Part 9: Pediatric Basic Life Support

Major Guidelines Changes
Changes in the pediatric section of the International Guidelines 2000 generally represent qualifications and refinements rather than major paradigm shifts from the 1992 Guidelines. The new guidelines continue to emphasize prevention of cardiac arrest. Pediatric BLS guidelines detail specific modifications of adult techniques necessary to address anatomic, physiological, etiologic, and psychosocial issues for infants and children. The initial sequence of BLS interventions in the pediatric Chain of Survival continues to be based on the most common etiology of arrest for a given age group, with modifications encouraged for special resuscitation circumstances.

Multiple studies have documented poor skills retention by participants of traditional BLS courses and improved skills retention when course information is simplified. As a result, all potential science changes were evaluated with respect to their effect on the complexity of teaching. Changes expected to simplify CPR teaching were encouraged.

Highlights of the pediatric resuscitation section of the International Guidelines 2000 are as follows:

Chain of Survival
- An etiology-based sequence for resuscitation was considered, but the age-based sequence (“phone fast” for infants and children, “phone first” for children >8 years old and adults) was retained (Class Indeterminate).
- Lay rescuers should be taught exceptions to the age-based sequence of resuscitation, which may include the following:
  - Lone rescuers should “phone fast” (provide immediate rescue breathing and other steps of CPR before phoning the EMS system) when submersion victims of any age are rescued from the water.
  - Lone rescuers should “phone first” (phone EMS before beginning CPR) after the sudden collapse of a child with a known history of heart disease.
- There is a need for more and better data regarding the epidemiology, treatment, and outcome of pediatric cardiopulmonary arrest. There is insufficient data to guide recommendations for pediatric resuscitation. Data collection efforts should use consistent terminology and record important time intervals. Critical elements for data collection have been described by an international consensus process, the Pediatric Utstein Guidelines for Reporting Outcome of Pediatric Cardiopulmonary Arrest.
- Teaching of cardiopulmonary resuscitation skills must be simplified, and courses must be skill-based and outcome driven.

Basic Life Support Sequence

Pulse Check
- All rescuers are instructed to assess for signs of circulation before beginning chest compressions:
  - Lay rescuers are instructed to assess for signs of circulation rather than attempt to check a pulse (Class IIa).
  - Healthcare providers are instructed to assess for signs of circulation, including a pulse check.

Rescue Breathing and Bag-Mask Ventilation
Education in bag-mask ventilation should be included in all BLS curricula for the healthcare provider (Class IIa).
Bag-mask ventilation can provide lifesaving support for infants and children in both the out-of-hospital and in-hospital settings and is a skill that BLS providers should master (Class IIa).

Chest Compressions and Use of Automated External Defibrillators
- If 2 or more suitably trained healthcare providers are present, the 2 thumb–encircling hands chest compression technique is preferred over the 2-finger compression technique for infants when technically feasible. This technique is not taught to lay rescuers.
- If the victim of out-of-hospital cardiac arrest is ≥8 years old (approximately ≥25 kg body weight), use of automated external defibrillators (AEDs) is encouraged (Class IIb), although data regarding the use of AEDs in this age group is limited.

Relief of Foreign-Body Airway Obstruction
- The extremely complex skills sequence for lay rescuer relief of foreign-body airway obstruction (FBAO) in the unconscious victim has been simplified. The sequence for healthcare provider relief of FBAO in the unconscious victim remains unchanged (Class IIb).

Introduction
Pediatric BLS refers to the provision of CPR, with no devices or with bag-mask ventilation or barrier devices, until advanced life support (ALS) can be provided. The population addressed in this chapter includes infants from birth to 1 year of age and children from 1 to 8 years of age.

CPR and life support in the pediatric age group should be part of a community-wide Chain of Survival that links the child to the best hope of survival following emergencies. The Chain of Survival integrates education in prevention of cardiopulmonary arrest, BLS, early access to EMS systems prepared for children’s needs, early and effective pediatric care.
ALS, and pediatric postresuscitation and rehabilitative care (Figure 1).

Sudden cardiopulmonary arrest in infants and children is much less common than sudden cardiac arrest in adults. In contrast to cardiac arrest in adults, cardiac arrest in infants and children is rarely a sudden event, and non-cardiac causes predominate. The etiology of cardiac arrest in infants and children varies by age, setting, and the underlying health of the child. For these reasons, the sequence of CPR for infants and children requires a different approach from that used for adult victims.

Cardiac arrest in the under-21-year-old age group occurs most commonly at either end of the age spectrum: under 1 year of age and during the teenage years. In the newly born infant, respiratory failure is the most common cause of cardiopulmonary deterioration and arrest. During infancy the most common causes of arrest include sudden infant death syndrome (SIDS), respiratory diseases, airway obstruction (including foreign-body aspiration), submersion, sepsis, and neurological disease. Beyond 1 year of age, injuries are the leading cause of death.

Cardiac arrest in children typically represents the terminal event of progressive shock or respiratory failure. Either shock or respiratory failure may include a compensated state from which children can rapidly deteriorate to a decompensated condition with progression to respiratory or cardiac arrest. Therefore, rescuers must detect and promptly treat early signs of respiratory and circulatory failure to prevent cardiac arrest. In children, early effective bystander CPR has been associated with successful return of spontaneous circulation and neurologically intact survival. BLS courses should be offered to target populations such as expectant parents, child care providers, teachers, sports supervisors, and others who regularly care for children. Parents and child care providers of children with underlying conditions that predispose them to cardiopulmonary failure should be particularly targeted for these courses.

These guidelines are based on a review and analysis of clinical and experimental evidence. Because this evidence varies widely in quality and quantity, each new guideline recommendation includes information about the strength of the scientific data on which it was based. In addition, a summary class of recommendation is indicated. For more information on the evidence evaluation process, see Evidence-Based Evaluation in “Part 1: Introduction.”

Throughout these Guidelines, the following definitions of classes of recommendations are used:

- **Class I** recommendations are always acceptable. They are proven safe and definitely useful, and they are supported by excellent evidence from at least 1 prospective, randomized controlled clinical trial.
- **Class IIa** recommendations are considered acceptable and useful with good to very good evidence providing support. The weight of evidence and expert opinions strongly favor these interventions.
- **Class IIb** recommendations are considered acceptable and useful with weak or only fair evidence providing support. The weight of evidence and expert opinion are not strongly in favor of the intervention.
- **Class III** refers to interventions that are unacceptable. These interventions lack any evidence of benefit, and often the evidence suggests or confirms harm.
- **Class Indeterminate** refers to an intervention that is promising, but the evidence is insufficient in quantity and/or quality to support a definitive class of recommendation. The Indeterminate Class was added to indicate interventions that are considered safe and perhaps effective and are recommended by expert consensus. However, the available evidence supporting the recommendation is either too weak or too limited at present to make a definite recommendation based on the published data.

Levels of evidence and classes of recommendations are fully defined in “Part 1: Introduction.” Ideally, treatments of choice are supported by excellent evidence and are Class I recommendations. Unfortunately the limited depth or quality of published pediatric cardiac arrest and resuscitation data often limited the strength of recommendations included in these guidelines to Class IIa or IIb.

**International Guidelines: International Liaison Committee on Resuscitation Advisory Statements**

Following the implementation of the 1992 guidelines, the representatives of 7 of the world’s resuscitation councils formed the International Liaison Committee on Resuscitation (ILCOR). For the next 8 years, members of ILCOR developed advisory statements containing consensus recommendations based on existing resuscitation guidelines, practical
experience, and informal interpretation. During this time an ILCOR task force met to address issues regarding resuscitation of the newly born, infant, and child; these meetings produced 2 ILCOR advisory statements.18,19

A high degree of uniformity exists in current guidelines for resuscitation of the newly born, neonates, infants, and young children endorsed by the resuscitation councils in developed countries around the world. Differences are largely the result of local and regional preferences or customs, training networks, and equipment/medication availability rather than differences in interpretation of scientific evidence.

To develop the pediatric resuscitation section of the International Guidelines 2000, the Subcommittee on Pediatric Resuscitation of the American Heart Association and other pediatric representatives from ILCOR identified issues or new developments worthy of further in-depth evaluation. From this list, areas of active research and evolving controversy were identified. Evidence-based evaluation of each of these areas was conducted and debated, culminating in assignment of consensus-defined levels of evidence for specific Guidelines questions. After identification and careful review of this evidence, the Pediatric Working Group of ILCOR and the AHA Pediatric Resuscitation Subcommittee updated the Pediatric guidelines and objectively attempted to link the class of recommendation to the identified level of evidence.

During these discussions the authors recognized the need to make recommendations for important interventions and treatment even when the only level of evidence was poor or absent. In the absence of specific pediatric data (outcome validity), recommendations were made on the basis of common sense (face validity) or ease of teaching or skills retention (construct validity).

To reduce confusion and simplify education, pediatric recommendations are consistent with the adult and neonatal BLS and ALS algorithms and guidelines whenever possible and appropriate. Areas of departure from the adult algorithms and interventions are noted with the rationale. Ultimately the practicality of implementing recommendations must be considered in the context of local resources (technology and personnel) and customs. No resuscitation protocol or guideline can be expected to appropriately anticipate all potential scenarios. These guidelines and treatment algorithms should serve as a guiding template to provide most critically ill children with appropriate support while thoughtful and appropriate etiology-based interventions are assembled and implemented.

The ILCOR advisory statements targeted existing and developing national resuscitation councils. The pediatric section of the International Guidelines 2000 attempts to apply the ILCOR advisory statements and updated international review of evidence to create advisory guidelines for local and regional EMS systems and organizations that care for children. Individual systems must adapt these guidelines to fit the needs and resources of their community, especially in regions in which EMS systems are not well developed. The principles and mechanics of resuscitation presented here should apply to all children, but application and methodology of a specific Chain of Survival is largely dependent on EMS systems and availability of resources. Specific training materials are necessary to target individual instructors and resuscitation providers in a given community.

Response to Cardiovascular Emergencies During Infancy and Childhood

Definition of Newly Born, Neonate, Infant, Child, and Adult

The term “neonate” is applied to infants in the first 28 days (month) of life.2 The term “newly born” is used in these guidelines to refer specifically to the neonate in the first minutes to hours after birth. This term is used to focus attention on the needs of the infant at and immediately after birth (including the first hours of life). The terms newborn or neonate were previously used but did not clearly refer to the first hours—rather than month—of life. The term “infant” includes the neonatal period and extends to the age of 1 year (12 months). For the purposes of these guidelines, the term “child” refers to ages 1 to 8 years. The term “adult” applies to victims ≥8 years of age through adult years.

Pediatric BLS and ALS interventions tend to “blur at the margins” of the age definitions of infant, child, and adult because no single anatomic or physiological characteristic consistently distinguishes the infant from the child from the adult victim of cardiac arrest. Furthermore, new technologies such as AEDs and airway and vascular access adjuncts that can be implemented with minimal advanced training create the need to re-examine previous age-based recommendations for therapies. The child’s developing anatomy and physiology and the most common causes of cardiopulmonary arrest should be considered in the development and use of resuscitation guidelines for children of different ages.

For the purposes of BLS, the term “infant” is defined by the approximate size of the young child who can receive effective chest compression given with 2 fingers or 2 thumbs with encircling hands. By consensus, the age cut-off for infants is 1 year. Note, however, that this definition is not based on physiological differences between infants and children. For example, the differences between an 11-month-old “infant” and a 17-month-old “child” are smaller than the differences in anatomy and physiology between a 1-week-old and a 10-month-old infant.

Historically the use of the term “child” in the ECC guidelines has been limited to age 8 years to simplify BLS education. Cardiac compression can generally be accomplished with 1 hand for victims between the ages of 1 and 8 years. However, variability in the size of the victim or the size and strength of the rescuer can require use of the 2-finger or 2 thumb–encircling hands technique for chest compression in a small toddler or 2-handed “adult” compression technique for chest compression in a large child who is 6 to 7 years old.

Anatomic and Physiological Differences Affecting Cardiac Arrest and Resuscitation

Respiratory failure or arrest is a common cause of cardiac arrest during infancy and childhood. These guidelines emphasize immediate provision of bystander CPR—including opening of the airway and delivery of rescue breathing—
before activation of the local EMS system. This emphasis on immediate support of oxygenation and ventilation is based on knowledge of the important role of respiratory failure in cardiac arrest. Optimal application of early oxygenation and ventilation requires an understanding of airway anatomy and physiology.

Airway Anatomy and Physiology

For many reasons, the infant and child are at risk for the development of airway obstruction and respiratory failure.22,23 The upper and lower airways of the infant and child are much smaller than the upper and lower airways of the adult. As a result, modest airway obstruction from edema, mucous plugs, or a foreign body can significantly reduce pediatric airway diameter and increase resistance to air flow and work of breathing.

1. The infant tongue is proportionately large in relation to the size of the oropharynx. As a result, posterior displacement of the tongue occurs readily and may cause severe airway obstruction in the infant.

2. In the infant and child the subglottic airway is smaller and more compliant and the supporting cartilage less developed than in the adult. As a result, this portion of the airway can easily become obstructed by mucus, blood, pus, edema, active constriction, external compression, or pressure differences created during spontaneous respiratory effort in the presence of airway obstruction. The pediatric airway is very compliant and may collapse during spontaneous respiratory effort in the face of airway obstruction.

3. The ribs and sternum normally contribute to maintenance of lung volume. In infants these ribs are very compliant and may fail to maintain lung volume, particularly when the elastic recoil of the lungs is increased and/or lung compliance is decreased. As a result, functional residual capacity is reduced when respiratory effort is diminished or absent. In addition, the limited support of lung volume expansion by the ribs makes the infant more dependent on diaphragm movement to generate a tidal volume. Anything that interferes with diaphragm movement (eg, gastric distention, acute abdomen) may produce respiratory insufficiency.

4. Infants and children have limited oxygen reserve. Physiological collapse of the small airways at or below lung functional residual capacity and an interval of hypoxemia and hypercarbia preceding arrest often influence oxygen reserve and arrest metabolic conditions.24

Cardiac Output, Oxygen Delivery, and Oxygen Demand

Cardiac output is the product of heart rate and stroke volume. Although the pediatric heart is capable of increasing stroke volume, cardiac output during infancy and childhood is largely dependent on maintenance of an adequate heart rate. Bradycardia may be associated with a rapid fall in cardiac output, leading to rapid deterioration in systemic perfusion. In fact, bradycardia is one of the most common terminal rhythms observed in children. For this reason, lay rescuers are taught to provide chest compressions when there are no observed signs of circulation. Healthcare providers are taught to provide chest compressions when there are no observed signs of circulation (including absence of a pulse) or when severe bradycardia (heart rate <60 beats per minute [bpm]) develops in the presence of poor systemic perfusion.

Epidemiology of Cardiopulmonary Arrest: “Phone Fast” (Infant, Child)/“Phone First” (Adult)

In adults, most sudden, nontraumatic cardiopulmonary arrest is cardiac in origin, and the most common terminal cardiac rhythm is ventricular fibrillation (VF).25 In research studies the “gold standard” type of out-of-hospital adult arrest used to compare outcomes is nontraumatic, witnessed arrest with a presenting rhythm of VF or pulseless ventricular tachycardia.26 For these victims, the time from collapse to defibrillation is the single greatest determinant of survival.27–31 In addition, bystander CPR increases survival after sudden, witnessed adult cardiopulmonary arrest (relative odds of survival=2.6; 95% CI=2.0 to 3.4).33,34

In children, the incidence, precise etiology, and outcome of cardiac arrest and resuscitation are difficult to ascertain because most reports contain insufficient patient numbers or use exclusion criteria or inconsistent definitions that prohibit broad generalization to all children.18 The causes of pediatric cardiopulmonary arrest are heterogeneous, including SIDS, asphyxia, near-drowning, trauma, and sepsis.35–40 Therefore, there is no single gold standard pediatric cardiac arrest stereotype for research or single accepted gold standard resuscitation outcome.41 Reported successful “outcomes” from arrest may include change in cardiac rhythm, improved hemodynamics during CPR, return of spontaneous circulation, survival to hospital admission, survival to hospital discharge, short- or long-term survival, or neurologically intact survival. Selection of the appropriate outcome variable and its specific relation to a single resuscitation intervention is often difficult.

In the pediatric age group, resuscitation is most frequently required at the time of birth. Approximately 5% to 10% of newly born infants require some degree of active resuscitation at birth, including stimulation to breathe,42 and approximately 1% to 10% born in the hospital may require assisted ventilation.43 Worldwide, >5 million neonatal deaths occur annually, with asphyxia at birth responsible for approximately 19% of these deaths.44 Implementation of relatively simple resuscitation techniques could save an estimated 1 million infants per year.19 For further information about resuscitation at the time of birth, see “Part 11: Neonatal Resuscitation.”

Throughout infancy and childhood, most out-of-hospital cardiac arrest occurs in or around the home, where children are under the supervision of parents and child care providers. In this setting, conditions such as SIDS, trauma, drowning, poisoning, choking, severe asthma, and pneumonia are the most common causes of arrest. In industrialized nations, trauma is the leading cause of death from the age of 6 months through young adulthood.53 In general, pediatric out-of-hospital arrest is characterized by a progression from hypoxia and hypercarbia to respiratory arrest and bradycardia and then asystolic cardiac arrest.4,37,40 Ventricular tachycardia or fibrillation has been reported in ≤15% of pediatric victims of out-of-hospital arrest,16,45,46 even when rhythm is assessed by first responders.47,48 Survival after out-of-hospital cardiopul-
monary arrest ranges from 3% to 17% in most studies,* and survivors are often neurologically devastated. Neurologically intact survival rates ≥50% have been reported for resuscitation of children with respiratory arrest alone.³⁵,⁵⁵ Prompt, effective chest compressions and rescue breathing have been shown to improve return of spontaneous circulation and increase neurologically intact survival in children with cardiac arrest¹⁶,⁴⁰; however, no other intervention has been definitively shown to improve survival or neurological outcome.

Organized rapid delivery of out-of-hospital BLS and ALS has improved the outcome of drowning victims in cardiac arrest, perhaps the best-studied scenario of out-of-hospital cardiac arrest.¹⁵,⁵⁷ Because most pediatric arrests are secondary to progressive respiratory failure and/or shock and because VF is relatively uncommon, immediate CPR (“phone fast”) is recommended for pediatric victims of cardiopulmonary arrest in the out-of-hospital setting rather than the adult approach, immediate EMS activation (“phone first”) and/or defibrillation. Effective BLS should be provided for infants and children as quickly as possible.

There are some circumstances in which primary arrhythmic cardiac arrest (ie, VF or pulseless ventricular tachycardia) is more likely; in these circumstances the lay rescuer may be instructed to activate the EMS system before beginning CPR. Examples include the sudden collapse of children with underlying cardiac disease or a history of arrhythmias. Families of children with identified risk for sudden cardiac arrest should be taught the “phone first” or adult sequence of CPR: if the child collapses suddenly, a lone bystander should first activate the local emergency medical response system and then return to the victim to begin CPR. Of course, whenever multiple rescuers are present for the victim of any age, one rescuer should remain with the victim to begin CPR while the other activates the emergency medical response system.

A sudden witnessed collapse in a previously healthy child or adolescent suggests that the arrest is cardiac in origin, and immediate activation of the EMS system may be beneficial, even if the victim is <8 years of age. Potential causes of sudden collapse in children with no known history of heart disease include prolonged-QT syndrome, hypertrophic cardiomyopathy, and drug-induced cardiac arrest.³⁶,⁵⁸,⁵⁹ Drug-induced arrest is most likely to occur in the adolescent age group related to a drug overdose.

Although it may be ideal to ask rescuers to individualize each resuscitation sequence on the basis of the most likely etiology of the victim’s cardiac arrest, this approach is impractical. Education of the lay rescuer is most effective if the message is simple and can be applied in a wide variety of situations. The more complex the teaching sequence or message, the less likely it is that the rescuer will remember what to do and do it.⁶⁰,⁶¹ Therefore, a simple, consistent message for lone lay rescuers of most infants and children is to “phone fast”—provide approximately 1 minute of CPR and then activate (phone) the EMS system.

In victims ≥8 years of age in the out-of-hospital setting, the adult Chain of Survival and resuscitation sequence is recommended. If the victim is unresponsive, the lone rescuer should immediately activate the EMS response system and retrieve the AED, if available. The “phone first” approach is particularly appropriate if the victim has experienced a sudden arrest. Again, exceptions to this rule should be noted. If the victim’s arrest is secondary to submersion (near-drowning), a “phone fast” approach is appropriate. For near-drowning victims of all ages, immediate CPR should begin while the victim is still in the water. Immediate bystander CPR is associated with improved early return of spontaneous circulation and neurologically intact survival for submersion victims of all ages.¹⁵,⁶² Other victims ≥8 years of age who may benefit from immediate CPR include those with respiratory or cardiac arrest caused by trauma and those with respiratory or cardiac arrest caused by drug overdose.

In the hospital setting the most common causes of cardiac arrest include sepsis, respiratory failure, drug toxicity, metabolic disorders, and arrhythmia. These in-hospital causes of arrest are often complicated by underlying (premorbid) conditions. The emergency department represents a transition from the out-of-hospital to hospital location; therefore, cardiac arrest may develop in children with underlying conditions typical for the hospital setting and in children with conditions seen more often in the out-of-hospital setting.

**BLS for Children With Special Needs**

Children with special health care needs have chronic physical, developmental, behavioral, or emotional conditions and require health and related services of a type or amount not usually required by typically developing children.⁶³–⁶⁵ These children may need emergency care for acute, life-threatening complications that are unique to their chronic conditions,⁶⁶ such as obstruction of a tracheostomy, failure of support technology (eg, ventilator failure), or progression of underlying respiratory failure or neurological disease. However, approximately half of EMS responses to children with special health care needs are unrelated to the child’s special needs and may include traditional causes of EMS calls, such as trauma,⁶⁸ which require no treatment beyond the normal EMS standard of care.

Emergency care of children with special health care needs, however, can be complicated by lack of specific medical information about the child’s baseline condition, medical plan of care, current medications, and any “do not attempt to resuscitate” orders. Certainly the best source of information about a chronically ill child is the person who cares for the child on a daily basis. However, if that person is unavailable or incapacitated (eg, following an automobile crash), some means is needed to access important information. A wide variety of methods have been developed to make this information immediately accessible, including the use of standard forms, containers kept in a standard place in the home (eg, the refrigerator), window stickers, wallet cards, and medical alert bracelets. No single method of communicating information has proved to be superior. A standardized form, the Emergency Information Form (EIF), was developed by the American Academy of Pediatrics and the American College of

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*References 4, 6, 8, 9, 16, 18, 35, 40, 46, 47, 49–56.*
Emergency Physicians65 and is available on the Worldwide Web (http://www.pediatrics.org/cgi/content/full/104/4/e53). Parents and child care providers should keep essential medical information at home, with the child, and at the child’s school or child care facility. Child care providers should have access to this information and should be familiar with signs of deterioration in the child and any existing advance directives.66,67

If the physician, parents, and child (as appropriate) have made a decision to limit resuscitation efforts or withhold attempts at resuscitation, a physician order indicating the limits of resuscitative efforts must be written for use in the in-hospital setting; in most countries, a separate order must be written for the out-of-hospital setting. Legal issues and regulations regarding requirements for these out-of-hospital no-CPR directives vary from country to country and, in the United States, from state to state. However, it is always important for families to inform the local EMS system when such directives are established for out-of-hospital care. For further information about ethical issues of resuscitation, see “Part 2: Ethical Aspects of CPR and ECC.”

Whenever a child with a chronic or life-threatening condition is discharged from the hospital, parents, school nurses, and any home healthcare providers should be informed about possible complications that the child may experience and anticipated signs of deterioration and their cause. Specific instructions should be given regarding CPR and other interventions that the child may require, as well as instructions about who to contact and why.67

If the child has a tracheostomy, anyone responsible for the child’s care (including parents, school nurses, and home healthcare providers) should be taught to assess airway patency, clear the airway, and provide CPR with the artificial airway. If CPR is required, rescue breathing and bag-mask ventilation are performed through the tracheostomy tube. As with any form of rescue breathing, effective ventilation is judged by adequate bilateral chest expansion. If the tracheostomy tube becomes obstructed and impossible to use, even after attempts to clear the tube with suctioning, the tube should be replaced. If a clean tube is not available, provide ventilations at the tracheostomy stoma until an artificial airway can be placed. If the upper airway is patent, it may be possible to provide effective conventional bag-mask ventilation through the nose and mouth while occluding the suprificial tracheal stoma site.

Out-of-Hospital (EMS) Care
EMS systems were initially created for adults in developed nations. EMS equipment, training, experience, and expertise are often less well developed to meet the needs of children. In the United States death rates are higher in children than in adults treated in the EMS system, especially in areas where tertiary pediatric care is unavailable.68–75 To improve pediatric out-of-hospital care, EMS personnel should be optimally trained and equipped to care for pediatric victims (see “Part 10: Pediatric Advanced Life Support”), medical dispatchers should use emergency protocols appropriate for children, and emergency departments caring for children should be appropriately staffed and equipped. Emergency departments that care for acutely ill or injured children should have an ongoing agreement with a pediatric tertiary service through which patients can receive postresuscitation care in a pediatric intensive care unit (ICU) under the supervision of trained personnel.

Prevention of Cardiopulmonary Arrest in Infants and Children

Prevention of Sudden Infant Death Syndrome
SIDS is the sudden death of an infant, typically between the ages of 1 month and 1 year, that is unexpected from history and unexplained by other causes when a postmortem examination is performed. SIDS probably represents a variety of conditions, all of which result in death while sleeping. It is probably caused by several mechanisms, including rebreathing asphyxia, with a decreased arousal and possible blunted response to hypoxemia or hypercarbia.76 The peak incidence of SIDS occurs in infants 2 to 4 months of age; 70% to 90% of SIDS deaths are reported in the first 6 months of life.76 Many characteristics are associated with increased risk of SIDS, including prone sleeping position, the winter months, infants of lower-income families, males, siblings of SIDS victims, infants of mothers who smoke cigarettes, infants who have survived severe apparent life-threatening events, infants of mothers who are drug addicts, and low birthweight infants.

One of the most successful public health initiatives to reduce infant mortality was based on the observation that the risk of SIDS is associated with the prone (on the stomach) sleeping position. Infants who sleep prone have a much higher frequency of SIDS than infants who sleep supine (on the back) or on their sides.77–79 The prone position, particularly on a soft surface, is thought to contribute to rebreathing asphyxia.76 Australia, New Zealand, and several European countries have documented a significant reduction in the incidence of SIDS when parents and child care providers are taught to place healthy infants to sleep supine or on their sides.80 This “Back to Sleep” public education campaign was introduced in the United States in 1992, when approximately 7000 infants died of SIDS. In 1997, 2991 infants died of SIDS in the United States.5

Recent reports from New Zealand80 and England81 have documented a slightly greater risk of SIDS when infants are placed on their sides than when they are placed supine for sleep. Either side or supine position, however, continues to be associated with a much lower risk of SIDS than the prone position.

All parents and those responsible for the care of children should be aware of the need to place healthy infants supine for sleeping. The supine sleeping position has not been associated with an increase in any significant adverse events, such as vomiting or aspiration.77 A side position may be used as an alternative, but infants in this position should be propped and positioned to prevent them from rolling to the prone position. In addition, the infant should not sleep on soft surfaces, such as lambswool, fluffy comforters, or other objects that might trap exhaled air near the infant’s face.

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Injury: The Magnitude of the Problem
In the United States, injury is the leading cause of death in children and adults aged 1 to 44 years and is responsible for more childhood deaths than all other causes combined.12,14 Internationally, injury death rates are highest for children 1 to 14 years of age and young adults 15 to 24 years of age, relative to other causes of death.13,82 The term injury is emphasized rather than the term accident because the injury is often preventable, and the term accident implies that nothing can be done to prevent the episode.

The Science of Injury Control
Injury control attempts to prevent injury or minimize its effects on the child and family in 3 phases: prevention, minimization of injury damage, and postinjury care. In planning of injury prevention strategies, 3 principles deserve emphasis. First, passive injury prevention strategies are generally preferred because they are more likely to be used than active strategies, which require repeated, conscious effort. Second, specific instructions (eg, keep the water heater temperature <120°F to 130°F or 48.9°C to 54.4°C) are more likely to be followed than general advice (eg, reduce the maximum temperature of home tap hot water). Third, individual education reinforced by community-wide educational programs is more effective than isolated educational sessions.83,84 Although current prevention efforts can be directed to those groups with the highest incidence and cost estimates (eg, males, adolescents, and low-income background), more specific strategies will need to be developed with more cause-specific injury morbidity data.82

Epidemiology and Prevention of Common Childhood and Adolescent Injuries
Injury prevention will have the greatest effect by focusing on injuries that are frequent and for which effective strategies are available. The leading causes of death internationally in children 1 to 14 years of age are depicted in Figure 2. The 6 most common types of fatal childhood injuries amenable to injury prevention strategies are motor vehicle passenger injuries, pedestrian injuries, bicycle injuries, submersion, burns, and firearm injuries.12,13,83,85

Prevention of these common fatal injuries would substantially reduce childhood deaths and disability internationally. For this reason, information regarding injury prevention is included with information about infant/child resuscitation. In an attempt to make this information relevant to the largest possible segment of the pediatric population over many years, the following section addresses prevention of injuries in infants, children, and adolescents.

Motor Vehicle Injuries
Motor vehicle–related trauma accounts for nearly half of all pediatric injuries and deaths in the United States and 40% of injury mortality in children 1 to 14 years of age internationally.12,13,57 Motor vehicle traffic death rates for children are lowest in England and Wales, Norway, The Netherlands, and Australia and highest in New Zealand.13 Contributing factors include failure to use proper passenger restraints, inexperienced adolescent drivers, and alcohol abuse. Each of these should be addressed by injury prevention programs.

Proper use of child seat restraints and lap-shoulder harnesses will prevent an estimated 65% to 75% of serious injuries and fatalities to passengers <4 years of age and 45% to 55% of all pediatric motor vehicle passenger injuries and deaths.12,86 The American Academy of Pediatrics, the Centers for Disease Control and Prevention, National Center for Health Statistics, No. 303, October 7, 1998.

1. Children should ride in rear-facing infant seats until they are at least 20 pounds (9 kg) and at least 1 year of age, with good head control. These seats should be secured in the back seat of the automobile.
   • A rear-facing safety seat must never be placed in the front passenger seat of a car with a passenger-side airbag.
   • Convertible seats can be used for children <1 year of age and <20 pounds (9 kg) if they are used in the reclined and rear-facing position.

2. A child who is >1 year old and weighs 20 to 40 pounds (9 to 18 kg) should be placed in a convertible car safety seat used in the upright and forward-facing position as long as he or she fits well in the seat. The harness straps should be positioned at or above the child’s shoulders. These seats should also be placed in the back seat of the automobile.

3. Belt-positioning booster seats should be used for children weighing 40 to 80 pounds (18 to 36 kg) until they are at least 58 to 60 inches (148 cm) in height. These belt-positioning seats ensure that the lap and shoulder belts restrain the child over bones rather than soft tissues.

4. Children may be restrained in automobile lap and shoulder belts when they weigh 40 to 80 pounds (18 to
Pedestrian Injuries

Pedestrian injuries are a leading cause of death among children 5 to 9 years of age in the United States.\textsuperscript{57,83} Internationally, childhood pedestrian injuries are highest in New Zealand, the United States, and Australia.\textsuperscript{13} Pedestrian injuries typically occur when a child darts out into the street, crossing between intersections.\textsuperscript{12} Although educational programs aimed at improving children’s street-related behavior hold promise, roadway interventions, including adequate lighting, construction of sidewalks, and roadway barriers, must also be pursued in areas of high pedestrian traffic.

Bicycle Injuries

Bicycle crashes are responsible for approximately 200,000 injuries and >600 deaths to children and adolescents in the United States every year.\textsuperscript{57,99} Head injuries are the cause of most bicycle injury–related morbidity and mortality. In fact, bicycle-related trauma is a leading cause of severe pediatric closed-head injuries.\textsuperscript{100} Bicycle helmets can prevent an estimated 85% of head injuries and 88% of brain injuries. Yet many parents are unaware of the need for helmets, and children may be reluctant to wear them.\textsuperscript{100,101} A successful bicycle helmet education program includes an ongoing community-wide multidisciplinary approach that provides focused information about the protection afforded by a helmet. Such programs should ensure the acceptability, accessibility, and affordability of helmets.\textsuperscript{99,101}

Submersion/Drowning

Internationally, drowning is responsible for approximately 15% of injury deaths to children 1 to 14 years of age.\textsuperscript{13} It is a significant cause of death and disability in children <4 years old and is a leading cause of death in this age group in the United States.\textsuperscript{12,57,83,102} Drowning constitutes 1 of the top 3 mechanisms of injury death in the 1- to 14-year-old age group in New Zealand, Australia, the United States, France, Canada, The Netherlands, and Israel. New Zealand has the highest rate of childhood drowning.\textsuperscript{13} For every death due to submersion, 6 children are hospitalized, and approximately 20% of hospitalized survivors are severely brain damaged.\textsuperscript{57,103}

Parents should be aware of the dangers to young children posed by any body of water. Young children and children with seizure disorders should never be left unattended in bathtubs or near swimming pools, ponds, or beaches. Some drownings in swimming pools may be prevented by completely surrounding the pool with appropriate fencing, including gates with secure latching mechanisms.\textsuperscript{102,104} The house will not serve as an effective barrier to the pool if it has a door opening onto the pool area.

Children >5 years of age should learn how to swim. No one should ever swim alone, and even supervised children should wear personal flotation devices when playing in rivers, streams, or lakes.

Alcohol appears to be a significant risk factor in adolescent drowning. As a result, adolescent education, limiting access to alcohol, and the use of personal flotation devices on waterways should be encouraged.

Burns

Fires, burns, and suffocation are a leading cause of injury death worldwide and are higher in the United States and Scotland than in the other countries surveyed.\textsuperscript{13} Approximately 80% of fire- and burn-related deaths result from house fires, with associated smoke inhalation injury.\textsuperscript{86,105–108} Most fire-related deaths occur in private residences, usually in homes without working smoke detectors.\textsuperscript{86,105,106,109} From 1995 to 1996 nearly 15% of total US fatalities related to home fires were children <5 years old.\textsuperscript{12} Nonfatal burns and burn
complications, including smoke inhalation, scalds, and contact and electric burns are especially likely to affect children.

Socioeconomic factors such as overcrowding, single-parent families, scarce financial resources, inadequate child care/supervision, and distance from fire department all contribute to increased risk for burn injury. Smoke detectors are one of the most effective interventions for preventing deaths from burns and smoke inhalation. When used correctly, they can reduce fire-related death and severe injury by 86% to 88%. Smoke detectors should be placed near or on the ceilings outside the doors to sleeping or napping rooms and on each floor at the top of the stairway. Parents should be aware of the effectiveness of these devices and the need to change device batteries every 6 months. Families and schools should develop and practice a fire evacuation plan. Continued improvements in flammability standards for furniture, bedding, and home builders’ materials should further reduce the incidence of fire-related injuries and deaths. Child-resistant ignition products are also under investigation. School-based fire-safety programs should be continued and evaluated.

Firearm Injuries
Firearms, particularly handguns, are responsible for a large number of injuries and deaths to infants, children, and adolescents, particularly in the United States, Norway, Israel, and France. Firearm-related deaths may be labeled as unintentional, homicide, or suicide. The United States has the highest firearm-related injury rate of any industrialized nation—more than twice that of any other country.

Although firearm-related deaths have declined from 1995 to 1997 compared with previous years, firearm homicide remains the leading cause of death among African-American adolescents and young adults and the second-highest cause of death among all adolescents and young adults in the United States, Norway, Israel, and France. Firearms have been used in an increasing proportion of child and adolescent suicides. Mortality from firearm injuries is highest in young children, whether the firearm injury is unintentional or related to homicide or suicide.

Most guns used in childhood unintentional shootings, school shootings, and suicides are found in the home. Many firearm owners admit to storing guns loaded and in readily accessible locations. Thirty-four percent of high school students surveyed reported easy access to guns, and an increasing number of children carry guns to school.

If guns are present in homes in which children and adolescents live and visit, it is likely that the children and adolescents will find and handle the guns. The mere presence of a gun in the home is associated with an increased likelihood of adolescent suicide as well as an increased incidence of adult suicide or homicide. Every gun owner, potential gun purchaser, and parent must be made aware of the risks of unsecured firearms and the need to ensure that weapons in the home are inaccessible to unsupervised children and adolescents. Guns should be stored locked and unloaded, with ammunition stored separately from the gun. The consistent use of trigger locks may not only reduce the incidence of unintentional injury and suicide among children and young adolescents but will most likely reduce the number of gun homicides. In addition, locked guns obtained during burglaries would be useless. “Smart” guns, which can only be fired by the gun owner, are expected to reduce the frequency of unintentional injuries and suicides among children and young adolescents and limit the usefulness of guns obtained during burglaries.

Prevention of Choking (Foreign-Body Airway Obstruction)
More than 90% of deaths from foreign-body aspiration in children occur in those younger than 5 years; 65% of victims are infants. With the development of consumer product safety standards regulating the minimum size of toys and toy parts for young children, the incidence of foreign-body aspiration has decreased significantly. However, toys, balloons, small objects, and foods (eg, hot dogs, round candies, nuts, and grapes) may still produce FBAO and should be kept away from infants and small children.

Sequence of Pediatric BLS: The ABCs of CPR
The BLS sequence (see Figure 3) described below refers to both infants (neonate outside the delivery room setting to 1 year of age) and children (1 to 8 years of age) unless specified. For information on newly born infants (resuscitation immediately after birth), see “Part 11: Neonatal Resuscitation.” For BLS for children >8 years of age, see “Part 3: Adult Basic Life Support.”

Resuscitation Sequence
To maximize survival and neurologically intact outcome following life-threatening cardiovascular emergencies, each link in the Chain of Survival must be strong, including prevention of arrest, early and effective bystander CPR, rapid activation of the EMS system, and early and effective ALS (including rapid stabilization and transport to definitive care and rehabilitation). When a child develops respiratory or cardiac arrest, immediate bystander CPR is crucial to survival. In both adult and pediatric studies, bystander CPR is linked to improved return of spontaneous circulation and neurologically intact survival. The greatest impact of bystander CPR will probably be on children with noncardiac (respiratory) causes of out-of-hospital arrest.

Two studies report on the outcome of series of children who were successfully resuscitated before EMS arrival solely by bystander CPR. The true frequency of this type of resuscitation is unknown, but it is likely to be underestimated, because victims successfully resuscitated by bystanders are often excluded from studies of out-of-hospital cardiac arrest. Unfortunately, bystander CPR is provided for only approximately 30% of out-of-hospital pediatric arrests.

BLS guidelines delineate a series of skills performed sequentially to assess and support or restore effective ventilation and circulation to the child with respiratory or cardiorespiratory arrest. Pediatric resuscitation requires a process of observation, evaluation, interventions, and assessments that is difficult to capture in a sequential description of CPR. You should initially assess the victim’s responsiveness and then continuously monitor the victim’s response to intervention (appearance, movement, breathing, etc). Evaluation and intervention are often
simultaneous processes, especially when more than 1 trained provider is present. Although this process is taught as a sequence of distinct steps to enhance skills retention, several actions may be accomplished simultaneously (eg, begin CPR and phone EMS) if multiple rescuers are present. The appropriate BLS actions also depend on the interval since the arrest, how the victim responded to previous resuscitative interventions, and whether special resuscitation circumstances exist.

**Ensure the Safety of Rescuer and Victim**
When CPR is provided in the out-of-hospital setting, the rescuer should first verify the safety of the scene. If resusci-
Assess Responsiveness

Gently stimulate the child and ask loudly, “Are you all right?” Quickly assess the presence or extent of injury and determine whether the child is responsive. Do not move or shake the victim who has sustained head or neck trauma, because such handling may aggravate a spinal cord injury. If the child is responsive, he or she will answer your questions or move on command. If the child responds but is injured or needs medical assistance, you may leave the child in the position found to summon help (phone the EMS system, if needed). Return to the child as quickly as possible and recheck the child’s condition frequently. Responsive children with respiratory distress will often assume a position that maintains airway patency and optimizes ventilation; they should be allowed to remain in the position that is most comfortable to them.

If the child is unresponsive and you are the only rescuer present, be prepared to provide BLS, if necessary, for approximately 1 minute before leaving the child to activate the EMS system. As soon as you determine that the child is unresponsive, shout for help. If trauma has not occurred and the child is small, you may consider moving the child near a telephone so that you can contact the EMS system more quickly. The EMS medical dispatcher may then guide you through CPR. The child must be moved if he or she is in a dangerous location (eg, a burning building) or if CPR cannot be performed where the child was found.

If a second rescuer is present during the initial assessment of the child, that rescuer should activate the EMS system as soon as the emergency is recognized. If trauma is suspected, the second rescuer should activate the EMS system and then may assist in immobilizing the child’s cervical spine, preventing movement of the neck (extension, flexion, and rotation) and torso. If the child must be positioned for resuscitation or moved for safety reasons, support the head and body and turn as a unit.

Activate EMS System if Second Rescuer Is Available

Because all of the links in the Chain of Survival are connected, it is difficult to evaluate the effect of EMS system activation or specific EMS interventions in isolation. In addition, local EMS response intervals, dispatcher training, and EMS protocols may dictate the most appropriate sequence of EMS activation and early life support interventions for a given situation.

Current AHA guidelines instruct the rescuer to provide approximately 1 minute of CPR before activating the EMS system in out-of-hospital arrest for infants and children up to the age of 8 years.1 In the International Guidelines 2000 the “phone first” sequence of resuscitation continues to be recommended for children ≥8 years of age and adults. The “phone fast” sequence of resuscitation continues to be recommended for children <8 years of age on the basis of face and construct validity (Class Indeterminate).

The AHA Subcommittees on Pediatric Resuscitation and BLS and a panel addressing the citizen’s response in the Chain of Survival debated a proposal to teach lay rescuers to tailor the CPR sequence and EMS activation to the likely cause of the victim’s arrest rather than the victim’s age. This proposed approach would teach lone lay rescuers to provide 1 minute of CPR before activating the EMS system if a victim of any age collapses with what is thought to be a probable breathing/respiratory problem. Lone lay rescuers would also be taught to activate the EMS system immediately if a victim of any age collapses suddenly (presumed sudden cardiac arrest). Although the proposal has appeal when considered for an individual victim, it was rejected for several reasons. First, no data was presented that indicated that a change to an etiology-based triage method for all age groups would improve survival for victims of out-of-hospital cardiac arrest. Second, the proposal would probably complicate the education of lay rescuers. CPR instruction must remain simple for lay rescuers. Retention of CPR skills and knowledge is already suboptimal. The addition of complex instructions to existing CPR guidelines would most likely make them more difficult to teach, learn, remember, and perform.132–136

It is important to note that the “phone first” or “phone fast” sequence is applicable only to the lone rescuer. When multiple rescuers are present, 1 rescuer remains with the victim of any age to begin CPR while another rescuer goes to activate the EMS system. It is unknown how frequently 2 or more lay responders are present during initial evaluation of a pediatric cardiopulmonary emergency.

Sophisticated healthcare providers, family members, and potential rescuers of infants and children at high risk for cardiopulmonary emergencies should be taught a sequence of rescue actions tailored to the potential victim’s specific high-risk condition.139 For example, parents and child care providers of children with congenital heart disease who are known to be at risk for arrhythmias should be instructed to “phone first” (activate the EMS system before beginning CPR) if they are alone and the child suddenly collapses.
Alternatively, there may be exceptions to the “phone first” approach for victims ≥8 years of age, including adults. Parents of children ≥8 years of age who are at high risk for apnea or respiratory failure should be instructed to provide 1 minute of CPR before activating the EMS system if they are alone and find the child unresponsive. Submersion (near-drowning) victims of all ages who are unresponsive when pulled from the water should receive approximately 1 minute of BLS support (opening of the airway and rescue breathing and chest compressions, if needed) before the lone rescuer leaves to phone the local EMS system. Trauma victims or those with a drug overdose or apparent respiratory arrest of any age may also benefit from 1 minute of CPR before the EMS system is contacted. Knowledgeable and experienced providers should use common sense and “phone first” for any apparent sudden cardiac arrest (eg, sudden collapse at any age) and “phone fast” in other circumstances in which breathing difficulties are documented or likely to be present (eg, trauma or an apparent choking event).

The rescuer calling the EMS system should be prepared to provide the following information:

1. Location of the emergency, including address and names of streets or landmarks
2. Telephone number from which the call is being made
3. What happened, eg, auto accident, submersion
4. Number of victims
5. Condition of victim(s)
6. Nature of aid being given
7. Any other information requested

The caller should hang up only when instructed to do so by the dispatcher, and then caller should report back to rescuer doing CPR.

Hospitals and medical facilities and many businesses and building complexes have established emergency medical response systems that provide a first response or early response on-site. Such a response system notifies rescuers of the location of an emergency and the type of response needed. If the cardiopulmonary emergency occurs in a facility with an established medical response system, that system should be notified, because it can respond more quickly than EMS personnel arriving from outside the facility. For rescuers in these facilities, the emergency medical response system should replace the EMS system in the sequences below.

Airway

Position the Victim
If the child is unresponsive, move the child as a unit to the supine (face up) position, and place the child supine on a flat, hard surface, such as a sturdy table, the floor, or the ground. If head or neck trauma is present or suspected, move the child only if necessary and turn the head and torso as a unit. If the victim is an infant, and no trauma is suspected, carry the child supported by your forearm (your forearm should support the long axis of the infant’s torso, with the infant’s legs straddling your elbow and your hand supporting the infant’s head). It may be possible to carry the infant to the phone in this manner while beginning the steps of CPR.

Open the Airway

The most common cause of airway obstruction in the unresponsive pediatric victim is the tongue. Therefore, once the child is found to be unresponsive, open the airway using a maneuver designed to lift the tongue away from the back of the pharynx, creating an open airway.

Head Tilt–Chin Lift Maneuver
If the victim is unresponsive and trauma is not suspected, open the child’s airway by tilting the head back and lifting the chin (Figure 4). Place one hand on the child’s forehead and gently tilt the head back. At the same time place the fingertips of your other hand on the bony part of the child’s lower jaw, near the point of the chin, and lift the chin to open the airway. Do not push on the soft tissues under the chin as this may block the airway. If injury to the head or neck is suspected, use the jaw-thrust maneuver to open the airway; do not use the head tilt–chin lift maneuver.

Jaw-Thrust Maneuver
If head or neck injury is suspected, use only the jaw-thrust method of opening the airway. Place 2 or 3 fingers under each side of the lower jaw at its angle, and lift the jaw upward and outward (Figure 5). Your elbows may rest on the surface on which the victim is lying. If a second rescuer is present, that rescuer should immobilize the cervical spine (see “BLS in Trauma” below) after the EMS system is activated.

Foreign-Body Airway Obstruction

If the victim becomes unresponsive with an FBAO or if an FBAO is suspected, open the airway wide and look for an object in the pharynx. If an object is present, remove it carefully (under vision). Healthcare providers should perform a tongue-jaw lift to look for obstructing objects (see next section), but this maneuver will not be taught to lay rescuers.

Techniques for Healthcare Providers

Hypoxia and respiratory arrest may cause or contribute to acute deterioration and cardiopulmonary arrest. Thus, maintenance of a patent airway and support of adequate ventilation are essential. Both the head tilt–chin lift and jaw-thrust
techniques should be taught to lay rescuers. Healthcare providers should also learn additional maneuvers, such as the tongue-jaw lift, for use in unresponsive victims of FBAO. Healthcare providers are taught a sequence of actions to attempt to relieve FBAO in the unresponsive victim. If FBAO is suspected, open the airway using a tongue-jaw lift and look for the foreign body before attempting ventilation. If you see the foreign body, remove it carefully (under vision).

Breathing
Assessment: Check for Breathing
Hold the victim’s airway open and look for signs that the victim is breathing. Look for the rise and fall of the chest and abdomen, listen at the child’s nose and mouth for exhaled breath sounds, and feel for air movement from the child’s mouth on your cheek for no more than 10 seconds.

It may be difficult to determine whether the victim is breathing. Care must be taken to differentiate ineffective, gasping, or obstructed breathing efforts from effective breathing. If you are not confident that respirations are adequate, proceed with rescue breathing.

If the child is breathing spontaneously and effectively and there is no evidence of trauma, turn the child to the side in a recovery position (Figure 6). This position should help maintain a patent airway. Although many recovery positions are used in the management of pediatric patients, no single recovery position can be universally endorsed on the basis of scientific studies of children. There is consensus that an ideal recovery position should be a stable position that enables the following: maintenance of a patent airway, maintenance of cervical spine stability, minimization of risk for aspiration, limitation of pressure on bony prominences and peripheral nerves, visualization of the child’s respiratory effort and appearance (including color), and access to the patient for interventions.

Provide Rescue Breathing
If no spontaneous breathing is detected, maintain a patent airway by head tilt–chin lift or jaw thrust. Carefully (under vision) remove any obvious airway obstruction, take a deep breath, and deliver rescue breaths. With each rescue breath, provide a volume sufficient for you to see the child’s chest rise. Provide 2 slow breaths (1 to 1½ seconds per breath) to the victim, pausing after the first breath to take a breath to maximize oxygen content and minimize carbon dioxide concentration in the delivered breaths. Your exhaled air can provide oxygen to the victim, but the rescue breathing pattern you use will affect the amount of oxygen and carbon dioxide delivered to the victim. When ventilation adjuncts and oxygen are available (eg, bag-mask) to assist with ventilation, provide high flow oxygen to all unresponsive victims or victims in respiratory distress.

The 1992 guidelines recommended that 2 initial breaths be delivered. The current ILCOR recommendations suggest that between 2 and 5 rescue breaths should be delivered initially to ensure that at least 2 effective ventilations are provided. There is no data to support the choice of any single number of initial breaths to be delivered to the unresponsive, nonbreathing victim. Most pediatric victims of cardiac arrest are both hypoxic and hypercarbic. If the rescuer is unable to establish effective ventilation with 2 rescue breaths, additional breaths may be beneficial in improving oxygenation and restoring an adequate heart rate for an apneic, bradycardic infant or child. There is inadequate data to recommend changing the number of initial ventilations delivered during CPR at this time. Therefore, lay rescuers and healthcare providers should administer 2 initial effective breaths to the unresponsive, nonbreathing infant or child (Class Indeterminate). The rescuer should ensure that at least 2 breaths delivered are effective and produce visible chest rise.

Mouth-to-Mouth-and-Nose and Mouth-to-Mouth Breathing
If the victim is an infant (<1 year old), place your mouth over the infant’s mouth and nose to create a seal (Figure 7). Blow into the infant’s nose and mouth (pausing to inhale between breaths), attempting to make the chest rise with each breath. A variety of techniques can be used to provide rescue breathing for infants. A rescuer with a small mouth may have difficulty covering both the nose and open mouth of a large infant. Under these conditions, mouth-to-nose ventilation may be adequate. There is no convincing data to justify a change from the recommendation that the rescuer attempt mouth-to-mouth-and-nose ventilation for infants up to 1 year of age. During rescue breathing attempts you must maintain good head position for the infant (head tilt–chin lift to maintain a patent airway) and create an airtight seal over the airway.

The mouth-to-nose rescue breathing technique is a reasonable adjunctive or alternative method of providing rescue breathing for an infant (Class IIb). The mouth-to-nose breath-
ing technique may be particularly useful if you have difficulty with the mouth-to-mouth-and-nose technique. To perform mouth-to-nose ventilation, place your mouth over the infant’s nose and proceed with rescue breathing. It may be necessary to close the infant’s mouth during rescue breathing to prevent the rescue breaths from escaping through the infant’s mouth. A chin lift will help maintain airway patency by moving the tongue forward and may help keep the mouth closed.

If the victim is a large infant or a child (1 to 8 years of age), provide mouth-to-mouth rescue breathing. Maintain a head tilt–chin lift or jaw thrust (to keep the airway patent), and pinch the victim’s nose tightly with thumb and forefinger. Make a mouth-to-mouth seal and provide 2 rescue breaths, making sure that the child’s chest rises visibly with each breath (Figure 8). Inhale between rescue breaths.

**Evaluation of Effectiveness of Breaths Delivered**

Rescue breaths provide essential support for a nonbreathing infant or child. Because children vary widely in size and lung compliance, it is impossible to make precise recommendations about the pressure or volume of breaths to be delivered during rescue breathing. Although the goal of assisted ventilation is delivery of adequate oxygen and removal of carbon dioxide with the smallest risk of iatrogenic injury, measurement of oxygen and CO₂ levels during pediatric BLS is often not practical. Therefore, the volume of each rescue breath should be sufficient to cause the chest to visibly rise without causing excessive gastric distention. If the child’s chest does not rise during rescue breathing, ventilation is not effective. Because the small airway of the infant or child may provide high resistance to air flow, particularly in the presence of large or small airway obstruction, a relatively high pressure may be required to deliver an adequate volume of air to ensure chest expansion. The correct volume for each breath is the volume that causes the chest to rise.

If air enters freely and the chest rises, the airway is clear. If air does not enter freely (if the chest does not rise), either the airway is obstructed or greater volume or pressure is needed to provide adequate rescue breaths. Improper opening of the airway is the most common cause of airway obstruction and inadequate ventilation during resuscitation. As a result, if air does not enter freely and the chest does not rise during initial ventilation attempts, reposition the airway and reattempt ventilation. It may be necessary to move the child’s head through a range of positions to obtain optimal airway patency and effective rescue breathing. The head should not be moved if neck or spine trauma is suspected; the jaw thrust should be used to open the airway in these victims. If rescue breathing fails to produce chest expansion despite repeated attempts at opening the airway, an FBAO may be present (see “Foreign-Body Airway Obstruction” below).

The ideal ventilation rate during CPR and low circulatory flow states is unknown. Current recommended ventilation (rescue breathing) rates are derived from normal respiratory rates for age, with some adjustments for the time needed to coordinate rescue breathing with chest compressions to ensure that ventilation is adequate.

**Cricoid Pressure**

Rescue breathing, especially if performed rapidly, may cause gastric distention. Excessive gastric distention can interfere with rescue breathing by elevating the diaphragm and decreasing lung volume, and it may result in regurgitation of gastric contents. Gastric distention may be minimized if rescue breaths are delivered slowly during rescue breathing, because slow breaths will enable delivery of effective tidal volume at low inspiratory pressure. Deliver initial breaths slowly, over 1 to 1½ seconds, with a force sufficient to make the chest visibly rise. Firm but gentle pressure on the cricoid cartilage during ventilation may help compress the esophagus
and decrease the amount of air transmitted to the stomach.\textsuperscript{172,173} Healthcare providers may insert a nasogastric or orogastric tube to decompress the stomach if gastric distention develops during resuscitation. Ideally this is done after tracheal intubation.

**Ventilation With Barrier Devices**

Mouth-to-mouth rescue breathing is a safe and effective technique that has saved many lives. Despite decades of experience indicating its safety for victims and rescuers alike, some potential rescuers may hesitate to perform mouth-to-mouth rescue breathing because of concerns about transmission of infectious diseases. Most children who require resuscitation outside the hospital arrest at home, and the primary child care provider is aware of the child’s infectious status. Adults who work with children (particularly infants and preschool children) are exposed to pediatric infectious agents daily and often may experience the consequent illnesses. In contrast, the exposure of rescuers to victims is brief, and infections after mouth-to-mouth rescue breathing are extremely rare.\textsuperscript{130}

Although healthcare providers typically have access to barrier devices, in most lay rescue situations these devices are not immediately available. If the child is unresponsive and apneic, immediate provision of mouth-to-mouth rescue breathing may be lifesaving. Rescue breathing should not be delayed while the rescuer searches for a barrier device or tries to learn how to use it.

If an infection control barrier device is readily available, some rescuers may prefer to provide rescue breathing with such a device (Class Indeterminate). Barrier devices may improve esthetics for the rescuer but have not been shown to reduce the risk of disease transmission.\textsuperscript{130,174} In addition, barrier devices may increase resistance to gas flow.\textsuperscript{175,176} Rescuers with a duty to respond and those who respond in the workplace should have a supply of barrier devices readily available for use during any attempted resuscitation and should be trained in their use.

Two broad categories of barrier devices are available: masks and face shields. Most masks have a 1-way valve, which prevents the victim’s exhaled air from entering the rescuer’s mouth. When barrier devices are used in resuscitation of infants and children, they are used in the same manner as in resuscitation of adults (see “Part 3: Adult BLS”).

**Bag-Mask Ventilation**

Healthcare providers who provide BLS for infants and children should be trained to deliver effective oxygenation and ventilation with a manual resuscitator bag and mask (Class IIa). Ventilation with a bag-mask device requires more skill than mouth-to-mouth or mouth-to-mask ventilation and should be used only by personnel who have received proper training. Training should focus on selection of an appropriately sized mask and bag, opening the airway and securing the mask to the face, delivering adequate ventilation, and assessing the effectiveness of ventilation. Periodic demonstration of proficiency is recommended.

**Types of Ventilation Bags (Manual Resuscitators).** There are 2 basic types of manual resuscitators (ventilation bags): self-inflating and flow-inflating resuscitators. Ventilation bags should be self-inflating and available in child and adult sizes suitable for the entire pediatric age range.

Flow-inflating bags (also called anesthesia bags) refill only with oxygen inflow, and the inflow must be individually regulated. Since flow-inflating manual resuscitators are more difficult to use, they should be used only by trained personnel.\textsuperscript{177} Flow-inflating bags permit continuous delivery of supplemental oxygen to a spontaneously breathing victim. In contrast, self-inflating bag-mask systems that contain a fish-mouth or leaf-flap outlet valve cannot be used to provide continuous supplemental oxygen during spontaneous ventilation. When the bag is not squeezed, the child’s inspiratory effort may be insufficient to open the valve. In such a case the child will receive inadequate oxygen flow (a negligible flow of oxygen escapes through the outlet valve) and will rebreathe the exhaled gases contained in the mask.

Neonatal-size (250 mL) ventilation bags may be inadequate to support effective tidal volume and the longer inspiratory times required by full-term neonates and infants.\textsuperscript{178,179} For this reason, resuscitation bags used for ventilation of full-term newly born infants, infants, and children should have a minimum volume of 450 to 500 mL. Studies involving infant manikins demonstrated that effective infant ventilation can be achieved with pediatric (and larger) resuscitation bags.\textsuperscript{165}

Regardless of the size of the manual resuscitator used, the rescuer should use only the force and tidal volume necessary to cause the chest to rise visibly. Excessive ventilation volumes and airway pressures may have harmful effects. They may compromise cardiac output by raising intrathoracic pressure, distending alveoli and/or the stomach, impeding ventilation, and increasing the risk of regurgitation and aspiration.\textsuperscript{180} In patients with small-airway obstructions (eg, asthma and bronchiolitis), excessive tidal volume and ventilation rate can result in air trapping, barotrauma, air leak, and severely compromised cardiac output. In the patient with a head injury or cardiac arrest, excessive ventilation volume and rate may result in hyperventilation with potentially adverse effects on neurological outcome. Therefore, the goal of ventilation with a bag and mask should be to approximate normal ventilation and achieve physiological oxygen and carbon dioxide levels while minimizing risk of iatrogenic injury (Class IIa).

Ideally, bag-mask systems used for resuscitation should either have no pressure-relief valve or have a valve with an override feature to permit use of high pressures, if necessary, to achieve visible chest expansion.\textsuperscript{180} High pressures may be required during bag-mask ventilation of patients with upper or lower airway obstruction or poor lung compliance. In these patients a pressure-relief valve may prevent delivery of sufficient tidal volume.\textsuperscript{181} The self-inflating bag delivers only room air (21% oxygen) unless the bag is joined to an oxygen source. At an oxygen inflow of 10 L/min, pediatric bag-valve devices without oxygen reservoirs deliver from 30% to 80% oxygen to the patient.\textsuperscript{181} The actual concentration of oxygen delivered is unpredictable because a variable amount of room air is pulled into the bag to replace some of the gas mixture delivered to the patient. To deliver consistently higher oxygen concentra-
tions (60% to 95%), all bag-valve devices used for resuscitation should be equipped with an oxygen reservoir. At least 10 to 15 L/min of oxygen flow is required to maintain an adequate oxygen volume in the reservoir of a pediatric manual resuscitator, and this should be considered the minimum flow rate.181 The larger adult manual resuscitators require $15 \text{ L/min}$ of oxygen flow to reliably deliver high oxygen concentrations.

**Technique.** To provide bag-mask ventilation, select a bag and mask of appropriate size. The mask must be able to completely cover the victim’s mouth and nose without covering the eyes or overlapping the chin. Once the bag and mask are selected and connected to an oxygen supply, open the victim’s airway and seal the mask to the face.

If no signs of trauma are present, tilt the victim’s head back to help open the airway. If trauma is suspected, do not move the head. To open the airway of the victim with trauma, lift the jaw, using the last 3 fingers (fingers 3, 4, and 5) of one hand. Position these 3 fingers under the angle of the mandible to lift the jaw up and forward. Do not put pressure on the soft tissues under the jaw, because this may compress the airway. When lifting the jaw, you also lift the tongue off the posterior pharynx, preventing the tongue from obstructing the pharynx. Place your thumb and forefinger in a “C” shape over the mask and exert downward pressure on the mask. This hand position uses the thumb and forefinger to squeeze the mask onto the face while the remaining fingers of the same hand lift the jaw, pulling the face toward the mask. This should create a tight seal between the mask and the victim’s face (Figure 9A). This technique of opening the airway and sealing the mask to the face is called the “E-C clamp” technique. Fingers 3, 4, and 5 form an E positioned under the jaw to provide a chin lift; the thumb and index finger form a C and hold the mask on the child’s face. Once you successfully apply the mask with one hand, compress the ventilation bag with the other hand until the chest visibly rises.

Superior bag-mask ventilation can be achieved with 2 rescuers, and 2 rescuers may be required when the victim has significant airway obstruction or poor lung compliance (Figure 9B). One rescuer uses both hands to open the airway and maintain a tight mask-to-face seal while the other rescuer compresses the ventilation bag (see “Part 3: Adult BLS,” 2-rescuer technique for bag-mask ventilation).182 Both rescuers should observe the chest to ensure that it rises visibly with each breath.

**Gastric Inflation.** Gastric inflation in unresponsive or obtunded patients can be minimized by increasing inspiratory time so the necessary tidal volume can be delivered at low peak inspiratory pressures. Pace the ventilation rate and ensure adequate time for exhalation. To reduce gastric inflation, a second trained provider can apply cricoid pressure, but only with an unconscious victim.173 Cricoid pressure may also prevent regurgitation (and possible aspiration) of gastric contents.183,184 Do not use excessive pressure on the cricoid cartilage, because it may produce tracheal compression and obstruction or distortion of the upper airway anatomy.185 Gastric distention after prolonged bag-mask ventilation can limit effective ventilation.166 If gastric distention develops, healthcare providers should decompress the stomach with an orogastric or a nasogastric tube. If tracheal intubation is planned, you ideally defer gastric intubation until after tracheal intubation is accomplished. This will reduce the risk of vomiting and laryngospasm.

**Ventilation Through a Tracheostomy or Stoma**

Anyone responsible for the care of a child with a tracheostomy (including parents, school nurses, and home healthcare providers) should be taught to ensure that the airway is patent and to provide CPR by using the artificial airway. If CPR is required, perform rescue breathing and bag-mask ventilation through the tracheostomy. As with any form of rescue breathing, the key sign of effective ventilation is adequate chest expansion bilaterally. If the tracheostomy becomes obstructed and ventilation cannot be provided through it, remove and replace the tracheostomy tube. If a clean tube is not available, provide ventilation at the tracheostomy stoma until the site can be intubated with a tracheostomy or tracheal tube. If the child’s upper airway is patent, it may be possible to provide bag-mask ventilation through the nose and mouth.

![Figure 9. Bag-mask ventilation for child victim. A, 1 rescuer; B, 2 rescuers.](http://circ.ahajournals.org/)

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**Figure 9.** Bag-mask ventilation for child victim. A, 1 rescuer; B, 2 rescuers.
using a conventional bag and mask while occluding the superficial tracheal stoma site.

Oxygen
Healthcare providers should administer oxygen to all seriously ill or injured patients with respiratory insufficiency, shock, or trauma as soon as it is available. In these patients inadequate pulmonary gas exchange and/or inadequate cardiac output limits tissue oxygen delivery.

During cardiac arrest a number of factors contribute to severe progressive tissue hypoxia and the need for supplementary oxygen administration. At best, mouth-to-mouth ventilation provides 16% to 17% oxygen with a maximal alveolar oxygen tension of 80 mm Hg. Because even optimal external chest compressions provide only a fraction of the normal cardiac output, blood flow to the brain and body and tissue oxygen delivery are markedly diminished. In addition, CPR is associated with right-to-left pulmonary shunting due to ventilation-perfusion mismatch. Preexisting expiratory conditions may further compromise oxygenation. The combination of low blood flow and low oxygenation contributes to metabolic acidosis and organ failure. For these reasons, oxygen should be administered to children with demonstrated cardiopulmonary arrest or compromise, even if measured arterial oxygen tension is high. Whenever possible, administered oxygen should be humidified to prevent drying and thickening of pulmonary secretions; dried secretions may contribute to obstruction of natural or artificial airways.

Occasionally an infant may require reduced inspired oxygen concentration or manipulation of oxygenation and ventilation to control pulmonary blood flow (eg, the neonate with single ventricle). A review of these unique situations is beyond the scope of this document.

Oxygen may be administered during bag-mask ventilation. In addition, if the victim is breathing spontaneously, oxygen may be delivered by nasal cannula, simple face masks, and nonrebreathing masks (for further information, see “Part 10: Pediatric Advanced Life Support”). The concentration of oxygen delivered depends on the oxygen flow rate, the type of mask being used, and the patient’s minute ventilation. As long as the flow of oxygen exceeds the maximal inspiratory flow rate, the prescribed concentration of oxygen will be delivered. If the inspiratory flow rate exceeds the oxygen flow rate, room air is entrained, reducing the oxygen concentration delivered to the patient.

Circulation
Assessment: No Pulse Check for Lay Rescuers
When you have opened the airway and provided 2 effective rescue breaths, determine whether the victim is in cardiac arrest and requires chest compressions. Cardiac arrest results in the absence of signs of circulation, including the absence of a pulse. The pulse check has been the “gold standard” usually relied on by professional rescuers to evaluate circulation. The carotid artery is palpated for the pulse check in adults and children; brachial artery palpation is recommended in infants. In the previous guidelines the pulse check was used to identify pulseless patients in cardiac arrest who required chest compression. If the rescuer failed to detect a pulse in 5 to 10 seconds in an unresponsive nonbreathing victim, cardiac arrest was presumed to be present and chest compressions were initiated.

Since 1992 several published studies have questioned the validity of the pulse check as a test for cardiac arrest, particularly when used by laypersons. Previous guidelines de-emphasized the pulse check for infant-child CPR for 2 reasons. First, 3 small studies suggested that parents had difficulty finding and counting the pulse even in healthy infants. Second, the reported complication rate from chest compressions in infants and children is low. After publication of the 1992 ECC Guidelines, additional investigators evaluated the reliability of the pulse check with adult manikin simulation in unconscious adult patients undergoing cardiopulmonary bypass, unconscious mechanically ventilated adult patients, and conscious adult “test persons.” These studies concluded that as a diagnostic test for cardiac arrest, the pulse check has serious limitations in accuracy, sensitivity, and specificity.

When lay rescuers check the pulse, they often spend a long time deciding whether or not a pulse is present; then they may fail 1 time out of 10 to recognize the absence of a pulse or cardiac arrest (poor sensitivity). When assessing unresponsive victims who do have a pulse, lay rescuers miss the pulse 4 times out of 10 (poor specificity). Details of the published studies include the following conclusions:

1. Rescuers take far too much time to check the pulse: most rescue groups, including laypersons, medical students, paramedics, and physicians, take much longer than the recommended period of 5 to 10 seconds to check for the carotid pulse in adult victims. In 1 study half of the rescuers required >24 seconds to decide whether a pulse was present. Only 15% of the participants correctly confirmed the presence of a pulse within 10 seconds, the maximum time allotted for the pulse check.

2. When used as a diagnostic test, the pulse check is extremely inaccurate. In the most comprehensive study documented, the accuracy of the pulse check was described as follows:
   a. Sensitivity (ability to correctly identify victims who have no pulse and are in cardiac arrest) is only 90%. When subjects were pulseless, rescuers thought a pulse was present approximately 10% of the time. By mistakenly thinking a pulse is present when it is not, rescuers fail to provide chest compressions for 10 of every 100 victims of cardiac arrest. Without a resuscitation attempt, the consequence of such errors would be death for 10 of every 100 victims of cardiac arrest.
   b. Specificity (ability to correctly recognize victims who have a pulse and are not in cardiac arrest) is only 60%. When the pulse was present, rescuers assessed the pulse as being absent approximately 40% of the time. By erroneously thinking a pulse is absent, rescuers provide chest compressions for approximately 4 of 10 victims who do not need them.
   c. Overall accuracy was 65%, leaving an error rate of 35%.

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Data is limited regarding the specificity and sensitivity of the pulse check in pediatric victims of cardiac arrest. Three studies have documented the inability of lay rescuers to find and count a pulse in healthy infants. Healthcare providers may also have difficulty reliably separating venous from arterial pulsation during CPR.

On a review of this and other data, the experts and delegates at the 1999 Evidence Evaluation Conference and the International Guidelines 2000 Conference concluded that the pulse check could not be recommended as a tool for lay rescuers to use in the CPR sequence to identify victims of cardiac arrest. If rescuers use the pulse check to identify victims of cardiac arrest, they will “miss” true cardiac arrest at least 10 of 100 times. In addition, rescuers will provide unnecessary chest compressions for many victims who are not in cardiac arrest and do not require such an intervention. This error is less serious but still undesirable. Clearly more worrisome is the potential failure to intervene for a substantial number of victims of cardiac arrest who require immediate intervention to survive.

Therefore, the lay rescuer should not rely on the pulse check to determine the need for chest compressions. Lay rescuers should not perform the pulse check and will not be taught the pulse check in CPR courses (Class IIa). Instead laypersons will be taught to look for signs of circulation (normal breathing, coughing, or movement) in response to rescue breaths. This recommendation applies to victims of any age. Healthcare providers should continue to use the pulse check as one of several signs of circulation. Other signs of circulation include breathing, coughing, or movement in response to rescue breaths. It is anticipated that this guideline change will result in more rapid and accurate identification of cardiac arrest. More importantly, it should reduce the number of missed opportunities to provide CPR and early defibrillation using an AED for victims ≥8 years of age) for victims of cardiac arrest.

Assessment: Check for Signs of Circulation
The International Guidelines 2000 refer to assessment of signs of circulation. For the lay rescuer, this means the following: deliver initial rescue breaths and evaluate the victim for normal breathing, coughing, or movement in response to rescue breaths. The lay rescuer will look, listen, and feel for breathing while scanning the victim for other signs of movement. Lay rescuers will look for “normal” breathing to minimize confusion with agonal respirations.

In practice, lay rescuers should assess the victim for signs of circulation as follows:

1. Provide initial rescue breaths to the unresponsive, non-breathing victim.
2. Look for signs of circulation:
   a. With your ear next to the victim’s mouth, look, listen, and feel for normal breathing or coughing.
   b. Quickly scan the victim for any signs of movement.
3. If the victim is not breathing normally, coughing, or moving, immediately begin chest compressions.

Healthcare professionals should assess signs of circulation by performing a pulse check while simultaneously evaluating the victim for breathing, coughing, or movement after delivering rescue breaths. Healthcare providers should look for breathing because they are trained to distinguish between agonal breathing and other forms of ventilation not associated with cardiac arrest. This assessment should take no more than 10 seconds. If you do not confidently detect a pulse or other signs of circulation or if the heart rate is <60 bpm with signs of poor perfusion, provide chest compressions. It is important to note that unresponsive, nonbreathing infants and children are very likely to have a slow heart rate or no heart rate at all. Therefore, do not delay the initiation of chest compressions to locate a pulse.

Healthcare providers should learn to palpate the brachial pulse in infants and the carotid pulse in children 1 to 8 years of age. The short, chubby neck of children <1 year of age makes rapid location of the carotid artery difficult. In addition, it is easy to compress the airway while attempting to palpate a carotid pulse in the infant’s neck. For these reasons, the healthcare provider should attempt to palpate the brachial artery when performing the pulse check in infants. The brachial pulse is on the inside of the upper arm, between the infant’s elbow and shoulder. Press the index and middle fingers gently on the inside of the upper arm for no more than 10 seconds, in an attempt to feel the pulse (Figure 10).

Healthcare providers should learn to locate and palpate the child’s carotid artery on the side of the neck. It is the most accessible central artery in children and adults. The carotid artery lies on the side of the neck between the trachea and the strap (sternocleidomastoid) muscles. To feel the artery, locate the victim’s thyroid cartilage (Adam’s apple) with 2 or 3 fingers of one hand while maintaining head tilt with the other hand. Then slide the fingers into the groove on the side closer to the rescuer, between the trachea and the sternocleidomastoid muscles, and gently palpate the area over the artery (Figure 11) for no more than 10 seconds.

If signs of circulation are present but spontaneous breathing is absent, provide rescue breathing at a rate of 20 breaths per minute (once every 3 seconds) until spontaneous breathing resumes. After provision of approximately 20 breaths (slightly longer than 1 minute), the lone rescuer should...
activate EMS. If adequate breathing resumes and there is no suspicion of neck trauma, turn the child onto the side into a recovery position.

If signs of circulation are absent (or, for the healthcare provider, the heart rate is $<60$ bpm with signs of poor perfusion), begin chest compressions. This will include a series of compressions coordinated with ventilations. If there are no signs of circulation, the victim is $\geq 8$ years of age, and an AED is available in the out-of-hospital setting, use the AED. A weight of 25 kg corresponds to a body length of approximately 50 inches (128 cm) using the Broselow color-coded tape. For information about use of AEDs for victims $\geq 8$ years of age, see “Part 4: The Automated External Defibrillator.”

Provide Chest Compressions

Chest compressions are serial, rhythmic compressions of the chest that cause blood to flow to the vital organs (heart, lungs, and brain) in an attempt to keep them viable until ALS can be provided. Chest compressions provide circulation as a result of changes in intrathoracic pressure and/or direct compression of the heart. Chest compressions for infants and children should be provided with ventilations.

Compress the lower half of sternum to a relative depth of approximately one third to one half the anterior/posterior diameter of the chest at a rate of at least 100 compressions per minute for the infant and approximately 100 compressions per minute for the child victim. Be sure to avoid compression of the xiphoid. This depth of compression differs slightly from that recommended for the newly born. The neonatal resuscitation guidelines call for compression to approximately one third the depth of the chest. The wider range of recommended compression depth and potentially deeper compressions in infants and children is not evidence based but consensus based. Chest compressions must be adequate to produce a palpable pulse during resuscitation. Lay rescuers will not attempt to feel a pulse, so they should be taught a compression technique that will most likely result in delivery of effective compressions.

Healthcare providers should evaluate the effectiveness of compressions during CPR. If effective compressions are provided, they should all produce palpable pulses in a central artery (eg, the carotid, brachial, or femoral artery). Although pulses palpated during chest compression may actually represent venous pulsations rather than arterial pulses, pulse assessment by the healthcare provider during CPR remains the most practical quick assessment of chest compression efficacy.

Exhaled carbon dioxide detectors and displayed arterial pressure waveforms (if invasive arterial monitoring is in place) can assist the healthcare provider in evaluating the effectiveness of chest compressions. If chest compressions produce inadequate cardiac output and pulmonary blood flow, exhaled carbon dioxide will remain extremely low throughout resuscitation. If an arterial catheter is in place during resuscitation (eg, during chest compressions provided to a patient in the ICU with an arterial monitor in place), chest compressions can be guided by the displayed arterial waveform.

To facilitate optimal chest compressions, the child should be supine on a hard, flat surface. CPR should be performed where the victim is found. If cardiac arrest occurs in a hospital bed, place firm support (a resuscitation board) beneath the patient’s back. Optimal support is provided by a resuscitation board that extends from the shoulders to the waist and across the full width of the bed. The use of a wide board is particularly important when providing chest compressions to larger children. If the board is too small, it will be pushed deep into the mattress during compressions, dispersing the force of each compression. Spine boards, preferably with head wells, can be used in ambulances and mobile life support units. They provide a firm surface for CPR in the emergency vehicle or on a wheeled stretcher and may also be useful for extricating and immobilizing victims.

Infants with no signs of head or neck trauma may be successfully carried during resuscitation on the rescuer’s forearm. The palm of one hand can support the infant’s back while the fingers of the other hand compress the sternum. This maneuver effectively lowers the infant’s head, allowing the head to tilt back slightly into a neutral position that maintains airway patency. If the infant is carried during CPR, the hard surface is created by the rescuer’s forearm, which
supports the length of the infant’s torso, while the infant’s head and neck are supported by the rescuer’s hand. Take care to keep the infant’s head no higher than the rest of the body. Use the other hand to perform chest compressions. You can lift the infant to provide ventilation (Figure 12).

**Indications for Chest Compressions**

Lay rescuers should provide chest compressions if the infant or child shows no signs of circulation (normal breathing, coughing, or movement) after delivery of rescue breaths. Healthcare providers should provide chest compressions if the infant or child shows no signs of circulation (breathing, coughing, movement, or pulse) or if the heart rate/pulse is <60 bpm with signs of poor perfusion after delivery of rescue breaths. Profound bradycardia in the presence of poor perfusion is an indication for chest compressions because cardiac output in infancy and childhood is largely dependent on heart rate, and an inadequate heart rate with poor perfusion indicates that cardiac arrest is imminent. No scientific data has identified an absolute heart rate at which chest compressions should be initiated; the recommendation to provide cardiac compression for a heart rate <60 bpm with signs of poor perfusion is based on ease of teaching and skills retention.

**Chest Compression in the Infant (<1 Year of Age) (Figures 13 and 14)**

**Two-finger technique** (the preferred technique for laypersons and lone rescuers):

1. Place the 2 fingers of one hand over the lower half of the sternum approximately 1 finger’s width below the intermammary line, ensuring that you are not on or near the xiphoid process. The intermammary line is an imaginary line located between the nipples, over the breastbone. An alternative method of locating compression position is to run 1 finger along the lower costal margin to locate the bony end of the sternum and place 1 finger over the end of the sternum; this will mark the xiphoid process. Then place 2 fingers of your other hand above the finger (moving up the sternum toward the head). The 2 fingers will now be in the appropriate position for chest compressions, avoiding the xiphoid. You may place your other hand under the infant’s chest to create a compression surface and slightly elevate the chest so that the neck is neither flexed nor hyperextended and the airway will be maintained in a neutral position.

2. Press down on the sternum to depress it approximately one third to one half the depth of the infant’s chest. This will correspond to a depth of about ½ to 1 inch (1½ to 2½ cm), but these measurements are not precise. After each compression, completely release the pressure on the sternum and allow the sternum to return to its normal position without lifting your fingers off the chest wall.

3. Deliver compressions in a smooth fashion, with equal time in the compression and relaxation phases. A somewhat shorter time in the compression phase offers theoretical advantages for blood flow in a very young infant animal model of CPR and is reviewed in the neonatal guidelines. As a practical matter, with compression rates ≥100 per minute (nearly 2 compressions per second), it is unrealistic to think that rescuers will be able to judge or manipulate compression and relaxation phases. In addition, details about such manipulation would increase the complexity of CPR instruction. For these reasons, provide compressions in approximately equal compression and relaxation phases for infants and children.

4. Compress the sternum at a rate of at least 100 times per minute (this corresponds to a rate that is slightly less than 2 compressions per second during the groups of 5 compressions). The compression rate refers to the speed of compressions, not the actual number of compressions delivered per minute. Note that this compression rate will actually result in provision of <100 compressions each minute, because you will pause to provide 1 ventilation after every fifth compression. The actual number of compressions delivered per minute will vary from rescuer to rescuer and will be influenced by the compression rate and the speed with which you can position the head, open the airway, and deliver ventilation.

5. After 5 compressions, open the airway with a head tilt–chin lift (or, if trauma is present, use the jaw thrust) and give 1 effective breath. Be sure that the chest rises with the breath. Coordinate compressions and ventilations to avoid simultaneous delivery and ensure adequate ventilation and chest expansion, especially when...
the airway is unprotected." You may use your other hand (the one not compressing the chest) to maintain the infant’s head in a neutral position during the 5 chest compressions. (Again see Figure 3.) This may help you provide ventilation without the need to reposition the head after each set of 5 compressions. Alternatively, to maintain a neutral head position, place your other hand behind the infant’s chest (this will elevate the chest, ensuring that the head is in neutral position relative to the chest). If there are signs of head or neck trauma, you can place your other hand on the infant’s forehead to maintain stability (do not tilt head).

Continue compressions and breaths in a ratio of 5:1 (for 1 or 2 rescuers). Note that this differs from the recommended ratio of 3:1 (compressions to ventilations) for the newly born or premature infant in the neonatal ICU. (See “Part 11: Neonatal Resuscitation.”) This difference is based on ease of teaching and skills retention for specifically trained providers in the delivery room setting, with increased emphasis on effective and frequent ventilation for the newly born infant.

Two thumb-encircling hands technique (this is the preferred 2-rescuer technique for healthcare providers when physically feasible; see Figure 14):

1. Place both thumbs side by side over the lower half of the infant’s sternum, ensuring that the thumbs do not compress on or near the xiphoid process. Encircle the infant’s chest and support the infant’s back with the fingers of both hands. Place both thumbs on the lower half of the infant’s sternum, approximately 1 finger’s width below the intermammary line. The intermammary line is an imaginary line located between the nipples, over the breastbone.

2. With your hands encircling the chest, use both thumbs to depress the sternum approximately one third to one half the depth of the child’s chest. This will correspond to a depth of approximately ½ to 1 inch, but these measurements are not precise. After each compression, completely release the pressure on the sternum and allow the sternum to return to its normal position without lifting your thumbs off the chest wall.

3. Deliver compressions in a smooth fashion, with equal time in the compression and relaxation phases. A somewhat shorter time in the compression than relaxation phase offers theoretical advantages for blood flow in a very young infant animal model of CPR and is discussed in the neonatal guidelines. As a practical matter, with compression rates of at least 100 per minute (nearly 2 compressions per second), it is unrealistic to think that rescuers will be able to judge or manipulate compression and relaxation phases. In addition, details regarding such manipulation would increase the complexity of CPR instruction. For these reasons, provide compressions in approximately equal compression and relaxation phases for infants and children.

4. Compress the sternum at a rate of at least 100 times per minute (this corresponds to a rate that is slightly less than 2 compressions per second during the groups of 5 compressions). The compression rate refers to the speed of compressions, not the actual number of compressions delivered per minute. Note that this compression rate will actually result in provision of <100 compressions per minute, because you will pause to allow a second rescuer to provide 1 ventilation after every fifth compression. The actual number of compressions delivered per minute will vary from rescuer to rescuer and will be influenced by the compression rate and the speed with which the second rescuer can position the head, open the airway, and deliver ventilation.

5. After 5 compressions, pause briefly for the second rescuer to open the airway with a head tilt–chin lift (or, if trauma is suspected, with a jaw thrust) and give 1 effective breath (the chest should rise with the breath). Compressions and ventilations should be coordinated to avoid simultaneous delivery and ensure adequate ventilation and chest expansion, especially when the airway is unprotected.

Continue compressions and breaths in a ratio of 5:1 (for 1 or 2 rescuers). Note that this differs from the recommended ratio of 3:1 (compressions to ventilations) for the newly born or premature infant in the neonatal ICU (see “Part 11: Neonatal Resuscitation”). This difference is based on ease of teaching and skills retention for specific trained providers in the delivery room setting, with increased emphasis on effective and frequent ventilation needed for resuscitation of the newly born.

The 2 thumb-encircling hands technique may generate higher peak systolic and coronary perfusion pressure than the 2-finger technique, and healthcare providers prefer this technique to the alternative. For this reason the 2 thumb-encircling hands chest compression technique is the preferred technique for 2 healthcare providers to use in newly born infants and infants of appropriate size (Class IIb). This technique is not taught to the lay rescuer and is not practical for the healthcare provider working alone, who must alternate compression and ventilation.

Chest Compression Technique in the Child (Approximately 1 to 8 Years of Age) (Figure 15)

1. Place the heel of one hand over the lower half of the sternum, ensuring that you do not compress on or near the xiphoid process. Lift your fingers to avoid pressing on the child’s ribs.

2. Position yourself vertically above the victim’s chest and, with your arm straight, depress the sternum approximately one third to one half the depth of the child’s chest. This corresponds to a compression depth of approximately 1 to 1 ½ inches, but these measurements are not precise. After the compression, release the pressure on the sternum, allowing it to return to normal position, but do not remove your hand from the surface of the chest.

3. Compress the sternum at a rate of approximately 100 times per minute (this corresponds to a rate that is slightly less than 2 compressions per second during the groups of 5 compressions). The compression rate refers to the speed of compressions, not the actual number of compressions delivered per minute. Note that this compression rate will actually result in provision of <100 compressions per minute because you will pause to provide 1 ventilation after every fifth compression. The actual number of compressions delivered per minute will vary from rescuer to rescuer and will be influenced...
by the compression rate and the speed with which you can position the head, open the airway, and deliver ventilations.4,136,232

4. After 5 compressions, open the airway and give 1 effective rescue breath. Be sure the chest rises with the breath.
5. Return your hand immediately to the correct position on the sternum and give 5 chest compressions.
6. Continue compressions and breaths in a ratio of 5:1 (for 1 or 2 rescuers).

Note that many reasonable techniques are available to teach proper hand position for chest compression. The technique used should emphasize the importance of locating the lower half of the sternum, avoiding force on or near the xiphoid process and asymmetric force on the ribs. Emphasis should be placed on optimizing mechanics to depress the chest rhythmically approximately one third to one half the depth of the chest at a rate of approximately 100 times per minute and coordinating with rescue breaths to ensure delivery of adequate ventilation in between compressions without delay.

In large children and children ≥8 years of age, the adult 2-handed method of chest compression should be used to achieve an adequate depth of compression as follows (see “Part 3: Adult BLS”):

1. Place the heel of one hand on the lower half of the sternum. Place the heel of your other hand on top of the back of the first hand.
2. Interlock the fingers of both hands and lift the fingers to avoid pressure on the child’s ribs.
3. Position yourself vertically above the victim’s chest and, with your arm straight, press down on the sternum to depress it approximately 1½ to 2 inches. Release the pressure completely after each compression, allowing the sternum to return to its normal position, but do not remove your hands from the surface of the chest.
4. Compress the sternum at a rate of approximately 100 times per minute (this corresponds to a rate of slightly <2 compressions per second during the groups of 15 compressions). The compression rate refers to the speed of compressions, not the actual number of compressions delivered per minute. Note that this compression rate will actually result in provision of <100 compressions each minute because you will pause to provide 2 ventilations after every group of 15 compressions. The actual number of compressions delivered per minute will vary from rescuer to rescuer and will be influenced by the compression rate and the speed with which you can position the head, open the airway, and deliver ventilation.4,136,232
5. After 15 compressions, open the airway with the head tilt–chin lift (if trauma to the head and neck is suspected, use the jaw-thrust maneuver to open the airway) and give 2 effective breaths.
6. Return your hands immediately to the correct position on the sternum and give 15 chest compressions.
7. Continue compressions and breaths in a ratio of 15:2 for 1 or 2 rescuers until the airway is secure (see “Part 3: Adult BLS”).

Until the airway is secured, the compression-ventilation ratio of 15:2 is recommended for 1 or 2 rescuers for adult victims and victims ≥8 years of age. Once the airway is secured, 2 rescuers should use a 5:1 ratio of compressions and ventilations.

Coordination of Compressions and Rescue Breathing

External chest compressions for infants and children should always be accompanied by rescue breathing. In the infant and child, a compression-ventilation ratio of 5:1 is maintained for both 1 and 2 rescuers. The 2-rescuer technique should be taught to healthcare providers. For infants in the special resuscitation circumstances of the delivery room and neonatal intensive care setting, even more emphasis is placed on ventilation during resuscitation, and a 3:1 compression-ventilation ratio is recommended (see “Part 11: Neonatal Resuscitation”).

When 2 rescuers are providing CPR for an infant or child with an unsecured airway, the rescuer providing the compressions should pause after every fifth compression to allow the second rescuer to provide 1 effective ventilation. This pause is necessary until the airway is secure (intubated). Once the airway is secure (the trachea is intubated), the pause is no longer necessary. However, coordination of compressions and ventilation may facilitate adequate ventilation even after tracheal intubation and is emphasized in the newly born (see “Part 11: Neonatal Resuscitation”). Compressions may be initiated after chest inflation and may augment active exhalation during CPR. Although the technique of simultaneous compression and ventilation may augment coronary perfusion pressure in some settings,239–242 it may produce barotrauma and decrease ventilation and is not recommended. Priority is given to assuring adequate ventilation and avoidance of potentially harmful excessive barotrauma in children.241

Reassess the victim after 20 cycles of compressions and ventilations (slightly longer than 1 minute) and every few minutes thereafter for any sign of resumption of spontaneous breathing or signs of circulation. The number 20 is easy to remember, so it is used to provide a guideline interval for reassessment rather than an indication of the absolute number of cycles delivered in exactly 1 minute. In the delivery room setting, more frequent assessments of heart rate—approxi-
In infants, coordination of rapid compressions and ventilations by a single rescuer in a 5:1 ratio may be difficult. To minimize delays, if no trauma is present, the rescuer can maintain airway patency during compressions by using the hand that is not performing compressions to maintain a head tilt (refer to Figure 15). Effective chest expansion should be visible with each breath you provide. If the chest does not rise, use the hand performing chest compressions to perform a chin lift (or jaw thrust) to open the airway when rescue breaths are delivered. Then return the hand to the sternum compression position to resume compressions after the breath is delivered. If trauma is present, the hand that is not performing compressions should maintain head stability during chest compressions.

In children, head tilt alone is often inadequate to maintain airway patency. Often both hands are needed to perform the head tilt–chin lift maneuver (or jaw thrust) with each ventilation. The time needed to position the hands for each breath, locate landmarks, and reposition the hand to perform compressions may reduce the total number of compressions provided in a minute. Therefore, when moving the hand performing the compressions back to the sternum, visualize and return your hand to the approximate location used for the previous sequence of compressions.

**Compression-Ventilation Ratio**

Ideal compression-ventilation ratios for infants and children are unknown. From an educational standpoint, a single universal compression-ventilation ratio for victims of all ages and all rescuers providing BLS and ALS interventions would be desirable. Studies of monitored rescuers have demonstrated that the 15:2 compression-ventilation ratio delivers more compressions per minute, and the 5:1 compression-ventilation ratio delivers more ventilations per minute. There is consensus among resuscitation councils that pediatric guidelines should recommend a compression-ventilation ratio of 3:1 for newly born infants (see “Part 11: Neonatal Resuscitation”) and 5:1 for infants and children up to 8 years of age. A 15:2 compression-ventilation ratio is now recommended for older children (≥8 years of age) and adults for 1- or 2-rescuer CPR until the airway is secure. The rationale for maintaining age-specific differences in compression-ventilation ratios during resuscitation includes the following:

1. Respiratory problems are the most common cause of pediatric arrest, and most victims of pediatric cardiopulmonary arrest are hypoxic and hypercarbic. Therefore, effective ventilation should be emphasized.
2. Physiological respiratory rates in infants and children are faster than in adults.
3. Current providers are trained in and accustomed to these ratios. Any change from the current guidelines in a fundamental aspect of resuscitation steps should be supported by a high level of scientific evidence.

The actual number of delivered interventions (compressions and ventilations) per minute will vary from rescuer to rescuer and will depend on the compression rate, amount of time the rescuer spends opening the airway and providing ventilation, and rescuer fatigue. At present there is insufficient evidence to justify changing the current recommendations for compression-ventilation ratios in infants and children to a universal ratio (Class Indeterminate).

Emerging evidence in adult victims of cardiac arrest suggests that the provision of longer sequences of uninterrupted chest compressions (a compression-ventilation ratio >5:1) may be easier to teach and retain. In addition, animal data suggests that longer sequences of uninterrupted chest compressions may improve coronary perfusion. Finally, longer sequences of compressions may allow more efficient second-rescuer interventions in the out-of-hospital EMS setting. These observations have led to a Class IIb recommendation for a 15:2 compression-ventilation ratio for 1- and 2-rescuer CPR in older children (≥8 years) and adults.

**Compression-Only CPR**

Clinical studies have established that outcomes are dismal when the pediatric victim of cardiac arrest remains in cardiac arrest until the arrival of EMS personnel. By comparison, excellent outcomes are typical when the child is successfully resuscitated before the arrival of EMS personnel. Some of these patients were apparently resuscitated with “partial CPR,” consisting of chest compressions or rescue breathing only. In some published surveys, healthcare providers have expressed reluctance to perform mouth-to-mouth ventilation for unknown victims of cardiopulmonary arrest. This reluctance has also been expressed by some surveyed potential lay rescuers, although reluctance has not been expressed about resuscitation of infants and children.

The effectiveness of “compression-only” or “no ventilation” CPR has been studied in animal models of acute VF sudden cardiac arrest and in some clinical trials of adult out-of-hospital cardiac arrest. Some evidence in adult animal models and limited adult clinical trials suggests that positive-pressure ventilation may not be essential during the initial 6 to 12 minutes of an acute VF cardiac arrest. Spontaneous gasping and passive chest recoil may provide some ventilation during that time without the need for active rescue breathing. In addition, cardiac output during chest compression is only approximately 25% of normal, so the ventilation necessary to maintain optimal ventilation-perfusion relationships may be minimal. However, it does not appear that these observations can be applied to resuscitation of infants and children.

Well-controlled animal studies have established that simulated bystander CPR with chest compressions plus rescue breathing is superior to chest compressions alone or rescue breathing alone for asphyxial cardiac arrest and severe asphyxial hypoxic-ischemic shock (pulseless cardiac arrests). However, chest compression-only CPR and rescue breathing-only CPR have been shown to be effective early in animal models of pulseless arrest, and the application of either of these forms of “partial CPR” was found to be superior to no bystander CPR.

Preliminary evidence suggests that both chest compressions and active rescue breathing are necessary for optimal
resuscitation of the asphyxial arrests most commonly encountered in children.\textsuperscript{223,224} For pediatric cardiac arrest, the lay rescuer should provide immediate chest compressions and rescue breathing. If the lay rescuer is unwilling or unable to provide rescue breathing or chest compressions, it is better to provide either chest compressions or rescue breathing than no bystander CPR (Class IIb).

**Circulatory Adjuncts and Mechanical Devices for Chest Compression**

The use of mechanical devices to provide chest compressions during CPR is not recommended for children. These devices have been designed and tested for use in adults, and their safety and efficacy in children have not been studied. Active compression-decompression CPR (ACD-CPR) has been shown to increase cardiac output compared with standard CPR in adult animal models.\textsuperscript{266,267} ACD-CPR maintains coronary perfusion during compression and decompression in humans\textsuperscript{268,269} and provides ventilation if the airway is patent.\textsuperscript{268} In clinical trials ACD-CPR has produced variable results, including improved short-term outcome (eg, return of spontaneous circulation and survival for 24 hours).\textsuperscript{271–274} However, these improved outcomes are not consistent,\textsuperscript{275} and no long-term survival benefits of ACD-CPR have been reported in most trials. On the basis of these variable clinical results, ACD-CPR is considered an optional technique for adult CPR (Class IIa). This technique cannot be recommended for use in children because it has not been studied in this age group (Class Indeterminate).

Interposed abdominal compression CPR (IAC-CPR) has been shown to increase blood flow in laboratory and computer models\textsuperscript{276–278} of adult CPR. IAC-CPR has been shown to improve hemodynamics of CPR and return of spontaneous circulation for adult patients in some clinical in-hospital settings.\textsuperscript{279,280} with no evidence of excessive harm. The technique is slightly more complex than standard CPR, however, and it does require an additional rescuer. IAC-CPR has been recommended as an alternative technique (Class IIb in-hospital) for trained adult healthcare providers. This technique cannot be recommended for use in children because it has not been studied in this age group.

**Recovery Position**

Although many recovery positions are used in the management of children, particularly in those emerging from anesthesia, no specific optimal recovery position can be universally endorsed on the basis of scientific study in children. There is consensus that an ideal recovery position should provide overall stability and considers the following: etiology of the arrest and stability of the cervical spine, risk for aspiration, attention to pressure points, ability to monitor adequacy of ventilation and perfusion, maintenance of a patent airway, and access to the patient for interventions.

**Relief of Foreign-Body Airway Obstruction**

BLS providers should be able to recognize and relieve complete FBAO. Three maneuvers to remove foreign bodies are suggested: back blows, chest thrusts, and abdominal thrusts. There are some differences between resuscitation councils as to the sequence of actions used to relieve FBAO, but the published data does not support the effectiveness of one sequence over another. There is consensus that lack of protection of the upper abdominal organs by the rib cage renders infants and young children at risk for iatrogenic trauma from abdominal thrusts.\textsuperscript{281} Therefore, the use of abdominal thrusts is not recommended for relief of FBAO in infants (Class III).

**Epidemiology and Recognition of FBAO**

Most reported cases of FBAO in adults are caused by impacted food and occur while the victim is eating. Most reported episodes of choking in infants and children occur during eating or play, when parents or child care providers are present. The choking event is therefore commonly witnessed, and the rescuer usually intervenes when the victim is conscious.

Signs of FBAO in infants and children include the sudden onset of respiratory distress associated with coughing, gagging, or stridor (a high-pitched, noisy sound or wheezing). These signs and symptoms of airway obstruction may also be caused by infections such as epiglottitis and croup, which result in airway edema. However, signs of FBAO typically develop very abruptly, with no other signs of illness or infection. Inflammatory airway obstruction is often accompanied by fever, with other signs of congestion, hoarseness, drooling, lethargy, or limpness. If the child has an infectious cause of airway obstruction, the Heimlich maneuver and back blows and chest thrusts will not relieve the airway obstruction. The child must be taken immediately to an emergency facility.

**Priorities for Teaching Relief of Complete FBAO**

When FBAO produces signs of complete airway obstruction, act quickly to relieve the obstruction. If partial obstruction is present and the child is coughing forcefully, do not interfere with the child’s spontaneous coughing and breathing efforts. Attempt to relieve the obstruction only if the cough is ineffective (loss of sound), respiratory difficulty increases and is accompanied by stridor, or the victim becomes unresponsive. Activate the EMS system as quickly as possible if the child is having difficulty breathing. If >1 rescuer is present, the second rescuer activates the EMS system while the first rescuer attends to the child.

If a responsive infant demonstrates signs of complete FBAO, deliver a combination of back blows and chest thrusts until the object is expelled or the victim becomes unresponsive. Although the data in this age group is limited, Heimlich thrusts are not recommended because abdominal thrusts may damage the relatively large and unprotected liver.\textsuperscript{52,282}

If a responsive child (1 to 8 years of age) demonstrates signs of complete FBAO, provide a series of Heimlich subdiaphragmatic abdominal thrusts.\textsuperscript{283,284} These thrusts increase intrathoracic pressure, creating artificial “coughs” that force air and the foreign body out of the airway.

Epidemiological data\textsuperscript{13,285} does not distinguish between FBAO fatalities in which the victims are responsive when first encountered from those in which the victims are unresponsive when initially encountered. Anecdotal evidence,
Relief of FBAO in the Responsive Infant: Back Blows and Chest Thrusts

The following sequence is used to clear a foreign-body obstruction from the airway of an infant. Back blows (Figure 16) are delivered while the infant is supported in the prone position, straddling the rescuer’s forearm, with the head lower than the trunk. After 5 back blows, if the object has not been expelled, give up to 5 chest thrusts. These chest thrusts consist of chest compressions over the lower half of the sternum, 1 finger’s breadth below the intermammary line. This landmark is the same location used to provide chest compressions during CPR. Chest thrusts are delivered while the infant is supine, held on the rescuer’s forearm, with the infant’s head lower than the body.

Perform the following steps to relieve airway obstruction (the rescuer is usually seated or kneeling with the infant on the rescuer’s lap):

1. Hold the infant prone with the head slightly lower than the chest, resting on your forearm. Support the infant’s head by firmly supporting the jaw. Take care to avoid compressing the soft tissues of the infant’s throat. Rest your forearm on your thigh to support the infant.
2. Deliver up to 5 back blows forcefully in the middle of the back between the infant’s shoulder blades, using the heel of the hand. Each blow should be delivered with sufficient force to attempt to dislodge the foreign body.
3. After delivering up to 5 back blows, place your free hand on the infant’s back, supporting the occiput of the infant’s head with the palm of your hand. The infant will be effectively cradled between your 2 forearms, with the palm of one hand supporting the face and jaw, while the palm of the other hand supports the occiput.
4. Turn the infant as a unit while carefully supporting the head and neck. Hold the infant in the supine position, with your forearm resting on your thigh. Keep the infant’s head lower than the trunk.
5. Provide up to 5 quick downward chest thrusts in the same location as chest compressions—lower third of the sternum, approximately 1 finger’s breadth below the intermammary line. Chest thrusts are delivered at a rate of approximately 1 per second, each with the intention of creating enough of an “artificial cough” to dislodge the foreign body.
6. If the airway remains obstructed, repeat the sequence of up to 5 back blows and up to 5 chest thrusts until the object is removed or the victim becomes unresponsive.

Relief of FBAO in the Responsive Child:

Abdominal Thrusts (Heimlich Maneuver)

Note: Three maneuvers are suggested to relieve FBAO in the child: back blows, chest thrusts, and abdominal thrusts. Back blows and chest thrusts may be alternative interventions for...
FBAO in children, and international training programs should train providers on the basis of ease of teaching and retention in their community.

Abdominal Thrusts With Victim Standing or Sitting
The rescuer should perform the following steps to relieve complete airway obstruction:

1. Stand or kneel behind the victim, arms directly under the victim’s axillae, encircling the victim’s torso.
2. Place the flat, thumb side of 1 fist against the victim’s abdomen in the midline slightly above the navel and well below the tip of the xiphoid process.
3. Grasp the fist with the other hand and exert a series of up to 5 quick inward and upward thrusts (Figure 17). Do not touch the xiphoid process or the lower margins of the rib cage, because force applied to these structures may damage internal organs.281,294,295
4. Each thrust should be a separate, distinct movement, delivered with the intent to relieve the obstruction. Continue the series of up to 5 thrusts until the foreign body is expelled or the victim becomes unresponsive.

Relief of FBAO in the Unresponsive Infant or Child

Lay Rescuer Actions
If the infant or child becomes unresponsive, attempt CPR with a single addition—each time the airway is opened, look for the obstructing object in the back of the throat. If you see an object, remove it. This recommendation is designed to simplify layperson CPR training and ensure the acquisition of the core skills of rescue breathing and compression while still providing treatment to the FBAO victim.

Healthcare Provider Actions
Blind finger sweeps should not be performed in infants and children because the foreign body may be pushed back into the airway, causing further obstruction or injury to the supraglottic area.296,297 When abdominal thrusts or chest thrusts are provided to the unresponsive/unconscious, non-breathing victim, open the victim’s mouth by grasping both the tongue and lower jaw between the thumb and finger and lifting (tongue-jaw lift).144 This action draws the tongue away from the back of the throat and may itself partially relieve the obstruction. If the foreign body is seen, carefully remove it.

If the infant victim becomes unresponsive, perform the following sequence:

1. Open the victim’s airway using a tongue-jaw lift and look for an object in the pharynx. If an object is visible, remove it with a finger sweep. Do not perform a blind finger sweep.
2. Open the airway with a head tilt–chin lift and attempt to provide rescue breaths. If the breaths are not effective, reposition the head and reattempt ventilation.
3. If the breaths are still not effective, perform the sequence of up to 5 back blows and up to 5 chest thrusts.
4. Repeat steps 1 through 3 until the object is dislodged and the airway is patent or for approximately 1 minute. If the infant remains unresponsive after approximately 1 minute, activate the EMS system.
5. If breaths are effective, check for signs of circulation and continue CPR as needed, or place the infant in a recovery position if the infant demonstrates adequate breathing and signs of circulation.

If the child victim becomes unresponsive, place the victim in the supine position and perform the following sequence:

1. Open the victim’s airway using a tongue-jaw lift and look for an object in the pharynx. If an object is visible, remove it with a finger sweep. However, do not perform a blind finger sweep.
2. Open the airway with a head tilt–chin lift, and attempt to provide rescue breaths. If breaths are not effective, reposition the head and reattempt ventilation.
3. If the breaths are still not effective, kneel beside the victim or straddle the victim’s hips and prepare to perform the Heimlich maneuver abdominal thrusts as follows:
   a. Place the heel of one hand on the child’s abdomen in the midline slightly above the navel and well below the rib cage and xiphoid process. Place the other hand on top of the first.
   b. Press both hands onto the abdomen with a quick inward and upward thrust (Figure 18). Direct each thrust upward in the midline and not to either side of the abdomen. If necessary, perform a series of up to 5 thrusts. Each thrust should be a separate and distinct movement of sufficient force to attempt to dislodge the airway obstruction.
4. Repeat steps 1 through 3 until the object is retrieved or rescuer breaths are effective.
5. Once effective breaths are delivered, assess for signs of circulation and provide additional CPR as needed or place the child in a recovery position if the child demonstrates adequate breathing and signs of circulation.

BLS in Special Situations

BLS for the Trauma Victim

The principles of resuscitation of the seriously injured child are the same as those for any pediatric patient. However, some aspects of pediatric trauma care require emphasis because improper resuscitation is a major cause of preventable pediatric trauma death. Common errors in pediatric trauma resuscitation include failure to open and maintain the airway with cervical spine protection, inadequate or overzealous fluid resuscitation, and failure to recognize and treat internal bleeding. Ideally, a qualified surgeon should be involved early in the course of resuscitation. In regions with developed EMS systems, children with multisystem trauma should be transported rapidly to trauma centers with pediatric expertise. The relative value of aeromedical transport compared with ground transport of children with multiple trauma is unclear and should be evaluated by individual EMS systems. It is likely that mode of transport preference will depend on EMS system characteristics.

BLS support requires meticulous attention to airway, breathing, and circulation from the moment of injury. The airway may become obstructed by soft tissues, blood, or dental fragments. These causes of airway obstruction should be anticipated and treated. Airway control includes spinal immobilization, which is continued during transport and stabilization in an ALS facility. This is best accomplished by a combined jaw-thrust and spinal stabilization maneuver, using only the amount of manual control necessary to prevent cranial-cervical motion (Figure 19). The head tilt–chin lift is contraindicated because it may worsen existing cervical spinal injury. Rescuers should ensure that the neck is maintained in a neutral position because the prominent occiput of the child predisposes the neck to slight flexion when the child is placed on a flat surface.

It may be difficult to immobilize the cervical spine of an infant or young child in a neutral position. When a young child is placed supine on a firm surface, the large occiput tends to encourage neck flexion. Spinal immobilization of young children with a backboard with a recess for the head is recommended. If such a board is unavailable, the effect of a head recess can be simulated by placing a layer of towels or sheets ¼ to 1 inch high on the board so that it elevates the torso (from shoulders to buttocks) and maintains the neck in neutral alignment. Semirigid cervical collars are available in a wide range of sizes to help immobilize children of various sizes. The child’s head and neck should be further immobilized with linen rolls and tape, with secondary immobilization of the child on a spine board.

If 2 rescuers are present, the first rescuer opens the airway with a jaw-thrust maneuver while the second rescuer ensures that the cervical spine is absolutely stabilized in a neutral position. Avoid traction on or movement of the neck because it may result in converting a partial to a complete spinal cord injury. Once the airway is controlled, immobilize the cervical spine with a semirigid cervical collar and a spine board, linen rolls, and tape. Throughout immobilization and during transport, support oxygenation and ventilation.

BLS for the Submersion Victim

Submersion is a leading cause of death in children worldwide. The duration and severity of hypoxia sustained as the result of
submersion is the single most important determinant of outcome. CPR, particularly rescue breathing, should be attempted as soon as the unresponsive submersion victim is pulled from the water. If possible, rescue breathing should be provided even while the victim is still in the water, if the rescuer’s safety is ensured.

Many infants and children submerged for brief periods of time will respond to stimulation or rescue breathing alone. If the child does not have signs of circulation (normal breathing, coughing, or movement) after initial rescue breaths are provided, begin chest compressions.

In 1994 the Institute of Medicine reviewed the recommendations of the AHA regarding resuscitation of submersion victims and supported the emphasis on initial establishment of effective ventilation. There is no evidence that water acts as an obstructive foreign body, and time should not be wasted in attempting to remove water from the victim. Such maneuvers can cause injury but—more importantly—will delay CPR, particularly support of airway and ventilation.

Additional special resuscitation situations are addressed in “Part 3, Adult BLS: Special Resuscitation Circumstances” and in “Part 11: Neonatal Resuscitation.”

Family Presence During Resuscitation
Most family members would like to be present during the attempted resuscitation of a loved one, according to surveys in the United States and the United Kingdom. Parents and those who care for chronically ill children are often knowledgeable about and comfortable with medical equipment and emergency procedures. Family members with no medical background report that being at the side of a loved one and saying goodbye during the final moments of life is extremely comforting. Parents or family members often fail to ask if they can be present, but healthcare providers should offer the opportunity whenever possible.

Family members present during resuscitation report that their presence helped them adjust to the death of their loved one, and most indicate they would do so again. Standardized psychological examinations suggest that family members present during resuscitation demonstrate less anxiety and depression and more constructive grief behavior than family members not present during resuscitation.

When family members are present during resuscitative efforts, resuscitation team members should be sensitive to their presence. If possible, 1 member of the healthcare team should remain with the family to answer questions, clarify information, and offer comfort.

In the prehospital setting, family members are typically present during resuscitation of a loved one. Prehospital care providers are often too busy to give undivided attention to the needs of family members. However, brief explanations and the opportunity to remain with the loved one can be comforting. Some EMS systems provide follow-up visits to family members after unsuccessful resuscitation attempts.

Termination of Resuscitative Efforts
Despite the best efforts of healthcare providers, most children who experience a cardiac arrest do not survive and never demonstrate return of spontaneous circulation. Return of spontaneous circulation is unlikely if the child fails to respond to effective BLS and ALS and ≥2 doses of epinephrine. Special resuscitation circumstances, local resources, and underlying conditions and prognoses create a complex decision matrix for the resuscitation team. In general, in the absence of recurring or refractory VF or ventricular tachycardia, history of a toxic drug exposure or electrolyte imbalance, or a primary hypothermic injury, the resuscitation team should discontinue resuscitation efforts after 30 minutes, especially if there is no return of spontaneous circulation (Class IIa). For further discussion, see “Part 2: Ethical Aspects of CPR and ECC.”

Maximizing the Effectiveness of Pediatric Basic Life Support Training
CPR is the critical link in the Chain of Survival, particularly for infants and children. For many years the AHA and members of ILCOR have promoted the goal of appropriate bystander (lay rescuer) response to every witnessed cardiopulmonary emergency, such as a choking child, a child in respiratory distress, or an infant or child in cardiac arrest. Although immediate bystander CPR can result in resuscitation even before the arrival of emergency personnel, bystander CPR is not provided for a majority of victims of cardiac arrest. Witnesses may fail to initiate resuscitation for several reasons; the most obvious is that they have not learned CPR.

CPR courses have evolved into instructor-based, classroom-based programs. Yet this approach is not effective in teaching the critical psychomotor skills of CPR. Several studies have documented the failure of lay rescuers to perform CPR after participating in these traditional courses. In 1998 these findings led the AHA to convene the National ECC Educational Conference to discuss how to improve CPR skills performance and retention. The experts came to 2 major conclusions:

- Current CPR programs for lay rescuers contain too much cognitive material and provide insufficient “hands on” practice time.
- CPR programs for lay rescuers should focus on acquisition of specific psychomotor skills and retention of those skills over time.

Core Objectives
The core objectives for the Pediatric Basic Life Support course and modules are simple. After participation in a BLS course, the rescuer who assists an unresponsive victim will be able to

1. Recognize a situation in which resuscitation is appropriate.
2. Activate the EMS system when appropriate.
3. Retrieve and use an AED for the adult victim and the child victim ≥8 years old.
4. Provide effective ventilations (chest rises following use of mouth-to-mouth, mouth-to-mask, and mouth-to-barrier devices). Healthcare providers should be capable of providing bag-mask ventilation.
5. Provide effective chest compressions that generate a palpable pulse.
6. Perform all skills in a manner that is safe for the victim, rescuer, and bystanders.

The participant should remember how to perform these skills for ≥1 year after training.

If participants are to achieve core objectives, CPR programs must be simplified. They must focus on skills acquisition rather than cognitive knowledge. Training programs that attempt to teach large amounts of material fail to achieve core educational objectives (eg, the psychomotor skills of CPR), with poor participant skills retention and performance. By comparison, focused training programs emphasizing skills acquisition result in superior levels of skills performance.

This compelling data mandates consideration of the potential negative effects of science changes on teaching CPR. Consideration of these effects influenced debates about guidelines changes. Interventions that could produce even modest improvements in survival were more readily endorsed if they were easy to teach and would simplify CPR instruction. Conversely, interventions that would have a negative impact on CPR training (eg, complex instruction and extensive practice) had to be supported by higher levels of evidence of effectiveness to justify their introduction.

Course instructors should focus on ensuring participant mastery of core objectives. Skills practice time must be maximized and lecture time minimized. Resuscitation councils should evaluate skills acquisition by participants and use it to continuously improve resuscitation programs.

Audio and Visual CPR Performance Aids for BLS Interventions
CPR is a complex psychomotor task that is difficult to teach, learn, remember, and perform. Not surprisingly, observed CPR performance is often poor (inadequate compression depth, inadequate compression rate, etc). The use of audio and visual CPR performance aids during training can improve acquisition of CPR psychomotor skills (Class IIa). The use of audio prompts (eg, an audiotope with the appropriate cadence of “compress-compress-compress-breath”) improves CPR performance in both clinical and laboratory settings (Class IIb). Use of these devices should be considered in areas where CPR is performed infrequently.

Areas of Overlap Within Guidelines for Pediatric BLS/ALS, Adult ACLS, and Newborn Resuscitation
Note that recommendations will overlap in areas where distinctions between age cutoffs and target audiences are blurred. Examples of overlapping areas between adult, pediatric, and neonatal recommendations include

- Compression-ventilation ratios of 15:2 versus 5:1 versus 3:1 and 2-finger versus 2 thumb–encircling hands versus 1-hand versus 2-hand compression technique
- When to “phone first” versus “phone fast”
- Chest-compression rate of approximately 120 events per minute for the newly born/neonate in the delivery room versus at least 100 compressions per minute for BLS for infants beyond the newly born period and in the out-of-hospital setting versus approximately 100 compressions per minute for pediatric BLS
- Pulse check locations: carotid versus brachial versus femoral versus umbilical

Most of these overlapping areas are easily interpreted in the context of the training environment and target audience.

Areas of Controversy in International Guidelines 2000: Unresolved Issues and Need for Additional Research
There is great difficulty in creating advisory pediatric BLS statements for universal application. The ILCOR Pediatric Task Force reviewed the rationale for current internationally recognized guidelines in North America, South America, Europe, Australia, New Zealand, and southern Africa. The group identified several areas of controversy that require focused research. They are as follows:

- What is the prevalence and time course for presentation of VF during or after resuscitation?
- Should resuscitation sequences of interventions/algorithms be taught on the basis of the likelihood of presenting rhythm (eg, bradycardia-asystole most likely for children) or reversible etiology (eg, VF treated with defibrillation is most likely to be successfully resuscitated)?
- How many breaths should be initially attempted after opening the airway?
- At what heart rate should chest compressions be initiated?
- What is the optimal depth for chest compressions (one third to one half depth of chest versus specified number of inches or centimeters)?
- What sequence of interventions for the choking child is most appropriate: back blows versus abdominal thrusts versus chest thrusts?
- What defibrillation dose, type of waveform, and number of defibrillation shocks should be delivered after medication has been provided for VF in children?
- Should visual inspection of the mouth for a foreign body precede ventilation attempts in infants?
- What is an optimal recovery position for infants and children?
- Can a universal compression-ventilation ratio be adopted (5:1 versus 10:2 versus 15:2) that can accommodate all victims from infancy to adulthood?
- Is mouth-and-nose ventilation a better method than maternal mouth-to-infant-mouth-and-nose for ventilation of neonates and small infants?
- Can AEDs accurately and reliably be used in pediatric patients? Can AEDs provide a single optimal defibrillation “dose”?
- What are the frequency, etiology, and outcome of CPR provided by laypersons versus trained providers in a variety of home, out-of-hospital, and in-hospital settings?
- What is the impact of implementing universal resuscitation guidelines on arrest prevention, successful resuscitation,
and neurological performance outcomes from potential or actual cardiopulmonary arrest in infants and children?

Summary
The epidemiology and outcome of pediatric cardiopulmonary arrest and the priorities, techniques, and sequence of pediatric resuscitation assessments and interventions differ from those of adults. Current guidelines have been updated after extensive multinational evidence-based review and discussion over several years. Areas of controversy in current guidelines and recommendations made by consensus are detailed. A large degree of uniformity exists in the current guidelines advocated by the AHA, Council on Latin American Resuscitation, Heart and Stroke Foundation of Canada, European Resuscitation Council, Australian Resuscitation Council, and Resuscitation Council of Southern Africa. Differences are currently based on local and regional preferences, training networks, and customs rather than scientific controversy. Unresolved issues with potential for future universal application are highlighted.

Appendix
List of Pediatric BLS Classes of Recommendation
Phone first versus phone fast: Indeterminate
Provide chest compressions or rescue breathing as “better than nothing”: Class IIb
Use of barrier devices in children: Indeterminate
Two versus 5 initial breaths: Indeterminate
Mouth-to-nose breathing: Class IIb
Healthcare providers should be trained to provide effective bag-mask ventilation: Class IIa
Goal of ventilation is “physiological” ventilation: Class IIa
Pulse check should not be taught to laypersons: Class IIa
Two thumb–encircling hands technique preferable to 2-finger technique for 2-rescuer healthcare provider CPR for infants: Class IIb
Universal compression-ventilation ratio: Indeterminate
ACD-CPR: Indeterminate
IAC-CPR: Indeterminate
Audio prompt for training: Class IIa
Audio prompt for CPR: Class IIb
Lay rescuers should not be taught complex relief of FBAO skills for unresponsive victim: Class IIb
Abdominal thrusts for infants: Class III
Termination of efforts after 30 minutes if no exceptional circumstances: Class IIa

Comparison Across Age Groups of Resuscitation Interventions
See the following Table.
TABLE. Comparison Across Age Groups of Resuscitation Interventions

<table>
<thead>
<tr>
<th>CPR/Rescue Breathing</th>
<th>Adult and Older Child</th>
<th>Child (Approximately 1–8 Years of Age)</th>
<th>Infant (Less Than 1 Year of Age)</th>
<th>Neonate and Newly Born</th>
</tr>
</thead>
<tbody>
<tr>
<td>Establish unresponsiveness, activate EMS</td>
<td>Head tilt–chin lift (if trauma is present, use jaw thrust)</td>
<td>Head tilt–chin lift (if trauma is present, use jaw thrust)</td>
<td>Head tilt–chin lift (if trauma is present, use jaw thrust)</td>
<td>Head tilt–chin lift (if trauma, use jaw thrust)</td>
</tr>
<tr>
<td>Open airway</td>
<td>Initial</td>
<td>2 effective breaths at 2 seconds per breath</td>
<td>2 effective breaths at 1 to 1½ seconds per breath</td>
<td>2 effective breaths at 1 to 1½ seconds per breath</td>
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<td>Subsequent</td>
<td>12 breaths/min (approximate)</td>
<td>20 breaths/min (approximate)</td>
<td>20 breaths/min (approximate)</td>
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<td>Foreign-body airway obstruction</td>
<td>Abdominal thrusts or back blows or chest thrusts</td>
<td>Abdominal thrusts or back blows or chest thrusts</td>
<td>Back blows or chest thrusts (no abdominal thrusts)</td>
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<td>Signs of Circulation: Check for normal breathing, coughing or movement, pulse.*</td>
<td>Pulse check (healthcare providers)*</td>
<td>(Healthcare providers)*</td>
<td>(Healthcare providers)*</td>
<td>(Healthcare providers)*</td>
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<tr>
<td></td>
<td>Compression landmarks</td>
<td>Carotid</td>
<td>Lower half of sternum</td>
<td>Lower half of sternum</td>
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<td></td>
<td>Compression method</td>
<td>Heel of 1 hand, other hand on top</td>
<td>Heel of 1 hand</td>
<td>Two thumbs–encircling hands for 2-rescuer healthcare provider or 2 fingers</td>
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<td></td>
<td>Compression depth</td>
<td>Approximately 1½ to 2 in</td>
<td>Approximately ½ to ½ the depth of the chest (1 to 1½ in)</td>
<td>Approximately ½ to ½ the depth of the chest (½ to 1 in)</td>
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<td>Compression rate</td>
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<td>Approximately 100/min</td>
<td>At least 100/min</td>
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<td>Compression/ventilation ratio</td>
<td>15:2 (1 or 2 rescuers, unprotected airway)</td>
<td>5:1 (1 or 2 rescuers)</td>
<td>5:1 (1 or 2 rescuers)</td>
<td>3:1 (1 or 2 rescuers)</td>
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<td></td>
<td>5:1 (2 rescuers, protected airway)</td>
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*Pulse check is performed as one of the “signs of circulation” assessed by healthcare providers. Lay rescuers check for other signs of circulation but do not check pulse.

References
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