

## Part 11: Pediatric Basic Life Support and Cardiopulmonary Resuscitation Quality

Key Words: automatic external defibrillator cardiopulmonary resuscitation pediatrics

### 1 Highlights

OCT. 2017

#### 2017 Summary of Key Issues and Major Changes

The changes for pediatric BLS were a result of weighing the survival benefits of CPR using chest compressions with rescue breaths against chest compression-only CPR, with the conclusion that the incremental benefit of rescue breaths justified a distinct recommendation. The topics reviewed here include the following:

- Reaffirming that compressions and ventilation are needed for infants and children in cardiac arrest
- Strongly recommending that bystanders who are unwilling or unable to deliver rescue breaths should provide chest compressions for infants and children

OCT. 2015

#### 2015 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.

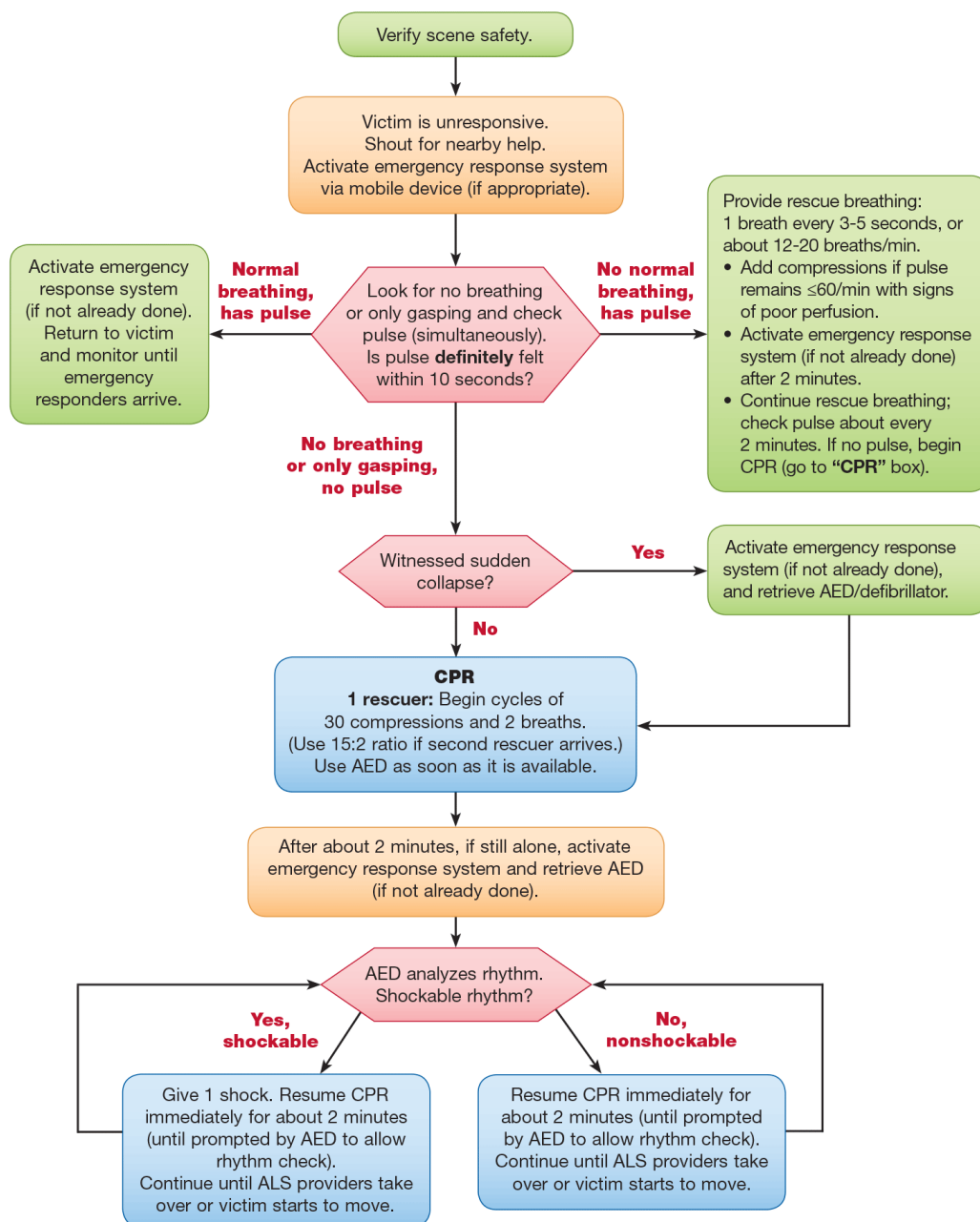
**Why:** In the absence of new data, the 2010 sequence has not been changed. Consistency in the order of compressions, airway, and breathing for CPR in victims of all ages may be easiest for rescuers who treat people of all ages to remember and perform. Maintaining the same sequence for adults and children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

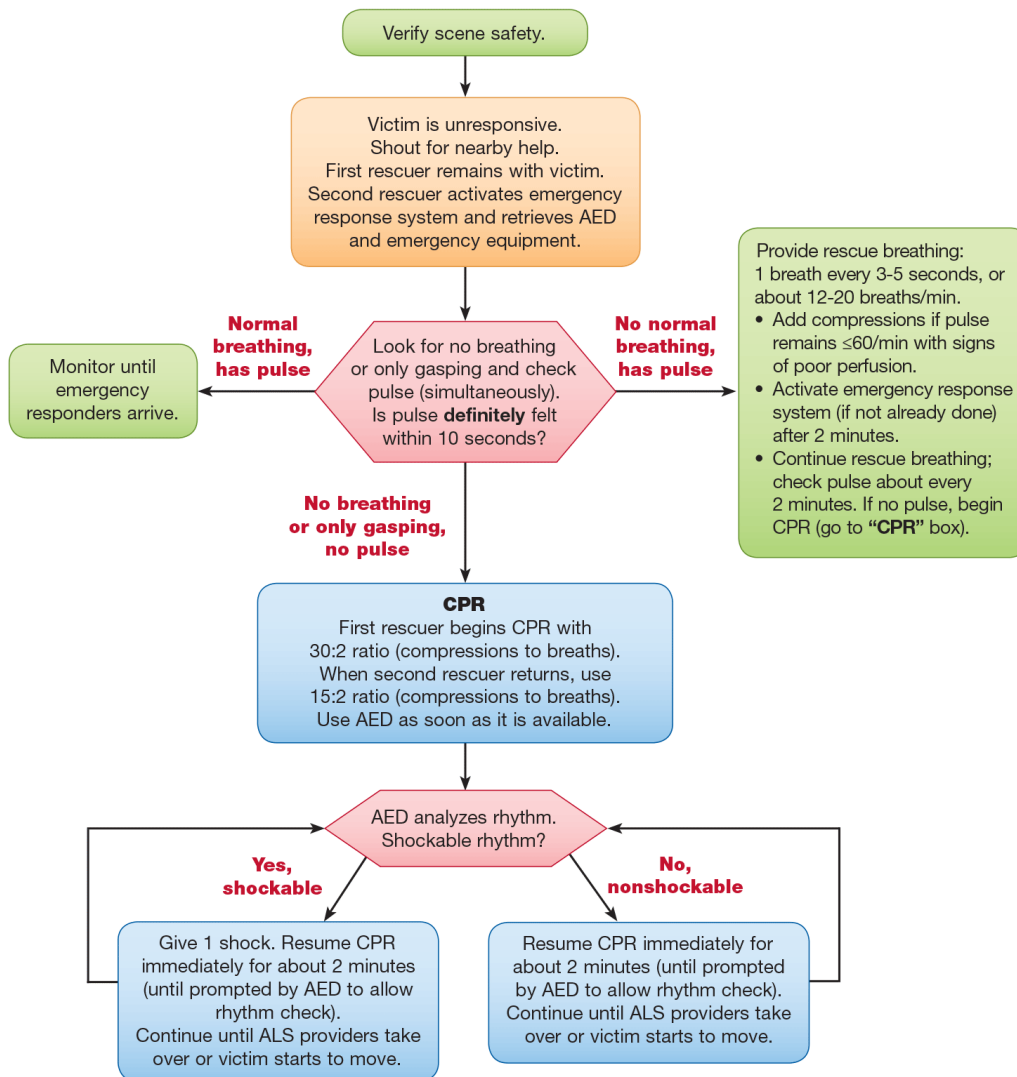
### New Algorithms for 1-Rescuer and Multiple-Rescuer HCP CPR

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

© 2015 American Heart Association

**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

**2017 (Updated):** CPR using chest compressions with rescue breaths should be provided for infants and children in cardiac arrest. If bystanders are unwilling or unable to deliver rescue breaths, we recommend that rescuers provide chest compressions for infants and children.

**2015 (Old):** Conventional CPR (chest compressions and rescue breaths) should be provided for pediatric cardiac arrests. 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.

**Why:** These recommendations have been updated for clarity. The asphyxial nature of most pediatric cardiac arrests necessitates ventilation as part of effective CPR. 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. Growing evidence since 2015 reinforces the survival benefits of CPR using chest compressions with rescue breaths for children and infants.

## 2 Introduction

NOV. 2017

These Web-based Integrated Guidelines incorporate all relevant recommendations from 2010, 2015 and 2017.

The 2017 American Heart Association Focused Update on Pediatric Basic Life Support and Cardiopulmonary Resuscitation Quality addresses the comparison of chest compression-only CPR to CPR using chest compressions with rescue breaths for cardiac arrest in infants and children. It includes 2 additional out-of-hospital cardiac arrest (OHCA) studies published after 2015 that further expand the evidence base used to develop the 2015 Guidelines Update.

OCT. 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.”<sup>1,2</sup> 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%.<sup>3</sup> 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.<sup>4</sup>

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

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.**”

The 2017 pediatric International Consensus on Science on CPR and ECC Science with Treatment Recommendations summarizes the evidence review and treatment recommendations for chest compression-only CPR versus CPR using chest compression with rescue breaths for children less than 18 years of age.

*NOTE: Providers will note that the upper limit of the child age range published in some research studies differs slightly from that used in the AHA Guidelines for CPR and ECC and in the AHA Training materials. However, the AHA still recommends the use of child BLS Guidelines for children approximately one year of age until puberty and the Adult BLS Guidelines for children at or beyond puberty, because, in an emergency, physical characteristics are likely to be easier to identify than specific ages.*

### 3 Prevention of Cardiopulmonary Arrest

OCT. 2010

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.<sup>7,8</sup> 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](http://www.nhtsa.gov). The World Health Organization provides information on the prevention of violence and injuries at [www.who.int/violence\\_injury\\_prevention/en/](http://www.who.int/violence_injury_prevention/en/).

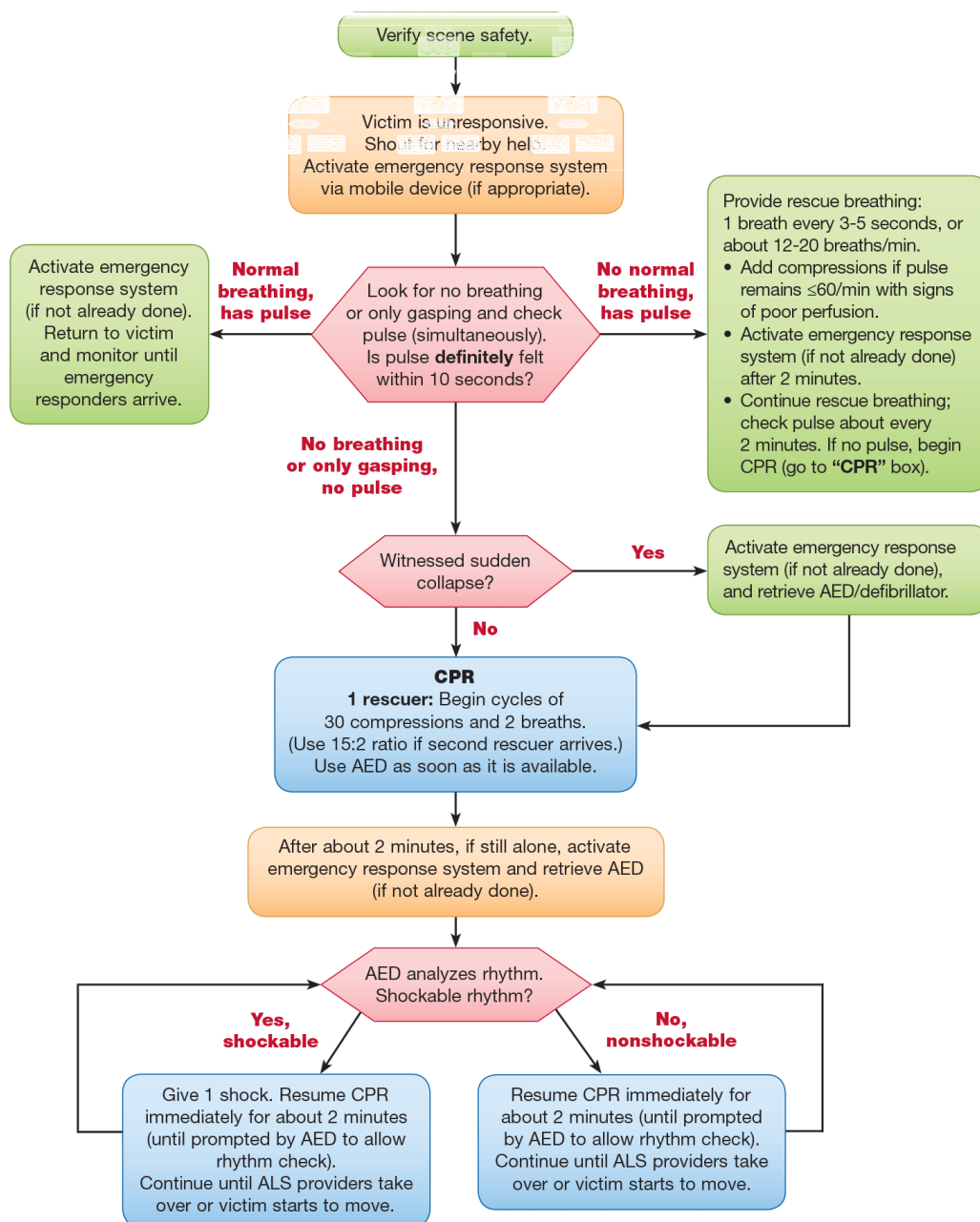
### 4 Algorithms - Updated 2015

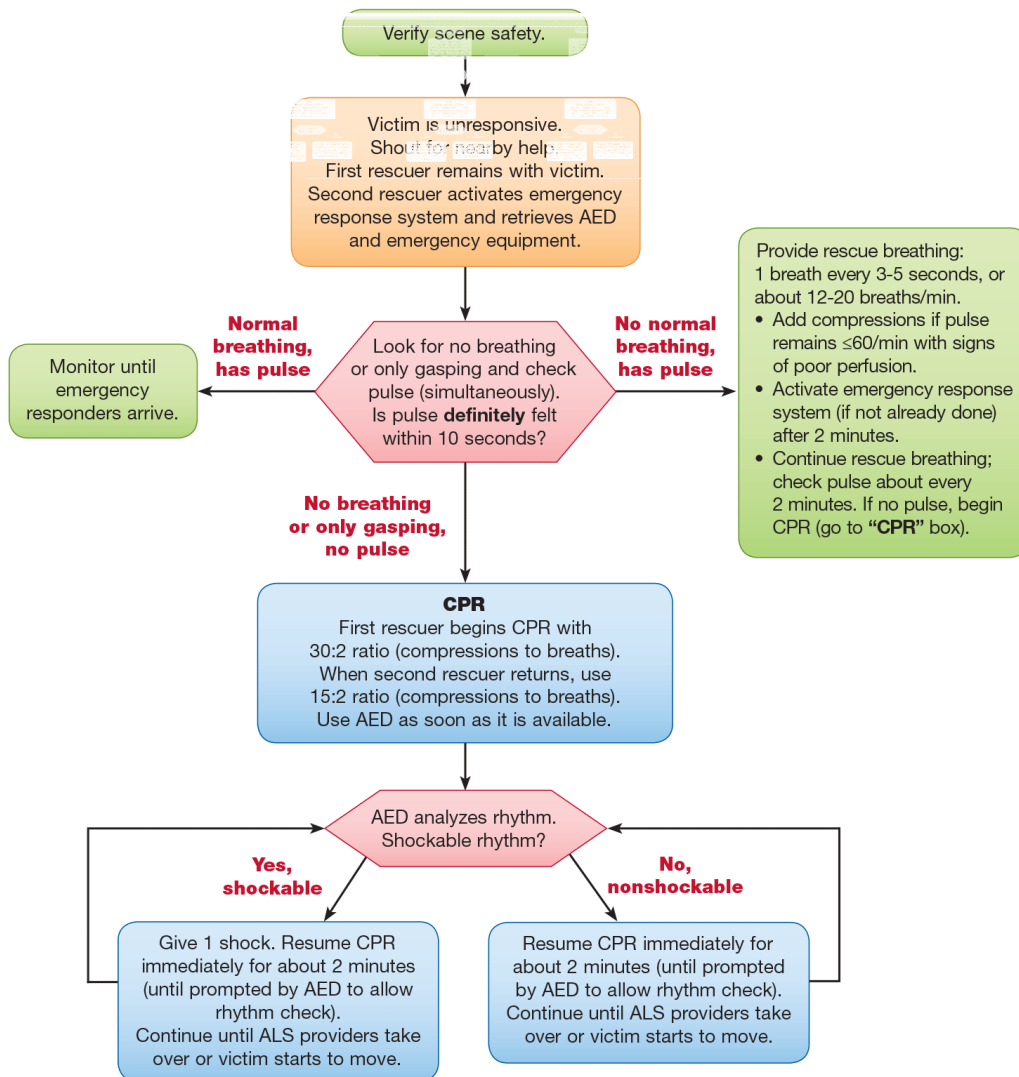
OCT. 2015

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.

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

© 2015 American Heart Association

**5 BLS Sequence for Lay Rescuers****5.1 Safety of Rescuer and Victim**

OCT. 2010

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.<sup>9</sup>

**5.2 Assess Need for CPR**

OCT. 2010

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

OCT. 2010

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

OCT. 2010

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

OCT. 2010

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

OCT. 2010

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.<sup>10-12</sup>

***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.<sup>13</sup> 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.<sup>13</sup> 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.<sup>14-16</sup> (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

OCT. 2010

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).<sup>17-20</sup>

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.<sup>21-25</sup>

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.<sup>26</sup>

An observational human study<sup>27</sup> 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 studies<sup>28-30</sup> 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,<sup>31,26,32</sup> as well as in- and out-of-hospital adult human studies,<sup>33,34,35</sup> have documented long interruptions in chest compressions. Adult studies<sup>36-38</sup> have also demonstrated that these interruptions reduce the likelihood of ROSC.

## 5.8 Activate Emergency Response System

OCT. 2010

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<sup>39,40,41</sup>; 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

OCT. 2010

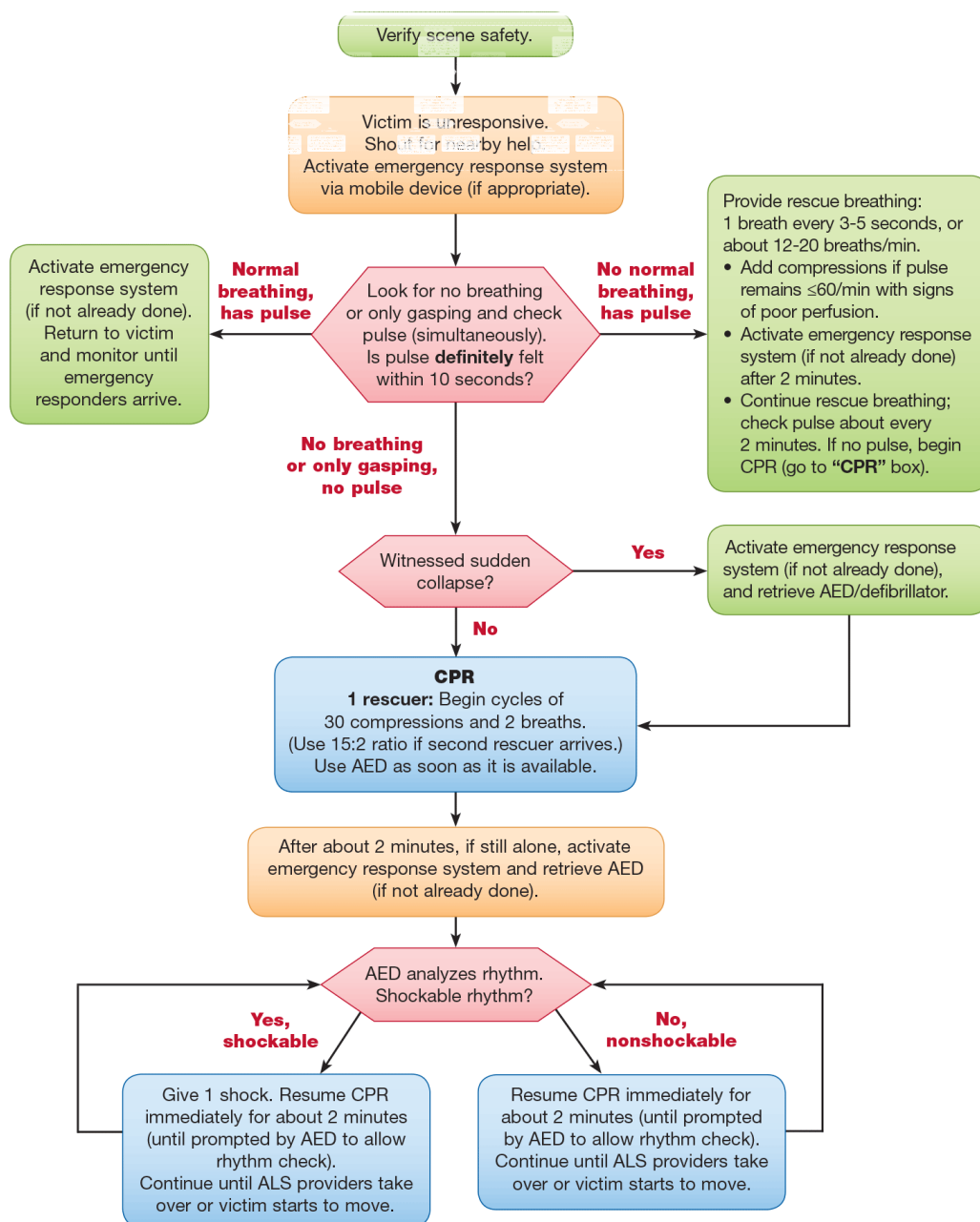
As stated previously, in 2015 the algorithms for 1- and 2-person pediatric HCP CPR have been separated to better guide rescuers through the initial stages of resuscitation (Figure 1 and Figure 2).

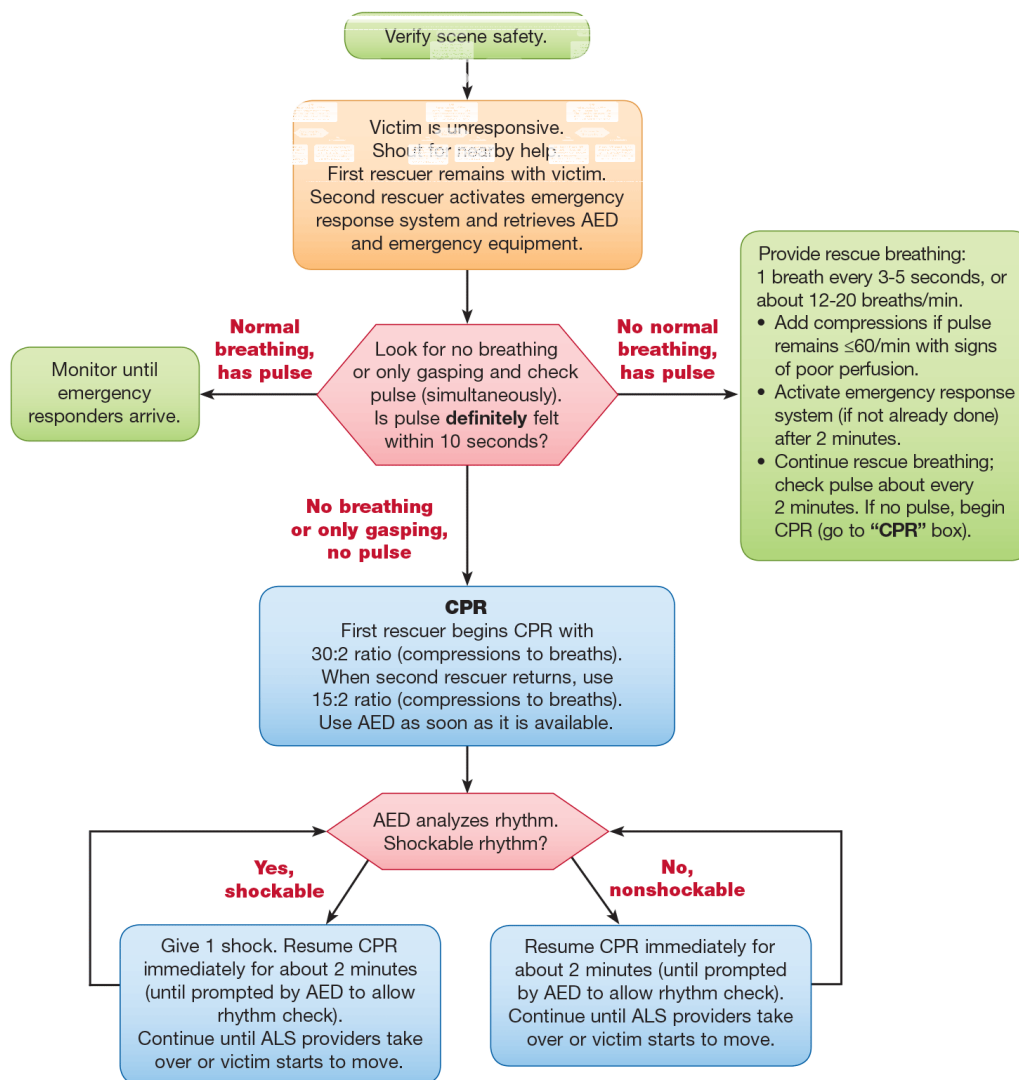
For the most part the sequence of BLS for healthcare providers is similar to that for laypeople with some variation as indicated (Figure 1 and Figure 2). Healthcare providers are more likely to work in teams and less likely to be lone rescuers. Activities described as a series of individual sequences 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.<sup>42, 43, 44</sup> (Class IIa LOE C)***

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

© 2015 American Heart Association

**6.1 Assess the Need for CPR**

OCT. 2010

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

**6.2 Pulse Check**

OCT. 2010

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,<sup>45</sup> as well as lay rescuers, are unable to reliably detect a pulse.<sup>46-60</sup>

### 6.3 Inadequate Breathing With Pulse

OCT. 2010

If there is a palpable pulse  $\geq 60$  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

OCT. 2010

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.<sup>61</sup>

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

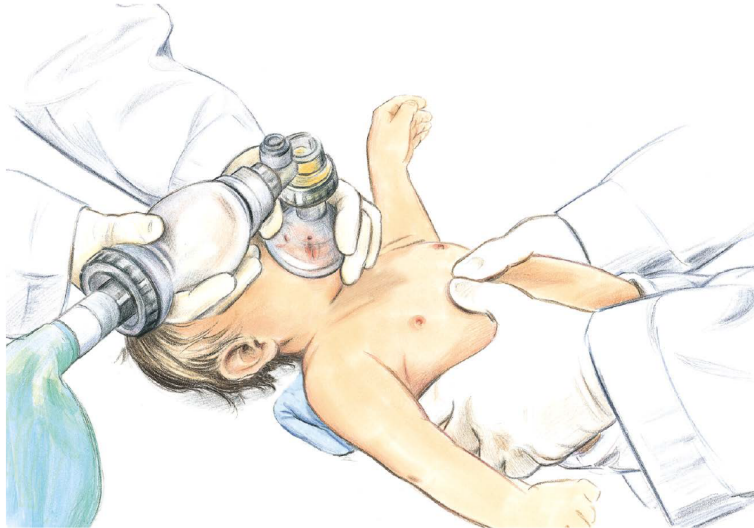
OCT. 2010

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.<sup>62-66,67-73</sup> 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,<sup>69-72</sup> and may generate higher systolic and diastolic pressures.<sup>67,68,73,74</sup> 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

OCT. 2010

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

OCT. 2010

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

OCT. 2010

VF can be the cause of sudden collapse<sup>43,75</sup> or may develop during resuscitation attempts.<sup>76,77</sup> 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.<sup>78-80</sup>

***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 <8 years of age. If neither is available, an AED without a dose attenuator may be used. (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.<sup>81,82</sup>

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

OCT. 2010

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

OCT. 2010

Despite its safety,<sup>9</sup> some healthcare providers<sup>83-85</sup> and lay rescuers<sup>40,86,87</sup> 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,<sup>9</sup> and some may increase resistance to air flow.<sup>88,89</sup> 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)

OCT. 2010

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 mL<sup>90</sup> 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.<sup>91</sup> In older children or adolescents, an adult self-inflating bag (1000 mL) may be needed to reliably achieve chest rise.

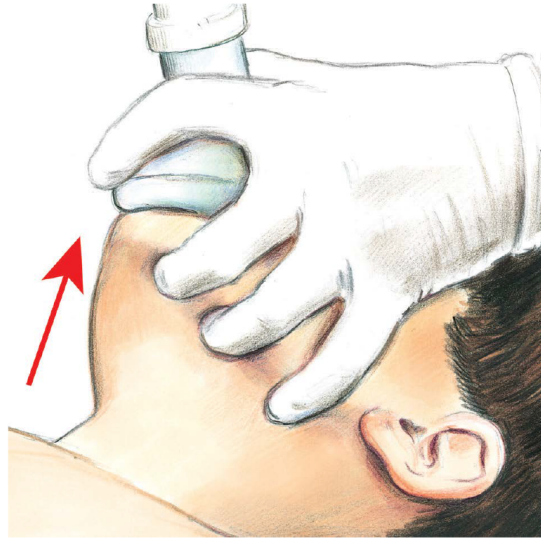
A self-inflating bag delivers only room air unless supplementary oxygen is attached, but even with an oxygen inflow of 10 L/min, the concentration of delivered oxygen varies from 30% to 80% and is affected by the tidal volume and peak inspiratory flow rate.<sup>92</sup> To deliver a high oxygen concentration (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 bag<sup>92</sup> 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

OCT. 2010

Healthcare providers often deliver excessive ventilation during CPR,<sup>34,93,94</sup> 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.<sup>94</sup>

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.<sup>92</sup> 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.<sup>95</sup>

#### 6.10.4 Two-Person Bag-Mask Ventilation

OCT. 2010

If skilled rescuers are available, a 2-person technique may provide more effective bag-mask-ventilation than a single-person technique.<sup>96</sup> A 2-person technique may be required to provide effective bag-mask ventilation when there is significant airway obstruction, poor lung compliance,<sup>95</sup> 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

OCT. 2010

Gastric inflation may interfere with effective ventilation<sup>97</sup> and cause regurgitation. To minimize gastric inflation

Avoid creation of excessive peak inspiratory pressures by delivering each breath over approximately 1 second.<sup>98</sup>

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

#### 6.10.6 Oxygen

OCT. 2010

Animal and theoretical data suggest possible adverse effects of 100% oxygen,<sup>103-106</sup> but studies comparing various concentrations of oxygen during resuscitation have been performed only in the newborn period.<sup>104,106-112</sup> 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 ≥94%. Provided appropriate equipment is available, once ROSC is achieved, adjust the FIO<sub>2</sub> 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 PaO<sub>2</sub> anywhere between 780 and 500 mm Hg, in general it is appropriate to wean the FIO<sub>2</sub> for a saturation of 100%, provided the oxyhemoglobin saturation can be maintained ≥94%. (Class IIb, LOE C)***

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

#### 6.10.7 Oxygen Masks

OCT. 2010

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 nonrebreathing mask with an oxygen inflow rate of approximately 15 L/min to maintain inflation of the reservoir bag.

#### 6.10.8 Nasal Cannulas

OCT. 2010

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,<sup>113</sup> but the concentration of inspired oxygen is limited unless a high-flow device is used.

## 6.11 Other CPR Techniques and Adjuncts

OCT. 2010

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

OCT. 2010

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,<sup>114</sup> 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.<sup>115-118</sup>

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

OCT. 2010

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)<sup>119,120</sup> 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 compressions<sup>121-123</sup> 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.<sup>124-126</sup>

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

OCT. 2010

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.<sup>127</sup> 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.<sup>127,128</sup> An Emergency Information Form (EIF) developed by the American Academy of Pediatrics and the American College of Emergency Physicians<sup>129</sup> is available online (<http://pediatrics.aappublications.org/content/pediatrics/125/4/829.full.pdf?ck=nck>).

### 6.13.2 Advanced Directives

OCT. 2010

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.<sup>128</sup>

### 6.13.3 Ventilation With a Tracheostomy or Stoma

OCT. 2010

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

OCT. 2010

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 occiput<sup>130</sup> or elevating the torso to avoid undesirable backboard-induced cervical flexion.<sup>130,131</sup>

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

### 6.13.5 Drowning

OCT. 2010

Outcome after drowning is determined by the duration of submersion, the water temperature, and how promptly and effectively CPR is provided.<sup>132,133,134</sup> Neurologically intact survival has been reported after prolonged submersion in icy waters.<sup>135,136</sup> 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 water<sup>137</sup> 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 2015

### 7.1 C-A-B Versus A-B-C - Updated 2015<sup>PEDS 709</sup>

OCT. 2015

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.<sup>1,2</sup>

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<sup>138,139</sup> and 2 pediatric studies<sup>140,141</sup> 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

OCT. 2015

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<sup>142,143</sup> and pediatric<sup>144</sup> 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.<sup>142,144</sup>

#### 7.1.2 Recommendation - Updated 2015

OCT. 2015

***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 2015 | 2017

OCT. 2015

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 2015 BLS 343 PEDS 394

#### 8.1.1 2015 Evidence Summary

OCT. 2015

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.<sup>145</sup> Adult data have demonstrated the importance of adequate chest compression depth to the outcome of resuscitation,<sup>146</sup> 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.<sup>147</sup> 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.<sup>148</sup>

#### 8.1.2 Recommendations - Updated 2015

OCT. 2015

***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.<sup>146</sup> (Class I, LOE C-LD)***

OCT. 2010

Inadequate compression depth is common<sup>149-34</sup> even by health care providers. For best results, deliver chest compressions on a firm surface.<sup>150,151</sup>

## **8.2 Finger and Hand Placement**

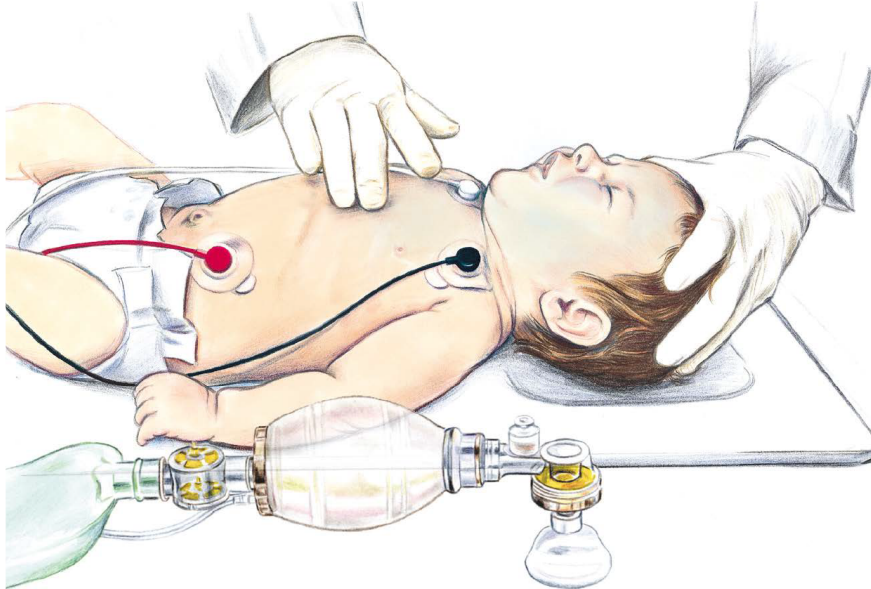
OCT. 2010

***For an infant, lone rescuers (whether lay rescuers or healthcare providers) should compress the sternum with 2 fingers placed just below the intermammary line.<sup>62-66</sup> (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 obtained<sup>152</sup> with less rescuer fatigue<sup>153</sup> 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

OCT. 2010

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.***<sup>154-156</sup>

During pediatric CPR incomplete chest wall recoil is common, particularly when rescuers become fatigued.<sup>149, 157,158</sup> Incomplete recoil during CPR is associated with higher intrathoracic pressures and significantly decreased venous return, coronary perfusion, blood flow, and cerebral perfusion.<sup>155,156</sup> 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.<sup>154,159</sup>

## 8.4 Minimizing Interruptions

OCT. 2010

Minimize interruptions of chest compressions.

### 8.4.1 Rescuer fatigue

OCT. 2010

Rescuer fatigue can lead to inadequate compression rate, depth, and recoil.<sup>149,157,160</sup> The quality of chest compressions may deteriorate within minutes even when the rescuer denies feeling fatigued.<sup>161,162</sup> 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.<sup>157</sup> 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

OCT. 2010

Avoid excessive ventilation.

## 8.6 Compression-Only CPR - Updated 2017<sup>PEDS 414</sup>

OCT. 2015

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. A brief summary of each study reviewed in 2015 is provided below in the section titled, “2015 Evidence Summary.”

NOV. 2017

The “2017 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science With Treatment Recommendations Summary”<sup>163</sup> addresses the comparison of chest compression-only CPR and CPR using chest compressions with rescue breaths for cardiac arrest in infants and children. It includes 2 additional out-of-hospital cardiac arrest studies published after 2015 that further expand the evidence base used to develop the 2015 guidelines. A brief summary of each study included in the review is provided below in the section titled, “2017 Evidence Summary.”

### 8.6.1 2015 Evidence Summary

OCT. 2015

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.<sup>140</sup> 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.<sup>141</sup> 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 2017 Evidence Summary

NOV. 2017

A large observational study from the All-Japan Utstein Registry<sup>164</sup> compared bystander-administered chest compression–only CPR and CPR using chest compressions with rescue breaths from 2005 through 2007, a period when guidelines transitioned from a compression-to-ventilation ratio of 15:2 to 30:2 for postpubertal children and adults. Favorable neurologic outcome and survival at 1 month was observed less frequently with chest compression–only CPR. When the results were stratified by age, children 1 through 17 years of age had worse outcomes with chest compression–only CPR, whereas no statistical difference between chest compression–only CPR and CPR using chest compressions with rescue breaths was observed in infants < 1 year of age. When further stratified by arrest cardiac cause, there was no difference between chest compression–only CPR and CPR using chest compressions with rescue breaths in patients with a presumed cardiac cause.

A subsequent study examined dispatch-assisted CPR in children using the same national Japanese database but with a later time interval, 2008 through 2010.<sup>165</sup> CPR using chest compressions with rescue breaths was generally offered by dispatchers, but chest compression–only CPR could be offered depending on the skill and knowledge of the rescuer.

Chest compression–only CPR resulted in worse 1-month survival and worse 1-month survival with favorable neurologic outcome compared with CPR using chest compressions with rescue breaths. Chest compression–only CPR was no different from no CPR.

A large observational study from the US-based Cardiac Arrest Registry to Enhance Survival (CARES) evaluated the association of bystander CPR with overall and favorable neurologic survival. The CARES registry is an emergency medical services–based, voluntary data set that includes a catchment area of 90 million people from 37 states within the United States. The authors compared bystander-administered chest compression–only CPR to CPR using chest compressions with rescue breaths.<sup>166</sup> The cohort was analyzed based on age: < 1 or 1 to 18 years. For infants, CPR using chest compressions with rescue breaths was better than no CPR but was no different from chest compression–only CPR for favorable neurologic outcome. CPR using chest compressions with rescue breaths had higher survival to discharge than either no CPR or chest compression–only CPR. For children 1 to 18 years of age, CPR using chest compressions with rescue breaths was better than no CPR but was no different from chest compression–only CPR for both survival to hospital discharge and favorable neurological status. Of note, outcomes were statistically better in both bystander CPR strategies compared with no bystander CPR, as opposed to the Kitamura et al<sup>164</sup> and Goto et al<sup>165</sup> reports.

The most recent study originated from Japan with the use of the All-Japan Utstein Registry. The authors directly compared bystander chest compression–only CPR and CPR using chest compressions with rescue breaths in children >1 year of age who had cardiac arrest, including traumatic arrest, during 2011 and 2012.<sup>167</sup> A national dispatch-assisted instruction protocol was in use, and CPR guidelines recommended a compression-to-ventilation ratio of 30:2. Chest compression–only CPR and CPR using chest compressions with rescue breaths were associated with improved survival at 1 month and favorable neurologic survival at 1 month compared with no bystander CPR. There was no difference between chest compression–only CPR and CPR using chest compressions with rescue breaths.

### 8.6.3 Recommendations - Updated 2017

NOV. 2017

These recommendations have been updated for clarity. The focus of the recommendations remains the same as before.

***CPR using chest compressions with rescue breaths should be provided for infants and children in cardiac arrest. (Class I, LOE B-NR)***

The asphyxial nature of the majority of pediatric cardiac arrests necessitates ventilation as part of effective CPR. Based on growing evidence since the 2015 Guidelines Update publication, this recommendation reinforces the



[illegible]



This table represents the relationships of reviewers that may be perceived as actual or reasonably perceived conflicts of interest as reported on the Disclosure Questionnaire, which all reviewers 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.

## OCT. 2015

Dianne L. Atkins, Chair; Stuart Berger; Jonathan P. Duff; John C. Gonzales; Elizabeth A. Hunt; Benny L. Joyner; Peter A. Meaney; Dana E. Niles; Ricardo A. Samson; Stephen M. Schexnayder

**Table 3: Part 11: Pediatric Basic Life Support and Cardiopulmonary Resuscitation Quality: 2015 Guidelines Update Writing Group Disclosures**

[Open table in a new window](#)

## Part 11: Pediatric Basic Life Support and Cardiopulmonary Resuscitation Quality: 2015 Guidelines Update

### Writing Group Disclosures

[illegible]

[illegible]

Writing Group Member	Employment	Research Grant	Other Research Support	Speakers' Bureau/Honorary	Expert Witness	Ownership Interest	Consultant/Advisory Board	Other
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
<p>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.</p> <p>*Modest. †Significant.</p>								

## 10.4 2010 Writing Team

OCT. 2010

Marc D. Berg, Chair; Stephen M. Schexnayder; Leon Chameides; Mark Terry; Aaron Donoghue; Robert W. Hickey; Robert A. Berg; Robert M. Sutton; Mary Fran Hazinski

**Table 4: 2010 - Guidelines Part 13: Pediatric BLS Writing Group Disclosures**

Open table in a new window

2010 Guidelines Part 13: Pediatric BLS Writing Group Disclosures							
Writing Group Member	Employment	Research Grant	Other Research Support	Speakers' Bureau/Honorary	Ownership Interest	Consultant/Advisory Board	Other
Marc D. Berg	University of Arizona/University Physician's Healthcare (UPH)—Associate Professor of Clinical Pediatrics and Member, Board of Directors	None	None	None	None	None	None

Writing Group Member	Employment	Research Grant	Other Research Support	Speakers' Bureau/Honoraria	Ownership Interest	Consultant/Advisory Board	Other
Stephen M. Schexnayder	University of Arkansas for Medical Sciences—Professor/Division Chief; AHA Compensated Consultant as Associate Senior Science Editor. <sup>†</sup>	<sup>*</sup> Pharmacokinetics of Proton Pump Inhibitors	None	<sup>*</sup> Contemporary Forums	None	None	
Leon Chameides	Emeritus Director Pediatric Cardiology, Connecticut Children's Medical Center Clinical Professor, University of Connecticut	None	None	None	None	None	None
Mark Terry	Johnson County Med-Act—Deputy Chief Operations	None	None	None	None	None	None
Aaron Donoghue	University of Pennsylvania—Assistant Professor of Pediatrics	None	None	None	None	None	None
Robert W. Hickey	University of Pittsburgh—MD	<sup>†</sup> Salary support on NIH grant to investigate the role of cyclopentenone prostaglandins in hypoxic-ischemic brain injury	None	None	None	None	
Robert A. Berg	University of Pennsylvania Professor	None	None	None	None	None	None

Writing Group Member	Employment	Research Grant	Other Research Support	Speakers' Bureau/Honoraria	Ownership Interest	Consultant/Advisory Board	Other
Robert M. Sutton	The Children's Hospital of Philadelphia—Critical Care Attending	None	None	None	None	None	None
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

Writing Group Member	Employment	Research Grant	Other Research Support	Speakers' Bureau/Honoraria	Ownership Interest	Consultant/Advisory Board	Other
<ul style="list-style-type: none"> <li>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.</li> <li>?* Modest.</li> <li>?† Significant.</li> </ul>							

## 11 Footnotes

OCT. 2015

The American Heart Association requests that this document be cited as follows:

American Heart Association. Web-based Integrated Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care – Part 11: Pediatric Basic Life Support and Cardiopulmonary Resuscitation Quality. [ecctemp.wpengine.com](http://ecctemp.wpengine.com).

© Copyright 2015, 2017 American Heart Association, Inc.

## References

1. Berg MD, Schexnayder SM, Chameides L, Terry M, Donoghue A, Hickey RW, Berg RA, Sutton RM, Hazinski MF. Part 13: pediatric basic life support: 2010 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care. *Circulation*. 2010;122(suppl 3):S862–S875. doi: 10.1161/CIRCULATIONAHA.110.971085.
2. de Caen AR, Maconochie IK, Aickin R, Atkins DL, Biarent D, Guerguerian AM, Kleinman ME, Kloeck DA, Meaney PA, Nadkarni VM, Ng KC, Nuthall G, Reis AG, Shimizu N, Tibballs J, Veliz Pintos R; on behalf of the Pediatric Basic Life Support and Pediatric Advanced Life Support Chapter Collaborators. Part 6: pediatric basic life support and pediatric advanced life support: 2015 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science With Treatment Recommendations. *Circulation*. 2015;132 (suppl 1):S177–S203. doi: 10.1161/CIR.0000000000000275.
3. Maconochie IK, de Caen AR, Aickin R, Atkins DL, Biarent D, Guerguerian AM, Kleinman ME, Kloeck DA, Meaney PA, Nadkarni VM, Ng KC, Nuthall G, Reis AG, Shimizu N, Tibballs J, Veliz Pintos R; on behalf of the Pediatric Basic Life Support and Pediatric Advanced Life Support Chapter Collaborators. Part 6: pediatric basic life support and pediatric advanced life support: 2015 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science With Treatment Recommendations. *Resuscitation*. 2015. In press.
4. Girotra S, Spertus JA, Li Y, Berg RA, Nadkarni VM, Chan PS; American Heart Association Get With The Guidelines–Resuscitation Investigators. Survival trends in pediatric in-hospital cardiac arrests: an analysis from Get With The Guidelines–Resuscitation. *Circ Cardiovasc Qual Outcomes*. 2013;6:42–49. doi: 10.1161/CIRCOUTCOMES.112.967968.
5. Matos RI, Watson RS, Nadkarni VM, Huang HH, Berg RA, Meaney PA, Carroll CL, Berens RJ, Praestgaard A, Weissfeld L, Spinella PC; American Heart Association's Get With The Guidelines–Resuscitation (Formerly the National Registry of Cardiopulmonary Resuscitation) Investigators. Duration of cardiopulmonary resuscitation and illness category impact survival and neurologic outcomes for in-hospital pediatric cardiac arrests. *Circulation*. 2013;127:442–451. doi: 10.1161/CIRCULATIONAHA.112.125625.
6. Atkins DL, Everson-Stewart S, Sears GK, Daya M, Osmond MH, Warden CR, Berg RA; Resuscitation Outcomes Consortium Investigators. Epidemiology and outcomes from out-of-hospital cardiac arrest in children: the Resuscitation Outcomes Consortium Epistry–Cardiac Arrest. *Circulation*. 2009;119:1484–1491. doi: 10.1161/CIRCULATIONAHA.108.802678.

7. Sutton RM, Case E, Brown SP, Atkins DL, Nadkarni VM, Kaltman J, Callaway C, Idris A, Nichol G, Hutchison J, Drennan IR, Austin M, Daya M, Cheskes S, Nuttall J, Herren H, Christenson J, Andrusiek D, Vaillancourt C, Menegazzi JJ, Rea TD, Berg RA; ROC Investigators. A quantitative analysis of out-of-hospital pediatric and adolescent resuscitation quality - A report from the ROC epistudy-cardiac arrest. *Resuscitation*. 2015;93:150–157. doi: 10.1016/j.resuscitation.2015.04.010.
8. Crewdson K, Lockey D, Davies G. Outcome from paediatric cardiac arrest associated with trauma. *Resuscitation*. 2007;75:29–34.
9. Donoghue AJ, Nadkarni V, Berg RA, Osmond MH, Wells G, Nesbitt L, Stiell IG. Out-of-hospital pediatric cardiac arrest: an epidemiologic review and assessment of current knowledge. *Ann Emerg Med*. 2005;46:512–522.
10. Mejicano GC, Maki DG. Infections acquired during cardiopulmonary resuscitation: estimating the risk and defining strategies for prevention. *Ann Intern Med*. 1998;129:813–828.
11. Ruben HM, Elam JO, et al. Investigations of pharyngeal xrays and performance by laymen. *Anesthesiology*. 1961;22:271–279.
12. Safar P, Aguto-Escarraga L. Compliance in apneic anesthetized adults. *Anesthesiology*. 1959;20:283–289.
13. Elam JO, Greene DG, Schneider MA, Ruben HM, Gordon AS, Hustead RF, Benson DW, Clements JA, Ruben A. Head-tilt method of oral resuscitation. *JAMA*. 1960;172:812–815.
14. Zideman DA. Paediatric and neonatal life support. *Br J Anaesth*. 1997;79:178–187.
15. Tonkin SL, Davis SL, Gunn TR. Nasal route for infant resuscitation by mothers. *Lancet*. 1995;345:1353–1354.
16. Segedin E, Torrie J, Anderson B. Nasal airway versus oral route for infant resuscitation. *Lancet*. 1995;346:382.
17. Tonkin SL, Gunn AJ. Failure of mouth-to-mouth resuscitation in cases of sudden infant death. *Resuscitation*. 2001;48:181–184.
18. Dorph E, Wik L, Steen PA. Effectiveness of ventilation-compression ratios 1:5 and 2:15 in simulated single rescuer paediatric resuscitation. *Resuscitation*. 2002;54:259–264.
19. Greingor JL. Quality of cardiac massage with ratio compression-ventilation 5/1 and 15/2. *Resuscitation*. 2002;55:263–267.
20. Kinney SB, Tibballs J. An analysis of the efficacy of bag-valve-mask ventilation and chest compression during different compression-ventilation ratios in manikin-simulated paediatric resuscitation. *Resuscitation*. 2000;43:115–120.
21. Srikanthan SK, Berg RA, Cox T, Tice L, Nadkarni VM. Effect of one-rescuer compression/ventilation ratios on cardiopulmonary resuscitation in infant, pediatric, and adult manikins. *Pediatr Crit Care Med*. 2005;6:293–297.
22. Betz AE, Callaway CW, Hostler D, Rittenberger JC. Work of CPR during two different compression to ventilation ratios with real-time feedback. *Resuscitation*. 2008;79:278–282.
23. Haque IU, Udassi JP, Udassi S, Theriaque DW, Shuster JJ, Zaritsky AL. Chest compression quality and rescuer fatigue with increased compression to ventilation ratio during single rescuer pediatric CPR. *Resuscitation*. 2008;79:82–89.
24. Bjorshol CA, Soreide E, Torsteinbo TH, Lexow K, Nilsen OB, Sunde K. Quality of chest compressions during 10 min of single-rescuer basic life support with different compression: ventilation ratios in a manikin model. *Resuscitation*. 2008;77:95–100.
25. Deschilder K, De Vos R, Stockman W. The effect on quality of chest compressions and exhaustion of a compression–ventilation ratio of 30:2 versus 15:2 during cardiopulmonary resuscitation—a randomised trial. *Resuscitation*. 2007;74:113–118.
26. Yannopoulos D, Aufderheide TP, Gabrielli A, Beiser DG, McKnite SH, Pirrallo RG, Wigginton J, Becker L, Vanden Hoek T, Tang W, Nadkarni VM, Klein JP, Idris AH, Lurie KG. Clinical and hemodynamic comparison of 15:2 and 30:2 compression-to-ventilation ratios for cardiopulmonary resuscitation. *Crit Care Med*. 2006;34:1444–1449.
27. Odegaard S, Saether E, Steen PA, Wik L. Quality of lay person CPR performance with compression: ventilation ratios 15:2, 30:2 or continuous chest compressions without ventilations on manikins. *Resuscitation*. 2006;71:335–340.
28. Hostler D, Rittenberger JC, Roth R, Callaway CW. Increased chest compression to ventilation ratio improves delivery of CPR. *Resuscitation*. 2007;74:446–452.
29. Berg RA, Sanders AB, Kern KB, Hilwig RW, Heidenreich JW, Porter ME, Ewy GA. Adverse hemodynamic effects of interrupting chest compressions for rescue breathing during cardiopulmonary resuscitation for ventricular fibrillation cardiac arrest. *Circulation*. 2001;104:2465–2470.
30. Kern KB, Hilwig RW, Berg RA, Sanders AB, Ewy GA. Importance of continuous chest compressions during cardiopulmonary resuscitation: improved outcome during a simulated single lay-rescuer scenario. *Circulation*. 2002;105:645–649.
31. Ewy GA, Zuercher M, Hilwig RW, Sanders AB, Berg RA, Otto CW, Hayes MM, Kern KB. Improved neurological outcome with continuous chest compressions compared with 30:2 compressions-to-ventilations cardiopulmonary resuscitation in a realistic swine model of out-of-hospital cardiac arrest. *Circulation*. 2007;116:2525–2530.

32. Assar D, Chamberlain D, Colquhoun M, Donnelly P, Handley AJ, Leaves S, Kern KB. Randomised controlled trials of staged teaching for basic life support, 1: skill acquisition at bronze stage. *Resuscitation*. 2000;45:7–15.
33. Heidenreich JW, Sanders AB, Higdon TA, Kern KB, Berg RA, Ewy GA. Uninterrupted chest compression CPR is easier to perform and remember than standard CPR. *Resuscitation*. 2004;63:123–130.
34. Wik L, Kramer-Johansen J, Myklebust H, Sorebo H, Svensson L, Fellows B, Steen PA. Quality of cardiopulmonary resuscitation during out-of-hospital cardiac arrest. *JAMA*. 2005;293:299–304.
35. Abella BS, Alvarado JP, Myklebust H, Edelson DP, Barry A, O'Hearn N, Vanden Hoek TL, Becker LB. Quality of cardiopulmonary resuscitation during in-hospital cardiac arrest. *JAMA*. 2005;293:305–310.
36. Valenzuela TD, Kern KB, Clark LL, Berg RA, Berg MD, Berg DD, Hilwig RW, Otto CW, Newburn D, Ewy GA. Interruptions of chest compressions during emergency medical systems resuscitation. *Circulation*. 2005;112:1259–1265.
37. Abella BS, Sandbo N, Vassilatos P, Alvarado JP, O'Hearn N, Wigder HN, Hoffman P, Tynus K, Vanden Hoek TL, Becker LB. Chest compression rates during cardiopulmonary resuscitation are suboptimal: a prospective study during in-hospital cardiac arrest. *Circulation*. 2005;111:428–434.
38. Eftestol T, Sunde K, Steen PA. Effects of interrupting precordial compressions on the calculated probability of defibrillation success during out-of-hospital cardiac arrest. *Circulation*. 2002;105:2270–2273.
39. Christenson J, Andrusiek D, Everson-Stewart S, Kudenchuk P, Hostler D, Powell J, Callaway CW, Bishop D, Vaillancourt C, Davis D, Aufderheide TP, Idris A, Stouffer JA, Stiell I, Berg R. Chest compression fraction determines survival in patients with out-of-hospital ventricular fibrillation. *Circulation*. 2009;120:1241–1247.
40. Kitamura T, Iwami T, Kawamura T, Nagao K, Tanaka H, Nadkarni VM, Berg RA, Hiraide A. Conventional and chest-compression-only cardiopulmonary resuscitation by bystanders for children who have out-of-hospital cardiac arrests: a prospective, nationwide, population-based cohort study. *Lancet*. 2010;375():1347–1354.
41. Sirbaugh PE, Pepe PE, Shook JE, Kimball KT, Goldman MJ, Ward MA, Mann DM. A prospective, population-based study of the demographics, epidemiology, management, and outcome of out-of-hospital pediatric cardiopulmonary arrest. *Ann Emerg Med*. 1999;33:174–184.
42. Young KD, Seidel JS. Pediatric cardiopulmonary resuscitation: a collective review. *Ann Emerg Med*. 1999;33:195–205.
43. Hickey RW, Cohen DM, Strausbaugh S, Dietrich AM. Pediatric patients requiring CPR in the prehospital setting. *Ann Emerg Med*. 1995;25:495–501.
44. Mogayzel C, Quan L, Graves JR, Tiedeman D, Fahrenbruch C, Herndon P. Out-of-hospital ventricular fibrillation in children and adolescents: causes and outcomes. *Ann Emerg Med*. 1995;25:484–491.
45. Appleton GO, Cummins RO, Larson MP, Graves JR. CPR and the single rescuer: at what age should you “call first” rather than “call fast”? *Ann Emerg Med*. 1995;25:492–494.
46. Tibballs J, Russell P. Reliability of pulse palpation by healthcare personnel to diagnose paediatric cardiac arrest. *Resuscitation*. 2009;80:61–64.
47. Bahr J, Klingler H, Panzer W, Rode H, Kettler D. Skills of lay people in checking the carotid pulse. *Resuscitation*. 1997;35:23–26.
48. Brearley S, Shearman CP, Simms MH. Peripheral pulse palpation: an unreliable physical sign. *Ann R Coll Surg Engl*. 1992;74:169–171.
49. Cavallaro DL, Melker RJ. Comparison of two techniques for detecting cardiac activity in infants. *Crit Care Med*. 1983;11:189–190.
50. Inagawa G, Morimura N, Miwa T, Okuda K, Hirata M, Hiroki K. A comparison of five techniques for detecting cardiac activity in infants. *Paediatr Anaesth*. 2003;13:141–146.
51. Kamlin CO, O'Donnell CP, Everest NJ, Davis PG, Morley CJ. Accuracy of clinical assessment of infant heart rate in the delivery room. *Resuscitation*. 2006;71:319–321.
52. Lee CJ, Bullock LJ. Determining the pulse for infant CPR: time for a change? *Mil Med*. 1991;156:190–193.
53. Mather C, O'Kelly S. The palpation of pulses. *Anaesthesia*. 1996;51:189–191.
54. Ochoa FJ, Ramalle-Gomara E, Carpintero JM, Garcia A, Saralegui I. Competence of health professionals to check the carotid pulse. *Resuscitation*. 1998;37:173–175.
55. Owen CJ, Wyllie JP. Determination of heart rate in the baby at birth. *Resuscitation*. 2004;60:213–217.
56. Sarti A, Savron F, Casotto V, Cuttini M. Heartbeat assessment in infants: a comparison of four clinical methods. *Pediatr Crit Care Med*. 2005;6:212–215.

57. Sarti A, Savron F, Ronfani L, Pelizzo G, Barbi E. Comparison of three sites to check the pulse and count heart rate in hypotensive infants. *Paediatr Anaesth*. 2006;16:394–398.
58. Tanner M, Nagy S, Peat JK. Detection of infant's heart beat/pulse by caregivers: a comparison of 4 methods. *J Pediatr*. 2000;137:429–430.
59. Whitelaw CC, Goldsmith LJ. Comparison of two techniques for determining the presence of a pulse in an infant. *Acad Emerg Med*. 1997;4:153–154.
60. Dick WF, Eberle B, Wisser G, Schneider T. The carotid pulse check revisited: what if there is no pulse? *Crit Care Med*. 2000;28(11 Suppl):N183–185.
61. Eberle B, Dick WF, Schneider T, Wisser G, Doetsch S, Tzanova I. Checking the carotid pulse check: diagnostic accuracy of first responders in patients with and without a pulse. *Resuscitation*. 1996;33:107–116.
62. Donoghue A, Berg RA, Hazinski MF, Praestgaard AH, Roberts K, Nadkarni VM. Cardiopulmonary resuscitation for bradycardia with poor perfusion versus pulseless cardiac arrest. *Pediatrics*. 2009;124:1541–1548.
63. Clements F, McGowan J. Finger position for chest compressions in cardiac arrest in infants. *Resuscitation*. 2000;44:43–46.
64. Finholt DA, Kettrick RG, Wagner HR, Swedlow DB. The heart is under the lower third of the sternum: implications for external cardiac massage. *Am J Dis Child*. 1986;140:646–649.
65. Phillips GW, Zideman DA. Relation of infant heart to sternum: its significance in cardiopulmonary resuscitation. *Lancet*. 1986;1:1024–1025.
66. Orlowski JP. Optimum position for external cardiac compression in infants and young children. *Ann Emerg Med*. 1986;15:667–673.
67. Shah NM, Gaur HK. Position of heart in relation to sternum and nipple line at various ages. *Indian Pediatr*. 1992;29:49–53.
68. David R. Closed chest cardiac massage in the newborn infant. *Pediatrics*. 1988;81:552–554.
69. Todres ID, Rogers MC. Methods of external cardiac massage in the newborn infant. *J Pediatr*. 1975;86:781–782.
70. Menegazzi JJ, Auble TE, Nicklas KA, Hosack GM, Rack L, Goode JS. Two-thumb versus two-finger chest compression during CRP in a swine infant model of cardiac arrest. *Ann Emerg Med*. 1993;22:240–243.
71. Hourii PK, Frank LR, Menegazzi JJ, Taylor R. A randomized, controlled trial of two-thumb vs two-finger chest compression in a swine infant model of cardiac arrest. *Prehosp Emerg Care*. 1997;1:65–67.
72. Dorfsman ML, Menegazzi JJ, Wadas RJ, Auble TE. Two-thumb vs two-finger chest compression in an infant model of prolonged cardiopulmonary resuscitation. *Acad Emerg Med*. 2000;7:1077–1082.
73. Whitelaw CC, Slywka B, Goldsmith LJ. Comparison of a two-finger versus two-thumb method for chest compressions by healthcare providers in an infant mechanical model. *Resuscitation*. 2000;43:213–216.
74. Thaler MM, Stobie GH. An improved technique of external cardiac compression in infants and young children. *N Engl J Med*. 1963;269:606–610.
75. Ishimine P, Menegazzi J, Weinstein D. Evaluation of two-thumb chest compression with thoracic squeeze in a swine model of infant cardiac arrest. *Acad Emerg Med*. 1998;5:397.
76. Atkins DL, Jorgenson DB. Attenuated pediatric electrode pads for automated external defibrillator use in children. *Resuscitation*. 2005;66:31–37.
77. Nadkarni VM, Larkin GL, Peberdy MA, Carey SM, Kaye W, Mancini ME, Nichol G, Lane-Truitt T, Potts J, Ornato JP, Berg RA. First documented rhythm and clinical outcome from in-hospital cardiac arrest among children and adults. *JAMA*. 2006;295:50–57.
78. Samson RA, Nadkarni VM, Meaney PA, Carey SM, Berg MD, Berg RA. Outcomes of in-hospital ventricular fibrillation in children. *N Engl J Med*. 2006;354:2328–2339.
79. Atkinson E, Mikysa B, Conway JA, Parker M, Christian K, Deshpande J, Knilans TK, Smith J, Walker C, Stickney RE, Hampton DR, Hazinski MF. Specificity and sensitivity of automated external defibrillator rhythm analysis in infants and children. *Ann Emerg Med*. 2003;42:185–196.
80. Cecchin F, Jorgenson DB, Berul CI, Perry JC, Zimmerman AA, Duncan BW, Lupinetti FM, Snyder D, Lyster TD, Rosenthal GL, Cross B, Atkins DL. Is arrhythmia detection by automatic external defibrillator accurate for children? Sensitivity and specificity of an automatic external defibrillator algorithm in 696 pediatric arrhythmias. *Circulation*. 2001;103:2483–2488.
81. Atkins DL, Scott WA, Blaurock AD, Law IH, Dick M II., Geheb F, Sobh J, Brewer JE. Sensitivity and specificity of an automated external defibrillator algorithm designed for pediatric patients. *Resuscitation*. 2008;76:168–174.

82. Bar-Cohen Y, Walsh EP, Love BA, Cecchin F. First appropriate use of automated external defibrillator in an infant. *Resuscitation*. 2005;67:135–137.
83. Konig B, Benger J, Goldsworthy L. Automatic external defibrillation in a 6 year old. *Arch Dis Child*. 2005;90:310–311.
84. Ornato JP, Hallagan LF, McMahan SB, Peeples EH, Rostafinski AG. Attitudes of BCLS instructors about mouth-to-mouth resuscitation during the AIDS epidemic. *Ann Emerg Med*. 1990;19:151–156.
85. Brenner BE, Van DC, Cheng D, Lazar EJ. Determinants of reluctance to perform CPR among residents and applicants: the impact of experience on helping behavior. *Resuscitation*. 1997;35:203–211.
86. Hew P, Brenner B, Kaufman J. Reluctance of paramedics and emergency medical technicians to perform mouth-to-mouth resuscitation. *J Emerg Med*. 1997;15:279–284.
87. Locke CJ, Berg RA, Sanders AB, Davis MF, Milander MM, Kern KB, Ewy GA. Bystander cardiopulmonary resuscitation. Concerns about mouth-to-mouth contact. *Arch Intern Med*. 1995;155:938–943.
88. Shibata K, Taniguchi T, Yoshida M, Yamamoto K. Obstacles to bystander cardiopulmonary resuscitation in Japan. *Resuscitation*. 2000;44:187–193.
89. Terndrup TE, Warner DA. Infant ventilation and oxygenation by basic life support providers: comparison of methods. *Prehospital Disaster Med*. 1992;7:35–40.
90. Hess D, Ness C, Oppel A, Rhoads K. Evaluation of mouth-to-mask ventilation devices. *Respir Care*. 1989;34:191–195.
91. Terndrup TE, Kanter RK, Cherry RA. A comparison of infant ventilation methods performed by prehospital personnel. *Ann Emerg Med*. 1989;18:607–611.
92. Field D, Milner AD, Hopkin IE. Efficiency of manual resuscitators at birth. *Arch Dis Child*. 1986;61:300–302.
93. Finer NN, Barrington KJ, Al-Fadley F, Peters KL. Limitations of self-inflating resuscitators. *Pediatrics*. 1986;77:417–420.
94. Kern KB, Sanders AB, Raife J, Milander MM, Otto CW, Ewy GA. A study of chest compression rates during cardiopulmonary resuscitation in humans: the importance of rate-directed chest compressions. *Arch Intern Med*. 1992;152:145–149.
95. Aufderheide TP, Sigurdsson G, Pirrallo RG, Yannopoulos D, McKnite S, von Briesen C, Sparks CW, Conrad CJ, Provo TA, Lurie KG. Hyperventilation-induced hypotension during cardiopulmonary resuscitation. *Circulation*. 2004;109:1960–1965.
96. Hirschman AM, Kravath RE. Venting vs ventilating. A danger of manual resuscitation bags. *Chest*. 1982;82:369–370.
97. Davidovic L, LaCovey D, Pitetti RD. Comparison of 1- versus 2-person bag-valve-mask techniques for manikin ventilation of infants and children. *Ann Emerg Med*. 2005;46:37–42.
98. Berg MD, Idris AH, Berg RA. Severe ventilatory compromise due to gastric distention during pediatric cardiopulmonary resuscitation. *Resuscitation*. 1998;36:71–73.
99. Gausche M, Lewis RJ, Stratton SJ, Haynes BE, Gunter CS, Goodrich SM, Poore PD, McCollough MD, Henderson DP, Pratt FD, Seidel JS. Effect of out-of-hospital pediatric endotracheal intubation on survival and neurological outcome: a controlled clinical trial. *JAMA*. 2000;283:783–790.
100. Moynihan RJ, Brock-Utne JG, Archer JH, Feld LH, Kreitzman TR. The effect of cricoid pressure on preventing gastric insufflation in infants and children. *Anesthesiology*. 1993;78:652–656.
101. Salem MR, Wong AY, Mani M, Sellick BA. Efficacy of cricoid pressure in preventing gastric inflation during bag- mask ventilation in pediatric patients. *Anesthesiology*. 1974;40:96–98.
102. Sellick BA. Cricoid pressure to control regurgitation of stomach contents during induction of anaesthesia. *Lancet*. 1961;2:404–406.
103. Hartsilver EL, Vanner RG. Airway obstruction with cricoid pressure. *Anaesthesia*. 2000;55:208–211.
104. Lipinski CA, Hicks SD, Callaway CW. Normoxic ventilation during resuscitation and outcome from asphyxial cardiac arrest in rats. *Resuscitation*. 1999;42:221–229.
105. Liu Y, Rosenthal RE, Haywood Y, Miljkovic-Lolic M, Vanderhoek JY, Fiskum G. Normoxic ventilation after cardiac arrest reduces oxidation of brain lipids and improves neurological outcome. *Stroke*. 1998;29:1679–1686.
106. Lefkowitz W. Oxygen and resuscitation: beyond the myth. *Pediatrics*. 2002;109:517–519.
107. Zwemer CF, Whitesall SE, D'Alecy LG. Cardiopulmonary-cerebral resuscitation with 100% oxygen exacerbates neurological dysfunction following nine minutes of normothermic cardiac arrest in dogs. *Resuscitation*. 1994;27:159–170.

108. Balan IS, Fiskum G, Hazelton J, Cotto-Cumba C, Rosenthal RE. Oximetry-guided reoxygenation improves neurological outcome after experimental cardiac arrest. *Stroke*. 2006;37:3008–3013.
109. Marsala J, Marsala M, Vanicky I, Galik J, Orendacova J. Post cardiac arrest hyperoxic resuscitation enhances neuronal vulnerability of the respiratory rhythm generator and some brainstem and spinal cord neuronal pools in the dog. *Neurosci Lett*. 1992;146:121–124.
110. Richards EM, Rosenthal RE, Kristian T, Fiskum G. Postischemic hyperoxia reduces hippocampal pyruvate dehydrogenase activity. *Free Radic Biol Med*. 2006;40:1960–1970.
111. Richards EM, Fiskum G, Rosenthal RE, Hopkins I, McKenna MC. Hyperoxic reperfusion after global ischemia decreases hippocampal energy metabolism. *Stroke*. 2007;38:1578–1584.
112. Vereczki V, Martin E, Rosenthal RE, Hof PR, Hoffman GE, Fiskum G. Normoxic resuscitation after cardiac arrest protects against hippocampal oxidative stress, metabolic dysfunction, and neuronal death. *J Cereb Blood Flow Metab*. 2006;26:821–835.
113. Feet BA, Yu XQ, Rootwelt T, Oyasaeter S, Saugstad OD. Effects of hypoxemia and reoxygenation with 21% or 100% oxygen in newborn piglets: extracellular hypoxanthine in cerebral cortex and femoral muscle. *Crit Care Med*. 1997;25:1384–1391.
114. Finer NN, Bates R, Tomat P. Low flow oxygen delivery via nasal cannula to neonates. *Pediatr Pulmonol*. 1996;21:48–51.
115. Vilke GM, Smith AM, Ray LU, Steen PJ, Murrin PA, Chan TC. Airway obstruction in children aged less than 5 years: the prehospital experience. *Prehosp Emerg Care*. 2004;8:196–199.
116. Morley RE, Ludemann JP, Moxham JP, Kozak FK, Riding KH. Foreign body aspiration in infants and toddlers: recent trends in British Columbia. *J Otolaryngol*. 2004;33:37–41.
117. Harris CS, Baker SP, Smith GA, Harris RM. Childhood asphyxiation by food. A national analysis and overview. *JAMA*. 1984;251:2231–2235.
118. Rimell FL, Thome AJ, Stool S, Reilly JS, Rider G, Stool D, Wilson CL. Characteristics of objects that cause choking in children. *JAMA*. 1995;274:1763–1766.
119. Prevention of choking among children. *Pediatrics*. 2010;125:601–607.
120. Heimlich HJ. A life-saving maneuver to prevent food-choking. *JAMA*. 1975;234:398–401.
121. Sternbach G, Kiskaddon RT. Henry Heimlich: a life-saving maneuver for food choking. *J Emerg Med*. 1985;3:143–148.
122. Langhelle A, Sunde K, Wik L, Steen PA. Airway pressure with chest compressions versus Heimlich manoeuvre in recently dead adults with complete airway obstruction. *Resuscitation*. 2000;44:105–108.
123. Redding JS. The choking controversy: critique of evidence on the Heimlich maneuver. *Crit Care Med*. 1979;7:475–479.
124. Guildner CW, Williams D, Subitch T. Airway obstructed by foreign material: the Heimlich maneuver. *JACEP*. 1976;5:675–677.
125. Kabbani M, Goodwin SR. Traumatic epiglottitis following blind finger sweep to remove a pharyngeal foreign body. *Clin Pediatr (Phila)*. 1995;34:495–497.
126. Hartrey R, Bingham RM. Pharyngeal trauma as a result of blind finger sweeps in the choking child. *J Accid Emerg Med*. 1995;12:52–54.
127. Gjoni D, Mbamalu D, Banerjee A, James K. An unusual complication of an attempt to open the airway in a choking child. *Br J Hosp Med (Lond)*. 2009;70:595.
128. Spaite DW, Conroy C, Tibbitts M, Karriker KJ, Seng M, Battaglia N, Criss EA, Valenzuela TD, Meislin HW. Use of emergency medical services by children with special health care needs. *Prehosp Emerg Care*. 2000;4:19–23.
129. Schultz-Grant LD, Young-Cureton V, Kataoka-Yahiro M. Advance directives and do not resuscitate orders: nurses' knowledge and the level of practice in school settings. *J Sch Nurs*. 1998;14:4–10, 12–13.
130. Policy statement—emergency information forms and emergency preparedness for children with special health care needs. *Pediatrics*. 2010;125:829–837.
131. Herzenberg JE, Hensinger RN, Dedrick DK, Phillips WA. Emergency transport and positioning of young children who have an injury of the cervical spine. The standard backboard may be hazardous. *J Bone Joint Surg Am*. 1989;71:15–22.
132. Nypaver M, Treloar D. Neutral cervical spine positioning in children. *Ann Emerg Med*. 1994;23:208–211.
133. Kyriacou DN, Arcinue EL, Peek C, Kraus JF. Effect of immediate resuscitation on children with submersion injury. *Pediatrics*. 1994;94():137–142.
- 134.

- Suominen P, Baillie C, Korpela R, Rautanen S, Ranta S, Olkkola KT. Impact of age, submersion time and water temperature on outcome in near-drowning. *Resuscitation*. 2002;52:247–254.
135. Graf WD, Cummings P, Quan L, Brutocao D. Predicting outcome in pediatric submersion victims. *Ann Emerg Med*. 1995;26:312–319.
  136. Modell JH, Idris AH, Pineda JA, Silverstein JH. Survival after prolonged submersion in freshwater in Florida. *Chest*. 2004;125:1948–1951.
  137. Mehta SR, Srinivasan KV, Bindra MS, Kumar MR, Lahiri AK. Near drowning in cold water. *J Assoc Physicians India*. 2000;48:674–676.
  138. Szpilman D, Soares M. In-water resuscitation—is it worthwhile? *Resuscitation*. 2004;63:25–31.
  139. Berg RA, Hilwig RW, Kern KB, Babar I, Ewy GA. Simulated mouth- to-mouth ventilation and chest compressions (bystander cardiopulmonary resuscitation) improves outcome in a swine model of prehospital pediatric asphyxial cardiac arrest. *Crit Care Med*. 1999;27:1893–1899.
  140. Yannopoulos D, Matsuura T, McKnite S, Goodman N, Idris A, Tang W, Aufderheide TP, Lurie KG. No assisted ventilation cardiopulmonary resuscitation and 24-hour neurological outcomes in a porcine model of cardiac arrest. *Crit Care Med*. 2010;38:254–260. doi: 10.1097/CCM.0b013e3181b42f6c.
  141. Kitamura T, Iwami T, Kawamura T, Nagao K, Tanaka H, Nadkarni VM, Berg RA, Hiraide A; implementation working group for All-Japan Utstein Registry of the Fire and Disaster Management Agency. Conventional and chest-compression-only cardiopulmonary resuscitation by bystanders for children who have out-of-hospital cardiac arrests: a prospective, nationwide, population-based cohort study. *Lancet*. 2010;375:1347–1354. doi: 10.1016/S0140-6736(10)60064-5.
  142. Goto Y, Maeda T, Goto Y. Impact of dispatcher-assisted bystander cardio- pulmonary resuscitation on neurological outcomes in children with out-of- hospital cardiac arrests: a prospective, nationwide, population-based cohort study. *J Am Heart Assoc*. 2014;3:e000499. doi: 10.1161/JAHA.113.000499.
  143. Marsch S, Tschan F, Semmer NK, Zobrist R, Hunziker PR, Hunziker S. ABC versus CAB for cardiopulmonary resuscitation: a prospective, random- ized simulator-based trial. *Swiss Med Wkly*. 2013;143:w13856. doi: 10.4414/ smw.2013.13856.
  144. Sekiguchi H, Kondo Y, Kukita I. Verification of changes in the time taken to initiate chest compressions according to modified basic life support guidelines. *Am J Emerg Med*. 2013;31:1248–1250. doi: 10.1016/j.ajem.2013.02.047.
  145. Lubrano R, Cecchetti C, Bellelli E, Gentile I, Loayza Levano H, Orsini F, Bertazzoni G, Messi G, Rugolotto S, Pirozzi N, Elli M. Comparison of times of intervention during pediatric CPR maneuvers using ABC and CAB sequences: a randomized trial. *Resuscitation*. 2012;83:1473–1477. doi: 10.1016/j.resuscitation.2012.04.011.
  146. Sutton RM, Wolfe H, Nishisaki A, Leffelman J, Niles D, Meaney PA, Donoghue A, Maltese MR, Berg RA, Nadkarni VM. Pushing harder, pushing faster, minimizing interruptions... but falling short of 2010 cardiopulmonary resuscitation targets during in-hospital pediatric and adolescent resuscitation. *Resuscitation*. 2013;84:1680–1684. doi: 10.1016/j.resuscitation.2013.07.029.
  147. Kleinman ME, Brennan EE, Goldberger ZD, Swor RA, Terry M, Bobrow BJ, Gazmuri RJ, Travers AH, Rea T. Part 5: adult 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):S000–S000.
  148. Maher KO, Berg RA, Lindsey CW, Simsic J, Mahle WT. Depth of sternal compression and intra-arterial blood pressure during CPR in infants following cardiac surgery. *Resuscitation*. 2009;80:662–664. doi: 10.1016/j.resuscitation.2009.03.016.
  149. Sutton RM, French B, Niles DE, Donoghue A, Topjian AA, Nishisaki A, Leffelman J, Wolfe H, Berg RA, Nadkarni VM, Meaney PA. 2010 American Heart Association recommended compression depths during pediatric in-hospital resuscitations are associated with survival. *Resuscitation*. 2014;85:1179–1184. doi: 10.1016/j.resuscitation.2014.05.007.
  150. Sutton RM, Niles D, Nysaether J, Abella BS, Arbogast KB, Nishisaki A, Maltese MR, Donoghue A, Bishnoi R, Helfaer MA, Myklebust H, Nadkarni V. Quantitative analysis of CPR quality during in-hospital resuscitation of older children and adolescents. *Pediatrics*. 2009;124:494–499.
  151. Nishisaki A, Nysaether J, Sutton R, Maltese M, Niles D, Donoghue A, Bishnoi R, Helfaer M, Perkins GD, Berg R, Arbogast K, Nadkarni V. Effect of mattress deflection on CPR quality assessment for older children and adolescents. *Resuscitation*. 2009;80:540–545.
  152. Noordergraaf GJ, Paulussen IW, Venema A, van Berkomp PF, Woerlee PH, Scheffer GJ, Noordergraaf A. The impact of compliant surfaces on in-hospital chest compressions: effects of common mattresses and a backboard. *Resuscitation*. 2009;80:546–552.
  153. Stevenson AG, McGowan J, Evans AL, Graham CA. CPR for children: one hand or two? *Resuscitation*. 2005;64:205–208.
  154. Peska E, Kelly AM, Kerr D, Green D. One-handed versus two-handed chest compressions in paediatric cardio-pulmonary resuscitation. *Resuscitation*. 2006;71:65–69.
  155. Aufderheide TP, Pirrallo RG, Yannopoulos D, Klein JP, von Briesen C, Sparks CW, Deja KA, Conrad CJ, Kitscha DJ, Provo TA, Lurie KG. Incomplete chest wall decompression: a clinical evaluation of CPR performance by EMS personnel and assessment of alternative manual chest compression-decompression techniques. *Resuscitation*. 2005;64:353–362.

156. Yannopoulos D, McKnite S, Aufderheide TP, Sigurdsson G, Pirralo RG, Benditt D, Lurie KG. Effects of incomplete chest wall decompression during cardiopulmonary resuscitation on coronary and cerebral perfusion pressures in a porcine model of cardiac arrest. *Resuscitation*. 2005;64:363–372.
157. Zuercher M, Hilwig RW, Ranger-Moore J, Nysaether J, Nadkarni VM, Berg MD, Kern KB, Sutton R, Berg RA. Leaning during chest compressions impairs cardiac output and left ventricular myocardial blood flow in piglet cardiac arrest. *Crit Care Med*. 2010;38:1141–1146.
158. Sutton RM, Maltese MR, Niles D, French B, Nishisaki A, Arbogast KB, Donoghue A, Berg RA, Helfaer MA, Nadkarni V. Quantitative analysis of chest compression interruptions during in-hospital resuscitation of older children and adolescents. *Resuscitation*. 2009;80:1259–1263.
159. Niles D, Nysaether J, Sutton R, Nishisaki A, Abella BS, Arbogast K, Maltese MR, Berg RA, Helfaer M, Nadkarni V. Leaning is common during in-hospital pediatric CPR, and decreased with automated corrective feedback. *Resuscitation*. 2009;80:553–557.
160. Aufderheide TP, Pirralo RG, Yannopoulos D, Klein JP, von Briesen C, Sparks CW, Deja KA, Kitscha DJ, Provo TA, Lurie KG. Incomplete chest wall decompression: A clinical evaluation of CPR performance by trained laypersons and an assessment of alternative manual chest compression-decompression techniques. *Resuscitation*. 2006;71:341–351.
161. Ashton A, McCluskey A, Gwinnutt CL, Keenan AM. Effect of rescuer fatigue on performance of continuous external chest compressions over 3 min. *Resuscitation*. 2002;55:151–155.
162. Ochoa FJ, Ramalle-Gomara E, Lisa V, Saralegui I. The effect of rescuer fatigue on the quality of chest compressions. *Resuscitation*. 1998;37:149–152.
163. Hightower D, Thomas SH, Stone CK, Dunn K, March JA. Decay in quality of closed-chest compressions over time. *Ann Emerg Med*. 1995;26:300–303.
164. Olasveengen TM, de Caen AR, Mancini ME, Maconochie IK, Aickin R, Atkins DL, Berg RA, Bingham R, Brooks SC, Castrén M, Chung SP, Considine J, Couto TB, Escalante R, Gazmuri RJ, Guerguerian AM, Hatanaka T, Koster RW, Kudenchuk PJ, Lang E, Lim SH, Løfgren B, Meaney PA, Montgomery WH, Morley PT, Morrison LJ, Nation KJ, Ng KC, Nadkarni VM, Nishiyama C, Nuthall G, Ong YKG, Perkins GD, Reis AG, Ristagno G, Sakamoto T, Sayre MR, Schexnayder SM, Sierra A, Singletary EM, Shimizu N, Smyth MA, Stanton D, Tijssen JA, Travers AH, Vaillancourt C, van de Voorde P, Hazinski MF, Nolan JP; on behalf of the ILCOR Collaborators. 2017 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science With Treatment Recommendations summary. *Circulation*. 2017;136:XXX–XXX. doi: 10.1161/CIR.0000000000000541.
165. Kitamura T, Iwami T, Kawamura T, Nagao K, Tanaka H, Nadkarni VM, Berg RA, Hiraide A; for the Implementation Working Group for All-Japan Utstein Registry of the Fire and Disaster Management Agency. Conventional and chest-compression-only cardiopulmonary resuscitation by bystanders for children who have out-of-hospital cardiac arrests: a prospective, nationwide, population-based cohort study. *Lancet*. 2010;375:1347–1354. doi: 10.1016/s0140-6736(10)60064-5.
166. Goto Y, Maeda T, Goto Y. Impact of dispatcher-assisted bystander cardiopulmonary resuscitation on neurological outcomes in children with out-of-hospital cardiac arrests: a prospective, nationwide, population-based cohort study. *J Am Heart Assoc*. 2014;3:e000499. doi: 10.1161/jaha.113.000499.
167. Naim MY, Burke RV, McNally BF, Song L, Griffis HM, Berg RA, Vellano K, Markenson D, Bradley RN, Rossano JW. Association of bystander cardiopulmonary resuscitation with overall and neurologically favorable survival after pediatric out-of-hospital cardiac arrest in the United States: a report from the Cardiac Arrest Registry to Enhance Survival Surveillance Registry. *JAMA Pediatr*. 2017;171:133–141. doi: 10.1001/jamapediatrics.2016.3643.
168. Fukuda T, Ohashi-Fukuda N, Kobayashi H, Gunshin M, Sera T, Kondo Y, Yahagi N. Conventional versus compression-only versus no-bystander cardiopulmonary resuscitation for pediatric out-of-hospital cardiac arrest. *Circulation*. 2016;134:2060–2070. doi: 10.1161/circulationaha.116.023831.