 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.¹⁴⁶ (Class I, LOE C-LD)

Inadequate compression depth is common¹⁴⁹⁻³⁴ even by health care providers. For best results, deliver chest compressions on a firm surface.^{150,151}

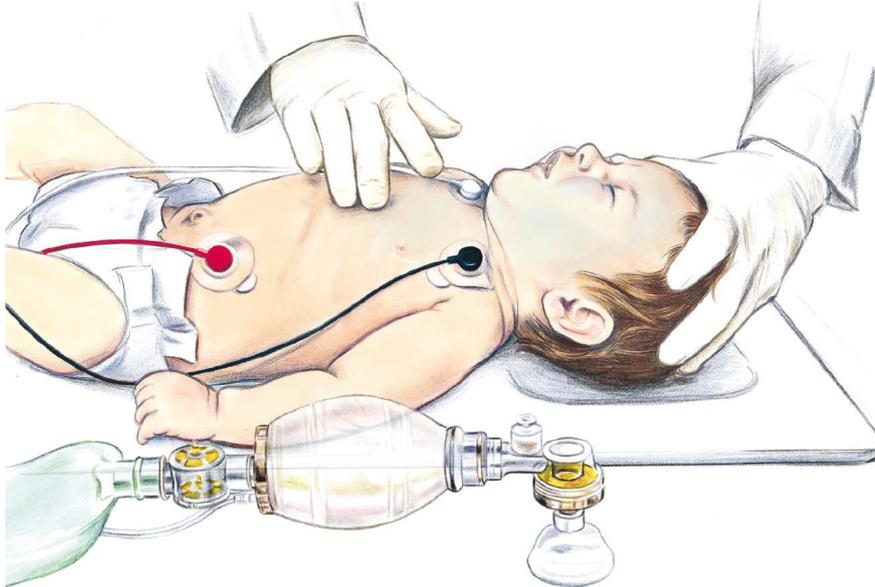
8.2 Finger and Hand Placement

For an infant, lone rescuers (whether lay rescuers or healthcare providers) should compress the sternum with 2 fingers placed just below the intermammary line.⁶²⁻⁶⁶ (Class IIb, LOE C)

Do not compress over the xiphoid or ribs. Rescuers should compress at least one third the depth of the chest, or about 4 cm (1.5 inches).

Figure 5: Two-finger chest compression technique in infant (1 rescuer)

Two-finger chest compression technique in infant (1 rescuer)



For a child, lay rescuers and healthcare providers should compress the lower half of the sternum at least one third of the AP dimension of the chest or approximately 5 cm (2 inches) with the heel of 1 or 2 hands. Do not press on the xiphoid or the ribs.

There are no data to determine if the 1- or 2-hand method produces better compressions and better outcome. (Class IIb, LOE C)

In a child manikin study, higher chest compression pressures were obtained¹⁵² with less rescuer fatigue¹⁵³ with the 2-hand technique. Because children and rescuers come in all sizes, rescuers may use either 1 or 2 hands to compress the child's chest. Whichever you use, make sure to achieve an adequate compression depth with complete release after each compression.

8.3 Chest Recoil

Allow complete chest recoil after each compression to allow the heart to refill with blood.

After each compression, allow the chest to recoil completely (Class IIb, LOE B) because complete chest re-expansion improves the flow of blood returning to the heart and thereby blood flow to the body during CPR.¹⁵⁴⁻¹⁵⁶

During pediatric CPR incomplete chest wall recoil is common, particularly when rescuers become fatigued.^{149, 157, 158} Incomplete recoil during CPR is associated with higher intrathoracic pressures and significantly decreased venous return, coronary perfusion, blood flow, and cerebral perfusion.^{155, 156} Manikin studies suggest that techniques to lift the heel of the hand slightly, but completely, off the chest can improve chest recoil, but this technique has not been studied in humans.^{154, 159}

8.4 Minimizing Interruptions

Minimize interruptions of chest compressions.

8.4.1 Rescuer fatigue

Rescuer fatigue can lead to inadequate compression rate, depth, and recoil.^{149,157,160} The quality of chest compressions may deteriorate within minutes even when the rescuer denies feeling fatigued.^{161,162} Rescuers should therefore rotate the compressor role approximately every 2 minutes to prevent compressor fatigue and deterioration in quality and rate of chest compressions. Recent data suggest that when feedback devices are used and compressions are effective, some rescuers may be able to effectively continue past the 2-minute interval.¹⁵⁷ The switch should be accomplished as quickly as possible (ideally in less than 5 seconds) to minimize interruptions in chest compressions.

8.5 Avoiding Excessive Ventilation

Avoid excessive ventilation.

8.6 Compression-Only CPR Peds 414 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.

8.6.1 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 associated with worse 30-day intact neurologic survival.¹⁴⁰ 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.¹⁴¹ Although not stratified for etiology of arrest, outcomes after compression-only CPR were no better than for patients who received no bystander CPR.

8.6.2 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)

9 The Quality of BLS

Immediate CPR can improve survival from cardiac arrest in children, but not enough children receive high-quality CPR. We must increase the number of laypersons who learn, remember, and perform CPR, and must improve the quality of CPR provided by lay rescuers and healthcare providers alike.

Writing Group Member	Employment	Research Grant	Other Research Support	Speakers' Bureau/Honorary	Expert Witness	Ownership Interest	Consultant/Advisory Board	Other
John C. Gonzales	Williamson County EMS	None	None	None	None	None	None	None
Elizabeth A. Hunt	Johns Hopkins University School of Medicine	None	Laerdal Foundation for Acute Care Medicine*	None	I have filed several patents on inventions related to simulators to be used in teaching and studying resuscitation*	None	None	None
Benny L. Joyner	University of North Carolina	None	None	None	None	None	None	None
Peter A. Meaney	The Children's Hospital of Philadelphia	None	None	None	None	None	None	None
Dana E. Niles	The Children's Hospital of Philadelphia	None	None	None	None	None	None	None
Consultants								
Ricardo A. Samson	University of Arizona	None	None	None	None	None	American Heart Association†	None
Stephen M. Schexnayder	University of Arkansas; Arkansas Children's Hospital	None	None	None	None	None	American Heart Association†	None

This table represents the relationships of writing group members that may be perceived as actual or reasonably perceived conflicts of interest as reported on the Disclosure Questionnaire, which all members of the writing group are required to complete and submit. A relationship is considered to be "significant" if (a) the person receives \$10 000 or more during any 12-month period, or 5% or more of the person's gross income; or (b) the person owns 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 the preceding definition. *Modest. †Significant.

10.2 2010 Writing Team

Writing Group Member	Employment	Research Grant	Other Research Support	Speakers' Bureau/Honoraria	Ownership Interest	Consultant/Advisory Board	Other
Mary Fran Hazinski	Vanderbilt University School of Nursing—Professor; AHA ECC Product Development—Senior Science Editor. † Significant compensation from the AHA to provide protected time to edit, review, write for the development of the 2010 AHA Guidelines for CPR and ECC and the 2010 International Liaison Committee on Resuscitation Consensus on CPR and ECC Science with Treatment Recommendation	None	None	None	None	None	None

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

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