FOURTH EDITION

PALS

PEDIATRIC ADVANCED LIFE SUPPORT STUDY GUIDE

Barbara Aehlert, MSEd, BSPA, RN

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To

My daughters, Andrea and Sherri

For the beautiful young women you have become

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CHAPTER 1

Patient Assessment and Teamwork

Learning Objectives

After completing this chapter, you should be able to do the following:

1. Distinguish between the components of a pediatric assessment and describe techniques for successful assessment of infants and children.
2. Summarize the components of the pediatric assessment triangle and the reasons for forming a general impression of the patient.
3. Differentiate between respiratory distress and respiratory failure.
4. Summarize the purpose and components of the primary assessment.
5. Identify normal age group related vital signs.
6. Discuss the benefits of pulse oximetry and capnometry or capnography during patient assessment.
7. Identify the major classifications of pediatric cardiac rhythms.
8. Differentiate between central and peripheral pulses.
9. Summarize the purpose and components of the secondary assessment.
10. Discuss the use of the SAMPLE mnemonic when obtaining a patient history.
11. Describe the tertiary assessment.
12. Summarize the purpose and components of the reassessment.
13. Discuss the purpose and typical configuration of a rapid response team.
14. Recognize the importance of teamwork during a resuscitation effort.
15. Assign essential tasks to team members while working as the team leader of a resuscitation effort.
16. Discuss the phases of a typical resuscitation effort.

After completing this chapter, and with supervised practice during a PALS course, you will be skilled at the following:

- Ensuring scene safety and the use of personal protective equipment.
- Assigning team member roles or performing as a team member in a simulated patient situation.
- Directing or performing an initial patient assessment.
- Obtaining vital signs, establishing vascular access, attaching a pulse oximeter and blood pressure and cardiac monitor, and giving supplemental O_2 if indicated.
- Implementing a treatment plan based on the patient's history and clinical presentation.
- Recognizing when it is best to seek expert consultation.
- Reviewing your performance as a team leader or team member during a postevent debriefing.

ASSESSMENT EVIDENCE

Learning Plan

- Read this chapter before your PALS course.
- Complete the chapter quiz and review the answers provided.

KEY TERMS

Apnea
The cessation of breathing for more than 20 seconds with or without cyanosis, decreased muscle tone, or bradycardia

Bradypnea
A slower than normal rate of breathing for the patient's age

Capnograph
A device that provides both a numeric reading and a waveform of carbon dioxide concentrations in exhaled gases

Capnography
The process of continuously analyzing and recording carbon dioxide concentrations in expired air

Capnometer
A device that measures the concentration of carbon dioxide at the airway opening at the end of exhalation

Capnometry
A numeric reading of exhaled CO_2 concentrations without a continuous waveform

Crackles
Abnormal breath sounds produced as air passes through airways containing fluid or moisture (formerly called *rales*)

Fontanels
Membranous spaces formed where cranial bones intersect

Grunting
A short, low-pitched sound heard as the patient exhales against a partially closed glottis; it is a compensatory mechanism to help maintain the patency of the alveoli and prolong the period of gas exchange

Gurgling
A bubbling sound that occurs when blood or secretions are present in the upper airway

Head bobbing
An indicator of increased work of breathing in infants; the head falls forward with exhalation and comes up with expansion of the chest on inhalation

Minute volume
The amount of air moved in and out of the lungs in one minute, determined by multiplying the tidal volume by the ventilatory rate

Nasal flaring
Widening of the nostrils on inhalation; an attempt to increase the size of the nasal passages for air to enter during inhalation

Pediatric assessment triangle (PAT)
A rapid, systematic approach to forming a general impression of the ill or injured child that focuses on three main areas: (1) appearance, (2) work of breathing, and (3) circulation to the skin

Petechiae
Reddish-purple nonblanchable discolorations in the skin less than 0.5 cm in diameter

PQRST
An acronym used when evaluating patients in pain: Precipitating or provoking factors, Quality of pain, Region and radiation of pain, Severity, and Time of pain onset

Primary assessment
A hands-on assessment that is performed to rapidly find and treat life-threatening conditions by evaluating the nervous, respiratory, and circulatory systems; also called a *primary survey*, *initial assessment*, or *ABCDE assessment*

Pulse oximetry
A noninvasive method of monitoring the percentage of hemoglobin that is saturated with oxygen

Purpura
Red-purple nonblanchable discolorations greater than 0.5 cm in diameter; large purpura are called *ecchymoses*

Respiratory distress
A clinical condition characterized by increased work of breathing and a rate of breathing outside the normal range for the patient's age

Respiratory failure
A clinical condition in which there is inadequate oxygenation, ventilation, or both to meet the metabolic demands of body tissues

Retractions
Sinking in of the soft tissues above the sternum or clavicle, or between or below the ribs during inhalation

SAMPLE
Acronym used when obtaining a patient history; Signs and symptoms (as they relate to the chief complaint), Allergies, Medications, Past medical history, Last oral intake, and Events surrounding the illness or injury

Seesaw breathing
An ineffective breathing pattern in which the abdominal muscles move outward during inhalation while the chest moves inward; a sign of impending respiratory failure

Sniffing position
A position in which the patient sits upright and leans forward with the chin slightly raised, thereby aligning the axes of the mouth, pharynx, and trachea to open the airway and increase airflow

Snoring
Noisy, low-pitched sounds usually caused by partial obstruction of the upper airway by the tongue

Stridor
A harsh, high-pitched sound heard on inhalation that is associated with inflammation or swelling of the upper airway often described as a high-pitched "seal bark" sound; caused by disorders such as croup, epiglottitis, the presence of a foreign body, or an inhalation injury

Tachypnea
A rate of breathing that is more rapid than normal for the patient's age

TICLS
A mnemonic developed by the American Academy of Pediatrics that is used to recall the areas to be assessed related to a child's overall appearance; Tone, Interactivity, Consolability, Look or gaze, and Speech or cry

Tidal volume
The volume of air moved into or out of the lungs during a normal breath

Tripod position
A position in which the patient attempts to maintain an open airway by sitting upright and leaning forward supported by his or her arms with the neck slightly extended, chin projected, and mouth open

Wheeze
High- or low-pitched sound produced as air passes through airways that have been narrowed because of swelling, spasm, inflammation, secretions, or the presence of a foreign body

INTRODUCTION

Assessment of an ill or injured child requires a systematic approach, knowledge of normal growth and development, and knowledge of the anatomic and physiologic differences between children and adults. Approaches to obtaining historical information and physical examination vary depending on the child's age and presentation.

Regardless of the healthcare environment in which you work, patient care is delivered by a team of professionals. A *team* has been defined as "two or more individuals who perform some work-related task, interact with one another dynamically, have a shared past and a foreseeable shared future, and share a common fate" (Weinstock & Halamek, 2008). This chapter discusses the importance of patient assessment and teamwork in the delivery of safe and effective patient care.

PART I: PATIENT ASSESSMENT

Patient assessment is one of the most important skills that you perform as a healthcare professional. An organized approach to patient assessment will help you differentiate between patients who require immediate emergency care and those who do not and will help ensure that no significant findings or problems are missed. Make sure that the scene is safe before approaching the patient, and always use appropriate personal protective equipment.

General Impression

- Because approaching an ill or injured child can increase his or her agitation, it is important to form a general impression (also called a *first impression* or *initial impression*) *before* approaching or touching the patient. Pause a short distance from the child and, using your senses of sight and hearing, use the **pediatric assessment triangle (PAT)** to form a general impression. The PAT reflects a rapid, systematic approach to the assessment of the ill or injured child (American Academy of Pediatrics, 2014)
- The PAT focuses on three main areas: (1) appearance, (2) work of breathing, and (3) circulation to the skin. Assessment of these areas corresponds with assessment of the nervous, respiratory, and circulatory systems. An abnormal finding in *any* area of the PAT indicates that the child is "sick" and requires immediate intervention (Horeczko, Enriquez, McGrath, Gausche-Hill, & Lewis, 2013). Remember that your patient's condition can change

at any time. A patient that initially appears "not sick" may rapidly deteriorate and appear "sick." Frequently reassess.

- The PAT is widely used by healthcare professionals in clinical practice to distinguish between the "sick" and "not sick" child, and has been incorporated into most pediatric life support courses in the United States (Dieckmann, Brownstein, & Gausche-Hill, 2010). In clinical practice, the general impression is often done while the clinician simultaneously begins obtaining the history and the chief complaint (Mace & Mayer, 2008). Use of the PAT has been found to be reliable in identifying high-acuity pediatric patients and their category of pathophysiology (Horeczko et al., 2013).

Appearance

- Assessment of the child's appearance includes your observations of the child's mental status, muscle tone, and body position (**Figure 1-1**). Appearance is a reflection of the adequacy of oxygenation, ventilation, brain perfusion, and central nervous system function (American Academy of Pediatrics, 2014). The mnemonic TICLS, pronounced *tickles*, was developed by the American Academy of Pediatrics and is used to recall the areas to be assessed as they are related to the child's overall appearance (**Table 1-1**). When forming a general impression, the American Academy of Pediatrics considers identification of a child's abnormal appearance to be more effective in spotting subtle behavioral abnormalities than the use of the Alert, Verbal, Pain, Unresponsive (AVPU) scale or the pediatric Glasgow Coma Scale (GCS) (American Academy of Pediatrics, 2014).
- While assessing a child's appearance, allow the child to remain in the arms of the caregiver. As you observe the child, keep in mind that a child's age and developmental characteristics influence what is considered "normal" for his or her age group.
  - An example of a child with a normal appearance is a toddler who is responsive to his caregiver, attentive to his environment, readily consoled when held by his caregiver, and who has good muscle tone and a strong cry.

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Figure 1-1 Appearance is the first area assessed when forming a general impression.

Table 1-1 Assessing Appearance Using the Mnemonic TICLS

Characteristic	Assessment Considerations
Tone	Is the child vigorously moving or is the child limp and listless?
Interactivity	Is the child alert and attentive to his or her surroundings? Does the child respond to his or her name (if older than 6 to 8 months)? Does the child recognize his or her parents or caregiver? Is the child readily distracted by a person, sound, or toy, or is he or she uninterested in his or her surroundings?
Consolability	Can the child readily be comforted by the caregiver or healthcare professional or is the child inconsolable?
Look or gaze	Do the child's eyes fix their gaze on your face or is there a vacant stare?
Speech or cry	Is the child's speech spontaneous and age-appropriate? Is his or her cry strong or is it high-pitched? Is his or her speech or cry weak, muffled, or hoarse?

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  - Examples of abnormal findings that warrant further exploration include agitation, marked irritability, poor eye contact, decreased interactivity, drooling (beyond infancy), limp or rigid muscle tone, inconsolable crying, a vacant or glassy-eyed stare, a cry that is weak or high-pitched, or speech that is muffled or hoarse. If the child exhibits abnormal findings with regard to his or her appearance, proceed immediately to the primary assessment.

Breathing

- The second component of the PAT is assessment of the work of breathing (i.e., ventilatory effort), which reflects the adequacy of the patient's oxygenation and ventilation (American Academy of Pediatrics, 2014).
- Assessment areas include the child's body position, visible movement of the chest and abdomen, ventilatory rate, ventilatory effort, and audible airway sounds. Normal breathing is quiet with equal chest rise and fall, without excessive respiratory muscle effort, and with a ventilatory rate within normal range.
  - **Respiratory distress** is characterized by increased work of breathing and a rate of breathing outside the normal range for the patient's age. Respiratory distress may result from a problem in the tracheobronchial tree, lungs, pleura, or chest wall.
  - **Respiratory failure** is a clinical condition in which there is inadequate oxygenation, ventilation, or both to meet the metabolic demands of body tissues.
- Begin your breathing assessment by listening for abnormal respiratory sounds that can be heard without a stethoscope and that can indicate respiratory compromise, such as gasping, grunting, gurgling, snoring, stridor, or wheezing. Next, look for

movement of the chest and abdomen to confirm that the child *is* breathing and then observe the work of breathing. A patient who is working hard or struggling to breathe is said to have *labored* breathing. The child may be unable to speak in full sentences without pausing to take a breath. Signs associated with increased work of breathing, which are generally best observed with the patient's shirt removed, may include the presence of suprasternal, clavicular, intercostal, subcostal, or substernal **retractions** and accessory muscle use (i.e., muscles of the neck, chest, and abdomen that become active during labored breathing) (**Figure 1-2**). **Head bobbing** is an indicator of increased work of breathing in infants. The head falls forward on exhalation, and comes up when the infant breathes in and its chest expands.

- Because a child's nasal passages are very small, short, and narrow, these areas are easily obstructed with mucus or foreign objects.
  - **Nasal flaring**, which is widening of the nostrils while the patient breathes in, is the body's attempt to increase the size of the nasal passages for air to enter during inhalation. Nasal flaring may be intermittent or continuous (Wilson, 2011).
  - **Seesaw breathing**, an ineffective breathing pattern in which the abdominal muscles move outward during inhalation while the chest moves inward, is a sign of impending respiratory failure (Santillanes, 2014).
- Observing the position of the child can provide important clues with regard to the patient's level of distress and work of breathing. For example, a child may assume a **sniffing position** to decrease his or her work of breathing. In this position, the child sits upright and leans forward with the chin slightly raised, aligning the axes of the mouth, pharynx, and trachea to open the airway and increase airflow. When a child assumes a **tripod position**, also called *tripoding*, the child attempts to maintain an open airway by sitting upright and leaning forward, supported by his or her arms (or with the arms braced against the knees, a chair, or a bed), with the neck slightly extended, chin projected, and mouth open. If the child exhibits abnormal findings with regard to breathing, immediately proceed to the primary assessment.

Circulation

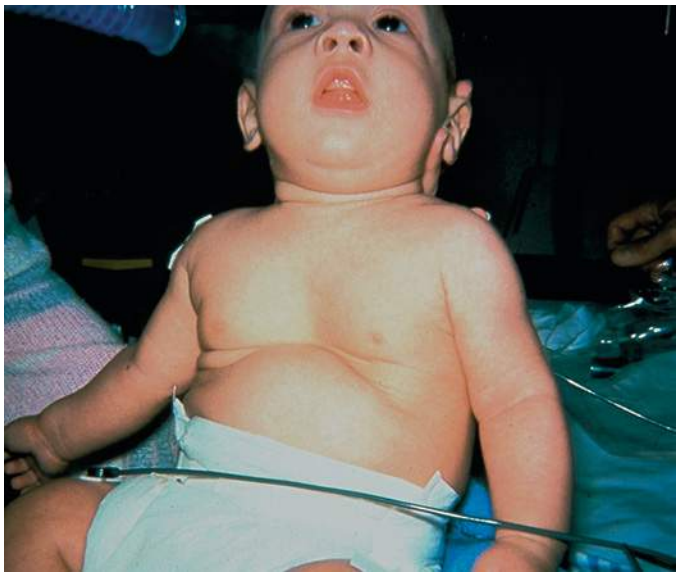
The final component of the PAT is assessment of the circulation to the skin, which is a reflection of the adequacy of cardiac output and the perfusion of vital organs (i.e., core perfusion) (American Academy of Pediatrics, 2014). The child's skin color should appear normal for his or her ethnic group. Possible causes of flushed (i.e., red) skin include fever, heat exposure, and the presence of a toxin. The presence of pale, cyanotic, or mottled skin suggests inadequate oxygenation, poor perfusion, or both (**Figure 1-3**). If the child exhibits abnormal findings with regard to his or her skin color, immediately proceed to the primary assessment.

Category of Pathophysiology

Findings of the PAT can be used to determine the severity of the child's condition, the general category of the physiologic problem, and the urgency with which interventions must be performed (American Academy of Pediatrics, 2014) (**Table 1-2**).

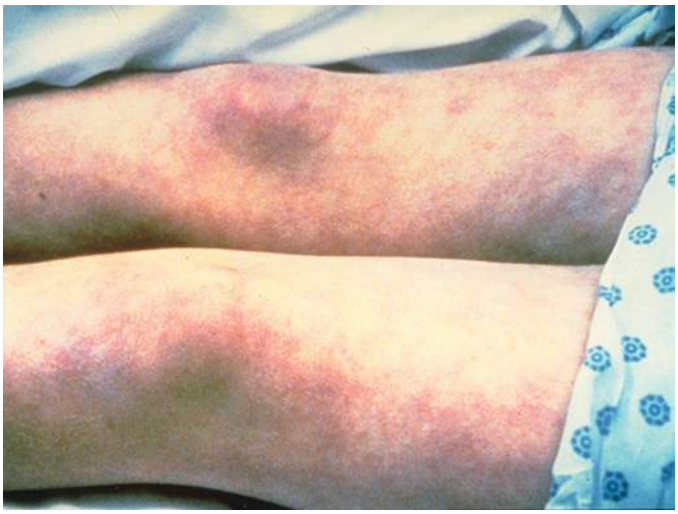
Primary Assessment

The next phase of patient assessment is the **primary assessment**, which is a rapid, systematic, hands-on evaluation. The purpose of a primary assessment, also called a *primary survey*, *initial assessment*, or *ABCDE assessment*, is to quickly find and treat life-threatening conditions by assessing the nervous, respiratory, and circulatory systems. The primary assessment consists of the following components: Airway, Breathing, Circulation, Disability, and Exposure (for examination).



EMSC Slide Set (CD-ROM). 1996. Courtesy of the Emergency Medical Services for Children Program, administered by the U.S. Department of Health and Human Service's Health Resources and Services Administration, Maternal and Child Health Bureau.

Figure 1-2 Retractions are a sign of increased ventilatory effort.



EMSC Slide Set (CD-ROM). 1996. Courtesy of the Emergency Medical Services for Children Program, administered by the U.S. Department of Health and Human Service's Health Resources and Services Administration, Maternal and Child Health Bureau.

Figure 1-3 Pallor, cyanosis, and mottling suggest the presence of inadequate oxygenation, poor perfusion, or both.

Table 1-2 Categorization of the Pediatric Assessment Triangle Findings

Physiologic Abnormality	Appearance	Work of Breathing	Circulation to Skin
Cardiopulmonary failure	Abnormal	Abnormal	Abnormal
Compensated shock	Normal	Normal	Abnormal
Hypotensive shock	Abnormal	Normal or abnormal	Abnormal
Primary brain dysfunction or systemic problem	Abnormal	Normal	Normal
Respiratory distress	Normal	Abnormal	Normal
Respiratory failure	Abnormal	Abnormal	Normal or abnormal

Modified from Dieckmann, R. A. (2012). Pediatric assessment. In S. Fuchs, & L. Yamamoto (Eds.), APLS: The pediatric emergency medicine resource (5th ed., pp. 2–37). Burlington, MA: Jones & Bartlett and Santillanes, G. (2014). General approach to the pediatric patient. In J. A. Marx, R. S. Hockberger, & R. M. Walls (Eds.), Rosen's emergency medicine: Concepts and clinical practice (8th ed., pp. 2087–2095). Philadelphia: Elsevier Saunders.

Responsiveness

- Although assessment of responsiveness is technically not the first step of the primary assessment, it is worthwhile to establish the child's level of responsiveness using the AVPU mnemonic before continuing your assessment.
  A = Alert; the patient is awake and aware of your presence.
  V = The patient responds to a Verbal stimulus; the child opens his or her eyes in response to your voice; the patient appropriately responds to a simple command.
  P = The patient responds to a Painful stimulus; the patient is unaware of your presence and does not respond to your loud voice; the patient responds only when you apply some form of irritating stimulus.
  U = Unresponsive, the patient does not respond to any stimulus.
- While forming a general impression of your patient's appearance, you learned important information about his or her mental status. It is important to consider these findings when determining your next steps. If your general impression revealed that the child was alert or responsive to verbal stimuli, it is not necessary to reassess responsiveness at this point—move on to assessment of the patient's airway. However, if your general impression revealed that the child was unresponsive, you must quickly determine if the child is in cardiac arrest. This distinction is important because current cardiopulmonary resuscitation guidelines have established that the priorities of care for the cardiac arrest patient are circulation, airway, and then breathing (i.e., a C-A-B approach) rather than an ABCDE approach. Rationales for the C-A-B approach include shortening the time to the start of chest compressions and reducing the time of no blood flow (Atkins et al., 2015).
- If the child is unresponsive, quickly check to see if he is breathing. If normal breathing is present, continue the primary assessment. If the child is not breathing (or only gasping), call for help and check for a pulse. If a pulse is present, open the airway and begin rescue breathing. If there is no pulse or you are unsure if there is a pulse, begin chest compressions.
- The assessment sequence described below assumes the patient is responsive or that a pulse is present if he or she is unresponsive.

Airway

- Assess the patient's ability to maintain an open (i.e., clear of debris and obstruction) airway. A child who is alert and talking clearly or crying without difficulty has an open airway. If the airway is open, move on to evaluation of the patient's breathing.
- Sounds associated with noisy breathing such as gurgling, snoring, or stridor suggest a partial airway obstruction and require further investigation.
  - **Gurgling** is a bubbling sound that occurs when blood or secretions are present in the airway, and is an indication for immediate suctioning.
  - **Snoring** sounds are noisy and low-pitched and are usually caused by partial obstruction of the upper airway by the tongue. Snoring can generally be corrected using simple measures such as stimulating the patient to wake up, repositioning the patient, or opening the airway using a head tilt–chin lift or jaw thrust maneuver. Insertion of an oral or nasal airway may be needed to keep the airway open (see Chapter 2).
  - **Stridor** is a harsh, high-pitched sound that is usually an indication of inflammation or swelling of the upper airway. Stridor may be inspiratory or expiratory (Wilson, 2011). Possible causes of stridor include the presence of a foreign body, an inhalation injury, and disorders such as croup, epiglottitis, or tracheitis. Generally, the presence of stridor warrants the administration of supplemental oxygen and additional interventions that are dependent on the cause of the stridor.

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The responsive child may have assumed a position to maximize his or her ability to maintain an open airway. Allow the child to maintain this position as you continue your assessment.

Airway Interventions

- A child who is decompensating may require simple interventions such as head positioning, suctioning, or the insertion of an airway adjunct (see Chapter 2) to maintain an open airway (**Box 1-1**). When basic interventions are ineffective, more advanced measures to maintain an open airway may be needed such as insertion of an advanced airway (e.g., endotracheal tube, laryngeal mask airway), direct laryngoscopy to remove a foreign body, application of continuous positive airway pressure (CPAP), or cricothyrotomy.

Box 1-1 Possible Airway Interventions

Allowing the patient to assume a position of comfort to maintain airway patency
Head positioning
Suctioning
Using a manual airway maneuver (e.g., head tilt–chin lift, jaw thrust) to open the airway
Inserting an airway adjunct (e.g., oral airway, nasal airway)
Inserting an advanced airway (e.g., endotracheal tube, laryngeal mask airway)
Applying continuous positive airway pressure
Removing a foreign body with direct laryngoscopy
Performing a cricothyrotomy

- If the child is responsive but is unable to speak, cry, forcefully cough, or make any other sound, his airway is completely obstructed. Clear the obstruction by performing subdiaphragmatic abdominal thrusts (if the patient is 1 year or older) or back slaps and chest thrusts (if the patient is younger than 1 year).
- If the child is unresponsive and trauma is not suspected, open the child's airway by using the head tilt–chin lift or jaw thrust maneuver. Both of these maneuvers lift the tongue away from the back of the throat. If the patient is unresponsive and trauma to the cervical spine is suspected, open the child's airway by using the jaw thrust without neck extension maneuver to prevent additional cervical insult (see Chapter 2).
- If trauma is suspected but you are unable to open the airway (or maintain an open airway) by using the jaw thrust without neck extension maneuver, it is acceptable to use a head tilt–chin lift or jaw thrust with neck extension maneuver because opening the airway is a priority (Kleinman et al., 2015). If there is blood, vomitus, or other fluid in the child's airway, clear it with suctioning. After ensuring that the patient's airway is open, move on to evaluation of his or her breathing.

Breathing

When assessing breathing, determine the child's rate of breathing, evaluate his or her ventilatory effort, listen for breath sounds, assess his or her oxygenation by using pulse oximetry, and evaluate the effectiveness of ventilation by using capnography (**Box 1-2**). If the patient is breathing, determine if breathing is adequate or inadequate. If breathing is adequate, move on to assessment of circulation.

Box 1-2 Breathing Assessment

Assess the rate of breathing
Evaluate ventilatory effort
Auscultate breath sounds
Measure oxygen saturation with a pulse oximeter
Measure exhaled carbon dioxide using capnography

Ventilatory Rate

- Determine the child's rate of breathing by counting the number of times the patient's chest rises in 30 seconds. Double this number to determine the breaths per minute. The patient with breathing difficulty often has a ventilatory rate outside the normal limits for his or her age (**Table 1-3**).
- While counting the rate, observe the child's chest wall and note the rhythm of breathing (e.g., regular, irregular, periodic). The ventilatory rate is often irregular in newborns and very young infants (Duderstadt, 2014). Prolonged inspiration suggests an upper airway problem (e.g., croup, foreign body). Prolonged expiration suggests a lower airway problem (e.g., asthma, pneumonia, foreign body).

Tachypnea

Tachypnea is a rate of breathing that is more rapid than normal for the patient's age. Tachypnea may be a compensatory response secondary to excitement, anxiety, fever, and pain (among other causes), or it may be associated with disorders such as metabolic acidosis, sepsis, exposure to a toxin, or a brain lesion. As fatigue begins and hypoxia worsens, the child progresses to respiratory failure with slowing and possible cessation of the ventilatory rate.

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At any age, a ventilatory rate greater than 60 per minute is abnormal.

Bradypnea

Bradypnea is a slower than normal rate of breathing for the patient's age. It is an ominous sign in an acutely ill infant or child and may be caused by respiratory muscle fatigue, hypothermia, metabolic disorders, brain injury, central nervous system infection, hypoperfusion, or opioids or sedative drugs, among other causes. The patient who has bradypnea may also have episodes of apnea and may require both supplemental oxygen and ventilatory assistance (National Association of Emergency Medical Technicians, 2011).

Apnea

Apnea is the cessation of breathing for more than 20 seconds, or less than 20 seconds if it is associated with cyanosis, pallor, decreased muscle tone, or bradycardia (Merves, 2012). There are three main

Table 1-3 Normal Ventilatory Rates by Age at Rest

Age	Ventilatory Rate (breaths/min)
Infant (birth to 1 year)	30 to 60
Toddler (1 to 3 years)	24 to 40
Preschooler (4 to 5 years)	22 to 34
School-age child (6 to 12 years)	18 to 30
Adolescent (13 to 18 years)	12 to 16

types of apnea: (1) central apnea, (2) obstructive apnea, and (3) mixed apnea. With central apnea, there is an absence of chest wall movement and airflow that is related to the failure of the central nervous system to transmit signals to the respiratory muscles. With obstructive apnea, inspiratory effort is present but airflow is absent because of an anatomic obstruction in the upper airway, usually at the level of the pharynx. Obstructive apnea may be accompanied by snoring and gasping. Possible causes of obstructive apnea include decreased muscle tone, enlarged tonsils and adenoids, and congenital disorders such as Pierre Robin syndrome (Betz & Snowden, 2008). With mixed apnea, components of both central and obstructive apnea are present.

Ventilatory Effort

- Assess the chest for movement, evaluating the depth and symmetry of movement with each breath. **Tidal volume** is the volume of air moved into or out of the lungs during a normal breath. Tidal volume can be indirectly evaluated by observing the rise and fall of the patient's chest and abdomen.
- **Minute volume** is the amount of air moved in and out of the lungs in one minute and is determined by multiplying the tidal volume by the ventilatory rate. Thus, a change in either the tidal volume *or* ventilatory rate will affect minute volume. A ventilatory rate that is too slow will decrease minute volume because tidal volume cannot be increased to compensate; a ventilatory rate that is too fast will result in a marked decrease in tidal volume and subsequently minute volume (Dieckmann, 2012).
- Ventilations in infants and children younger than 6 or 7 years are primarily abdominal (diaphragmatic) because the intercostal muscles of the chest wall are not well developed and will easily fatigue from the work of breathing. Effective ventilation may be jeopardized when diaphragmatic movement is compromised (e.g., gastric or abdominal distension) because the chest wall cannot compensate. As the child grows older, the chest muscles strengthen and chest expansion becomes more noticeable. The transition from abdominal (diaphragmatic) breathing to intercostal breathing begins between 2 and 4 years of age and is complete by 7 to 8 years of age.
- Look for signs of increased work of breathing, which may include the following (**Figure 1-4**):
  - Restlessness, anxious appearance, concentration on breathing
  - Leaning forward to inhale
  - Nasal flaring
  - Head bobbing
  - Use of accessory muscles of breathing
  - Retractions
  - Seesaw breathing

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Retractions indicate increased work of breathing. They may be observed below (subcostal) or between (intercostal) the ribs with mild to moderate breathing difficulty. As the level of breathing difficulty worsens, retractions may extend to the sternum, suprasternal notch, and supraclavicular areas.

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Figure 1-4 When assessing breathing, look for signs of increased ventilatory effort.

Breath Sounds

- Audible signs of breathing difficulty include stridor, gurgling, grunting, wheezing, and crackles. Stridor and gurgling have been discussed.
  - **Grunting** is a short, low-pitched sound heard as the patient exhales against a partially closed glottis. It is a compensatory mechanism to help maintain the patency of the alveoli and prolong the period of gas exchange.
  - **Wheezes** are high- or low-pitched sounds produced as air passes through airways that have narrowed because of swelling, spasm, inflammation, secretions, or the presence of a foreign body. If air movement is inadequate, wheezing may not be heard.
  - **Crackles**, formerly called *rales*, are crackling sounds produced as air passes through airways containing fluid or moisture.
- Because the chest of a child is small and the chest wall is thin, breath sounds are easily transmitted from one side of the chest to the other. As a result, breath sounds may be heard despite the presence of a pneumothorax, hemothorax, or atelectasis. To minimize the possibility of sound transmission from one side of the

Figure 1-5 Auscultate the anterior and posterior chest for breath sounds.

Figure 1-6 The sensor of a pulse oximeter is placed over thin tissue with reasonably good blood flow such as a finger, toe, or ear lobe.

chest to the other, auscultate along the midaxillary line (under each armpit) and in the midclavicular line under each clavicle. Alternate from side to side and compare your findings. The anterior and posterior chest should also be auscultated for breath sounds (**Figure 1-5**).

Oxygen Saturation

- **Pulse oximetry** is a noninvasive method of monitoring the percentage of hemoglobin (Hb) that is saturated with oxygen (SpO_2) by using selected wavelengths of light. Continuous monitoring of oxygen saturation by means of pulse oximetry is considered the standard of care in any circumstance in which detection of hypoxemia is important. A pulse oximeter is an adjunct to, not a replacement for, vigilant patient assessment. It is essential to correlate your assessment findings with pulse oximeter readings to determine appropriate treatment interventions for your patient.

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When combined with your patient assessment skills, pulse oximetry is a valuable tool that is used to assess the effectiveness of the patient's oxygenation. A capnometer or capnograph, which measures carbon dioxide during exhalation, is used to assess the effectiveness of the patient's ventilation.

- A pulse oximeter consists of a sensor that is placed over thin tissue with reasonably good blood flow (such as a finger, toe, or ear lobe) (**Figure 1-6**). The sensor is connected to a monitor that displays the percentage of Hb saturated with oxygen and provides an audible signal for each heartbeat, a calculated heart rate, and in some models, a graphic display of the blood flow past the sensor. Make certain that the wiring used to connect a sensor and oximeter is compatible. Considerable heat can be generated at the tip of a sensor when incompatible wiring is used, causing second- and third-degree burns under the sensor (Wilson, 2011).
- To ensure an accurate measurement when using a pulse oximeter, check that the pulse rate according to the oximeter is consistent with that obtained by palpation. Sensors should not be placed on extremities used for blood pressure monitoring because pulsatile blood flow can be affected, thereby distorting SpO_2 readings (Wilson, 2011). Check the skin under the sensor often because tissue injury may occur when sensors are attached too tightly. The frequency with which the sensor site should be changed should be in accordance with the manufacturer's guidelines.
- Because pulsatile blood flow is necessary for a pulse oximeter to work, it may provide inaccurate results in a child with poor peripheral perfusion (e.g., shock, cardiac arrest). Pulse oximetry may also be inaccurate in children with chronic hypoxemia (e.g., cyanotic congenital heart disease, pulmonary hypertension), significant anemia, carboxyhemoglobinemia, or methemoglobinemia.

Carbon Dioxide Measurement

- A **capnometer** is a device that measures the concentration of carbon dioxide at the airway opening at the end of exhalation. With **capnometry**, a numeric reading of exhaled CO_2 concentrations is provided without a continuous waveform.
- A **capnograph** is a device that provides both a numeric reading and a waveform of carbon dioxide concentrations in exhaled gases. **Capnography**, the process of continuously analyzing and recording carbon dioxide concentrations in expired air, is an assessment tool that is used in both intubated and nonintubated patients to assess the effectiveness of ventilation.
- Because capnometry and capnography reflect the elimination of CO_2 from the lungs during breathing, use of these devices can alert the clinician to respiratory compromise such as apnea, airway obstruction, hypoventilation, hyperventilation, and abnormal breathing patterns.

Breathing Interventions

During your assessment of breathing, evaluate the child's ventilatory rate and ventilatory effort, auscultate breath sounds, asses the child's oxygen saturation, and evaluate the effectiveness of ventilation. If the child's breathing is inadequate, necessary interventions may include administering supplemental oxygen, assisting ventilation with a bag-mask device, and inserting an advanced airway (**Box 1-3**). To ensure proper minute ventilation, the use of a capnometer or capnograph is recommended when assisted ventilation is necessary (Dieckmann, 2012).

Circulation

When assessing circulation, you will evaluate the patient's heart rate and rhythm, pulse quality, skin color and temperature, capillary refill time, and blood pressure (**Box 1-4**).

Heart Rate and Regularity

- Determine if the patient's heart rate is within normal limits for the child's age (**Table 1-4**) and if the rhythm is regular or irregular. Heart rate may be determined by counting the rate for 30 seconds and then doubling the number to calculate the rate per minute, by auscultating the heart, or by viewing the patient's heart rate on the monitor of an electrocardiogram (ECG) or pulse oximeter.
- Heart rate is influenced by the child's age and level of activity. A very slow or rapid rate may indicate or may be the cause of cardiovascular compromise. The terms *arrhythmia* and *dysrhythmia* are used interchangeably to refer to an abnormal heart rhythm. In the pediatric patient, dysrhythmias are divided into four broad categories based on heart rate: (1) normal for age, (2) slower than normal for age (bradycardia), (3) faster than normal for age (tachycardia), or (4) absent (cardiac arrest). In children, dysrhythmias are treated only if they compromise cardiac output or if they have the potential for deteriorating into a lethal rhythm. For example, fever, pain, and fear are common causes of a temporary increase in heart rate. The heart rate typically returns to normal as the underlying cause is treated. In contrast, ventricular fibrillation is a lethal rhythm that requires prompt treatment with chest compressions and defibrillation.

Box 1-3 Possible Breathing Interventions

Administering supplemental oxygen
Assisting ventilation
Inserting an advanced airway
Additional interventions as necessary

Box 1-4 Circulation Assessment

Assess the heart rate and rhythm
Evaluate pulse quality (e.g., central and peripheral pulses)
Assess skin color and temperature
Determine capillary refill time
Measure the blood pressure

Table 1-4 Normal Heart Rates by Age at Rest

Age	Heart Rate (beats/min)
Infant (birth to 1 year)	100 to 160
Toddler (1 to 3 years)	95 to 150
Preschooler (4 to 5 years)	80 to 140
School-age child (6 to 12 years)	70 to 120
Adolescent (13 to 18 years)	60 to 100

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The values used to define a tachycardia (above 100 beats/min) and a bradycardia (below 60 beats/min) in an adult are not the same in the pediatric patient. In infants and children, a tachycardia is present if the heart rate is faster than the upper limit of normal for the patient's age. A bradycardia is present when the heart rate is slower than the lower limit of normal.

Pulse Quality

- *Pulse quality*, which reflects the adequacy of peripheral perfusion, refers to the strength of the heartbeat felt when taking a pulse. Pulse quality is assessed by feeling central and peripheral pulses and comparing their strengths. It is also important to compare differences between the upper and lower extremities. Lower extremity pulses that are absent or weak when compared with the upper extremities suggest coarctation of the aorta (Duderstadt, 2014).

- A central pulse is a pulse found close to the trunk of the body. Central pulse locations that are generally easily accessible include the brachial artery (in infants), the carotid artery (in older children), the femoral artery, and the axillary artery. Determining the presence and strength of a femoral pulse can be challenging in overweight and obese children because of the necessity to palpate through adipose tissue (Duderstadt, 2014).
- Peripheral pulse locations include the radial, dorsalis pedis, and posterior tibial arteries (**Figure 1-7**). Assess a peripheral pulse while keeping one hand on the central pulse location to compare their strengths. For example, feel a femoral (central) and dorsalis pedis (peripheral) pulse.
- A *strong* pulse is one that is easily felt and that is not easily obliterated with pressure. A *bounding* pulse is not obliterated with pressure. A *weak* pulse is difficult to feel and a *thready* pulse is one that is weak and fast. A weak, thready, or absent pulse is an indication for fluid resuscitation, chest compressions, or both (Lee & Marcdante, 2011).
  - Several systems are used for grading the strength or intensity of a patient's peripheral pulse. One system uses a scale of 0 to 4 where an absent pulse is 0, a palpable but weak pulse is 1+, a normal pulse is 2+, a stronger than normal (full) pulse is 3+, and a bounding pulse is 4+. Another system uses a scale of 0 to 3 where an absent pulse is 0, a diminished or weaker than expected pulse is 1+, a brisk (normal) pulse is 2+, and a bounding pulse is 3+. Use the scale adopted by your organization.
- The presence of strong central and peripheral pulses suggests that the child has an adequate blood pressure. A weak central pulse may indicate hypotensive shock. A peripheral pulse that is difficult to find, weak, or irregular suggests poor peripheral perfusion and may be a sign of shock or hemorrhage. If no central pulse is present, chest compressions should be started using rates and techniques (e.g., compression depth, finger or hand placement) in accordance with current resuscitation guidelines.

Figure 1-7 A central pulse is a pulse found close to the trunk of the body. The radial artery is an example of a peripheral pulse location.

Skin Color and Temperature

- Skin color is most reliably evaluated in the sclera, conjunctiva, nail beds, tongue, oral mucosa, palms, and soles (**Figure 1-8**). Possible causes of flushed (red) skin include fever, infection, toxic exposure, exposure to warm ambient temperatures, and heat-related emergencies.
- Pallor may be the result of respiratory failure, anemia, shock, or chronic disease. Cool, pale extremities are associated with decreased cardiac output, as seen in shock and hypothermia. In children with dark skin, pallor may be observed as ashen gray skin. Pallor in brown-skinned individuals may appear as a yellow color.
- Blue (cyanosis) coloration of the nails, palms, and soles suggests hypoxemia or inadequate perfusion. In dark skin, cyanosis may be observed as ashen gray lips, gums, or tongue. Possible causes of *peripheral cyanosis*, which is a blue discoloration of the hands and feet, include anxiety, cold, shock, peripheral vascular disease, and heart failure. *Central cyanosis*, which is a blue discoloration of the trunk or mucous membranes of the eyes, nose, and mouth, reflects a marked decrease in the oxygen carrying capacity of the blood. Possible causes of central cyanosis are shown in **Box 1-5**. The presence of central cyanosis is an indication for the administration of supplemental oxygen and ventilatory support (American Heart Association, 2011).
- Mottling is an irregular or patchy skin discoloration that is usually a mixture of blue and white. The presence of mottling suggests decreased cardiac output, ischemia, or hypoxia, but it can be normal in an infant that has been exposed to a cool environment. Mottled skin is usually seen in patients in shock, with hypothermia, or in cardiac arrest.
- Jaundice is a yellow color seen in the skin, the sclera of the eyes, and the mucus membranes of the mouth. It is caused by elevated levels of bilirubin in the blood resulting from an increased breakdown of hemoglobin.
- The skin is normally warm and dry with good turgor. Use the dorsal surfaces of your hands and fingers to assess skin

Figure 1-8 Assessment of circulation includes evaluation of skin color and temperature.

Box 1-5 Possible Causes of Central Cyanosis

Acute respiratory distress syndrome
Asthma
Bronchiolitis
Cyanotic heart disease (e.g., tetralogy of Fallot, transposition of great vessels, hypoplastic heart syndrome)
Drug overdose
Heart failure
High altitude
Pneumonia
Respiratory failure
Traumatic brain injury

temperature. As cardiac output decreases, coolness will begin in the hands and feet and ascend toward the trunk.

- *Turgor* refers to the elasticity of the skin. To assess skin turgor, grasp the skin on the upper arm or abdomen between your thumb and index finger. Pull the skin taut and then quickly release. Observe the speed with which the skin returns to its original contour once released. The skin should immediately resume its shape with no tenting or wrinkling.
- Good skin turgor indicates adequate hydration. Decreased skin turgor is present when the skin is released and it remains pinched (tented) before it slowly returns to its normal shape (**Figure 1-9**). Decreased skin turgor is a sign of dehydration, malnutrition, or both and may also be observed in patients with chronic disease and muscle disorders (Engel, 2006c).

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A positive finding is more helpful than a negative one. Never assume a child is well hydrated based on good skin turgor.

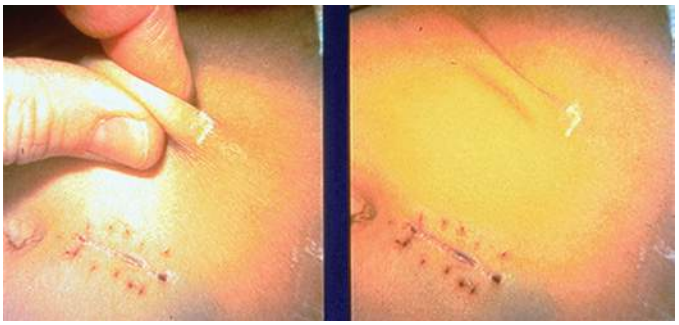

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Figure 1-9 Tenting of the skin after it is released is a sign of dehydration, malnutrition, or both.

Capillary Refill Time

- Capillary refill, also called the *blanching test*, is assessed by applying pressure to tissue until it blanches and then rapidly releasing pressure and observing the time it takes for the tissue to return to its original color. Sites that may be used to assess capillary refill include the nail beds, forearm, forehead, chest, abdomen, kneecap, and fleshy part of the palm.
- If the ambient temperature is warm, color should return within 2 to 3 seconds. A capillary refill time of 3 to 5 seconds is said to be *delayed*. This may indicate poor perfusion or exposure to cool temperatures. A capillary refill time of more than 5 seconds is said to be *markedly delayed* and suggests shock.
- If capillary refill is initially assessed in the hand or fingers and it is delayed, recheck it in a more central location such as the chest.

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Because capillary refilling time can be influenced by many factors, including environmental temperature, medications, and chronic medical conditions, it is important to consider these findings in conjunction with other assessments of the child's perfusion (e.g., heart rate, quality of peripheral pulses, skin color, and temperature).

Blood Pressure

- A child's blood pressure varies with age (**Table 1-5**). It may be affected by emotion, the child's degree of activity, the presence of pain, and medications. In children younger than 3 years, a strong central pulse is considered an acceptable sign of adequate blood pressure.
- When measuring blood pressure, use a cuff that completely encircles the extremity and ensure that the width of the cuff is two-thirds the length of the long bone used (such as the upper arm or thigh). Use of a cuff that is too large will result in a falsely low reading; use of a cuff that is too small will result in a falsely high reading.
- Pulse pressure, which is the difference between the systolic and diastolic blood pressure, provides important information about a patient's stroke volume. A narrowed pulse pressure is an indicator of circulatory compromise.

Table 1-5 Lower Limit of Normal Systolic Blood Pressure by Age

Age	Lower Limit of Normal Systolic Blood Pressure
Term neonate (0 to 28 days)	More than 60 mm Hg or strong central pulse
Infant (1 to 12 months)	More than 70 mm Hg or strong central pulse
Child 1 to 10 years	More than 70 + (2 × age in years)
Child 10 years or older	More than 90 mm Hg

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It is important to know your facility's policy with regard to blood pressure measurement because some organizations require the assessment of blood pressure in *all* children and others require that blood pressure be measured in children older than 3 years.

Circulation Interventions

- During your assessment of circulation, evaluate the patient's heart rate and rhythm, pulse quality, skin color and temperature, capillary refill time, and blood pressure.
- If no central pulse is present, begin chest compressions and assist breathing with a bag-mask device (**Box 1-6**). Apply a cardiac monitor and identify the rhythm. The next steps will be determined by the rhythm on the cardiac monitor. For example, if the rhythm is asystole or if pulseless electrical activity is present, vascular access (e.g., intravenous, intraosseous) should be established and medications should be given. If the rhythm is pulseless ventricular tachycardia or ventricular fibrillation, defibrillation should be performed followed by vascular access and medications.
- If the child has a pulse but signs of shock are present (e.g., tachycardia, weak peripheral pulses, pallor or mottling, delayed capillary refill), call for additional assistance, position the child on his or her back unless breathing is compromised, administer supplemental oxygen, establish vascular access, and administer fluids to stabilize perfusion, if indicated (see Chapter 3).

Disability

- Assessment of mental status is one of the most important components of the physical examination and should be frequently reassessed (Wing & James, 2013). Altered mental status may be evidenced by irritability, moaning, or a weak or high-pitched cry, and it may range from mild confusion to unresponsiveness. Examples of causes of altered mental status in the pediatric patient include hypoxia, infection (e.g., meningitis, encephalitis), shock, seizures, hypoglycemia, electrolyte abnormalities, poisoning, or a previous illness or injury (e.g., brain injury). The patient's caregiver, if available, should be asked if the child's responsiveness, mood, eating and sleeping habits, and level of activity are consistent with or different from his or her normal behavior (**Figure 1-10**). This is particularly important if the child is preverbal (Wing & James, 2013).

Figure 1-10 The patient's caregiver may be an important source of information when a child has an altered mental status.

- An infant's level of responsiveness is largely based on assessment of his or her alertness, cry, level of activity, response to the environment, and recognition of parents or caregivers (Hazinski, 2013). Assessment of orientation (i.e., to person, place, time, and event) and the ability to follow commands can be assessed if the child is sufficiently mature to comprehend and answer questions (Hazinski, 2013). Significant changes in a child's mental status should prompt early airway management (Bakes & Sharieff, 2013).

Box 1-6 Possible Circulation Interventions

Positioning the patient
Administering supplemental oxygen
Assisting ventilation
Establishing vascular access
Replacing fluids
Performing chest compressions
Performing defibrillation

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The airway of a child with an altered mental status is vulnerable to airway obstruction because of decreased muscle tone and depressed gag and cough reflexes. This may lead to airway obstruction, resulting in hypoxemia and respiratory failure or respiratory arrest. Repeat the primary assessment at frequent intervals throughout your management of these patients and revise your treatment plan based on the patient's response to your interventions.

- In addition to evaluating appearance while forming a general impression and the use of the AVPU scale earlier in the primary assessment, the Pediatric Glasgow Coma Scale (GCS) is often used during this phase of patient assessment to establish a baseline and for comparison with later serial observations. The AVPU scale evaluates what stimulus it takes to get a response; the GCS evaluates what response results from the stimulus given (Shade, Collins, Wertz, Jones, & Rothenberg, 2007). The Pediatric GCS has not been well validated as a predictive instrument in children (Dieckmann, 2012).
  - Three categories are assessed with the GCS: (1) eye opening, (2) verbal response, and (3) motor response (see **Table 1-6**). The GCS score is the sum of the scores in these categories; the lowest possible score is 3 and the highest possible score is 15. Consider the need for aggressive airway management when the GCS is 8 or less.
  - Motor response is the most important component of the GCS if the patient is unresponsive, intubated, or preverbal (American Heart Association, 2011). Verbal and motor responses must be evaluated with respect to a child's age (Wing & James, 2013). In a responsive patient, assess motor function and the ability to follow commands by asking the child to stick out his or her tongue, wiggle toes, or raise two fingers (Hazinski, 2013). If it is necessary to apply a painful stimulus and assess the patient's response, apply the stimulus over the trunk to avoid confusion with spinal reflexes.
  - Because the verbal component of the GCS may be affected by a child's fear or discomfort, it should be reassessed after the child has been calmed and (if applicable) pain medication has been administered (Wing & James, 2013).

Table 1-6 Glasgow Coma Scale

Glasgow Coma Scale	Adult/Child	Score	Infant
Eye Opening	Spontaneous	4	Spontaneous
	To verbal command	3	To speech
	To pain	2	To pain
	No response	1	No response
Best **V**erbal Response	Oriented	5	Coos, babbles
	Disoriented	4	Cries but consolable
	Inappropriate words	3	Cries to pain
	Incomprehensible sounds	2	Moans to pain
	No response	1	No response
Best **M**otor Response	Follows commands	6	Spontaneous movement
	Localizes pain	5	Withdraws to touch
	Withdraws to pain	4	Withdraws to pain
	Abnormal flexion	3	Abnormal flexion
	Abnormal extension	2	Abnormal extension
	No response	1	No response
	Total = E + V + M	3 to 15	

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When assessing a child's level of orientation, ask age-appropriate questions. For example, ask the child to tell you about his favorite cartoon character, pet, sports personality, toy, or television show.

- Assess pupil size, symmetry, and reactivity to light. Normally, the pupils are equal and round, and both pupils briskly constrict when a light shines in one eye and dilate in darkness. When a toxic exposure is suspected, pupils that are dilated or constricted can be helpful in determining the substance involved. For example, narcotics and exposure to organophosphate insecticides typically produce small pupils. Exposure to antihistamines, amphetamines, and hallucinogens usually produce large pupils.
- Pupillary changes may also be observed with other conditions such as trauma to the eye or increases in intracranial pressure. Unilateral pupil dilation in a child with a history of trauma may be a sign of brain herniation. Pupillary changes caused by compression of the oculomotor nerve as the brain herniates are usually observed on the same side as the lesion. Initially, the pupil on the same side of the lesion (i.e., the ipsilateral pupil) reacts to light, but sluggishly. As herniation continues, the ipsilateral pupil remains dilated. Bilateral pupil dilation may occur as intracranial pressure increases and both halves of the brain become affected. *Anisocoria*, a condition characterized by pupils that are unequal in size, is a normal finding in some patients.

Disability Interventions

- Regardless of the cause of the patient's altered mental status, the priorities of care remain the same. If cervical spine injury is suspected (by physical examination, history, or mechanism of injury), manually stabilize the head and neck in a neutral, in-line position or maintain spinal stabilization if already completed. Use positioning or airway adjuncts as necessary to maintain airway patency. Suction as needed. Avoid the use of an oral airway unless the patient is unresponsive; use in a semi-responsive child may cause vomiting if a gag reflex is present. Insertion of an advanced airway may be needed if the airway cannot be maintained by positioning or if prolonged assisted ventilation is anticipated.
- Patients with an altered mental status may breathe shallowly, even when skin color and ventilatory rate appear normal. Close observation is necessary to ensure adequate ventilation.
- Assist breathing with a bag-mask device as necessary. Insertion of an advanced airway may be necessary to ensure an open airway and adequate ventilation.

- Pulse oximetry and continuous cardiac monitoring should be routinely performed for any infant or child who displays an altered mental status.
- Capnography or capnometry should be measured if possible.
- Attach a cardiac monitor, establish vascular access, and determine the serum glucose level.

Exposure

- Undress the patient for further examination, taking care to preserve body heat. Maintaining appropriate temperature is particularly important in the pediatric patient because children have a large body surface area to weight ratio, providing a greater area for heat loss. Respect the child's modesty by keeping the child covered if possible. Promptly replace clothing after examining each body area.
- With the patient's body exposed, look for visible external hemorrhage and other signs of trauma (e.g., deformity, contusions, abrasions, lacerations, punctures, burns). Control major bleeding, if present, by applying direct pressure over the bleeding site. Note the presence of petechiae, purpura, chickenpox, measles, or other skin rash.

Secondary Assessment

The next phase of patient assessment is the secondary assessment. The purpose of a secondary assessment, also called a *secondary survey*, is to obtain a focused history and perform a head-to-toe examination to identify any problems that were not identified during the primary assessment.

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When caring for the pediatric patient, treatment interventions are usually based on the weight of the child. As a result, a range of age- and size-appropriate equipment, including bag-mask devices, endotracheal tubes, and intravenous catheters, must be readily available for use in pediatric emergencies. The equipment and supplies must be logically organized, routinely checked, and readily available.

Although a child's weight can be estimated by using the following formula: weight in kg = 8 + (2 × age in years), it is best to obtain a measured weight. If obtaining a measured weight is not possible, a length-based resuscitation tape may be used to estimate weight by length and simplify selection of the medications and supplies needed during the emergency care of children. Appropriate resuscitation medication doses and equipment sizes are listed on the tape, as well as abnormal vital signs, fluid calculations, and energy levels recommended for defibrillation.

Focused History

- The history is often obtained at the same time as the physical examination and while therapeutic interventions are performed. While performing the physical examination, ask the patient, family, or bystanders questions regarding the patient's history. When possible, use open-ended questions such as, "How can I help you today?" This allows the patient, caregiver, or family an opportunity to tell their story in their own words.
- Several mnemonics have been suggested in regard to obtaining a patient history. **SAMPLE** stands for Signs and symptoms (as they relate to the chief complaint), Allergies, Medications, Past medical history, Last oral intake, and Events surrounding the illness or injury.
- The Emergency Nurses Association (ENA) recommends use of the CIAMPEDS mnemonic, which stands for Chief complaint, Immunizations or isolation (communicable disease exposure), Allergies, Medications, Past medical history, Events surrounding the illness or injury, Diet or diapers (bowel and bladder history), and Symptoms associated with the illness or injury.
- **OLDCART** is a mnemonic that stands for Onset of symptoms, Location of problem, Duration of symptoms, Characteristics of symptoms, Aggravating factors, Relieving factors, and Treatment before arrival (Mace & Mayer, 2008).
- **PQRST** is an acronym that is often used when evaluating patients in pain: Precipitating or provoking factors, Quality of pain, Region and radiation of pain, Severity, and Time of pain onset. It is important to keep in mind that when a child suffers from pain because of illness or injury, his or her caregivers experience almost equal anxiety and emotional stress (Sharieff, 2013).

Physical Examination

- The physical examination usually proceeds in a head-to-toe sequence to ensure that no areas are overlooked. However, the sequence may need to be altered to accommodate the child's temperament, developmental needs, or the severity of the child's illness or injury. When circumstances permit, much of the physical examination of infants and young children is performed on the lap of the child's caregiver or with the caregiver nearby to decrease fear and stranger anxiety (**Figure 1-11**) (Duderstadt, 2014). Try to gain the child's trust as you proceed by being calm, friendly, and reassuring. Additional considerations when performing a physical examination are shown in **Table 1-7**.
- A detailed physical examination is presented here for completeness. A focused physical examination may be more appropriate, based on the patient's presentation, chief complaint, your primary assessment findings, and the severity of the child's illness or injury.
- During the examination, compare one side of the body with the other. For example, if an illness or injury involves one side of the body, use the unaffected side as the normal finding for comparison.

Skin

- Examine the skin for contusions, abrasions, lacerations, punctures, burns, scars, and the presence of **petechiae**, **purpura**, or a rash (**Figure 1-12**). Palpate for edema by pressing a thumb into areas that look swollen (Engel, 2006c).

Figure 1-11 When circumstances permit, perform the physical examination of an infant or young child with the patient on the caregiver's lap or with the caregiver nearby.

- Accidental bruises in children tend to be nonspecific in configuration and are usually distributed over bony prominences such as the scalp, forehead, chin, shins, and knees. Bruises of the ears, neck, or trunk of an infant or bruises of the ears, neck, torso, back, buttocks, or posterior thighs and calves of a child younger than 4 years should raise concern. Dating bruises based on their color was once practiced to help distinguish between accidental and nonaccidental trauma. This practice is now discouraged because recent literature has suggested that the dating of bruises by color has no scientific basis; however, multiple bruises in various stages of healing should prompt concern (Leetch & Woolridge, 2013).

Head

- Examine the head for bruising and swelling. If trauma is suspected, gently palpate the child's head and feel for tenderness, swelling, or depressions that may indicate a skull fracture. Gently palpate the facial bones for instability or tenderness.
- Because a child's head is large in proportion to the rest of his or her body until about 4 years of age, it is not unusual for children to have forehead bruises from hitting their heads on tables and floors. Toddlers are also at increased risk of head injuries from falls and motor vehicle crashes because of their higher center of gravity. The relatively large occiput of infants and young children predisposes them to flexion injuries of the cervical spine during deceleration. Flexion of the neck may compromise air exchange and increase the risk of an anatomical airway obstruction.
- Gently palpate the fontanels on the top of the head. **Fontanels** are membranous spaces formed where cranial bones meet and intersect. Normally, only the posterior and anterior fontanels can be palpated (Engel, 2006b). Pulsations of the fontanel reflect the heart rate. The posterior fontanel usually closes

Table 1-7 Physical Examination Considerations by Age

Age	Physical Examination Considerations
Infant (birth to 1 year)	Keep the infant on the caregiver's lap or in the caregiver's arms during the physical examination if possible. Examine while speaking softly and smiling. Handle the patient gently but firmly, supporting head and neck. Keep the caregiver in sight if possible to decrease separation anxiety and involve the caregiver in care of infant whenever possible. Return the infant to the caregiver as soon as possible after procedures; allow the caregiver to comfort. Perform the least invasive parts of the examination first. Keep the infant warm, warm anything that touches the infant (e.g., hands, stethoscope), and keep the environment warm. Distract with rattle, penlight, or musical toy in the infant's field of vision.
Toddler (1 to 3 years)	Encourage the child's trust by gaining cooperation of caregiver. Try not to separate child from the caregiver. Address the child by name; smile and speak in calm, quiet tone. Allow the child to participate in his or her care when possible. Respect modesty; keep the child covered if possible and promptly replace clothing after examining each body area.

	Allow the child to hold comfort objects (e.g., blanket, toy). Explain that illness or injury is not the child's fault. Reassure the child if a procedure will not hurt. Do not show needles, scissors unless necessary. Avoid procedures on the dominant hand or arm.
Preschooler (4 to 5 years)	When possible, examine and treat the child in an upright position because the child may feel vulnerable and out of control while lying down. Respect the child's modesty and keep the child warm. Explain procedures in brief, simple terms as they are performed. Speak quietly in clear and simple language; avoid baby talk and frightening or misleading comments (e.g., shot, deaden, cut, germs, put to sleep). Allow the child to hold a comfort object or keep it in sight. Tell the child what will happen next and encourage the child to help with his or her care. Warn the child of a painful procedure just before carrying it out. Allow the caregiver to remain with the child whenever possible to help relieve the child's fear of separation from his or her caregiver.
School-age child (6 to 12 years)	Enlist the child's cooperation. Respect the child's modesty. Explain procedures before carrying them out and warn the child of a painful procedure just before carrying it out. Allow the child to see and touch samples of equipment that may be used in his or her care (e.g., medicine cup, cotton swab, tongue depressor). Tell the child what will happen next and encourage the child to help with his or her care. Answer the child's questions honestly. Offer the child alternatives (e.g., "It is OK to yell, but don't move"). Make a contract with the child ("I promise to tell you everything I am going to do if you will help me by cooperating"). While speaking with the caregiver, include the child.
Adolescent (13 to 18 years)	Speak in a respectful, friendly manner, as if speaking to an adult. Respect the patient's modesty and ensure privacy. Obtain a history from the patient if possible; provide the option of having a parent present for any or all phases of the history and physical examination. Respect independence; directly address the adolescent. Explain things clearly and honestly; allow time for questions. Address patient concerns of body integrity and disfigurement. Include the patient in discharge instructions.

by 2 months of age. The anterior fontanel closes between 12 and 18 months of age in most infants. A sunken anterior fontanel is seen in dehydrated or malnourished infants. Temporary bulging of the anterior fontanel may be caused by crying, coughing, or vomiting (**Figure 1-13**). Persistent bulging of the anterior fontanel in an ill-appearing quiet infant may indicate increased intracranial pressure that is the result of a head injury or meningitis.

Figure 1-12 Chickenpox in a young child.

Figure 1-13 In children 18 months or younger, gently palpate the fontanels on the top of the head.

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Assume that any child who has significant facial trauma also has a cervical spine and head injury until proved otherwise.

Eyes

- Compare the size, shape, and movement of the eyes. Look for symmetry and the presence of any drainage. Inspect the conjunctivae for redness, pus, and foreign bodies by pulling down on the lower eyelid as the child looks up (**Figure 1-14**). Look at the color of the sclerae, which should be white.
- Note the presence of *raccoon eyes*, which is a blue discoloration associated with subcutaneous bleeding around the orbits. This sign can occur because of direct trauma to the face and is also associated with a basilar skull fracture.
- To quickly assess the cranial nerves in a child who can follow commands, ask the child to open and close his or her eyes, follow a toy or light with his or her eyes, smile or show his or her teeth, blow out his or her cheeks, and stick out his or her tongue. It may be helpful to use an approach such as Simon Says to encourage a young child to show teeth, shrug shoulders, lift an arm or leg, or squeeze a hand (Hockenberry, 2011).

Figure 1-14 Inspect the conjunctivae for redness, pus, and foreign bodies.

Nose

Inspect the nose for the drainage of blood or fluid, nasal flaring, and the presence of foreign objects. A child's nasal passages are small, short, and narrow, and are easily obstructed (e.g., swelling of the nasal mucosa, accumulation of mucus, foreign objects). Young infants are preferential nose breathers (Miller et al., 1985; Rodenstein, Perlmutter, & Stănescu, 1985). Gently suction the nasal passages if indicated.

Ears

Look for drainage from the ear canals and check for bruising behind the ears (Battle sign), which is a sign of a basilar skull fracture. Examine each ear canal for the presence of foreign bodies, which may include pebbles, beans, pasta, peas, raisins, plastic toys, or a variety of small objects (**Figure 1-15**).

Figure 1-15 Examine each ear canal for the presence of a foreign body.

Mouth and Throat

- A child's tongue is large in proportion to the mouth. The large tongue and shorter distance between the tongue and hard palate makes rapid upper airway obstruction possible. In children of preschool age, the tonsils and adenoids occupy a larger proportion of the airway than in any other age group. A small degree of airway edema can be significant in infants and young children because of the small diameter of the airway, resulting in disproportionately higher resistance to airflow than in an adult.
- Listen for hoarseness. Note the presence of drooling, which may be present with conditions affecting airway structures above the glottis, such as a peritonsillar abscess and epiglottitis. If the child has stridor, avoid looking in the mouth (Dieckmann, 2012): Doing so may agitate the child and worsen respiratory distress. If stridor is not present, look in the mouth for blood, vomitus, loose teeth, an injured or swollen tongue, and foreign material (**Figure 1-16**). Suction the upper airway as needed. Note the color of the patient's lips and the mucous membranes of the mouth. They should appear pink and moist, regardless of the child's race.
- Note the presence of any odors that may help determine the cause of the patient's condition. For example, the sweet or fruity odor of acetone may be detected on the breath of the child with diabetic ketoacidosis. An odor of bitter almonds may be detected in a child with cyanide poisoning.

Figure 1-16 Inspect the mouth if stridor is not present.

Neck

Assess the neck for the use of accessory muscles and the presence of a stoma. Palpate the neck to assess the position of the trachea. It is difficult to assess distended neck veins in infants and young children.

Chest

- Look at the chest and assess the child's work of breathing, the symmetry of chest movement, the use of accessory muscles, and the presence of retractions or open wounds (**Figure 1-17**).
- Listen for stridor, hoarseness, snoring, grunting, and wheezing.
- Note any abnormal breathing pattern, bruises, rashes, and the presence of vascular access devices.
- Auscultate breath sounds and heart sounds. Encourage the child to breathe deeply by pretending to blow out a candle or by blowing away a piece of tissue.
- If trauma is suspected, palpate the clavicles, ribs, and chest wall for tenderness and deformity.

Abdomen and Pelvis

- Assessment of an infant or young child's abdomen can be difficult. An infant will naturally tense his or her abdominal muscles when palpated, simulating guarding. A toddler may scream throughout the examination. It may be necessary to evaluate the abdomen more than once for an accurate assessment.

Figure 1-17 Assess the child's work of breathing, the symmetry of chest movement, the use of accessory muscles, and the presence of retractions.

- The abdomen of infants and young children is naturally protuberant and round because of poorly developed abdominal muscles; it may appear somewhat distended (**Figure 1-18**). Inspect the abdomen for distention, bruising, use of abdominal muscles during breathing, scars, feeding tubes, and stomas or pouches.
- Auscultate the presence or absence of bowel sounds in all quadrants.
- Gently palpate each abdominal quadrant for tenderness, guarding, rigidity, and masses. If the child complains of pain in a specific abdominal area, palpate that area last. Observe the child as you palpate. A child who is awake and experiencing discomfort will tend to watch the palpating hand of his or her examiner closely (Engel, 2006a).
- Palpate the pelvis for tenderness and instability. If pain, crepitation, or instability is elicited when assessing the pelvis, suspect a fracture of the pelvic ring. Assess the quality of femoral pulses.

Extremities

- Assess skin temperature, capillary refill, the quality of pulses, motor function, and sensory function in each extremity. Evaluate the extremities for deformities, open injuries, tenderness, and swelling (**Figure 1-19**). Because they can be a source of significant blood loss, long bone fractures can contribute to the development of hypovolemic shock.
- Assess motor function in an upper extremity in an alert patient by instructing the child to "Squeeze my fingers in your hand." To assess motor function in a lower extremity, instruct the child to "Push down on my fingers with your toes."
- When assessing a child's sensory function, carefully consider the method you will use. For example, pinching a child may result in more distress, distrust, or a lack of cooperation. Consider a less distressing method such as, "Can you feel my hand touching your skin? Where?"

Back

Assess the back for tenderness, bruises, purpura, petechiae, rashes, edema, and open wounds. Auscultate the posterior chest for breath sounds. If trauma is suspected, ensure that manual in-line stabilization of the head and spine is maintained throughout the examination.

Figure 1-18 The abdomen of a young child is naturally protuberant.

Figure 1-19 Assess skin temperature, capillary refill, pulse quality, motor function, and sensory function in each extremity.

Tertiary Assessment

During the primary and secondary assessments, the diagnostic tests performed are often limited to pulse oximetry, capnography, and point-of-care serum glucose levels. During the tertiary assessment, also called the *diagnostic assessment*, additional tests and procedures are performed to determine the cause of the patient's illness or the extent of the patient's injuries. Examples of diagnostic tests that are used to assess problems with the respiratory and circulatory systems are shown in **Box 1-7**.

Box 1-7 Diagnostic Tests

Arterial blood gas
Arterial lactate
Bacterial and viral cultures
Central venous oxygen saturation
Central venous pressure monitoring
Chest radiograph
Complete blood count
Computed tomography
Echocardiogram
Electrocardiogram
Invasive arterial pressure monitoring
Peak expiratory flow rate
Serum electrolytes
Venous blood gas

Reassessment

- Reassessment of the patient's condition is essential to assess the effectiveness of the emergency care provided, to identify any missed injuries or conditions, to observe subtle changes or trends in the patient's condition, and to alter the patient's treatment plan as needed based on your findings. Reassessments should be repeated and documented every 5 minutes for an unstable patient and every 15 minutes for a stable patient.
- Reassessment consists of the following components:
  - Repeating the PAT and primary assessment
  - Reassessing and documenting vital signs
  - Repeating the focused physical examination
  - Reevaluating the emergency care provided
- Repeat the PAT and primary assessment to identify and treat life-threatening conditions that may have been missed. Reassess the patency of the patient's airway and use pulse oximetry to monitor the patient's oxygen saturation. If indicated, give supplemental oxygen to maintain an oxygen saturation level of 94% or higher. If an oral airway or nasal airway has been placed, ensure that it is properly positioned. Ensure that suction is within arm's reach.
- Early warning signs of impending breathing difficulty include depth of breathing and changes in the patient's ventilatory rate and rhythm. Reassess breathing effectiveness (e.g., rise and fall of the chest, ventilatory rate and effort, depth and equality of breathing, rhythm of breathing, breath sounds, capnography). Anticipate the need for ventilatory assistance. For example, if the PAT and primary assessment initially revealed that the patient was breathing adequately but upon reassessment you find that the patient now has marked tachypnea, is using accessory muscles, and is pale and tachycardic, ventilatory assistance with a bag-mask device that is connected to supplemental oxygen is warranted (see Chapter 2).
- Reassess the patient's circulatory status to detect early warning signs of shock. Assess the child's heart rate and the strength of central and peripheral pulses. Evaluate the patient's cardiac rhythm and blood pressure. Look for changes in the color of the skin and mucous membranes. Reassess skin temperature and capillary refill time. If present, ensure that bleeding is controlled. Assess and document the type and amount of drainage through dressings. If vascular access has been obtained, assess the site for patency.
- Reassess the child's level of responsiveness, noting any changes in his or her mental status. Early indicators of inadequate oxygenation include increased restlessness, confusion, and irritability, which can be easily overlooked or attributed to fear or pain. If the patient has an altered mental status, document the patient's response to a specific stimulus.
- Reassess and document vital signs. Compare these values with previously taken vital signs, carefully noting any changes or trends in the patient's condition. Reevaluate the emergency care provided and assess the patient's response to therapy. Ensure that the trauma patient's cervical spine is adequately stabilized, injured extremities are effectively immobilized, and open wounds are properly dressed and bandaged.

PART II: TEAMS AND TEAMWORK

Teamwork is important when providing patient care and is essential to patient safety. To be effective, team members must communicate, anticipate the needs of other team members, coordinate their actions, and work cooperatively (Salas, DiazGranados, Weaver, & King, 2008). It is essential that all members of the team demonstrate respect for each other and communicate using a calm, confident tone.

Rapid Response Teams

- The concept of *rapid response systems* has emerged from the awareness that early recognition and treatment of respiratory failure and shock may reduce the incidence of respiratory or cardiac arrest and improve patient outcome. A *rapid response team* (RRT), also known as a *medical emergency team* (MET), typically consists of multidisciplinary members such as a physician, a critical care nurse, and a respiratory therapist who are mobilized by other hospital staff based on predetermined criteria. A fundamental goal of the RRT is to identify patients at risk for sudden deterioration. The Joint Commission National Patient Safety Goals require hospitals to implement systems that enable healthcare workers to request additional assistance from specially trained individuals when a patient's condition appears to be worsening (Joint Commission on Accreditation of Healthcare Organizations, 2007).

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Use of a standardized communication method such as Situation, Background, Assessment, and Recommendation (SBAR) is recommended to decrease the incidence of errors and to ensure rapid, effective communication among members of the healthcare team.

- Criteria for RRT activation vary widely among hospitals and may include warning signs of patient deterioration such as acute changes in ventilatory rate or effort, heart rate, blood pressure, and mental status, in addition to clinical judgment. When a bedside nurse activates the RRT, it is important that he or she remain with the patient after the arrival of the RRT to convey the reason or reasons for activating the team, to provide information with regard to the patient's medical history, medications, and laboratory studies, and to assist members of the RRT.
- In keeping with the philosophy of patient- and family-centered care, some hospitals have incorporated patient and family activation of the RRT into their rapid response systems. In others, "family concern" is included in protocols as a trigger for activation of the RRT by a nurse (McCurdy & Wood, 2012).

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In most hospitals, the Rapid Response Team (RRT) is separate from the resuscitation team. In some facilities, RRT members may begin resuscitation protocols before the arrival of the code team if the RRT members have been trained in pediatric advanced life support.

Resuscitation Team

- The configuration of a resuscitation team, also called a *code team*, and the skills of each team member vary.
  - In the prehospital setting, an ambulance may be staffed with either EMTs, paramedics, or some combination of both, or in some states, an EMT and a registered nurse. A fire department response to a request for assistance typically includes a vehicle staffed with two EMTs and two paramedics. An air transport team may be composed of registered nurses, paramedics, physicians, or respiratory therapists, depending on the type of patient transport.
  - In the hospital setting, an overhead paging system or team pagers are typically used to summon a predesignated team of individuals to the patient's bedside when a patient experiences a respiratory arrest, a cardiac arrest, or both. Within most hospitals, this situation is referred to as a *code* or *code blue*. You must know your facility's procedure for activating the code team.
- The *code director* or *team leader* is the person who guides the efforts of the resuscitation team. The team leader should be in a position to "stand back" while overseeing and directing the resuscitation effort (**Figure 1-20**). Chest compressions, ECG monitoring and defibrillation, airway management, vascular access and medication administration, and documentation of all aspects of the event are essential tasks that must be coordinated during a resuscitation effort. The American College of Critical Care Medicine recommends that a family support person be a recognized member of the code team (Davidson et al., 2007). Additional members of the resuscitation team may include pharmacists, clergy, and security personnel.
- Although the team leader is responsible for directing the overall actions of the team, a resuscitation effort requires *teamwork*. Each member of the resuscitation team must:
  - Be familiar with current resuscitation algorithms.
  - Know the location of resuscitation equipment.
  - Clearly understand his or her assigned role.
  - Know his or her limitations.
  - Be proficient with the hands-on skills required during resuscitation.
  - Maintain situational awareness and anticipate the needs of other team members.
  - Maintain professional behavior throughout the resuscitation effort.
- Because cardiac arrests occur infrequently, it is essential that resuscitation skills be practiced frequently using methods such as simulation-based mock codes to minimize errors, maintain skills, and optimize patient outcome (Morrison et al., 2013).

Figure 1-20 The team leader of a resuscitation effort should be in a position to "stand back" while overseeing and directing the code team.

Phases of Resuscitation

A resuscitation effort has been described as having seven phases, with each phase encompassing specific priorities for the resuscitation team (Burkle & Rice, 1987).

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Regardless of your level of licensure or certification, if you know that a mistake is being made or is about to occur during a resuscitation effort, step up and tactfully question the intervention.

Anticipation Phase

During the anticipation phase of a resuscitation effort, team members either move to the scene of a possible cardiac arrest or await the patient's arrival from outside of the hospital. As the members of the team come together, the team leader is identified and then he or she assigns roles to team members (if they had not been preassigned). During this time, team members position themselves for optimum access to the patient and equipment, and resuscitation equipment is checked and readied for use.

Entry Phase

- During the entry phase, the team leader identifies him- or herself and a coordinated but rapid and efficient exchange of information occurs as the resuscitation effort begins or continues. For example, the caregiver or clinician who first identified signs of patient deterioration or the patient's cardiac arrest relays important patient-related information to the code team. At the same time, team members ensure that the patient is positioned on a firm surface. If the patient is being transferred from another bed, they ensure that the transfer occurs in a safe and orderly manner from the stretcher or gurney to the resuscitation bed or another stretcher.

- Team members obtain baseline vital signs and physical examination information while the team leader obtains a concise history of the circumstances surrounding the patient's arrest and the care given before the team's arrival. The team leader also considers baseline laboratory values (if available) and other relevant patient data.

Resuscitation Phase

- During this phase, the team leader directs the code team through the various resuscitation protocols. Clear communication is particularly important during this phase of the resuscitation effort. Closed-loop communication methods should be used to avoid errors and promote patient safety. For example, the team leader should state his or her instructions one at a time using the team member's name, if known (e.g., "Tanya, please start an IV and let me know when that is done"). Team members should acknowledge that the message has been received and is understood (e.g., "Starting IV now"). By repeating back the message received, the team leader who conveyed the message is assured that the received message was the intended one. This practice allows those sending and receiving messages an opportunity to recognize and correct errors and also helps to ensure accurate documentation of the interventions performed.
- It is important that team members request clarification of any messages that are unclear. Team members must also convey any change in the status of the patient's pulse, cardiac rhythm, oxygenation, or ventilation to the team leader. For example, "Dr. Lowrey, the rhythm on the monitor has changed from asystole to ventricular fibrillation."

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Having current copies of resuscitation algorithms in the pockets of team members, on the code cart, or in the paramedic drug box can help reduce the risk of errors and can also serve as a resource during a resuscitation effort.

Maintenance Phase

During the maintenance phase of the resuscitation effort, a spontaneous pulse has returned. Efforts of the code team should be focused on the following:

- Anticipating changes in the patient's condition (and preventing deterioration)
- Repeating the primary assessment
- Stabilizing vital signs
- Securing tubes and lines
- Troubleshooting any problem areas
- Preparing the patient for transport or transfer
- Accurately documenting the events that took place during the resuscitation effort
- Drawing blood for laboratory tests and treating the patient as needed on the basis of results

Family Notification Phase

- Although family notification is described here as a separate phase, it actually occurs throughout the resuscitation effort. At least one member of the code team should be a designated liaison with the family, whether or not the family is present in the resuscitation room (Mellick & Adams, 2009). Before entering the room, it is important that the assigned liaison prepare the family for what they will see. Upon entering the room, the liaison should instruct the family with regard to where they should stand and the liaison should then remain with the family. Clear explanations of the procedures being performed and the expected responses should be provided (Sharieff, 2013). While speaking with the family, questions should be answered honestly and with sensitivity, using nonmedical terms. Enlist the assistance of a professional language interpreter to explain the patient's condition to the family if needed.
- Allowing Family Presence During Resuscitation (FPDR) or procedures is consistent with the philosophy of family-centered patient care and has steadily evolved with support from professional organizations (e.g., Emergency Nurses Association, American Heart Association, American Association of Critical Care Nurses, American Academy of Pediatrics, American College of Critical Care Medicine) and research related to this topic. Concerns with regard to disruption of a resuscitation effort or the performance of invasive procedures because of family interference, the distraction of staff, or fear that family members who witness errors may be more likely to sue have not been borne out in the literature.
- Research has shown that 75% or more of families surveyed would like to be offered the option of being in the resuscitation room (Davidson et al., 2007). From the perspective of the family member, perceived benefits of FPDR include the following:
  - Decreased anxiety and fear with regard to what is happening to their loved one (American Association of Critical Care Nurses, 2010).
  - Removal of doubt about the seriousness of the patient's condition; family members can see, rather than being told, that everything possible is being done (Royal College of Nursing, 2002).
  - Family members will be able to touch the patient and say what needs to be said while there is still a chance that the patient can hear (Royal College of Nursing, 2002).
  - Sustaining the family's need to be together and let the patient know that they are present (American Association of Critical Care Nurses, 2010).
  - Allowance of closure and facilitation of the grieving process should death occur (Davidson et al., 2007).
- Written policies and procedures with regard to FPDR should be in place and should include criteria for assessing the family to ensure uninterrupted patient care, the role of the family liaison in preparing families for being at the bedside and supporting them before, during, and after the event, support for the patient's or family members' decision not to have family members present, and documentation standards for family presence, including the rationale for when family presence would not be offered as an option to family members (American Association of Critical Care Nurses, 2010).

- Contraindications to family presence may include family members who demonstrate combative or violent behaviors, uncontrolled emotional outbursts, behaviors consistent with an altered mental state from drugs or alcohol, or those suspected of abuse (American Association of Critical Care Nurses, 2010).

Transfer Phase

The resuscitation team's responsibility to the patient continues until patient care is transferred to a healthcare team with equal or greater expertise. When transferring care, provide information that is well organized, concise, and complete.

Critique Phase

- Because every resuscitation effort is different, it is important that the team leader ensure that a postevent debriefing takes place. The purpose of a debriefing is to provide an opportunity for each team member to reflect on *what* they did, *when* they did it, *how* they did it, *why* they did it, and *how* they can improve. A debriefing also provides an opportunity to address performance gaps (the gap between desired and actual performance) and perception gaps (the difference between the team member's perception of their performance and actual performance as defined by objective measures) (Phrampus & O'Donnell, 2013).
- During the debriefing, and under the guidance of a facilitator, each team member has an opportunity to reflect on their critical thinking ability, clinical judgment, and clinical performance and to compare their actions with current resuscitation algorithms, professional standards, institution policies, and local protocols. Data captured from the defibrillator, the code sheet, checklists, and other sources should be provided as feedback to the code team. The debriefing also provides a means by which team members can process their reactions and feelings related to the resuscitation event (Wickers, 2010).

PUTTING IT ALL TOGETHER

The chapter quiz and case studies presented on the following pages are provided to help you integrate the information presented in this chapter.

Chapter Quiz

Multiple Choice

Identify the choice that best completes the statement or answers the question.

____ 1. A 7-month-old infant has a 2-day history of poor feeding. Which of the following should be used to assess a central pulse in this patient?

a. Radial pulse
b. Carotid pulse
c. Femoral pulse
d. Brachial pulse

____ 2. The pediatric assessment triangle (PAT):

a. Is a hands-on assessment of an infant or child.
b. Requires a minimum of 15 minutes to complete.
c. Is used to quickly determine if a child is "sick" or "not sick."
d. Is a systematic head-to-toe assessment that requires the use of a stethoscope and blood pressure cuff.

____ 3. You are the designated team leader of an emergency department resuscitation team. As your team gathers to begin the resuscitation effort, which of the following reflects the essential tasks that must be delegated to your team members?

a. Vascular access, vital signs, event recording, and chest compressions
b. Vital signs, family support, crowd control, and event recording
c. Crowd control, airway management, chest compressions, medication administration, and defibrillation
d. Cardiac monitoring and defibrillation, airway management, vascular access and medication administration, chest compressions, and event recording

____ 4. A normal ventilatory rate for a toddler (age 1 to 3 years) is _____. A normal heart rate for a child of this age is _____.

a. 12 to 16 breaths/min; 60 to 100 beats/min
b. 22 to 34 breaths/min; 70 to 120 beats/min
c. 24 to 40 breaths/min; 95 to 150 beats/min
d. 30 to 60 breaths/min; 100 to 160 beats/min

____ 5. To gain the cooperation of a 2-year-old presenting with shortness of breath, you should:

a. Introduce yourself and try to hold him.
b. Separate the mother and child and perform a primary assessment.
c. Remove the child's clothing and inspect his airway with a penlight.
d. Sit down and attentively listen while speaking with the child's mother.

____ 6. Although configurations may vary by institution, which of the following reflects the typical members of a rapid response team?

a. Anesthesiologist, pharmacist, and clergy
b. Physician, pharmacist, and respiratory therapist
c. Medical-surgical nurse, physician, and pharmacist
d. Critical care nurse, physician, and respiratory therapist

____ 7. The formula used to approximate the lower limit of normal systolic blood pressure in children 1 to 10 years of age is:

a. Age in years × 2.2
b. 2 × 90/age in years
c. 16 + age in years × 4
d. 70 + (2 × age in years)

____ 8. Which of the following should you keep in mind while caring for an adolescent?

a. Adolescents typically fear separation from their caregiver.
b. Adolescents appreciate being told the truth, value their privacy, and relate to adults who demonstrate respect.
c. Most adolescents are likely to view their illness or injury as punishment for bad behavior or thoughts.
d. Although the influence of peers is important to children of other age groups, it is of little importance to most adolescents.

____ 9. During which patient assessment phase are diagnostic tests such as laboratory specimens and radiographs usually obtained?

a. Tertiary assessment
b. Reassessment
c. Secondary assessment
d. Primary assessment

10. Which of the following statements is true?

    a. Capnography is a useful tool for assessing the effectiveness of oxygenation.
    b. Pulse oximetry may be inaccurate in patients with poor peripheral perfusion.
    c. When capnometry is used, a numeric reading of exhaled CO_2 concentrations is provided without a continuous waveform.
    d. Pulse oximetry can alert the clinician to signs of respiratory compromise such as hypoventilation and hyperventilation.

Matching

Match each description below with its corresponding answer:

a. Radial artery
b. Abdominal thrusts
c. TICLS
d. Anticipation phase
e. Seesaw breathing
f. PQRST
g. Glasgow Coma Scale
h. Work of breathing
i. Wheezing
j. Back slaps and chest thrusts
k. Stridor
l. SAMPLE
m. Carotid artery
n. Snoring
o. Resuscitation
p. Circulation to the skin

____ 11. An ineffective breathing pattern in which the abdominal muscles move outward during inhalation while the chest moves inward

____ 12. Noisy, low-pitched sounds that are usually caused by partial obstruction of the upper airway by the tongue

____ 13. Foreign body airway obstruction techniques for those younger than 1 year

____ 14. Third area assessed with the pediatric assessment triangle

____ 15. Scoring tool used to evaluate the patient's response to a stimulus

____ 16. Peripheral pulse location

____ 17. Mnemonic used to recall the areas to be assessed related to appearance

____ 18. A harsh, high-pitched inspiratory or expiratory sound that is usually an indication of inflammation or swelling of the upper airway

____ 19. Stage of a resuscitation effort during which communication is particularly important while the team is directed through resuscitation protocols

____ 20. Foreign body airway obstruction techniques for those 1 year or older

____ 21. Mnemonic used when evaluating patients in pain

____ 22. Central pulse location

____ 23. Second area assessed with the pediatric assessment triangle

____ 24. Stage of a resuscitation effort during which the roles of team members are delegated, if not preassigned

____ 25. High- or low-pitched sounds produced as air passes through narrowed airways

____ 26. Common mnemonic used when obtaining a focused history

Chapter Quiz Answers

Multiple Choice

1. D. Central pulse locations that are generally easily accessible include the brachial artery (in infants), carotid artery (in older children), the femoral artery, and the axillary artery. Peripheral pulse locations include the radial, dorsalis pedis, and posterior tibial arteries.

OBJ: Differentiate between central and peripheral pulses.

2. C. The PAT is used to (1) establish the severity of the child's illness or injury (sick or not sick), (2) identify the general category of physiologic abnormality (cardiopulmonary, neurologic, etc.), and (3) determine the urgency of further assessment and intervention. Because approaching an ill or injured child can increase agitation, possibly worsening the child's condition, the PAT is an "across the room" assessment that is performed before approaching or touching the child and that can usually be completed in 60 seconds or less. No equipment is required.

OBJ: Summarize the components of the pediatric assessment triangle and the reasons for forming a general impression of the patient.

3. D. Chest compressions, electrocardiogram monitoring and defibrillation, airway management, vascular access and medication administration, and documentation of all aspects of the event are essential tasks that must be coordinated during a resuscitation effort. A team member should also be assigned to provide family support. There are many support roles in a resuscitation effort, including designating a nurse to contact the patient's attending physician, crowd control, ensuring the availability of a critical care bed, and the provision of ongoing care to other patients in the department.

OBJ: Given a patient situation, and working as the team leader of a resuscitation effort, assign essential tasks to team members.

4. C. A normal ventilatory rate for a toddler is 24 to 40 breaths/min. A normal heart rate for a child of this age is 95 to 150 beats/min.

OBJ: Identify normal age-group-related vital signs.

5. D. To gain the child's cooperation, sit down and attentively listen while speaking with the child's mother. Toddlers distrust strangers, are likely to resist examination and treatment, and do not like having their clothing removed. They fear pain, separation from their caregiver, and separation from comfort objects (e.g., blanket, toy). Slowly approach the child and talk to him or her at eye level using simple words and phrases and a reassuring tone of voice. The child will understand your tone, even if he or she does not understand your words.

OBJ: Distinguish among the components of a pediatric assessment and describe techniques for successful assessment of infants and children.

6. D. A rapid response team (also known as a medical emergency team) typically consists of multidisciplinary members (e.g., physician, critical care nurse, respiratory therapist) who are mobilized by other hospital staff based on predetermined criteria for activation of the team.

OBJ: Discuss the purpose and typical configuration of a rapid response team.

7. D. The formula used to approximate the lower limit of systolic blood pressure in children 1 to 10 years of age is 70 + (2 × age in years).

OBJ: Identify normal age-group-related vital signs.

8. B. Adolescents appreciate being told the truth, value their privacy, relate to adults who demonstrate respect, and are concerned about maintaining their independence. Adolescents are capable of making up or misrepresenting physical or mental symptoms and may be greatly influenced by the opinions of their peers. Common fears of this age group include being left out or socially isolated, fear that they will inherit their parent's problems (e.g., alcoholism, mental illness), fear of an early and violent death, loss of control, altered body image (e.g., scarring, disfigurement), and separation from their peer group. When providing care for an adolescent, speak in a respectful, friendly manner as if speaking to an adult. Respect the patient's modesty, ensure privacy, and obtain a history from the patient, if possible; provide a choice of having a parent present for any or all phases of the history and physical examination. Directly address the adolescent and provide clear and honest explanations, allowing time for questions.

OBJ: Distinguish among the components of a pediatric assessment and describe techniques for successful assessment of infants and children.

9. A. During the primary and secondary assessments, the diagnostic tests performed are often limited to pulse oximetry, capnography, and serum glucose levels. During the tertiary assessment (also called the diagnostic assessment), additional tests and procedures are performed to determine the cause of the patient's illness or the extent of the patient's injuries.

OBJ: Describe the tertiary assessment.

10. B. Capnography, the process of continuously analyzing and recording carbon dioxide concentrations in expired air, is an assessment tool that is used in both intubated and nonintubated patients to assess the effectiveness of ventilation. With capnometry, a numeric reading of exhaled CO_2 concentrations is provided without a continuous waveform. Because capnography and capnometry reflect the elimination of CO_2 from the lungs during breathing, use of these devices can alert the clinician to respiratory compromise such as apnea, airway obstruction, hypoventilation, hyperventilation, and abnormal breathing patterns. Pulse oximetry is a noninvasive method of monitoring the percentage of hemoglobin that is saturated with oxygen (SpO_2) by using selected wavelengths of light. Because pulsatile blood flow is necessary for a pulse oximeter to work, it may provide inaccurate results in a child with poor peripheral perfusion (e.g., shock, cardiac arrest). Pulse oximetry may also be inaccurate in children with chronic hypoxemia (e.g., cyanotic congenital heart disease, pulmonary hypertension), significant anemia, carboxyhemoglobin, or methemoglobinemia.

OBJ: Discuss the benefits of using pulse oximetry and capnometry or capnography during patient assessment.

Matching

11. E
12. N
13. J
14. P
15. G
16. A
17. C
18. K
19. O
20. B
21. F
22. M
23. H
24. D
25. I
26. L

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CHAPTER 2

Respiratory Emergencies

Learning Objectives

After completing this chapter, you should be able to:

1. Identify key anatomic and physiologic differences between children and adults and discuss their implications in the patient with a respiratory illness.
2. Differentiate among respiratory distress, respiratory failure, and respiratory arrest.
3. Describe the pathophysiology, assessment findings, and treatment plan for the infant or child experiencing respiratory distress, respiratory failure, or respiratory arrest.
4. Differentiate between upper and lower airway obstruction.
5. Describe the general approach to the treatment of children with upper or lower airway obstruction.
6. Describe the pathophysiology, assessment findings, and treatment plan for the child experiencing croup, epiglottitis, foreign body aspiration, and anaphylaxis.
7. Describe the pathophysiology, assessment findings, and treatment plan for the child experiencing asthma or bronchiolitis.
8. Describe the pathophysiology, assessment findings, and treatment plan for the child who has lung tissue disease or disordered ventilatory control.

ASSESSMENT EVIDENCE

Learning Plan

- Read this chapter before your PALS course. Create flashcards and memory aids to help you recall key points. Carefully review each of the medications discussed in this chapter.
- Complete the chapter quiz and review the answers provided.

KEY TERMS

Anaphylaxis
A severe allergic response to a foreign substance with which the patient has had prior contact

Asthma
A disease of the lower airway characterized by chronic inflammation of bronchial smooth muscle, hyperreactive airways, and episodes of bronchospasm that limit airflow

Bilevel positive airway pressure (BPAP)
The delivery of positive pressure during inspiration and a lesser positive pressure during expiration

Bronchiolitis
An acute infection of the bronchioles, most commonly caused by respiratory syncytial virus

Bronchopulmonary dysplasia (BPD)
A chronic lung disease characterized by persistent respiratory distress

Continuous positive airway pressure (CPAP)
The delivery of a continuous, fixed pressure of air throughout the respiratory cycle by means of a medical device through a soft mask worn over the nose or over the mouth and nose

Cystic fibrosis (CF)
A hereditary disease of the exocrine glands characterized by production of viscous mucus that obstructs the bronchi

Noninvasive positive pressure ventilation (NPPV)
The delivery of mechanical ventilatory support, typically by means of a snug fitting nasal or facial mask, without using an endotracheal or tracheostomy tube

Toxidrome
A constellation of signs and symptoms useful for recognizing a specific class of poisoning

INTRODUCTION

Caring for a patient with a respiratory emergency requires patient assessment and knowledge of the interventions for the management of upper airway obstruction, lower airway obstruction, lung tissue disease, and disordered ventilatory control. This chapter discusses the anatomic differences between children and adults, categories of respiratory compromise, common types of respiratory problems, and the initial emergency care for respiratory emergencies. Procedures for managing respiratory emergencies are discussed in Chapter 3.

ANATOMIC AND PHYSIOLOGIC CONSIDERATIONS

Awareness of the anatomic differences between children and adults will help you to understand the signs and symptoms exhibited by children who have a respiratory illness. Anatomic differences are most pronounced in children younger than 2 years; the airway of children older than 8 years is anatomically similar to that of an adult (Luten & Mick, 2012).

Head

- In infants and young toddlers, the head is large in proportion to the body with a larger occipital region. Because of the large occiput, natural flexion of the neck occurs while the patient is in a supine position, which can compromise air exchange (**Figure 2-1**). A rolled towel placed beneath the shoulders will elevate the upper torso relative to the head and help to ensure a neutral position.
- Muscles that support the head are weak. Head bobbing often occurs in an infant experiencing respiratory distress.

Nose and Pharynx

- Nasal passages are soft, narrow, and distensible; they have little supporting cartilage; and they have more mucosa and lymphoid tissue than those of an adult. Because young infants are preferential nose breathers, it is important to keep the nares clear. Any degree of obstruction (e.g., swelling of the nasal mucosa, accumulation of mucus) can result in respiratory difficulty and problems with feeding.
- Tonsils and adenoids enlarge during early childhood and may force the child to become a mouth breather. Because of their increased size, trauma to these tissues during insertion of a nasal airway can result in significant bleeding. Generally, tonsils and adenoids begin to decrease in size during middle childhood.
- The tongue is disproportionately large in relation to the oral cavity (**Figure 2-2**). The large tongue and shorter distance between

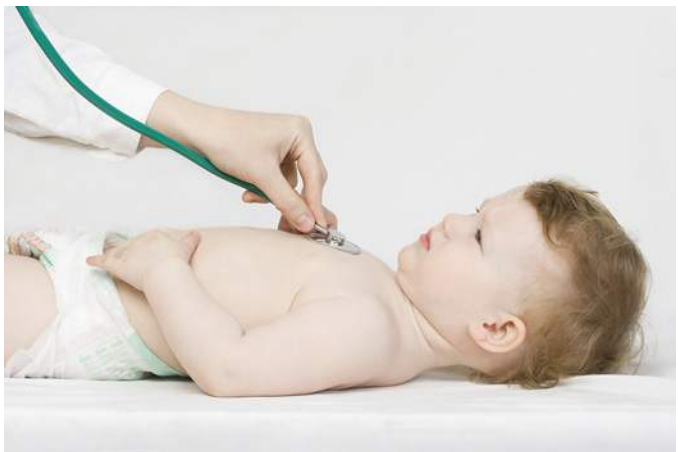


Figure 2-1 The large occiput of an infant or young toddler can result in neck flexion, predisposing the patient to airway obstruction.

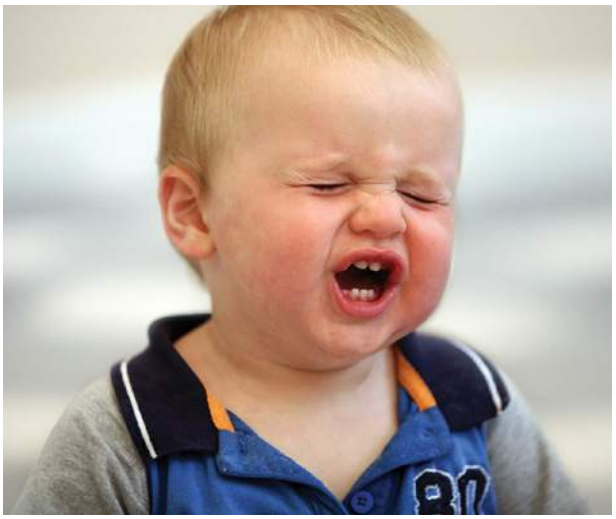


Figure 2-2 A child's tongue is large in relation to his mouth.

the tongue and hard palate increase the potential for obstruction by a foreign body and make rapid upper airway obstruction possible if the tongue relaxes in a posterior position because of a loss of muscle tone (Padlipsky & Gausche-Hill, 2008).

PALS Pearl

Any child with an altered mental status is at risk of an upper airway obstruction secondary to a loss of muscle tone affecting the tongue.

Larynx and Trachea

- A series of open (incomplete) C-shaped rings of cartilage on the posterior surface of the trachea support and hold open the walls of the trachea. The three largest cartilages of the larynx are the epiglottis, the thyroid cartilage, and the cricoid cartilage (**Figure 2-3**).
- The epiglottis is a small cartilage located at the top of the larynx. The adult epiglottis is broad and flexible. In infants and toddlers, the epiglottis is large, long, and U-shaped. It extends vertically beyond the opening of the cords, making a clear view of the airway difficult. A straight blade directly lifts the epiglottis during endotracheal intubation and is recommended for use in children younger than three years but may be used in a child of any age (Luten & Mick, 2012).
- The thyroid cartilage is the largest cartilage of the larynx. In an adult, the glottic opening (the space between the true vocal cords) is located behind the thyroid cartilage.
- The cricoid cartilage is the most inferior of the laryngeal cartilages. It is the only completely cartilaginous ring in the larynx and helps to protect the airway from compression. In an adult, the narrowest part of the larynx is at the level of the vocal cords. The smallest diameter of the pediatric airway is at the cricoid ring, below the vocal cords (Hendry, 2012).

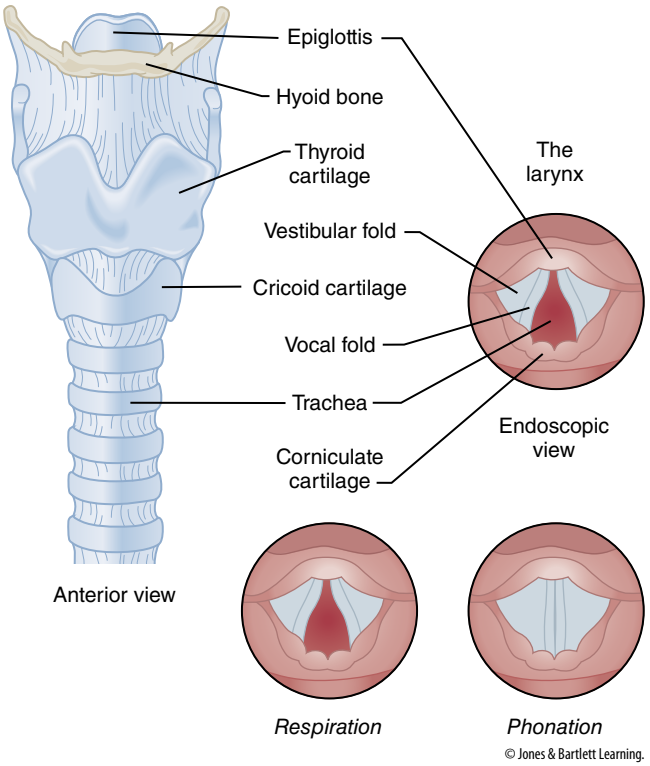


Figure 2-3 Larynx and trachea.

- The cricothyroid membrane is a fibrous membrane located between the cricoid and thyroid cartilages. It is virtually nonexistent in children younger than 3 to 4 years (Luten & Mick, 2012).
- In an adult, the larynx is located opposite the fifth to sixth cervical vertebrae (C5 to C6). The larynx of the pediatric airway is higher and more anterior in the neck. The larynx of the infant and young child resembles a funnel, with the narrowest portion being at the cricoid ring. This area creates a natural seal (a physiologic cuff) around a tracheal tube, making cuffed tubes generally unnecessary in children younger than 8 years. If a cuffed tube is used, it is important to ensure that the cuff is not overinflated (Padlipsky & Gausche-Hill, 2008).
- The trachea is smaller and shorter than that of an adult. Movement of an endotracheal (ET) tube may occur during changes in head position. The small, short trachea may result in intubation of the right primary bronchus, or inadvertent extubation. Securing an ET tube before movement of an intubated infant or child is important to prevent tube displacement.
- A small change in airway size results in a significant increase in resistance to air flow while edema or a foreign body is present. A marked increase in airway resistance can result in partial or complete airway obstruction.

PALS Pearl

The tracheal rings are soft and susceptible to compression with improper positioning of the neck.

Chest and Lungs

- The chest wall of the infant and young child is thin and more compliant than that of the adult. Because the ribs are more pliable, they offer less protection to underlying organs. Significant internal injury can be present without external signs. The thin chest wall allows for easily transmitted breath sounds, which can make it easy to miss a pneumothorax or misplaced ET tube.
- The diaphragm and intercostal muscles are the primary muscles of ventilation. Respiratory movement is primarily abdominal or diaphragmatic in infants and children younger than 6 or 7 years (Hockenberry, 2011). Young children cannot sustain rapid ventilatory rates for long periods because of immature intercostal muscles that easily fatigue from the work of breathing. Because the chest wall cannot compensate, effective breathing may be jeopardized when pressure above or below the diaphragm impedes diaphragmatic movement (Rowan James, Nelson, & Weiler Ashwill, 2013). Consider insertion of an orogastric or nasogastric tube if gastric distention is present and impairs ventilation.
- Children have fewer and smaller alveoli, thus the potential area for gas exchange is smaller. To increase minute volume, the child must increase his or her ventilatory rate.
- Infants and children have a higher metabolic rate than do adults. Their oxygen requirements are approximately twice those of adolescents and adults, yet children have proportionally smaller oxygen reserves. Hypoxia can rapidly develop because of increased oxygen requirements and decreased oxygen reserves.

PALS Pearl

The compliant chest wall of an infant or young child should expand easily during positive-pressure ventilation. If the chest wall does not expand equally during positive-pressure ventilation, ventilation is inadequate or the airway may be obstructed.

RESPIRATORY COMPROMISE

Respiratory illnesses are common in children and can be acute, chronic, or life threatening. You must be able to differentiate among respiratory emergencies by type (**Table 2-1**) and severity (**Table 2-2**).

Respiratory Distress

Respiratory distress is characterized by increased work of breathing and a rate of breathing outside the normal range for the patient's age. Respiratory distress may result from a problem in the tracheobronchial tree, lungs, pleura, or chest wall. As the child's ventilatory rate increases, carbon dioxide levels in the blood initially decrease. With continued respiratory distress, the child will begin to tire and carbon dioxide levels will increase. If uncorrected, respiratory distress leads to respiratory failure. Causes of respiratory distress in children are shown in **Box 2-1**.

Signs and symptoms of respiratory distress include the following:

- Audible wheezing
- Central cyanosis that resolves with oxygen

Box 2-1 Causes of Respiratory Distress in Children

Aspiration
Asthma/reactive airway disease
Congenital heart disease
Foreign body
Infection (e.g., pneumonia, croup, epiglottitis, bronchiolitis)
Medication or toxin exposure
Trauma

- Increased depth of breathing (hyperpnea)
- Inspiratory stridor
- Irritability, anxiety, restlessness
- Labored breathing (dyspnea)
- Mild tachycardia
- Nasal flaring
- Pallor or mottled color
- Retractions
- See-saw breathing (abdominal breathing)
- Ventilatory rate faster than normal for age (tachypnea)

Approach a child in respiratory distress promptly and work at a moderate pace. Permit the child to assume a position of comfort. Correct hypoxia by giving oxygen without causing agitation. Provide further care based on your assessment findings.

Respiratory Failure

Respiratory failure is a clinical condition in which there is inadequate blood oxygenation and/or inadequate ventilation to meet the metabolic demands of body tissues. It is often, but not always, preceded by respiratory distress in which the child's work of breathing is increased in an attempt to compensate for hypoxia (Padlipsky & Gausche-Hill, 2008). Possible causes of respiratory failure are listed in **Box 2-2**.

Box 2-2 Causes of Respiratory Failure in Children

Asthma/reactive airway disease
Congenital abnormalities
Foreign body
Heart failure
Infection (e.g., croup, epiglottitis, bronchiolitis, pneumonia)
Medication or toxin exposure
Metabolic disease with acidosis
Neuromuscular disease
Pneumothorax, hemothorax
Smoke inhalation
Submersion syndrome
Trauma

Table 2-1 Differentiating Respiratory Emergencies

	Upper Airway Obstruction	Lower Airway Obstruction	Lung Tissue Disease	Disordered Ventilatory Control
Location of obstruction	Nose, pharynx, or larynx	Lower trachea, bronchi, or bronchioles	Lungs	Respiratory system
Possible causes	Anaphylaxis Congenital anomalies Croup Epiglottitis Foreign body aspiration	Asthma Bronchiolitis Foreign body aspiration	Bronchopulmonary dysplasia Cystic fibrosis Pneumonia Pulmonary edema Submersion injury	Acute poisoning Brain tumor CNS infections Head injury Increased intracranial pressure Neuromuscular disease Seizures
Clinical Signs				
Ventilatory rate	Increased	Increased	Increased	Irregular
Work of breathing	Increased	Increased	Increased	Varies
Airway/breath sounds	Coughing Gurgling Hoarse voice Nasal flaring Snoring Stridor of varying degrees	Forced or prolonged expiratory phase Wheezing (usually expiratory)	Coughing Crackles Grunting Decreased breath sounds Possible wheezing	Normal
Air movement	Decreased air movement Inspiratory retractions Poor chest rise	Accessory muscle use Decreased air movement Retractions	Decreased air movement	Normal or decreased air movement Possible accessory muscle use
Heart rate	Tachycardia (early) → bradycardia (late)			
Skin	Normal → pallor → cyanosis (late)			
Mental status	Alert → restless, agitated → drowsy, lethargic → unresponsive			

CNS = central nervous system.

Signs and symptoms of impending respiratory failure include the following:

- Acute mental status changes; inability to focus
- Central cyanosis despite being given oxygen; mottling
- Inadequate ventilatory rate, effort, or chest excursion
- Low oxygen saturation despite being given oxygen
- Normal or decreased muscle tone
- Retractions and accessory muscle use
- Tachycardia (early) slowing to bradycardia (late)
- Tachypnea (early) slowing to bradypnea and apnea (late)
- Weak or absent speech or cry

If an infant or child shows signs of respiratory failure, move quickly to support the patient's airway and breathing and to prevent deterioration to cardiac arrest. Open the airway and provide suction if necessary. Correct hypoxia by giving supplemental oxygen. Begin assisted ventilation with a bag-mask device connected to 100% oxygen if the patient does not improve. **Noninvasive positive pressure ventilation (NPPV)**, which is the delivery of mechanical ventilatory support without the use of an endotracheal or tracheostomy tube,

Table 2-2 Determining the Severity of Respiratory Emergencies

Respiratory Distress	Respiratory Failure	Respiratory Arrest
Audible wheezing	Acute mental status changes	Absent chest wall motion
Central cyanosis that resolves with oxygen	Central cyanosis despite giving oxygen; mottling	Absent ventilations
Increased depth of breathing	Inadequate ventilatory rate, effort, or chest excursion	Bradycardia deteriorating to asystole
Inspiratory stridor	Low oxygen saturation despite giving oxygen	Limp muscle tone
Irritability, anxiety, restlessness	Normal or decreased muscle tone	Mottling; peripheral and central cyanosis
Labored breathing	Retractions and accessory muscle use	Unresponsiveness to voice or touch
Mild tachycardia	Tachycardia (early) slowing to bradycardia (late)	Weak to absent pulses
Nasal flaring	Tachypnea (early) slowing to bradypnea and apnea (late)	
Pallor or mottled color		
Retractions		
See-saw breathing (abdominal breathing)		
Ventilatory rate faster than normal for age		

may be required. NPPV is typically applied by delivering positive airway pressure through a snug-fitting nasal or facial mask.

Continuous positive airway pressure (CPAP) and **bilevel positive airway pressure (BPAP)** are two modes that may be used to provide NPPV. CPAP delivers a continuous fixed pressure throughout the respiratory cycle, whereas BPAP provides positive pressure during inspiration and a lower positive pressure during expiration, decreasing the work of the muscles of breathing. Give further care based on your assessment findings.

PALS Pearl

Bradycardia in a child with respiratory failure is a warning of imminent cardiopulmonary arrest.

Respiratory Arrest

Respiratory arrest is the absence of breathing. Signs and symptoms of respiratory arrest include the following:

- Absent chest wall motion
- Absent ventilations
- Bradycardia deteriorating to asystole
- Limp muscle tone
- Mottling; peripheral and central cyanosis
- Unresponsiveness to voice or touch
- Weak to absent pulses

If an infant or child shows signs of respiratory arrest, move quickly. Immediately open the airway and suction if necessary. Ventilate with a bag-mask device connected to 100% oxygen. Frequently reassess for the return of spontaneous breathing. Endotracheal intubation may be needed if positive-pressure ventilation does not rapidly improve the child's condition. Indicators of improvement in the child's condition include improvement in the level of responsiveness, color, oxygen saturation, and pulse rate. Provide further care based on your assessment findings.

UPPER AIRWAY OBSTRUCTION

- Children are susceptible to upper airway obstruction because of the small diameters of their nose, pharynx, and larynx. Even slight decreases in the diameter of any of these structures can cause significant resistance to air flow. Possible causes of upper airway obstruction include secretions that block the nasal passages, airway swelling (e.g., croup, epiglottitis, anaphylaxis), the presence of a foreign body, and congenital airway abnormalities.
- Upper airway obstruction is a common cause of stridor in children. Additional signs and symptoms that may accompany upper airway obstruction appear in **Box 2-3**.
- Consider the following measures when caring for a child with an upper airway obstruction:
  - Allow the child to assume a position of comfort (**Figure 2-4**). Do not force the child to lie down.
  - If necessary, use manual airway maneuvers to open the airway, such as a head tilt–chin lift or, if trauma to the

Box 2-3 Signs and Symptoms of Upper Airway Obstruction

Barking cough
Hoarse voice
Increased work of breathing
Inspiratory retractions
Nasal flaring
Respiratory distress of varying degrees
Stridor of varying degrees
Tachypnea

Figure 2-4 Allow a child with a respiratory complaint to assume a position of comfort.

cervical spine is suspected, a jaw thrust without neck extension (see Chapter 3).

- If a foreign body is visible in the upper airway, remove it.
- Clear the nose and mouth of secretions with suctioning, if doing so will not worsen the child's agitation and respiratory distress.
- If the child is unresponsive, consider the use of an oral airway to prevent the tongue from blocking the airway (see Chapter 3). Use of an oral airway in responsive or semi-responsive patients may stimulate the gag reflex when the back of the tongue or posterior pharynx is touched, resulting in retching, vomiting, and/or laryngospasm. Consider the use of a nasal airway in a child who has an intact gag reflex when an oral airway is contraindicated or impossible (e.g., seizing patient, biting, clenched jaws or teeth).
- Apply a pulse oximeter and monitor the child's oxygen saturation. If indicated, administer supplemental oxygen.
- Apply a cardiac monitor and assess the child's heart rate and rhythm. Obtain the child's blood pressure.
- If indicated, establish vascular access.
- It is prudent to have equipment readily available for performing endotracheal intubation and equipment for performing a surgical airway in case the child's condition worsens.

Croup

- Croup (laryngotracheobronchitis) is typically caused by a respiratory virus that is spread by person-to-person contact or by large droplets and contaminated nasopharyngeal secretions. It primarily affects children between 6 months and 6 years of age and is the most common cause of upper airway distress in childhood (Cukor & Manno, 2014). Croup affects the upper respiratory tract, causing inflammation and swelling of mucosal and submucosal tissues at the level of the cricoid ring, which is the narrowest part of the pediatric airway (Luten & Mick, 2012).
- The diagnosis of croup is usually based on the history and physical examination. The child typically has a history of a runny nose, cough, and sore throat for one to two days before the onset of croup symptoms. Symptoms are often worse at night and while the child is agitated (Wright & Klassen, 2008). Narrowing of the upper airway because of laryngeal inflammation and swelling leads to associated hoarseness, stridor, and a barking "seal-like" cough that may last 5 to 10 days (**Figure 2-5**). A low-grade fever may be present.
- The initial emergency care for croup is determined by the severity of the child's illness.
  - Mild croup is characterized by an absence of stridor at rest, minimal respiratory distress, and an occasional cough (Choi & Lee, 2012).
  - With moderate croup, the child's behavior and mental status are normal but inspiratory stridor and retractions

Figure 2-5 A runny nose, cough, and sore throat are often present for one to two days before the onset of croup symptoms.

are present at rest and the amount of respiratory distress is increased.

- Severe croup is characterized by mental status changes accompanied by significant respiratory distress and decreasing air entry, indicating impending respiratory failure (Choi & Lee, 2012). Suprasternal and intercostal retractions and inspiratory and expiratory stridor are often present (Wright & Klassen, 2008).

Mild Croup

- Perform an initial assessment and obtain a focused history.
- Maintaining an airway takes precedence over any other procedures. Because agitation can worsen hypoxia, keep the child calm. Allow the child to assume a position of comfort to maintain airway patency, usually sitting up on the caregiver's lap.
- Initiate pulse oximetry and cardiac monitoring. If indicated, give supplemental oxygen in a manner that does not agitate the child.
- Consider administration of a systemic steroid, such as dexamethasone (**Table 2-3**), to reduce inflammation. Signs of decreased respiratory distress are usually apparent about 30 minutes after administration (Bjornson, Russell, Vandermeer, Klassen, & Johnson, 2013). Studies have shown that when compared with a placebo, the administration of corticosteroids for croup resulted in improved symptoms within 6 hours, reduced the length of hospital stays, and reduced the number of emergency department return visits (Bjornson et al., 2013).

Moderate to Severe Croup

- Initiate pulse oximetry and cardiac monitoring.
- Although some experts recommend the administration of humidified O_2 (American Heart Association, 2011), significant benefits of this therapy have not been demonstrated in clinical trials (Hendry, 2012).
- Children with moderate to severe croup should receive nebulized epinephrine (**Figure 2-6**, **Table 2-4**). The clinical effects of nebulized epinephrine are usually apparent 30 minutes after treatment and disappear within 2 hours following treatment (Bjornson et al., 2013). A systemic steroid, such as dexamethasone or budesonide, should be given early because of its anti-inflammatory effects. At present, there is a lack of sufficient evidence to establish a beneficial effect of heliox (a mixture of helium and oxygen) in the treatment of croup in children (Hendry, 2012).
- The child with severe croup may progress to respiratory failure. If signs of respiratory failure are present, assist ventilation using a bag-mask device with supplemental oxygen. If endotracheal intubation is required, this high-risk procedure should only be performed by those with significant skill in pediatric intubation (American Heart Association, 2011). Use of a tracheal tube one-half to one full size smaller than that calculated for age and size is recommended because of the swelling and inflammation of the trachea at the subglottic level (Choi & Lee, 2012).

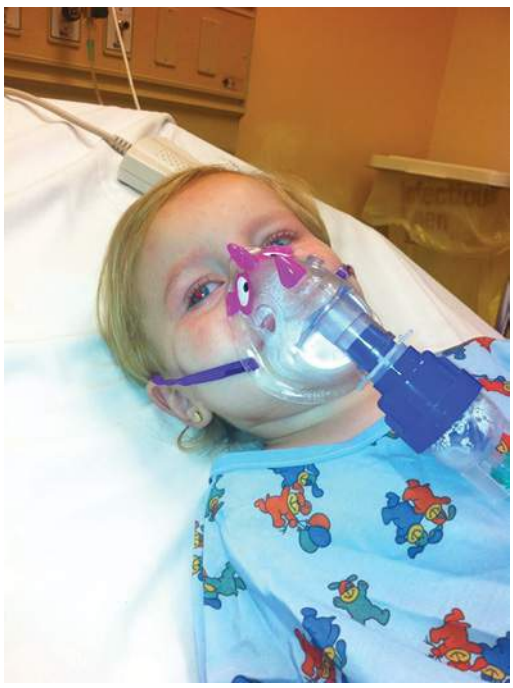
Table 2-3 Dexamethasone

Trade name	Decadron
Classification	Long-acting glucocorticoid
Mechanism of action	Reduces inflammation; enhances the responsiveness of bronchial smooth muscle to beta-adrenergic receptor stimulation
Indications	Asthma, croup
Dosage	IV/IM/PO: 0.6 mg/kg as a single dose (maximum dose 16 mg)
Contraindications	Hypersensitivity to the drug
Adverse effects	Pharyngeal irritation, dry mouth, coughing, oral fungal infections

IV = intravenous, IM = intramuscular, PO = oral.

Epiglottitis

- Epiglottitis is an acute bacterial infection of the upper airway that may progress to complete airway obstruction and death within hours unless adequate treatment is provided. *Haemophilus influenzae* type b (Hib) was once the most commonly



Courtesy of Barbara Aehlert.

Figure 2-6 The child with moderate to severe croup should receive nebulized epinephrine and a systemic steroid.

Table 2-4 Racemic Epinephrine

Trade name	Asthmanephrine, VapoNefrin
Classification	Catecholamine, sympathomimetic
Mechanism of action	Epinephrine acts on alpha- and beta-adrenergic receptors. The alpha-adrenergic effect of epinephrine causes vasoconstriction and reduces mucosal edema. Beta-adrenergic effects cause relaxation of the smooth muscle of the bronchioles. After nebulized therapy, these effects are noted within 10 to 30 minutes and last for about 1 hour.
Indications	Moderate to severe croup
Dosage	• Children age 4 or younger: 0.25 mL of racemic epinephrine 2.25% inhalation solution mixed in 3 mL NS *or* 0.5 mL/kg of 1:1,000 (1 mg/mL) epinephrine mixed in 3 mL NS (maximum dose 2.5 mL) • Children older than 4 years: Up to 0.5 mL of racemic epinephrine 2.25% inhalation solution mixed in 3 mL NS *or* 0.5 mL/kg of 1:1,000 (1 mg/mL) epinephrine mixed in 3 mL NS (maximum dose 5 mL)
Adverse effects	Moderate anxiety, agitation, tremor, tachycardia, hypertension, weakness, dizziness, palpitations, nausea and vomiting, headache
Notes	• Epinephrine use is typically reserved for patients who have moderate to severe croup because of the potential for adverse effects, including agitation, tachycardia, and hypertension. • Cardiac monitoring is wise because of epinephrine's tachycardic effect and the potential for dysrhythmias. Observe the child for *at least* 2 hours, and preferably for 3 to 4 hours, after treatment to monitor for rebound symptoms. *Rebound symptoms* refer to an improvement in the child's condition for a short period after treatment, with a subsequent return to the pretreatment level of obstruction or deterioration to a more severe state a few hours later. • Some oral inhalation solutions may contain sulfites.

NS = normal saline.

identified cause of acute epiglottitis in the United States. Because of the widespread use of the Hib vaccine since 1988, the incidence of epiglottitis caused by Hib in pediatric patients has been significantly reduced. Although epiglottitis can occur at any age, it typically affects children between 2 and 7 years of age. Diagnosis is often based on history and observation of the child from a distance.

- Drooling, dysphagia, and distress (the "three D's") are considered the classic clinical findings of acute epiglottitis (Sobol & Zapata, 2008). The child appears acutely ill and usually prefers to sit up and lean forward with his or her mouth open. Signs and symptoms typically include restlessness accompanied by a sore throat, muffled voice, increased ventilatory rate, increased heart rate, and elevated temperature, usually 102° to 104°F (38.9° to 40°C). The child's muffled voice may be referred to as "hot potato voice" because it sounds as if the child is talking with a hot potato in his or her mouth (Padlipsky & Gausche-Hill, 2008). Stridor is a late finding and suggests near-complete airway obstruction.

Emergency Care

The most common complication of epiglottitis is airway obstruction (Hendry, 2012). Allow the child's caregiver to remain with the patient. Because an aggressive physical examination, attempts to visualize the epiglottis, blood drawing and diagnostic tests, or establishing vascular access may provoke anxiety and worsen the child's respiratory distress, these procedures should be deferred until the diagnosis of epiglottitis is confirmed and the airway is secured. Close observation and frequent reassessment are *essential*. Ensure that the resuscitation cart, including equipment for bag-mask ventilation, intubation, and suctioning, is at the patient's bedside.

- Allow the child to assume a position of comfort and disturb the child as little as possible. Initiate pulse oximetry and, if indicated, give supplemental oxygen in a manner that does not agitate the child (e.g., blow-by) (see Chapter 3). Do not administer anything by mouth.
- If the child is stable, the diagnosis of epiglottitis is uncertain, and no evidence of obstruction exists, obtain a lateral neck radiograph. The child should be accompanied by a clinician capable of intubating the patient and intubation equipment at all times, including during the trip to and from the radiology department.
- If the child is stable with a high suspicion of epiglottitis, the patient should be escorted with an epiglottitis team (e.g., anesthesiologist, critical care intensivist, otolaryngologist) to the operating room for intubation under general anesthesia.
- If the child has severe respiratory distress with signs of complete or near-complete airway obstruction, the clinician most skilled in pediatric intubation should emergently intubate (Hendry, 2012).

Endotracheal intubation should be performed using a tracheal tube that is one to two sizes smaller than that calculated for age and size (Hendry, 2012).

- After the airway is secured, establish an intravenous (IV) line. Blood cultures, cultures of the epiglottis and supraglottic surfaces, and other diagnostic tests are generally ordered and antibiotic therapy started. The patient should be observed in the intensive care unit.

Foreign Body Aspiration

- Foreign body airway obstruction (FBAO) may be seen at any age, but most often occurs in children between 9 months and 5 years of age (Betz & Snowden, 2008a). In adults, an FBAO most often occurs during eating. In infants and children, most episodes of choking occur during eating or play. Occasionally, poor supervision by adults or older siblings is a contributing factor. Suspect FBAO in any previously well, afebrile child with a sudden onset of respiratory distress and associated coughing, choking, stridor, or wheezing.
- Common culprits associated with foreign body aspiration in children include small foods, such as nuts, raisins, sunflower seeds, watermelon seeds, popcorn, and improperly chewed pieces of meat, grapes, hot dogs, raw carrots, or sausages (**Figure 2-7**). Other items commonly found in the home that may cause FBAO include disc (button cell) batteries, pins, rings, nails, buttons, coins, plastic or metal toy objects, and marbles. Aspiration of balloons, including those made from inflated examination gloves, can be fatal. Frequently, the child presents after a sudden episode of coughing or choking while eating, with subsequent wheezing, coughing, or stridor. The longer a foreign body remains lodged in place, the higher the likelihood of complications related to increasing edema, inflammation, and the threat of infection (Betz & Snowden, 2008a). Possible signs and symptoms associated with foreign body aspiration are shown in **Box 2-4**.

Box 2-4 Possible Signs and Symptoms of Foreign Body Aspiration

Agitation
Coughing or gagging
Cyanosis
Diminished breath sounds distal to the foreign body
Fever
Hoarseness
Inspiratory stridor
Respiratory distress
Respiratory arrest
Wheezing

PALS Pearl

Because they absorb moisture, dried foods (such as beans and peas) may cause progressive airway obstruction.

Emergency Care

- Perform an initial assessment and obtain a focused history.
- If the infant or child is conscious, maintaining his or her own airway, and able to cough and make some sounds, do not interfere. Allow the child to assume a position of comfort and continue his or her efforts to clear the foreign body. Administer supplemental oxygen if indicated. Encourage the child to cough while you provide emotional support.
- If the conscious infant or child cannot cough or make any sound, clear the obstruction by performing abdominal thrusts (if the patient is 1 year or older) or back slaps and chest thrusts (if the patient is younger than 1 year) (**Figure 2-8**).

EMSC Slide Set (CD-ROM). 1996. Courtesy of the Emergency Medical Services for Children Program, administered by the U.S. Department of Health and Human Service's Health Resources and Services Administration, Maternal and Child Health Bureau.

Figure 2-7 Common culprits associated with foreign body aspiration in children.

Figure 2-8 If a conscious infant (the patient is younger than 1 year) cannot cough or make any sound, clear the airway obstruction by performing back slaps and chest thrusts.

- If the infant or child becomes unresponsive, begin cardiopulmonary resuscitation (CPR), starting with chest compressions. Chest compressions should be performed even if a pulse is present. The rationale for this action is that performing chest compressions may help to dislodge the foreign body (American Heart Association, 2011). Before ventilating the patient, look into the mouth and remove the foreign body, if visualized. Continue with cycles of chest compressions and ventilations until the object is expelled.

Anaphylaxis

Anaphylaxis occurs when the body is exposed to a substance that produces a severe allergic reaction, usually within minutes of the exposure. Although there is more than one mechanism by which anaphylaxis occurs, type I hypersensitivity is the most common (Hendry, 2012). Type I hypersensitivity occurs when an individual is exposed to a specific allergen and develops IgE antibodies. These antibodies attach to mast cells in specific body locations, creating sensitized mast cells. Histamine and other chemical mediators are released on reexposure to the same allergen, causing widespread responses in the skin, respiratory tract, and cardiovascular and gastrointestinal systems. Common causes of anaphylaxis include insect stings, latex, medications (e.g., penicillin, sulfa), and some foods (e.g., shellfish, nuts, strawberries). Signs and symptoms associated with anaphylaxis are shown in **Box 2-5**.

Box 2-5 Possible Signs and Symptoms of Anaphylaxis

Anxiety, restlessness
Coughing
Crampy abdominal pain
Difficulty breathing
Difficulty swallowing (dysphagia)
Hives (urticaria)
Hoarseness
Hypotension
Itching (pruritus)
Retractions
Stridor
Swelling of the face and lips
Tachycardia
Vomiting, diarrhea
Warm, flushed skin
Wheezing

Emergency Care

- Perform an initial assessment and obtain a focused history. Remove/discontinue the causative agent.
- Apply a pulse oximeter and administer supplemental oxygen if indicated; ensure effective oxygenation and ventilation. Initiate cardiac monitoring.
- Give epinephrine via intramuscular (IM) injection (Hendry, 2012) (**Table 2-5**). The anterolateral thigh is the preferred injection site (Hendry, 2012).

Table 2-5 Epinephrine for Anaphylaxis

Trade name	Adrenalin, EpiPen
Classification	Catecholamine, sympathomimetic
Mechanism of action	• Can reduce the release of inflammatory mediators from mast cells and basophils • Alpha-adrenergic effects of vasoconstriction can reduce mucosal swelling and increase blood pressure • $Beta_1$-adrenergic effects result in increased rate and force of myocardial contractions • $Beta_2$-adrenergic effects result in the dilation of bronchial smooth muscle

(*Continues*)

Table 2-5 Epinephrine for Anaphylaxis (*continued*)

Trade name	Adrenalin, EpiPen
Indications	Anaphylaxis
Dosage	• 0.01 mg/kg (0.01 mL/kg) of 1:1,000 solution via IM injection (Hendry, 2012). Maximum single dose 0.3 mg. May be repeated every 5 to 15 minutes if necessary to control symptoms and maintain blood pressure (Hendry, 2012). • When using an epinephrine auto-injector, administer 0.3 mg IM for patients weighing 30 kg or more and 0.15 mg IM for patients weighing 10 to 30 kg. • If hypotension is present, give 0.01 mg/kg (0.1 mL/kg) of 1:10,000 solution IV/IO every 3 to 5 minutes to a maximum dose of 1 mg. • Consider a continuous epinephrine infusion if hypotension persists despite bolus therapy and fluid administration. Start at 0.1 mcg/kg/min and titrate according to patient response up to 1 mcg/kg/min.
Adverse effects	Increases myocardial oxygen demand
Notes	• Because of its vascularity, the site of choice for IM administration is the anterolateral aspect of the thigh (Valente, 2012). • A continuous epinephrine infusion should only be infused using an infusion pump. Check the IV/IO site frequently for evidence of tissue sloughing. • Low-dose infusions (less than 0.3 mcg/kg/min) primarily produce beta-adrenergic effects. Infusions above 0.3 mcg/kg/min produce a mix of beta- and alpha-adrenergic effects. • Epinephrine's onset of action is immediate when administered IV/IO and within 5 to 10 minutes when administered IM.

IM = intramuscular, IO = intraosseous, IV = intravenous

- Administer albuterol by metered-dose inhaler (MDI) or nebulizer for bronchospasm (**Table 2-6**). Listen to breath sounds before and after administration to assess the child's response to treatment.
- Establish IV access and administer additional medications to help stop the inflammatory reaction. Give diphenhydramine IV to reduce hives and itching (**Table 2-7**). Administration of an H_2 blocker (e.g., ranitidine) IV is also recommended (American Heart Association, 2011). Give methylprednisolone (**Table 2-8**) or an equivalent corticosteroid IV to stabilize capillary membranes and to reduce angioedema and bronchospasm.
- If the child is hypotensive, give a 20 mL/kg fluid bolus of an isotonic crystalloid solution (e.g., normal saline or Lactated Ringer's solution). If perfusion does not improve, repeat the fluid bolus and reassess the child's response, repeating the primary assessment after each fluid bolus. Monitor closely for increased work of breathing and the development of crackles.
- An epinephrine IV infusion may be necessary if the child's hypotension persists despite fluid boluses and the administration of IM epinephrine. Titrate the infusion to achieve an adequate blood pressure for the child's age (American Heart Association, 2011).

Table 2-6 Albuterol

Trade name	Proventil, Ventolin
Classification	Synthetic sympathomimetic, $beta_2$-adrenergic agonist, bronchodilator
Mechanism of action	Albuterol possesses a relatively selective specificity for $beta_2$-adrenergic receptors. Stimulation of these receptor sites in bronchial smooth muscle results in relaxation and decreased resistance to the flow of air in and out of the lungs.
Indications	Bronchospasm associated with asthma or anaphylaxis
Dosage	• For mild to moderate symptoms, administer 4 to 8 puffs using a MDI equipped with a spacer every 20 minutes as needed. Alternately, administer by nebulizer every 20 minutes as needed. For patients weighing 20 kg or more administer 5 mg/dose; give 2.5 mg/dose for patients weighing less than 20 kg. • For severe symptoms, administer albuterol by continuous nebulization (0.5 mg/kg/hour) to a maximum dose of 20 mg/hour.

Contraindications	Hypersensitivity to albuterol or to sympathomimetics
Adverse effects	• CV: Dysrhythmias, palpitations, tachycardia, angina, peripheral vasodilation, systolic hypertension, diastolic hypotension • CNS: Tremors, anxiety, headache, dizziness, restlessness, irritability • GI: Nausea, vomiting, heartburn • Resp: Bronchospasm (paradoxical with excessive use) • Skin: Flushing • Other: Dry nose, irritation of nose and throat, hyperglycemia, hypokalemia
Notes	• Assess clinical signs of respiratory distress, including ventilatory rate, oxygen saturation, and peak expiratory flow rate. Any deterioration may require prompt intervention. • Because stimulation of beta-adrenergic receptors affects the shifting of potassium ions into cells, serum potassium levels can be affected, contributing to hypokalemia. Consider obtaining a serum potassium level before beginning therapy to be used as a baseline for later comparison. • Albuterol's onset of action is within 5 to 15 minutes. Its duration of action is generally 4 to 6 hours but may vary with the severity of the patient's disease.

CNS = central nervous system, CV = cardiovascular, GI = gastrointestinal, MDI = metered-dose inhaler, Resp = respiratory.

Table 2-7 Diphenhydramine

Trade name	Benadryl
Classification	Antihistamine, a receptor antagonist
Mechanism of action	Decreases the allergic response by binding to histamine receptor sites and blocking the effects of histamine
Indications	Anaphylaxis and moderate to severe allergic reactions (after epinephrine)
Dosage	• 1 to 2 mg/kg per dose every 4 to 6 hours; do not exceed 50 mg per single dose • Maximum dose: 50 mg/dose and 300 mg/24 hours (Lee, Tschudy, & Arcara, 2012)
Contraindications	Known hypersensitivity to diphenhydramine or drugs of similar chemical structure
Adverse effects	• CV: Hypotension, reflex tachycardia, palpitations • CNS: Drowsiness, dizziness, poor coordination, confusion, paradoxical excitation (especially in children), seizures, dystonic reaction • GI: Diarrhea, nausea, vomiting, loss of appetite • Resp: Wheezing, chest tightness, increased thick secretions • Other: Blurred vision, pupil dilation; dry nose, throat, mouth
Notes	• Do not give subcutaneously because of its irritating effects. • Diphenhydramine's onset of action is immediate when given IV and within 30 minutes when administered IM. Its duration of action is 4 to 8 hours.

CNS = central nervous system, CV = cardiovascular, GI = gastrointestinal, IM = intramuscular, IV = intravenous, Resp = respiratory.

Table 2-8 Methylprednisolone Sodium Succinate

Trade name	Solu-Medrol, A-Methapred, Depo-Medrol
Classification	Corticosteroid
Mechanism of action	Reduces the inflammatory response and diminishes the allergic response
Indications	Asthma, anaphylaxis
Dosage	2 mg/kg loading dose IV/IO/IM, maximum dose 60 mg/24 hours
Contraindications	Hypersensitivity to corticosteroids
Adverse effects (seen with long-term use)	• MS: Pathologic fractures of long bones, osteoporosis, muscle weakness, loss of muscle mass • Other: Increased vulnerability to infection, glucose intolerance, peptic ulcer disease
Notes	• Methylprednisolone is considered an intermediate-acting steroid with a duration of action of 18 to 36 hours. • When administering IM, avoid using the deltoid muscle. Inject deep into a large muscle mass. • Tissue damage may result if administered subcutaneously.

IM = intramuscular, IO = intraosseous, IV = intravenous, MS = musculoskeletal.

LOWER AIRWAY OBSTRUCTION

Whereas an upper airway obstruction typically produces *inspiratory* symptoms, a lower airway obstruction produces more *expiratory* symptoms. Asthma and bronchiolitis are common causes of lower airway obstruction in children. These conditions are characterized by coughing, wheezing, and a prolonged expiratory phase (Valente, 2012).

Asthma

Asthma, also known as *reactive airway disease*, is a disease of the lower airway characterized by chronic inflammation of bronchial smooth muscle, hyperreactive airways, and episodes of bronchospasm that limit airflow (**Figure 2-9**). Common signs and symptoms associated with asthma are shown in **Box 2-6**. Symptoms may be precipitated by or worsen in the presence of viral respiratory infections, specific allergens (e.g., animal dander, dust, mold, cigarette smoke, pollen), and other factors, such as weather changes, chemical irritants, exercise, strong emotional responses, and gastroesophageal reflux.

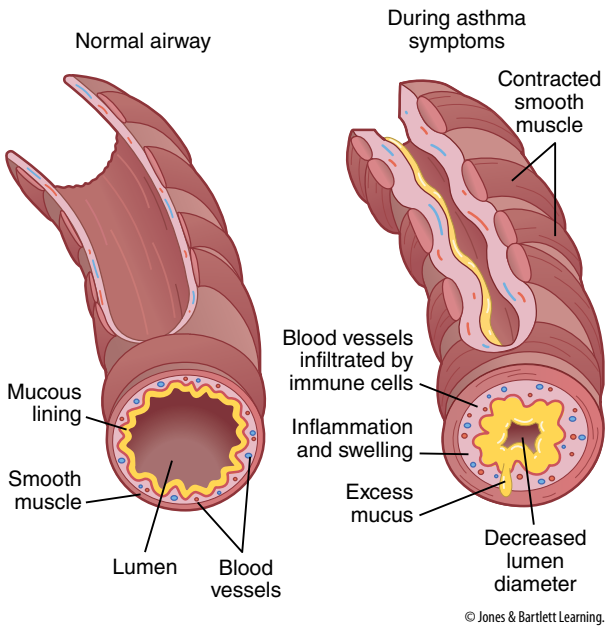


Figure 2-9 Asthma is a chronic inflammatory disorder of the airways.

Box 2-6 Clinical Manifestations of Asthma

Accessory muscle use
Anxiety, irritability
Chest tightness
Decreased expiratory flow rate
Dry cough
Dyspnea with prolonged expiratory phase
Hypoxia
Nasal flaring
Poor air entry
Retractions
Shortness of breath with exertion
Tachypnea
Wheezing (most common finding)

PALS Pearl

Wheezing is an unreliable sign when evaluating the degree of distress in an asthmatic patient. An absence of wheezing may represent severe obstruction. With improvement, wheezing may become more prominent.

An asthma exacerbation is an episode of progressively increasing shortness of breath, coughing, wheezing, or chest tightness, or some combination of these symptoms (Global Initiative for Asthma, 2012). Assessment of the severity of an asthma exacerbation helps to determine management, evaluate the patient's response to treatment, and communicate with other medical providers (Smith, 2008). Asthma exacerbations are categorized as mild, moderate, or severe.

- The child with mild signs and symptoms talks in sentences, may be agitated but is able to lie down, has dyspnea with activity (e.g., walking), has an increased ventilatory rate, and has moderate end-expiratory wheezing (Global Initiative for Asthma, 2012).
- The child with moderate signs and symptoms talks in phrases, prefers sitting, is usually agitated, commonly uses accessory muscles, and has an increased ventilatory rate. Loud wheezing can often be heard throughout expiration (Global Initiative for Asthma, 2012).
- The child with severe signs and symptoms is usually breathless at rest and talks in words rather than phrases or sentences, often sits upright and may be hunched forward, is usually agitated, usually uses accessory muscles, and has an increased ventilatory rate. Loud wheezing can often be heard throughout inspiration and expiration (Global Initiative for Asthma, 2012).
- Signs of imminent respiratory arrest include drowsiness or confusion, bradycardia, an absence of wheezing, and paradoxical movement of the chest and abdomen (Global Initiative for Asthma, 2012).

Emergency Care

- Perform an initial assessment and obtain a focused history. Ask the child's caregiver about triggers (e.g., cigarette smoke, allergies, infection, exercise), infectious symptoms, duration of asthma symptoms, frequency of rescue medications, chronic medications, time of last medication doses, and peak flow rates (discussed below) (Smith, 2008).
- Allow the child to assume a position of comfort. Initiate pulse oximetry and place the child on a cardiac monitor.
- Assessment of the child's peak expiratory flow (PEF) rate may be useful in determining the severity of an asthma exacerbation (**Figure 2-10**). Peak expiratory flow rates reflect the caliber of the airways and the degree of obstruction (Smith, 2008). Because PEF measurements require the child's cooperation in making a maximal expiratory effort, PEF measurements are used to assess the severity of an episode and the response to therapy in children over 5 years of age with mild to moderate exacerbations and who currently perform peak flow with home management. PEF measurements should be compared to the patient's own previous best measurements.
- If ventilation is adequate and the patient exhibits signs of respiratory distress, give supplemental oxygen in a manner that does not agitate the child. Maintain an oxygen saturation of 95% or higher (Global Initiative for Asthma, 2012). If signs of respiratory failure or respiratory arrest are present, ventilate using a bag-mask device with supplemental oxygen.
- Assess the status of the child's hydration. An infant or young child can quickly become dehydrated because of an increased ventilatory rate and decreased oral intake. Be sure to assess fluid status and treat appropriately.
- Obtain vascular access if the patient shows signs of severe respiratory distress, respiratory failure, or respiratory arrest.
- Children with mild asthma should receive albuterol (a short-acting beta$_2$ agonist) by MDI or nebulizer and oral corticosteroids (**Figure 2-11**, see Table 2-6). Listen to breath sounds before and after administration to assess the child's response to treatment.
- Children experiencing a moderate episode should receive albuterol by MDI or nebulizer and oral corticosteroids. Nebulized

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Figure 2-10 Peak expiratory flow meter.

© Nagy-bagoly Ilona/Dreamstime.com.

Figure 2-11 The administration of supplemental oxygen, short-acting inhaled bronchodilators, and corticosteroids are the primary therapies used for asthma exacerbations.

ipratropium bromide, an anticholinergic, should also be administered (**Table 2-9**). Consider establishing vascular access for fluid and medication administration (American Heart Association, 2011). Assess the child's response to treatment.

- Children experiencing a severe episode should receive albuterol by MDI or nebulizer and IV corticosteroids. Continuous albuterol administration may be necessary if symptoms do not improve. Give nebulized ipratropium bromide. Establish vascular access and consider administering a magnesium IV infusion (**Table 2-10**) over 20 to 30 minutes while monitoring the child's heart rate and blood pressure (American Heart Association, 2011). Assess the child's response to treatment.
- The most common cause of acute respiratory failure in the asthmatic child is ineffective ventilation resulting from severe obstruction and muscle fatigue (Smith, 2008). If endotracheal intubation becomes necessary, this high-risk procedure should only be performed by those with significant skill in pediatric intubation.

Bronchiolitis

- **Bronchiolitis** is an acute infection of the bronchioles, most commonly caused by respiratory syncytial virus (RSV). It occurs primarily in late fall, winter, and early spring and is uncommon in children older than 5 years. RSV is highly contagious and is primarily transmitted through direct contact with respiratory secretions.
- Acute bronchiolitis is one of the most frequent causes of emergency department visits in infants (Jat & Mathew, 2015). The virus causes inflammation, the production of thick mucus, and swelling of varying degrees in the small bronchi and smaller bronchioles. The resulting narrowing of the bronchioles leads to limitations in airflow and an increased work of breathing.
- The child with bronchiolitis typically presents with symptoms similar to the common cold with a cough, runny nose, low-grade fever, and irritability (**Figure 2-12**). Within one to three days, signs and symptoms progress to an increasingly productive cough, increasing respiratory distress, and wheezing. As the disease progresses, coughing and wheezing increase and air hunger follows. These signs and symptoms are accompanied by restlessness, an increased ventilatory rate, intercostal and subcostal retractions, and hyperexpansion of the chest. Signs of dehydration (e.g., sunken eyes, dry mucous membranes, sunken fontanel, and fatigue) may be present because of decreased fluid intake and increased fluid losses from fever and tachypnea.

PALS Pearl

Because asthma accompanied by an upper respiratory infection and bronchiolitis present similarly, it may be difficult to distinguish between these conditions.

Table 2-9 Ipratropium Bromide

Trade name	Atrovent
Classification	Bronchodilator, anticholinergic, parasympathetic blocker, parasympatholytic
Mechanism of action	Antagonizes muscarinic receptors in bronchial smooth muscle, preventing bronchoconstriction and reducing secretions
Indications	Bronchospasm associated with asthma
Dosage	For acute symptoms, administer by nebulizer • Children younger than 12 years: Administer 250 mcg/dose every 20 minutes × 3, then every 2 to 4 hours as needed (Lee et al., 2012) • Children 12 years and older: Administer 500 mcg/dose every 20 minutes × 3, then every 2 to 4 hours as needed (Lee et al., 2012)
Contraindications	Known hypersensitivity to ipratropium bromide or to atropine and its derivatives
Adverse effects	• CNS: Dizziness, nervousness, headache, tremor, insomnia • CV: Palpitations • GI: Nausea, vomiting • Other: Cough, skin rash, dry mouth, nasal irritation
Notes	• Minimal systemic absorption • Slightly slower to act than beta-adrenergic agonists

CNS = central nervous system, CV = cardiovascular, GI = gastrointestinal.

Table 2-10 Magnesium Sulfate

Classification	Electrolyte, bronchodilator, antiarrhythmic
Mechanism of action	Plays an important role with regard to neurochemical transmission and muscular excitability; mild vasodilator; CNS depressant
Indications	Moderate to severe asthma exacerbation, documented hypomagnesemia, Torsades de pointes (TdP)
Dosage	• Asthma: 25 to 50 mg/kg slow IV/IO infusion over 15 to 30 minutes. Maximum recommended single dose: 2 g. • Hypomagnesemia: 25 to 50 mg/kg IV/IO infusion over 10 to 20 minutes. May repeat at 4- to 6-hour intervals for three or four doses. Maximum recommended single dose: 2 g. • TdP: 25 to 50 mg/kg IV/IO infusion over 10 to 20 minutes. Maximum recommended single dose: 2 g.
Contraindications	• Heart block • Respiratory depression
Adverse effects	• CNS: Depressed deep tendon reflexes, flaccid paralysis, confusion, weakness, stupor • CV: Hypotension (may be transient), complete AV block, increased PR interval, widened QRS complex, prolonged QT interval, circulatory collapse • GI: Nausea, vomiting • Resp: Respiratory depression and failure • Skin: Flushing, sweating
Notes	• Magnesium is available in multiple concentrations. Before administration, carefully check the concentration of the solution to avoid medication errors. • During administration, continuous monitoring of heart rate and rhythm and oxygen saturation is essential. Closely monitor the patient's blood pressure. • Rapid administration may result in severe hypotension, bradycardia, and cardiovascular collapse. • Monitor magnesium levels. • Have calcium available for IV/IO injection to reverse AV block and respiratory depression. • While treating TdP, search for possible reversible causes of the dysrhythmia, such as an electrolyte disturbance. • Use with caution in patients with impaired renal function and with patients who are taking digoxin. • Onset of action is immediate and lasts for about 30 minutes.

AV = atrioventricular, CNS = central nervous system, CV = cardiovascular, GI = gastrointestinal, IO = intraosseous, IV = intravenous, Resp = respiratory.

Figure 2-12 The initial symptoms of bronchiolitis resemble those of the common cold.

Emergency Care

Supportive care with suctioning, maintaining adequate hydration, and the use of antipyretics are the mainstays of treatment. Standard precautions and handwashing are essential to prevent the spread of the virus.

- Perform an initial assessment and obtain a focused history.
- Assist the child into a position of comfort, usually sitting up on the caregiver's lap. Keep the child as calm and as comfortable as possible.
- Perform nasal suctioning if needed to clear secretions.
- Initiate pulse oximetry and maintain adequate oxygenation. If ventilation is adequate and the patient exhibits signs of respiratory distress, give supplemental oxygen in a manner that does not agitate the child. If signs of respiratory failure or respiratory

arrest are present, ventilate using a bag-mask device with supplemental oxygen.

- Mild dehydration is often present. Ensure adequate fluid intake. Because the child may be tachypneic, weak, and tired, close monitoring is essential. IV fluids may be preferred over fluids by mouth, particularly if the child's respiratory distress is severe enough that aspiration is a concern.
- The use of bronchodilators in the management of bronchiolitis is controversial. Current literature does not support the routine use of bronchodilators but does support a trial dose of nebulized epinephrine or albuterol to be continued only if improvement is observed after treatment (Hendry, 2012).

LUNG TISSUE DISEASE

Lung tissue diseases are disorders that affect the tissues surrounding the alveoli and bronchi of the lungs or that directly affect the alveoli and bronchi. Lung tissue diseases have many causes, including aspiration, autoimmune diseases (e.g., collagen vascular disease), infectious diseases (e.g., pneumonia), inherited conditions (e.g., cystic fibrosis, surfactant disorders), cardiogenic and noncardiogenic pulmonary edema, connective tissue disorders (e.g., rheumatoid arthritis), trauma (e.g., pulmonary contusion), and exposure to environmental substances (e.g., chemicals, molds). Selected lung tissue diseases are discussed below.

Bronchopulmonary Dysplasia

Bronchopulmonary dysplasia (BPD), also known as *chronic lung disease of infancy*, is a disease that occurs in full-term and preterm infants who experienced respiratory problems in the first few days after birth that required mechanical ventilation, oxygen under pressure, or both for prolonged periods. Signs and symptoms of BPD include the following:

- Bronchospasm
- Cough
- Crackles
- Hypoxia
- Increased ventilatory rate at rest
- Mucus plugging
- Retractions
- Tachypnea
- Wheezing

Complications associated with BPD include recurrent respiratory infections, increased airway resistance, trapping of air in the lungs, and exercise-induced bronchospasm.

Emergency Care

- Perform an initial assessment and obtain a focused history. Avoid agitating the infant, which can worsen hypoxia.
- Apply a pulse oximeter. Hypoxia may occur because of a decrease in respiratory drive, alterations in pulmonary mechanics, excessive stimulation, and bronchospasm. If ventilation is adequate and the patient exhibits signs of respiratory distress, give supplemental oxygen in a manner that does not agitate the infant. Keep the oxygen saturation at 92% or higher (Hendry, 2012). If signs of respiratory failure or respiratory arrest are present, ventilate using a bag-mask device with supplemental oxygen.
- If wheezing is present, nebulized bronchodilator therapy may be used to improve airflow in the lungs. Inhaled corticosteroids may be used to reduce airway swelling and inflammation. Use of these therapies is controversial because bronchial smooth muscle may not be fully developed in infants (Hendry, 2012).
- Diuretics may be administered to decrease fluid accumulation in the lungs.
- Antibiotics may be administered to manage a suspected bacterial infection.

Cystic Fibrosis

- **Cystic fibrosis (CF)** is a chronic progressive inherited disease that is associated with abnormal sodium and chloride transport across the epithelium. The disorder causes the body to produce thick, sticky mucus that affects multiple organs, most commonly the lungs, pancreas, liver, bile ducts, and small intestine (**Figure 2-13**). CF most often presents in early childhood with persistent respiratory illness, malnutrition and poor growth, diarrhea, or a combination of these.
- Signs and symptoms associated with CF vary. Physical findings associated with cystic fibrosis include poor weight gain, abdominal distention, thin extremities, muscle wasting, mild to severe clubbing of nail beds because of chronic hypoxia, salty-tasting

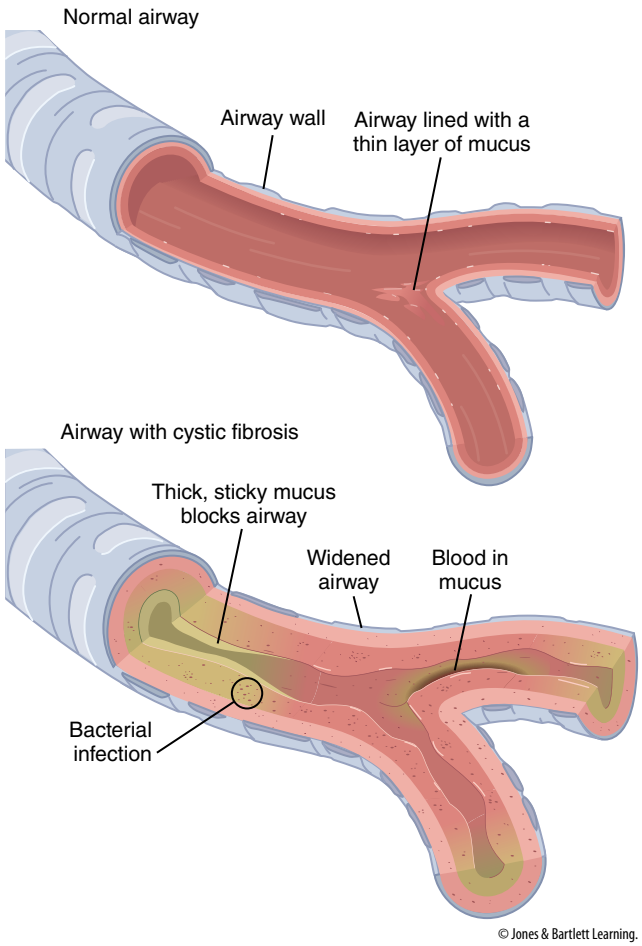

Figure 2-13 With cystic fibrosis, a defective gene causes the body to produce abnormally thick, sticky mucus that affects multiple organs.

skin, profuse sweating in warm temperatures, and fatty, foul-smelling diarrhea. The effects of CF on the respiratory system include a chronic cough that is initially dry and hacking. Over time, the cough becomes productive of thick sputum. Vomiting may occur after a prolonged coughing episode. During an acute pulmonary exacerbation, the child may present with fatigue, fever, accessory muscle use, and an increased coughing frequency that is productive of purulent sputum that may be blood-streaked.

Emergency Care

Because the management of the CF patient is complex, emergency care should be coordinated with a CF care team or pulmonologist (Hendry, 2012).

- Perform an initial assessment and obtain a focused history.
- Allow the child to assume a position of comfort, usually sitting up on the caregiver's lap.
- Apply a pulse oximeter. If ventilation is adequate and the patient exhibits signs of respiratory distress, give supplemental oxygen in a manner that does not agitate the child. If signs of respiratory failure or respiratory arrest are present, ventilate using a bag-mask device with supplemental oxygen.
- Obtain vascular access for hydration or medication administration if necessary. Because CF patients have frequent infections, many will have an implanted central vascular access device in place.
- Chest physiotherapy is used to help loosen and drain mucus from the lungs.
- Decongestants, bronchodilators, or both (before and after chest physiotherapy) are used to relieve bronchospasm, enable the removal of thick secretions, and improve airflow in the lungs.
- Mucolytics may be administered to alter the consistency of mucus, making it more fluid and easier to expectorate.
- Corticosteroids may be used to reduce airway swelling and inflammation.
- Antibiotics may be administered to control infection. More than one antibiotic is often necessary to treat suspected pathogens.

Pneumonia

Pneumonia is an inflammation and infection of the lower airway and lungs caused by a viral, bacterial, parasitic, or fungal organism. It may occur as a primary infection or as secondary to another illness or infection. Pneumonia is often preceded by symptoms of an upper respiratory infection. Signs and symptoms may include cough, decreased breath sounds, fever, hypoxia, malaise, nasal flaring, pleuritic chest pain, retractions, shortness of breath, and tachypnea. Abdominal pain caused by irritation of the diaphragm by the adjacent infected lung may be present (Betz & Snowden, 2008b).

Emergency Care

- Perform an initial assessment and obtain a focused history.
- Assist the child into a position of comfort, usually sitting up on the caregiver's lap.
- Apply a pulse oximeter. Administer supplemental oxygen if indicated. If ventilation is adequate and the patient exhibits signs of respiratory distress, give supplemental oxygen in a manner that does not agitate the child. If signs of respiratory failure or respiratory arrest are present, ventilate with a bag-mask device with supplemental oxygen. Noninvasive positive pressure ventilation may be needed.
- Assess hydration. An infant or young child can become quickly dehydrated because of an increased ventilatory rate and decreased oral intake. Obtain vascular access for hydration or medication administration if necessary.
- Albuterol, administered by MDI or nebulizer, may be ordered to treat wheezing and to help clearing of secretions.
- Antibiotics may be used to treat bacterial pneumonia. Most viral pneumonias are treated symptomatically; however, specific antiviral therapy may be beneficial in certain situations.
- Antipyretics may be used to control fever.

Pulmonary Edema

Pulmonary edema may result from cardiogenic or noncardiogenic causes. The child may present with varying degrees of respiratory distress that may progress to respiratory failure. Common findings include a moist cough, crackles, labored breathing, tachypnea, tachycardia, and anxiety or confusion that is associated with poor oxygenation. The child's sputum is often a frothy white that may be blood-tinged.

Noncardiogenic Pulmonary Edema

Noncardiogenic pulmonary edema (NCPE) is a condition in which fluid flows from the pulmonary capillaries and accumulates in the interstitial spaces or in the alveoli, impairing the diffusion of oxygen and carbon dioxide. Examples of conditions or factors that may lead to NCPE include acute head injury, aspiration, high altitude, inhalation injuries (e.g., ammonia, chlorine), allergic reactions, overzealous fluid administration, drowning, metal poisoning (e.g., iron, lead), and some overdoses (e.g., salicylates, opioids).

Cardiogenic Pulmonary Edema

Cardiogenic pulmonary edema is most commonly caused by left-sided heart failure, but it may also result from congenital heart disease, myocarditis, mitral, or aortic valve disease, cardiomyopathies, and cardiac depressant medications (e.g., beta-blockers), among other causes. When the left ventricle is unable to pump out all of the blood that it receives from the lungs, blood pressure increases within the pulmonary veins and capillaries. The increased pressure forces fluid from the pulmonary capillaries, through the capillary walls, and into the alveoli, resulting in pulmonary edema.

Emergency Care

- Management of the patient with pulmonary edema often is dependent on its cause.
- Allow the child to assume a position of comfort, which is typically sitting up. Closely monitor for signs and symptoms of

impending respiratory failure. Apply a pulse oximeter and ECG monitor. Administer supplemental oxygen. The patient in moderate to severe respiratory distress typically requires mechanical ventilation to maintain adequate gas exchange. This may include noninvasive ventilatory support with CPAP or mechanical ventilation with positive end-expiratory pressure (PEEP).

- Treatment of cardiogenic pulmonary edema may require the administration of diuretics to assist with fluid removal and the use of inotropic agents to improve myocardial contractility. If cardiogenic shock ensues, the administration of vasopressors to improve blood pressure may also be necessary.

DISORDERS OF VENTILATORY CONTROL

Respiratory centers in the brainstem are responsible for the primary control of breathing. Central and peripheral chemoreceptors are responsive to O_2, CO_2, and pH levels in the body. Imbalances in these control mechanisms can result in disorders of ventilatory control. Examples of conditions that may disrupt control of ventilation include increased intracranial pressure, neuromuscular disease, and acute poisoning or drug overdose.

Increased Intracranial Pressure

- Maintenance of an adequate blood volume and blood pressure is critical for brain perfusion. Cerebral mechanisms (referred to as *autoregulation*) adjust the diameter of cerebral blood vessels to maintain cerebral blood flow at a relatively constant rate despite fluctuations in blood pressure. Cerebral perfusion pressure (CPP) is determined by the difference between mean arterial blood pressure and intracranial pressure (ICP). Cerebral perfusion pressure may decrease if the MAP decreases or ICP increases; thus, cerebral autoregulation can become impaired because of edema or hypotension, among other causes. Severe increases in ICP can result in disruptions in cerebral perfusion or result in cerebral herniation.
- Head trauma is the most common cause of increased ICP in children (Mar, 2010). Examples of other possible causes include brain tumor, meningitis, a shunt obstruction from a patient with hydrocephalus, subdural or epidural hematomas, and hemorrhage from a vascular malformation.
- Signs of increased ICP in an infant include a high-pitched cry, irritability, distended scalp veins, vomiting, altered feeding habits, and a tense or bulging fontanel. In a verbal child, signs may include blurry vision, headache, an inability to follow simple commands (e.g., hold up two fingers), intermittent vision loss, neck pain, seizures, restlessness and irritability, and then lethargy and drowsiness.
- Cushing triad consists of a combination of systolic hypertension, a change in heart rate (bradycardia or tachycardia in children), and an altered breathing pattern. This triad is a *late* sign of increased ICP and may signal impending cerebral herniation; however, the absence of Cushing triad does not rule out the presence of increased ICP. In addition to Cushing triad, signs of impending brain herniation include hemiparesis or hemiplegia, unequal pupil size, failure of the pupil to react to light, and possible decorticate or decerebrate posturing. Progression from decorticate to decerebrate posturing is an ominous sign.
- Because management of increased ICP can differ depending on its cause, obtain a neurosurgical consult if increased ICP is suspected. Regardless of the cause, it is essential to maintain an open airway, to ensure adequate oxygenation and ventilation, and to ensure adequate systemic perfusion.
- The use of pulse oximetry and capnography is useful in recognizing hypoxemia and increasing carbon dioxide levels. Endotracheal intubation with mechanical ventilation is often necessary.
- Establish vascular access. Isotonic crystalloid fluid boluses of 20 mL/kg may be ordered if signs of poor perfusion are present. Reassess the child's response after each bolus. Vasopressors may be ordered if hypotension persists despite an adequate intravascular volume. Hypertonic saline and osmotic agents may be ordered to control ICP.
- Perform serial neurologic checks, including vital signs, arousability, size and reactivity of the pupils to light, and the extent and symmetry of motor responses. Use the Glasgow Coma Scale (GCS) for serial comparisons. A GCS score that falls two points suggests significant deterioration requiring urgent patient reassessment.
- Compromised cerebral perfusion can produce a shift in brain tissue resulting in herniation. When signs of impending brain herniation are present, short-term hyperventilation may be ordered. Hyperventilation induces vasoconstriction by decreasing the amount of carbon dioxide dissolved in the blood. Although hyperventilation causes a transient reduction in ICP, it also decreases cerebral blood flow. Therefore, hyperventilation may be used as a temporizing measure in the management of acute elevations in increased ICP until more definitive treatment measures can be undertaken (Robertson, 2004).

Neuromuscular Disease

- Respiratory muscle weakness associated with neuromuscular disorders (e.g., Duchenne muscular dystrophy, Friedreich ataxia, spinal muscular atrophy) can affect breathing. Respiratory failure can result from chronic respiratory muscle weakness, altered control of breathing, and pneumonia.
- Physical examination findings in the patient who has a chronic neuromuscular disease may include bilateral limited chest expansion, chaotic breathing patterns, diminished breath sounds, increased work of breathing, ineffective cough, and ineffective clearing of secretions.
- Respiratory muscle weakness and resulting respiratory failure may necessitate noninvasive or invasive ventilatory support.

Acute Poisoning or Drug Overdose

- Respiratory distress or failure may occur because of central respiratory depression or respiratory muscle weakness that is associated with a toxicologic emergency (e.g., intentional overdose, unintentional poisoning, envenomation, environmental exposure) (**Figure 2-14**).

Figure 2-14 Young children are curious by nature and are unable to distinguish between toxic and nontoxic substances.

- When performing a physical examination on a patient with a known or suspected toxic exposure, be vigilant in your search for information regarding the severity and cause of the exposure (**Box 2-7**).
- Changes in the patient's mental status, vital signs, skin temperature and moisture, and pupil size may provide a pattern of physical findings that are typical of a specific toxin. Characteristic findings that are useful in recognizing a specific class of poisoning are called **toxidromes** (see **Tables 2-11**, **2-12**). Your physical examination findings may provide the only clues to the presence of a toxin if the patient is unresponsive. Familiarity with

Box 2-7 Toxic Exposure History

In addition to the SAMPLE history, consider the following questions when obtaining a focused history for a patient with a toxic exposure. Critical questions to ask include what, when, where, why, and how.

- What is the poison? Determine the exact name of the product, if possible.
- How was it taken (i.e., ingested, inhaled, absorbed, or injected) and when?
- Where was the child found? How long was the child alone? Any witnesses? Any other children around?
- How much was taken?
- What is the child's age? Weight?
- Has the child vomited? How many times?
- Has a poison control center been contacted? If so, what instructions were received? What treatment has already been given?
- Why was it taken (e.g., depression, recent emotional stress)?

Table 2-11 Clinical Presentations of Specific Toxidromes

Anticholinergic	Signs/symptoms	Agitation or reduced responsiveness, tachypnea, tachycardia, slightly elevated temperature, blurred vision, dilated pupils, urinary retention, decreased bowel sounds; dry, flushed skin
	Typical agents	Atropine, diphenhydramine, scopolamine
Cholinergic	Signs/symptoms	Altered mental status, tachypnea, bronchospasm, bradycardia or tachycardia, salivation, constricted pupils, polyuria, defecation, emesis, fever, lacrimation, seizures, diaphoresis
	Typical agents	Organophosphate insecticides (malathion), carbamate insecticides (carbaryl), some mushrooms, nerve agents
Opioid	Signs/symptoms	Altered mental status, bradypnea or apnea, bradycardia, hypotension, pinpoint pupils, hypothermia
	Typical agents	Codeine, fentanyl, heroin, meperidine, methadone, morphine, oxycodone
Sedative/Hypnotic	Signs/symptoms	Slurred speech, confusion, hypotension, tachycardia, pupil dilation or constriction, dry mouth, respiratory depression, decreased temperature, delirium, hallucinations, coma, paresthesias, blurred vision, ataxia, nystagmus
	Typical agents	Ethanol, anticonvulsants, barbiturates, benzodiazepines
Sympathomimetic	Signs/symptoms	Agitation, tachypnea, tachycardia, hypertension, excessive speech and motor activity, tremor, dilated pupils, disorientation, insomnia, psychosis, fever, seizures, diaphoresis
	Typical agents	Albuterol, amphetamines, cocaine, epinephrine, ephedrine, methamphetamine, phencyclidine, pseudoephedrine

Table 2-12 Odors and Toxins

Odor	Toxin
Acetone	Acetone, isopropyl alcohol, salicylates
Alcohol	Ethanol, isopropyl alcohol
Bitter almonds	Cyanide
Carrots	Water hemlock
Fishy	Zinc or aluminum phosphide
Fruity	Isopropyl alcohol, chlorinated hydrocarbons (e.g., chloroform)
Garlic	Arsenic, organophosphates, DMSO, phosphorus, thallium
Glue	Toluene
Mothballs	Camphor
Pears	Chloral hydrate, paraldehyde
Rotten eggs	Sulfur dioxide, hydrogen sulfide
Shoe polish	Nitrobenzene
Vinyl	Ethchlorvynol
Wintergreen	Methyl salicylates

common toxidromes will enable you to recognize the diagnostic significance of your history and physical examination findings and to implement an appropriate treatment plan. It is important to note that a patient may not present with all of the signs and symptoms associated with a single toxidrome, and it may be impossible to identify a specific toxidrome when multiple substances are involved.

- Many toxins can produce changes in the patient's blood pressure, heart rate, ventilatory rate, and temperature (**Table 2-13**). Frequent reassessment to note any trends or changes in the patient's condition is important.
- Consult with a medical toxicologist or poison control center as needed for specific treatment to prevent further absorption of the toxin or to provide antidotal therapy.

Emergency Care

Management of the patient with disordered ventilatory control is dependent on the cause.

- Perform an initial assessment and obtain a focused history. Stabilize the cervical spine when indicated.
- Continually assess and reassess the child's level of responsiveness, pupillary reaction, and vital signs. Closely monitor for signs and symptoms of impending respiratory failure and abnormal breathing patterns.
- Apply a pulse oximeter and ECG monitor. Administer supplemental oxygen as indicated. The patient may require noninvasive ventilatory support or intubation with mechanical ventilation.
- Consider hypoglycemia in an unresponsive or seizing patient. Assess the child's serum glucose level and administer glucose if indicated.
- Obtain vascular access for hydration or medication administration if necessary. If the child is hypotensive, give a 20 mL/kg fluid bolus of an isotonic crystalloid solution (e.g., normal saline or lactated Ringer's solution). Assess the child's response after each fluid bolus. Closely monitor for increased work of breathing and the development of crackles.
- Administer hypertonic saline, osmotic agents (e.g., mannitol), or both, if required, to reduce intracranial pressure.
- In cases of poisoning or drug overdose, consult with a poison control center as needed for specific treatment to prevent further absorption of the toxin (or antidotal therapy).

Table 2-13 Toxins and Vital Sign Changes

Vital Sign	Increased	Decreased
Temperature	Amphetamines, anticholinergics, antihistamines, antipsychotic agents, cocaine, monoamine oxidase inhibitors, nicotine, phenothiazines, salicylates, sympathomimetics, theophylline, tricyclic antidepressants, serotonin reuptake inhibitors	Barbiturates, carbon monoxide, clonidine, ethanol, insulin, opiates, oral hypoglycemic agents, phenothiazines, sedative/hypnotics
Pulse	Amphetamines, anticholinergics, antihistamines, cocaine, phencyclidine, sympathomimetics, theophylline	Alcohol, beta-blockers, calcium channel blockers, carbamates, clonidine, digoxin, opiates, organophosphates
Ventilations	Amphetamines, barbiturates (early), caffeine, cocaine, ethylene glycol, methanol, salicylates	Alcohols and ethanol, barbiturates (late), clonidine, opiates, sedative/hypnotics
Blood Pressure	Amphetamines, anticholinergics, antihistamines, caffeine, clonidine, cocaine, marijuana, phencyclidine, sympathomimetics, theophylline	Antihypertensives, barbiturates, beta-blockers, calcium channel blockers, clonidine, cyanide, opiates, phenothiazines, sedative/hypnotics tricyclic antidepressants (late)

PUTTING IT ALL TOGETHER

The chapter quiz and case studies presented on the following pages are provided to help you integrate the information presented in this chapter.

Chapter Quiz

True/False

Indicate whether the statement is true or false.

____ 1. When administered to a child experiencing a respiratory emergency, corticosteroids may be ordered to alter the consistency of mucus.

____ 2. Before administering inhaled medications, listen to breath sounds to establish a baseline and for comparison with later observations.

____ 3. The child with severe signs and symptoms of asthma talks in phrases, prefers sitting, is usually agitated, commonly uses accessory muscles, and has an increased ventilatory rate.

____ 4. Drowsiness, dyspnea, and dry cough are classic findings associated with acute epiglottitis.

____ 5. Control of breathing may be disrupted in a patient with increased intracranial pressure.

____ 6. Bronchiolitis is most commonly caused by *haemophilus influenzae* type b.

Multiple Choice

Identify the choice that best completes the statement or answers the question.

____ 7. Which of the following statements is true?

a. The tongue is proportionally smaller in children than in adults.
b. A slow ventilatory rate is an early sign of impending respiratory distress.
c. Grunting during exhalation is a common but insignificant finding in children.
d. A young infant is primarily a nose breather and may not open his or her mouth to breathe if the nose is obstructed.

____ 8. Absent chest wall motion, limp muscle tone, and mottling are all signs of which respiratory emergency?

a. Bronchiolitis
b. Respiratory arrest
c. Respiratory failure
d. Respiratory distress

Matching

Match each description with the appropriate term.

a. Cystic fibrosis
b. Respiratory syncytial virus
c. Anaphylaxis
d. Pneumonia
e. Epiglottitis
f. Bronchopulmonary dysplasia
g. Croup
h. Cardiogenic pulmonary edema

____ 9. A disease that occurs in infants who have required mechanical ventilation, oxygen under pressure, or both for prolonged periods

____ 10. An emergency that typically results from a severe allergic reaction and usually occurs within minutes of the exposure

____ 11. Respiratory distress that is most commonly caused by left-sided heart failure

____ 12. An inherited disease caused by a gene mutation that leads to abnormal sodium and chloride transport across the epithelium

____ 13. A highly contagious disease that is transmitted through direct contact with respiratory secretions and that primarily affects children younger than 5 years

____ 14. An acute bacterial infection of the upper airway that typically affects children between 2 and 7 years of age

____ 15. An inflammation and infection of the lower airway and lungs caused by a viral, bacterial, parasitic, or fungal organism

____ 16. A respiratory disease caused by a virus that primarily affects the upper airway, most commonly the subglottic area, of children between 6 months and 6 years of age

Chapter Quiz Answers

True/False

1. F. Corticosteroids may be used to reduce airway swelling and inflammation. Mucolytics alter the consistency of mucus, making it more fluid and easier to expectorate.

OBJ: Describe the general approach to the treatment of children with upper or lower airway obstruction.

2. T. Listen to breath sounds before and after administration of inhaled medications to assess the child's response to treatment.

OBJ: Describe the general approach to the treatment of children with upper or lower airway obstruction.

3. F. The severity of asthma exacerbations can be categorized as mild, moderate, or severe. The category of exacerbation is used to determine the treatment administered. The child with mild signs and symptoms talks in sentences, may be agitated but is able to lie down, has dyspnea with activity (e.g., walking), has an increased ventilatory rate, and has moderate end-expiratory wheezing. The child with moderate signs and symptoms talks in phrases, prefers sitting, is usually agitated, commonly uses accessory muscles, and has an increased ventilatory rate. The child with severe signs and symptoms is usually breathless at rest and talks in words rather than phrases or sentences, often sits upright and may be hunched forward, is usually agitated, usually uses accessory muscles, and has an increased ventilatory rate.

OBJ: Describe the pathophysiology, assessment findings, and treatment plan for the child experiencing asthma or bronchiolitis.

4. F. Drooling, dysphagia (difficulty swallowing), and distress (the "three D's") are considered the classic clinical findings of acute epiglottitis.

OBJ: Describe the pathophysiology, assessment findings, and treatment plan for the child experiencing croup, epiglottitis, foreign body aspiration, and anaphylaxis.

5. T. Increased intracranial pressure, neuromuscular disease, and acute poisoning or drug overdose are examples of conditions that may disrupt control of ventilation.

OBJ: Describe the pathophysiology, assessment findings, and treatment plan for the child who has lung tissue disease or disordered ventilatory control.

6. F. Bronchiolitis is most commonly caused by respiratory syncytial virus (RSV). *Haemophilus influenzae* type b (Hib) was once the most commonly identified cause of acute epiglottitis in the United States; however, because of the widespread use of the Hib vaccine since 1988, the incidence of epiglottitis caused by Hib in pediatric patients has been significantly reduced.

OBJ: Describe the pathophysiology, assessment findings, and treatment plan for the child experiencing asthma or bronchiolitis.

Multiple Choice

7. D. The tongue is proportionately larger in children and infants than in adults. A slow ventilatory rate is a *late* and worrying sign of distress. Infants and children compensate for distress much longer than do adults, but when they crash, they crash fast. Do not wait for measurable signs of injury or illness before starting treatment. Grunting with each exhalation is a significant sign of possible respiratory collapse. If grunting is present and breathing is adequate, provide supplemental oxygen and often reassess the child. If breathing is inadequate, assist ventilations with a bag-mask device and supplemental oxygen. Young infants are obligate nose breathers who depend on open nasal passages for breathing. If the nasal passages are obstructed, these infants may not "think" to breathe through their mouths.

OBJ: Identify key anatomic and physiologic differences between children and adults and discuss their implications in the patient with a respiratory illness.

8. B. Respiratory arrest is the absence of breathing. Signs and symptoms of respiratory arrest include the following:

   - Absent chest wall motion
   - Absent ventilations
   - Bradycardia deteriorating to asystole
   - Limp muscle tone
   - Mottling; peripheral and central cyanosis
   - Unresponsiveness to voice or touch
   - Weak to absent pulse

OBJ: Differentiate among respiratory distress, respiratory failure, and respiratory arrest.

Matching

9. F
10. C
11. H
12. A
13. B
14. E
15. D
16. G

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CHAPTER 3

Procedures for Managing Respiratory Emergencies

Learning Objectives

After completing this chapter, you should be able to:

1. Describe the methods used for opening the airway and discuss the preferred method of opening the airway in cases of suspected cervical spine injury.
2. Describe suctioning, including its indications, correct technique, and possible complications associated with this procedure.
3. Describe the method of correct sizing, insertion technique, and possible complications associated with the use of the oropharyngeal airway and nasopharyngeal airway.
4. Discuss oxygen delivery systems used for infants and children.
5. Discuss the blow-by technique for administering oxygen.
6. Discuss positive-pressure ventilation using a bag-mask device and troubleshooting ineffective bag-mask ventilation.
7. Describe types of advanced airways and methods used to confirm their correct placement.
8. Discuss the DOPE mnemonic with regard to the intubated patient.
9. Describe the delivery of inhaled medications by means of a small-volume nebulizer and by a metered-dose inhaler.
10. Given a patient situation, and working in a team setting, competently direct the initial emergency care for a patient experiencing a respiratory emergency.

After completing this chapter, and with supervised practice during a Pediatric Advanced Life Support (PALS) course, you will be skilled at the following:

- Ensuring scene safety and the use of personal protective equipment.
- Assigning team member roles or performing as a team member in a simulated patient situation.
- Directing or performing an initial patient assessment.
- Obtaining vital signs, establishing vascular access, attaching a pulse oximeter and blood pressure and cardiac monitor, and giving supplemental O_2 if indicated.
- Recognizing the clinical signs of upper airway obstruction, lower airway obstruction, lung tissue disease, and disordered ventilatory control.
- Determining if a patient is demonstrating signs and symptoms consistent with respiratory distress, respiratory failure, or respiratory arrest.
- Implementing a treatment plan based on the type and severity of the patient's respiratory emergency.
- Using manual methods for opening the airway.
- Oral airway and endotracheal tube suctioning.
- Sizing and inserting an oral airway and a nasal airway.
- Assisting ventilations with a bag-mask device when indicated.
- Demonstrating how to confirm the position of an advanced airway using assessment techniques and an exhaled CO_2 detector.
- Securing an endotracheal tube.
- Troubleshooting sudden deterioration in the intubated patient using the DOPE mnemonic.
- Demonstrating knowledge of the indications, dosages, and effects of the medications used when managing respiratory emergencies.
- Recognizing when it is best to seek expert consultation.
- Reviewing your performance as a team leader or team member during a postevent debriefing.

ASSESSMENT EVIDENCE

Performance Tasks

During the PALS course, you will be functioning as the team leader of the Rapid Response Team or Code Team within your organization. Your classmates are similarly trained members of the team who will assist you. Your task is to direct, without prompting, the emergency care efforts of your team according to current resuscitation guidelines.

Key Criteria

Assessment of your ability to manage a patient who is experiencing a respiratory emergency and your ability to manage the team who will assist you in providing patient care is part of the PALS course. An evaluation checklist that reflects key steps and interventions in the patient management process will be used to assess your performance (see **Checklists 3-1** through **3-4**). The appropriate box is checked by a PALS instructor as you complete each step during your management of the patient.

Learning Plan

- Read this chapter before your PALS course.
- Complete the chapter quiz and review the answers provided.
- Complete the case studies at the end of the chapter. Read the scenario and answer each question that follows it. The questions are intended to reinforce important points pertinent to the case that are discussed in this text. Compare your answers with the answers provided at the end of the case study and with the checklist pertinent to the case study.

INTRODUCTION

Management of a respiratory emergency may require procedures such as opening the airway, suctioning, inserting an airway adjunct, administering supplemental oxygen, performing bag-mask ventilation, inserting an advanced airway, or administering inhaled medications by nebulizer or metered-dose inhaler.

OPENING THE AIRWAY

The tongue is a common cause of airway obstruction in the unresponsive patient. When the unresponsive patient is supine and the soft tissues of the throat and the base of the tongue relax because of a loss of muscle tone, the tongue can fall into the back of the throat and block the airway. If the patient is breathing, snoring respirations are a characteristic sign of airway obstruction caused by tongue displacement. In the apneic patient, an airway obstruction caused by the tongue may go undetected until ventilation is attempted. Because the tongue is attached to the mandible, moving the patient's jaw forward lifts the tongue away from the back of the throat. Thus, manual airway maneuvers such as the head tilt–chin lift or jaw thrust may be all that is needed to open the airway.

Head Tilt–Chin Lift

The head tilt–chin lift is the preferred technique for opening the airway of an unresponsive patient without suspected cervical spine injury (**Table 3-1**). To perform the head tilt–chin lift, place the patient in a supine position. Place the hand closest to the child's head on the patient's forehead (**Figure 3-1**). Apply firm backward pressure with your palm to tilt the patient's head gently back into a neutral or slightly extended position. Place the tips of the fingers of your other hand under the *bony* part of the patient's chin. Gently lift the chin anteriorly (i.e., toward the ceiling) to open the airway.

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Hyperextension of the patient's neck or compression of the soft tissue under the patient's chin can obstruct the airway.

Table 3-1 Manual Airway Maneuvers

	Head Tilt–Chin Lift	Jaw Thrust without Neck Extension
Indications	• Unresponsive patient who does not have a mechanism for cervical spine injury • Unresponsive patient who is unable to protect his or her own airway	• Unresponsive patient with possible cervical spine injury • Unresponsive patient who is unable to protect his or her own airway
Advantages	• Simple procedure • Noninvasive • Requires no special equipment	• Noninvasive • Requires no special equipment • May be used with cervical collar in place
Disadvantages	• Head tilt hazardous to patients with cervical spine injury • Neck hyperextension can cause an airway obstruction • Does not protect the lower airway from aspiration	• Difficult to maintain • Requires second rescuer for bag-mask ventilation • Does not protect the lower airway against aspiration

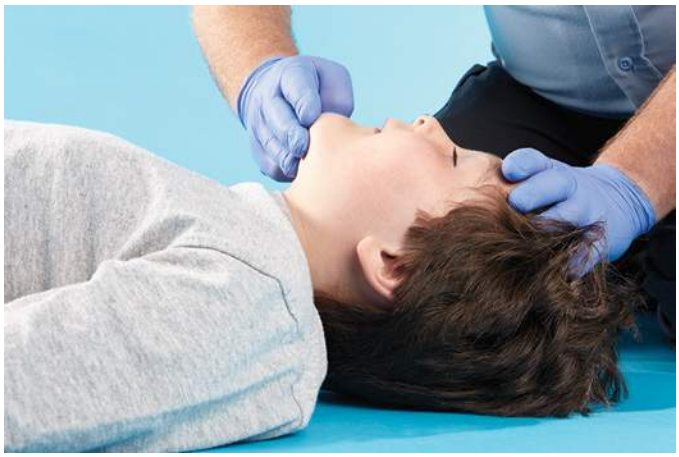

Figure 3-1 Head tilt–chin lift.

Jaw Thrust

The manual maneuver recommended for opening the airway of a patient with suspected cervical spine injury is the jaw thrust *without neck extension* maneuver. To perform this maneuver, place the patient in a supine position. While stabilizing the patient's head in a neutral position, grasp the angles of the patient's lower jaw with the tips of the middle or index fingers of both hands, one on each side, and lift, displacing the mandible upward and outward (**Figure 3-2**). The combination of a head tilt, forward displacement of the jaw, and opening of the mouth is called the *triple airway maneuver*, or *jaw thrust maneuver.*

SUCTIONING

- Suctioning is a procedure used to remove secretions from the patient's nose (nasopharynx), mouth (oropharynx), or trachea. Suctioning is indicated when there are signs of secretions in the airway such as a moist cough, bubbling of mucus, drooling, noisy breathing, or when visible secretions are present (e.g., saliva, blood, vomitus, mucus).

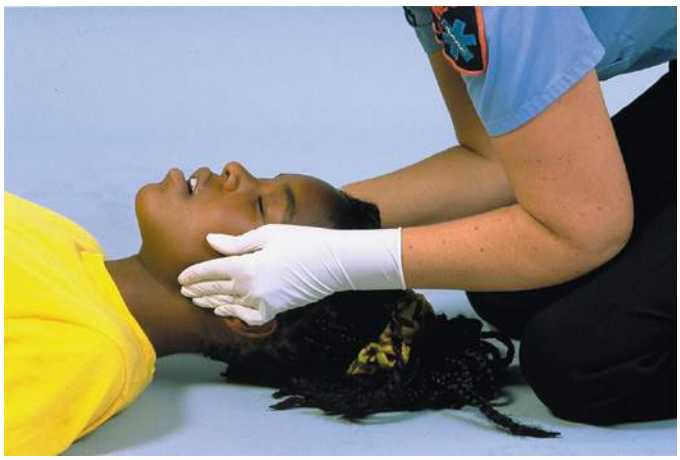

Figure 3-2 Jaw thrust without neck extension maneuver.

Box 3-1 Possible Complications of Suctioning

Agitation
Bronchospasm
Cardiac dysrhythmias
Gagging
Hypertension or hypotension
Hypoxia
Increased intracranial pressure
Increased respiratory distress
Local edema
Hemorrhage
Hypertension
Soft tissue injury
Vagal stimulation resulting in bradycardia
Vomiting

- Preoxygenate the patient before suctioning. Monitor the child's color, vital signs, and oxygen saturation before, during, and after the procedure. Bradycardia may result from stimulation of the posterior pharynx, larynx, or trachea. If bradycardia occurs or the child's condition worsens, interrupt suctioning and ventilate with supplemental oxygen until the child's heart rate returns to normal. Possible complications of suctioning are shown in **Box 3-1**.

Bulb Syringe

- A bulb syringe, also called a *nasal aspirator*, is most often used to remove secretions from the nose and mouth of newborns and infants (**Figure 3-3**).

Figure 3-3 Bulb syringe.

- To use a bulb syringe, depress the rounded end of the bulb to remove air from the device. Place the tip of the syringe snugly into one side of the nose (or mouth). Release the bulb slowly; the bulb will operate as a vacuum to remove the secretions from the nose or mouth. When the bulb is reinflated, remove the syringe and empty the contents.

Soft Suction Catheter

- A soft suction catheter is a long, narrow, flexible piece of plastic used to clear thin secretions from the oropharynx, nasopharynx, or trachea. A side opening is present at the proximal end of most catheters that is covered with the thumb to produce suction (**Figure 3-4**). (In some cases, suctioning is initiated when a button is pushed on the suction device itself.) A soft suction catheter can be inserted into the nares or mouth, through an oral airway or nasal airway, or through an endotracheal (ET) tube or tracheostomy tube.
- Before using a soft suction catheter, ensure that the suction device is powered on and that mechanical suction is present. When preparing to suction through an ET tube or tracheostomy tube, select a suction catheter with a diameter that is about one half that of the tube. This helps to ensure that the ET or tracheostomy tube is not blocked or dislodged during the procedure. To determine the proper flexible catheter insertion depth for nasopharyngeal suctioning, a rule of thumb is to measure from the tip of the nose or corner of the mouth to the bottom of the earlobe or angle of the mandible. Note this distance on the catheter. This distance is typically 2 to 3 inches (4 to 8 cm) in infants and young children and 3 to 5 inches (8 to 12 cm) in older children.
- Gently insert the catheter without applying suction. To apply suction, cover the port on the catheter with your nondominant thumb while withdrawing the catheter. Rotate the catheter between your dominant thumb and forefinger as it is withdrawn. While suctioning an ET tube or tracheostomy tube, rotating the catheter as it is withdrawn allows the removal of secretions on all sides of the tube. Ventilate the patient with supplemental oxygen before repeating the procedure.

Rigid Suction Catheter

- Rigid suction catheters, also called "tonsil tip" suction catheters, are made of hard plastic angled to aid in the removal of thick secretions and particulate matter from the oropharynx (**Figure 3-5**). A rigid suction catheter typically has one large and several small holes at the distal end through which blood and secretions may be suctioned.
- Ensure that the suction device is powered on and that mechanical suction is present. Without applying suction, gently place the tip of the catheter in the child's mouth along one side until it reaches the posterior pharynx. Slowly withdraw the catheter while applying suction, sweeping from side to side across the oropharynx to clear the airway. Ventilate the patient with supplemental oxygen before repeating the procedure.

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Insertion of a suction catheter and routine suctioning should take no longer than 10 seconds per attempt. When suctioning to remove material that completely obstructs the airway, more time may be necessary.

AIRWAY ADJUNCTS

Oropharyngeal and nasopharyngeal airways are adjuncts used to maintain an open airway by keeping the tongue away from the posterior pharynx. An oropharyngeal airway is inserted into the mouth and a nasopharyngeal airway is inserted into a nostril. Airway adjuncts are devices used to help keep a patient's airway open. When using an airway adjunct, the patient's airway must first be opened by using one of the manual airway maneuvers previously described. After the patient's airway is open, insert the airway adjunct and maintain proper head position while the device is in place.

Figure 3-4 Soft suction catheter.

Figure 3-5 Rigid suction catheter.

Oropharyngeal Airway

- An oropharyngeal airway (OPA), also called an *oral airway*, is a curved plastic tube. The body of the device curves over the unresponsive patient's tongue, holding it away from the back of throat. Because insertion may stimulate vomiting, an oral airway is not used in responsive or semi-responsive patients with a gag reflex.
- When correctly positioned, the flange (or outer flat surface) of the oral airway rests on the patient's lips and the distal tip lies between the base of the tongue and the back of the throat, preventing the tongue from blocking the airway. Air passes around and through the device. Because an oral airway does not isolate the trachea, it does not protect the lower airway from aspiration.
- Oral airways are available in many sizes that vary in length and internal diameter (ID) (**Figure 3-6**). The size of the airway is based on the distance in millimeters from the flange to the distal tip. Proper airway size is determined by holding the device against the side of the patient's face and selecting an airway that extends from the corner of the mouth to the angle of the lower jaw or to the earlobe (**Figure 3-7**). Selecting an airway of proper size is important because insertion of an improperly sized device can compromise the airway. If the airway is too long, it may press the epiglottis against the laryngeal opening, resulting in complete airway obstruction. If the airway is too short, the device will not bypass the tongue and the obstruction by the tongue will not be relieved (Shilling & Durbin, Jr, 2010) or the tongue may be pushed back into the throat, causing an airway obstruction.
- Before inserting an oral airway, use personal protective equipment, open the airway, and ensure that the mouth and pharynx are clear of secretions. After selecting an airway of proper size, open the patient's mouth and gently insert the airway with the curve downward and the tip following the base of the tongue. Place the airway over the tongue and down into the mouth until the flange of the airway rests against the patient's lips (**Table 3-2**). A tongue blade may be used to depress the tongue while inserting the airway to aid in placement.
- If the patient begins to gag or choke during or after insertion of an oral airway, remove it and suction the airway if necessary. Proper positioning of the patient's head must be maintained after an airway adjunct is in place to ensure an open airway.

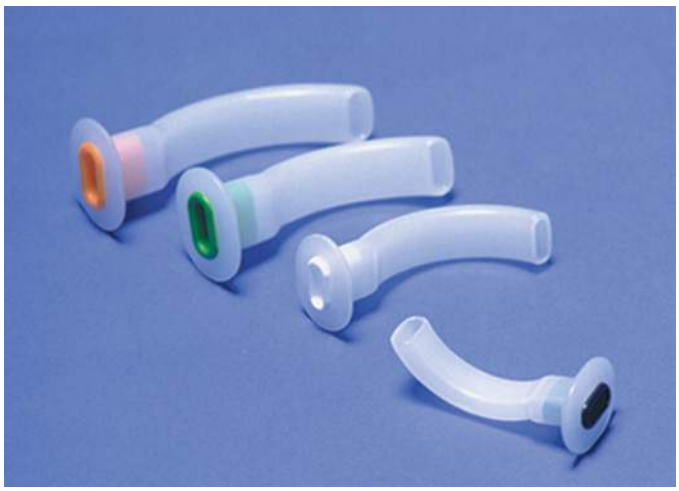

Figure 3-6 Oral airways are available in many sizes.

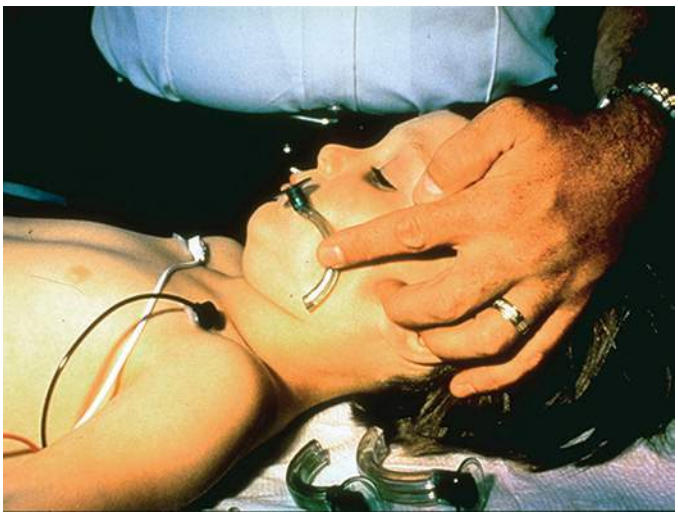

Figure 3-7 Sizing an oropharyngeal airway.

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While ventilating a patient with a bag-mask device, be vigilant about observing the position of the oral airway in the patient's mouth. An important sign that the airway adjunct is displaced is seeing the distance between the flange of the airway and the patient's lips increase as it advances out of the mouth during ventilatory efforts. Removing and replacing the device may be necessary.

Nasopharyngeal Airway

- A nasopharyngeal airway (NPA), also called a *nasal trumpet* or *nasal airway*, is a soft rubber, latex, or polyethylene tube designed to keep the tongue away from the back of the throat. Place the device in one nostril and advance until the bevel-shaped distal tip lies in the posterior pharynx just below the base of the tongue and above the epiglottis, while the proximal tip rests at the external nasal opening. The use of a nasal airway does not protect the patient's lower airway from aspiration and it does not eliminate the need for maintaining proper head position.
- Nasal airways are available in many sizes that vary in length and ID. Proper airway size is determined by holding the device against the side of the patient's face and selecting an airway that extends from the tip of the nose to the earlobe (**Figure 3-8**). A nasal airway that is too long may stimulate the gag reflex or enter

Table 3-2 Airway Adjuncts

	Oropharyngeal Airway	Nasopharyngeal Airway
Indications	• To aid in maintaining an open airway in an unresponsive patient who is not intubated • To aid in maintaining an open airway in an unresponsive patient with no gag reflex who is being ventilated with a bag-mask or other positive-pressure device • May be used as a bite block after insertion of an endotracheal tube or orogastric tube	• To aid in maintaining an open airway when use of an oral airway is contraindicated or impossible (e.g., jaw fractures, clenched jaws or teeth, soft tissue trauma to the tongue) • May be useful in patients who require frequent suctioning (decreases tissue trauma, bleeding)
Contraindications	• Patient with an intact gag reflex • Jaw fractures • Significant soft tissue injury to the tongue or pharynx	• Patient intolerance • Nasal obstruction • History of nasal facial surgery • Significant mid-face trauma • Presence of cerebrospinal fluid drainage from the nose • Moderate to severe head trauma • Known or suspected basilar skull fracture • Suspected foreign body aspiration
Advantages	• Positions the tongue away from the back of the throat • Enables suctioning of the pharynx • Can be inserted quickly	• Reasonably well tolerated in the patient with an intact gag reflex • Does not require the mouth to be open • Can be inserted quickly
Disadvantages	• Improper insertion technique may result in damage to the teeth, soft tissue injury to the mouth, or both • Does not protect the lower airway from aspiration • May induce vomiting if used in a patient with a gag reflex • Can easily be dislodged	• Improper insertion technique may result in severe epistaxis or adenoid bleeding that may be difficult to control • Does not protect the lower airway from aspiration • Difficult to suction through
Sizing	Select an airway that extends from the corner of the mouth to the angle of the lower jaw or to the earlobe	Select an airway that extends from the tip of the nose to the earlobe

the esophagus, causing gastric distention and hypoventilation when ventilating with a bag-mask device. A nasal airway that is too short will not extend past the tongue, thus it will not keep the tongue away from the posterior pharynx.

- Before inserting a nasal airway, use personal protective equipment and open the airway. The nasal cavity is delicate and vascular. During insertion, do not force the airway because it may cause abrasions or lacerations of the nasal mucosa and result in significant bleeding, increasing the risk of aspiration. After selecting a nasal airway of the proper size, liberally lubricate its distal tip with a water-soluble lubricant to minimize resistance and decrease irritation to the nasal passage.
- Hold the device at its flange end like a pencil and slowly insert it into the patient's nostril with the bevel pointing toward the nasal septum. Because of its design, this is most easily accomplished by placing the nasal airway into the patient's right nostril. If the left nostril is selected, insert the nasal airway with the device turned upside down until the distal tip is past the nasal turbinates (National Association of Emergency Medical Technicians, 2011).
- Advance the airway along the floor of the nostril, following the natural curvature of the nasal passage, until the flange rests against the outside of the nostril. During insertion, do *not* direct the bevel of the airway upward. If resistance is encountered, a gentle back-and-forth rotation of the device between your fingers

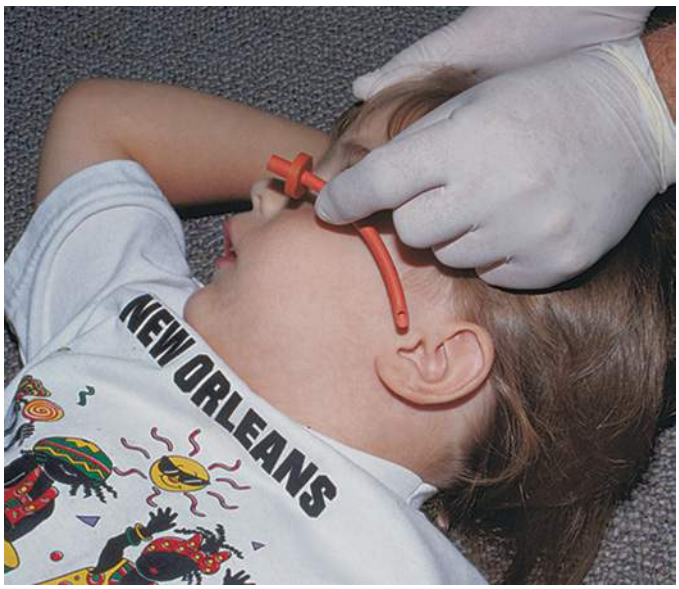

Figure 3-8 Sizing a nasopharyngeal airway.

may ease insertion. If resistance continues, withdraw the airway, reapply lubricant, and attempt insertion in the other nostril. If blanching of the nostril is present after insertion of a nasal airway, the diameter of the device is too large. Remove the airway, select a slightly smaller size, and reinsert. Be sure to maintain the patient's proper head position after insertion of the airway.

- Although most responsive and semi-responsive patients can tolerate a nasal airway, the gag reflex may be stimulated in sensitive patients, precipitating coughing, laryngospasm, or vomiting. Small diameter nasal airways can easily become obstructed with blood, mucus, or vomitus. Suctioning may be necessary to keep the nasal airway free of secretions.

OXYGEN DELIVERY SYSTEMS

- Oxygen therapy is referred to as the fraction of inspired gas that is oxygen (FiO_2).
- A low-flow oxygen delivery system such as a nasal cannula or simple face mask provides oxygen at a flow rate that is less than the patient's maximum inspiratory flow. The inspired oxygen is diluted with room air and the FiO_2 that enters the patient's airway is affected by the relationships among oxygen flow, the patient's inspiratory flow, and the patient's breathing pattern.
- A high-flow oxygen delivery system can provide a specific delivered oxygen concentration at flow rates that exceed the patient's inspiratory flow requirement so that the patient's breathing pattern and inspiratory flow do not affect the FiO_2.

Nasal Cannula

- A nasal cannula is a low-flow oxygen delivery device that is used for the infant or child who requires only low levels of supplemental oxygen. It consists of plastic tubing with two soft prongs that project from the tubing (**Figure 3-9**). The prongs are inserted into the patient's nares, and the tubing is secured to the patient's face. Oxygen flows from the cannula into the patient's nasopharynx, which acts as an anatomic reservoir (**Box 3-2**).
- The oxygen flow rate used with this device is 0.25 to 4 L/minute, which can deliver an oxygen concentration of 22% to 60% (American Heart Association, 2012).

Figure 3-9 Nasal cannula.

Simple Face Mask

- A simple face mask, also called a *standard mask*, is a low-flow oxygen delivery system that consists of a plastic reservoir designed to fit over the patient's nose and mouth. Small holes on each side of the mask allow for the passage of inspired and expired air (**Figure 3-10**). Supplemental oxygen is delivered

Box 3-2 Nasal Cannula

Advantages

Allows the patient to eat and drink

Does not interfere with patient assessment or impede patient communication with healthcare personnel

Does not require humidification

Easy to use

No rebreathing of expired air

Disadvantages

Can only be used in the spontaneously breathing patient

Drying of mucosa

Easily displaced

May irritate nose

May cause sinus pain

Nasal passages must be open

Figure 3-10 Simple face mask.

through a small diameter tube connected to the base of the mask. The mask is secured in position by means of an elastic strap around the back of the patient's head. The internal capacity of the mask produces a reservoir effect.

- The oxygen flow rate used with this device is 6 to 10 L/minute, which can deliver an oxygen concentration of 35% to 60% (American Heart Association, 2012). The patient's actual inspired oxygen concentration will vary because the amount of air that mixes with supplemental oxygen is dependent on the patient's inspiratory flow rate and breathing pattern (**Box 3-3**).

Box 3-3 Simple Face Mask

Advantages

Higher oxygen concentration delivered than by nasal cannula

Patient accessibility

Disadvantages

Can be uncomfortable

Can only be used with spontaneously breathing patients

Dangerous for the child with poor airway control and at risk for emesis

Difficult to hear the patient speaking when the device is in place

FiO_2 varies with inspiratory flow rate

Must be removed at meals

Not tolerated well by severely dyspneic patients (feeling of suffocation)

Requires a tight face seal to prevent leakage of oxygen

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When using a simple face mask, the oxygen flow rate must be at least 6 L/minute to flush the accumulation of the patient's exhaled carbon dioxide from the mask.

Nonrebreather Mask

- A nonrebreather mask, also called a *nonrebreathing mask*, is a high-flow oxygen delivery system that does not permit mixing of the patient's exhaled air with 100% oxygen (**Box 3-4**). A one-way valve between the mask and reservoir bag prevents the inhalation of room air. When the patient breathes in, oxygen is drawn into the mask from the reservoir (bag) through the one-way valve that separates the bag from the mask (**Figure 3-11**). When the patient breathes out, the exhaled air exits through an open side port on the mask. The one-way valve prevents the patient's exhaled air from returning to the reservoir bag (thus the name "nonrebreather"). This ensures a supply of 100% oxygen to the patient with minimal dilution from the entrainment of room air.
- A nonrebreather mask can deliver an inspired oxygen concentration of up to 95% at a flow rate of 10 to 15 L/minute (American Heart Association, 2012). When applying a nonrebreather mask,

Box 3-4 Nonrebreather Mask

Advantages

Higher oxygen concentration delivered than by nasal cannula and simple face mask

Disadvantages

Same as for simple mask

EMSC Slide Set (CD-ROM). 1996. Courtesy of the Emergency Medical Services for Children Program, administered by the U.S. Department of Health and Human Service's Health Resources and Services Administration, Maternal and Child Health Bureau.

Figure 3-11 Nonrebreather mask.

be sure to fill the reservoir bag with oxygen before placing the mask on the patient. After placing the mask on the patient, adjust the flow rate so the bag does not completely deflate when the patient inhales.

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When using a nonrebreather mask, ensure that the bag does not collapse when the child inhales. Should the bag collapse, increase the oxygen flow rate in small increments until the bag remains inflated. The reservoir bag must remain at least two-thirds full so that sufficient supplemental oxygen is available for each breath.

Blow-by Oxygen Delivery

Because an infant or child may become agitated with the use of an oxygen mask, use of the blow-by method of oxygen delivery may be necessary (**Figure 3-12**). Ask the child or the child's caregiver to hold oxygen tubing or an oxygen mask with a flow rate of at least 10 L/minute close to the child's nose and mouth. Alternately, consider attaching the oxygen tubing to a toy and encouraging the child to hold the toy near the face; or try placing the tubing in a paper cup, then asking the child to "drink from the cup."

BAG-MASK VENTILATION

- If the patient's ventilatory efforts are inadequate, breathing may be assisted by forcing air into the lungs (i.e., delivering positive-pressure ventilation). Bag-mask ventilation (BMV) is one of several methods that may be used to deliver positive-pressure ventilation.
- A bag-mask device consists of a self-inflating bag, an oxygen inlet, a one-way valve that prevents the patient's exhaled air from entering the bag, an adapter that can be attached to a mask or to an advanced airway, and a see-through mask equipped with an air-filled cuff that is attached to the bag (**Figure 3-13**). A bag-mask device may also be referred to as a *bag-valve-mask device* or *bag-mask resuscitator* (when the mask is used), or a *bag device* (when the mask is not used, i.e., when ventilating a patient with an advanced airway in place).
- A bag-mask used for resuscitation should have either no pop-off (pressure-release) valve or a pop-off valve that can be disabled during resuscitation. Pop-off valves were originally added to pediatric devices to guard against pulmonary hyperinflation and barotrauma. However, some situations require higher ventilatory pressure, such as drowning, CPR, pulmonary edema, or asthma. To effectively ventilate a patient in these situations, the needed ventilatory pressure may exceed the limits of the pop-off valve. Thus, a pop-off valve may prevent generation of sufficient tidal volume to overcome the increase in airway resistance. Disabling the pop-off valve, or using a bag-mask with no pop-off valve, helps to ensure delivery of adequate tidal volumes to the patient during resuscitation. Follow the manufacturer's directions with regard to disabling pop-off valves.
- Bag-mask devices are available in various sizes. It is important to select a device with sufficient volume for the patient's size. Use a pediatric bag (at least 450 to 500 mL) for infants and young children (Atkins et al., 2015) (**Figure 3-14**). When ventilating older children and adolescents, an adult bag (1,000 mL or more) may be needed to achieve chest rise (Atkins et al., 2015). A child can be ventilated with a larger bag as long as proper technique is used: squeeze the bag *just* until the chest begins to rise, and then release the bag.
- A bag-mask device used without supplemental oxygen will deliver 21% oxygen (room air) to the patient. A bag-mask should be connected to an oxygen source. Attach one end of a piece of oxygen-connecting tubing to the oxygen inlet on the bag-mask and the other end to an oxygen regulator. The oxygen flow rate should be 10 to 15 L/minute when using a pediatric bag and at least 15 L/minute when using an adult bag (American Heart

Figure 3-12 Blow-by oxygen delivery.

Figure 3-13 Bag-mask device.

Figure 3-14 Pediatric bag-mask device.

Association, 2012). A pediatric bag-mask device used with supplemental oxygen set at a flow rate of 10 L/minute will deliver about 30% to 80% oxygen to the patient (Atkins et al., 2015). An adult bag-mask device used with supplemental oxygen set at a flow rate of 15 L/minute will deliver approximately 40% to 60% oxygen to the patient.

- An oxygen-collecting device (i.e., a reservoir) should be attached to the bag-mask to deliver high-concentration oxygen. The reservoir collects a volume of 100% oxygen equal to the capacity of the bag. After squeezing the bag, the bag reinflates, drawing 100% oxygen from the reservoir into the bag. A pediatric bag-mask device used with supplemental oxygen (set at a flow rate of 10 to 15 L/minute) and an attached reservoir will deliver approximately 60% to 95% oxygen to the patient (Atkins et al., 2015). An adult bag-mask device used with supplemental oxygen (set at a flow rate of 15 L/minute) and an attached reservoir will deliver approximately 90% to 100% oxygen to the patient (**Box 3-5**).

Technique

- Using personal protective equipment, position yourself at the top of the supine patient's head. The patient should be connected to a pulse oximeter, capnometer, and cardiac monitor to ensure effective bag-mask ventilation.

Box 3-5 Bag-Mask Ventilation

Advantages

Can be used with the spontaneously breathing patient as well as the apneic patient

Conveys a sense of the compliance of the patient's lungs to the bag-mask operator

Provides a means for delivery of an oxygen-enriched mixture to the patient

Provides a means for immediate ventilatory support

Disadvantages

Gastric distention

Inability to deliver adequate ventilatory volumes

- Because of the relatively large occiput of infants and young toddlers, and if trauma to the cervical spine is not suspected, it may be necessary to place a thin layer of padding under the *shoulders* or *upper torso* to align the airway and optimize ventilation (**Figure 3-15**). In contrast, a child older than 2 years may require padding under the *occiput*.
- Select an appropriate bag for ventilation based on the patient's size. The bag should have an oxygen reservoir. Connect one end of the oxygen tubing to an oxygen source and the other end to an oxygen flow meter. Set the flow meter to the appropriate liter flow. Open the patient's airway using a head tilt–chin lift or, if trauma is suspected, use a jaw thrust without neck extension. If needed, clear the patient's airway of secretions or vomitus with suctioning. If the patient is unresponsive, insert an oral airway.
- Select a mask of appropriate size and place it on the patient's face.
  - A properly sized mask extends from the bridge of the patient's nose to the groove between his or her lower lip and chin. Use of an improperly sized mask allows air to leak from between the mask and the patient's face, resulting in less oxygen being delivered to the patient.
  - The transparent mask of a bag-mask device helps ensure that blood, vomit, or other secretions in the patient's mouth can easily be seen during bag-mask ventilation.
  - The mask on most bag-mask devices has an inflatable cushion that can be adjusted with the use of a syringe. Because too much air in the cushion will not allow a tight seal between the patient's face and the mask, assess the cushion's firmness before applying the mask to the patient's face. If indicated, inflate the cushion with air so that it is flexible enough to make a tight seal over the patient's mouth and nose—this limits the amount of room air that enters or oxygen that escapes from the mask.

EMSC Slide Set (CD-ROM). 1996. Courtesy of the Emergency Medical Services for Children Program, administered by the U.S. Department of Health and Human Service's Health Resources and Services Administration, Maternal and Child Health Bureau.

Figure 3-15 To optimize ventilation, padding under the shoulders or occiput may be necessary depending on the child's age.

- Position the narrow portion (apex) of the mask over the bridge of the patient's nose and the wide end (base) of the mask over the groove between the lower lip and chin (**Figure 3-16**). If the mask has a large, round cuff surrounding a ventilation port, center the port over the mouth. Avoid compressing the soft tissues of the face and neck, and ensure that the mask does not compress the eyes.

- Finger and hand placement for bag-mask ventilation is called the *E-C clamp*. Stabilize the mask in place with your thumb and index finger, creating a "C" around the ventilation port. With gentle pressure, push down on the mask to establish an adequate seal. Place your third, fourth, and fifth fingers along the bony portion of the patient's jaw, forming an "E." Use these fingers to lift the jaw and pull the patient's chin into the mask, creating a good mask seal (**Figure 3-17**). Connect the bag to the mask (if not already done) and ensure that the bag is connected to oxygen. Slowly squeeze the bag with your other hand (or with one hand and your arm or chest if necessary) so that each breath is delivered over about 1 second (Atkins et al., 2015). Saying "one-one thousand" to yourself while the bag is squeezed is a technique that can be used to estimate the delivery of one breath over a period of 1 second. Stop ventilation when you see a gentle chest rise. Ventilate at a rate of 1 breath every 3 to 5 seconds (12 to 20 breaths per minute) until spontaneous breathing resumes (Atkins et al., 2015).

- Bag-mask ventilation is optimally a two-rescuer operation: one to hold the mask to the face (ensuring a good mask to face seal) and maintain an open airway, the other to compress the bag with two hands. Ask an assistant to squeeze the bag with two hands until the patient's chest begins to rise while you press the mask firmly against the patient's face with both hands and simultaneously maintain proper head position. Release the bag as soon as chest rise is visible.

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Figure 3-16 Position the narrow portion of the mask over the bridge of the patient's nose, the wide end of the mask over the groove between the lower lip and chin, and center the ventilation port over the mouth.

© Chanawit/Dreamstime.com.

Figure 3-17 The E-C clamp is recommended for bag-mask ventilation.

- Assess the effectiveness of ventilation by doing the following:
  - Ensure the mask forms an airtight seal on the patient's face.
  - Evaluate lung compliance (resistance to ventilation).
  - Observe the rise and fall of the patient's chest with each ventilation.
  - Assess for an improvement in the patient's mental status, heart rate, color of the patient's skin or mucous membranes, and blood pressure.
  - Auscultate for bilateral breath sounds.

Troubleshooting

The most frequent problem with bag-mask ventilation is the inability to deliver adequate ventilatory volumes to patients who do not have an advanced airway in place. Inadequate tidal volume delivery may be the result of gastric distention, an improper mask seal, or incomplete bag compression.

- Excess air may enter the stomach during positive-pressure ventilation with a bag-mask device causing gastric distention and leading to vomiting and subsequent aspiration. If enough air builds up in the patient's stomach to push on the lungs and

diaphragm, effective breathing can be compromised. To reduce the risk of gastric distention while performing bag-mask ventilation, avoid using excessive force and volume. Only use enough volume to cause a gentle chest rise.

- A common problem when ventilating with a bag-mask device is tightly placing the mask on the face without performing an adequate maneuver to open the patient's airway. This results in an airway obstruction because of improper airway positioning. Readjust the patient's head position, ensure the mouth is open, and try again to ventilate.
- An inadequate mask seal may result in hypoxia or hypoventilation. If air is escaping from under the mask, reposition your fingers and the mask. If the leak persists, ask for assistance with the patient's airway and use the two-rescuer technique or consider using another mask.
- Incomplete bag compression can occur if the bag is large or the rescuer's hands are small and only one hand is used to squeeze the bag. If the patient's chest does not rise and fall during bag-mask ventilation, recheck the technique that is being used to squeeze the bag.
- Remember that higher than normal inspiratory pressures may be required for adequate ventilation in certain situations (e.g., drowning, asthma). Check to see if the bag-mask device has a pop-off valve. If a pop-off valve is present, disable the valve and attempt to ventilate again. Reevaluate the effectiveness of bag compression.

ADVANCED AIRWAYS

- Advanced airways may be categorized as *extraglottic airway devices* (formerly called *supraglottic airways*) and *intraglottic airway devices*. Endotracheal intubation is an example of an *intraglottic* airway procedure.
- Extraglottic airways are blindly inserted (i.e., they do not require visualization of the vocal cords) and rest between the base of the tongue and the glottis, permitting rapid oxygenation and ventilation. Examples of extraglottic airway devices available for pediatric use include the Air-Q (Cookgas, St. Louis, MO), i-Gel (Intersurgical LTD, Wokingham, Berkshire, UK), Laryngeal Mask Airway (LMA), and laryngeal tube (King LT-D, Kingsystems, Noblesville, IN). The Combitube is an extraglottic device that may be used for children who are at least 4 feet tall.
- Endotracheal intubation is an advanced airway procedure in which a tube is placed directly into the trachea. This procedure requires special training and frequent refresher training to maintain skill proficiency. Endotracheal intubation may be performed for a variety of reasons including for delivering anesthesia, maintaining oxygenation, providing positive-pressure ventilation, and protecting the patient's lower airway from aspiration (**Box 3-6**). Because extraglottic airways are relatively easy to insert, it is prudent to have them immediately available in case of a failed intubation attempt.

Box 3-6 Endotracheal Intubation

Advantages

Ensures delivery of a high concentration of oxygen

Ensures delivery of a selected tidal volume to maintain lung inflation

Isolates the airway

Keeps the airway patent

Permits suctioning of the lower airway

Provides a route for administration of some medications

Reduces the risk of aspiration of gastric contents

Disadvantages

Bypasses physiologic functions of upper airway (e.g., warming, filtering, humidifying of inhaled air)

Requires considerable training and experience

Requires direct visualization of vocal cords

Needs special equipment

- Before endotracheal intubation is performed, it is essential that all necessary equipment be available and functional (**Box 3-7**). The patient should be preoxygenated and attached to a pulse oximeter, blood pressure monitor, and cardiac monitor. Vascular access, either intravenous or intraosseous, should be established. Although a length-based resuscitation tape should be used to determine the correct endotracheal tube size, it is desirable to have several sizes of endotracheal tubes on hand. At a minimum, have endotracheal tubes (ETT) available that are 0.5 mm smaller and 0.5 mm larger than the estimated tube size. If a cuffed ETT is inserted, use a cuff pressure monitor and follow the manufacturer's recommendations.
- Length-based resuscitation tapes are more accurate than age-based formula estimates for determining the correct endotracheal tube size up to about 35 kg (de Caen et al., 2015). If an uncuffed tracheal tube is used for intubation, use of a 3.5-mm ID tube for infants up to 1 year of age and a 4-mm ID tube for patients between 1 and 2 years of age is considered reasonable (de Caen et al., 2015). After age 2, the following formula can be used to estimate uncuffed tracheal tube size: Uncuffed tracheal tube ID (mm) = 4 + (age in years/4) (de Caen et al., 2015).

PALS Pearl

Selection of an endotracheal tube of the correct size is important. An ETT that is too small may provide too little airflow and may lead to the delivery of inadequate tidal volumes. A tube that is too large may cause tracheal edema, vocal cord damage, or both.

Box 3-7 Endotracheal Intubation Equipment Checklist

- 3-, 5-, and 10-mL syringes for inflation of the tracheal tube cuff (if present)
- Adhesive tape or commercial tube-holder
- Bag-mask device of appropriate size with supplemental oxygen and a reservoir
- Blood pressure and cardiac monitors
- Cuffed and uncuffed endotracheal tubes of various sizes
- Curved and straight pediatric laryngoscope blades
- End-tidal CO_2 detector
- Esophageal detector device
- Extraglottic airway devices
- Oral airways of assorted sizes with tongue blades
- Oxygen source
- Padding for placement under the occiput, shoulders, or upper torso
- Pediatric ventilation face masks
- Pediatric laryngoscope
- Pediatric stylets
- Personal protective equipment
- Pulse oximeter
- Spare laryngoscope bulbs and batteries
- Suction equipment
- Surgical airway equipment
- Water-soluble lubricant

Confirming Proper Tube Placement

- After placement of an ETT, confirm proper positioning of the tube using *both* clinical assessments and an exhaled CO_2 device. Initially, the clinician performing the intubation can confirm placement of the ETT in the trachea by seeing the tube pass through the vocal cords.
- While providing positive-pressure ventilation with a bag device, auscultate for bilateral breath sounds over the chest and then confirm the absence of sounds over the stomach. After intubation, the presence of bubbling or gurgling sounds during auscultation of the stomach suggests that the tube is incorrectly positioned in the esophagus. To correct this problem, deflate the ETT cuff (if a cuffed tube was used), remove the tube, and oxygenate before reattempting intubation. Breath sounds may be heard over the stomach in infants but should not be louder than midaxillary sounds. If baseline breath sounds (i.e., breath sounds before intubation) were equal bilaterally, diminished breath sounds on the left side after intubation suggest that the ETT has entered the right primary bronchus. To correct this problem, deflate the ETT cuff (if a cuffed tube was used) and auscultate the left side of the chest while slowly withdrawing the tube until breath sounds are equal and chest expansion is symmetric, and then reinflate the ETT cuff.
- Use capnography to measure the concentration of CO_2 at the end of exhalation and confirm proper ETT placement. Waveform capnography is preferred.
  - Alternately, a colorimetric capnometer may be used when waveform capnography is not available (**Figure 3-18**). A colorimetric capnometer is placed between an ETT (or other advanced airway) and a ventilation device. The patient's breath causes a chemical reaction on pH-sensitive litmus paper housed in the detector. The paper color is initially purple and changes to yellow upon exposure to normal or high levels of CO_2. During bag-mask ventilation, color changes should be observed as CO_2 levels increase and decrease with each breath. A yellow color suggests placement of the ETT in the trachea, but may also be observed if the pH-sensitive paper is exposed to acidic stomach contents. A lack of CO_2 (no color change) suggests tube placement in the esophagus, particularly in patients with spontaneous circulation. Regardless of the CO_2 monitoring method used, and because CO_2 may inadvertently enter the stomach, wash out any retained CO_2 by ventilating the patient at least six times before obtaining a reading.
- An esophageal detector device (EDD) may be used as an aid in verifying correct placement of an ETT. Esophageal detector devices are inexpensive, easy-to-use, and may be used in children with a perfusing rhythm who weigh more than 20 kilograms. These devices operate under the principle that the esophagus is a collapsible tube and the trachea is a rigid one. The syringe-type EDD is connected to an ETT with the plunger fully inserted into the barrel of the syringe. If the ETT is in the trachea, the plunger can easily be withdrawn from the syringe barrel. If the ETT is in the esophagus, resistance will be felt as

Figure 3-18 Colorimetric capnometer.

PALS Pearl

False-positive results (CO_2 is detected despite tube placement in the esophagus) have been reported when large amounts of carbonated beverages were ingested before a cardiac arrest. False-negative results (lack of CO_2 detection despite tube placement in the trachea) may occur in cardiac arrest or in a patient who has a significant pulmonary embolus because of reduced blood flow and delivery of CO_2 to the lungs (Neumar et al., 2010). Colorimetric capnometers are susceptible to inaccurate results because of the age of the paper, exposure of the paper to the environment, patient secretions (such as vomitus), or acidic drugs such as tracheally administered epinephrine.

the plunger is withdrawn because the walls of the esophagus will collapse when negative pressure is applied to the syringe. The bulb-type EDD is compressed before it is connected to an ETT. A vacuum is created as the pressure on the bulb is released. If the ETT is in the trachea, the bulb will easily refill when pressure is released, indicating proper tube placement. If the ETT is in the esophagus, the bulb will remain collapsed, indicating improper tube placement.

- If an EDD is used to confirm placement of a cuffed ETT, do *not* inflate the cuff before using the esophageal detector. Inflating the cuff moves the distal end of the ETT away from the walls of the esophagus. If the tube was inadvertently inserted into the esophagus, this movement will cause the detector bulb to reexpand, falsely suggesting that the tube was in the trachea.
- After confirming proper position of the ETT, note the tube depth at the patient's teeth and then secure the tube in place using a commercial tube-holder or tape. The correct tube depth can be found on a length-based resuscitation tape. Alternately, the appropriate depth in centimeters can be estimated by multiplying the ETT size by three. For example, if a 3-mm ETT was inserted, the centimeter marking that should appear at the patient's lips is nine. Provide ventilatory support with supplemental oxygen. After securing the tube, reassess to ensure that the ETT is in the proper position. Reassess and document the tube depth at the patient's teeth. On chest radiography, the tip of the ETT should be positioned midway between the vocal cords and the carina.

PALS Pearl

Movement of the head and neck of an intubated infant or child can affect the placement of the endotracheal tube. Reassess and confirm the position of the tube:

- Immediately after ETT insertion
- Whenever the patient is moved or repositioned
- Whenever a procedure is performed (e.g., suctioning)
- When there is a change in the patient's clinical status
- During interhospital and intrahospital transport

DOPE

- The status of the patient's airway must immediately be reevaluated if sudden deterioration occurs in an intubated patient. Clinical signs of acute deterioration may include the following:
  - Asymmetric or decreased breath sounds
  - Asymmetric or decreased chest rise
  - Bradycardia
  - Decreased oxygen saturation
  - Decreased exhaled CO_2
  - Decreased lung compliance during bag-mask ventilation
  - Jugular venous distention
  - Tracheal deviation
- The DOPE mnemonic (**Box 3-8**) is a useful tool for recalling common causes of acute airway compromise in the intubated patient (American Heart Association, 2011). It is essential that equipment to perform suctioning and a bag-mask device be within arm's reach should complications occur.
- Observe the patient's chest rise, skin color, and heart rate while ventilating with a bag device. If poor skin color and bradycardia persist after intubation, consider these possible causes:
  - The ETT is too small, allowing air leaks
  - The ETT cuff (if used) is underinflated
  - The pop-off valve on the bag device is not disabled
  - The bag device operator is not delivering an adequate volume for each breath
  - A pneumothorax is present
  - The ETT is clogged or kinked
  - Esophageal intubation
  - Primary bronchus intubation
  - There is a leak (or other malfunction) in the bag device (mechanical failure)
  - Disconnected oxygen source (mechanical failure)
- If the patient is connected to a mechanical ventilator, you suspect a ventilator malfunction, and you cannot quickly find and correct the problem, take the following steps:
  - Disconnect the ventilator tubing from the ETT.

Box 3-8 DOPE

- **D**isplaced tube (e.g., right primary bronchus or esophageal intubation) or **D**isconnection of the tube or ventilator circuit—reassess tube position, ventilator connections
- **O**bstructed tube (e.g., kinked tube, blood or secretions are obstructing air flow)—suction, remove tube if obstruction cannot be cleared, and ventilate with bag-mask
- **P**neumothorax (e.g., tension pneumothorax)—needle thoracostomy
- **E**quipment malfunction (e.g., empty oxygen source, disconnected oxygen tubing, inadvertent change in ventilator settings, air leak around tube, pop-off valve activated, low battery)—check equipment and oxygen source

- Attach a bag-mask device to the tube and provide manual ventilation with supplemental oxygen. Watch for equal chest rise and listen for equal breath sounds.
- If the patient's chest rise is shallow, ensure that the bag-mask device is securely connected to the tube.
- If chest rise does not improve, assess the tube for obstruction. Quickly suction the tube to relieve the obstruction. If the obstruction cannot quickly be removed, it may be necessary to remove the ETT and provide bag-mask ventilation until reintubation can be performed by a healthcare professional who is skilled in airway management (Kline-Tilford, Sorce, Levin, & Anas, 2013).

NEBULIZER

- Inhaled medications such as bronchodilators, corticosteroids, and mucolytics may be administered by a small-volume nebulizer (SVN), also called a *nebulizer* or *handheld nebulizer*, or by a metered-dose inhaler (MDI). When a nebulizer is used, liquid medication is placed into a closed chamber consisting of a nebulizer reservoir (cup) and cap through which oxygen or compressed air flows, forming a fine mist. The patient inhales the mist using a face mask or handheld mouthpiece. A face mask may be required for children younger than 5 years who are unable to effectively seal their lips around the nebulizer's mouthpiece (**Figure 3-19**).

Figure 3-19 A small-volume nebulizer is used to administer inhaled medications directly to the respiratory tract.

- When using a nebulizer, begin by assembling the necessary equipment. Assess the patient's lung sounds, oxygen saturation, ventilatory rate, and heart rate to establish a baseline.
  - Remove the cap from the nebulizer cup, pour the medication into the cup, and then reattach the cap.
  - Attach a T-piece to the nebulizer cap. Connect a spacer to one end of the T-piece and the mouthpiece to the other end. Attach the nebulizer's oxygen tubing to an oxygen regulator and set the regulator at a flow rate of 5 to 6 L/minute.
  - While holding the nebulizer cup upright, place the mouthpiece in the child's mouth and instruct him or her to seal his or her lips around it. Tell the child to breathe slowly in and out through the nebulizer's mouthpiece. Alternately, a face mask may be used instead of the handheld mouthpiece.
  - Have the child continue breathing through the nebulizer face mask or mouthpiece until the nebulizer cup is empty. A typical SVN treatment takes about 10 to 15 minutes to complete.
  - If an oxygen delivery device was being used before the nebulizer treatment (e.g., nasal cannula, simple face mask, nonrebreather mask), reattach it to the patient after the treatment is completed. Reassess the patient's lung sounds, oxygen saturation, and vital signs and compare your findings with the previously obtained baseline values.

METERED-DOSE INHALER

- A metered-dose inhaler (MDI) consists of a handheld medication canister that fits into a plastic dispenser with a mouthpiece. Each squeeze of the canister delivers a premeasured (i.e., metered) dose of the drug. A spacer, which is a plastic holding chamber that attaches to the canister's mouthpiece or to a spacer face mask, is often used with the MDI to increase the amount of medication delivered into the respiratory tract (**Figure 3-20**). When the medication canister is squeezed, a fine mist of medication is dispersed into the spacer, which is then inhaled by the patient.

Figure 3-20 Metered-dose inhaler and spacer.

- When using an MDI, begin by assessing the patient's lung sounds, oxygen saturation, ventilatory rate, and heart rate to establish a baseline.
- Remove the mouthpiece covers from the MDI and the mouthpiece of the spacer device. Vigorously shake the inhaler five or six times to ensure that the medication mixes within the canister. Insert the MDI into the spacer device.
- Ask the child to take a deep breath and then exhale. Place the mouthpiece end of the spacer device into the patient's mouth and then instruct the patient to close his or her lips around the mouthpiece and to breathe normally. Alternately, if a spacer with a face mask is used, position the mask firmly on the child's face. Ensure that the mask covers the nose and mouth and forms a tight seal. Encourage the child to breathe through his or her mouth.
- Depress the medication canister to disperse a metered medication dose into the spacer. Ask the child to slowly breathe in and hold the breath for a count of 10 (10 seconds) to allow the medication to reach the lungs, and then exhale. If a face mask is used, ask the child to continue to breathe through the mask for five or six breaths.
- If an oxygen delivery device was being used before the MDI, reattach it to the patient. Reassess the patient's lung sounds, oxygen saturation, and vital signs and compare your findings with the previously obtained baseline values.
- After using an MDI containing an inhaled corticosteroid, have the patient rinse his or her mouth with water and spit to remove excess medication from the mouth and back of the throat to avoid an oral yeast infection (i.e., thrush).

PUTTING IT ALL TOGETHER

The chapter quiz and case studies presented on the following pages are provided to help you integrate the information presented in this chapter.

Chapter Quiz

True/False

Indicate whether the statement is true or false.

____ 1. A pediatric bag-mask device is recommended when ventilating older children and adolescents.

____ 2. A properly positioned oral airway protects the lower airway from aspiration.

Multiple Choice

Identify the choice that best completes the statement or answers the question.

____ 3. You respond to a coworker's call for help and find a 10-year-old who is unresponsive. A slow pulse is present but the patient is not breathing. Which of the following should be used in this situation?

a. Nasal cannula
b. Simple face mask
c. Bag-mask device
d. Nonrebreather mask

____ 4. Select the **correct** statement with regard to the use of airway adjuncts.

a. An oral airway can effectively protect the lower airway from aspiration.
b. Positioning of the patient's head is unimportant after placement of an airway adjunct.
c. An oral airway is inserted with its curve downward and the tip following the base of the tongue.
d. A nasal airway that is too long will be ineffective in keeping the tongue away from the posterior pharynx.

____ 5. After assessing the airway of a 3-month-old infant, you determine a need for suctioning. Which of the following is correct with regard to suctioning this patient's nasal passages?

a. Use a rigid catheter and apply suction on insertion.
b. Use a soft suction catheter and apply suction on insertion.
c. Use a soft suction catheter and apply suction on withdrawal using a rotating motion.
d. Use a bulb syringe and release the bulb after insertion of the tip into the patient's nostril.

____ 6. When delivering positive-pressure ventilation by means of a bag-mask device, you can successfully deliver about __ oxygen without the use of supplemental oxygen.

a. 16%
b. 21%
c. 50%
d. 80%

____ 7. A 14-year-old has overdosed on antidepressants. Your assessment reveals that she is snoring and only responds to painful stimuli. She has an adequate tidal volume and is breathing at a rate of 16 per minute. The patient gagged when you attempted to insert an oral airway. Your best course of action will be to:

a. Insert a nasal airway.
b. Attempt endotracheal intubation.
c. Try again to insert an oral airway.
d. Suction the patient's upper airway and then reassess.

____ 8. A toddler has been intubated. Breath sounds are heard on the right side of the chest but are absent on the left. You suspect:

a. Esophageal intubation
b. A blocked endotracheal tube
c. Intubation of the left primary bronchus
d. Intubation of the right primary bronchus

Short Answer

9. What should you do if you observe blanching of the patient's nostril after inserting a nasal airway?

10. Gastric distention is a common complication of positive-pressure ventilation. Explain how you can avoid this complication when providing artificial ventilation.

Case Study 3-1

Your patient is a 2-year-old child who presents with difficulty breathing. You have a sufficient number of advanced life support personnel available to assist you and carry out your instructions. Emergency equipment is available.

1. You are putting on personal protective equipment as you approach the patient and prepare to form a general impression. What are the general impression ABCs?

   A. _____
   B. _____
   C. _____

2. You see a child who is awake and sitting upright on a stretcher. Inspiratory stridor is audible and his work of breathing is increased. His skin color is normal. The child's mother is present. How would you like to proceed?

3. A team member informs you that the patient's SpO_2 on room air is 91%. Is supplemental oxygen therapy indicated at this time?

4. Your primary assessment reveals the following:

Primary Assessment	
A	Inspiratory stridor at rest, nasal discharge present
B	Ventilatory rate 50 breaths/minute, intercostal retractions
C	Heart rate 170 beats/minute (sinus tachycardia), strong peripheral pulses, skin warm and dry, capillary refill 2 seconds
D	Alert, Glasgow Coma Scale score 15
E	Temperature 38°C (100.4°F), weight 12 kg (26.4 pounds); no rash, edema, bleeding, or other signs of trauma

The patient's SpO_2 is now 95% with blow-by oxygen. On the basis of your general impression and primary assessment findings, how would you categorize the severity of the patient's respiratory emergency?

5. You have obtained a SAMPLE history and performed a focused physical examination with the following results:

SAMPLE History	
Signs/symptoms	History of a low-grade fever, a cold, and a runny nose for 2 days. Mom noticed hoarseness and an occasional barking cough last evening.
Allergies	None
Medications	None
Past medical history	Normal development, immunizations current
Last oral intake	Lunch at noon today, normal appetite and fluid intake
Events prior	Mom observed increased breathing difficulty over the past 3 hours

Physical Examination	
Head, eyes, ears, nose, throat	Nasal discharge, inspiratory stridor at rest, mucous membranes moist, no drooling
Neck	Trachea midline, no jugular venous distention
Chest	Breath sounds clear, equal rise and fall, intercostal retractions present
Abdomen	Soft, nontender
Pelvis	No abnormalities noted
Extremities	Distal pulses present, no rash, no evidence of trauma
Back	Unremarkable

On the basis of these findings, what type of respiratory emergency do you suspect that this child is experiencing?

6. Would you categorize this patient's presentation as mild, moderate, or severe?

7. After oxygen, what is the next medication that should be administered in this situation? What precautions should be observed after it is given?

8. What additional therapeutic interventions should be implemented for this child?

Case Study 3-2

Your patient is a 6-year-old female who presents with difficulty breathing. You have a sufficient number of advanced life support personnel available to assist you and carry out your instructions. Emergency equipment is available.

1. Your general impression reveals an anxious-appearing child who is sitting upright in a chair. She is breathing rapidly and expiratory wheezes are audible from across the room. Her skin color is normal. The child's mother is present. How would you like to proceed?

2. While you are performing a primary assessment, mom states that the child began having difficulty breathing while attending a family reunion after sitting with relatives who were smoking cigarettes. The patient began coughing and her breathing difficulty worsened, despite having left the smoking area. Your primary assessment reveals the following:

Primary Assessment	
A	No stridor, no secretions
B	Ventilatory rate 40 breaths/minute, accessory muscle use, audible expiratory wheezing
C	Heart rate 130 beats/minute (sinus tachycardia), strong peripheral pulses, skin warm and dry, capillary refill less than 2 seconds
D	Alert and anxious, Glasgow Coma Scale score 15
E	Temperature 37.4°C (99.3°F), weight 21.8 kg (48 pounds); no rash, no signs of trauma

On the basis of your general impression and primary assessment findings, how would you categorize the severity of the patient's respiratory emergency?

3. Your SAMPLE history and focused physical examination revealed the following:

SAMPLE History	
Signs/symptoms	Coughing and wheezing with increasing breathing difficulty
Allergies	Animal dander, cigarette smoke, pollen
Medications	Previously prescribed albuterol but has not used inhaler since last asthma exacerbation
Past medical history	Asthma (last asthma attack was 1 year ago, never intubated)
Last oral intake	Lunch 3 hours ago, normal appetite and fluid intake
Events prior	Breathing difficulty after exposure to cigarette smoke

Physical Examination	
Head, eyes, ears, nose, throat	No drooling or stridor, talks in phrases
Neck	Trachea midline, no jugular venous distention
Chest	Wheezing in upper lobes, equal rise and fall, accessory muscle use
Abdomen	No abnormalities noted
Pelvis	No abnormalities noted
Extremities	Distal pulses present, no rash, no evidence of trauma
Back	No abnormalities noted

On the basis of these findings, what type of respiratory emergency do you suspect that this child is experiencing?

4. In addition to the questions asked when obtaining a SAMPLE history, list four important questions to ask the patient and caregiver when obtaining a history from a patient who has reactive airway disease.

1.
2.
3.
4.

5. On the basis of the information you have gathered thus far, would you categorize this patient's symptoms as mild, moderate, or severe?

6. The child's blood pressure is 92/50 mm Hg. Her glucose level is 112 mg/dL and her SpO_2 on room air was 92%. Supplemental oxygen is being administered by nonrebreather mask. At a flow rate of 10 to 15 L/minute, what is the inspired oxygen concentration that can be delivered to this patient?

7. After oxygen, what is the next medication that should be administered to this child and how should it be administered?

8. An infant or young child can quickly become dehydrated because of an increased ventilatory rate and decreased oral intake. How will you manage this child's hydration?

9. How you will assess the patient's response to the therapeutic interventions that you have instructed your team members to deliver?

Case Study 3-3

Your patient is a 12-year-old male who presents with difficulty breathing. You have a sufficient number of advanced life support personnel available to assist you and carry out your instructions. Emergency equipment is available.

1. Your general impression reveals an anxious-appearing child who is sitting in a tripod position. He is rapidly breathing and frequently coughing. His skin color is normal. The child's mother is present. How would you like to proceed?

2. As you begin your primary assessment, mom states that her son has been more tired than usual over the last few days and has had little appetite. Although he has a chronic cough, his sputum production has increased during the past 24 hours and his breathing difficulty has worsened. Your primary assessment reveals the following:

Primary Assessment	
A	No stridor, no secretions
B	Ventilatory rate 40 breaths/minute, accessory muscle use, crackles present, decreased breath sounds on left side
C	Heart rate 146 beats/minute (sinus tachycardia), skin warm and dry, capillary refill 2 seconds
D	Alert and anxious, Glasgow Coma Scale score 15
E	Temperature 38.8°C (101.8°F), weight 38 kg (85 pounds); no rash, no signs of trauma

On the basis of your general impression and primary assessment findings, how would you categorize the severity of the patient's respiratory emergency?

3. Your SAMPLE history and focused physical examination revealed the following:

SAMPLE History	
Signs/symptoms	Increased coughing with thick sputum and occasional vomiting
Allergies	None
Medications	Pancreatic enzyme supplement, multivitamin, albuterol, dornase alfa (mucolytic agent), Megace oral suspension, ibuprofen
Past medical history	Cystic fibrosis; upper respiratory infection 6 weeks ago required hospitalization for intravenous antibiotic therapy
Last oral intake	Sips of water this morning; decreased appetite and fluid intake
Events prior	Dry, hacking cough for 2 weeks that has gradually progressed to a productive cough; increased breathing difficulty during the past 24 hours with dyspnea on exertion

Physical Examination	
Head, eyes, ears, nose, throat	No drooling or stridor
Neck	No abnormalities noted
Chest	Barrel-chest, crackles throughout, accessory muscle use, decreased breath sounds on left side
Abdomen	No abnormalities noted
Pelvis	No abnormalities noted
Extremities	Distal pulses present, clubbing of nail beds noted
Back	No abnormalities noted

On the basis of these findings, what type of respiratory emergency do you suspect that this child is experiencing?

4. The child's blood pressure is 88/54 mm Hg. His glucose level is 76 mg/dL and his SpO_2 on room air was 90%. Supplemental oxygen is being administered by nonrebreather mask. What is your treatment plan for this patient?

Case Study 3-4

Your patient is an 8-year-old boy who is unresponsive after a 6-foot fall down a flight of stairs. Emergency medical technicians (EMTs) report that the child struck his head on a piece of metal on the ground sustaining a 1-inch full thickness laceration and a 0.5-inch avulsion to the left temporal area, which has been bandaged. The patient has been secured to a backboard. An EMT is assisting the child's breathing with a bag-mask device. The child's father is present. You have a sufficient number of advanced life support personnel available to assist you and carry out your instructions. Emergency equipment is available.

1. Your general impression reveals a child who is supine on a backboard with his eyes closed. When bag-mask ventilation is paused, you observe that shallow chest movement is visible and his rate and depth of breathing are irregular. His face, lips, and extremities appear pink. How would you like to proceed?

2. At what rate should bag-mask ventilation be performed?

3. While you are performing a primary assessment, dad states that he observed the child have a seizure before the EMTs arrived. Upon questioning, dad describes a generalized tonic-clonic seizure that he estimates lasted about 90 seconds. Dad says the child has been unresponsive since the fall. Your primary assessment reveals the following:

Primary Assessment	
A	No stridor or gurgling
B	Ventilatory rate varies from 6 to 42 breaths/minute, irregular depth
C	Heart rate 48 beats/minute (sinus bradycardia), weak peripheral pulses, skin warm and dry, capillary refill less than 2 seconds
D	Moans in response to painful stimulus, Glasgow Coma Scale score 6
E	Temperature 37°C (98.6°F), weight 25 kg (55 pounds)

On the basis of your general impression and primary assessment findings, how would you categorize the severity of the patient's respiratory emergency?

4. Your SAMPLE history and focused physical examination revealed the following:

SAMPLE History	
Signs/symptoms	Unresponsive, obvious injury to left temporal area
Allergies	None
Medications	None
Past medical history	Normal development, immunizations current
Last oral intake	Lunch at 12:30
Events prior	6-foot fall down a flight of stairs

Physical Examination	
Head, eyes, ears, nose, throat	1-inch full thickness laceration and 0.5-inch avulsion to temporal area, minimal bleeding
Neck	No abnormalities noted
Chest	Breath sounds clear, irregular breathing pattern, abrasions on anterior chest, equal chest rise and fall
Abdomen	No abnormalities noted
Pelvis	No abnormalities noted
Extremities	Distal pulses weak, abrasions on both thighs
Back	No abnormalities noted

On the basis of these findings, what type of respiratory emergency do you suspect that this child is experiencing?

5. On the basis of this child's mechanism of injury, what factors should you consider while caring for him?

6. The child's blood pressure is 158/70 mm Hg and his oxygen saturation is 99% with bag-mask ventilation. His point-of-care glucose reading is 104 mg/dL. What are your management priorities at this time?

7. What additional interventions may be ordered to manage this child's increased intracranial pressure?

8. Endotracheal intubation has been performed. Describe how you will confirm proper positioning of the endotracheal tube.

Chapter Quiz Answers

True/False

1. F. Use a pediatric bag (at least 450 to 500 mL) for infants and young children (American Heart Association, 2011). When ventilating older children and adolescents, an adult bag (1,000 mL or more) may be needed to achieve chest rise (American Heart Association, 2011). A child can be ventilated with a larger bag as long as proper technique is used—squeeze the bag just until the chest begins to rise, and then release the bag.

OBJ: Discuss positive-pressure ventilation using a bag-mask device and troubleshooting ineffective bag-mask ventilation.

2. F. The use of an oral airway does not protect the lower airway from aspiration and it does not eliminate the need for maintaining proper head position of the unresponsive patient.

OBJ: Describe the method of correct sizing, insertion technique, and possible complications associated with the use of the oropharyngeal airway and nasopharyngeal airway.

Multiple Choice

3. C. The nasal cannula, simple face mask, and nonrebreather mask are oxygen delivery devices that are used with a patient who is spontaneously breathing. Because this patient is apneic, these devices are contraindicated. This patient needs positive-pressure ventilation, which can be delivered with a bag-mask device.

OBJ: Discuss positive-pressure ventilation using a bag-mask device and troubleshooting ineffective bag-mask ventilation.

4. C. After selecting an oral airway of proper size, open the patient's mouth and gently insert the airway with the curve downward and the tip following the base of the tongue. Place the airway over the tongue and down into the mouth until the flange of the airway rests against the patient's lips. A tongue blade may be used to depress the tongue while inserting the airway to aid in placement. Because an oral airway does not isolate the trachea, it does not protect the lower airway from aspiration. A nasal airway that is too long may stimulate the gag reflex or enter the esophagus, causing gastric distention and hypoventilation when ventilating with a bag-mask device. A nasal airway that is too short will not extend past the tongue; thus it will not keep the tongue away from the posterior pharynx. Proper positioning of the patient's head must be maintained after an airway adjunct is in place to ensure an open airway.

OBJ: Describe the method of correct sizing, insertion technique, and possible complications associated with the use of the oropharyngeal airway and nasopharyngeal airway.

5. D. Bulb syringes are excellent for suctioning nasal and oral secretions in infants and young children. To use this device correctly, depress the bulb, insert the tip gently in the patient's mouth or nose, and then slowly release the bulb. Remove the syringe from the airway and expel its contents, depress the bulb,

and repeat as necessary. Do not suction for more than 10 seconds per attempt; provide supplemental oxygen between suctioning attempts.

OBJ: Describe suctioning, including its indications, correct technique, and possible complications associated with this procedure.

6. B. A bag-mask device used without supplemental oxygen will deliver 21% oxygen (room air, not exhaled air) to the patient.

OBJ: Discuss positive-pressure ventilation using a bag-mask device and troubleshooting ineffective bag-mask ventilation.

7. A. The patient's noisy breathing, as evidenced by her snoring, reflects a partial airway obstruction—most likely from the tongue. Because a nasal airway is usually well tolerated by patients with a gag reflex, insertion should be attempted. If the patient gagged with attempts to insert an oral airway, attempts at endotracheal intubation are unlikely to be successful unless sedation is used.

OBJ: Describe the method of correct sizing, insertion technique, and possible complications associated with the use of the oropharyngeal airway and nasopharyngeal airway.

8. D. If baseline breath sounds (i.e., breath sounds before intubation) were equal bilaterally, diminished breath sounds on the left side after intubation suggest that the ETT has entered the right primary bronchus. To correct this problem, deflate the ETT cuff (if a cuffed tube was used) and auscultate the left side of the chest while slowly withdrawing the tube until breath sounds are equal and chest expansion is symmetric, and then reinflate the ETT cuff.

OBJ: Describe types of advanced airways and methods used to confirm their correct placement.

Short Answer

9. If blanching of the nostril is present after insertion of a nasal airway, the diameter of the device is too large. Remove the airway, select a slightly smaller size, and reinsert. Be sure to maintain the patient's proper head position after insertion of the airway.

OBJ: Describe the method of correct sizing, insertion technique, and possible complications associated with the use of the oropharyngeal airway and nasopharyngeal airway.

10. During normal ventilation, the esophagus remains closed and no air enters the stomach. During positive-pressure ventilation with a bag-mask device, excess air may enter the stomach to cause gastric distention that may lead to vomiting and subsequent aspiration. To reduce the risk of gastric distention when performing bag-mask ventilation, avoid using excessive force and volume. Use only enough volume to cause a gentle chest rise. If gastric distention is present, consider insertion of an orogastric or nasogastric tube to decompress the stomach.

Case Study 3-1 Answers

1. The Pediatric Assessment Triangle (PAT) is used to form a general impression of the patient and focuses on three main areas: (1) appearance, (2) work of breathing, and (3) circulation to the skin. Assessment of these areas corresponds with assessment of the nervous, respiratory, and circulatory systems.

OBJ: Summarize the components of the pediatric assessment triangle and the reasons for forming a general impression of the patient.

2. Ask a team member to apply a pulse oximeter, blood pressure monitor, and cardiac monitor while you perform a primary assessment and obtain a SAMPLE history. Administer supplemental oxygen in a manner that will not agitate the child.

OBJ: Given a patient situation, and working in a team setting, competently direct the initial emergency care for a patient experiencing a respiratory emergency.

3. Yes. Supplemental oxygen therapy should be administered to maintain an oxygen saturation level of 94% or higher.

OBJ: Given a patient situation, and working in a team setting, competently direct the initial emergency care for a patient experiencing a respiratory emergency.

4. This child's increased ventilatory rate, inspiratory stridor, retractions, and tachycardia are consistent with respiratory distress. To promote maximum ventilatory function, allow the child to assume a position of comfort as you continue to provide care.

OBJ: Differentiate among respiratory distress, respiratory failure, and respiratory arrest.

5. This child's history and physical examination findings suggest an upper airway obstruction caused by croup.

OBJ: Differentiate between upper and lower airway obstruction.

6. This child's presentation is consistent with moderate croup. Mild croup is characterized by an absence of stridor at rest, minimal respiratory distress, and an occasional cough. With moderate croup, the child's behavior and mental status are normal but stridor is present at rest and the amount of respiratory distress is increased. Severe croup is characterized by mental status changes accompanied by significant respiratory distress and decreasing air entry, indicating impending respiratory failure

OBJ: Describe the pathophysiology, assessment findings, and treatment plan for the child experiencing croup, epiglottitis, foreign body aspiration, and anaphylaxis.

7. Because the child's oxygenation has improved with the use of blow-by oxygen, this therapy should be continued to enhance tissue oxygenation. Nebulized epinephrine is the next medication that should be administered. Cardiac monitoring is prudent because of epinephrine's tachycardiac effect and the potential for dysrhythmias. Observe the child for *at least* 2 hours, and preferably for 3 to 4 hours after treatment to monitor for rebound symptoms.

OBJ: Given a patient situation, and working in a team setting, competently direct the initial emergency care for a patient experiencing a respiratory emergency.

8. To reduce inflammation, administer a systemic steroid such as dexamethasone. Obtain a serum glucose level (98 mg/dL). Reassess the patient's oxygenation, ventilation, and vital signs to determine the need for alternative interventions. (Stridor and retractions are less severe.)

OBJ: Describe the pathophysiology, assessment findings, and treatment plan for the child experiencing croup, epiglottitis, foreign body aspiration, and anaphylaxis.

Case Study 3-2 Answers

1. Continue to allow the child to assume a position of comfort to promote maximum ventilatory function. Ask a team member to apply a pulse oximeter, blood pressure monitor, and cardiac monitor while you perform a primary assessment and obtain a SAMPLE history. Administer supplemental oxygen in a manner that will not agitate the child.

OBJ: Given a patient situation, and working in a team setting, competently direct the initial emergency care for a patient experiencing a respiratory emergency.

2. This child's anxiety, increased ventilatory rate, expiratory wheezes, accessory muscle use, and tachycardia are consistent with respiratory distress.

OBJ: Differentiate between respiratory distress, respiratory failure, and respiratory arrest.

3. This child's history and physical examination findings suggest a lower airway obstruction caused by asthma.

OBJ: Differentiate between upper and lower airway obstruction.

4. In addition to the SAMPLE history, consider the following questions when obtaining a focused history from a patient who has reactive airway disease:

   - When did the patient's symptoms start/occur (time, sudden, gradual)? What was the child doing when it started/occurred?
   - Does the child have a cough? If yes, what does the cough sound like? When does it occur and what relieves it?
   - Does the child bring up any sputum when he or she coughs? What does the sputum look like?
   - Does anything (e.g., tripod position, use of inhaler) make the symptoms better or worse?
   - Has the child ever been hospitalized or intubated for this condition?
   - What have you tried so far to relieve the patient's symptoms?

OBJ: Describe the pathophysiology, assessment findings, and treatment plan for the infant or child experiencing respiratory distress, respiratory failure, or respiratory arrest.

5. The severity of asthma exacerbations may be categorized as mild, moderate, or severe. The child with moderate signs and symptoms talks in phrases, prefers sitting, is usually agitated, commonly uses accessory muscles, and has an increased ventilatory rate. Loud wheezing can often be heard throughout expiration. Assessment of the child's peak expiratory flow (PEF) rate may be useful in determining the severity of an asthma exacerbation. Because they require the child's cooperation in making a maximal expiratory effort, PEF measurements are used to assess the severity of an episode and the response to therapy in children older than 5 years with mild to moderate exacerbations and who currently perform peak flow with home management.

OBJ: Describe the pathophysiology, assessment findings, and treatment plan for the child experiencing asthma or bronchiolitis.

6. A nonrebreather mask can deliver an inspired oxygen concentration of up to 95% at a flow rate of 10 to 15 L/minute. Remember to fill the reservoir bag of a nonrebreather mask with oxygen *before* placing the mask on the patient. After placing the mask on the patient, adjust the flow rate so the bag does not completely deflate when the patient inhales.

OBJ: Discuss oxygen delivery systems used for infants and children.

7. Children experiencing a moderate asthma exacerbation should receive albuterol by metered-dose inhaler or nebulizer and oral corticosteroids. Nebulized ipratropium bromide should also be administered. These medications are given to open constricted airways and allow air exchange and to enhance tissue oxygenation. Continue to allow the child to assume a position of comfort and provide reassurance as you continue to provide care.

OBJ: Describe the delivery of inhaled medications by means of a small-volume nebulizer and by a metered-dose inhaler.

8. Because this child is alert, it is reasonable to maintain hydration by encouraging small amounts of clear oral fluids.

OBJ: Describe the pathophysiology, assessment findings, and treatment plan for the child experiencing asthma or bronchiolitis.

9. Listen to breath sounds before and after administration to assess the child's response to treatment. Also, reassess the patient's vital signs (including oxygen saturation) for improvement and see if the patient's accessory muscle use decreases after therapy. Because this child is older than 5 years, measurement of peak expiratory flow rate (PEFR) may be helpful in assessing the child's response to therapy if peak flow is used with home management. Generally, a child needs frequent reviews of the technique used to obtain a PEFR for accurate results. Although this child has a history of asthma, the history obtained from mom indicates that she has not used her medications since her last asthma exacerbation a year ago; therefore, the child may not be familiar with PEF measurements or she may not be able to use a flow meter successfully.

OBJ: Given a patient situation, and working in a team setting, competently direct the initial emergency care for a patient experiencing a respiratory emergency.

Case Study 3-3 Answers

1. Allow the child to assume a position of comfort to promote maximum ventilatory function. Ask a team member to apply a pulse oximeter, blood pressure monitor, and cardiac monitor while you perform a primary assessment and obtain a SAMPLE history. Administer supplemental oxygen in a manner that will not agitate the child.

OBJ: Given a patient situation, and working in a team setting, competently direct the initial emergency care for a patient experiencing a respiratory emergency.

2. This child's anxiety, increased ventilatory rate, accessory muscle use, and tachycardia are consistent with respiratory distress.

OBJ: Differentiate between respiratory distress, respiratory failure, and respiratory arrest.

3. This child's history and physical examination findings suggest an exacerbation of the child's chronic lung tissue disease, cystic fibrosis.

OBJ: Describe the pathophysiology, assessment findings, and treatment plan for the child who has lung tissue disease or disordered ventilatory control.

4. Emergency care for the child with cystic fibrosis (CF) should be coordinated with a CF care team or pulmonologist. Bronchodilator therapy should be started to relieve bronchospasm, enable the removal of thick secretions, and improve airflow in the lungs. Chest physiotherapy should be performed to help loosen secretions and aid their expectoration. Assess and document the child's heart rate, ventilatory rate, breath sounds, and oxygen saturation before and after treatment to evaluate effectiveness. Obtain a sputum culture to identify infective organisms. Obtain vascular access for hydration and antibiotic therapy. Obtain a chest radiograph and draw blood for laboratory studies.

OBJ: Given a patient situation, and working in a team setting, competently direct the initial emergency care for a patient experiencing a respiratory emergency.

Case Study 3-4 Answers

1. Ask a team member to apply a pulse oximeter, blood pressure monitor, and cardiac monitor while you perform a primary assessment and obtain a SAMPLE history. Ask team members to take over bag-mask ventilation from the EMTs.

OBJ: Given a patient situation, and working in a team setting, competently direct the initial emergency care for a patient experiencing a respiratory emergency.

2. Give 1 breath every 3 to 5 seconds (12 to 20 breaths per minute). Allow 1 second per breath while watching for chest rise. As soon as chest rise is visible, release the bag.

OBJ: Discuss positive-pressure ventilation using a bag-mask device and troubleshoot for ineffective bag-mask ventilation.

3. This child's presentation is consistent with respiratory failure.

OBJ: Differentiate between respiratory distress, respiratory failure, and respiratory arrest.

4. This child's history and physical examination findings suggest disordered ventilatory control (irregular breathing pattern) that is likely the result of increased intracranial pressure.

OBJ: Describe the pathophysiology, assessment findings, and treatment plan for the child who has lung tissue disease or disordered ventilatory control.

5. Falls are common causes of injury in children. Factors to consider in a fall include the following:

   - The height from which the child fell
   - The mass of the child
   - The surface on which the child landed
   - The part of the child's body that struck first

   In general, the greater the height from which the child falls, the more severe the injury. However, the type of surface onto which the child falls and the degree to which the fall is broken on the way down affect the type and severity of injuries.

OBJ: N/A.

6. Continue bag-mask ventilation. Obtain vascular access and blood for laboratory studies. Direct a team member to insert a urinary catheter. On the basis of the child's mechanism of injury, a focused assessment with sonography for trauma (FAST) examination (i.e., bedside ultrasound) should be performed if the equipment is available, to look for bleeding in the pericardium, in the pleural space, in the upper abdominal quadrants, and in the pelvis. Results are negative: Order radiographs of the cervical spine and chest. Results are normal: Because the child has an irregular breathing pattern and a Glasgow Coma Scale score of 6, endotracheal intubation should be performed by a qualified individual. Obtain a neurosurgical consult and order a computed tomography (CT) scan of the head. (The result of the head CT scan is normal.)

OBJ: Describe the pathophysiology, assessment findings, and treatment plan for the child who has lung tissue disease or disordered ventilatory control.

7. Administration of hypertonic saline, osmotic agents (e.g., mannitol), or both may be required to reduce intracranial pressure.

OBJ: Given a patient situation, and working in a team setting, competently direct the initial emergency care for a patient experiencing a respiratory emergency.

8. After placement of an endotracheal tube (ETT), confirm proper positioning of the tube using *both* clinical assessments and an exhaled CO_2 device. Observe the patient's chest rise, skin color, and heart rate while ventilating with a bag device. While providing positive-pressure ventilation, auscultate for bilateral breath

sounds over the chest and then confirm the absence of sounds over the stomach. In addition, use capnography to measure the concentration of CO_2 at the end of exhalation and confirm proper position of the ETT. Waveform capnography is preferred.

OBJ: Describe types of advanced airways and methods used to confirm their correct placement.

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Checklist 3-1 Upper Airway Obstruction

Action Steps	Performed Correctly
Ensures scene safety. Takes or communicates the use of personal protective equipment for blood and body substances.	☐
Assigns team member roles.	☐
Assessment	
Forms a general impression: Assesses patient's appearance, work of breathing, and circulation.	☐
Directs assessment of airway/responsiveness; directs the use of a manual airway maneuver to open the airway, if indicated.	☐
Directs assessment of breathing including estimation of ventilatory rate and evaluation of ventilatory effort; directs assessment of breath sounds.	☐
Directs assessment of central/peripheral pulse quality, estimation of heart rate, and evaluation of skin (color, temperature, and moisture) and capillary refill.	☐
Directs team members to determine a Glasgow Coma Scale score and patient weight.	☐
Directs team members to obtain vital signs, apply a pulse oximeter, and apply blood pressure and cardiac monitors.	☐
Obtains a brief history and performs a focused physical examination.	☐
Recognizes signs and symptoms of upper airway obstruction.	☐
Determines the severity of the respiratory emergency (e.g., respiratory distress, respiratory failure, respiratory arrest).	☐
Treatment Plan	
Verbalizes a treatment plan and initiates appropriate interventions for an upper airway obstruction.	☐
Directs insertion of an oral airway or nasal airway, if indicated.	☐
Directs application of appropriate oxygen therapy; directs team member to begin assisted ventilation, if indicated.	☐
Instructs team member to establish vascular access.	☐
Orders diagnostic tests and procedures, if indicated.	☐
Considers the need for an advanced airway.	☐
Correctly verbalizes indications, dosages, and routes of administration for medications administered.	☐
Reassessment	
Repeats the primary assessment and obtains another set of vital signs.	☐
Monitors for, recognizes, and appropriately treats any changes in the patient's physiological status.	☐
Team Leader Assessment	
Effectively leads team members throughout patient care.	☐
Directs the transfer of patient care for ongoing monitoring and care.	☐
Requests a team debriefing after the transfer of patient care is complete.	☐

Checklist 3-2 Lower Airway Obstruction

Action Steps	Performed Correctly
Ensures scene safety. Takes or communicates the use of personal protective equipment for blood and body substances.	☐
Assigns team member roles.	☐
Assessment	
Forms a general impression: Assesses patient's appearance, work of breathing, and circulation.	☐
Directs assessment of airway/responsiveness; directs the use of a manual airway maneuver to open the airway, if indicated.	☐
Directs assessment of breathing including estimation of ventilatory rate and evaluation of ventilatory effort; directs assessment of breath sounds.	☐
Directs assessment of central/peripheral pulse quality, estimation of heart rate, and evaluation of skin (color, temperature, and moisture) and capillary refill.	☐
Directs team members to determine a Glasgow Coma Scale score and patient weight.	☐
Directs team members to obtain vital signs, apply a pulse oximeter, and apply blood pressure and cardiac monitors.	☐
Obtains a brief history and performs a focused physical examination.	☐
Recognizes signs and symptoms of lower airway obstruction.	☐
Determines the severity of the respiratory emergency (e.g., respiratory distress, respiratory failure, respiratory arrest).	☐
Treatment Plan	
Verbalizes a treatment plan and initiates appropriate interventions for a lower airway obstruction.	☐
Directs insertion of an oral airway or nasal airway, if indicated.	☐
Directs application of appropriate oxygen therapy; directs team member to begin assisted ventilation, if indicated.	☐
Instructs team member to establish vascular access.	☐
Orders diagnostic tests and procedures, if indicated.	☐
Considers the need for an advanced airway.	☐
Correctly verbalizes indications, dosages, and routes of administration for medications administered.	☐
Reassessment	
Repeats the primary assessment and obtains another set of vital signs.	☐
Monitors for, recognizes, and appropriately treats any changes in the patient's physiological status.	☐
Team Leader Assessment	
Effectively leads team members throughout patient care.	☐
Directs the transfer of patient care for ongoing monitoring and care.	☐
Requests a team debriefing after the transfer of patient care is complete.	☐

Checklist 3-3 Lung Tissue Disease

Action Steps	Performed Correctly
Ensures scene safety. Takes or communicates the use of personal protective equipment for blood and body substances.	☐
Assigns team member roles.	☐
Assessment	
Forms a general impression: Assesses patient's appearance, work of breathing, and circulation.	☐
Directs assessment of airway/responsiveness; directs the use of a manual airway maneuver to open the airway, if indicated.	☐
Directs assessment of breathing including estimation of ventilatory rate and evaluation of ventilatory effort; directs assessment of breath sounds.	☐
Directs assessment of central/peripheral pulse quality, estimation of heart rate, and evaluation of skin (color, temperature, and moisture) and capillary refill.	☐
Directs team members to determine a Glasgow Coma Scale score and patient weight.	☐
Directs team members to obtain vital signs, apply a pulse oximeter, and blood pressure and cardiac monitors.	☐
Obtains a brief history and performs a focused physical examination.	☐
Recognizes signs and symptoms of lung tissue disease.	☐
Determines the severity of the respiratory emergency (e.g., respiratory distress, respiratory failure, respiratory arrest).	☐
Treatment Plan	
Verbalizes a treatment plan and initiates appropriate interventions for a patient with lung tissue disease.	☐
Directs insertion of an oral airway or nasal airway, if indicated.	☐
Directs application of appropriate oxygen therapy; directs team member to begin assisted ventilation, if indicated.	☐
Instructs team member to establish vascular access.	☐
Orders diagnostic tests and procedures, if indicated.	☐
Considers the need for an advanced airway.	☐
Correctly verbalizes indications, dosages, and routes of administration for medications administered.	☐
Reassessment	
Repeats the primary assessment and obtains another set of vital signs.	☐
Monitors for, recognizes, and appropriately treats any changes in the patient's physiological status.	☐
Team Leader Assessment	
Effectively leads team members throughout patient care.	☐
Directs the transfer of patient care for ongoing monitoring and care.	☐
Requests a team debriefing after the transfer of patient care is complete.	☐

Checklist 3-4 Disordered Ventilatory Control

Action Steps	Performed Correctly
Ensures scene safety. Takes or communicates the use of personal protective equipment for blood and body substances.	☐
Assigns team member roles.	☐
Assessment	
Forms a general impression: Assesses patient's appearance, work of breathing, and circulation.	☐
Directs assessment of airway/responsiveness; directs the use of a manual airway maneuver to open the airway, if indicated.	☐
Directs assessment of breathing including estimation of ventilatory rate and evaluation of ventilatory effort; directs assessment of breath sounds.	☐
Directs assessment of central/peripheral pulse quality, estimation of heart rate, and evaluation of skin (color, temperature, and moisture) and capillary refill.	☐
Directs team members to determine a Glasgow Coma Scale score and patient weight.	☐
Directs team members to obtain vital signs, apply a pulse oximeter, and apply blood pressure and cardiac monitors.	☐
Obtains a brief history and performs a focused physical examination.	☐
Recognizes signs and symptoms of disordered ventilatory control.	☐
Determines the severity of the respiratory emergency (e.g., respiratory distress, respiratory failure, respiratory arrest).	☐
Treatment Plan	
Verbalizes a treatment plan and initiates appropriate interventions for disordered ventilatory control.	☐
Directs insertion of an oral airway or nasal airway, if indicated.	☐
Directs application of appropriate oxygen therapy; directs team member to begin assisted ventilation, if indicated.	☐
Instructs team member to establish vascular access.	☐
Orders diagnostic tests and procedures, if indicated.	☐
Considers the need for an advanced airway.	☐
Correctly verbalizes indications, dosages, and routes of administration for medications administered.	☐
Reassessment	
Repeats the primary assessment and obtains another set of vital signs.	☐
Monitors for, recognizes, and appropriately treats any changes in the patient's physiological status.	☐
Team Leader Assessment	
Effectively leads team members throughout patient care.	☐
Directs the transfer of patient care for ongoing monitoring and care.	☐
Requests a team debriefing after the transfer of patient care is complete.	☐

CHAPTER 4

Shock

Learning Objectives

After completing this chapter, you should be able to:

1. Identify key anatomic and physiologic differences between children and adults and discuss their implications in the patient with a cardiovascular condition.
2. Differentiate between compensated and hypotensive shock.
3. Discuss the physiologic types of shock.
4. Describe the initial emergency care for hypovolemic, distributive, cardiogenic, and obstructive shock in infants and children.
5. Discuss the pharmacology of medications used during shock.
6. Discuss age-appropriate vascular access sites for infants and children.
7. Given a patient situation, formulate a treatment plan for a patient in shock.

After completing this chapter, and with supervised practice during a Pediatric Advanced Life Support (PALS) course, you will be skilled at the following:

- Ensuring scene safety and the use of personal protective equipment.
- Assigning team member roles or performing as a team member in a simulated patient situation.
- Directing or performing an initial patient assessment.
- Obtaining vital signs, establishing vascular access, attaching a pulse oximeter and blood pressure and cardiac monitors, and giving supplemental O_2 if indicated.

- Implementing a treatment plan based on the type of shock the patient is experiencing.
- Demonstrating knowledge of the indications, dosages, and effects of the medications and fluids used when managing shock.
- Establishing vascular access by means of the intraosseous route.
- Recognizing when an intraosseous needle is properly positioned.
- Recognizing when it is best to seek expert consultation.
- Reviewing your performance as a team leader or team member during a postevent debriefing.

ASSESSMENT EVIDENCE

Performance Tasks

During the PALS course, you will function as the team leader of the Rapid Response Team or Code Team within your organization. Your classmates are similarly trained members of the team who will assist you. Your task is to direct, without prompting, the emergency care efforts of your team according to current resuscitation guidelines.

Key Criteria

Assessment of your ability to manage a patient who is experiencing shock and your ability to manage the team who will assist you in providing patient care is part of the PALS course. An evaluation checklist that reflects key steps and interventions in the patient management process is used to assess your performance (see **Checklists 4-1** through **4-4**). A PALS instructor will check the appropriate box as you complete each step during your management of the patient.

Learning Plan

- Read this chapter before your PALS course. Create flashcards and memory aids to help you recall key points. Carefully review each of the medications discussed in this chapter.
- Complete the chapter quiz and review the answers provided.
- Complete the case studies at the end of the chapter. Read each scenario and answer all questions that follow. The questions are intended to reinforce important points pertinent to the case that are discussed in this text. Compare your answers with the answers provided at the end of the case study and with the checklist pertinent to the case study.

KEY TERMS

Afterload
The pressure or resistance against which the ventricles must pump to eject blood

Cardiac Output (CO)
The amount of blood pumped into the aorta each minute by the heart

Extravasation
The inadvertent administration of a vesicant (irritating to human tissue) solution or medication into surrounding tissue because of catheter dislodgment

Hypovolemic shock
A state of inadequate circulating blood volume relative to the capacity of the vascular space

Infiltration
The inadvertent administration of a nonvesicant (nonirritating to human tissue) solution or medication into surrounding tissue because of catheter dislodgment

Perfusion
The circulation of blood through an organ or a part of the body

Preload
The volume of blood in the ventricle at the end of diastole

Septic shock
A physiologic response to infectious organisms or their by-products that results in cardiovascular instability and organ dysfunction

Shock
Inadequate tissue perfusion that results from the failure of the cardiovascular system to deliver sufficient oxygen and nutrients to sustain vital organ function; also called *hypoperfusion* or *circulatory failure*

Vascular resistance
The amount of opposition that the blood vessels give to the flow of blood

INTRODUCTION

Perfusion is the circulation of blood through an organ or a part of the body. Perfusion delivers oxygen and other nutrients to the cells of all organ systems and removes waste products. **Shock**, also called *hypoperfusion* or *circulatory failure*, is inadequate tissue perfusion that results from the failure of the cardiovascular system to deliver sufficient oxygen and nutrients to sustain vital organ function. The underlying cause must be recognized and treated promptly to avoid cell and organ dysfunction and death.

ANATOMIC AND PHYSIOLOGIC CONSIDERATIONS

Awareness of the anatomic differences between children and adults will help you understand the signs and symptoms exhibited by children in shock.

Vasculature

- Arteries are conductance vessels. The primary function of the large arteries is to conduct blood from the heart to the arterioles. The middle layer of an artery is encircled by smooth muscle and is innervated by fibers of the autonomic nervous system (ANS). This allows constriction and dilation of the vessel. Smooth muscle cells function to maintain vascular tone and regulate local blood flow depending on metabolic requirements.
- Arterioles are resistance vessels and are the smallest branches of the arteries. They connect arteries and capillaries. Precapillary sphincters contract and relax to control blood flow throughout the capillaries (**Figure 4-1**). The presence of smooth muscle in the walls of arterioles allows the vessel to alter its diameter, thereby controlling the amount of blood flow to specific tissues. Altering the diameter of the arterioles also affects the resistance to the flow of blood. A dilated (widened) vessel offers less resistance to blood flow. A constricted (narrowed) vessel offers more resistance to blood flow.
- Capillaries are exchange vessels. They are the smallest and most numerous of the blood vessels and they connect arterioles and venules. The capillary wall consists of a single layer of cells (endothelium) through which substances in the blood are exchanged with substances in tissue fluids surrounding cells of the body.
- Venules connect capillaries and veins. Post-capillary sphincters are present where the venules and capillaries meet. Post-capillary sphincters contract and relax to control blood flow to body tissues. Venules carry blood under low pressure.

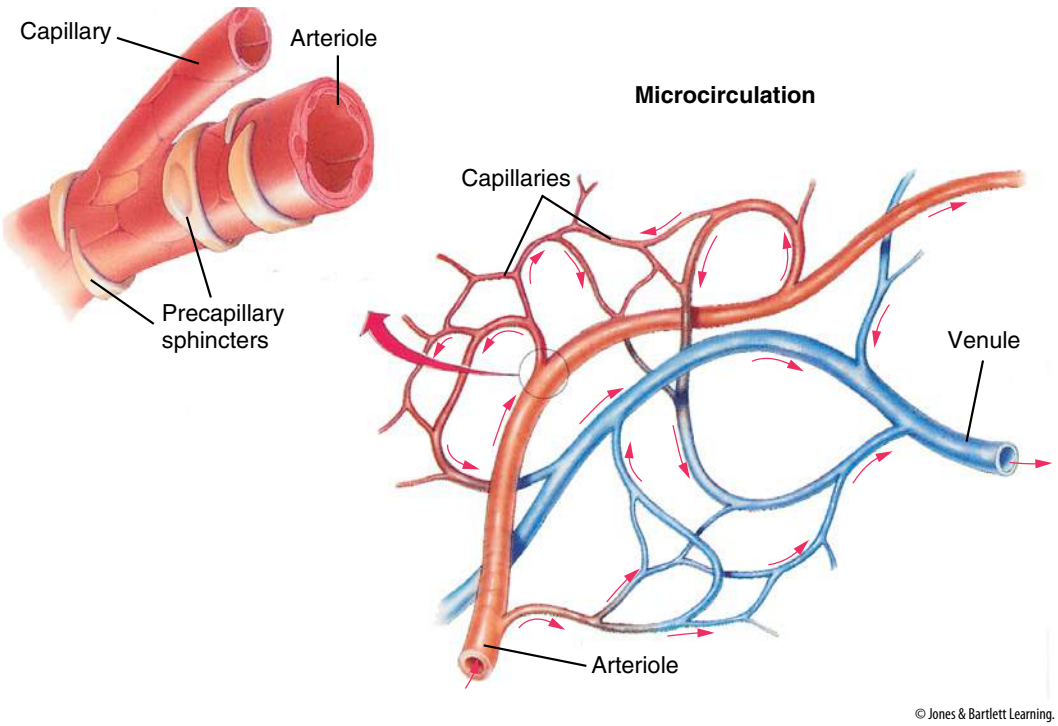


Figure 4-1 Arterioles play an important role in regulating blood flow.

- Veins are capacitance (storage) vessels that carry deoxygenated (oxygen-poor) blood from the body to the right side of the heart. Venous blood flow depends on skeletal muscle action, respiratory movements, and gravity. Valves in the larger veins of the extremities and neck allow blood flow in one direction, toward the heart.

PALS Pearl

Infants and children are capable of more effective vasoconstriction than adults are. As a result, a previously healthy infant or child is able to maintain a normal blood pressure and organ perfusion for a longer time in the presence of shock.

Blood Pressure

- Blood pressure is the force exerted by the blood on the inner walls of the blood vessels. *Systolic blood pressure* is the pressure exerted against the walls of the large arteries at the peak of ventricular contraction. *Diastolic blood pressure* is the pressure exerted against the walls of the large arteries during ventricular relaxation. Pulse pressure, an indicator of stroke volume, is the difference between the systolic and diastolic blood pressure.
- Blood pressure is equal to cardiac output multiplied by peripheral vascular resistance. **Vascular resistance** is the amount of opposition that the blood vessels give to the flow of blood. Resistance is affected by the diameter and length of the blood vessel, blood viscosity, and the tone (the normal state of balanced tension in body tissues) of the vessel. A narrowed pulse pressure, which may be seen with hypovolemic or cardiogenic shock, reflects increased peripheral vascular resistance and is an early sign of impending shock. A widened pulse pressure, which may be seen with early septic shock, reflects decreased peripheral vascular resistance.
- Blood pressure is affected by any condition that increases peripheral vascular resistance or cardiac output. Thus, an increase in either cardiac output or peripheral resistance will result in an increase in blood pressure. Conversely, a decrease in either will result in a decrease in blood pressure.
  - Mottling and cool extremities are early indicators of decreased tissue perfusion, which is a reflection of decreased cardiac output. Hypotension is a *late* sign of cardiovascular compromise in an infant or child.
  - The strength of peripheral pulses (e.g., radial, dorsalis pedis) is reduced in the child whose cardiac output is decreased (Moller, 1992). As cardiac output becomes more severely decreased, the strength of more proximal pulses (e.g., brachial, femoral, carotid) is also reduced.

Cardiac Output

- Adequate cardiac output is necessary to maintain oxygenation and perfusion of body tissues. **Cardiac Output (CO)** is the amount of blood pumped into the aorta each minute by the heart. It is calculated as the stroke volume (the amount of blood ejected from a ventricle with each heartbeat) multiplied by the heart rate (HR) and is expressed in liters per minute.
  - Although changes in HR *or* stroke volume can affect cardiac output, tachycardia is the primary method of increasing cardiac output in the child (Perkin, de Caen, Berg, Schexnayder, & Hazinski, 2013).
  - Clinically, cardiac output is assessed by evaluating heart rate, blood pressure, and end-organ perfusion, including mentation, the quality of peripheral pulses, capillary refill, urine output, and acid-base status.
- Stroke volume is determined by the degree of ventricular filling during diastole (preload), the resistance against which the ventricle must pump (afterload), and cardiac contractility.
- **Preload** is the volume of blood in the ventricle at the end of diastole. Preload in the right heart depends on venous return to the heart from the systemic circulation. Preload in the left heart depends on venous return from the pulmonary system.
- **Afterload** is the pressure or resistance against which the ventricles must pump to eject blood. It is influenced by arterial blood pressure, arterial distensibility (ability to become stretched), and arterial resistance. The less the resistance (lower afterload), the more easily blood can be ejected. Increased afterload (increased resistance) results in increased cardiac workload.
- Because of the immaturity of sympathetic innervation to the ventricles, infants and children have a relatively fixed stroke volume and are therefore dependent on an adequate HR to maintain adequate cardiac output. With age, the HR decreases as the ventricles mature and stroke volume plays a greater role in cardiac output (Sharieff & Rao, 2006).
- Heart rate is influenced by the child's age, size, and level of activity. A very slow or rapid rate may indicate or may be the cause of cardiovascular compromise.

Circulating Blood Volume

- The circulating blood volume is about 75 to 80 mL/kg in infants, about 70 to 75 mL/kg in children, and 65 to 70 mL/kg in adolescents and adults (Perkin et al., 2013). Although the circulating blood volume is proportionately larger in infants and children than in adults, the *total* blood volume is smaller than in adults (**Figure 4-2**).
- A 2-year-old, 12-kg child has a normal circulating blood volume of about 70 mL/kg or 840 mL. A loss of 10% to 15% of the circulating blood volume is usually well tolerated and easily compensated for in a previously healthy child. However, a volume loss of only 250 mL (about 30% of the circulating blood volume) is significant and is likely to produce signs and symptoms of shock with hypotension in this child.

Physiologic Reserves

- Infants and children have less glycogen stores and larger glucose requirements than adults. Hypoglycemia can result when the body's fuel sources have been depleted.
- Children have strong but limited cardiovascular reserves, which enables them to demonstrate little change in their HR or blood pressure despite moderate to profound blood or fluid loss. However, when their reserves are depleted, they decompensate quickly. It is easy to underestimate, or fail to recognize, the severity of a child's volume loss because of his or her ability to compensate.

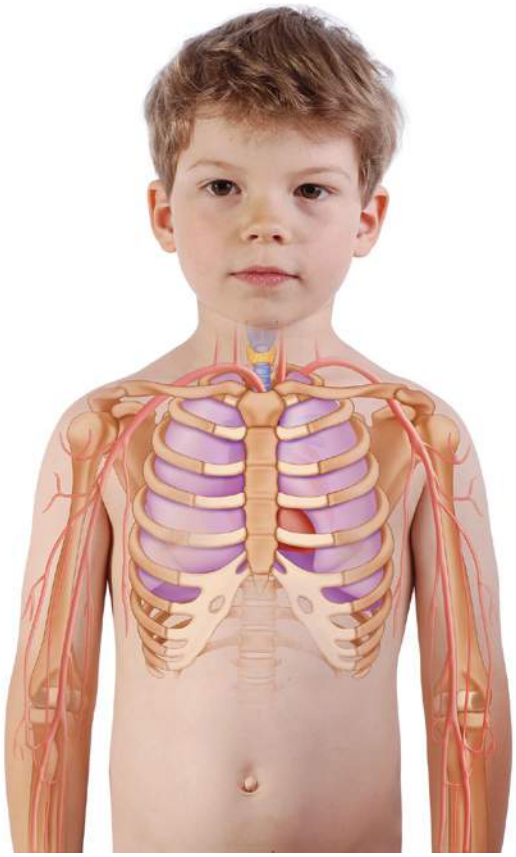


Figure 4-2 The circulating blood volume is proportionately larger in infants and children than in adults.

SHOCK

Adequate tissue perfusion requires an intact cardiovascular system. This includes an adequate fluid volume (the blood), a container to regulate the distribution of the fluid (the blood vessels), and a pump (the heart) with sufficient force to move the fluid throughout the container. A malfunction or deficiency of any of these components can affect perfusion. The signs and symptoms of shock vary depending on the cause of the shock and the response of multiple organs to changes in perfusion.

PALS Pearl

Different types of shock can occur together. For example, an inadequate fluid intake and fluid loss may contribute to hypovolemia in an already septic child.

Shock Severity

Shock is identified either by severity or by type. *Shock severity* refers to the effect of shock on blood pressure.

Compensated Shock

- Compensated shock, also called *early shock*, is inadequate tissue perfusion without hypotension (i.e., shock with a "normal" blood pressure).
- During compensated shock, the body's defense mechanisms attempt to preserve perfusion of the brain, heart, kidneys, and liver at the expense of nonvital organs (e.g., skin, muscles, gastrointestinal tract) (Turner & Cheifetz, 2016).
  - Baroreceptors in the carotid sinus respond to a drop in mean arterial pressure, which can occur because of a decrease in cardiac output, a decrease in circulating blood volume, or an increase in the size of the vascular bed. Compensatory responses include increases in HR, stroke volume, and vascular smooth muscle tone (Turner & Cheifetz, 2016).
  - Chemoreceptors in the medulla, carotid bodies, and aorta respond to changes in oxygen, carbon dioxide (CO_2), and pH levels in the body. Poor tissue perfusion can result in metabolic acidosis and the increased production of CO_2. The respiratory center responds to changes detected by the chemoreceptors (e.g., rise in CO_2 level, drop in pH) by increasing the ventilatory rate in an effort to blow off excess CO_2.
  - Additional compensatory mechanisms that help to maintain perfusion include the release of cortisol, activation of the renin-angiotensin-aldosterone system, the release of vasopressin from the posterior pituitary, and the redistribution of blood flow from the skin, muscles, and splanchnic viscera to the vital organs.
- Physical findings often include the following:
  - Neurologic changes such as restlessness, irritability, or confusion
  - Normal systolic blood pressure, narrowed pulse pressure
  - Mild increase in ventilatory rate
  - Normal HR to mild tachycardia
  - Strong central pulses; weak peripheral pulses
  - Pale mucous membranes
  - Mild decrease in urine output
  - Peripheral vasoconstriction: a compensatory mechanism that is seen with hypovolemic, cardiogenic, and obstructive shock, evidenced by cool, pale, extremities with weak pulses and delayed capillary refill. In contrast, peripheral vasodilation is usually present with early distributive shock, resulting in warm, pink extremities with bounding peripheral pulses and brisk capillary refill.
- The compensatory stage of shock is also called *reversible shock* because, at this stage, the shock syndrome is reversible with prompt recognition and appropriate intervention. If uncorrected, shock will progress to the next stage.

PALS Pearl

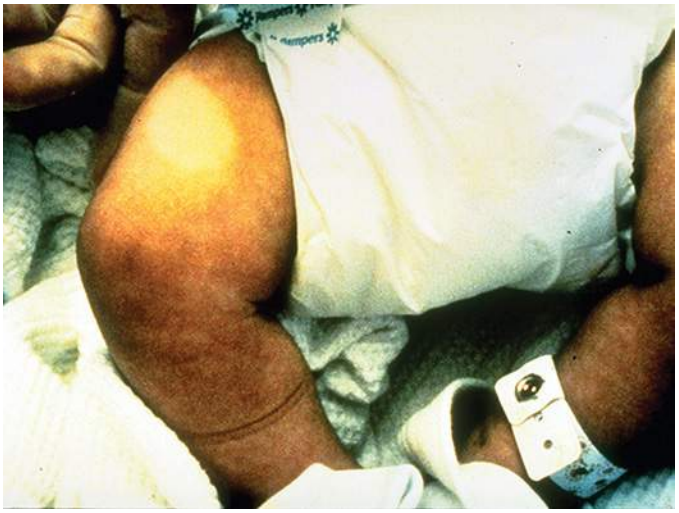
The initial signs of shock may be subtle in an infant or child. The effectiveness of compensatory mechanisms is largely dependent on the child's previous cardiac and pulmonary health. In the pediatric patient, the progression from compensated to hypotensive shock occurs suddenly and rapidly. When decompensation occurs, cardiopulmonary arrest may be imminent.

Hypotensive Shock

- Hypotensive shock, formerly called *decompensated shock*, begins when compensatory mechanisms begin to fail. During this stage of shock, the "classic" signs and symptoms of shock are evident because mechanisms previously used to maintain perfusion have become ineffective. **Table 4-1** shows the lower limit of normal systolic blood pressure by age.
- Physical findings often include the following:
  - Neurologic changes such as agitation or lethargy
  - Fall in systolic and diastolic blood pressures
  - Moderate increase in ventilatory rate, possible respiratory muscle fatigue or failure
  - Moderate tachycardia, possible dysrhythmias
  - Weak central pulses, thready peripheral pulses
  - Delayed capillary refill (**Figure 4-3**)
  - Pale or cyanotic mucous membranes
  - Marked decrease in urine output
- Hypotensive shock is difficult to treat, but is still reversible if appropriate aggressive treatment is begun. As shock progresses, the patient becomes refractory to therapeutic interventions and shock becomes irreversible. Hypotension worsens and cardiac dysrhythmias may develop as ventricular irritability increases. Cell membranes break down and release harmful enzymes. Irreversible damage to vital organs occurs because of sustained altered perfusion and metabolism, resulting in multisystem organ failure, cardiopulmonary arrest, and death.

Table 4-1 Lower Limit of Normal Systolic Blood Pressure by Age

Age	Lower Limit of Normal Systolic Blood Pressure
Term neonate (0 to 28 days)	More than 60 mm Hg or strong central pulse
Infant (1 to 12 months)	More than 70 mm Hg or strong central pulse
Child 1 to 10 years	More than 70 + (2 × age in years)
Child 10 years or older	More than 90 mm Hg



EMSC Slide Set (CD-ROM). 1996. Courtesy of the Emergency Medical Services for Children Program, administered by the U.S. Department of Health and Human Service's Health Resources and Services Administration, Maternal and Child Health Bureau.

Figure 4-3 Delayed capillary refill.

PALS Pearl

Pulse quality reflects the adequacy of peripheral perfusion. A weak central pulse may indicate hypotensive shock. A peripheral pulse that is difficult to find, weak, or irregular suggests poor peripheral perfusion and may be a sign of shock or hemorrhage.

Types of Shock

The four types of shock are hypovolemic, distributive (or vasogenic), cardiogenic, and obstructive (**Table 4-2**). Distinguishing between these types of shock can be done by considering the child's general appearance, vital signs, and physical examination findings, and linking that information with the child's history (**Box 4-1**).

Table 4-2 Types of Shock

Category	Cause	Examples
Hypovolemic	Sudden decrease in the circulating blood volume relative to the capacity of the vascular space	Hemorrhage, plasma loss, fluid and electrolyte loss, endocrine disease
Distributive	Altered vascular tone results in peripheral vasodilation, which increases the size of the vascular space and alters the distribution of the available blood volume, resulting in a relative hypovolemia	Severe infection (septic shock), severe allergic reaction (anaphylactic shock), or autonomic dysfunction secondary to spinal cord injury (neurogenic shock)
Cardiogenic	Impaired cardiac muscle function leads to decreased cardiac output and inadequate tissue oxygenation	Conduction abnormalities, cardiomyopathy, congenital heart disease
Obstructive	Obstruction to ventricular filling or the outflow of blood from the heart	Tension pneumothorax, massive pulmonary embolus, cardiac tamponade

Box 4-1 Key Assessment Areas for Patients at Risk of Shock

Mucous membrane color and moisture

Neurologic status

Pulse rate, rhythm, strength, and differences at central versus peripheral sites

Skin temperature, color, moisture, and turgor

Urine output

Ventilatory rate, depth, and rhythm

A history should be obtained as soon as possible from the parent or caregiver. The information acquired may help identify the type of shock present, establish the child's previous health, and determine the onset and duration of symptoms.

Hypovolemic Shock

- Hypovolemia is the most common cause of shock in infants and children worldwide (Turner & Cheifetz, 2016). **Hypovolemic shock** is a state of inadequate circulating blood volume relative to the capacity of the vascular space.
- Physiology: ↓ intravascular volume → ↓ preload → ↓ ventricular filling → ↓ stroke volume → ↓ cardiac output → inadequate tissue perfusion
- Hemorrhagic shock, which is a type of hypovolemic shock, is caused by severe internal or external bleeding. Possible causes of hemorrhagic shock in children are shown in **Box 4-2**.
- Hypovolemic shock may also be caused by a loss of plasma, fluids, and electrolytes, or by endocrine disorders.
  - Plasma loss: burns, third spacing (e.g., pancreatitis, peritonitis)
  - Fluid and electrolyte loss: renal disorder, excessive sweating (e.g., cystic fibrosis), diarrhea, vomiting
  - Endocrine disease: diabetes mellitus, diabetes insipidus, hypothyroidism, adrenal insufficiency

Box 4-2 Possible Causes of Hemorrhagic Shock in Children

Arterial bleeding
Gastrointestinal bleeding (e.g., esophageal varices, ulcers)
Intracranial bleeding in a newborn or infant
Large vessel injury
Long bone fracture
Pelvic fracture
Scalp laceration
Solid organ (e.g., liver, spleen) injury

Assessment Findings

The amount and the rapidity with which volume is lost affects the severity and number of signs and symptoms (**Table 4-3**).

- In addition to the findings noted in Table 4-3, injuries to the organs of the thorax may result in decreased or absent breath sounds on the affected side, dyspnea, and paradoxical chest wall motion. Abdominal distention, tenderness, and bruising of the abdominal wall may be present in a child who has experienced abdominal trauma.
- Hypovolemia resulting from nonhemorrhagic causes such as diarrhea or vomiting can result in signs and symptoms of

Table 4-3 Response to Volume Loss in the Pediatric Patient

	Class I	Class II	Class III	Class IV
% Blood volume loss	**Up to 15%**	**15% to 30%**	**30% to 45%**	**More than 45%**
Mental status	Slightly anxious	Mildly anxious; restless	Altered; lethargic; apathetic; decreased pain response	Extremely lethargic; unresponsive
Blood pressure	Normal	Lower range of normal	Decreased	Severe hypotension
Capillary refill	Normal	More than 2 seconds	Delayed (more than 3 seconds)	Prolonged (more than 5 seconds)
Heart rate	Normal or minimal tachycardia	Mild tachycardia	Significant tachycardia; possible dysrhythmias; peripheral pulse weak, thready, or may be absent	Marked tachycardia to bradycardia (preterminal event)
Muscle tone	Normal	Normal	Normal to decreased	Limp
Pulse pressure	Normal or increased	Narrowed	Decreased	Decreased
Skin color (extremities)	Pink	Pale, mottled	Pale, mottled, mild peripheral cyanosis	Pale, mottled, central and peripheral cyanosis
Skin temperature	Cool	Cool	Cool to cold	Cold
Skin turgor	Normal	Poor; sunken eyes and fontanels in infant/young child	Poor; sunken eyes and fontanels in infant/young child	Tenting
Urine output	Normal to concentrated	Decreased	Minimal	Minimal to absent
Ventilatory rate/effort	Normal	Mild tachypnea	Moderate tachypnea	Severe tachypnea to agonal (preterminal event)

dehydration. Research has suggested that four clinical findings can be used to assess dehydration: abnormal general appearance, capillary refill longer than two seconds, dry mucous membranes, and absent tears. The presence of any two of these four findings indicates a deficit of 5% or more, and three or more findings indicates a deficit of at least 10% (Gorelick, Shaw, & Murphy, 1997).

Emergency Care

- Emergency care is directed toward controlling fluid loss and restoring vascular volume.
- Perform an initial assessment. Obtain a focused history as soon as possible from the parent or caregiver to assist in identifying the etiology of shock.
- Initiate pulse oximetry and cardiac and blood pressure monitoring. Control external bleeding, if present. If ventilation is adequate, give supplemental oxygen in a manner that does not agitate the child. If signs of respiratory failure or respiratory arrest are present, assist ventilation using a bag-mask device with supplemental oxygen.
- Obtain vascular access. Venous access may be difficult to obtain in an infant or child in shock. When shock is present, the most readily available vascular access site is preferred. If immediate vascular access is needed and reliable intravenous (IV) access cannot be rapidly achieved, early intraosseous (IO) access is appropriate.
- After vascular access has been obtained, begin fluid resuscitation. After *each* fluid bolus, reassess the child's mental status, HR, blood pressure, capillary refill, peripheral perfusion, and urine output.
  - Administration of an initial 20 mL/kg fluid bolus of an isotonic crystalloid solution such as normal saline (NS) or lactated Ringer's (LR) is reasonable (de Caen et al., 2015). Generally, the administration of about 3 mL of crystalloid is needed to replace every 1 mL of blood lost (American Heart Association, 2011a). An IV tubing system that incorporates an in-line three-way stopcock is often useful for rapid fluid administration.
  - Assess the child's response after *each* bolus. Monitor closely for increased work of breathing and the development of crackles. Because excessive fluid administration can be harmful, some experts have recommended that transthoracic echocardiography in combination with clinical assessments be used to guide patient management (i.e., additional fluid boluses, fluid boluses using less volume, initiation of vasopressor therapy) (Polderman & Varon, 2015; Sirvent, Ferri, Baró, Murcia, & Lorencio, 2015).
  - Colloids are protein-containing fluids with large molecules that remain in the vascular space longer than crystalloid fluids. Colloids exert oncotic pressure and draw fluid out of the tissues and into the vascular compartment. Although colloids (such as albumin) are not routinely indicated during the initial management of hypovolemic shock, they may be ordered for volume replacement in children with large third-space losses or albumin deficits (American Heart Association, 2011a).
  - Blood products may need to be transfused when hemorrhage is the cause of volume loss. Consider a transfusion of packed red blood cells if the child remains unstable after two to three 20 mL/kg isotonic crystalloid fluid boluses (American Heart Association, 2011a).
  - Vasopressors (e.g., dopamine, norepinephrine, epinephrine) are generally considered only if shock remains refractory after 60 to 80 mL/kg of volume resuscitation (Turner & Cheifetz, 2016).
- Obtain a Focused Assessment with Sonography for Trauma (FAST) examination (i.e., bedside ultrasound) if the equipment is available and bleeding is suspected in the chest, abdomen, or pelvis.
- Check the serum glucose level. Some children in shock are hypoglycemic because of rapidly depleted carbohydrate stores. If the serum glucose is below 60 mg/dL, administer dextrose IV or IO (**Table 4-4**).
- Maintain normal body temperature.

Table 4-4 Dextrose

Classification	Carbohydrate
Mechanism of action	Main action is to replace glucose that is needed as the principal energy source for body cells; rapidly increases serum glucose concentration
Indications	Known or suspected hypoglycemia
Dosage	IV/IO: 0.5 to 1 g/kg Newborn: 5 to 10 mL/kg $D_{10}W$ Infants and children: 2 to 4 mL/kg $D_{25}W$ Adolescents: 1 to 2 mL/kg $D_{50}W$
Adverse effects	• Hyperglycemia • Extravasation leads to severe tissue necrosis • Cerebral edema when given IV undiluted
Notes	• Before administration, draw blood to determine the baseline serum glucose level. • Because extravasation can cause tissue necrosis, ensure the patency of the IV line before administration. • Diluting a 50% dextrose solution 1:1 with sterile water or normal saline = $D_{25}W$. Diluting 50% dextrose solution 1:4 with sterile water or normal saline = $D_{10}W$.

IO = intraosseous, IV = intravenous.

- Insert a urinary catheter. Urine output is a sensitive measure of perfusion status and the adequacy of therapy.
- Obtain appropriate diagnostic studies. Laboratory studies should include a complete blood count with differential, electrolytes, glucose, renal function tests, and coagulation studies. The patient should undergo computed tomography (CT) imaging of area(s) of suspected hemorrhage.

PALS Pearl

If a peripheral vein is used to administer a vasopressor, close monitoring of the intravenous site is essential because extravasation can result in tissue sloughing.

Distributive Shock

- Distributive shock, also called *vasogenic shock*, results from an abnormality in vascular tone. A relative hypovolemia occurs when vasodilation increases the size of the vascular space and the available blood volume must fill a greater space. This results in an altered distribution of the blood volume (relative hypovolemia) rather than actual volume loss (absolute hypovolemia).
- Physiology: ↓ peripheral vascular resistance → inadequate tissue perfusion → ↑ venous capacity and pooling → ↓ venous return to the heart → ↓ cardiac output
- Distributive shock may be caused by a severe infection (septic shock), a severe allergic reaction (anaphylactic shock), or a central nervous system injury (neurogenic shock).

PALS Pearl

Signs and symptoms of distributive shock that are unusual in the presence of hypovolemic shock include warm, flushed skin (especially in dependent areas), and, in neurogenic shock, a normal or slow pulse rate (relative bradycardia).

Septic Shock

- **Septic shock** is a physiologic response to infectious organisms or their by-products that results in cardiovascular instability and organ dysfunction. Septic shock is the most common type of distributive shock in children (American Heart Association, 2011b). Some experts have considered septic shock to be a combination of hypovolemic, cardiogenic, and distributive shock in which hypovolemia occurs because of intravascular fluid losses through capillary leak, cardiogenic shock results from the depressant effects of endotoxins on the myocardium, and distributive shock results from decreased systemic vascular resistance (Turner & Cheifetz, 2016).
- Septic shock occurs in two clinical stages.
  - The early phase is characterized by peripheral vasodilation (warm shock) caused by endotoxins that prevent catecholamine-induced vasoconstriction. During this phase, cardiac output increases in an attempt to maintain adequate oxygen delivery and meet the increased metabolic demands of the organs and tissues (Turner & Cheifetz, 2016).
  - As septic shock progresses, inflammatory mediators cause cardiac output to fall, which leads to a compensatory increase in peripheral vascular resistance that is evidenced by cool extremities (cold shock) (Turner & Cheifetz, 2016). Late septic shock is usually indistinguishable from other types of shock.

Assessment Findings

- Early (hyperdynamic, increased cardiac output) phase
  - Blood pressure may be normal; possible widened pulse pressure
  - Bounding peripheral pulses
  - Brisk capillary refill
  - Chills
  - Fever
  - Normal urine output
  - Tachypnea
  - Warm, dry, flushed skin
- The progression from increased to decreased cardiac output may occur quickly (in minutes or hours) or slowly (over a period of days) (Perkin, 1992).
- Late (hypodynamic/decompensated) phase
  - Altered mental status
  - Cool, mottled extremities
  - Delayed capillary refill
  - Diminished or absent peripheral pulses
  - Diminished urine output
  - Tachycardia

PALS Pearl

If you observe a change in mental status in a febrile child (inconsolable, inability to recognize parents, unarousable), *immediately* consider the possibility of septic shock.

Emergency Care

- The Surviving Sepsis Campaign provides clinicians with recommendations for managing severe sepsis and septic shock in adults and children (Dellinger et al., 2013). Emergency care is directed toward rapidly restoring hemodynamic stability, identifying and controlling the infectious organism, limiting the inflammatory response, supporting the cardiovascular system,

enhancing tissue perfusion, and ensuring nutritional therapy (Dellinger et al., 2013).

- Initial therapeutic endpoints of resuscitation of septic shock include a capillary refill of 2 seconds or less, normal blood pressure for age, normal pulses with no differential between peripheral and central pulses, warm extremities, urine output of more than 1 mL/kg per hour, and normal mental status (Dellinger et al., 2013).
- Ongoing care should be provided in a pediatric intensive care unit with central venous and arterial pressure monitoring and with access to additional resources.

- Perform an initial assessment and obtain a focused history.
- Initiate pulse oximetry and cardiac and blood pressure monitoring. Give supplemental oxygen if indicated. Assist ventilation using a bag-mask device with supplemental oxygen if indicated.
- Obtain vascular access and begin fluid resuscitation. An initial fluid bolus of 20 mL/kg of an isotonic crystalloid solution is suggested (de Caen et al., 2015). Carefully monitor for increased work of breathing, the development of crackles, or the development of hepatomegaly. Reassess the child's mental status, HR, blood pressure, capillary refill, peripheral perfusion, and urine output after *each* fluid bolus. Fluid boluses should be titrated to the goal of reversing hypotension, increasing urine output, and attaining normal capillary refill, peripheral pulses, and level of consciousness without inducing hepatomegaly or rales (Dellinger et al., 2013). Consider the use of transthoracic echocardiography in combination with clinical assessments to guide patient management (Polderman & Varon, 2015; Sirvent et al., 2015).
  - Current resuscitation guidelines recognize that children with septic shock may require inotropic support and mechanical ventilation in addition to fluid therapy. Because these therapies are not available in all settings, the administration of IV fluid boluses to children with febrile illness in settings with limited access to critical care resources should be undertaken with extreme caution because it may be harmful (de Caen et al., 2015).
  - Check the serum glucose level and the ionized calcium level and correct to normal values if indicated.
  - Administer a broad-spectrum antibiotic. Blood samples for culture should be obtained before giving antibiotics, but obtaining them should not delay antibiotic administration (Dellinger et al., 2013). Antimicrobials can be administered intramuscularly or orally if necessary until IV access is available (Dellinger et al., 2013).
  - If the child's response is poor despite fluid resuscitation (i.e., fluid-refractory shock), establish a second vascular access site. This site should be used for initial vasoactive medication therapy to improve tissue perfusion and blood pressure while continuing fluid resuscitation.
  - Norepinephrine is recommended for warm shock with a low blood pressure (Dellinger et al., 2013) (**Table 4-5**).
  - Dopamine is recommended for cold shock with a normal blood pressure (Dellinger et al., 2013) (**Table 4-6**). If perfusion does not rapidly improve with the administration of dopamine, begin an epinephrine or norepinephrine infusion (Dellinger et al., 2013).

Table 4-5 Norepinephrine

Trade name	Levophed
Classification	Catecholamine, vasopressor, sympathomimetic
Mechanism of action	• Norepinephrine stimulates alpha-adrenergic receptors, producing vasoconstriction and increasing peripheral vascular resistance. It also stimulates beta$_1$-adrenergic receptors, thereby increasing cardiac contractility and cardiac output.
Indications	Shock accompanied by hypotension that is unresponsive to fluid therapy
Dosage	IV/IO infusion: 0.1 to 2 mcg/kg per minute; begin infusion at 0.1 mcg/kg per minute and titrate slowly upward to desired clinical response (up to a maximum dose of 2 mcg/kg per minute)
Adverse effects	CNS: headache, anxiety, seizures CV: hypertension, tachycardia, bradycardia Resp: dyspnea
Notes	• Should be administered via an infusion pump into a central vein to reduce the risk of necrosis of the overlying skin from prolonged vasoconstriction. Check the IV/IO site frequently. • Continuously monitor the patient's ECG during administration. • Check BP every 2 minutes until stabilized at the desired level. Check every 5 minutes thereafter during therapy.

BP = blood pressure, CNS = central nervous system, CV = cardiovascular, ECG = electrocardiogram, IO = intraosseous, IV = intravenous, Resp = respiratory.

Table 4-6 Dopamine

Trade name	Intropin, Dopastat
Classification	Direct- and indirect-acting sympathomimetic, cardiac stimulant and vasopressor; natural catecholamine
Mechanism of action	• Naturally occurring immediate precursor of norepinephrine in the body • Dopamine's effects vary depending on its rate of infusion. When infused at low doses (less than 5 mcg/kg per minute), dopamine increases renal and mesenteric flow, thereby improving perfusion to these organs. At medium doses (rates of 5 to 15 mcg/kg per minute), dopamine increases cardiac contractility and thereby increases cardiac output, with little effect on vascular resistance. When infused at higher doses (20 mcg/kg per minute and higher), dopamine acts as a vasopressor, causing arteriolar vasoconstriction, which increases peripheral vascular resistance.
Indications	Hemodynamically significant hypotension (e.g., cardiogenic shock, distributive shock)
Dosage	IV/IO infusion: 2 to 20 mcg/kg per minute; titrate to improve BP and perfusion
Contraindications	• Hypersensitivity to sulfites • Hypovolemia • Pheochromocytoma • Uncorrected tachydysrhythmias
Adverse effects	CNS: headache CV: palpitations, dysrhythmias (especially tachycardia) GI: nausea, vomiting Other: tissue sloughing with extravasation
Notes	• Continuously monitor vital signs and BP during administration. • Correct volume deficits before dopamine therapy. • Extravasation into surrounding tissue may cause necrosis and sloughing. • Infuse through a central line or large vein using an infusion pump.

BP = blood pressure, CNS = central nervous system, CV = cardiovascular, GI = gastrointestinal, IO = intraosseous, IV = intravenous.

PALS Pearl

Inotropes, vasopressors, and vasodilators are types of vasoactive medications. Inotropes such as dopamine, epinephrine, dobutamine, and milrinone increase contractility, thereby increasing cardiac output. Vasopressors such as dopamine, norepinephrine, epinephrine, and vasopressin increase peripheral vascular resistance. Vasodilators such as nitroprusside and nitroglycerin decrease peripheral vascular resistance. The effects of some of these medications vary depending on the rate at which they are infused.

- Epinephrine is recommended for cold shock with a low blood pressure (Dellinger et al., 2013) (**Table 4-7**).

- Consider the need for insertion of an advanced airway.
  - Infants and young children with severe sepsis may require early intubation because of their relatively reduced functional residual capacity, increased oxygen consumption, immature intercostal and diaphragmatic muscles, and inefficient intercostal muscle positioning (Cho & Rothrock, 2008).
  - Fluid resuscitation is recommended before intubation. This is because intubation and mechanical ventilation can increase intrathoracic pressure, reduce venous return, and lead to worsening shock if the patient is not volume loaded (Dellinger et al., 2013).
- Treat fever with medications and cooling devices as needed.
- If the child remains in shock despite the infusion of norepinephrine, dopamine, or epinephrine (i.e., catecholamine-resistant shock), the patient is at risk for adrenal insufficiency. Obtain a serum cortisol level. Stress-dose hydrocortisone therapy is recommended for children with known or suspected adrenal insufficiency (e.g., adrenal disorder, chronic steroid medication therapy, central nervous system disorders, or purpura that suggests meningococcemia) (Dellinger et al., 2013).

Table 4-7 Epinephrine Infusion

Trade name	Adrenalin
Classification	Catecholamine, sympathomimetic, vasopressor
Mechanism of action	Stimulates alpha and beta adrenergic receptors
Indications	Continued shock after volume resuscitation
Dosage	IV/IO infusion: Start at 0.1 mcg/kg per minute and titrate according to patient response up to 1 mcg/kg per minute.
Adverse effects	CNS: anxiety, restlessness, dizziness, headache CV: palpitations, dysrhythmias (especially tachycardia), hypertension GI: nausea, vomiting Other: hyperglycemia, tissue sloughing with extravasation
Notes	• Continuous monitoring of the patient's ECG and oxygen saturation and frequent monitoring of the patient's vital signs is essential. • Infuse by means of an infusion pump and preferably through a central line. • Check the IV/IO site frequently for evidence of tissue sloughing. • Because of its beta-adrenergic stimulating effects, epinephrine acts as a potent inotropic agent when infused at low infusion rates (less than 0.3 mcg/kg per minute) (Turner & Cheifetz, 2016). When infused at higher rates (more than 0.3 mcg/kg per minute), epinephrine acts as a vasopressor, stimulating alpha-adrenergic receptors, producing vasoconstriction, and increasing peripheral vascular resistance.

CNS = central nervous system, CV = cardiovascular, ECG = electrocardiogram, GI = gastrointestinal, IO = intraosseous, IV = intravenous.

Anaphylactic Shock

Anaphylaxis is an acute allergic reaction that results from the release of chemical mediators (e.g., histamine) after exposure to an allergen. Common causes include foods (e.g., eggs, shellfish, milk, nuts), insect stings (e.g., bees, wasps, ants), medications (e.g., penicillin, aspirin, sulfa), and environmental agents (e.g., pollen, animal hair, latex).

Assessment Findings

Anaphylaxis typically affects multiple body systems, with cutaneous symptoms being the most common, followed by respiratory symptoms. Possible signs and symptoms include the following:

- Cardiovascular system: tachycardia, hypotension, shock, dysrhythmias
- Gastrointestinal system: abdominal cramping, diarrhea, nausea, vomiting
- Integumentary system: flushing, angioedema, pruritus (itching), urticaria (hives) (**Figure 4-4**)
- Neurologic system: anxiety, apprehension, restlessness, headache, confusion, dizziness, seizure, syncope, sense of impending doom
- Respiratory system: coughing, hoarseness, laryngeal edema, nasal congestion, shortness of breath, stridor, wheezing, intercostal and suprasternal retractions

Figure 4-4 Hives.

Emergency Care

- Emergency care is directed toward maintaining an open airway, reversing or blocking the effects of chemical mediators, supporting oxygenation and ventilation, and maintaining effective circulation.
- Perform an initial assessment and obtain a focused history. Remove/discontinue the causative agent.

- Initiate pulse oximetry and cardiac and blood pressure monitoring. If ventilation is adequate, give supplemental oxygen in a manner that does not agitate the child. If breathing is inadequate, ventilate using a bag-mask device with supplemental oxygen.
- The mainstay of treatment of anaphylaxis is the intramuscular (IM) administration of epinephrine (see Table 2-5). Epinephrine constricts blood vessels, reduces the release of inflammatory mediators from mast cells and basophils, dilates bronchial smooth muscle, and increases cardiac contractility. An epinephrine auto-injector may be used if it is available. The site of choice is the anterolateral aspect of the thigh. If symptoms persist or recur after 15 minutes, a second dose or an epinephrine infusion may be needed.
- Obtain vascular access and give 20 mL/kg fluid boluses of NS or LR as needed to support circulation (Gausche-Hill & Buitenhuys, 2012). Repeat the primary assessment after *each* fluid bolus. Closely monitor for increased work of breathing and the development of crackles.
- Consider inhaled bronchodilator therapy (e.g., albuterol) for bronchospasm (see Table 2-6).
- Administer other medications to help stop the inflammatory reaction (e.g., parenteral antihistamines, systemic corticosteroids).
- Discharge planning should include information about the agent that caused the anaphylaxis and possible methods to avoid it, information about the importance of wearing medical alert identification with regard to the allergy, and an anaphylaxis emergency treatment kit (i.e., an epinephrine auto-injector) with instructions for use.

Neurogenic Shock

- Neurogenic shock results from a disruption in the ability of the sympathetic division of the autonomic nervous system to control vessel dilation and constriction. The loss of sympathetic tone is most common when the disruption occurs at the sixth thoracic vertebrae (T6) or higher. Neurogenic shock may occur because of general anesthesia, spinal anesthesia, or a severe injury to the head or spinal cord such as a brainstem injury or a complete or incomplete spinal cord injury.
- Physiology: widespread arterial and venous vasodilation → ↓ peripheral vascular resistance → ↓ venous return → ↓ preload → ↓ stroke volume → ↓ cardiac output → ↓ blood pressure → ↓ tissue perfusion → impaired cellular metabolism. A relative hypovolemia exists because the total blood volume remains the same, but blood vessel capacity is increased.

Assessment Findings

- Signs and symptoms typically include hypotension with a wide pulse pressure, normal capillary refill, and an HR that is either within normal limits or is bradycardic. With most forms of shock, hypotension is usually accompanied by a compensatory increase in HR. With neurogenic shock, the patient does not become tachycardic because sympathetic activity is disrupted.
- The skin is initially warm and dry. Hypothermia may develop because of widespread vasodilation and heat loss (Mack, 2013).

Emergency Care

- Emergency care focuses on supporting oxygenation and ventilation, maintaining normal body temperature, and maintaining effective circulation.
- Perform an initial assessment and obtain a focused history. If trauma is suspected, maintain cervical spine stabilization until cervical spine injury is ruled out by history, examination, radiographs, computed tomography, or magnetic resonance imaging (MRI). If it is necessary to open the airway, use a jaw thrust without neck extension maneuver.
- Perform baseline and ongoing neurologic assessments.
- Initiate pulse oximetry and cardiac and blood pressure monitoring. If ventilation is adequate, give supplemental oxygen in a manner that does not agitate the child. If breathing is inadequate, ventilate using a bag-mask device with supplemental oxygen.
- Obtain vascular access. Consider careful administration of 20 mL/kg isotonic crystalloid fluid boluses (Gausche-Hill & Buitenhuys, 2012). Repeat the primary assessment after *each* fluid bolus to assess the child's response. Monitor closely for increased work of breathing and the development of crackles. Because the primary problem in neurogenic shock is a loss of sympathetic tone and not actual volume loss, the infusion of selective vasopressors (e.g., norepinephrine, epinephrine) may be more effective than fluid administration in increasing vascular resistance and improving perfusion (Gausche-Hill & Buitenhuys, 2012).
- Careful monitoring of the child's body temperature is important. Warming or cooling measures may be needed to maintain normal body temperature.

Cardiogenic Shock

- Cardiogenic shock results from impaired cardiac muscle function that leads to decreased cardiac output and inadequate tissue perfusion. The patient's initial clinical presentation may be identical to hypovolemic shock.
- Physiology: ↓ cardiac output → ↑ peripheral vascular resistance → ↑ afterload → ↑ myocardial oxygen requirements → ↓ cardiac output → ↓ blood pressure → ↓ coronary perfusion pressure → ↓ tissue perfusion → impaired cellular metabolism → progressive myocardial dysfunction
- Arrhythmogenic cardiogenic shock (**Box 4-3**) results from a heart rate that is either too fast or too slow to sustain a sufficient cardiac output (Gausche-Hill & Buitenhuys, 2012).
- Cardiogenic shock may also result from redirected blood flow caused by congenital anatomic heart lesions in which myocardial

Box 4-3 Possible Causes of Arrhythmogenic Cardiogenic Shock in Children

Atrial fibrillation
Atrial flutter
Atrial tachycardia
Idioventricular rhythm
Junctional bradycardia
Junctional tachycardia
Preexcitation syndromes
Second- or third-degree atrioventricular block
Sinus arrest
Sinus bradycardia
Supraventricular tachycardia
Toxic exposure (e.g., beta-blockers, cholinergics)
Ventricular tachycardia (e.g., monomorphic, polymorphic)

contractility may be impaired (**Box 4-4**), inflammatory disorders (**Box 4-5**), obstructive lesions (e.g., cardiac tamponade, severe pulmonary embolus), or other conditions (e.g., acute and chronic drug toxicity, acute valvular regurgitation, commotio cordis, ischemic heart disease, myocardial injury, pheochromocytoma, thyrotoxicosis).

Box 4-4 Congenital Heart Lesions That May Cause Cardiogenic Shock in Children

Atrial-septal defect
Critical aortic stenosis
Coarctation of the aorta
Hypertrophic cardiomyopathy
Hypoplastic left heart syndrome
Patent ductus arteriosus
Tetralogy of Fallot
Transposition of the great arteries
Tricuspid atresia
Ventricular-septal defect

Box 4-5 Inflammatory Conditions That May Contribute to Cardiogenic Shock in Children

Acute rheumatic fever
Juvenile rheumatoid arthritis
Kawasaki disease
Myocarditis
Pericarditis
Systemic lupus erythematosus

Assessment Findings

- Altered mental status
- Cool extremities
- Decreased urine output
- Hepatomegaly
- Hypotension
- Increased work of breathing
- Increasing pulmonary congestion and crackles
- Neck vein distention
- Pale, mottled, or cyanotic skin
- Peripheral edema
- Poor feeding
- Tachycardia
- Weak, thready, or imperceptible peripheral pulses

Emergency Care

- Emergency care focuses on reducing myocardial oxygen demand, improving preload, reducing afterload, improving contractility, and correcting dysrhythmias. Because management of the patient with cardiogenic shock can be difficult and complex, consultation with specialists should be sought as needed.
- Perform an initial assessment and obtain a focused history.
- Initiate pulse oximetry and cardiac and blood pressure monitoring. If ventilation is adequate, give supplemental oxygen in a manner that does not agitate the child. If breathing is inadequate, ventilate using a bag-mask device with supplemental oxygen.
- Obtain vascular access.
- Obtain a 12-lead electrocardiogram (ECG). Treat dysrhythmias if they are present and contributing to shock.
- Invasive hemodynamic monitoring can be helpful when determining the best pharmacological approach for the patient.
  - If indicated, preload may be optimized with administration of a *small* fluid bolus (5 to 10 mL/kg) given over 10 to 20 minutes accompanied by careful monitoring of mental status, lung sounds, work of breathing, and signs of hepatic congestion that indicate volume overload.
  - The patient who has significant hypotension and is unresponsive to fluid resuscitation or who becomes volume overloaded may require vasopressors to increase blood pressure.
  - Inotropic agents may be ordered to improve myocardial contractility. These medications must be carefully titrated to minimize increases in myocardial oxygen demand.
  - After the blood pressure has been stabilized, vasodilators may be ordered to decrease both preload and afterload.
- Obtain laboratory and diagnostic studies. Obtain a point-of-care glucose level and a complete blood count. An arterial blood gas should be obtained to assess the adequacy of oxygenation and ventilation. Obtain a chest radiograph to help differentiate cardiogenic from noncardiogenic shock and to identify the presence of a pulmonary infection, cardiomegaly, pulmonary edema, or evolving acute respiratory distress syndrome. An echocardiogram is helpful in assessing systolic and diastolic function, congenital lesions, and valvular abnormalities.

- Refractory cardiogenic shock may require mechanical support with extracorporeal membrane oxygenation (ECMO) or a ventricular assist device (VAD).
- Arrange for the patient's transfer to a pediatric intensive care unit for ongoing care.

PALS Pearl

Epinephrine, norepinephrine, and dopamine (at high doses) are examples of inotropic agents that have a vasoconstrictor effect on the peripheral vasculature. Dopamine (at low doses), isoproterenol, dobutamine, amrinone, and milrinone are examples of inotropic agents that have a vasodilator effect on the peripheral vasculature.

Obstructive Shock

- Obstructive shock occurs when low cardiac output results from an obstruction to ventricular filling or to the outflow of blood from the heart. The patient's initial clinical presentation may be identical to hypovolemic shock.
- Physiology: blood flow obstruction → ↓ ventricular filling → ↓ cardiac output → ↓ blood pressure → ↓ tissue perfusion → impaired cellular metabolism
- Possible causes of obstructive shock include cardiac tamponade, tension pneumothorax, ductal-dependent congenital heart lesions, and massive pulmonary embolism.
  - With cardiac tamponade, excessive fluid builds up in the pericardial sac that surrounds the heart, resulting in reduced ventricular filling, a decrease in stroke volume, and a subsequent decrease in cardiac output.
  - With a tension pneumothorax, air enters the pleural space on inspiration but cannot escape. Intrathoracic pressure increases and the lung on the affected side collapses. Air under pressure shifts the mediastinum away from the midline, toward the unaffected side. As intrathoracic pressure increases, the inferior vena cava becomes compressed, decreasing venous return and decreasing cardiac output.
  - With ductal-dependent congenital heart lesions, pulmonary or systemic blood flow decreases as the ductus arteriosus constricts and closes. Right-sided obstructive lesions (e.g., tricuspid atresia, pulmonary atresia, transposition of the great arteries) require an open ductus arteriosus to provide adequate pulmonary blood flow (Mastropietro, Tourner, & Sarnaik, 2008). Obstructive lesions of the left side of the heart (e.g., hypoplastic left ventricle, coarctation of the aorta, interrupted aortic arch) require an open ductus arteriosus to maintain adequate systemic blood flow (Mastropietro et al., 2008).
  - With a massive pulmonary embolism, a thrombus lodges in the pulmonary artery causing a partial or total obstruction. Because there are lung segments that are ventilated but not perfused, a ventilation-perfusion mismatch results.

Assessment Findings

Assessment findings are dependent on the cause of the obstruction.

- Cardiac tamponade: altered mental status, Beck triad (distended neck veins, hypotension, muffled or diminished heart sounds), dyspnea, narrowed pulse pressure, pulsus paradoxus, tachycardia, weak or absent peripheral pulses
- Tension pneumothorax: altered mental status, diminished or absent breath sounds on the affected side, distended neck veins (may be absent if hypovolemia present or hypotension is severe), hyperresonance of the affected side on percussion, hypotension, increased airway resistance when ventilating the patient (poor bag compliance), marked respiratory distress, progressively worsening dyspnea, pulsus paradoxus, tachycardia, tachypnea, tracheal deviation toward the contralateral side (may or may not be present)
- Ductal-dependent congenital heart lesions: see **Table 4-8**
- Massive pulmonary embolism: acute dyspnea, cough, hemoptysis, hypoxia, pleuritic chest pain

Emergency Care

Emergency care focuses on supporting oxygenation and ventilation and maintaining effective circulation.

- Perform an initial assessment and obtain a focused history.
- Initiate pulse oximetry and cardiac and blood pressure monitoring. If ventilation is adequate, give supplemental oxygen in a manner that does not agitate the child. If breathing is inadequate, assist ventilation using a bag-mask device with supplemental oxygen.
- Obtain vascular access and appropriate laboratory studies.
- Further management of obstructive shock depends on the cause. Seek consultation with specialists as needed.
  - Diagnostic studies such as bedside or transthoracic ultrasonography are helpful in diagnosing cardiac tamponade; pericardiocentesis is the definitive treatment for this condition. Aggressive volume expansion is controversial, especially in normovolemic or hypervolemic children, because fluid resuscitation may worsen tamponade (Perkin et al., 2013).

Table 4-8 Possible Assessment Findings with Ductal-Dependent Heart Lesions

Obstructive Lesions of the Right Side of the Heart	Obstructive Lesions of the Left Side of the Heart
Cyanosis	Cold, clammy, mottled skin
Dyspnea	Decreased lower extremity pulses
Feeding difficulty	Decreased urine output
Tachypnea	Poor feeding
	Progressive dyspnea

- Although diagnostic studies such as a chest radiograph, bedside ultrasound, or computed tomography are helpful in diagnosing a pneumothorax, the diagnosis is often made clinically. Management of a tension pneumothorax includes immediate needle decompression of the affected side followed by thoracostomy tube placement.
  - Needle decompression, also called *needle thoracostomy*, should be performed by a trained individual using a 14- or 16-gauge catheter-over-needle (a smaller gauge may be used for infants and young children).
  - After identifying the second intercostal space in the midclavicular line of the affected side, the skin is cleansed, the protective covering is removed from the needle, and the needle is inserted at a 90° angle to the chest wall through the skin and over the top of the third rib (second intercostal space).
  - Entry into the pleural space is evidenced by one or more of the following: a "popping" sound or "giving way" sensation, a sudden rush of air, or the ability to aspirate air into a syringe (if used). Then remove and appropriately discard the needle, leaving the catheter in place. The catheter is secured to the patient's chest wall to prevent dislodgement.
  - Assess the patient's response to the procedure by evaluating work of breathing, breath sounds, ventilatory rate, oxygen saturation, heart rate, and blood pressure.
  - Definitive treatment of a tension pneumothorax requires insertion of a chest tube, after which the needle thoracostomy catheter may be removed. After the procedure, obtain a chest radiograph to assess for lung reexpansion and evaluate thoracostomy tube position.
- Immediate management of an infant with signs of decompensation caused by a ductal-dependent congenital heart lesion typically requires an IV infusion of prostaglandin E_1 (PGE_1), which chemically opens the ductus arteriosus. In addition to diagnostic studies such as echocardiography, the administration of inotropic agents and other supportive care may be indicated.
- Management of a massive pulmonary embolism includes obtaining diagnostic studies such as an echocardiogram, computed tomography, or angiography as well as the administration of fibrinolytics to dissolve the clot, anticoagulation therapy, and possible surgical intervention.

LENGTH-BASED RESUSCITATION TAPE

- When caring for the pediatric patient, treatment interventions are usually based on the weight of the child. As a result, a range of age- and size-appropriate equipment (including bags and masks, endotracheal tubes, and IV catheters) must be readily available for use in pediatric emergencies. The equipment and supplies must be logically organized, routinely checked, and readily available.
- Studies have documented unreliability at estimating children's weights, a high rate of errors made when performing drug calculations, and a loss of valuable resuscitation time secondary to computing drug dosages and selecting equipment. Use the child's weight, if it is known, to calculate the dosage of resuscitation medications. If the child's weight is unknown, a length-based resuscitation tape with precalculated dosages may be used.
- Length-based resuscitation tapes may be used to estimate weight by length and simplify selection of the medications and supplies needed during the emergency care of children. The tape assigns children to a color zone with precalculated drug dosages, fluid volumes, vital signs, and equipment sizes appearing in each zone based on their length. If the child is taller than the tape, standard adult equipment and medication dosages are used.

PALS Pearl

Upon revision of the resuscitation guidelines every five years, be sure to closely examine the resuscitation tapes in use and determine if they should be replaced.

VASCULAR ACCESS

In the management of cardiopulmonary arrest and hypotensive shock, the preferred vascular access site is the largest, most readily accessible vein (Perkin et al., 2013). If no IV is in place at the onset of a cardiac arrest, the intraosseous route is useful as the initial means of vascular access.

Peripheral Venous Access

- Peripheral venous access is an effective route for fluid and medication administration that does not require interruption of resuscitation efforts. The peripheral route is acceptable during resuscitation if it can be achieved rapidly (Kleinman et al., 2010).
- Sites used for peripheral IV access in children include the hand, foot, arm, leg, or scalp (in infants younger than 9 months) (**Figure 4-5**). Peripheral veins are generally small in diameter and may be difficult to cannulate in an ill infant or a child who is dehydrated, in shock, or who is experiencing a cardiac arrest. Possible complications of peripheral venous access and IV fluid therapy appear in **Box 4-6**.

Intraosseous Infusion

- Intraosseous Infusion (IOI) is the process of infusing medications, fluids, and blood products into the bone marrow cavity. Because the marrow cavity is continuous with the venous circulation, fluids and medications administered by the IO route are subsequently delivered to the venous circulation.

Courtesy of Barbara Aehlert.

Figure 4-5 The veins of the hand are among the sites used for intravenous access in children.

Box 4-6 Possible Complications of Peripheral Venous Access and Intravenous Fluid Therapy

Air or catheter embolism
Cellulitis
Circulatory overload
Extravasation
Flare reactions (transient chemical phlebitis)
Hematoma
Inadvertent arterial puncture
Infection
Infiltration
Necrosis and skin sloughing from extravasation of sclerosing agents into surrounding tissue
Nerve damage
Phlebitis
Thrombosis

- An IOI should be established when peripheral IV access cannot be rapidly achieved (**Box 4-7**). Manual pressure, a syringe, a pressure infuser bag (alternately, a blood pressure cuff inflated at 300 mm Hg may be used), or an infusion pump should be used when administering viscous medications or rapid fluid boluses.

Box 4-7 Clinical Indications for Intraosseous Infusion

Anaphylaxis
Cardiac arrest
Edema or obesity in small children
Intravenous drug abuse
Loss of peripheral veins because of previous intravenous therapy
Massive trauma or major burns
Sepsis
Severe dehydration
Shock with vascular collapse
Status epilepticus

- IOI is considered a temporary means of vascular access because it is presumed that the longer the needle remains in place, the greater the risk of infection and possible dislodgment. The manufacturers of some IO devices recommend removal of the IOI within 24 hours. Venous access is often easier to obtain after initial fluid and medication resuscitation by means of the IO route.
- Several IOI devices are available including the EZ-IO (Teleflex Incorporated, Shavano Park, TX), the FAST-1 Intraosseous Infusion System (PYNG Medical Corporation, Richmond, British Columbia, Canada), the Bone Injection Gun (BIG; Waismed, Yokenam, Israel), the Sur-Fast Hand-Driven Threaded-Needle (Cook Critical Care, Bloomington, IL), and the Jamshidi Straight-Needle (Allegence Health Care, McGaw Park, IL).
- Possible sites for IO access are shown in **Table 4-9** and contraindications related to IO access appear in **Table 4-10**.
- The technique used for IO needle insertion depends on whether the IO needle is inserted manually or with a powered insertion device.
  - The operator determines the force required and the depth of insertion when manually inserting an IO needle.
  - When a powered insertion device such as the Bone Injection Gun is used, the operator adjusts the penetration depth of the IO needle according to the patient's age. The device's spring-loaded handle then injects the needle at the preset depth.
  - The EZ-IO is a battery-powered insertion device with three 15-gauge needles of varying lengths and colors. The operator selects the needle length to be used based on the tissue depth that overlies the intended insertion site.
  - Regardless of the powered device used, be sure to follow the manufacturer's instructions for IO needle insertion and subsequent removal.

PALS Pearl

After administering a medication by means of the intraosseous route, deliver a small fluid flush to ensure that the medication is pushed out of the medullary space and into the central circulation.

Table 4-9 Common Pediatric Intraosseous Infusion Sites

Bone	Insertion Site	Draining Vessel	Comments
Proximal tibia	1 to 3 cm (about the width of 1 to 2 fingers) below and medial to the tibial tuberosity on the flat surface of the tibia	Popliteal vein	Thin layer of skin covers the broad flat surface of the bone; it may be difficult to locate the tibial tuberosity in children younger than 2 years; avoid the growth plate during IO needle insertion
Distal tibia	1 to 2 cm proximal to the medial malleolus in the midline	Great saphenous vein	Thin layer of bone and overlying tissues; avoid the growth plate during IO needle insertion
Distal femur	2 to 3 cm above the femoral condyles in the midline	Branches of the femoral vein	Thick layer of muscle and fat in this area makes palpation of bony landmarks difficult; the bony cortex becomes thicker and more difficult to penetrate after 6 years of age; avoid the growth plate during IO needle insertion
Head of humerus	About two finger widths below the coracoid process and the acromion	Axillary vein	Readily accessible; may be used in older children and adolescents; the patient's forearm should be resting on his or her abdomen and the elbow should be close to the body (adducted)

IO = intraosseous

Table 4-10 Intraosseous Infusion—Contraindications

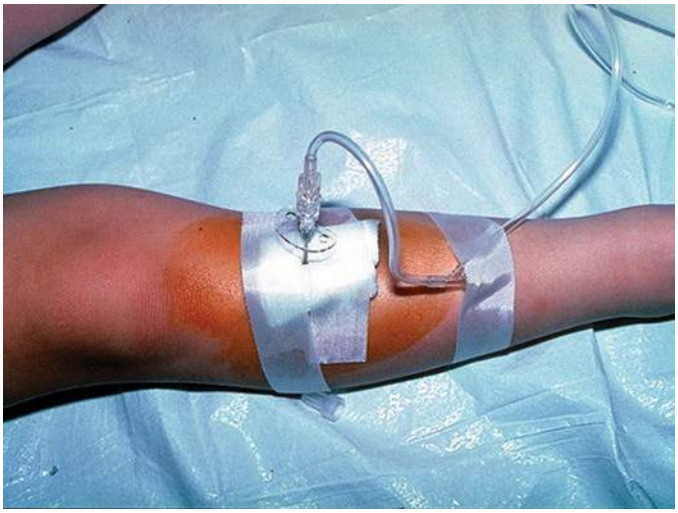
Contraindication	Rationale
Brittle bones (e.g., osteogenesis imperfecta, osteoporosis, osteopetrosis)	High potential for bone fracture
Crush injury of the extremity selected for IO infusion	Possible infiltration or extravasation of fluid into surrounding tissue
Excessive tissue or swelling over the intended IO infusion site	Inability to locate anatomical landmarks
Infection at the selected IO insertion site	Potential risk of spreading infection
Ipsilateral extremity fracture	Risk of infiltration or extravasation and compartment syndrome
Presence of a surgical scar (indicative of a previous orthopedic procedure) near the intended IO insertion site	Potential for presence of a titanium appliance, which cannot be penetrated with an IO needle
Previous IO insertion or attempted insertion within the past 24 hours on the same bone	Possible infiltration or extravasation of fluid into surrounding tissue through the previous puncture site
Recent fracture of the bone selected for IO infusion	Possible infiltration or extravasation of fluid into surrounding tissue through the fracture site

IO = intraosseous.

Accessing the Proximal Tibia

- When using the proximal tibia for IO access, begin by assembling all necessary equipment. Place the infant or child in a supine position. Position the leg with the knee slightly bent with slight external rotation. Place a towel roll behind the knee to provide support and to optimize positioning.
- Identify the landmarks for needle insertion. Palpate the tibial tuberosity. The site for IO insertion lies 1 to 3 cm below this tuberosity on the medial flat surface of the anterior tibia.
- Cleanse the intended insertion site with chlorhexidine, povidone-iodine, or an alcohol-based antibacterial solution according to agency or institutional policy. Local anesthesia should be used if the child is responsive or semiresponsive.
- Stabilize the patient's leg to guard against unexpected patient movement. With the needle angled away from the joint (i.e., toward the toes), insert the needle using gentle but firm pressure. Angling away from the joint reduces the likelihood of damage to the epiphyseal growth plate. Firm pressure pushes the needle through the skin and subcutaneous tissue.
- Advance the needle using a twisting motion until a sudden decrease in resistance or a "pop" is felt as the needle enters the marrow cavity. A twisting motion is necessary to advance the needle through the periosteum of the bone.

- Remove the stylet from the needle, attach a saline-filled syringe to the needle, and attempt to aspirate bone marrow into the syringe. If aspiration is successful, slowly inject a small amount of saline to clear the needle of marrow, bone fragments, and/or tissue. Observe for any swelling at the site, paying particular attention to the dependent tissue of the extremity. If aspiration is unsuccessful, consider other indicators of correct needle position:
  - The needle stands firmly without support.
  - A sudden loss of resistance occurs upon entering the marrow cavity (this is less obvious in infants than in older children because infants have soft bones).
  - Fluid flows freely through the needle without signs of significant swelling of the subcutaneous tissue.
- If signs of infiltration or extravasation are present, remove the IO needle and attempt the procedure at another site. **Infiltration** is the inadvertent administration of a *nonvesicant* (nonirritating to human tissue) solution or medication into surrounding tissue because of catheter dislodgment. **Extravasation** is the inadvertent administration of a *vesicant* (irritating to human tissue) solution or medication into surrounding tissue because of catheter dislodgment. If no signs of infiltration or extravasation are present, attach standard IV tubing. Manual pressure, a syringe, a pressure infuser, or an IV infusion pump may be needed to infuse fluids.
- Secure the needle and tubing in place with gauze padding and tape (**Figure 4-6**). Observe the site every 5 to 10 minutes for the duration of the infusion. Monitor for signs of infiltration or extravasation and assess distal pulses.



EMSC Slide Set (CD-ROM). 1996. Courtesy of the Emergency Medical Services for Children Program, administered by the U.S. Department of Health and Human Service's Health Resources and Services Administration, Maternal and Child Health Bureau.

Figure 4-6 The proximal tibia is among the sites used for pediatric intraosseous access.

PUTTING IT ALL TOGETHER

The chapter quiz and case studies presented on the following pages are provided to help you integrate the information presented in this chapter.

Chapter Quiz

Multiple Choice

Identify the choice that best completes the statement or answers the question.

____ 1. Which of the following is the most common type of distributive shock in children?

a. Septic shock
b. Anaphylaxis
c. Neurogenic shock
d. Cardiac tamponade

____ 2. Which of the following statements is true?

a. A narrowed pulse pressure reflects decreased peripheral vascular resistance.
b. In children, the strength of peripheral pulses increases as cardiac output decreases.
c. Hypotension is an early sign of cardiovascular compromise in an infant or child.
d. Skin mottling and cool extremities are early indicators of decreased tissue perfusion.

____ 3. Which of the following medications are examples of inotropic agents that have a vasoconstrictor effect on the peripheral vasculature?

a. Dobutamine and amrinone
b. Isoproterenol and milrinone
c. Epinephrine and norepinephrine
d. Norepinephrine and isoproterenol

____ 4. Which of the following findings would **NOT** be expected in the early (hyperdynamic) phase of septic shock?

a. Fever
b. Brisk capillary refill
c. Mottled, cool extremities
d. Bounding peripheral pulses

____ 5. The mainstay of treatment for anaphylaxis is:

a. Administering epinephrine.
b. Administering a fluid bolus.
c. Administering a corticosteroid.
d. Administering a bronchodilator.

Questions 6 through 11 pertain to the following scenario.

A 6-year-old boy is complaining of stomach pain. The child's father says his son has had frequent vomiting and diarrhea for the past 72 hours. He is seeking medical care because his son vomited immediately on awakening this morning and then had diarrhea. Dad put his son in the shower to wash him and his son "collapsed" for about 10 to 15 seconds. You observe the child sitting in a chair with his hand over his stomach. He appears uncomfortable and restless, but is aware of your presence. The child has listened intently to the conversation between you and his father. His face and lips appear pale. Some mottling of the extremities is present. His breathing is unlabored at a rate that appears normal for his age.

____ 6. Which of the following statements is true of your interactions with a child of this age?

a. Speak to the child as if speaking to an adult.
b. When speaking with the caregiver, include the child.
c. Avoid frightening or misleading terms such as *shot, deaden, germs*, and so on.
d. Establish a contract with the child: tell him that if he does not cooperate with you, you are certain he will have to have surgery.

____ 7. Your initial assessment reveals an open airway. The child's ventilatory rate is 20/minute. Auscultation of the chest reveals clear, bilateral breath sounds. A radial pulse is easily palpated at a rate of 157 beats/minute. The skin is pale and dry. The child's capillary refill is 3 seconds, temperature is 99.4°F, and his blood pressure is 82/56. The normal heart rate range for a 6-year-old child at rest is __ beats/minute.

a. 60 to 100
b. 70 to 120
c. 80 to 140
d. 90 to 150

____ 8. The lower limit of a normal systolic blood pressure for a child of this age is:

a. About 60 mm Hg.
b. About 70 mm Hg.
c. About 80 mm Hg.
d. About 90 mm Hg.

_____ 9. This child's history and presentation is consistent with:

a. Compensated hypovolemic shock.
b. Hypotensive obstructive shock.
c. Compensated distributive shock.
d. Hypotensive cardiogenic shock.

_____ 10. Which of the following have been shown to be useful when evaluating dehydration?

a. Assessment of mental status, heart rate, ECG rhythm, and capillary refill.
b. Assessment of mental status, pupil response to light, skin temperature, and the presence and strength of peripheral pulses.
c. Assessment of skin temperature, mucous membranes, the presence and strength of peripheral pulses, and the presence or absence of tears.
d. Assessment of general appearance, capillary refill, mucous membranes, and the presence or absence of tears.

_____ 11. Vascular access has successfully been established. You should begin volume resuscitation with a fluid bolus of:

a. 10 mL/kg of an isotonic crystalloid solution.
b. 20 mL/kg of an isotonic crystalloid solution.
c. 10 mL/kg of a 5% dextrose in water solution.
d. 20 mL/kg of a colloid solution, such as albumin.

Case Study 4-1

Your patient is a 7-year-old pedestrian who was struck by a car. You have a sufficient number of advanced life support personnel available to assist you and carry out your instructions. Emergency equipment is available.

1. You see a child who is supine on a stretcher with his eyes closed. The clothing over his chest and abdomen is torn and there is obvious deformity of both femurs. Chest movement is visible. His skin is pale, he is not moving his extremities, and he is unaware of your approach. Are these general impression findings normal or abnormal? If abnormal, what are the abnormal findings?

2. How would you like to proceed?

3. What injuries can you predict on the basis of the child's mechanism of injury?

4. As you begin your primary assessment, what technique should be used to open the child's airway?

5. Your primary assessment reveals the following:

Primary Assessment	
A	Clear, no blood or secretions in the mouth
B	Ventilatory rate 24 breaths/minute, clear and equal breath sounds, equal chest excursion
C	Heart rate 158 beats/minute (sinus tachycardia), weak peripheral pulses, skin cool, capillary refill 3 seconds
D	Glasgow Coma Scale score 11 (3 + 4 + 4)
E	Temperature 37.2°C (99°F), weight 23 kg (50.5 pounds)

The child's oxygen saturation on room air is 91%. What method of supplemental oxygen delivery should be used in this situation? What inspired oxygen concentration can be delivered with this device?

6. You have obtained a SAMPLE history and performed a focused physical examination with the following results:

SAMPLE History	
Signs/symptoms	Lethargic child after a car-pedestrian crash
Allergies	None
Medications	None
Past medical history	Normal development; immunizations current
Last oral intake	Breakfast; normal appetite and fluid intake
Events prior	The child was struck by a car (estimated vehicle speed 35 miles per hour) after darting out into the road after a basketball. The child was reportedly alert and responsive at the crash scene.

Physical Examination	
Head, eyes, ears, nose, throat	No abnormalities noted
Neck	Trachea midline, no jugular venous distention
Chest	Breath sounds clear, equal rise and fall, abrasions and ecchymosis on left side of chest wall; no crepitus or deformity
Abdomen	Soft, abrasions present
Pelvis	No abnormalities noted
Extremities	Obvious deformity of both femurs; distal pulses weak; skin cool
Back	No abnormalities noted

What should be done next?

7. In addition to the SAMPLE history, what questions might you ask that could provide helpful information related to this pedestrian injury?

8. The child's blood pressure is 70/40 mm Hg, pulse 158, and ventilatory rate 24. Is this child's presentation consistent with compensated or hypotensive shock?

9. Vascular access has been established. What is the appropriate fluid bolus to administer for this child?

10. What additional therapeutic interventions should be implemented for this child?

Case Study 4-2

Your patient is a lethargic 5-month-old infant. You have a sufficient number of advanced life support personnel available to assist you and carry out your instructions. Emergency equipment is available.

1. Your general impression reveals a lethargic, ill-appearing infant in her mother's arms. There are no signs of increased work of breathing or cyanosis. Her skin is mottled, her extremities are pale, and her muscle tone is poor. Red-purple lesions are observed on the infant's legs. Are these general impression findings normal or abnormal? If abnormal, what are the abnormal findings? On the basis of these findings, how would you categorize the patient's physiologic problem?

2. Your primary assessment reveals the following:

Primary Assessment	
A	Dry mouth, parched lips
B	Ventilatory rate 30 breaths/minute, clear and equal breath sounds, equal chest excursion
C	Heart rate 190 beats/minute, weak peripheral pulses, skin cool, capillary refill 4 seconds
D	Glasgow Coma Scale score 11 (3 + 4 + 4), unresponsive to mother
E	Temperature 39.2°C (102.4°F), weight 8.6 kg (19 pounds)

A team member has applied a pulse oximeter, blood pressure monitor, and cardiac monitor. The infant's oxygen saturation is 92% on room air. What should be done now?

3. You have obtained a SAMPLE history and performed a focused physical examination with the following results:

SAMPLE History	
Signs/symptoms	Sick appearing infant who developed a fever and lower extremity rash within the last 24 hours
Allergies	None
Medications	None
Past medical history	Normal development; immunizations current
Last oral intake	Minimal fluid intake during the past 24 hours
Events prior	Mom reports that the infant has been sleeping for longer intervals than usual and is difficult to arouse; red-purple lesions have been present on the infant's legs since yesterday and have been increasing in number

Physical Examination	
Head, eyes, ears, nose, throat	Flat anterior fontanel, pale and dry mucous membranes, absent tears
Neck	No abnormalities noted
Chest	Breath sounds clear, equal rise and fall, equal chest excursion, skin mottled, no rash
Abdomen	Skin mottled, no rash
Pelvis	Skin mottled, no rash
Extremities	Weak peripheral pulses, skin pale and cool, red-purple lesions present
Back	Skin mottled

Vascular access has been established and a team member is preparing to administer an isotonic crystalloid fluid bolus. What volume of fluid, in milliliters, should this infant receive?

4. After three fluid boluses, the infant's heart rate is 134, her ventilatory rate is 38, her capillary refill is 3 seconds, and she is more alert. Is this infant's presentation consistent with compensated or hypotensive shock?

5. What are the initial therapeutic endpoints of resuscitation of septic shock?

6. What additional therapeutic interventions should be implemented for this child?

Case Study 4-3

Your patient is a 12-year-old boy who presents with mild chest pain and shortness of breath that has been present for several days following an upper respiratory infection. You have a sufficient number of advanced life support personnel available to assist you and carry out your instructions. Emergency equipment is available.

1. Your general impression reveals an ill-appearing boy who is aware of your approach but quiet. He is sitting upright on a stretcher. His ventilatory rate is increased, his breathing is slightly labored, and his skin looks pale. Based on these findings, how would you categorize the patient's physiologic problem?

2. Your primary assessment reveals the following:

Primary Assessment	
A	Clear
B	Ventilatory rate 40 breaths/minute, coarse bibasilar crackles, equal chest excursion
C	Heart rate 135 beats/minute (sinus tachycardia), weak peripheral pulses, skin cool, capillary refill 3 seconds
D	Alert but quiet, Glasgow Coma Scale score 15
E	Temperature 38.5°C (101.3°F), weight 39.9 kg (88 pounds)

A team member has applied a pulse oximeter, blood pressure monitor, and cardiac monitor. The child's oxygen saturation is 92% on room air and his blood pressure is 90/45 mm Hg. What should be done now?

3. You have obtained a SAMPLE history and performed a focused physical examination with the following results:

SAMPLE History	
Signs/symptoms	Shortness of breath with exertion
Allergies	None
Medications	Guaifenesin for congestion
Past medical history	Normal development; immunizations current
Last oral intake	Decreased appetite and nausea for the past 3 days; had juice and toast at breakfast this morning
Events prior	Mild chest pain and shortness of breath that has been present for several days following an upper respiratory infection

Physical Examination	
Head, eyes, ears, nose, throat	No abnormalities noted
Neck	No abnormalities noted
Chest	Bibasilar crackles, equal rise and fall, distant heart sounds
Abdomen	Skin pale, no other abnormalities
Pelvis	Skin pale, no other abnormalities
Extremities	Weak peripheral pulses, skin pale and cool
Back	Skin pale, no other abnormalities

Vascular access has been obtained. Is this child's presentation consistent with compensated or hypotensive shock?

4. What should be done now?

5. What laboratory and diagnostic studies should be obtained at this time?

Case Study 4-4

Your patient is a 10-month-old boy who presents with a fever, wheezing, and increased work of breathing. You have a sufficient number of advanced life support personnel available to assist you and carry out your instructions. Emergency equipment is available.

1. Your general impression reveals a fussy infant who is being held in his mother's arms. His ventilatory rate is increased, subcostal retractions are visible, and his skin is pink. On the basis of these findings, how would you categorize the patient's physiologic problem?

2. Your primary assessment reveals the following:

Primary Assessment	
A	Nasal flaring present
B	Ventilatory rate 56 breaths/minute, scattered crackles and wheezes, subcostal retractions
C	Heart rate 170 beats/minute (sinus tachycardia), normal peripheral pulses, skin pink and warm, capillary refill 2 seconds
D	Alert but fussy, Glasgow Coma Scale score 15
E	Temperature 39.7°C (103.5°F), weight 8.6 kg (19 pounds)

A team member has applied a pulse oximeter and cardiac monitor. The infant's oxygen saturation is 93% on room air. What should be done now?

3. You have obtained a SAMPLE history and performed a focused physical examination with the following results:

SAMPLE History	
Signs/symptoms	Fever, labored breathing
Allergies	None
Medications	None
Past medical history	Normal development; immunizations current
Last oral intake	Formula 2 hours ago
Events prior	Worsening respiratory distress after recent upper respiratory infection

Physical Examination	
Head, eyes, ears, nose, throat	Frequent cough
Neck	No abnormalities noted
Chest	Increased ventilatory effort, scattered crackles and wheezes, subcostal retractions
Abdomen	No abnormalities
Pelvis	No abnormalities
Extremities	Normal peripheral pulses, skin pink and warm
Back	No abnormalities

On the basis of your general impression and primary assessment findings, how would you categorize the severity of the patient's respiratory emergency?

4. What should be done now?

5. A team member calls your attention to a sudden change in the infant's condition. His ventilatory rate is now 70 breaths/minute, his heart rate is 180 beats/minute, and his oxygen saturation is 87% despite assisted ventilation with a bag-mask device. Bag-mask ventilation has become increasingly difficult. Reassessment reveals decreased lung sounds on the left, weak peripheral pulses, and capillary refill about 4 seconds. What should be done now?

6. How you will assess the patient's response to the therapeutic interventions performed?

7. The patient's ventilatory rate is now 40 breaths/minute, his heart rate is 136 beats/minute, and his oxygen saturation is 96%. His work of breathing has improved and retractions have diminished. Central and peripheral pulses are strong. What additional interventions should be performed at this time?

Chapter Quiz Answers

1. A. Distributive shock may be caused by a severe infection (septic shock), a severe allergic reaction (anaphylactic shock), or a central nervous system injury (neurogenic shock). Septic shock is the most common type of distributive shock in children. Cardiac tamponade is one of the possible causes of *obstructive* (not distributive) shock.

OBJ: Discuss the physiologic types of shock.

2. D. A narrowed pulse pressure, which may be seen with hypovolemic or cardiogenic shock, reflects increased peripheral vascular resistance and is an early sign of impending shock. A widened pulse pressure, which may be seen with early septic shock, reflects decreased peripheral vascular resistance. The strength of peripheral pulses (e.g., radial, dorsalis pedis) is reduced in the child whose cardiac output is decreased. As cardiac output becomes more severely decreased, the strength of more proximal pulses (e.g., brachial, femoral, carotid) is also reduced. Hypotension is a *late* sign of cardiovascular compromise in an infant or child. Mottling and coolness of the skin are manifestations of increased peripheral vascular resistance. Thus, skin mottling and cool extremities are early indicators of decreased tissue perfusion, which is a reflection of decreased cardiac output.

OBJ: Identify key anatomic and physiologic differences between children and adults and discuss their implications in the patient with a cardiovascular condition.

3. C. Epinephrine, norepinephrine, and dopamine (at high doses) are examples of inotropic agents that have a vasoconstrictor effect on the peripheral vasculature. Dopamine (at low doses), isoproterenol, dobutamine, amrinone, and milrinone are examples of inotropic agents that have a vasodilator effect on the peripheral vasculature.

OBJ: Discuss the pharmacology of medications used during shock, symptomatic bradycardia, stable and unstable tachycardia, and cardiopulmonary arrest.

4. C. Assessment findings that may be observed during the early (hyperdynamic, increased cardiac output) phase of septic shock include the following: blood pressure may be normal (possible widened pulse pressure), bounding peripheral pulses, brisk capillary refill, chills, fever, normal urine output, tachypnea, and warm, dry, flushed skin. Findings that may be observed in the late (hypodynamic/decompensated) phase include the following: altered mental status; cool, mottled extremities; delayed capillary refill, diminished or absent peripheral pulses, diminished urine output, and tachycardia. Late septic shock is usually indistinguishable from other types of shock.

OBJ: Discuss the physiologic types of shock.

5. A. The mainstay of treatment of anaphylaxis is the intramuscular administration of epinephrine. Epinephrine constricts blood vessels, inhibits histamine release, dilates bronchioles, and increases cardiac contractility. An epinephrine auto-injector may be used if it is available. The site of choice is the lateral aspect of the thigh. If symptoms persist or recur after 15 minutes, a second dose or an epinephrine infusion may be needed.

OBJ: Describe the initial emergency care for hypovolemic, distributive, cardiogenic, and obstructive shock in infants and children.

6. B. When the patient is a school-age child (6 to 12 years of age), include the child when speaking with the caregiver. If the patient is an adolescent, speak to him in a respectful, friendly manner, as if speaking to an adult. Although it is reasonable to make a contract with a child of this age ("I promise to tell you everything I am going to do if you will help me by cooperating"), it is inappropriate and unprofessional to threaten him.

OBJ: Distinguish between the components of a pediatric assessment and describe techniques for successful assessment of infants and children.

7. B. The normal heart rate for a 6- to 12-year-old at rest is 70 to 120 beats/minute.

OBJ: Identify normal age-group-related vital signs.

8. C. The formula used to approximate the lower limit of systolic blood pressure in children 1 to 10 years of age is 70 + (2 × age in years). This child's minimum systolic blood pressure should be about 82 mm Hg.

OBJ: Identify normal age-group-related vital signs.

9. A. This child's history and presentation is consistent with compensated hypovolemic shock.

OBJ: Define shock and differentiate between compensated and hypotensive shock.

10. D. Research has suggested that four clinical findings can be used to assess dehydration: abnormal general appearance, capillary refill longer than 2 seconds, dry mucous membranes, and absent tears. The presence of any two of these four findings indicates a deficit of 5% or more, and three or more findings indicates a deficit of at least 10%.

OBJ: Discuss the physiologic types of shock.

11. B. The administration of a bolus of 20 mL/kg of isotonic crystalloid solution (NS or LR) is a reasonable course of action. After administration, reassess the child's mental status, heart rate, blood pressure, capillary refill, peripheral perfusion, and urine output. Colloids such as albumin are not routinely indicated during the initial management of hypovolemic shock, but they may be ordered for volume replacement in children with large third-space losses or albumin deficits.

OBJ: Describe the initial emergency care for hypovolemic, distributive, cardiogenic, and obstructive shock in infants and children.

Case Study 4-1 Answers

1. The general impression findings are abnormal (Appearance: unaware of your approach, not moving; Breathing: normal; Circulation: abnormal skin color). On the basis of these findings, it is important to proceed quickly and reassess the patient often.

OBJ: Summarize the components of the pediatric assessment triangle and the reasons for forming a general impression of the patient.

2. A cervical spine injury should be assumed because of the patient's mechanism of injury. Ask a team member to manually stabilize the head and neck in a neutral in-line position and maintain this position until cervical spine injury has been ruled out or until the patient has been properly secured to a backboard. Ask another team member to apply a pulse oximeter, blood pressure monitor, and cardiac monitor while you perform a primary assessment and obtain a SAMPLE history.

OBJ: Describe the initial emergency care for hypovolemic, distributive, cardiogenic, and obstructive shock in infants and children.

3. Pedestrian versus motor vehicle crashes have three separate phases, each with its own injury pattern. Because a child is usually shorter, the initial impact of the automobile occurs higher on the body than in adults. The bumper typically strikes the child's pelvis or legs (above the knees) and the fender strikes the abdomen. Predictable injuries from the initial impact include injuries to the chest, abdomen, pelvis, or femur. The second impact occurs as the front of the vehicle's hood continues forward and strikes the child's thorax. The child is thrown backward, forcing the head and neck to flex forward. Depending on the position of the child in relation to the vehicle, the child's head and face may strike the front or top of the vehicle's hood. An impression from the child's head may be left on the hood or windshield. Primary and contrecoup injuries to the head are common in this situation. Predictable injuries from the second impact include facial, abdominopelvic, and thoracic trauma, and head and neck injury. The third impact occurs as the child is thrown to the ground. Because of the child's smaller size and weight, the child may (1) fall under the vehicle and be trapped and dragged for some distance, (2) fall to the side of the vehicle and have his or her lower limbs run over by a front wheel, or (3) fall backward and end up completely under the vehicle. In this third situation, almost any injury can occur (e.g., run over by a wheel, being dragged).

OBJ: N/A.

4. Use the jaw-thrust without head extension maneuver to open the airway. If the airway is open, move on to evaluation of the patient's breathing. If the airway is not open, assess for sounds of airway compromise (snoring, gurgling, or stridor). Look in the mouth for blood, broken teeth, gastric contents, and foreign objects (e.g., loose teeth, gum).

OBJ: Describe the methods used for opening the airway and discuss the preferred method of opening the airway in cases of suspected cervical spine injury.

5. Supplemental oxygen should be administered by means of a nonrebreather mask, which can deliver an inspired oxygen concentration of up to 95% at a flow rate of 10 to 15 L/minute.

OBJ: Discuss oxygen delivery systems used for infants and children.

6. Obtain vascular access and blood for laboratory studies. In addition to the child's femurs, which show obvious signs of injury, the chest, abdomen, and pelvis can be sources of significant

bleeding. A surgical consult should be obtained and a Focused Assessment with Sonography for Trauma (FAST) examination (i.e., bedside ultrasound) should be performed if the equipment is available. Order radiographs of the cervical spine, chest, and lower extremities.

OBJ: Describe the initial emergency care for hypovolemic, distributive, cardiogenic, and obstructive shock in infants and children.

7. In addition to the SAMPLE history, questions that you might ask with regard to a pedestrian injury include the following:

- What type of vehicle struck the child (e.g., sport utility vehicle, pickup truck, van, car)?
- If the child was struck by a vehicle and thrown while walking, roller-skating, or bicycling, was a helmet worn? If so, is it still in place or was it knocked off the head on impact? Is there damage to the helmet?
- How fast was the vehicle traveling?
- Where was the child struck?
- How far was the child thrown?
- What type of surface did the child land on?

OBJ: Summarize the purpose and components of the secondary assessment.

8. This child's presentation is consistent with hypotensive shock.

OBJ: Differentiate between compensated and hypotensive shock.

9. Administer a bolus of 20 mL/kg of an isotonic crystalloid solution, such as normal saline or lactated Ringer's, over 5 to 10 minutes. After *each* fluid bolus, reassess the child's mental status, heart rate, blood pressure, capillary refill, peripheral perfusion, and urine output.

OBJ: Describe the initial emergency care for hypovolemic, distributive, cardiogenic, and obstructive shock in infants and children.

10. Check the serum glucose level. Some children in shock are hypoglycemic because of rapidly depleted carbohydrate stores. Administer dextrose IV or IO if the serum glucose is below 60 mg/dL. Maintain normal body temperature. Insert a urinary catheter to assess the adequacy of therapy.

OBJ: Describe the initial emergency care for hypovolemic, distributive, cardiogenic, and obstructive shock in infants and children.

Case Study 4-2 Answers

1. The general impression findings are abnormal (Appearance: lethargic, poor muscle tone; Breathing: normal; Circulation: abnormal skin color). An abnormal appearance, normal work of breathing, and abnormal skin color are consistent with hypotensive shock.

OBJ: Summarize the components of the pediatric assessment triangle and the reasons for forming a general impression of the patient.

2. Give supplemental oxygen and maintain an oxygen saturation of 94% or higher. Obtain vascular access and begin fluid resuscitation.

OBJ: Describe the initial emergency care for hypovolemic, distributive, cardiogenic, and obstructive shock in infants and children.

3. The infant weighs 8.6 kg. A fluid bolus of 20 mL/kg should be administered, which is 172 mL. Reassess the child's mental status, heart rate, blood pressure, capillary refill, peripheral perfusion, and urine output after *each* fluid bolus.

OBJ: Describe the initial emergency care for hypovolemic, distributive, cardiogenic, and obstructive shock in infants and children.

4. The infant is showing signs of improvement and her presentation is consistent with compensated shock.

OBJ: Differentiate between compensated and hypotensive shock.

5. Initial therapeutic endpoints of resuscitation of septic shock include a capillary refill of 2 seconds or less, normal blood pressure for age, normal pulses with no differential between peripheral and central pulses, warm extremities, urine output of more than 1 mL/kg per hour, and normal mental status.

OBJ: Describe the initial emergency care for hypovolemic, distributive, cardiogenic, and obstructive shock in infants and children.

6. Check the serum glucose level and the ionized calcium level. Administer a broad-spectrum antibiotic. Blood samples for culture should be obtained before antibiotic administration, but obtaining them should not delay antibiotic administration. Treat fever with medications and cooling devices as needed. Arrange for the patient's transfer to a pediatric intensive care unit for ongoing care.

OBJ: Describe the initial emergency care for hypovolemic, distributive, cardiogenic, and obstructive shock in infants and children.

Case Study 4-3 Answers

1. The general impression findings are abnormal (Appearance: ill-appearing and quiet; Breathing: abnormal; Circulation: abnormal skin color). An abnormal appearance, abnormal work of breathing, and abnormal skin color are consistent with cardiopulmonary failure.

OBJ: Summarize the components of the pediatric assessment triangle and the reasons for forming a general impression of the patient.

2. Give supplemental oxygen and maintain an oxygen saturation of 94% or higher. Obtain vascular access.

OBJ: Describe the initial emergency care for hypovolemic, distributive, cardiogenic, and obstructive shock in infants and children.

3. This child's history of present illness and signs and symptoms suggest myocarditis. His vital signs and presentation are consistent with compensated cardiogenic shock.

OBJ: Differentiate between compensated and hypotensive shock.

4. Carefully administer a *small* fluid bolus (5 to 10 mL/kg) of an isotonic crystalloid solution over 10 to 20 minutes. Closely monitor the child's mental status, lung sounds, and work of breathing, and assess for signs of hepatic congestion that indicate volume overload.

OBJ: Describe the initial emergency care for hypovolemic, distributive, cardiogenic, and obstructive shock in infants and children.

5. Check the serum glucose level. Obtain a complete blood count with differential, chemistry panel, blood cultures, and an arterial blood gas. Obtain a chest radiograph and an echocardiogram. Arrange for the patient's transfer to a pediatric intensive care unit for ongoing care.

OBJ: Describe the initial emergency care for hypovolemic, distributive, cardiogenic, and obstructive shock in infants and children.

Case Study 4-4 Answers

1. The general impression findings are abnormal (Appearance: fussy infant; Breathing: abnormal; Circulation: normal skin color). An abnormal appearance, abnormal work of breathing, and normal skin color are consistent with respiratory failure.

OBJ: Summarize the components of the pediatric assessment triangle and the reasons for forming a general impression of the patient.

2. Because signs of respiratory failure are present, assist ventilation using a bag-mask device with supplemental oxygen and maintain an oxygen saturation of 94% or higher.

OBJ: Describe the pathophysiology, assessment findings, and treatment plan for the child experiencing asthma or bronchiolitis.

3. This child's history of present illness and signs and symptoms suggest pneumonia. The presence of tachypnea, tachycardia, retractions, and an increased ventilatory effort are signs that respiratory failure is present. Move quickly to support the patient's airway and breathing and prevent deterioration to cardiac arrest.

OBJ: Differentiate between respiratory distress, respiratory failure, and respiratory arrest.

4. Obtain vascular access. Nebulized albuterol may be used to treat wheezing and to help clear secretions. Antibiotics may be used to treat bacterial pneumonia. Antipyretics may be used to control fever. Noninvasive positive pressure ventilation may be needed.

OBJ: Describe the pathophysiology, assessment findings, and treatment plan for the child who has lung tissue disease or disordered ventilatory control.

5. The patient's sudden deterioration and assessment findings suggest the development of a tension pneumothorax, which is one of the causes of obstructive shock. Immediate needle decompression of the affected (i.e., left) side is warranted. A qualified individual should identify the second intercostal space in the midclavicular line on the left side. After cleansing the skin, the needle is inserted at a 90° angle to the chest wall through the skin and over the top of the third rib (second intercostal space). The needle is then removed and appropriately discarded, leaving the catheter in place. The catheter is secured to the patient's chest wall to prevent dislodgement. Preparations should be made for chest tube insertion.

OBJ: Describe the initial emergency care for hypovolemic, distributive, cardiogenic, and obstructive shock in infants and children.

6. Assess the patient's response by evaluating work of breathing, breath sounds, ventilatory rate, oxygen saturation, heart rate, and blood pressure.

OBJ: Describe the initial emergency care for hypovolemic, distributive, cardiogenic, and obstructive shock in infants and children.

7. Replace bag-mask ventilation with a nonrebreather mask. Consider the need for an isotonic crystalloid fluid bolus. After chest tube insertion, obtain a chest radiograph to assess for lung reexpansion and evaluate thoracostomy tube position. Obtain a point-of-care glucose level and additional laboratory studies (complete blood count with differential, blood cultures, electrolytes, BUN/creatinine). Arrange for patient transfer for ongoing monitoring and care.

OBJ: Describe the initial emergency care for hypovolemic, distributive, cardiogenic, and obstructive shock in infants and children.

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Checklist 4-1 Hypovolemic Shock

Action Steps	Performed Correctly
Ensures scene safety. Takes or communicates the use of personal protective equipment for blood and body substances.	☐
Assigns team member roles.	☐
Assessment	
Forms a general impression: Assesses patient's appearance, work of breathing, and circulation.	☐
Directs assessment of airway/responsiveness; directs the use of a manual airway maneuver to open the airway, if indicated.	☐
Directs assessment of breathing including estimation of ventilatory rate and evaluation of ventilatory effort; directs assessment of breath sounds.	☐
Directs assessment of central/peripheral pulse quality, estimation of heart rate, and evaluation of skin (color, temperature, and moisture) and capillary refill.	☐
Directs team members to determine a Glasgow Coma Scale score and patient weight.	☐
Directs team members to obtain vital signs and to apply a pulse oximeter and to apply blood pressure and cardiac monitors.	☐
Obtains a brief history and performs a focused physical examination.	☐
Recognizes signs and symptoms of hypovolemic shock.	☐
Considers the patient's presentation and differentiates between compensated and hypotensive shock.	☐
Treatment Plan	
Verbalizes a treatment plan and initiates appropriate interventions.	☐
Directs insertion of an oral airway or nasal airway, if indicated.	☐
Directs application of appropriate oxygen therapy; directs team member to begin assisted ventilation, if indicated.	☐
Instructs team member to establish vascular access.	☐
Orders administration of an isotonic crystalloid fluid bolus.	☐
Orders diagnostic tests and procedures, if indicated.	☐
Considers the need for an advanced airway.	☐
Correctly verbalizes indications, dosages, and routes of administration for medications administered.	☐
Reassessment	
Repeats the primary assessment and obtains another set of vital signs.	☐
Monitors for, recognizes, and appropriately treats any changes in the patient's physiological status.	☐
Team Leader Assessment	
Effectively leads team members throughout patient care.	☐
Directs the transfer of patient care for ongoing monitoring and care.	☐
Requests a team debriefing after the transfer of patient care is complete.	☐

Checklist 4-2 Distributive Shock

Action Steps	Performed Correctly
Ensures scene safety. Takes or communicates the use of personal protective equipment for blood and body substances.	☐
Assigns team member roles.	☐
Assessment	
Forms a general impression: Assesses patient's appearance, work of breathing, and circulation.	☐
Directs assessment of airway/responsiveness; directs the use of a manual airway maneuver to open the airway, if indicated.	☐
Directs assessment of breathing including estimation of ventilatory rate and evaluation of ventilatory effort; directs assessment of breath sounds.	☐
Directs assessment of central/peripheral pulse quality, estimation of heart rate, and evaluation of skin (color, temperature, and moisture) and capillary refill.	☐
Directs team members to determine a Glasgow Coma Scale score and patient weight.	☐
Directs team members to obtain vital signs and to apply a pulse oximeter and to apply blood pressure and cardiac monitors.	☐
Obtains a brief history and performs a focused physical examination.	☐
Recognizes signs and symptoms of distributive shock.	☐
Considers the patient's presentation and differentiates between compensated and hypotensive shock.	☐
Treatment Plan	
Verbalizes a treatment plan and initiates appropriate interventions.	☐
Directs insertion of an oral airway or nasal airway, if indicated.	☐
Directs application of appropriate oxygen therapy; directs team member to begin assisted ventilation, if indicated.	☐
Instructs team member to establish vascular access.	☐
Orders administration of an isotonic crystalloid fluid bolus.	☐
Orders diagnostic tests and procedures, if indicated.	☐
Considers the need for an advanced airway.	☐
Correctly verbalizes indications, dosages, and routes of administration for medications administered.	☐
Reassessment	
Repeats the primary assessment and obtains another set of vital signs.	☐
Monitors for, recognizes, and appropriately treats any changes in the patient's physiological status.	☐
Team Leader Assessment	
Effectively leads team members throughout patient care.	☐
Directs the transfer of patient care for ongoing monitoring and care.	☐
Requests a team debriefing after the transfer of patient care is complete.	☐

Checklist 4-3 Cardiogenic Shock

Action Steps	Performed Correctly
Ensures scene safety. Takes or communicates the use of personal protective equipment for blood and body substances.	☐
Assigns team member roles.	☐
Assessment	
Forms a general impression: Assesses patient's appearance, work of breathing, and circulation.	☐
Directs assessment of airway/responsiveness; directs the use of a manual airway maneuver to open the airway, if indicated.	☐
Directs assessment of breathing including estimation of ventilatory rate and evaluation of ventilatory effort; directs assessment of breath sounds.	☐
Directs assessment of central/peripheral pulse quality, estimation of heart rate, and evaluation of skin (color, temperature, and moisture) and capillary refill.	☐
Directs team members to determine a Glasgow Coma Scale score and patient weight.	☐
Directs team members to obtain vital signs and to apply a pulse oximeter and to apply blood pressure and cardiac monitors.	☐
Obtains a brief history and performs a focused physical examination.	☐
Recognizes signs and symptoms of cardiogenic shock.	☐
Considers the patient's presentation and differentiates between compensated and hypotensive shock.	☐
Treatment Plan	
Verbalizes a treatment plan and initiates appropriate interventions.	☐
Directs insertion of an oral airway or nasal airway, if indicated.	☐
Directs application of appropriate oxygen therapy; directs team member to begin assisted ventilation, if indicated.	☐
Instructs team member to establish vascular access.	☐
Orders administration of a small isotonic crystalloid fluid bolus.	☐
Orders diagnostic tests and procedures, if indicated.	☐
Considers the need for an advanced airway.	☐
Correctly verbalizes indications, dosages, and routes of administration for medications administered.	☐
Reassessment	
Repeats the primary assessment and obtains another set of vital signs.	☐
Monitors for, recognizes, and appropriately treats any changes in the patient's physiological status.	☐
Team Leader Assessment	
Effectively leads team members throughout patient care.	☐
Directs the transfer of patient care for ongoing monitoring and care.	☐
Requests a team debriefing after the transfer of patient care is complete.	☐

Checklist 4-4 Obstructive Shock

Action Steps	Performed Correctly
Ensures scene safety. Takes or communicates the use of personal protective equipment for blood and body substances.	☐
Assigns team member roles.	☐
Assessment	
Forms a general impression: Assesses patient's appearance, work of breathing, and circulation.	☐
Directs assessment of airway/responsiveness; directs the use of a manual airway maneuver to open the airway, if indicated.	☐
Directs assessment of breathing including estimation of ventilatory rate and evaluation of ventilatory effort; directs assessment of breath sounds.	☐
Directs assessment of central/peripheral pulse quality, estimation of heart rate, and evaluation of skin (color, temperature, and moisture) and capillary refill.	☐
Directs team members to determine a Glasgow Coma Scale score and patient weight.	☐
Directs team members to obtain vital signs and to apply a pulse oximeter and blood pressure and cardiac monitors.	☐
Obtains a brief history and performs a focused physical examination.	☐
Recognizes signs and symptoms of obstructive shock.	☐
Considers the patient's presentation and differentiates between compensated and hypotensive shock.	☐
Treatment Plan	
Verbalizes a treatment plan and initiates appropriate interventions.	☐
Directs insertion of an oral airway or nasal airway, if indicated.	☐
Directs application of appropriate oxygen therapy; directs team member to begin assisted ventilation, if indicated.	☐
Instructs team member to establish vascular access.	☐
Orders administration of an isotonic crystalloid fluid bolus.	☐
Orders diagnostic tests and procedures, if indicated.	☐
Considers the need for an advanced airway.	☐
Correctly verbalizes indications, dosages, and routes of administration for medications administered.	☐
Reassessment	
Repeats the primary assessment and obtains another set of vital signs.	☐
Monitors for, recognizes, and appropriately treats any changes in the patient's physiological status.	☐
Team Leader Assessment	
Effectively leads team members throughout patient care.	☐
Directs the transfer of patient care for ongoing monitoring and care.	☐
Requests a team debriefing after the transfer of patient care is complete.	☐

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CHAPTER 5

Bradycardias

Learning Objectives

After completing this chapter, you should be able to:

1. Identify the major classifications of pediatric cardiac rhythms.
2. Discuss the types of bradycardias that may be observed in the pediatric patient.
3. Discuss the initial emergency care for symptomatic bradycardia in infants and children.
4. Discuss the pharmacology of medications used when managing a symptomatic bradycardia.
5. Identify a patient who is experiencing a bradycardia as asymptomatic, symptomatic but stable, or symptomatic and unstable.
6. Given a patient situation, formulate a treatment plan (including assessment, airway management, cardiopulmonary resuscitation, and pharmacological interventions where applicable) for a patient presenting with a symptomatic bradycardia.

After completing this chapter, and with supervised practice during a Pediatric Advanced Life Support (PALS) course, you will be skilled at the following:

- Ensuring scene safety and the use of personal protective equipment.
- Assigning team member roles or performing as a team member in a simulated patient situation.
- Directing or performing an initial patient assessment.
- Obtaining vital signs, establishing vascular access, attaching a pulse oximeter and blood pressure and cardiac monitors, and giving supplemental O_2 if indicated.

- Recognizing bradycardic rhythms.
- Implementing a treatment plan for symptomatic bradycardia in infants and children.
- Demonstrating knowledge of the indications, dosages, and effects of the medications used when managing a symptomatic bradycardia.
- Recognizing when it is best to seek expert consultation.
- Reviewing your performance as a team leader or team member during a postevent debriefing.

ASSESSMENT EVIDENCE

Performance Tasks

During the PALS course, you will be functioning as the team leader of the Rapid Response Team or Code Team within your organization. Your classmates are similarly trained members of the team who will assist you. Your task is to direct, without prompting, the emergency care efforts of your team according to current resuscitation guidelines.

Key Criteria

Assessment of your ability to manage a patient who is experiencing a symptomatic bradycardia and your ability to manage the team who will assist you in providing patient care is part of the PALS course. An evaluation checklist that reflects key steps and interventions in the patient management process will be used to assess your performance (see **Checklist 5-1**). A PALS instructor will check the appropriate box as you complete each step during your management of the patient.

Learning Plan

- Read this chapter before your PALS course. Create flashcards and memory aids to help you recall key points. Carefully review each of the medications discussed in this chapter.
- Complete the chapter quiz and review the answers provided.
- Complete the case study at the end of the chapter. Read the scenario and answer each question that follows it. The questions are intended to reinforce important points pertinent to the case that are discussed in this text. Compare your answers with the answers provided at the end of the case study and with the checklist pertinent to the case study.

KEY TERM

Structural heart disease

Congenital heart conditions or heart disease acquired because of aging, injury, or infection (e.g., valvular heart disease) resulting in an interruption of the flow of blood through the chambers and valves of the heart

INTRODUCTION

- A dysrhythmia, also called an *arrhythmia*, involves an abnormality in the rate, regularity, or sequence of cardiac activation. A child's heart rate (HR) is influenced by his or her age, size, and level of activity. A very slow or rapid rate can indicate or can be the cause of cardiovascular compromise.
- A child's heart rate is generally higher than the heart rate of an adult, peaking at 3 to 8 weeks of age and then decreasing throughout adolescence (Chan, Sharieff, & Brady, 2008). Because of the smaller stroke volume in neonates and young children, cardiac output is maintained by the higher heart rate (Chan et al., 2008). With age, the heart rate decreases as the ventricles mature and stroke volume plays a larger role in cardiac output (Sharieff & Rao, 2006).
- Electrocardiogram (ECG) monitoring is an important aspect of pediatric emergency care and is indicated for any pediatric patient who shows signs of significant illness or injury. The most common reasons for obtaining ECGs in children are chest pain, suspected dysrhythmias, seizures, syncope, drug exposure, electrical burns, electrolyte abnormalities, and abnormal physical examination findings (Doniger & Sharieff, 2008). ECG monitoring may also be used to evaluate the effects of disease or injury on heart function, evaluate the response to medications, or to obtain a baseline recording before, during, and after a medical procedure.
- In the pediatric patient, dysrhythmias are divided into four broad categories based on HR: (1) normal for age, (2) slower than normal for age (bradycardia), (3) faster than normal for age (tachycardia), or (4) absent/pulseless (cardiac arrest). In general, dysrhythmias are treated only if they compromise cardiac output or have the potential for deteriorating into a lethal rhythm.
- A systematic approach to analyzing a rhythm strip is recommended to ensure that no key findings are missed (**Figure 5-1**).
  - Determine if the rate is normal for age, too fast, too slow, or absent. The values used to define a tachycardia (above 100 beat/minute) and a bradycardia (below 60

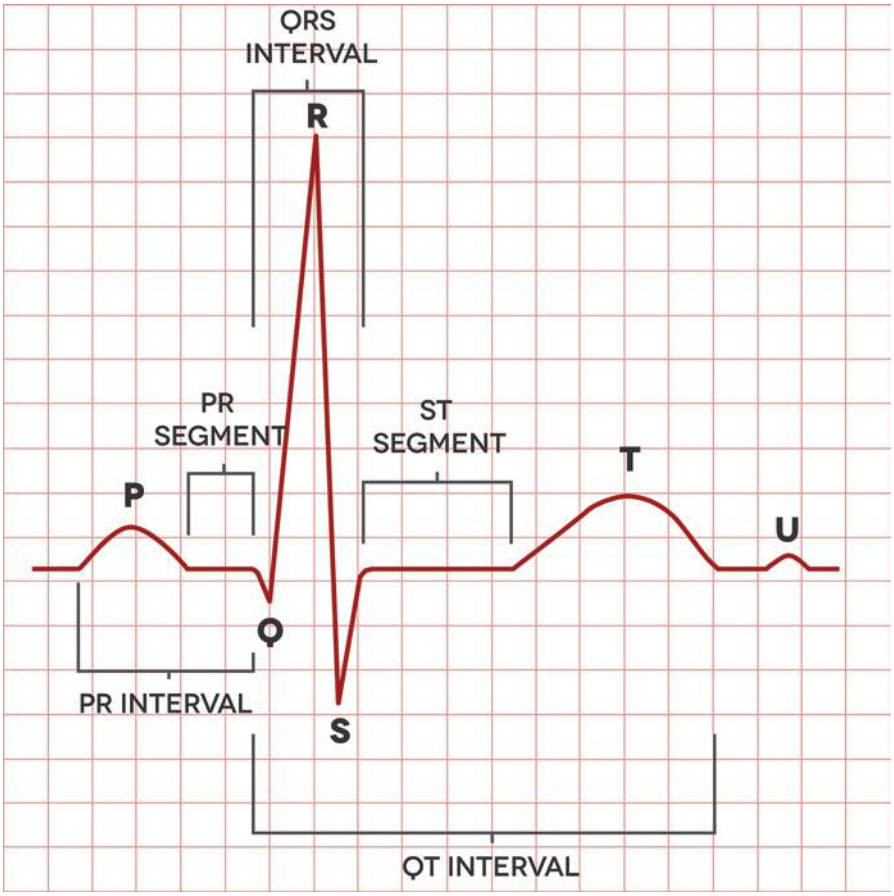

Figure 5-1 Electrocardiogram waveforms, segments, and intervals.

beats/minute) in an adult are not the same in the pediatric patient. In infants and children, a tachycardia is present if the HR is faster than the upper limit of normal for the patient's age. A bradycardia is present when the HR is slower than the lower limit of normal for his or her age.

- Examine each waveform and determine if every P wave is followed by a QRS complex.
- Measure the PR interval, the QRS duration, and the QT interval. The normal PR interval and QRS duration is shorter in children than in adults. The duration of the PR interval gradually increases with age and cardiac maturity and increased muscle mass (Sharieff & Rao, 2006). The normal PR interval ranges from 0.08 to 0.15 seconds in infants, from 0.09 to 0.17 seconds in children, and from 0.12 to 0.20 seconds in adolescents (Doniger & Sharieff, 2008). The duration of the QRS complex is short in an infant (i.e., 0.03 to 0.08 seconds) and increases with age (i.e., 0.04 to 0.09 seconds in a child). If the QRS measures 0.09 seconds or less, the QRS is "narrow" and is presumed to be supraventricular in origin. If the QRS is more than 0.09 seconds in duration, the QRS is "wide" and is presumed to be ventricular in origin until proven otherwise. Although the QT interval varies with heart rate, it is generally considered prolonged when it is 0.46 seconds or longer in duration (Doniger & Sharieff, 2008).
- Determine if the rhythm is regular or irregular.
- Assess how the patient is tolerating the rate and rhythm: (1) asymptomatic, (2) symptomatic but stable (i.e., there are no serious signs and symptoms because of the dysrhythmia), (3) symptomatic and unstable (i.e., serious signs and symptomatic are present because of the dysrhythmia), or (4) pulseless.

PALS Pearl

The initial emergency management of pediatric dysrhythmias requires a response to four important questions:

1. Is a pulse (and other signs of circulation) present?
2. Is the rate within normal limits for age, too fast, too slow, or absent?
3. Is the QRS narrow (supraventricular in origin) or wide (ventricular in origin)?
4. Is the patient sick (unstable) or not sick (stable)?

BRADYCARDIAS

- A persistent bradycardia can produce significant symptoms because of a fall in cardiac output unless stroke volume increases to compensate for the decrease in heart rate. A *relative bradycardia* is a heart rate that is too slow for the patient's level of activity and clinical condition (i.e., a heart rate of 70 beats/minute in a hypovolemic or septic school-age child).
- Hypoxia is the most common cause of bradycardia in children (Perkin, de Caen, Berg, Schexnayder, & Hazinski, 2013). It is important to identify and correct hypoxia before giving medications to increase the patient's heart rate (Doniger & Sharieff, 2006).
- Bradycardias can be classified as either primary or secondary.
  - A *primary bradycardia* is usually caused by structural heart disease. **Structural heart disease** refers to congenital heart defects or heart disease acquired because of aging, injury, or infection (e.g., valvular heart disease) resulting in an interruption of blood flow through the heart's chambers and valves. An infant or child with structural cardiac disease may develop bradycardia because of atrioventricular (AV) block or sinoatrial node dysfunction. Physical examination of these children may reveal a midline sternal scar and they may have an implanted pacemaker to treat the bradycardia.
  - A *secondary bradycardia* is a slow HR that results from a noncardiac cause such as hypoxia, increased vagal tone, acidosis, acute elevation of intracranial pressure, hypothermia, hyperkalemia, and medications such as calcium channel blockers (e.g., verapamil, diltiazem), digoxin, clonidine, opioids, and beta-blockers (e.g., propranolol).
- The term *symptomatic bradycardia* is used when a patient experiences signs and symptoms of cardiovascular compromise that are related to the slow heart rate. Possible signs and symptoms include the following:
  - Acute changes in mental status
  - Dizziness
  - Fall in urine output
  - Fatigue
  - Hypotension
  - Lightheadedness
  - Respiratory distress or failure
  - Shock
  - Syncope

Sinus Bradycardia

- With a sinus bradycardia, the HR is slower than the lower range of normal for the patient's age (**Figure 5-2**). A P wave precedes each QRS complex. The PR interval is within normal limits for age and is constant from beat to beat. The duration of the QRS complex is usually within normal limits.
- A sinus bradycardia may be normal in conditioned adolescent athletes and in some children during sleep (Doniger & Sharieff, 2008). Sinus bradycardia may also result from hypoxia, vagal (parasympathetic) stimulation (e.g., during suctioning, endotracheal tube placement), applying a cold stimulus to the face, electrolyte disturbances, respiratory failure, hypothermia, increased intracranial pressure, anorexia nervosa, or medications. Management of a symptomatic sinus bradycardia is directed at identifying and treating the underlying cause.

Atrioventricular Blocks

- AV blocks are divided into three main types: first, second, and third degree AV block.
- With first-degree AV block, all impulses from the sinoatrial (SA) node are conducted, but the impulses are delayed within the AV node before they reach the ventricles. This delay in AV conduction results in a consistently prolonged PR interval with no dropped beats (**Figure 5-3**). First-degree AV block may be seen in children with congenital heart disease, increased vagal tone, surgical trauma, or hypothyroidism. First-degree AV block may also be caused by antiarrhythmic medications, myocardial inflammation, myopathy, or infection (e.g., viral myocarditis, endocarditis, Lyme disease) (Walsh, Berul, & Triedman, 2006).
- In second-degree AV block, some impulses are not conducted to the ventricles. With second-degree AV block type I, also known as *Wenckebach* or *Mobitz type I*, P waves appear at regular intervals, but the PR interval gradually but progressively increases in duration until a P wave is not conducted (**Figure 5-4**). The duration of the QRS complex is usually within normal limits. This dysrhythmia may be observed in healthy patients as well as in those who have myocarditis, myocardial infarctions, cardiomyopathies, congenital heart disease, digoxin toxicity, and postoperatively after cardiac surgery (Doniger & Sharieff, 2006).
- In second-degree AV block type II, also known as *Mobitz type II*, P waves appear at regular intervals, and the PR interval is constant

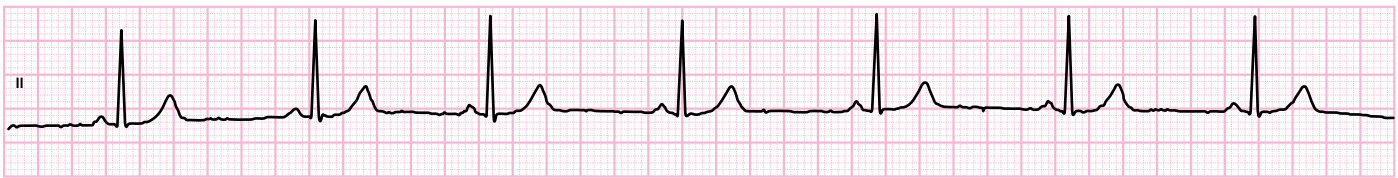

Figure 5-2 Sinus bradycardia. This rhythm strip is from a 16-year-old female complaining of chest pain.

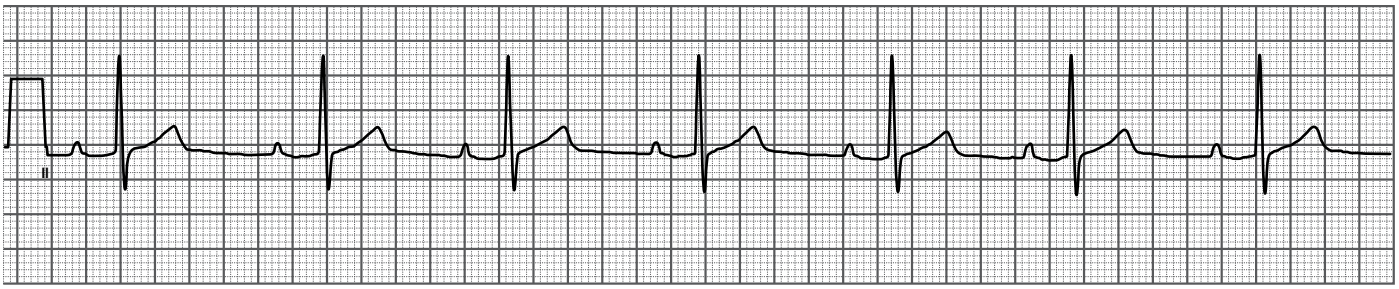

Figure 5-3 Sinus bradycardia with first-degree atrioventricular block. This rhythm strip is from a 7-year-old male who was being evaluated for a heart murmur.

before each conducted QRS. However, impulses are periodically blocked and will appear on the ECG as a P wave with no QRS after it (dropped beat) (**Figure 5-5**). This type of AV block is uncommon in children but may occur following an inflammatory or traumatic injury below the level of the AV node (Walsh et al., 2006). It may rapidly progress to third-degree AV block.

- In third-degree AV block, also known as *complete heart block*, the atria and ventricles beat independently of each other because impulses generated by the SA node are blocked before reaching the ventricles. A secondary pacemaker, either junctional or ventricular, stimulates the ventricles; therefore, the QRS may be narrow or wide depending on the location of the escape pacemaker and the condition of the intraventricular conduction system. Both the atrial and ventricular rhythms are regular (**Figure 5-6**). Third-degree AV block may be acquired or congenital. Acquired causes include AV node injury from cardiac surgery or cardiac catheterization, myocarditis, Lyme disease, rheumatic fever, diphtheria, inflammatory processes (e.g., Kawasaki disease, systemic lupus erythematosus), myocardial infarction, cardiac tumors, hypocalcemia, and drug overdoses (Doniger & Sharieff, 2006). Congenital causes of third-degree AV block include transposition of the great arteries and maternal connective tissue disorders (Doniger & Sharieff, 2006).

PALS Pearl

When determining whether an atrioventricular block exists, it is important to consider the normal duration of the PR interval, which varies with age.

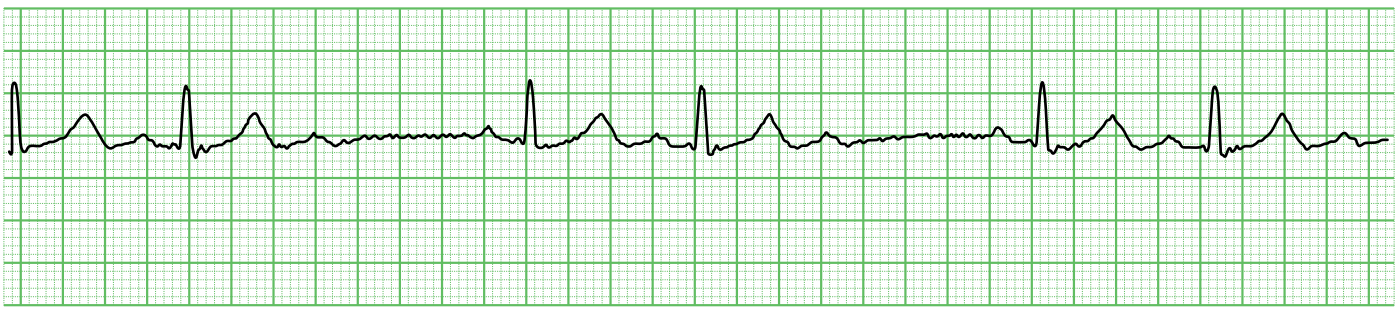

Figure 5-4 Second-degree atrioventricular block type I.

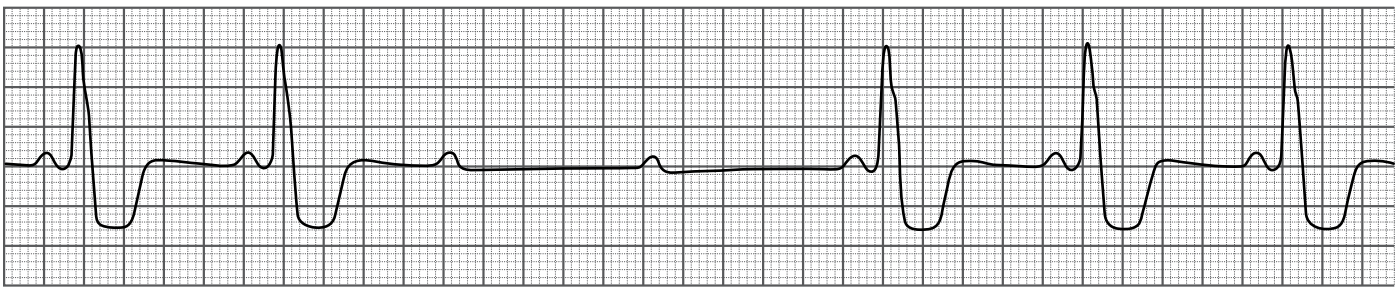

Figure 5-5 Second-degree atrioventricular block type II.

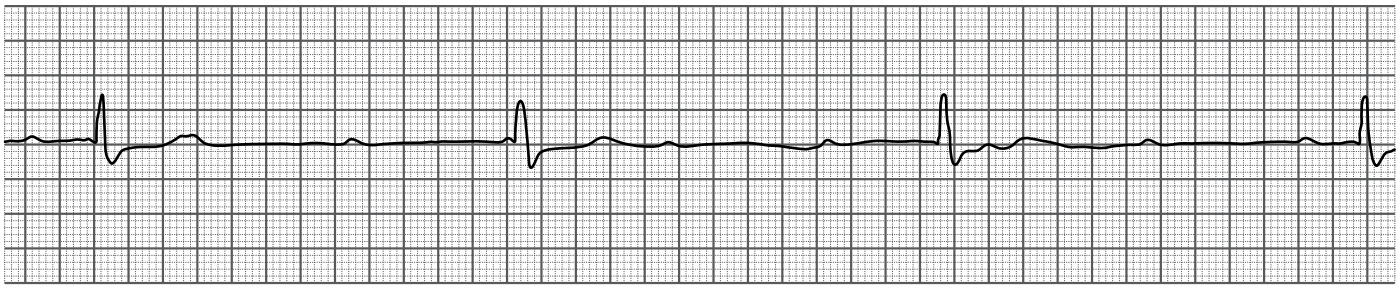

Figure 5-6 Third-degree atrioventricular block.

Emergency Care

- Assess the patient and obtain a focused history. Consider consultation with a specialist as needed.
- Because hypoxia is the most common cause of symptomatic bradycardia in children, initial interventions focus on assessment and support of the airway and ventilation and the administration of supplemental oxygen (**Figure 5-7**). Initiate pulse oximetry and cardiac and blood pressure monitoring. If ventilation is adequate, give supplemental oxygen in a manner that does not agitate the child. If breathing is inadequate, assist ventilation using an appropriate-sized bag-mask device with supplemental oxygen. If available, select a cardiac monitor with defibrillation and transcutaneous pacing capabilities.
- Identify the cardiac rhythm. Establish vascular access and obtain a 12-lead ECG, but do not delay ongoing emergency care to obtain the 12-lead ECG.
- Identify and treat possible reversible causes of the bradycardia (**Table 5-1**), which may include hypoxia, increased vagal tone, acidosis, acute elevation of intracranial pressure, hypothermia, hyperkalemia, or medications such as calcium channel blockers (e.g., verapamil, diltiazem), digoxin, clonidine, opioids, and beta-blockers (e.g., atenolol, propranolol).
- If the child's HR is slower than 60 beats per minute with signs of poor perfusion (e.g., acute changes in mental status, hypotension, delayed capillary refill, abnormal skin color) despite oxygenation and ventilation, begin chest compressions and

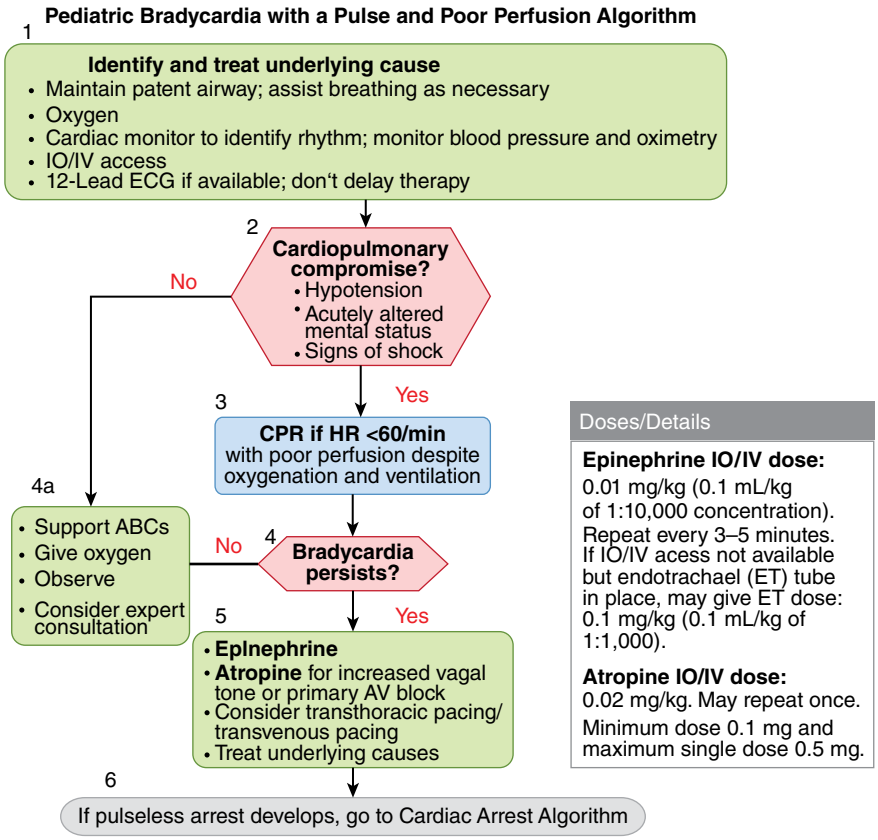

Figure 5-7 Pediatric bradycardia with a pulse and poor perfusion algorithm.

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Table 5-1 Possible Reversible Causes of Cardiac Dysrhythmias

Reversible Cause	Intervention
Hypoxia	Administer oxygen, support oxygenation and ventilation
Hypovolemia	Replace volume
Hydrogen ion	Correct acidosis
Hypoglycemia	Give dextrose if indicated
Hypokalemia/hyperkalemia	Correct electrolyte disturbances
Hypothermia	Rewarming measures
Toxins/poisons/drugs	Antidote/specific therapy
Trauma	Support oxygenation and ventilation
Tamponade (cardiac)	Pericardiocentesis
Tension pneumothorax	Needle decompression, chest tube insertion
Thrombosis (coronary or pulmonary)	Anticoagulation, surgery

ventilations. Reassess the patient after two minutes to determine if bradycardia and signs of hemodynamic compromise persist.

- Give epinephrine IV/IO if the bradycardia continues despite oxygenation and ventilation (**Table 5-2**). A continuous infusion should be considered if the bradycardia persists.
- Give atropine if the bradycardia is the result of suspected increased vagal tone, primary AV block, or cholinergic drug toxicity (**Table 5-3**).
- Consider pacing if the bradycardia is unresponsive to therapeutic interventions. Pacing is most likely to be necessary for children who develop blocks in AV conduction after cardiovascular surgery. Patients with denervated hearts following heart transplantation may also require pacing.

PALS Pearl

Although the endotracheal (ET) route can be used for the delivery of some medications (i.e., lidocaine, epinephrine, atropine, and naloxone), it is not the preferred route because optimal doses for ET administration are unknown and medication absorption is unpredictable. The intravenous and intraosseous routes are preferred (see Chapter 4).

Table 5-2 Epinephrine

Trade name	Adrenalin
Classification	Catecholamine, sympathomimetic, vasopressor
Mechanism of action	• Stimulates alpha and beta adrenergic receptors
Indications	Symptomatic bradycardia and cardiac arrest
Dosage	• IV/IO bolus: 0.01 mg/kg (0.1 mL/kg of 1:10,000 solution) every 3 to 5 minutes; maximum IV/IO dose 1 mg (de Caen et al., 2015) • If vascular access is not available and the patient is intubated, epinephrine may be given by means of an ET tube: 0.1 mg/kg (0.1 mL/kg of 1:1,000 solution), maximum ET dose 2.5 mg (de Caen et al., 2015)
Adverse effects	CNS: anxiety, restlessness, dizziness, headache CV: palpitations, dysrhythmias (especially tachycardia), hypertension GI: nausea, vomiting Other: hyperglycemia, tissue sloughing with extravasation
Notes	• Continuous monitoring of the patient's ECG and oxygen saturation and frequent monitoring of the patient's vital signs are essential. • Consider a continuous epinephrine infusion (0.1 to 0.3 mcg/kg per minute) if the bradycardia persists despite IV/IO bolus therapy. Infuse by means of an infusion pump and preferably through a central line. • Check the IV/IO site frequently for evidence of tissue sloughing. • As of May 1, 2016, ratio expressions no longer appear on single entity drug products. For example, epinephrine 1:1,000 is displayed as 1 mg/mL. Epinephrine 1:10,000 is displayed as 0.1 mg/mL (Cocchio, 2016).

CNS = central nervous system, CV = cardiovascular, ECG = electrocardiogram, ET = endotracheal, GI = gastrointestinal, IO = intraosseous, IV = intravenous.

Table 5-3 Atropine Sulfate

Classification	Anticholinergic, parasympatholytic, antimuscarinic, parasympathetic antagonist, parasympathetic blocker
Mechanism of action	• Anticholinergic agents such as atropine block the actions of acetylcholine of the parasympathetic division of the autonomic nervous system at muscarinic receptor sites. The effects of atropine in various organs depend on the degree to which the end organ is regulated by the parasympathetic nervous system. • Atropine enhances AV conduction and increases heart rate (positive chronotropic effect) by accelerating the SA node discharge rate and blocking the vagus nerves.
Indications	Symptomatic bradycardia
Dosage	• IV/IO: 0.02 mg/kg IV/IO push, may repeat once if needed. Minimum single dose 0.1 mg. Maximum single dose 0.5 mg (de Caen et al., 2015) • ET: 0.04 to 0.06 mg/kg (de Caen et al., 2015)
Adverse effects	• CNS: anxiety, dizziness, headache, confusion, delirium, hallucinations, coma • CV: tachycardia, palpitations, angina, ventricular ectopy, hypotension, hypertension • GI: nausea, vomiting • GU: urinary retention • Skin: flushed, hot skin
Notes	• Although epinephrine is the drug of choice for symptomatic bradycardia in children, give atropine first if the bradycardia is the result of suspected increased vagal tone, primary AV block, or cholinergic drug toxicity. • Continuous monitoring of the patient's ECG and oxygen saturation and frequent monitoring of the patient's vital signs are essential. • Transplanted hearts do not usually respond to atropine because they lack vagus nerve innervation.

AV = atrioventricular, CNS = central nervous system, CV = cardiovascular, ECG = electrocardiogram, ET = endotracheal, GI = gastrointestinal, GU = genitourinary, IO = intraosseous, IV = intravenous, SA = sinoatrial.

PUTTING IT ALL TOGETHER

The chapter quiz and case studies presented on the following pages are provided to help you integrate the information presented in this chapter.

Chapter Quiz

Multiple Choice

Identify the choice that best completes the statement or answers the question.

____ 1. Which of the following is a possible cause of sinus bradycardia?

a. Hypovolemia
b. Elevated temperature
c. Increased intracranial pressure
d. Administration of sympathomimetics

____ 2. A toddler is demonstrating signs of respiratory failure. The cardiac monitor reveals a sinus bradycardia that continues despite adequate oxygenation and ventilation. Which of the following medications should be administered at this time?

a. Atropine
b. Adenosine
c. Epinephrine
d. Norepinephrine

____ 3. What is the recommended intravenous/intraosseous (IV/IO) dosage of atropine when treating a symptomatic bradycardia?

a. 0.01 mg/kg IV/IO push
b. 0.02 mg/kg IV/IO push
c. 2 to 20 mcg/kg/minute IV/IO infusion
d. 0.1 to 0.3 mcg/kg/minute IV/IO infusion

____ 4. Which of the following is characteristic of first-degree atrioventricular (AV) block?

a. A consistently prolonged PR interval
b. A PR interval that is shorter than normal
c. A PR interval that varies from beat to beat
d. A PR interval that progressively increases in duration

____ 5. A 5-year-old heart transplant recipient is experiencing serious signs and symptoms related to a bradycardia two days after surgery. Which of the following statements is correct with regard to this situation?

a. Pacing should be considered in this circumstance.
b. Magnesium sulfate is the drug of choice for symptomatic bradycardia.
c. The administration of atropine usually causes an exaggerated response in the transplanted heart.
d. The administration of epinephrine usually results in a blunted response in the transplanted heart.

Case Study 5-1

Your patient is a 2-year-old child who was found unresponsive by her mother. Trauma is not suspected. You have a sufficient number of advanced life support personnel available to assist you and carry out your instructions. Emergency equipment is available.

1. Your general impression reveals a young girl who is lying supine on a stretcher and is not moving. You hear snoring sounds, and observe slow and shallow chest wall movement. Her skin is pale. On the basis of these findings, how would you categorize the patient's physiologic problem?

2. Your primary assessment reveals the following:

Primary Assessment	
A	Snoring sounds, no secretions
B	Ventilatory rate 6 breaths/minute and shallow
C	Heart rate 54 beats/minute (sinus bradycardia), weak peripheral pulses, skin pale and dry, capillary refill 3 seconds
D	Unresponsive, Glasgow Coma Scale score 3
E	Temperature 37°C (98.6°F), weight 12.7 kg (28 pounds)

The presence of snoring sounds suggests possible airway compromise. How will you manage this situation?

3. A team member has applied a pulse oximeter and cardiac monitor. The child's oxygen saturation is 83% on room air. What should be done now?

4. A SAMPLE history and focused physical examination have been obtained with the following results:

SAMPLE History	
Signs/symptoms	Unresponsive with slow and shallow breathing
Allergies	None
Medications	None
Past medical history	Normal development; immunizations current
Last oral intake	Cereal for breakfast
Events prior	Found unresponsive on her mother's bedroom floor next to an empty container of codeine

Physical Examination	
Head, eyes, ears, nose, throat	Snoring sounds (cleared with opening the airway), pinpoint pupils
Neck	No abnormalities noted
Chest	Slow, shallow ventilatory effort; breath sounds clear
Abdomen	No abnormalities noted
Pelvis	No abnormalities noted
Extremities	Weak peripheral pulses; skin pale, cool, and dry
Back	No abnormalities noted

On the basis of your general impression and primary assessment findings, what do you suspect is the cause of this child's bradycardia?

5. What should be done now? Because this child's heart rate is slower than normal for her age, should cardiopulmonary resuscitation be started at this time?

6. Vascular access has been successfully established. Bag-mask ventilation is being performed and the child's oxygen saturation is now 97%. Her heart rate is now 70 beats/minute. Despite your interventions, the child remains unresponsive. What should be done now?

Chapter Quiz Answers

1. C. A sinus bradycardia may be normal in conditioned adolescent athletes and in some children during sleep. Sinus bradycardia may also result from hypoxia, vagal (parasympathetic) stimulation (e.g., during suctioning, endotracheal tube placement), electrolyte disturbances, respiratory failure, hypothermia, increased intracranial pressure, anorexia nervosa, or medications. Hypovolemia, an elevated temperature, and the administration of sympathomimetics typically result in an *increased* heart rate, as seen with sinus tachycardia.

OBJ: Discuss the types of bradycardias that may be observed in the pediatric patient.

2. C. Epinephrine is the drug of choice for symptomatic bradycardia in children. Atropine is given first if the bradycardia is the result of suspected increased vagal tone, primary atrioventricular (AV) block, or cholinergic drug toxicity. Adenosine is the drug of choice for terminating supraventricular tachycardias that use the AV node for their continuation; it is not used in the treatment of bradycardias. Norepinephrine is a potent medication with alpha- and beta-adrenergic effects that is primarily used to increase blood pressure.

OBJ: Discuss the initial emergency care for symptomatic bradycardia in infants and children.

3. B. The recommended dosage of atropine is 0.02 mg/kg IV/IO push. The minimum single dose is 0.1 mg and the maximum single dose is 0.5 mg. Atropine may be repeated every 5 minutes up to a maximum total dose of 1 mg in a child and 3 mg in an adolescent.

OBJ: Discuss the pharmacology of medications used when managing a symptomatic bradycardia.

4. A. With first-degree AV block, all impulses from the sinoatrial node are conducted, but the impulses are delayed within the AV node before they reach the ventricles. This delay in AV conduction results in a consistently prolonged PR interval with no dropped beats.

OBJ: Discuss the types of bradycardias that may be observed in the pediatric patient.

5. A. Transplanted hearts lack sympathetic and parasympathetic nerve innervation. Despite the absence of sympathetic nerves, the transplanted heart is hypersensitive to circulating catecholamines (e.g., epinephrine, norepinephrine). Administration of sympathomimetic medications can result in an unpredictable response in the transplanted heart. Administration of parasympatholytics (e.g., atropine) generally results in an ineffective response. Pacing may be necessary when treating a symptomatic bradycardia in these patients. Magnesium sulfate is not indicated in the management of a bradycardia.

OBJ: Discuss the pharmacology of medications used when managing a symptomatic bradycardia.

Case Study 5-1 Answers

1. The general impression findings are abnormal (Appearance: unresponsive child; Breathing: abnormal; Circulation: abnormal skin color). An abnormal appearance, abnormal work of breathing, and abnormal skin color are consistent with respiratory failure or cardiopulmonary failure.

OBJ: Summarize the components of the pediatric assessment triangle and the reasons for forming a general impression of the patient.

2. Snoring sounds suggest the presence of an upper airway obstruction, such as that caused by displacement of the tongue in an unresponsive patient. The head tilt–chin lift is the preferred technique for opening the airway of an unresponsive patient without suspected cervical spine injury.

OBJ: Describe the methods used for opening the airway and discuss the preferred method of opening the airway in cases of suspected cervical spine injury.

3. Because signs of respiratory failure are present, assist ventilation using a bag-mask device with supplemental oxygen.

OBJ: Discuss positive-pressure ventilation using a bag-mask device and troubleshooting ineffective bag-mask ventilation.

4. This child's history of present illness and signs and symptoms suggest a possible opioid ingestion. Her bradycardia is most likely the result of hypoxia and the codeine ingested. The presence of ineffective breathing, pinpoint pupils, and bradycardia are signs that cardiopulmonary failure is present. Move quickly to support the patient's airway and breathing and to prevent deterioration to cardiac arrest.

OBJ: Given a patient situation, formulate a treatment plan (including assessment, airway management, cardiopulmonary resuscitation, and pharmacological interventions where applicable) for a patient presenting with a symptomatic bradycardia.

5. Continue to support the patient's breathing with bag-mask ventilation. Obtain vascular access and seek expert consultation as needed. Closely monitor the child's heart rate and oxygen saturation. If the child's heart rate does not rapidly improve with ventilation, begin chest compressions.

OBJ: Discuss the initial emergency care for symptomatic bradycardia in infants and children.

6. A point-of-care glucose level and 12-lead electrocardiogram should be obtained. Naloxone (Narcan), an opioid antagonist, should be administered to reverse the effects of the opioid ingested. Because the effects of narcotics are usually longer than naloxone, respiratory depression may return once the naloxone has worn off. Closely monitor the patient and continuously observe for resedation for at least two hours after the last dose of naloxone. Additional studies that should be obtained as time and the patient's condition permit include a chest radiograph, toxicology screen, electrolytes, and BUN/creatinine.

OBJ: Given a patient situation, formulate a treatment plan (including assessment, airway management, cardiopulmonary resuscitation, and pharmacological interventions where applicable) for a patient presenting with a symptomatic bradycardia.

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Checklist 5-1 Symptomatic Bradycardia

Action Steps	Performed Correctly
Ensures scene safety. Takes or communicates the use of personal protective equipment for blood and body substances.	☐
Assigns team member roles.	☐
Assessment	
Forms a general impression: Assesses patient's appearance, work of breathing, and circulation.	☐
Directs assessment of airway/responsiveness; directs the use of a manual airway maneuver to open the airway, if indicated.	☐
Directs assessment of breathing including estimation of ventilatory rate and evaluation of ventilatory effort; directs assessment of breath sounds.	☐
Directs assessment of central/peripheral pulse quality, estimation of heart rate, and evaluation of skin (color, temperature, and moisture) and capillary refill.	☐
Directs team members to determine a Glasgow Coma Scale score and patient weight.	☐
Directs team members to obtain vital signs and to apply a pulse oximeter and blood pressure and cardiac monitors.	☐
Obtains a brief history and performs a focused physical examination.	☐
Correctly identifies cardiac rhythm.	☐
Considers patient presentation and quickly determines if the child is asymptomatic, symptomatic but stable, symptomatic and unstable, or pulseless.	☐
Considers the need for chest compressions with ventilation.	☐
Considers possible reversible causes of cardiac dysrhythmias.	☐
Treatment Plan	
Verbalizes a treatment plan and initiates appropriate interventions.	☐
Directs insertion of an oral airway or nasal airway, if indicated.	☐
Directs application of appropriate oxygen therapy; directs team member to begin assisted ventilation, if indicated.	☐
Instructs team member to establish vascular access.	☐
Orders administration of intravenous/intraosseous medications appropriate for the dysrhythmia.	☐
Orders diagnostic tests and procedures, if indicated.	☐
Considers the need for an advanced airway.	☐
Correctly verbalizes indications, dosages, and routes of administration for medications administered.	☐
Reassessment	
Repeats the primary assessment and obtains another set of vital signs.	☐
Monitors for, recognizes, and appropriately treats any changes in the patient's physiological status.	☐
Team Leader Assessment	
Effectively leads team members throughout patient care.	☐
Directs the transfer of patient care for ongoing monitoring and care.	☐
Requests a team debriefing after the transfer of patient care is complete.	☐

CHAPTER 6

Tachycardias

Learning Objectives

After completing this chapter, you should be able to:

1. Discuss the types of tachycardias that may be observed in the pediatric patient.
2. Discuss the initial emergency care for stable or unstable tachycardia in infants and children.
3. Discuss the pharmacology of medications used while managing a tachycardia.
4. Identify a patient who is experiencing a tachycardia as asymptomatic, symptomatic but stable, or symptomatic and unstable.
5. Discuss the types of vagal maneuvers that may be used in the pediatric patient.
6. Discuss synchronized cardioversion and identify the indications and recommended energy levels for this procedure.
7. Given a patient situation, formulate a treatment plan (including assessment, airway management, pharmacological, and electrical interventions where applicable) for a patient presenting with a stable or unstable tachycardia.

After completing this chapter, and with supervised practice during a Pediatric Advanced Life Support (PALS) course, you will be skilled at the following:

- Ensuring scene safety and the use of personal protective equipment.
- Assigning team member roles or performing as a team member in a simulated patient situation.
- Directing or performing a patient assessment.

- Obtaining vital signs, establishing vascular access, attaching a pulse oximeter and blood pressure and cardiac monitors, and giving supplemental O_2 if indicated.
- Recognizing tachycardic rhythms.
- Implementing a treatment plan for symptomatic bradycardia in infants and children.
- Demonstrating knowledge of the indications, dosages, and effects of the medications used when managing a symptomatic tachycardia.
- Safely performing synchronized cardioversion when indicated.
- Recognizing when it is best to seek expert consultation.
- Reviewing your performance as a team leader or team member during a postevent debriefing.

ASSESSMENT EVIDENCE

Performance Tasks

During the PALS course, you will be functioning as the team leader of the Rapid Response Team or Code Team within your organization. Your classmates are similarly trained members of the team who will assist you. Your task is to direct, without prompting, the emergency care efforts of your team according to current resuscitation guidelines.

Key Criteria

Assessment of your ability to manage a patient who is experiencing a symptomatic stable or unstable tachycardia and your ability to manage the team who will assist you in providing patient care is part of the PALS course. An evaluation checklist that reflects key steps and interventions in the patient management process will be used to assess your performance (see **Checklist 6-1**). A PALS instructor will check the appropriate box as you complete each step during your management of the patient.

Learning Plan

- Read this chapter before your PALS course. Create flashcards and memory aids to help you recall key points. Carefully review each of the medications discussed in this chapter.
- Complete the chapter quiz and review the answers provided.
- Complete the case study at the end of the chapter. Read the scenario and answer each question that follows it. The questions are intended to reinforce important points pertinent to the cases that are discussed in this text. Compare your answers with the answers provided at the end of the case study and with the checklist pertinent to the case study.

KEY TERMS

Defibrillation
The therapeutic delivery of unsynchronized electrical current through the myocardium over a very brief period to terminate a cardiac dysrhythmia

Defibrillator
Device used to administer an electrical shock to terminate a cardiac dysrhythmia

Synchronized cardioversion
The delivery of a shock to the heart to terminate a rapid dysrhythmia that is timed to avoid the vulnerable period during the cardiac cycle

INTRODUCTION

- In infants and children, a tachycardia is present if the heart rate (HR) is faster than the upper limit of normal for the patient's age (Doniger & Sharieff, 2006). A tachycardia may represent either a normal compensatory response to the need for increased cardiac output or oxygen delivery or an unstable dysrhythmia. Tachycardias can produce ventricular rates so rapid that ventricular filling time is reduced, stroke volume decreases, and cardiac output falls.
- *Supraventricular tachycardia* is a term that encompasses rapid rhythms originating from the atrium, atrioventricular (AV) junction (i.e., the AV node and the bundle of His), or an accessory pathway (Walsh, Berul, & Triedman, 2006) (**Figure 6-1**). An *accessory pathway* is an extra bundle of myocardial tissue that forms a connection between the atria and ventricles outside the normal conduction system. Ventricular tachycardias arise from

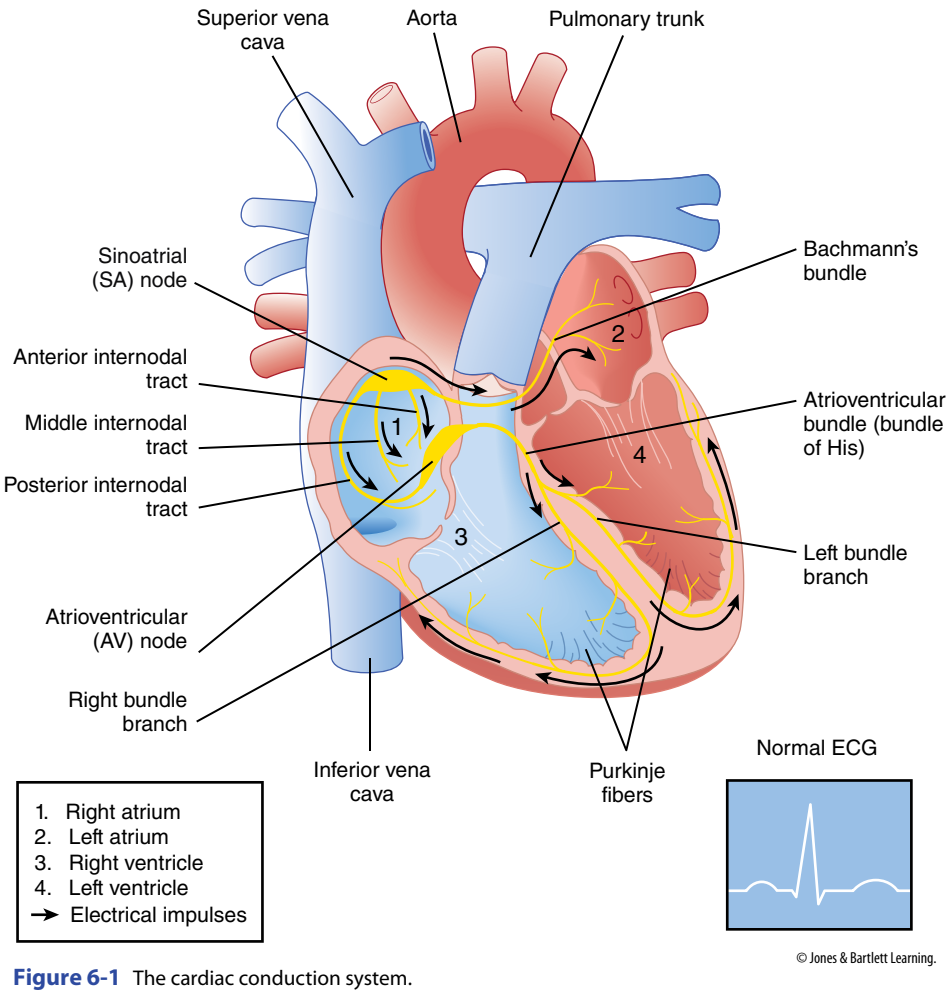

Figure 6-1 The cardiac conduction system.

sites below the bundle of His. Most tachycardias in children are supraventricular in origin (Sharieff & Rao, 2006).

- Recall that the duration of the QRS complex is short in an infant (i.e., 0.03 to 0.08 seconds) and increases with age (i.e., 0.04 to 0.09 seconds in a child). If the QRS measures 0.09 seconds or less, the QRS is "narrow," and is presumed to be supraventricular in origin. If the QRS is more than 0.09 seconds in duration, the QRS is "wide" and presumed to be ventricular in origin until proven otherwise. When evaluating a child with a tachycardia, a 12- or 15-lead ECG can help with differentiating the type of tachycardia.

SINUS TACHYCARDIA

Sinus tachycardia is a normal compensatory response to the need for increased cardiac output or oxygen delivery. With a sinus tachycardia, the HR is faster than normal for age but is usually less than 220 beats per minute in infants or 180 beats per minute in children. A sinus tachycardia begins gradually. The ECG shows a regular rhythm with a narrow QRS complex that often varies in response to activity or stimulation. A P wave precedes each QRS complex (**Figure 6-2**). The history given typically explains the rapid HR (i.e., pain, fever, volume loss caused by trauma, vomiting, or diarrhea). Although common causes of sinus tachycardia include dehydration and hypovolemia, it can also be associated with conditions such as hypoxia, anemia, shock, myocardial ischemia, pulmonary edema, hyperthyroidism, medications (e.g., catecholamines), hypocalcemia, and illicit drug use (Doniger & Sharieff, 2006).

Emergency Care

Treatment is directed at the underlying cause that precipitated the rhythm (e.g., administering medications to relieve pain, administering fluids to correct hypovolemia) (**Figure 6-3**).

SUPRAVENTRICULAR TACHYCARDIA (SVT)

- Supraventricular tachycardia is the most common tachydysrhythmia that necessitates treatment in the pediatric patient (Doniger & Sharieff, 2006). Unlike sinus tachycardia, SVT is not a normal compensatory response to physiologic stress.
- With SVT, the HR is usually more than 220 beats per minute in infants or 180 beats per minute in children (**Table 6-1**). Onset of the rhythm occurs abruptly. The ECG shows a regular rhythm with a narrow QRS complex (0.09 seconds or less) that does not vary in response to activity or stimulation. P waves are often indiscernible because of the rapid rate and may be lost in the T

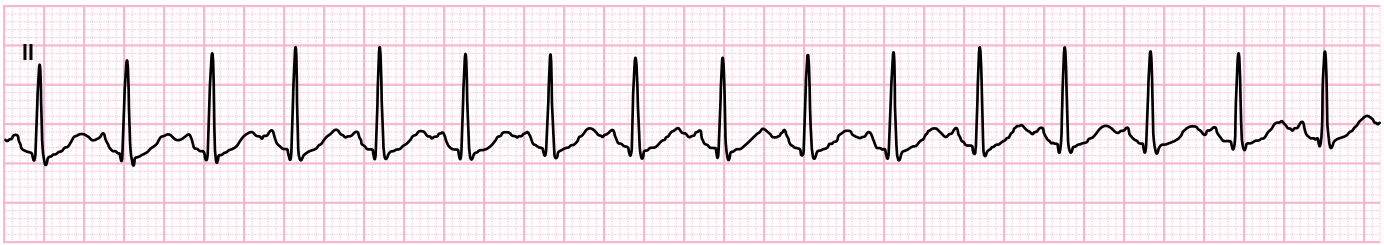

Figure 6-2 Sinus tachycardia in an 11-year-old boy.

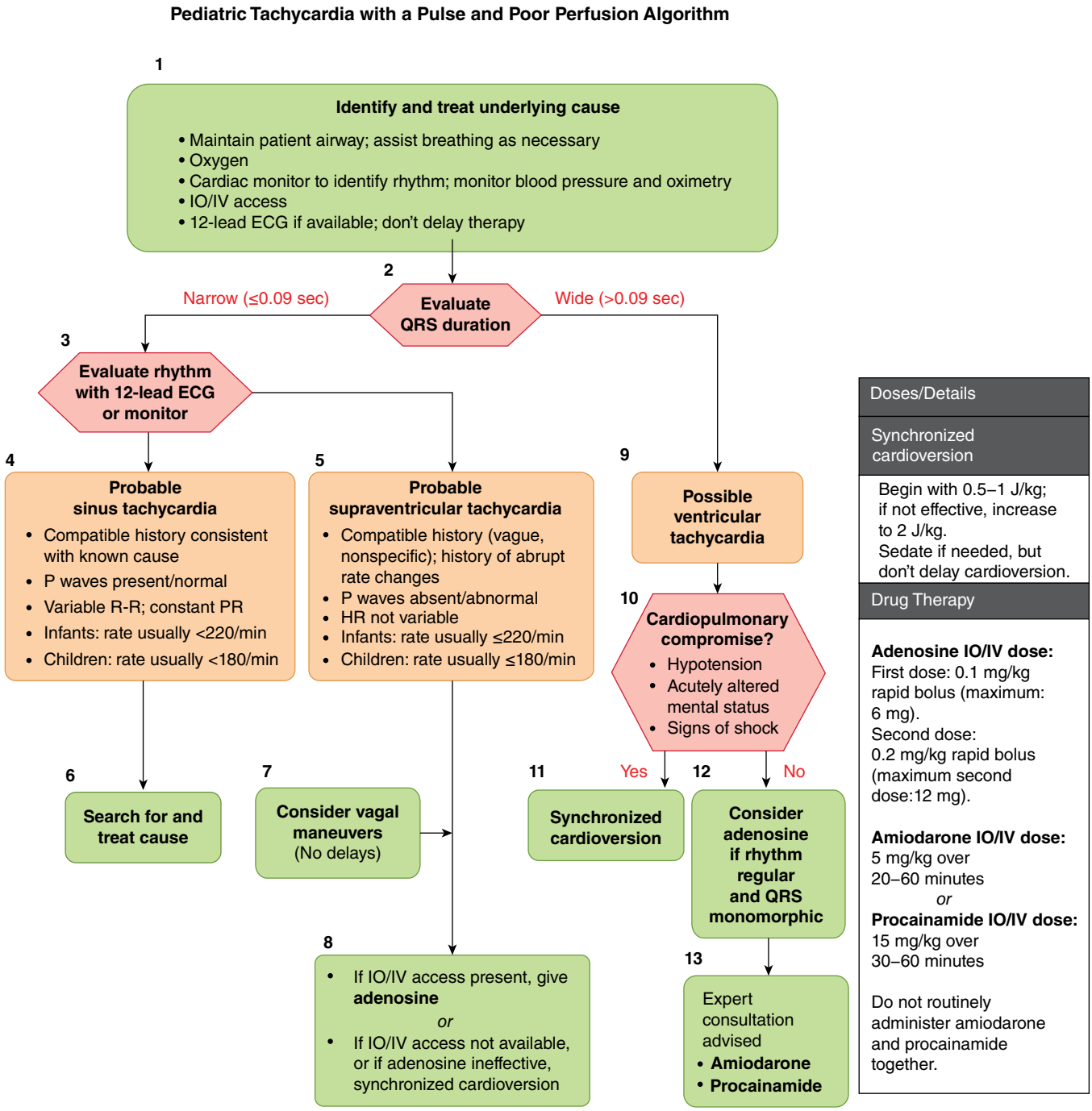

Figure 6-3 Pediatric tachycardia with a pulse and poor perfusion algorithm.

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Table 6-1 Differentiation of Sinus Tachycardia and Supraventricular Tachycardia

Characteristic	Sinus Tachycardia	Supraventricular Tachycardia
Rate	Usually slower than 220 beats per minute in infants and 180 beats per minute in children	Usually 220 beats per minute or more in infants and 180 beats per minute or more in children
Ventricular Rate and Regularity	Varies with activity/stimulation	Constant with activity/stimulation
Onset and End	Gradual	Abrupt
P waves	Visible; normal appearance	Often indiscernible; if visible, differ in appearance from SA node P waves
History	History given explains rapid heart rate; pain, fever, fluid or blood loss caused by trauma, vomiting, or diarrhea	In the absence of known congenital heart disease, history is usually nonspecific (i.e., history given does not explain rapid heart rate); infants may present with complaints such as poor feeding, "not acting right," sweating with feeding, or fussiness
Physical Examination	May be consistent with volume loss (blood, diarrhea, vomiting), possible fever, clear lungs, liver of normal size	Signs of poor perfusion including diminished peripheral pulses, delayed capillary refill, pallor, increased work of breathing, possible crackles, enlarged liver

SA = sinoatrial

wave of the preceding beat (**Figure 6-4**). If P waves are visible, they differ in appearance from P waves that originate in the sinoatrial (SA) node. In the absence of known congenital heart disease, the history obtained is usually nonspecific (i.e., the history does not explain the rapid HR).

Assessment Findings

- Infants with SVT may present with a history of fussiness, lethargy, irritability, poor feeding, and sweating during feeding. Pallor, cough, and respiratory distress may be observed if heart failure is present (Doniger & Sharieff, 2006). Infants may tolerate the rapid ventricular rate associated with SVT for 24 hours, but about 50% of them will develop signs of heart failure within 48 hours and may deteriorate rapidly (Doniger & Sharieff, 2006).
- Rapid ventricular rates may be associated with lightheadedness, syncope, dyspnea, weakness, nervousness, and complaints of palpitations, dizziness, and chest pain or pressure in the older child and adolescent. Signs of shock may be evident depending on the duration and rate of the tachycardia, and the presence of primary cardiac disease. A child with normal cardiovascular function may tolerate a rapid ventricular rate for several hours before signs of heart failure or shock develop.

Emergency Care

- Perform an assessment and obtain a focused history.
- Apply a pulse oximeter and administer supplemental oxygen if indicated; ensure effective oxygenation and ventilation.
- Apply blood pressure and cardiac monitors and establish vascular access. Identify the cardiac rhythm (including rate, QRS width, and regularity) (see Figure 6-3). Obtain a 12-lead ECG but do not delay emergency care.
- Quickly determine if the child is asymptomatic, symptomatic but stable, or symptomatic and unstable. Search for and treat the underlying cause.

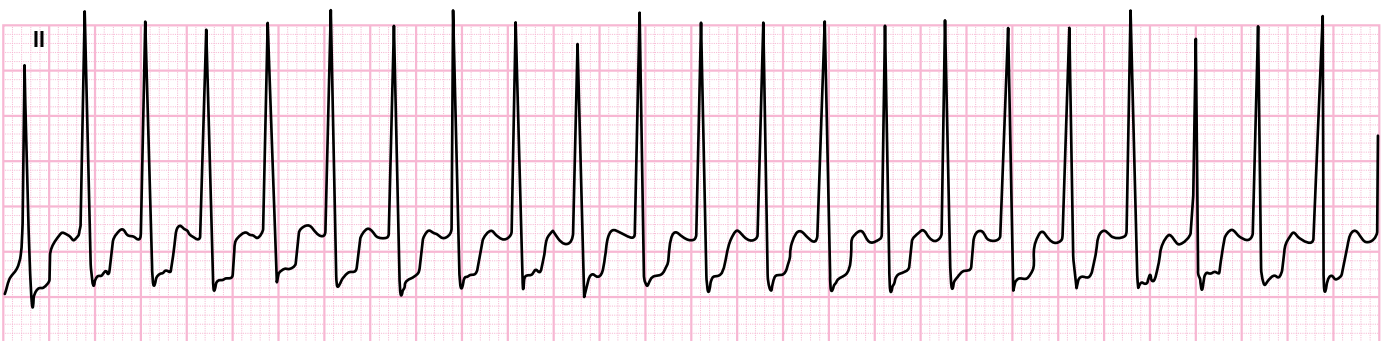

Figure 6-4 Supraventricular tachycardia in a child complaining of chest pain.

- If the child is asymptomatic, observe.
- If the child is symptomatic but stable:
  - Ensure that the patient's history does not indicate causes of *sinus* tachycardia (i.e., dehydration, fever).
  - Consider the use of vagal maneuvers, which are techniques used to slow conduction through the AV node and slow the heart rate. It is important to record the patient's cardiac rhythm before, during, and after a vagal maneuver. Vagal maneuvers are discussed later in this chapter.
  - If the rhythm persists and vascular access is available, give adenosine for pharmacologic cardioversion (**Table 6-2**, **Figure 6-5**). Adenosine is the drug of choice because of its rapid onset of action and minimal effects on cardiac contractility. Verapamil (**Table 6-3**) may be used to terminate SVT in older children (de Caen et al., 2015). Document the patient's cardiac rhythm before, during, and after administration of antiarrhythmic medications.
  - Perform synchronized cardioversion if adenosine is ineffective or if vascular access is unavailable (de Caen et al., 2015). Search for and treat the underlying cause.
  - Consider infusing amiodarone (**Table 6-4**) *or* procainamide (**Table 6-5**) while monitoring the child's blood pressure and ECG if SVT persists after a second shock or if the tachycardia recurs quickly (de Caen et al., 2015). Consultation with a pediatric cardiologist is advised before administration. Amiodarone and procainamide should not be administered together because both prolong the QT interval.

Table 6-2 Adenosine

Trade name	Adenocard
Classification	Antiarrhythmic
Mechanism of action	• Adenosine is a naturally occurring nucleoside that is derived from the metabolism of adenosine triphosphate (ATP) in the body. • Adenosine slows conduction velocity through the AV node, increases the AV node refractory period, can interrupt reentry pathways that involve the AV node, and can restore sinus rhythm in SVT. Reentry circuits are the underlying mechanism for most episodes of SVT in infants and children. Adenosine acts at specific adenosine receptors to cause a temporary block of conduction through the AV node, interrupting these reentry circuits.
Indications	Diagnosis and treatment of SVTs that involve the AV node
Dosage	• Initial dose 0.1 mg/kg (up to 6 mg) as rapidly as possible, IV/IO push followed by a normal saline (NS) flush (de Caen et al., 2015) • Second dose 0.2 mg/kg rapid IV/IO push (maximum single dose 12 mg) (de Caen et al., 2015)
Contraindications	• Atrial flutter or fibrillation • Known hypersensitivity • Second- or third-degree AV block • Sick sinus syndrome
Adverse effects	Adenosine may cause facial flushing because the drug is a mild cutaneous vasodilator and may cause coughing, dyspnea, and bronchospasm because it is a mild bronchoconstrictor. Use with caution in patients with obstructive lung disease.
Notes	• Obtain a baseline ECG before adenosine administration. Continuous ECG monitoring is essential for evaluation of the patient's response to therapy. • Adenosine has an onset of action of 10 to 40 seconds, a duration of 1 to 2 minutes, and a half-life of about 10 seconds. Because of its short half-life, and to enhance delivery of the drug to its site of action in the heart, select the injection port on the IV tubing that is nearest to the patient and administer the drug using a two-syringe technique. Prepare one syringe with the drug and the other with an NS flush of at least 5 mL. Insert both syringes into the injection port in the IV tubing. Administer the drug IV or IO as rapidly as possible (i.e., over a period of seconds) and immediately follow with the saline flush. • Consider the use of adenosine in differentiating SVT from VT only if the cardiac rhythm is regular and the QRS is monomorphic (de Caen et al., 2015). • Higher doses may be needed when a patient is taking methylxanthine preparations.

AV = atrioventricular, ECG = electrocardiogram, IO = intraosseous, IV = intravenous, SVT = supraventricular tachycardia.

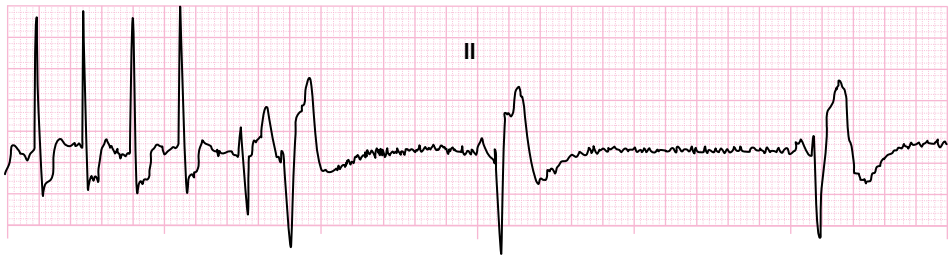

Figure 6-5 Same child as in Figure 6-4 after one dose of intravenous adenosine.

Table 6-3 Verapamil

Trade name	Isoptin, Calan
Classification	Calcium channel blocker, antiarrhythmic
Mechanism of action	• Inhibits movement of calcium ions across cell membranes in the heart and vascular smooth muscle • Slows conduction through the AV node and prolongs the refractory period of the AV node • Decreases myocardial contractility
Indications	Stable narrow-QRS tachycardia if the rhythm persists despite vagal maneuvers or adenosine or if the tachycardia is recurrent
Dosage	0.1 to 0.3 mg/kg IV/IO (de Caen et al., 2015)
Contraindications	Known hypersensitivity, sinus node dysfunction, cardiogenic shock, ventricular tachycardia
Adverse effects	Hypotension (most common), bradycardia, AV block
Notes	• Can worsen hypotension. Closely monitor BP, heart rate, and ECG. • Should not be administered to infants without expert consultation because it may cause myocardial depression, hypotension, and cardiac arrest (de Caen et al., 2015).

AV = atrioventricular, BP = blood pressure, ECG = electrocardiogram, IO = intraosseous, IV = intravenous.

Table 6-4 Amiodarone

Trade name	Cordarone
Classification	Class III antiarrhythmic
Mechanism of action	• Amiodarone directly depresses the automaticity of the SA and AV nodes, slows conduction through the AV node and in the accessory pathway of patients with Wolff–Parkinson–White syndrome, inhibits alpha- and beta-adrenergic receptors, and possesses both vagolytic and calcium-channel blocking properties. • Amiodarone prolongs the PR, QRS, and QT intervals, and has an additive effect with other medications that prolong the QT interval (e.g., procainamide, phenothiazines, some tricyclic antidepressants, thiazide diuretics, sotalol).
Indications	• SVT and VT with a pulse • Pulseless VT • VF
Dosage	• Pulseless VT/VF: 5 mg/kg rapid IV/IO push (maximum single dose 300 mg); may repeat to maximum dose of 15 mg/kg per day (2.2 g in adolescents) (de Caen et al., 2015). • Perfusing SVT or VT: 5 mg/kg IV/IO loading dose over 20 to 60 minutes. Repeat as needed to a maximum dose of 15 mg/kg per day (2.2 g in adolescents) (de Caen et al., 2015).
Contraindications	Second- or third-degree AV block, sinus node dysfunction

Adverse effects	Hypotension (most common), bradycardia, AV block
Notes	• Amiodarone is an antiarrhythmic that is a sodium blocker, potassium blocker, calcium blocker, and beta-blocker. Because of these properties, amiodarone is used for a wide range of both atrial and ventricular dysrhythmias in adults and children. • Like all antiarrhythmic agents, amiodarone may cause a worsening of existing dysrhythmias or precipitate a new dysrhythmia. • Seek expert consultation before use for a patient who has a perfusing rhythm. • Obtain a baseline ECG before amiodarone administration and then monitor the ECG continuously for evaluation of the patient's response to therapy. Document the patient's baseline PR and QT intervals, QRS width, and BP. • Assess the patient's BP often and observe the ECG closely for increasing PR and QT intervals, widening of the QRS, bradycardia, and AV block. If an AV block or prolongation of the QT interval is seen, slow the infusion rate. If the blood pressure falls or if the QRS widens to more than 50% of its baseline width, stop or slow the infusion (de Caen et al., 2015). • Amiodarone has a long half-life ranging from 15 to 60 days.

AV = atrioventricular, BP = blood pressure, ECG = electrocardiogram, IO = intraosseous, IV = intravenous, SA = sinoatrial, SVT = supraventricular tachycardia, VF = ventricular fibrillation, VT = ventricular tachycardia.

Table 6-5 Procainamide

Trade name	Pronestyl
Classification	Class Ia antiarrhythmic
Mechanism of action	• Depresses cardiac automaticity, excitability, and conductivity • Prolongs the PR and QT intervals • Exerts a peripheral vasodilatory effect
Indications	• Atrial flutter • SVT • VT with a pulse
Dosage	15 mg/kg slow IV/IO infusion over 30 to 60 minutes (de Caen et al., 2015)
Contraindications	• Third-degree AV block unless a functioning artificial pacemaker is present • Patients with a prolonged QRS duration or QT interval because of the potential for heart block • Use with caution in first- or second-degree AV blocks
Adverse effects	• CNS: dizziness, drowsiness • CV: hypotension, AV block, QT interval prolongation, torsades de pointes • GI: nausea, vomiting • Other: joint pain, bitter taste, rash
Notes	• Seek expert consultation before use for a patient who has a perfusing rhythm. • Obtain a baseline ECG before administration and then continuously monitor the ECG for evaluation of the patient's response to therapy. Document the patient's baseline QT interval, QRS width, and BP. • Assess the patient's BP often and closely observe the ECG for increasing QT intervals, widening of the QRS, and the development of heart block. If prolongation of the QT interval is seen or a heart block develops, slow the infusion rate. If the blood pressure falls or if the QRS widens to more than 50% of its baseline width, stop or slow the infusion (de Caen et al., 2015). • Onset of action is 2 to 3 minutes; half-life is 3 to 4 hours.

AV = atrioventricular, BP = blood pressure, CNS = central nervous system, CV = cardiovascular, ECG = electrocardiogram, GI = gastrointestinal, IO = intraosseous, IV = intravenous, SVT = supraventricular tachycardia, VT = ventricular tachycardia.

- If the child is symptomatic and unstable (i.e., acutely altered mental status, signs of shock, or hypotension), immediate treatment with electric or pharmacologic cardioversion is warranted.
  - If vascular access is already available, adenosine may be given before synchronized cardioversion, but do not delay cardioversion.
  - If SVT persists and the child is responsive, sedate if possible and perform synchronized cardioversion starting with 0.5 to 1 J/kg (de Caen et al., 2015). If cardioversion does not terminate the dysrhythmia, increase the energy level to 2 J/kg (de Caen et al., 2015). Obtain a 12-lead ECG after cardioversion. If the dysrhythmia persists despite a second shock, consider consultation with a pediatric cardiologist before giving amiodarone or procainamide IV/IO.

PALS Pearl

Supraventricular tachycardia (SVT) with abnormal (aberrant) conduction through the bundle branches produces a wide QRS complex. Differentiation of SVT with abnormal conduction (also called wide-QRS SVT) from ventricular tachycardia (VT) is often difficult. Because almost all wide-QRS tachycardias are VT, any wide-QRS tachycardia in an infant or child should be presumed to be ventricular in origin and treated as VT.

VENTRICULAR TACHYCARDIA

- Ventricular tachycardia (VT) is a serious cardiac dysrhythmia that originates from below the bundle of His. Because VT originates below the bundle, the ventricles may be depolarized without receiving the additional 10% to 30% of ventricular filling produced by atrial contraction. The inadequate ventricular filling and rapid ventricular rate associated with this rhythm results in decreased stroke volume and cardiac output, which can be life threatening. VT can degenerate into ventricular fibrillation.
- VT is described as *monomorphic* when the QRS complexes are of the same shape and amplitude (**Figure 6-6**). When the QRS complexes of VT vary in shape and amplitude, the rhythm is termed *polymorphic VT* (**Figure 6-7**). Torsades de pointes is a type of polymorphic VT that is associated with a long QT interval. Polymorphic VT associated with a normal QT interval is simply called *polymorphic VT*.
- With VT, the QRS complex is wide (with a duration of more than 0.09 seconds) and the ventricular rate typically ranges from 120 to 250 beats per minute. It may be difficult to differentiate between the QRS complex and T wave. When T waves are clearly seen, they usually appear in a direction opposite that of the R wave.
- Episodes that last for fewer than 30 seconds are termed *nonsustained VT. Sustained VT* is an episode that lasts for more than 30 seconds (Hanash & Crosson, 2010).
- VT is relatively uncommon in infants and children but it may be seen in children who have had cardiac surgery or who have a cardiomyopathy, myocarditis, or myocardial tumor. Other causes of VT include long QT syndrome, electrolyte imbalances (e.g., hyperkalemia, hypokalemia, hypocalcemia), acquired heart disease, drug toxicity, and idiopathic causes (Doniger & Sharieff, 2006).

Assessment Findings

- VT may occur at any age and can have a variable presentation, ranging from no symptoms to cardiovascular collapse.

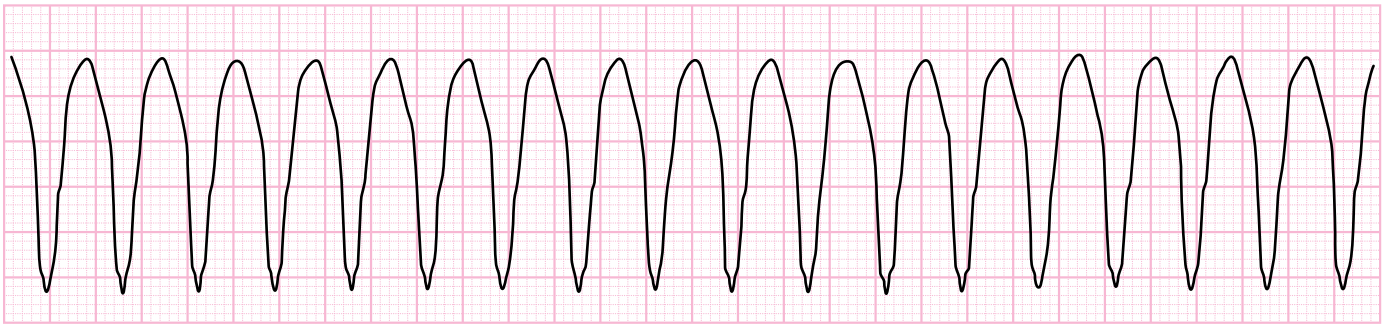

Figure 6-6 Monomorphic ventricular tachycardia.

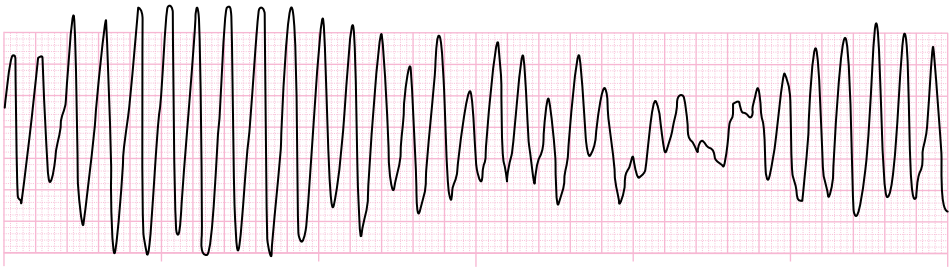

Figure 6-7 Polymorphic ventricular tachycardia.

- Infants may present with pallor, mottling, or cyanosis. They may be lethargic and have a history of feeding poorly. The older child may complain of palpitations, chest pain or discomfort, dizziness, or nausea and may present with syncope or seizures.

Emergency Care

- Perform an initial assessment and obtain a focused history, including family history for ventricular dysrhythmias or sudden death.
- Apply a pulse oximeter and administer oxygen if indicated; ensure effective oxygenation and ventilation.
- Apply blood pressure and cardiac monitors and establish vascular access. Identify the cardiac rhythm (including rate, QRS width, and regularity). Obtain a 12-lead ECG but do not delay emergency care.
- Quickly determine if the child is asymptomatic, symptomatic but stable, or symptomatic and unstable (see **Figure 6-3**). Search for and treat the underlying cause.
- If the child is asymptomatic, observe and consult a pediatric cardiologist. Search for and treat the underlying cause.
- If the child is symptomatic but stable:
  - Consult a pediatric cardiologist. Identify and treat possible reversible causes of the dysrhythmia.
  - If the rhythm is regular and the QRS is monomorphic, consider giving adenosine IV to help differentiate SVT from VT. Document the patient's cardiac rhythm before, during, and after administration of antiarrhythmic medications.
  - If the rhythm persists, consider electric cardioversion. After sedation, start with 0.5 to 1 J/kg (de Caen et al., 2015). If the initial shock does not terminate the dysrhythmia, increase the energy level to 2 J/kg (de Caen et al., 2015). Obtain a 12-lead ECG after cardioversion.
  - If the rhythm persists, consult with a cardiologist before attempting pharmacologic conversion with amiodarone or procainamide IV/IO. Closely monitor the child's blood pressure and ECG during administration of these medications. Stop or slow the infusion if the blood pressure falls or if the QRS widens (de Caen et al., 2015).
- If the child is symptomatic but unstable (i.e., acutely altered mental status, signs of shock, or hypotension), perform synchronized cardioversion starting with 0.5 to 1 J/kg (de Caen et al., 2015). Sedate if possible before the procedure, but do not delay cardioversion. Increase the energy level to 2 J/kg if the initial shock does not terminate the dysrhythmia (de Caen et al., 2015). Obtain a 12-lead ECG after cardioversion.

VAGAL MANEUVERS

- Vagal maneuvers are methods used to slow conduction through the AV node, resulting in slowing of the heart rate. While performing a vagal maneuver, continuous monitoring of the patient's ECG is essential. Note the onset and end of the vagal maneuver on the ECG rhythm strip. A 12-lead ECG should be obtained before and after the procedure.
- Vagal maneuvers may be tried in the stable but symptomatic child in SVT or during preparation for cardioversion or drug therapy for this dysrhythmia. Success rates with vagal maneuvers vary and depend on the patient's age, the presence of underlying conditions in the patient, and his or her level of cooperation (American Heart Association, 2011).
- The application of a cold stimulus to the face (e.g., a washcloth soaked in iced water, crushed ice mixed with water in a small plastic bag or glove) for 15 to 20 seconds is often effective in infants and young children (American Heart Association, 2011). When using this method, apply the cold stimulus to the upper half of the child's face (i.e., forehead, eyes, and bridge of the nose). Do not obstruct the patient's mouth or nose or apply pressure to the eyes.
- The Valsalva maneuver is another vagal maneuver that may be used in older, cooperative children. Ask the child to blow through a narrow straw, to take a deep breath and bear down as if having a bowel movement for 10 seconds, or to blow on a thumb as if it were a trumpet.

ELECTRICAL THERAPY

When preparing to deliver electrical therapy to a patient, it is *essential* that the operator be familiar with the type of device being used (i.e., monophasic versus biphasic), the manufacturer's recommended paddle/pad size and their placement, and the manufacturer's recommended energy levels for the dysrhythmia being treated.

Defibrillation

- **Defibrillation** is the therapeutic delivery of an unsynchronized electrical current (the delivery of energy has no relationship to the cardiac cycle) through the heart over a very brief period to terminate a cardiac dysrhythmia.
- *Manual defibrillation* refers to the placement of paddles or pads on a patient's chest, the interpretation of the patient's cardiac rhythm by a trained healthcare professional, and the healthcare professional's decision to deliver a shock, if indicated. *Automated external defibrillation* refers to the placement of pads on a patient's chest and the interpretation of the patient's cardiac rhythm by the defibrillator's computerized analysis system. Manual defibrillation and the use of an automated external defibrillator are discussed in more detail in Chapter 7.
- A **defibrillator** is a device used to administer an electrical shock to terminate a cardiac dysrhythmia. The machine has an adjustable high-voltage power supply that allows the operator to select an energy level (**Figure 6-8**). The strength of the electrical shocks used for defibrillation and cardioversion are expressed in joules (J) of energy. When electrical therapy is used to treat an abnormal heart rhythm, it is important to select the appropriate energy level for the patient's dysrhythmia.
- Handheld paddles or self-adhesive monitoring/defibrillator pads are the means by which current is delivered from the defibrillator to the patient. Self-adhesive pads record and monitor the patient's cardiac rhythm and are also used to deliver the shock. These pads are used during "hands-free" or "hands-off" defibrillation, which enhances operator safety by physically separating

Figure 6-8 A defibrillator is used to deliver an electrical shock to the heart by means of handheld paddles or adhesive pads applied to the patient's chest.

the operator from the patient. Instead of leaning over the patient with handheld paddles, the operator delivers a shock to the patient by means of discharge buttons located on a remote cable, an adapter, or on the defibrillator itself.

- Defibrillators deliver energy or current in "waveforms" that flow between two electrode patches (or paddles). Monophasic waveforms use energy delivered in one (mono) direction through the patient's heart. With biphasic waveforms, energy is delivered in two (bi) phases—the current moves in one direction, stops, and then passes through the heart a second time in the opposite direction within a very short period (milliseconds). Most defibrillators sold today use biphasic waveform technology.

PALS Pearl

Combination pads have multiple names, including "combo pads," "multi-purpose pads," "multi-function electrode pads," "combination electrodes," "therapy electrodes," and "self-adhesive monitoring/defibrillation pads." Not all combination pads are alike. Some pads can be used for defibrillation, synchronized cardioversion, ECG monitoring, and pacing. Others can be used for defibrillation, synchronized cardioversion, and ECG monitoring, but not for pacing. Be sure you are familiar with the capabilities of the pads you are using.

Paddle/Pad Size and Position

- Paddles and self-adhesive pads appear to be equally effective. Optimum paddle and pad sizes for electrical therapy based on patient age and weight vary by manufacturer. Follow the manufacturer's instructions regarding paddle/pad size and the proper placement of self-adhesive pads, handheld paddles, and pregelled defibrillation pads.
- Generally, adult paddles/pads should be used for patients weighing more than 10 kg (22 pounds) (about 1 year or older) (de Caen et al., 2015). Use infant-sized paddles/pads for infants weighing less than 10 kg (22 pounds).
- When using an AED, a pediatric attenuator (pad/cable system) should be used, if available, for an unresponsive, apneic, pulseless child younger than 8 years. If unavailable, use an AED with standard pads (de Caen et al., 2015). For infants, use of a manual defibrillator is preferred. If a manual defibrillator is not available, an AED equipped with a pediatric attenuator is desirable. If neither are available, use a standard AED (de Caen et al., 2015).

Conductive Material

- *Transthoracic impedance* refers to the resistance of the patient's chest wall to the flow of current at the interface between the patient's chest wall and combination pads or defibrillation paddles. Incorrect paddle or pad placement can increase transthoracic impedance (Fraser, Kou, Howell, Fullerton, & Sturek, 2014).
- When using handheld paddles, the use of gels, pastes, or pregelled defibrillation pads aids the passage of current at the interface between the defibrillator paddles and the body surface. Failure to use conductive material results in very high transthoracic impedance and a lack of current penetration. The use of improper pastes, creams, gels, or pads can cause burns to the skin surface. Combination pads are pre-gelled and do not require the application of additional gel to the patient's chest.

Synchronized Cardioversion

- **Synchronized cardioversion** is a type of electrical therapy in which a shock is "timed" or "programmed" for delivery during ventricular depolarization (QRS complex). When the "sync" control is pressed, a synchronizing circuit in the machine searches for QRS complexes and delivers the shock a few milliseconds after the QRS. Delivery of a shock during this portion of the cardiac cycle reduces the potential for the delivery of current during ventricular repolarization, which includes the vulnerable period of the T wave. When a QRS complex is detected, the monitor places a "flag" or "sync marker" on that complex, which may appear as an oval, square, line, or highlighted triangle on the ECG display depending on the machine used. When the shock controls are pressed while the defibrillator is charged in "sync" mode, the machine will discharge energy only if both discharge buttons are pushed and the monitor tells the defibrillator that a QRS complex has been detected.
- Because the machine must be able to detect a QRS complex in order to "sync," synchronized cardioversion is used to treat rhythms in the unstable patient who has a clearly identifiable QRS complex and a rapid ventricular rate such as SVT that is caused by reentry, atrial flutter, and monomorphic VT with a pulse. Synchronized cardioversion may be used in the management of the stable patient with SVT, atrial flutter, and monomorphic VT with a pulse under the direction of a pediatric cardiologist (American Heart Association, 2011). Synchronized cardioversion is not used to treat disorganized rhythms (such as polymorphic VT) or those that do not have a clearly identifiable QRS complex (such as ventricular fibrillation).
- When performing synchronized cardioversion, turn the monitor/defibrillator on and identify the rhythm on the cardiac

monitor. Print an ECG strip to document the patient's rhythm. Attach ECG electrodes to monitor the patient's ECG. Make sure suction and emergency medications are available. If using standard paddles, you must use defibrillation gel or defibrillation gel pads between the paddle electrode surface and the patient's skin. If using multipurpose adhesive electrodes, place them in proper position on the patient's bare chest.

- Press the "sync" control on the defibrillator (**Figure 6-9**). Select a lead with an optimum QRS complex amplitude (positive or negative) and no artifact. If using adhesive electrodes, select the "paddles" lead. Make sure the machine is marking or flagging each QRS complex and that no artifact is present. The sense marker should appear near the middle of each QRS complex. If sense markers do not appear or are seen in the wrong place (such as on a T wave), adjust the ECG size or select another lead.
- If the patient is awake and time permits, administer sedation per physician orders unless contraindicated. Make sure the machine is in "sync" mode and then select the appropriate energy level on the defibrillator (0.5 to 1 J/kg) for the initial shock (de Caen et al., 2015). Charge the defibrillator and recheck the ECG rhythm. If the rhythm is unchanged, call "Clear!" and look around you. Make sure everyone is clear of the patient, bed, and any equipment connected to the patient. A slight delay may occur while the machine detects the next QRS complex. Release the shock control after the shock has been delivered.
- Reassess the ECG rhythm and the patient. If the tachycardia persists, ensure that the machine is in sync mode before delivering another shock. The energy dose may be increased to 2 J/kg for the second and all subsequent attempts if necessary (de Caen et al., 2015).
- If the rhythm changes to ventricular fibrillation, then begin cardiopulmonary resuscitation, turn off the sync control, and prepare to defibrillate.

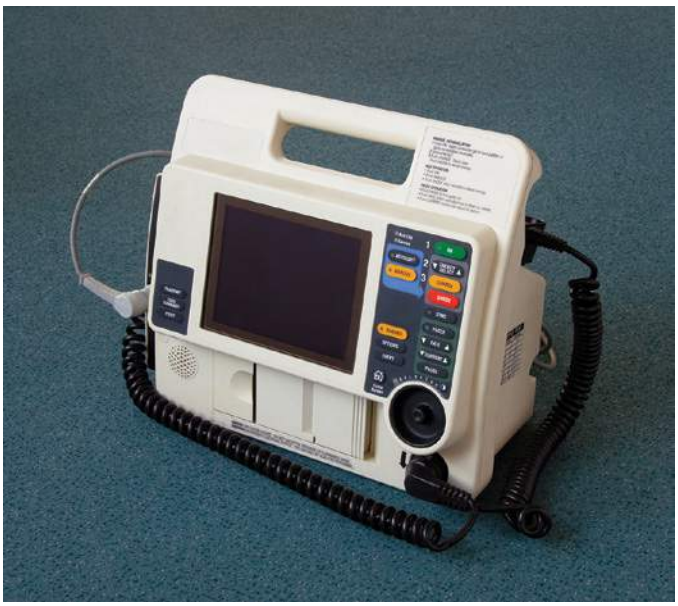

Figure 6-9 When performing synchronized cardioversion, make sure the machine is in "sync" mode and then select the appropriate energy level on the defibrillator.

PALS Pearl

Some defibrillators revert to the defibrillation (unsynchronized) mode after the delivery of a synchronized shock. This is done to allow immediate defibrillation in case synchronized cardioversion produces ventricular fibrillation (VF). Other defibrillators remain in sync mode after a synchronized shock. If VF occurs during synchronized cardioversion, make sure the sync control is off before attempting to defibrillate.

PUTTING IT ALL TOGETHER

The chapter quiz and case studies presented on the following pages are provided to help you integrate the information presented in this chapter.

Chapter Quiz

Multiple Choice

Identify the choice that best completes the statement or answers the question.

____ 1. A 3-month-old infant with supraventricular tachycardia is stable but symptomatic. Which of the following vagal maneuvers is recommended in this situation?

a. Valsalva maneuver
b. Blowing through a narrow straw
c. Application of external ocular pressure
d. Application of a cold stimulus to the face

Questions 2 and 3 pertain to the following scenario.

A 10-year-old child presents with a sudden onset of dizziness and palpitations.

____ 2. The child's ventilatory rate is 22/minute and his blood pressure is 100/68. His oxygen saturation is 97% on room air. Your general impression reveals that the patient is aware of your approach. He looks anxious, his breathing appears unlabored, and his skin color is pink. As you continue your assessment of this patient, a team member has applied the cardiac monitor, which reveals a supraventricular tachycardia. On the basis of the information provided thus far, this patient should be categorized as:

a. Asymptomatic.
b. Symptomatic but stable.
c. Symptomatic and unstable.
d. Pulseless.

____ 3. Which of the following reflects the initial emergency care that should be performed at this time?

a. Attempt vagal maneuvers
b. Establish vascular access and administer adenosine for pharmacologic cardioversion
c. Establish vascular access and administer amiodarone for pharmacologic cardioversion
d. Perform synchronized cardioversion

Questions 4 and 5 pertain to the following scenario.

A 12-year-old collapsed while playing soccer. He is unresponsive, breathing shallowly, and his skin looks pale.

____ 4. The cardiac monitor reveals monomorphic ventricular tachycardia. The patient's blood pressure is 74/40 and his ventilatory rate is 6/minute. This patient should be categorized as:

a. Asymptomatic.
b. Symptomatic but stable.
c. Symptomatic and unstable.
d. Pulseless.

____ 5. Vascular access has been established. Which of the following reflects the initial emergency care that should be performed at this time?

a. Defibrillate with 2 J/kg
b. Attempt vagal maneuvers
c. Administer procainamide for pharmacologic cardioversion
d. Perform synchronized cardioversion starting with 0.5 to 1 J/kg

Case Study 6-1

A 3-month-old infant presents with a history of poor feeding and irritability for 2 days. You have a sufficient number of advanced life support personnel available to assist you and carry out your instructions. Emergency equipment is available.

1. Your general impression reveals a fussy infant with mild retractions and normal skin color. Your primary assessment reveals the following:

Primary Assessment	
A	Clear
B	Ventilatory rate 50 breaths/minute, mild retractions
C	Heart rate too fast to count, normal peripheral pulses, skin pink and warm, capillary refill 2 seconds
D	Alert but fussy, Glasgow Coma Scale score 15
E	Temperature 37.4°C (99.4°F), weight 6.4 kg (14 pounds)

A team member has applied a pulse oximeter, blood pressure monitor, and cardiac monitor. The infant's oxygen saturation is 91% on room air and her blood pressure is 80/60. How would you like to proceed?

2. A SAMPLE history and focused physical examination have been obtained with the following results:

SAMPLE History	
Signs/symptoms	History of poor feeding and irritability for 2 days
Allergies	None
Medications	None
Past medical history	Term infant, normal development
Last oral intake	Breast fed 3 hours ago but did not feed well
Events prior	Mom states that her baby has been sweating and the area around her lips appears to turn blue during feeding

Physical Examination	
Head, eyes, ears, nose, throat	No abnormalities noted
Neck	No abnormalities noted
Chest	Breath sounds clear, mild retractions present, normal heart sounds
Abdomen	No abnormalities noted
Pelvis	No abnormalities noted
Extremities	Normal peripheral pulses; skin pink, warm, and dry
Back	No abnormalities noted

Intravenous access has been established. The cardiac monitor reveals a supraventricular tachycardia (SVT) at 240 beats/minute. On the basis of the information obtained so far, would you categorize this patient as asymptomatic, symptomatic but stable, or symptomatic and unstable?

3. A vagal maneuver was attempted with no change in the infant's heart rate. What is the initial dose of the first medication used in the treatment of supraventricular tachycardia? When administering this medication, what factors must be considered to help ensure its effectiveness?

4. If the rhythm persisted and the patient's condition changed from stable to unstable, what additional interventions should you consider to terminate the rhythm?

Chapter Quiz Answers

1. D. Vagal maneuvers that may be used in the pediatric patient include the application of a cold stimulus to the upper half of the child's face (e.g., a washcloth soaked in iced water, crushed ice mixed with water in a small plastic bag or glove) for 15 to 20 seconds. This technique is often effective in infants and young children. The Valsalva maneuver is another vagal maneuver that may be used in older, cooperative children. Ask the child to blow through a narrow straw, to take a deep breath and bear down as if having a bowel movement for 10 seconds, or to blow on a thumb as if it were a trumpet. Application of external ocular pressure may be dangerous and should not be used because of the risk of retinal detachment.

OBJ: Discuss the types of vagal maneuvers that may be used in the pediatric patient.

2. B. This child is symptomatic (palpitations and dizziness) but stable (blood pressure and ventilatory rate are within normal limits for age despite his cardiac dysrhythmia).

OBJ: Identify a patient who is experiencing a tachycardia as asymptomatic, symptomatic but stable, or symptomatic and unstable.

3. A. We have determined that this child with SVT is symptomatic but stable. Ensure that the patient's history does not indicate causes of *sinus* tachycardia (i.e., dehydration, fever). Consider the use of vagal maneuvers, which are techniques used to slow conduction through the AV node and slow the heart rate. If the rhythm persists and vascular access is available, adenosine is the drug of choice for pharmacologic cardioversion. Synchronized cardioversion should be performed if the child is symptomatic and unstable (i.e., acutely altered mental status, signs of shock, or hypotension).

OBJ: Discuss the initial emergency care for stable or unstable tachycardia in infants and children.

4. C. Because he is unresponsive and hypotensive, this patient is categorized as symptomatic and unstable.

OBJ: Identify a patient who is experiencing a tachycardia as asymptomatic, symptomatic but stable, or symptomatic and unstable.

5. D. If the child with monomorphic ventricular tachycardia is symptomatic but unstable (i.e., acutely altered mental status, signs of shock, or hypotension), synchronized cardioversion starting with 0.5 to 1 J/kg is recommended. Increase the energy level to 2 J/kg if the initial shock does not terminate the dysrhythmia. Defibrillation is not indicated because the patient has a pulse. Although vagal maneuvers may be considered in the symptomatic but stable patient with *supraventricular* tachycardia, they are not recommended in the treatment of stable or unstable patients with ventricular tachycardia. If the rhythm persists, consult with a pediatric specialist and consider pharmacologic conversion with amiodarone or procainamide.

Case Study 6-1 Answers

1. Administer oxygen by nonrebreather mask and establish vascular access.

OBJ: Discuss the initial emergency care for stable or unstable tachycardia in infants and children.

2. This patient's history of present illness and signs and symptoms indicate that the infant is symptomatic but stable.

OBJ: Identify a patient who is experiencing a tachycardia as asymptomatic, symptomatic but stable, or symptomatic and unstable.

3. The initial dose of adenosine is 0.1 mg/kg (up to 6 mg) intravenous (IV)/intraosseous (IO) push followed by a normal saline (NS) flush. Because of its short half-life, and to enhance delivery of the drug to its site of action in the heart, select the injection port on the IV tubing that is nearest to the patient and administer the drug using a two-syringe technique. Prepare one syringe with the drug and the other with an NS flush of at least 5 mL. Insert both syringes into the injection port in the IV tubing. Administer the drug IV or IO as rapidly as possible (i.e., over a period of seconds) and immediately follow with the saline flush.

OBJ: Discuss the pharmacology of medications used during when managing a tachycardia.

4. If the patient fails to respond to adenosine, perform synchronized cardioversion starting with 0.5 to 1 J/kg. If the patient is responsive, sedate if possible. If cardioversion does not terminate the dysrhythmia, increase the energy level to 2 J/kg.

OBJ: Discuss synchronized cardioversion and identify the indications and recommended energy levels for this procedure.

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Checklist 6-1 Tachycardia

Action Steps	Performed Correctly
Ensures scene safety. Takes or communicates the use of personal protective equipment for blood and body substances.	☐
Assigns team member roles.	☐
Assessment	
Forms a general impression: Assesses patient's appearance, work of breathing, and circulation.	☐
Directs assessment of airway/responsiveness; directs the use of a manual airway maneuver to open the airway, if indicated.	☐
Directs assessment of breathing including estimation of ventilatory rate and evaluation of ventilatory effort; directs assessment of breath sounds.	☐
Directs assessment of central/peripheral pulse quality, estimation of heart rate, and evaluation of skin (color, temperature, and moisture) and capillary refill.	☐
Directs team members to determine a Glasgow Coma Scale score and patient weight.	☐
Directs team members to obtain vital signs and to apply a pulse oximeter and apply blood pressure and cardiac monitors.	☐
Obtains a brief history and performs a focused physical examination.	☐
Correctly identifies cardiac rhythm.	☐
Considers patient presentation and quickly determines if the child is asymptomatic, symptomatic but stable, symptomatic and unstable, or pulseless.	☐
Considers possible reversible causes of cardiac dysrhythmias.	☐
Treatment Plan	
Verbalizes a treatment plan and initiates appropriate interventions.	☐
Directs insertion of an oral airway or nasal airway, if indicated.	☐
Directs application of appropriate oxygen therapy; directs team member to begin assisted ventilation, if indicated.	☐
Orders the performance of vagal maneuvers, if indicated.	☐
Instructs team member to establish vascular access.	☐
Orders administration of intravenous/intraosseous medications appropriate for the dysrhythmia.	☐
Orders diagnostic tests and procedures (including synchronized cardioversion); if indicated, uses appropriate energy doses for synchronized cardioversion.	☐
Considers the need for an advanced airway.	☐
Correctly verbalizes indications, dosages, and routes of administration for medications administered.	☐
Reassessment	
Repeats the primary assessment and obtains another set of vital signs.	☐
Monitors for, recognizes, and appropriately treats any changes in the patient's physiological status.	☐
Team Leader Assessment	
Effectively leads team members throughout patient care.	☐
Directs the transfer of patient care for ongoing monitoring and care.	☐
Requests a team debriefing after the transfer of patient care is complete.	☐

CHAPTER 7

Cardiac Arrest

Learning Objectives

After completing this chapter, you should be able to:

1. Discuss the epidemiology and phases of a cardiopulmonary arrest.
2. Discuss the dysrhythmias associated with pediatric cardiopulmonary failure or arrest.
3. Discuss defibrillation and identify the indications and recommended energy levels for this procedure.
4. Discuss the initial emergency care for a cardiopulmonary arrest.
5. Discuss the pharmacology of medications used during a cardiopulmonary arrest.
6. Examine circumstances in which additional factors should be considered during a cardiopulmonary arrest.
7. Discuss postresuscitation care.
8. Discuss termination of resuscitative efforts.
9. Given a patient situation, formulate a treatment plan (including assessment, airway management, cardiopulmonary resuscitation, pharmacological, and electrical interventions where applicable) for a patient presenting in cardiopulmonary arrest.

After completing this chapter, and with supervised practice during a Pediatric Advanced Life Support (PALS) course, you will be skilled at the following:

- Ensuring scene safety and the use of personal protective equipment.
- Assigning team member roles or performing as a team member in a simulated patient situation.

- Directing or performing a patient assessment.
- Establishing vascular access by means of the intravenous or intraosseous route, attaching a pulse oximeter and blood pressure and cardiac monitors, and administering supplemental O_2.
- Recognizing cardiac arrest rhythms.
- Demonstrating knowledge of the indications, dosages, and effects of the medications and fluids used for managing a cardiac arrest.
- Recognizing when an intraosseous needle is properly positioned.
- Safely performing defibrillation when indicated.
- Recognizing when it is best to seek expert consultation.
- Reviewing your performance as a team leader or team member during a postevent debriefing.

ASSESSMENT EVIDENCE

Performance Tasks

During the PALS course, you will function as the team leader of the rapid response team or code team within your organization. Your classmates are similarly trained members of the team who will assist you. Your task is to direct, without prompting, the emergency care efforts of your team according to current resuscitation guidelines.

Key Criteria

Part of the PALS course is assessment of your ability to manage a patient who is experiencing a cardiovascular emergency and of your ability to manage the team who will assist you in providing patient care. An evaluation checklist that reflects key steps and interventions in the patient management process will be used to assess your performance (see **Checklists 7-1** and **7-2**). The appropriate box will be checked by a PALS instructor as you complete each step during your management of the patient.

Learning Plan

- Read this chapter before your PALS course. Create flashcards and memory aids to help you recall key points. Carefully review each of the medications discussed in this chapter.
- Complete the chapter quiz and review the answers provided.
- Complete the case study at the end of the chapter. Read the scenario and answer each question that follows it. The questions are intended to reinforce important points pertinent to the case that is discussed in this text. Compare your answers with the answers provided at the end of the case study and with the checklist pertinent to the case study.

KEY TERMS

Cardiopulmonary (cardiac) arrest
The absence of cardiac mechanical activity, which is confirmed by the absence of a detectable pulse, unresponsiveness, and apnea or agonal, gasping breathing; also called *cardiac arrest*

Cardiopulmonary failure
A clinical condition identified by deficits in oxygenation, ventilation, and perfusion

Sudden cardiac arrest
The abrupt and unexpected loss of heart function

INTRODUCTION

Cardiopulmonary failure is a clinical condition identified by deficits in oxygenation, ventilation, and perfusion (**Box 7-1**). Without prompt recognition and management, cardiopulmonary failure will deteriorate to cardiopulmonary arrest. **Cardiopulmonary (cardiac) arrest** is

Box 7-1 Signs Associated with Cardiopulmonary Failure

- Bradycardia
- Bradypnea with irregular, ineffective ventilations
- Cool extremities
- Decreasing work of breathing (tiring)
- Delayed capillary refill time
- Diminished level of responsiveness
- Mottled or cyanotic skin
- Weak central pulses and absent peripheral pulses

the absence of cardiac mechanical activity, which is confirmed by the absence of a detectable pulse, unresponsiveness, and apnea or agonal, gasping breathing. **Sudden cardiac arrest** is defined as the abrupt and unexpected loss of heart function (American Academy of Pediatrics Section on Cardiology and Cardiac Surgery, 2012).

EPIDEMIOLOGY OF CARDIAC ARREST

- It has been estimated that approximately 16,000 children in the United States experience a cardiac arrest each year (Topjian, Berg, & Nadkarni, 2008). Although variables associated with survival of cardiac arrest have been identified (**Box 7-2**), no single factor can predict the outcome with sufficient accuracy to recommend termination or continuation of resuscitative efforts (de Caen et al., 2015). Outcomes for pediatric out-of-hospital cardiac arrest (OHCA) are generally poor, with survival to hospital discharge occurring in approximately less than 10% of children (American Academy of Pediatrics Section on Cardiology and Cardiac Surgery, 2012). Research has shown that the survival rate for pediatric in-hospital cardiac arrest (IHCA) markedly improved between 2001 and 2013, with rates of return of spontaneous circulation (ROSC) increasing from 39 to 77% and survival to hospital discharge improving from 24 to 36% and 43% (de Caen et al., 2015). These improvements were attributed to factors including emphasis on high-quality CPR and advances in postresuscitation care (de Caen et al., 2015).
- Although there are many possible causes of a cardiac arrest, three common pathophysiologic categories have been identified: (1) asphyxial arrests, (2) ischemic arrests, and (3) arrhythmogenic arrests (Berg, Nadkarni, Gausche-Hill, Kaji, & Berg, 2010).
  - In children, asphyxial cardiac arrests are caused by acute hypoxia or hypercarbia.
  - Ischemic arrests are caused by inadequate myocardial blood flow that most commonly results in children from shock caused by hypovolemia, sepsis, or cardiogenic shock (Berg et al., 2010). When cardiac arrest is caused by asphyxia, ischemia, or both, it is important to provide adequate myocardial perfusion and myocardial oxygen delivery with ventilation (Topjian, Berg, & Nadkarni, 2013).
  - Ventricular fibrillation (VF) or pulseless ventricular tachycardia (pVT) is the cause of an arrhythmogenic cardiac arrest (Berg et al., 2010). Ventricular fibrillation is the initial rhythm in 19% to 24% of out-of-hospital pediatric cardiac arrests, excluding deaths attributable to sudden infant death syndrome (American Academy of Pediatrics Section on Cardiology and Cardiac Surgery, 2012). When pVT or VF is the cause of a cardiac arrest, rapid identification of a shockable rhythm and prompt defibrillation is critical (Topjian et al., 2013).
- Most out-of-hospital and in-hospital pediatric cardiac arrests are caused by asphyxial or ischemic events rather than sudden cardiac dysrhythmias (Berg et al., 2010).

Box 7-2 Variables that Influence Cardiac Arrest Survival

- The mechanism of the arrest (e.g., traumatic, asphyxial)
- The environment in which the arrest occurs (e.g., out-of-hospital, in-hospital, ward, intensive care unit)
- Witnessed versus unwitnessed cardiac arrest
- Monitored versus unmonitored cardiac arrest
- The age and preexisting condition of the child and underlying pathophysiology (e.g., cardiomyopathy, congenital defect, drug toxicity, metabolic disturbance, single ventricle)
- The duration of the no-flow phase of the arrest
- The duration of cardiopulmonary resuscitation
- The initial and subsequent electrocardiographic rhythm detected
- The number of doses of epinephrine administered
- The quality of the basic and advanced life support interventions provided

PHASES OF CARDIAC ARREST

Four phases of cardiac arrest have been described: (1) the prearrest phase, (2) the no-flow phase, (3) the low-flow phase, and (4) the postresuscitation phase (Berg et al., 2010).

- The prearrest phase is the period that precedes a cardiac arrest. The goal during this phase is to identify and treat factors that may precipitate cardiac arrest (Tress, Kochanek, Saladino, & Manole, 2010). Hospitalized children who are at high risk for a cardiac arrest should be in a monitored unit where rapid identification and treatment of conditions such as respiratory failure, shock, and dysrhythmia is immediately available (Berg et al., 2010). In the hospital setting, multidisciplinary medical emergency teams (METs) and rapid response teams (RRTs) are often used to proactively identify and evaluate patients at risk for decompensation and facilitate the patient's transfer to a higher level of care if warranted (Topjian et al., 2013) (**Figure 7-1**).
- The no-flow phase reflects untreated cardiac arrest before it is recognized by a bystander in the community or by a medical provider in the hospital (Tress et al., 2010). The focus during this phase is on recognizing that a cardiac arrest has occurred, promptly initiating basic and advanced cardiac life support, and minimizing the interval to defibrillation, if indicated (Berg et al., 2010; Topjian et al., 2013).
  - Most out-of-hospital cardiac arrests are not witnessed; it has been estimated that only about one-third of infants and children who experience an out-of-hospital cardiac arrest receive bystander CPR (Topjian et al., 2013).
- The low-flow phase begins with the onset of cardiopulmonary resuscitation (CPR). The goal of this phase is to optimize coronary and cerebral perfusion pressure and blood flow to critical organs (Berg et al., 2010). High-quality CPR requires pushing hard (a depth of about 1.5 inches (4 cm) in infants and about 2 inches (5 cm) in children), pushing fast (100 to 120 compressions/minute), allowing full recoil of the chest, avoiding overventilation, and minimizing interruptions in compressions (de Caen et al., 2015) (**Figure 7-2**). Interruptions must be minimized because even brief pauses in chest compressions cause rapid and substantial decreases in coronary and cerebral perfusion during CPR.

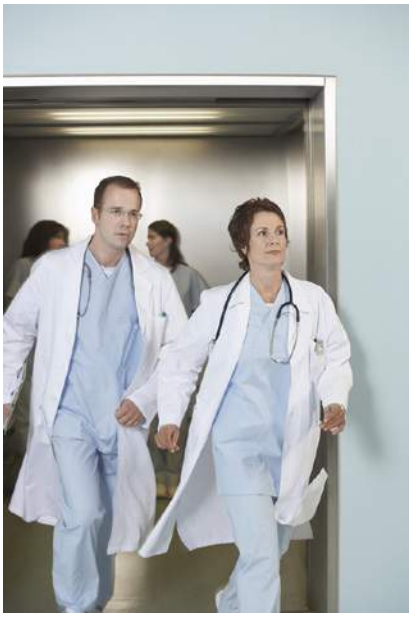

Figure 7-1 Rapid response teams identify and evaluate patients at risk for decompensation.

Other interventions performed during this phase include defibrillation (if indicated) and pharmacologic support.

- During cardiac arrest, the IV or IO route is preferred for medication administration.
- Examples of medications that are used during pediatric cardiac arrest include epinephrine (which is a vasopressor) and if a shockable rhythm is present, amiodarone or lidocaine (which are antiarrhythmics).

- The postresuscitation phase begins with the return of spontaneous circulation (ROSC). This phase of care focuses on preserving neurologic function, preventing secondary injury, determining and treating the cause of the illness, and enabling the patient to arrive at a pediatric tertiary-care facility in an optimal physiologic state (de Caen et al., 2015).

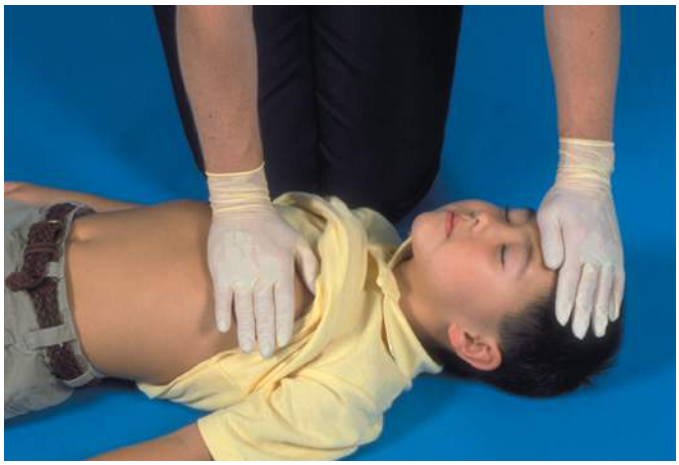

Figure 7-2 During cardiac arrest, achieving optimal coronary and cerebral perfusion pressures requires the performance of high-quality cardiopulmonary resuscitation.

CARDIAC ARREST RHYTHMS

- In cardiopulmonary arrest, the patient is unresponsive and central pulses and breathing are absent. Absent/pulseless rhythms include (1) pulseless ventricular tachycardia, (2) ventricular fibrillation, (3) asystole, and (4) pulseless electrical activity (PEA).
- The initial rhythm documented by first responders during an out-of-hospital pediatric cardiac arrest is asystole or PEA in 82% to 84% of patients and VF in 7% to 10% of patients (Tress et al., 2010). With regard to in-hospital pediatric cardiac arrest, asystole and bradycardia are the initial rhythms observed in most patients (Tress et al., 2010).

PALS Pearl

Cardiac arrest rhythms may be shockable (which means that using a defibrillator to deliver a shock to the heart may terminate the dysrhythmia) or nonshockable. Ventricular fibrillation and pulseless ventricular tachycardia are shockable rhythms. Asystole and pulseless electrical activity are nonshockable cardiac arrest rhythms.

Ventricular Tachycardia

Ventricular tachycardia was discussed in Chapter 6 (see Figure 6-6). Pulseless VT is treated as VF.

Ventricular Fibrillation

- VF is a ventricular dysrhythmia during which there is no organized depolarization of the ventricles. The ventricular myocardium quivers; as a result, there is no effective myocardial contraction and no pulse. The resulting rhythm is irregularly irregular with chaotic deflections that vary in shape and amplitude (**Figure 7-3**). No normal-looking waveforms are visible.
- Commotio cordis is a phenomenon in which sudden death without evidence of structural cardiac damage occurs after a sudden blunt blow to the chest wall (Link, 2012). It occurs most often in athletes between the ages of 8 and 18 years who are participating in sports involving projectiles such as a baseball, hockey puck, or lacrosse ball, although this condition may also occur secondary to impact with an elbow, fist, or helmet (Link, 2012). CPR and defibrillation within 3 minutes of the event have resulted in favorable outcomes in some cases.

Asystole

Asystole, also called *ventricular asystole* or *ventricular standstill*, is recognized on the cardiac monitor as a straight line, which reflects an absence of ventricular electrical activity (**Figure 7-4**).

Pulseless Electrical Activity

PEA is a clinical situation, not a specific dysrhythmia. PEA exists when organized electrical activity (other than VT) is observed on the cardiac monitor but a pulse is absent (**Figure 7-5**). Many conditions may cause PEA. PEA has a poor prognosis unless the underlying cause can be rapidly identified and appropriately managed.

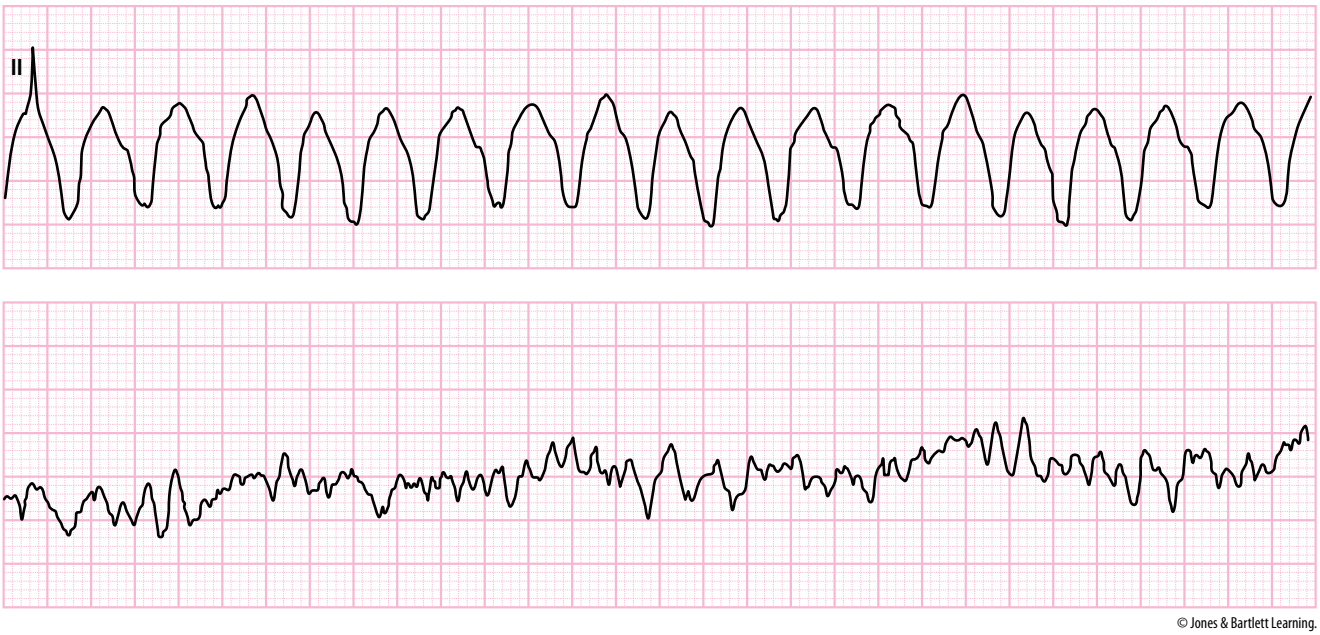

Figure 7-3 Shockable cardiac arrest rhythms. Top: Ventricular tachycardia. Bottom: Ventricular fibrillation.

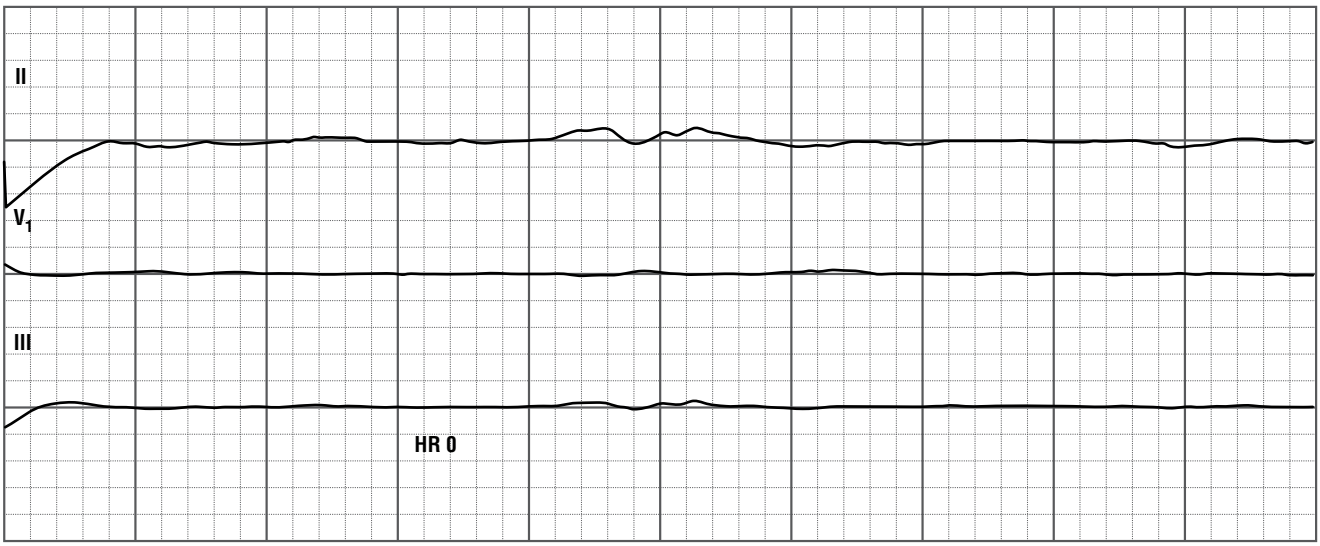

Figure 7-4 Asystole.

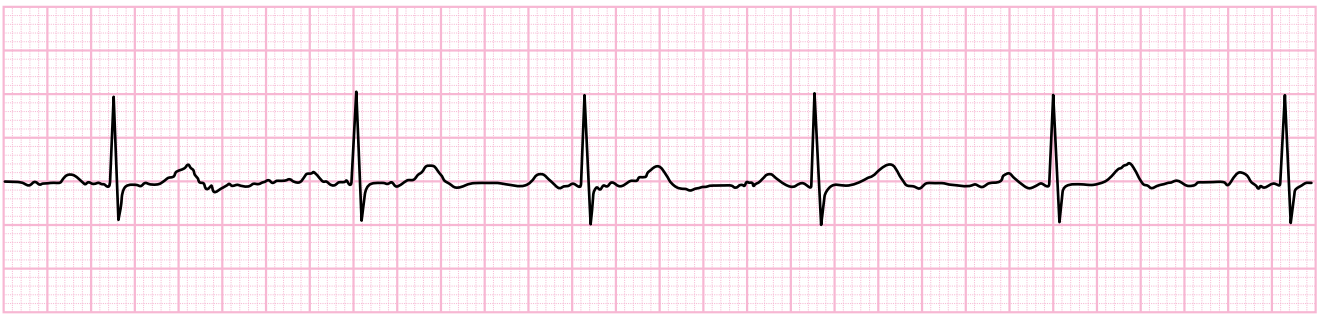

Figure 7-5 Pulseless electrical activity exists when organized electrical activity (other than ventricular tachycardia) is observed on the cardiac monitor but a pulse is absent.

DEFIBRILLATION

- Defibrillation was briefly discussed in Chapter 6. It is important for all medical personnel who participate in a cardiac arrest to be familiar with the selection of paddles or pads of the appropriate size and to know where to place them (Fraser, Kou, Howell, Fullerton, & Sturek, 2014). It is *essential* that the operator be familiar with the type of device being used (i.e., monophasic versus biphasic), the manufacturer's recommended paddle/pad size and their placement, and the manufacturer's recommended energy levels for the dysrhythmia being treated.
- Defibrillation is the definitive treatment for pVT or VF. It is acceptable to use an initial energy dose for pVT or VF of 2 to 4 J/kg (de Caen et al., 2015). If the dysrhythmia persists, it is reasonable to increase the dose to 4 J/kg. If the dysrhythmia persists, a dose of 4 J/kg may be reasonable for subsequent energy levels; higher energy levels may be considered but should not exceed 10 J/kg or the adult maximum dose (de Caen et al., 2015).

Manual Defibrillation

- When performing manual defibrillation, turn on the power to the defibrillator. If handheld paddles are used, select paddles of the appropriate size. Next, apply conductive gel to the paddles or place disposable pre-gelled defibrillator pads on the patient's bare torso. Place the defibrillator paddles on the patient's torso and apply firm pressure. If adhesive pads are used instead of paddles, place them in position on the patient's bare torso in accordance with the manufacturer's packaging instructions.
- Verify the presence of pVT or VF on the monitor. Chest compressions should continue while the defibrillator is charging. Select the appropriate energy level on the defibrillator, charge the machine, and quickly recheck the ECG rhythm. If the rhythm is unchanged, call "Clear!" and look around you (360°). Make sure everyone is clear of the patient, bed, and any equipment connected to the patient. If the area is clear, press the SHOCK control (**Figure 7-6**). After the shock has been delivered, release the control. Instruct the resuscitation team to resume CPR, beginning with chest compressions.

Automated External Defibrillation

- An automated external defibrillator (AED) is an external defibrillator equipped with a computerized cardiac rhythm analysis system. Voice prompts and visual indicators guide the user through a series of steps that may include defibrillation. Once the adhesive electrodes are attached to the patient's chest, the AED examines and analyzes the patient's cardiac rhythm. Some AEDs require the operator to press an "analyze" control to initiate rhythm analysis, whereas others automatically begin analyzing the patient's cardiac rhythm once the adhesive electrodes are attached to the patient's chest.

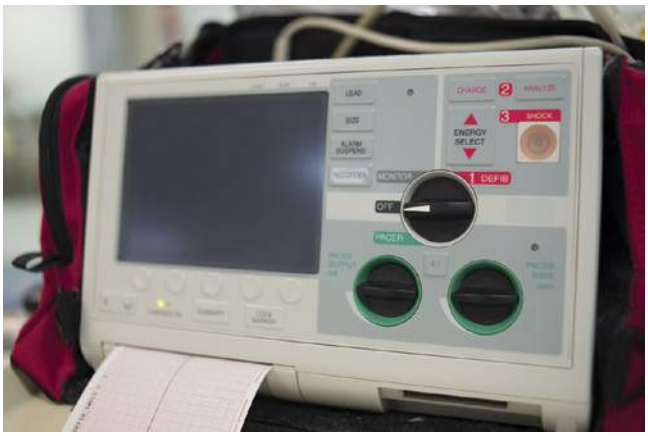

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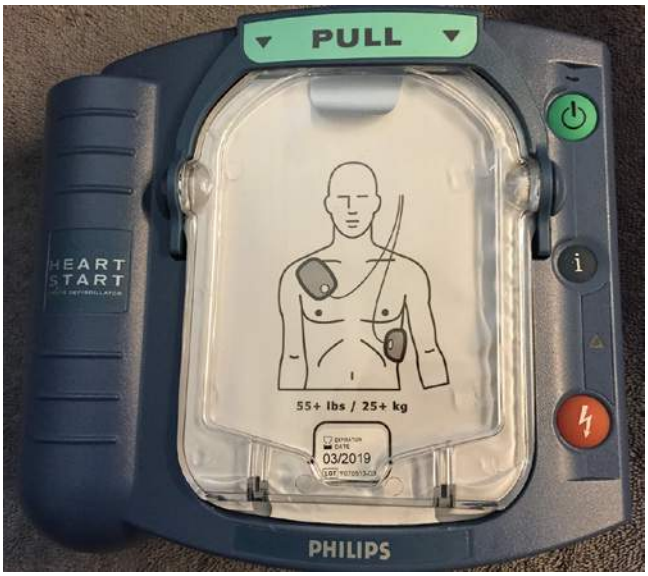
Figure 7-6 Before delivering a shock, ensure that everyone is clear of the patient, bed, and any equipment connected to the patient.

- Use a standard AED for a patient who is unresponsive, apneic, pulseless, and 8 years or older (**Figure 7-7**).
- Several AED manufacturers have designed pediatric attenuators (pad/cable systems) for use with standard AEDs for infants and children up to about 8 years of age (**Figure 7-8**). When the pediatric cable is attached to the AED, the machine will recognize the pediatric cable connection and automatically adjust its defibrillation energy to pediatric levels. Use an AED equipped with a pediatric attenuating system, if available, for an unresponsive, apneic, pulseless child younger than 8 years. If unavailable, use an AED with standard electrodes (de Caen et al., 2015).



Courtesy of Barbara Aehlert.

Figure 7-7 Use a standard automated external defibrillator for a patient who is unresponsive, apneic, pulseless, and 8 years or older.

Courtesy of Barbara Aehlert.

Figure 7-8 Use an automated external defibrillator equipped with a pediatric attenuator (if available) for an unresponsive, apneic, pulseless child younger than 8 years. If unavailable, use an AED with standard electrodes.

- For infants, use of a manual defibrillator is preferred. If a manual defibrillator is not available, an AED equipped with a pediatric attenuator is desirable. If neither are available, use a standard AED (de Caen et al., 2015).
- When using an AED, confirm that the patient is unresponsive, apneic (or has only gasping breathing), and pulseless. Perform chest compressions until the AED is ready.
  - Turn on the power to the AED. Depending on the brand of AED, this is accomplished either by pressing the "on" button or by lifting up the monitor screen or lid.
  - Open the package containing the self-adhesive monitoring/defibrillation pads. Connect the pads to the AED cables (if not pre-connected), and then apply the pads to the patient's bare chest in the locations specified by the AED manufacturer. Most models require connection of the AED cable to the AED before use.
  - Analyze the ECG rhythm. If a shockable rhythm is detected, the AED will signal that a shock is indicated. Listen for the voice prompts.
  - Clear the area surrounding the patient. Be sure to look around you. Ensure that everyone is clear of the patient, bed, and any equipment connected to the patient. If the area is clear, press the shock control to defibrillate the patient.
  - After delivering the shock, immediately resume CPR, beginning with chest compressions. Continue to listen to the AED's voice prompts.

EMERGENCY CARE

- After confirming that the patient is unresponsive, apneic, and pulseless, call for help, send for a defibrillator, and begin CPR (**Figure 7-9**). As soon as the machine is available, attach a monitor/defibrillator or an AED and identify the rhythm. Ask a team member to apply the pulse oximeter, insert an oropharyngeal airway, and begin bag-mask ventilation with 100% oxygen. Research has shown that patients in cardiac arrest often receive excessive ventilation (too many breaths, too large a volume). It is important that excessive ventilation be avoided because ventilating the patient too fast or with too much volume results in increased intrathoracic pressure, which results in decreased venous return into the chest, decreased coronary and cerebral blood flow, diminished cardiac output, and ultimately a decreased likelihood of return of spontaneous circulation (ROSC) (de Caen et al., 2015).
  - If the child is not intubated, coordinate chest compressions with ventilations. If only 1 rescuer is present, deliver 30 chest compressions and then 2 ventilations. If 2 (or more) rescuers are present, pause after 15 compressions and give 2 ventilations. Deliver each breath over 1 second.
- If a nonshockable rhythm is present (the rhythm is PEA or asystole):
  - Continue CPR and establish vascular access without interrupting chest compressions. Recheck the patient's cardiac rhythm every 2 minutes. Rotate chest compressors every 2 minutes to avoid rescuer fatigue.
  - Without interrupting CPR, give epinephrine (which is a vasopressor) IV/IO every 3 to 5 minutes as long as the patient does not have a pulse (see Table 5-2). Follow each dose with a saline flush to promote entry into the central circulation (de Caen et al., 2015).

PALS Pearl

Because there have been no pediatric studies that have demonstrated the effectiveness of any vasopressors in cardiac arrest, current resuscitation guidelines have downgraded the class of recommendation with regard to vasopressors for resuscitation (de Caen et al., 2015). The 2010 guidelines read, "Epinephrine should be given for pulseless cardiac arrest." The 2015 guidelines read, "It is reasonable to give epinephrine in pediatric cardiac arrest" (de Caen et al., 2015).

  - Search for and treat possible reversible causes of the arrest. Ultrasound imaging is being used with increasing frequency to detect potentially reversible causes (e.g., cardiac tamponade, hypovolemia, pulmonary embolism, tension pneumothorax).
  - Consider placement of an advanced airway. If inserted, confirm the tube's position with waveform capnography or capnometry. Capnography can help you evaluate the effectiveness of chest compressions during resuscitation efforts and detect the return of spontaneous circulation. After an

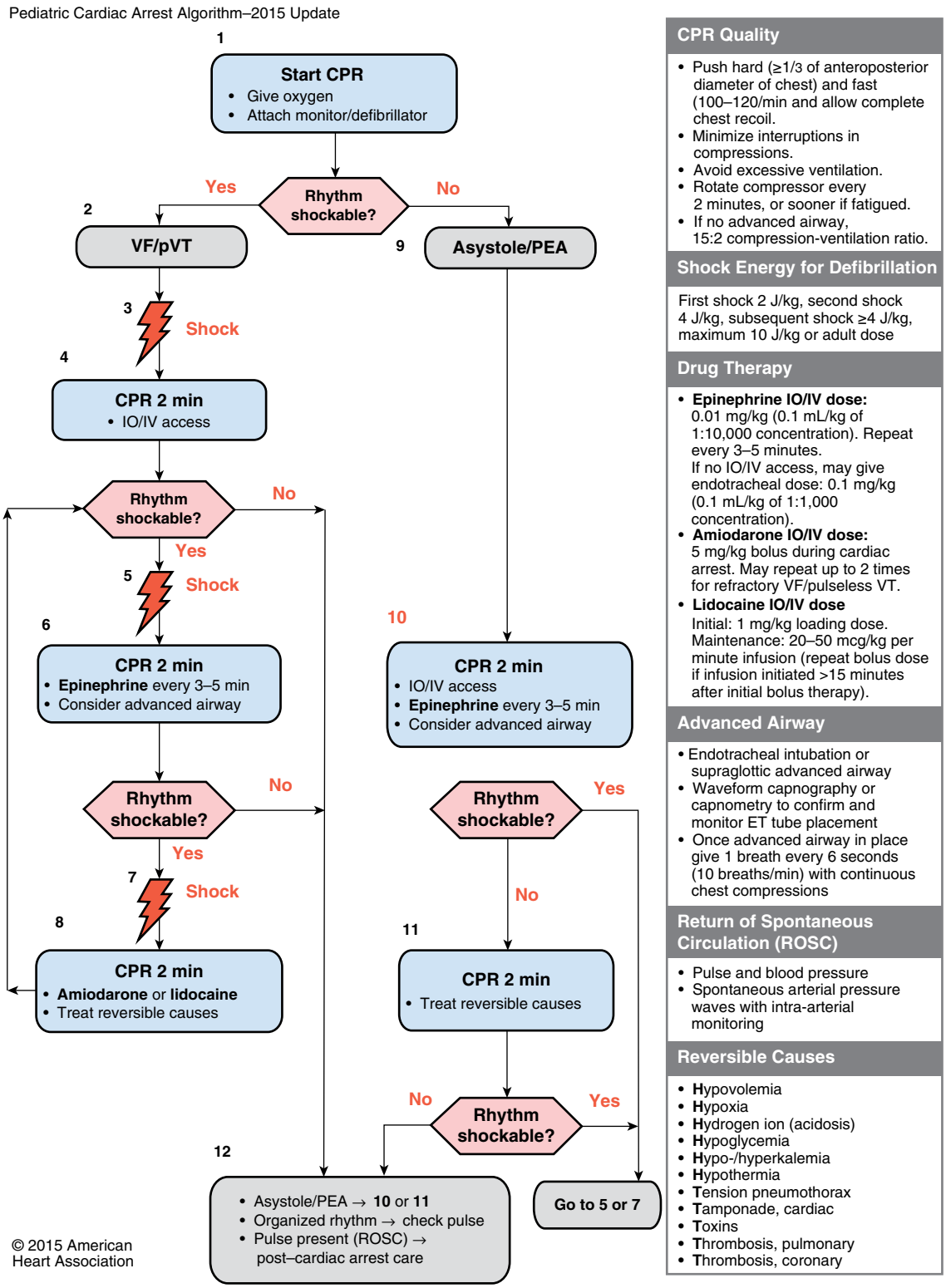


Figure 7-9 Pediatric cardiac arrest algorithm.

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advanced airway is inserted and its proper position has been confirmed, chest compressions should be performed continuously (i.e., without pausing for ventilations). Ventilate at a rate of 1 breath every 6 seconds, which is 10 breaths/minute (de Caen et al., 2015).

- After 2 minutes of CPR, quickly recheck the rhythm. Interruptions in chest compressions for rhythm checks should require fewer than 10 seconds.
- Periodically reassess advanced airway position, electrode position and contact, and the effectiveness of CPR. Check

PALS Pearl

Although the intravenous or intraosseous routes are the preferred methods for medication delivery during cardiopulmonary resuscitation, a limited number of lipid-soluble medications can be administered endotracheally if vascular access is unavailable. The acronym "LEAN" can be used to recall the medications that can be given endotracheally: lidocaine, epinephrine, atropine, and naloxone. When endotracheally administering a medication, briefly pause chest compressions and instill the medication down the endotracheal tube. Follow the medication with a flush of at least 5 mL of normal saline and then five consecutive positive-pressure ventilations to ensure adequate distribution of the drug, and then resume CPR (de Caen et al., 2015).

the child's blood glucose level during the resuscitation effort and treat hypoglycemia, if present. Ensure that the equipment in use is functioning properly, confirm appropriate interventions, and consider alternative medications and special resuscitation circumstances (e.g., trauma, drowning, poisoning).

- If a nonshockable rhythm persists, continue the delivery of high-quality CPR and epinephrine administration until there is a return of spontaneous circulation or termination of resuscitation efforts.

- If a shockable rhythm is present (the rhythm is pulseless VT or VF):
  - Continue CPR until the defibrillator is ready to deliver a shock. Clear the area around the patient and deliver one shock using an initial dose of 2 J/kg (de Caen et al., 2015). Immediately resume CPR, starting with chest compressions. Rotate chest compressors every 2 minutes to avoid rescuer fatigue. Establish vascular access without interrupting chest compressions.
  - After 2 minutes of CPR, quickly recheck the rhythm. If a shockable rhythm is present, clear the patient and defibrillate using 4 J/kg (de Caen et al., 2015). Immediately resume CPR. Give epinephrine IV/IO every 3 to 5 minutes as long as the patient does not have a pulse. Follow each dose with a saline flush. Consider placement of an advanced airway. If inserted, confirm the position of the tube. Search for possible reversible causes of the arrest.
  - Recheck the rhythm after 2 minutes of CPR. If a shockable rhythm is present, clear the patient, and defibrillate using 4 J/kg or more, up to 10 J/kg or the maximum adult dose (de Caen et al., 2015). Immediately resume CPR, starting with chest compressions. Without interrupting compressions, give amiodarone (see Table 6-3) or lidocaine IV/IO (**Table 7-1**), which are antiarrhythmic medications, and follow with a saline flush. Give magnesium sulfate if the rhythm is torsades de pointes (see Table 2-10).
  - Check the child's blood glucose level during the resuscitation effort and treat hypoglycemia, if present.
  - Check a pulse if an organized rhythm is present on the monitor or other signs of a perfusing rhythm are present (e.g., abrupt rise in end-tidal carbon dioxide). If a pulse is present, assess the patient's blood pressure and other vital signs and then begin post–cardiac arrest care.

PALS Pearl

As discussed in Chapter 1, teamwork is essential when providing patient care and it is particularly important when managing a patient who has experienced a cardiac arrest. In addition to using effective communication methods with team members, be certain to communicate with the family/caregivers to gain pertinent information about the patient and/or situation. Designate a liaison to talk with the family throughout the resuscitation effort, whether or not they are present in the room.

Special Considerations

The circumstances surrounding the cardiac arrest may require additional considerations during a resuscitation effort.

Trauma

Trauma resulting in cardiac arrest may have several etiologies, including the following (Ferguson & De Guzman, 2012):

- Hypoxia caused by airway obstruction or disruption, hemothorax, pneumothorax, tracheobronchial injury, or pulmonary contusion
- Diminished cardiac output caused by exsanguination, myocardial contusion, pericardial tamponade, or tension pneumothorax
- Distributive shock caused by spinal cord injury
- Severe head injury

In addition to the resuscitation measures used with nontraumatic cardiac arrest, stabilize the cervical spine in cases of known or suspected spinal injury. Use the jaw thrust without neck extension maneuver to open the airway and ventilate the patient using the two-person bag-mask ventilation technique. If the airway cannot be opened with a jaw thrust, use a head tilt–chin lift because establishing an open airway is essential (de Caen et al., 2015). Maintain cervical spine stabilization until the presence of a spinal injury has been ruled out. Control external bleeding using direct pressure. Assume that hypovolemia is present and rapidly infuse an isotonic crystalloid solution (American Heart Association, 2011). Promptly seal any significant open chest wounds with an occlusive (airtight) dressing taped on three sides. Consider bilateral needle decompression for suspected tension pneumothorax and consider pericardiocentesis for suspected cardiac tamponade (American Heart Association, 2011). Begin vasopressor therapy if spinal shock is suspected (American Heart Association, 2011).

Drowning

Hypoxia is the usual cause of cardiac arrest from drowning, but cardiac arrest may also occur secondary to head or spinal cord injury (Ferguson & De Guzman, 2012). In addition to the standard

Table 7-1 Lidocaine

Trade name	Xylocaine
Classification	Class Ib antiarrhythmic
Mechanism of action	• Lidocaine's effects are more pronounced on ischemic cardiac tissue than on nonischemic tissue. • Decreases conduction in ischemic cardiac tissue (secondary to blockade of cardiac sodium channels) without adversely affecting conduction in normal tissue. • Reduces automaticity in the ventricles and His-Purkinje system. • Suppresses ventricular dysrhythmias.
Indications	Pulseless VT/VF
Dosage	• Loading dose: 1 mg/kg IV/IO bolus (de Caen et al., 2015) • Maintenance IV/IO infusion: 20 to 50 mcg/kg per minute. Give a 1 mg/kg IV/IO bolus when the infusion is started if an IV/IO bolus dose has not been given within the previous 15 minutes (de Caen et al., 2015). • ET: Although the optimal ET dose is unknown, doubling or tripling the IV/IO dose is recommended (de Caen et al., 2015)
Contraindications	• Hypersensitivity to lidocaine or amide-type local anesthetics • Severe degrees of atrioventricular block in the absence of an artificial pacemaker • Bradycardia with a ventricular escape rhythm
Adverse effects	• CNS: paresthesias (often perioral), feelings of dissociation, slurred speech, dizziness, drowsiness, disorientation, muscle twitching, seizures • CV: bradycardia, hypotension; may cause SA node depression or conduction problems and hypotension in large doses or if given too rapidly; excessive doses may produce myocardial and circulatory depression • Other: blurred or double vision, tinnitus
Notes	• Continuous ECG monitoring is essential. Assess the patient's BP often. • Onset of action is within 2 minutes and lasts about 10 to 20 minutes. • The elimination half-life of lidocaine following an IV bolus injection is typically 1 to 3 hours. Because of the rapid rate at which lidocaine is metabolized, any condition that affects liver function may alter lidocaine kinetics. The half-life may be prolonged by twofold or more in patients with liver dysfunction.

BP = blood pressure, CNS = central nervous system, CV = cardiovascular, ECG = electrocardiogram, ET = endotracheal, IO = intraosseous, IV = intravenous, SA = sinoatrial, VF = ventricular fibrillation, VT = ventricular tachycardia.

resuscitation measures used with cardiac arrest, contributing factors such as cervical spine injury, hypothermia, and trauma should be considered.

The victim should be removed from the water as quickly as possible while ensuring rescuer safety. Begin high-quality CPR, attach a monitor/defibrillator or AED, wipe any water off of the child's chest, and defibrillate if indicated. Suctioning may be needed to remove gastric contents or other foreign material from the airway. Ventilate using a bag-mask device connected to 100% oxygen. Remove wet clothing as soon as possible and assess the child's temperature and glucose level.

Where it is readily available, the extracorporeal membrane oxygenation (ECMO) device can temporarily provide oxygenation, carbon dioxide removal, and hemodynamic support to patients when standard CPR is not promptly successful (Brooks, Toma, & Hsu, 2012; Topjian et al., 2008). ECMO may also be used for rewarming severely hypothermic cardiac arrest victims following submersion in icy water (American Heart Association, 2011). When ECMO is used, blood is removed from the patient's venous system by means of a catheter. The blood passes through a membrane oxygenator and is delivered back to the patient's circulatory system through a catheter in the arterial system (Brooks et al., 2012). The use of ECMO requires the continuation of high-quality CPR while a specialized care team is assembled and while the device is connected to the patient.

Single Ventricle

Cardiac arrest in patients with single ventricle anatomy requires special considerations including ascertaining the child's specific lesion, his or her stage of surgical repair, the child's baseline hemodynamic status, and his or her arterial oxygen saturation (American Heart Association, 2011). Standard resuscitation procedures are

recommended for infants and children with single ventricle anatomy after Stage I palliation or in the infant or neonate with a univentricular heart and an aortopulmonary shunt (de Caen et al., 2015). It is reasonable to consider ECMO during cardiac arrest for patients who have undergone Stage I palliation and for those patients with Fontan physiology (de Caen et al., 2015).

Pulmonary Hypertension

Provide standard resuscitation measures for patients in cardiac arrest with a history of pulmonary hypertension. Because hypercarbia causes pulmonary vasoconstriction, hypercarbia should be corrected if it is present. If a pulmonary vasodilator such as inhaled nitric oxide was being administered before the arrest, it should be continued during the resuscitation effort. Inhaled nitric oxide or IV or aerosolized prostacyclin should be considered to reduce pulmonary vascular resistance (de Caen et al., 2015). ECMO may be beneficial if it is begun early during the resuscitation effort (de Caen et al., 2015).

Poisoning

In addition to standard resuscitation measures, care of the poisoned patient who experiences a cardiac arrest may require additional medications and prolonged resuscitation efforts. Consult a clinical toxicologist/poison control center for assistance.

POSTRESUSCITATION CARE

The goals of postresuscitation care include preserving neurologic function, preventing secondary injury, determining and treating the cause of the illness, and enabling the patient to arrive at a pediatric tertiary-care facility in an optimal physiologic state (de Caen et al., 2015).

Oxygenation

- Immediately after ROSC, repeat the primary survey. Reassess the effectiveness of initial airway maneuvers and interventions.
- Apply a pulse oximeter and assess oxygen saturation. If the administration of supplemental oxygen is indicated, use the lowest inspired oxygen concentration that will maintain an SpO_2 of at least 94% (de Caen et al., 2015). If the patient's oxygen saturation is 100%, wean the supplemental oxygen to a saturation goal of between 94 and 99% (Topjian et al., 2013). Oxygen should be titrated to a value appropriate to the specific patient condition (de Caen et al., 2015).

Ventilation

- Assess and monitor the effectiveness of ventilations with capnography.
- Assist breathing if significant respiratory compromise is present. Mechanical ventilation may be necessary.
- After ROSC, it is reasonable to target a $PaCO_2$ appropriate to the specific patient condition (de Caen et al., 2015). Avoid hyperventilation, which can increase intrathoracic pressure and thus impair cardiac output, and can also contribute to cerebral vasoconstriction (Topjian et al., 2013). Avoid hypoventilation, which can lead to cerebral vasodilation and can contribute to hypoxia and hypercarbia.
- If an advanced airway has been placed, verify that the tube is patent and that it is properly secured. Obtain a chest radiograph to confirm the position of the advanced airway and to identify potential breathing complications from resuscitation (e.g., pneumothorax, rib fractures).
- Consider insertion of a gastric tube to relieve gastric distention.

Cardiovascular Support

- After ROSC, all patients should receive continuous ECG and hemodynamic monitoring. A 12-lead ECG may be helpful in determining the cause of the cardiac arrest (de Caen et al., 2015).
- Treat dysrhythmias, if present.
- The administration of fluids, inotropes (e.g., dobutamine), or vasoactive medications (e.g., norepinephrine) may be necessary to improve myocardial function and organ perfusion. Current resuscitation guidelines recommend the use of parenteral fluids, inotropes, or vasoactive drugs to maintain a systolic blood pressure greater than the fifth percentile for age (de Caen et al., 2015). Ensure the patency of the lines used for IV access before infusing vasoactive agents.
- Consider monitoring central venous pressure, central venous oxygen saturation, arterial lactate, and urine output to help guide the effectiveness of therapies (Topjian et al., 2013).
- Consider echocardiography for quantifying the degree of myocardial dysfunction and tracking any change or response to therapy (Perkin, de Caen, Berg, Schexnayder, & Hazinski, 2013).

Temperature Management

- After ROSC, it is essential to continuously monitor the patient's core body temperature.
- For infants and children who remain comatose after resuscitation from out-of-hospital cardiac arrest, current resuscitation guidelines consider it reasonable to maintain either 5 days of continuous normothermia (36° to 37.5°C) or to maintain 2 days of initial continuous hypothermia (32° to 34°C) followed by 3 days of continuous normothermia (de Caen et al., 2015). There is insufficient evidence to recommend cooling over normothermia for infants and children who remain comatose after in-hospital cardiac arrest (de Caen et al., 2015).
- Fever (38°C or higher) should be aggressively treated with antipyretics and cooling devices (Topjian et al., 2013).

TERMINATION OF EFFORTS

The decision to stop resuscitation efforts is often difficult, and it is particularly difficult for most healthcare professionals when the patient is a child. Multiple variables associated with cardiac arrest (see Box 7-2) should be considered when deciding to terminate resuscitative efforts.

PUTTING IT ALL TOGETHER

The chapter quiz and case studies presented on the following pages are provided to help you integrate the information presented in this chapter.

Chapter Quiz

True/False

Indicate whether the statement is true or false.

____ 1. The effectiveness of ventilations should be monitored with pulse oximetry upon the return of spontaneous circulation.

____ 2. After cardiac arrest, assess oxygenation and, if indicated, administer oxygen to maintain an SpO_2 of at least 97%.

Multiple Choice

Identify the choice that best completes the statement or answers the question.

Questions 3 and 4 pertain to the following scenario.

A 12-year-old has experienced a cardiac arrest after being struck by a motor vehicle. Cardiopulmonary resuscitation is in progress.

____ 3. The cardiac monitor reveals a sinus tachycardia. Which of the following interventions should be performed next?

a. Clear everyone from the patient and defibrillate.
b. Establish vascular access and administer a vasopressor.
c. Administer supplemental oxygen with a nonrebreather mask.
d. Obtain imaging studies such as chest and abdominal radiographs.

____ 4. On the basis of this patient's mechanism of injury, which of the following should be considered during resuscitation?

a. Injuries to the thorax and abdomen should be suspected.
b. Endotracheal intubation is contraindicated in traumatic cardiac arrest.
c. Hyperventilation should be performed because of the likelihood of a head injury.
d. Rapid fluid administration should be avoided unless signs of internal or external bleeding are present.

____ 5. During which phase of a cardiac arrest is the focus on initiating basic and advanced cardiac life support and minimizing the interval to defibrillation, if indicated?

a. The prearrest phase
b. The no-flow phase
c. The low-flow phase
d. The postresuscitation phase

____ 6. A 5-year-old girl is unresponsive, not breathing, and pulseless. Cardiopulmonary resuscitation is being performed. The cardiac monitor reveals ventricular fibrillation. Which of the following interventions should be performed next?

a. Defibrillate with 2 J/kg.
b. Perform synchronized cardioversion with 1 J/kg.
c. Establish vascular access and administer epinephrine.
d. Establish vascular access and insert an advanced airway.

____ 7. Which of the following medications is indicated if a rhythm check reveals torsades de pointes?

a. Lidocaine
b. Magnesium
c. Amiodarone
d. Procainamide

Case Study 7-1

A 6-year-old girl is found unresponsive by her parents. You have a sufficient number of advanced life support personnel available to assist you and carry out your instructions. Emergency equipment is available.

1. Your general impression reveals a child lying supine on a stretcher with her eyes closed. There is no visible chest movement and her skin is mottled. How would you like to proceed?

2. Your primary assessment reveals the following:

Primary Assessment	
A	Clear
B	No spontaneous ventilatory effort
C	Central and peripheral pulses absent, skin mottled and cool
D	Unresponsive, Glasgow Coma Scale score 3
E	Estimated weight 21.8 kg (48 pounds)

What should be done now?

3. High-quality cardiopulmonary resuscitation (CPR) is in progress and a defibrillator has arrived. An oral airway has been inserted and the patient is being ventilated with a bag-mask device. The cardiac monitor reveals monomorphic ventricular tachycardia. Should synchronized cardioversion or defibrillation be performed at this time?

4. What are the possible reversible causes of cardiac arrest that you should consider as resuscitation efforts continue?

5. What is the preferred method for establishing vascular access in this situation?

6. The patient's cardiac rhythm remains unchanged. Vascular access has been established and CPR is ongoing. What is the first medication that should be administered in this situation?

7. What energy level should be used for defibrillation attempts if the patient's cardiac rhythm persists?

8. What antiarrhythmic medication should be administered if the patient's cardiac rhythm persists?

9. When should pulse checks be performed during a resuscitation effort? On the basis of the patient's age, what site should be used?

Chapter Quiz Answers

True/False

1. F. Assess and monitor the effectiveness of ventilations with capnography upon the return of spontaneous circulation. If significant respiratory compromise is present (e.g., tachypnea, respiratory distress with agitation or decreased responsiveness, poor air exchange, cyanosis, hypoxemia), the child's ventilation should be assisted. Mechanical ventilation may be necessary.

OBJ: Discuss postresuscitation care.

2. F. Immediately after the return of spontaneous circulation, repeat the primary survey. Reassess the effectiveness of initial airway maneuvers and interventions. Apply a pulse oximeter and assess oxygen saturation. If the administration of supplemental oxygen is indicated, use the lowest inspired oxygen concentration that will maintain an SpO_2 of at least 94% (de Caen et al., 2015).

OBJ: Discuss postresuscitation care.

Multiple Choice

3. B. Despite the presence of an organized rhythm on the cardiac monitor, the patient has no pulse, which is consistent with the clinical situation referred to as pulseless electrical activity (PEA). Electrical therapy such as defibrillation is not indicated in the management of PEA. A nonrebreather mask is used to deliver supplemental oxygen to a breathing patient. In this situation, ventilations are delivered using a bag-mask device connected to 100% oxygen. Although imaging and laboratory studies are important and can provide useful information with regard to the patient's injuries, initial resuscitative efforts should focus on the performance of high-quality CPR, establishing vascular access, and administration of a vasopressor such as epinephrine.

OBJ: Discuss the initial emergency care for a cardiopulmonary arrest.

4. A. On the basis of this patient's mechanism of injury, injuries to the thorax and abdomen should be suspected even if external signs of injury are absent. If the decision to intubate is made, assign a team member to stabilize the head and neck in a neutral position while another team member performs the procedure. Routine hyperventilation is not recommended, even when a head injury is suspected (de Caen et al., 2015). Hyperventilation may be ordered for brief periods when signs of impending brain herniation are present. In traumatic cardiac arrest, assume that hypovolemia is present and rapidly infuse an isotonic crystalloid solution.

OBJ: Examine circumstances in which additional factors should be considered during a cardiopulmonary arrest.

5. B. Four phases of cardiac arrest have been described: (1) the prearrest phase, (2) the no-flow phase, (3) the low-flow phase, and (4) the postresuscitation phase. The no-flow phase reflects untreated cardiac arrest before it is recognized by a bystander in the community or by a medical provider in the hospital. The focus during this phase is on recognizing that a cardiac arrest has occurred, initiating basic and advanced cardiac life support, and minimizing the interval to defibrillation, if indicated.

OBJ: Discuss the epidemiology and phases of a cardiopulmonary arrest.

6. A. The definitive treatment for ventricular fibrillation (VF) or pulseless ventricular tachycardia (pVT) is defibrillation. When pVT or VF is present, defibrillation takes priority over attempts to establish vascular access, administration of medications, and placement of an advanced airway. Synchronized cardioversion is not indicated for VF.

OBJ: Given a patient situation, formulate a treatment plan (including assessment, airway management, cardiopulmonary resuscitation, pharmacology, and electrical interventions where applicable) for a patient presenting in cardiopulmonary arrest.

7. B. Magnesium sulfate should be administered for torsades de pointes.

OBJ: Discuss the pharmacology of medications used during a cardiopulmonary arrest.

Case Study 7-1 Answers

1. Quickly assess the child's responsiveness, check for breathing, and assess the rate and quality of central pulses.

OBJ: Discuss the initial emergency care for cardiac dysrhythmias in infants and children.

2. Call for a defibrillator and instruct a team member to begin chest compressions. Continuously assess the quality of compressions throughout the resuscitation effort. Instruct another team member to insert an oral airway and begin bag-mask ventilation. Direct another team member to apply a pulse oximeter and blood pressure monitor and cardiac monitor. Identify the rhythm on the cardiac monitor.

OBJ: Given a patient situation, formulate a treatment plan (including assessment, airway management, cardiopulmonary resuscitation, pharmacology, and electrical interventions where applicable) for a patient presenting in cardiopulmonary arrest.

3. Because the patient's cardiac rhythm is monomorphic ventricular tachycardia and this patient is pulseless, defibrillation is indicated. Continue CPR until the defibrillator is ready to deliver a shock. Clear the area around the patient and deliver one shock using an initial dose of 2 J/kg. Immediately resume CPR, starting with chest compressions, for about 2 minutes. Direct a team member to establish vascular access without interrupting chest compressions.

OBJ: Differentiate between defibrillation and synchronized cardioversion and identify the indications and recommended energy levels for these procedures.

4. The possible reversible causes of cardiac dysrhythmias include the Hs and Ts, which consist of the following:

   Hypoxia
   Hypovolemia
   Hydrogen ion (acidosis)
   Hypoglycemia
   Hypokalemia/hyperkalemia
   Hypothermia
   Toxins/poisons/drugs
   Trauma
   Tamponade (cardiac)
   Tension pneumothorax
   Thrombosis (coronary or pulmonary)

OBJ: Discuss the initial emergency care for cardiac dysrhythmias in infants and children.

5. Because establishment of peripheral intravenous access can be difficult and time-consuming for an infant or child who is in cardiac arrest, immediate vascular access should be established using the intraosseous route.

OBJ: Discuss age-appropriate vascular access sites for infants and children.

6. While CPR continues, administer epinephrine 0.01 mg/kg (0.1 mL/kg of 1:10,000 solution) IV/IO, maximum of 1 mg, every 3 to 5 minutes as long as the patient does not have a pulse.

OBJ: Discuss the pharmacology of medications used during shock, symptomatic bradycardia, stable and unstable tachycardia, and cardiopulmonary arrest.

7. It is acceptable to use an initial energy dose for pVT or VF of 2 J/kg. If pVT or VF persists, it is reasonable to attempt defibrillation with 4 J/kg. If the dysrhythmia persists, subsequent energy levels should be at least 4 J/kg. Higher energy levels may be considered but should not exceed 10 J/kg or the adult dose, whichever is lower (de Caen et al., 2015).

OBJ: Differentiate between defibrillation and synchronized cardioversion and identify the indications and recommended energy levels for these procedures.

8. If the rhythm persists, administer amiodarone 5 mg/kg IV/IO bolus or lidocaine 1 mg/kg IV/IO bolus.

OBJ: Given a patient situation, formulate a treatment plan (including assessment, airway management, cardiopulmonary resuscitation, pharmacology, and electrical interventions where applicable) for a patient presenting in cardiopulmonary arrest.

9. Perform a brief pulse check (fewer than 10 seconds) if an organized rhythm is observed on the cardiac monitor or other signs of a perfusing rhythm are present (e.g., abrupt rise in end-tidal carbon dioxide). Use the brachial pulse site if the patient is an infant. Check the carotid or femoral pulse if the patient is a child. If a pulse is present, check the patient's blood pressure and other vital signs and begin post–cardiac arrest care.

OBJ: Discuss the initial emergency care for cardiac dysrhythmias in infants and children.

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Checklist 7-1 Asystole/Pulseless Electrical Activity

Action Steps	Performed Correctly
Ensures scene safety. Takes or communicates the use of personal protective equipment for blood and body substances.	☐
Assigns team member roles.	☐
Assessment	
Forms a general impression: Assesses patient's appearance, work of breathing, and circulation.	☐
Directs assessment of responsiveness and breathing.	☐
Directs assessment of central and peripheral pulses.	☐
Recognizes cardiopulmonary arrest and calls for a defibrillator.	☐
Instructs team member to begin chest compressions; continuously assesses quality of compressions.	☐
Instructs team member to insert oral airway and begin bag-mask ventilation.	☐
Directs team members to apply a pulse oximeter and blood pressure and cardiac monitors, and to determine patient weight.	☐
Correctly identifies cardiac rhythm.	☐
Treatment Plan	
Verbalizes a treatment plan and initiates appropriate interventions.	☐
Instructs team member to establish vascular access.	☐
Orders administration of IV/IO medications appropriate for the dysrhythmia.	☐
Considers possible reversible causes of cardiac dysrhythmias.	☐
Orders diagnostic tests and procedures, if indicated.	☐
Considers the need for an advanced airway.	☐
Correctly verbalizes indications, dosages, and routes of administration for medications administered.	☐
Reassessment	
Rechecks the patient's cardiac rhythm approximately every 2 minutes.	☐
Monitors for, recognizes, and appropriately treats any changes in the patient's physiological status.	☐
Team Leader Assessment	
Effectively leads team members throughout patient care.	☐
Directs the transfer of patient care for ongoing monitoring and care, if applicable.	☐
Requests a team debriefing after the transfer of patient care is complete.	☐

Checklist 7-2 Ventricular Fibrillation/Pulseless Ventricular Tachycardia

Action Steps	Performed Correctly
Ensures scene safety. Takes or communicates the use of personal protective equipment for blood and body substances.	☐
Assigns team member roles.	☐
Assessment	
Forms a general impression: Assesses patient's appearance, work of breathing, and circulation.	☐
Directs assessment of responsiveness and breathing.	☐
Directs assessment of central and peripheral pulses.	☐
Recognizes cardiopulmonary arrest and calls for a defibrillator.	☐
Instructs team member to begin chest compressions; continuously assesses quality of compressions.	☐
Instructs team member to insert oral airway and begin bag-mask ventilation.	☐
Directs team members to apply a pulse oximeter and blood pressure and cardiac monitors, and to determine patient weight.	☐
Correctly identifies cardiac rhythm.	☐
Treatment Plan	
Verbalizes a treatment plan and initiates appropriate interventions.	☐
Directs team member to defibrillate using appropriate energy level.	☐
Directs team to resume CPR after defibrillation, beginning with chest compressions.	☐
Instructs team member to establish vascular access.	☐
Orders administration of IV/IO medications appropriate for the dysrhythmia.	☐
Considers possible reversible causes of cardiac dysrhythmias.	☐
Orders diagnostic tests and procedures, if indicated.	☐
Considers the need for an advanced airway.	☐
Correctly verbalizes indications, dosages, and routes of administration for medications administered.	☐
Reassessment	
Rechecks the patient's cardiac rhythm approximately every 2 minutes.	☐
Monitors for, recognizes, and appropriately treats any changes in the patient's physiological status.	☐
Team Leader Assessment	
Effectively leads team members throughout patient care.	☐
Directs the transfer of patient care for ongoing monitoring and care, if applicable.	☐
Requests a team debriefing after the transfer of patient care is complete.	☐

CHAPTER 8

Posttest

PUTTING IT ALL TOGETHER

Identify the choice that best completes the statement or answers the question.

Questions 1 through 5 pertain to the following scenario.

You are called to see a 14-month-old child with difficulty breathing and a history of poor feeding. Mom reports that the child has had a fever and cough for the past two days.

____ 1. Your general impression reveals that the child is poorly responsive to his surroundings and that he is breathing rapidly. Intercostal retractions are present. His skin color is pale. Which of the following accurately reflects your general impression findings?

a. Normal appearance, normal work of breathing, and normal circulation to the skin
b. Abnormal appearance, abnormal work of breathing, and normal circulation to the skin
c. Normal appearance, normal work of breathing, and abnormal circulation to the skin
d. Abnormal appearance, abnormal work of breathing, and abnormal circulation to the skin

____ 2. Your primary assessment reveals an open airway. The child's ventilatory rate is 48 per minute. Auscultation of the chest reveals bilateral expiratory wheezes. A weak brachial pulse is present and the skin is pale. Capillary refill is 2 to 3 seconds, temperature is 102.8°F, and the pulse oximeter reveals an SpO_2 of 86%. This child's presentation is most consistent with:

a. Respiratory distress
b. Respiratory failure
c. Respiratory arrest
d. Cardiopulmonary arrest

____ 3. The cardiac monitor has been applied and reveals the following rhythm (**Figure 8-1**). The rhythm displayed is:

a. Sinus bradycardia.
b. Ventricular fibrillation.
c. Supraventricular tachycardia.
d. Second-degree atrioventricular block type I.

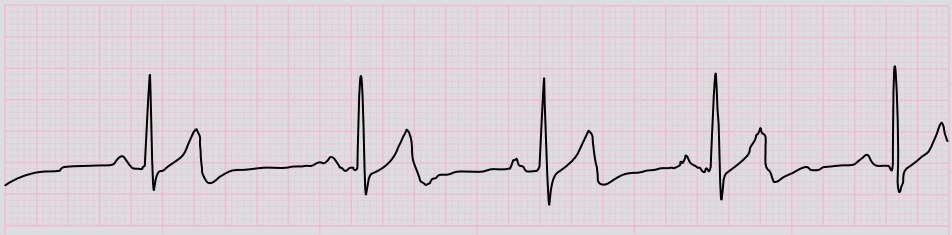

Figure 8-1

____ 4. Your next course of action should be to:

a. Begin chest compressions.
b. Administer supplemental oxygen by nasal cannula.
c. Administer supplemental oxygen using a nonrebreather mask.
d. Assist ventilations with supplemental oxygen and a bag-mask device.

____ 5. A physician orders a chest radiograph and nebulized albuterol. What is the rationale for the use of albuterol in this situation?

a. Albuterol is being ordered to suppress the child's cough.
b. Albuterol is being ordered to increase the child's heart rate.
c. Albuterol administration will relax bronchial smooth muscle.
d. Albuterol administration will reduce the child's fever and risk for infection.

Questions 6 through 9 pertain to the following scenario.

A 3-year-old presents with a history of vomiting and diarrhea over a period of 4 days. The child's blood pressure is 64/40 mm Hg and capillary refill is 3 seconds.

____ 6. The child's heart rate is 185 beats per minute. You would expect the normal heart rate for a child of this age to be between:

a. 70 and 120 beats per minute.
b. 80 and 140 beats per minute.
c. 95 and 150 beats per minute.
d. 100 and 160 beats per minute.

____ 7. The cardiac monitor reveals a sinus tachycardia. On the basis of the information provided, your best course of action will be to:

a. Begin fluid resuscitation to correct hypovolemia.
b. Perform a vagal maneuver to slow the child's heart rate.
c. Administer epinephrine to increase the child's heart rate.
d. Perform immediate synchronized cardioversion to convert the rhythm.

____ 8. Vascular access has been obtained. You should administer:

a. A bolus of 300 mL of a colloid solution.
b. A bolus of 10 mL/kg of a colloid solution.
c. A bolus of 500 mL of an isotonic crystalloid solution.
d. A bolus of 20 mL/kg of an isotonic crystalloid solution.

____ 9. For the infant or child in early shock, the body attempts to compensate by:

a. Increasing the heart rate.
b. Lowering blood pressure.
c. Decreasing the ventilatory rate.
d. Redistributing blood flow from the vital organs to the skin and muscles.

____ 10. Cardiac arrest in the pediatric population is most often the result of:

a. Hypothermia.
b. Prolonged hypoxia.
c. Ventricular fibrillation.
d. Congenital heart disease.

____ 11. You have attempted to deliver your first positive-pressure ventilation to a patient experiencing a respiratory arrest. The patient's chest did not rise when you delivered the first breath. You should now:

a. Check for a pulse.
b. Begin chest compressions.
c. Readjust the patient's head position.
d. Assemble the equipment needed for a surgical airway.

____ 12. Atropine:

a. Suppresses ventricular dysrhythmias.
b. Increases the force of myocardial contraction.
c. Causes vasoconstriction and increases cardiac output.
d. Increases heart rate and blocks the action of the vagus nerves.

____ 13. Which of the following statements is true with regard to supraventricular tachycardia (SVT)?

a. SVT begins abruptly.
b. SVT is a normal compensatory response to physiologic stress.
c. SVT is a regular rhythm with a narrow QRS complex that often varies in response to activity or stimulation.
d. The heart rate associated with SVT is usually fewer than 220 beats per minute in infants or 180 beats per minute in children.

____ 14. The team leader of a resuscitation effort:

a. Prepares, labels, and administers medications.
b. Performs chest compressions and periodic pulse checks.
c. Assembles the equipment for intubation and vascular access.
d. Assigns roles to team members and makes treatment decisions.

_____ 15. An adult bag-mask used with supplemental oxygen set at a flow rate of 15 L/minute and an attached reservoir will deliver approximately _____ oxygen to the patient.

a. 16% to 21%
b. 40% to 60%
c. 60% to 95%
d. 90% to 100%

_____ 16. Which of the following statements is correct?

a. Sodium bicarbonate should be routinely administered in cardiac arrest.
b. Assessment of blood glucose concentration is unnecessary during a resuscitation effort.
c. Family members should be given the option of being present during the resuscitation of an infant or child.
d. Central venous access is recommended as the initial route of vascular access in cardiac arrest.

_____ 17. The presence of compensated shock can be identified by:

a. Assessment of heart rate, cardiac rhythm, and skin temperature.
b. Assessment of end-organ perfusion, cardiac rhythm, and pupil response to light.
c. Assessment of the presence and strength of peripheral pulses, mental status, and pupil response to light.
d. Assessment of heart rate, the presence and strength of peripheral pulses, and the adequacy of end-organ perfusion.

_____ 18. Which of the following statements is true with regard to the use of the Glasgow Coma Scale (GCS)?

a. When assigning a score using the GCS, the maximum possible score is 13.
b. Verbal and motor responses must be evaluated with respect to a child's age.
c. The GCS is used to assess the patient's orientation to person, place, time, and event.
d. The need for aggressive airway management should be considered when the GCS is 12 or less.

_____ 19. The drug of choice for a stable but symptomatic child in supraventricular tachycardia is:

a. Atropine.
b. Albuterol.
c. Adenosine.
d. Amiodarone.

_____ 20. Which of the following would you expect to find when forming a general impression of a child with hypotensive shock?

a. Normal appearance, normal work of breathing, and abnormal circulation to the skin
b. Normal appearance, abnormal work of breathing, and normal circulation to the skin
c. Abnormal appearance, abnormal work of breathing, and normal circulation to the skin
d. Abnormal appearance, normal or abnormal work of breathing, and abnormal circulation to the skin

_____ 21. Essential tasks to be assigned to team members at the start of a resuscitation effort include:

a. Crowd control.
b. Equipment procurement.
c. Acquisition of blood samples for analysis.
d. Vascular access and medication administration.

_____ 22. Which of the following medications is used for all dysrhythmias associated with pediatric cardiopulmonary arrest?

a. Lidocaine
b. Epinephrine
c. Amiodarone
d. Magnesium sulfate

_____ 23. Appropriate interventions for a child with moderate to severe croup include the administration of:

a. Diuretics.
b. Nebulized ipratropium bromide.
c. Nebulized epinephrine and a systemic steroid.
d. Intramuscular epinephrine and nebulized albuterol.

_____ 24. What is the most common cause of symptomatic bradycardia in children?

a. Hypoxia
b. Hyperkalemia
c. Hypoglycemia
d. Atherosclerosis

_____ 25. Procainamide:

a. May cause narrowing of the QRS width and hypertension.
b. Is most effective when infused rapidly over 5 to 10 minutes.
c. Is the drug of choice in the management of symptomatic bradycardia.
d. Is used for a wide range of atrial and ventricular dysrhythmias, including supraventricular and ventricular tachycardia.

_____ 26. Which of the following statements regarding vagal maneuvers is correct?

a. The application of ocular pressure is safe if performed in older children.
b. Vagal maneuvers should be attempted only after administration of adenosine.
c. Vagal maneuvers may be tried in the child with pulseless ventricular tachycardia.
d. The application of a cold stimulus to the face may be effective in infants and young children.

_____ 27. Dopamine:

a. Acts as a vasopressor at high doses.
b. Causes renal vasoconstriction at low doses.
c. Is typically infused at a rate of 0.1 to 1 mcg/kg per minute.
d. Is administered rapid intravenous push over 5 to 10 minutes.

_____ 28. Which of the following statements is true of obstructive shock?

a. The patient's initial clinical presentation may be identical to hypovolemic shock.
b. The focus of emergency care is directed toward controlling fluid loss and restoring vascular volume.
c. Obstructive shock results from a heart rate that is either too fast or too slow to sustain a sufficient cardiac output.
d. Obstructive shock is caused by a sudden decrease in the circulating blood volume relative to the capacity of the vascular space.

_____ 29. Amiodarone:

a. Should be administered over 20 to 60 minutes in cardiac arrest.
b. Should be administered IV push in a patient with a perfusing rhythm.
c. Is most effective when simultaneously administered with procainamide.
d. May cause hypotension, bradycardia, and prolongation of the QT interval.

_____ 30. Which of the following statements is correct with regard to pediatric defibrillation?

a. Adult pads may be used if pediatric pads are unavailable.
b. Use of an automated external defibrillator (AED) in infants is not recommended.
c. If defibrillation of an infant is indicated, use of an AED with a pediatric attenuator is essential.
d. The initial recommended energy level for pulseless ventricular tachycardia or ventricular fibrillation is 4 to 10 J/kg.

_____ 31. An oropharyngeal airway:

a. Can effectively protect the lower airway from aspiration.
b. Can be used in both responsive and unresponsive patients.
c. Is of the correct size if it extends from the corner of the mouth to the tip of the earlobe or angle of the lower jaw.
d. Is placed in one nostril and advanced until the distal tip lies in the posterior pharynx just below the base of the tongue.

_____ 32. Which of the following reflects examples of conditions that may disrupt control of ventilation?

a. Croup and anaphylaxis
b. Asthma and bronchiolitis
c. Cystic fibrosis and cardiogenic pulmonary edema
d. Increased intracranial pressure and acute poisoning

_____ 33. When administered for symptomatic bradycardia or during a cardiac arrest, the intravenous dose of epinephrine for an infant or child is:

a. 0.1 mg/kg (0.1 mL/kg of 1:1,000 solution)
b. 0.01 mg/kg (0.1 mL/kg of 1:10,000 solution)
c. 0.02 mg/kg of 1:1,000 solution
d. 0.04 mg/kg of 1:10,000 solution

_____ 34. When ventilating a patient with a perfusing rhythm but absent or inadequate ventilatory effort, bag-mask ventilation should be provided at a rate of:

a. 8 to 10 breaths per minute
b. 10 to 14 breaths per minute
c. 12 to 20 breaths per minute
d. 14 to 30 breaths per minute

_____ 35. Synchronized cardioversion is:

a. Performed using an initial energy dose of 2 J/kg.
b. Recommended for pulseless ventricular tachycardia.
c. The procedure of choice when treating polymorphic ventricular tachycardia.
d. Used in the treatment of perfusing rhythms with a clearly identifiable QRS complex and a rapid ventricular rate.

Posttest Answers

1. D. Your general impression findings reflect an abnormal appearance (poorly responsive), abnormal work of breathing (rapid rate and presence of retractions), and abnormal circulation to the skin (pallor).

OBJ: Summarize the components of the pediatric assessment triangle and the reasons for forming a general impression of the patient.

2. B. This child's presentation is most consistent with respiratory failure. Aggressive intervention is essential.

OBJ: Differentiate between respiratory distress, respiratory failure, and respiratory arrest.

3. A. The rhythm shown is a sinus bradycardia.

OBJ: Identify the major classifications of pediatric cardiac rhythms.

4. D. When a patient demonstrates signs of respiratory failure or respiratory arrest, assist ventilation using a bag-mask device with supplemental oxygen. Noninvasive positive-pressure ventilation may be needed.

OBJ: Describe the pathophysiology, assessment findings, and treatment plan for the infant or child experiencing respiratory distress, respiratory failure, or respiratory arrest.

5. C. Albuterol is a short-acting bronchodilator with a rapid onset (a few minutes) that stimulates beta$_2$ receptor sites in bronchial smooth muscle, resulting in relaxation and decreased resistance to the flow of air in and out of the lungs. Although an increase in heart rate is a common adverse effect of albuterol administration, it is not the primary reason for ordering this medication in this situation. Because albuterol is a bronchodilator and not an antipyretic, it will have no effect with regard to reducing the child's fever.

OBJ: Describe the general approach to the treatment of children with upper or lower airway obstruction.

6. C. The normal heart rate for a toddler at rest is between 95 and 150 beats per minute.

OBJ: Identify normal age-group-related vital signs.

7. A. Sinus tachycardia is a normal compensatory response to the need for increased cardiac output or oxygen delivery. Treatment is directed at the underlying cause that precipitated the rhythm (e.g., administration of fluids to correct hypovolemia).

OBJ: Describe the initial emergency care for hypovolemic, distributive, cardiogenic, and obstructive shock in infants and children.

8. D. A rough estimate of a child's weight can be obtained using the following formula: weight in kg = 8 + (2 × age in years). This child's estimated weight is 14 kg. Administer a bolus of 20 mL/kg of an isotonic crystalloid solution (such as normal saline or lactated Ringer's) over 5 to 10 minutes. For this child, a 20 mL/kg fluid bolus would be about 280 mL. Assess the child's response. If perfusion does not improve, repeat fluid boluses and reassess response. Closely monitor for increased work of breathing and the development of crackles. Colloids such as albumin are not routinely indicated during the initial management of hypovolemic shock but they may be ordered for volume replacement in children with large third-space losses or albumin deficits.

OBJ: Given a patient situation, formulate a treatment plan for a patient in shock.

9. A. During compensated shock, the body's defense mechanisms attempt to preserve perfusion of the brain, heart, kidneys, and liver at the expense of nonvital organs (e.g., skin, muscles, gastrointestinal tract). Baroreceptors in the carotid sinus respond to a drop in mean arterial pressure, which can occur because of a decrease in cardiac output, a decrease in circulating blood volume, or an increase in the size of the vascular bed. Compensatory responses include increases in heart rate, stroke volume, and vascular smooth muscle tone. The respiratory center responds to changes detected by the chemoreceptors (e.g., rise in CO_2 level, drop in pH) by increasing the ventilatory rate in an effort to blow off excess CO_2. Additional compensatory mechanisms that help to maintain perfusion include the redistribution of blood flow from the skin, muscles, and splanchnic viscera to the vital organs.

OBJ: Differentiate between compensated and hypotensive shock.

10. B. In children, cardiac arrests are usually the result of an asphyxial event (precipitated by acute hypoxia or hypercarbia) or an ischemic event (from hypovolemia, sepsis, or cardiogenic shock) rather than sudden cardiac dysrhythmias.

OBJ: Discuss the epidemiology and phases of a cardiopulmonary arrest.

11. C. A common problem when ventilating with a bag-mask device is tightly placing the mask on the face without performing an adequate maneuver to open the patient's airway. This results in an airway obstruction because of improper airway positioning. Readjust the patient's head position, ensure the mouth is open, and try to ventilate again.

OBJ: Discuss positive-pressure ventilation using a bag-mask device and troubleshoot for ineffective bag-mask ventilation.

12. D. Atropine enhances atrioventricular conduction and increases heart rate by accelerating the rate of discharge of the sinoatrial node and blocking the vagus nerves.

OBJ: Discuss the pharmacology of medications used while managing a symptomatic bradycardia.

13. A. Supraventricular tachycardia (SVT) is the most common tachydysrhythmia that necessitates treatment in the pediatric patient. Sinus tachycardia is a normal compensatory response to the need for increased cardiac output or oxygen delivery. Unlike sinus tachycardia, SVT is *not* a normal compensatory response to physiologic stress. In SVT, the heart rate (HR) is usually more than 220 beats per minute in infants or 180 beats per minute in children. Onset of the rhythm occurs abruptly. The ECG shows a regular rhythm with a narrow QRS complex (0.09 seconds or less) that does not vary in response to activity or stimulation. In the absence of known congenital heart disease, the history obtained is usually nonspecific (i.e., the history does not explain the rapid HR).

OBJ: Discuss the types of tachycardias that may be observed in the pediatric patient.

14. D. The *code director* or *team leader* is the person who guides the efforts of the resuscitation team. As the members of the team come together, the team leader is identified and then assigns roles to team members if they have not been preassigned. The team leader should be in a position to "stand back" while overseeing and directing the resuscitation effort. Because every resuscitation effort is different, it is important that the team leader ensure that a postevent debriefing takes place.

OBJ: Recognize the importance of teamwork during a resuscitation effort.

15. D. An adult bag-mask used with supplemental oxygen set at a flow rate of 15 L/minute and an attached reservoir will deliver approximately 90% to 100% oxygen to the patient.

OBJ: Discuss positive-pressure ventilation using a bag-mask device and troubleshoot for ineffective bag-mask ventilation.

16. C. When possible, family members should be given the option of being present during the resuscitation of an infant or child. As energy requirements rise, infants and children may become hypoglycemic because of rapidly depleted carbohydrate stores. Check the blood glucose level during the resuscitation effort and promptly treat hypoglycemia. Routine administration of sodium bicarbonate is not recommended in cardiac arrest. Because insertion takes time and specially trained personnel to perform, central venous access is not recommended as the initial route of vascular access during an emergency; the intravenous or intraosseous routes are preferred.

OBJ: Discuss the initial emergency care for a cardiopulmonary arrest.

17. D. The presence of compensated shock can be identified by evaluation of heart rate, the presence and volume (strength) of peripheral pulses, and the adequacy of end-organ perfusion (brain—assess mental status, skin—assess capillary refill and skin temperature, and kidneys—assess urine output).

OBJ: Differentiate between compensated and hypotensive shock.

18. B. The Glasgow Coma Scale is used to assess a patient's level of responsiveness by evaluating best verbal response, best motor response, and eye opening. The GCS score is the sum of the scores in these categories; the lowest possible score is 3 and the highest possible score is 15. Motor response is the most important component of the GCS if the patient is unresponsive, intubated, or preverbal. Verbal and motor responses must be evaluated with respect to a child's age. Consider the need for aggressive airway management when the GCS is 8 or less.

OBJ: Summarize the purpose and components of the primary assessment.

19. C. In stable patients with SVT, adenosine is the drug of choice because of its rapid onset of action and minimal effects on cardiac contractility.

OBJ: Discuss the pharmacology of medications used while managing a tachycardia.

20. D. Expected general impression findings of a child with hypotensive shock include an abnormal appearance, normal or abnormal work of breathing, and abnormal circulation to the skin.

OBJ: Differentiate between compensated and hypotensive shock.

21. D. Chest compressions, ECG monitoring and defibrillation, airway management, vascular access and medication administration, and documentation are essential tasks that must be coordinated during a resuscitation effort. A family support person should be a recognized member of the code team. Additional members of the resuscitation team may include pharmacists, clergy, and security personnel.

OBJ: Given a patient situation, and working as the team leader of a resuscitation effort, assign essential tasks to team members.

22. B. Epinephrine is used for all dysrhythmias associated with pediatric cardiopulmonary arrest. Amiodarone or lidocaine is used for cardiac arrest associated with pulseless ventricular tachycardia or ventricular fibrillation. Magnesium sulfate is used for polymorphic VT associated with a long QT interval (i.e., torsades de pointes).

OBJ: Discuss the pharmacology of medications used during a cardiopulmonary arrest.

23. C. Children with moderate to severe croup should receive nebulized epinephrine. A systemic steroid such as dexamethasone or budesonide should be given early because of their anti-inflammatory effects. Diuretics are not used in the treatment of croup. Nebulized ipratropium bromide is used when treating a severe episode of asthma. The administration of intramuscular epinephrine and nebulized albuterol is part of the treatment plan for anaphylaxis.

OBJ: Describe the pathophysiology, assessment findings, and treatment plan for the child experiencing croup, epiglottitis, foreign body aspiration, and anaphylaxis.

24. A. The term *symptomatic bradycardia* is used when a patient experiences signs and symptoms of cardiovascular compromise that are related to slow heart rate. Hypoxia is the most common cause of symptomatic bradycardia in children. Initial interventions focus on assessment and support of the airway and ventilation, as well as the administration of supplemental oxygen. It is important to identify and correct hypoxia before giving medications to increase the patient's heart rate.

OBJ: Discuss the types of bradycardias that may be observed in the pediatric patient.

25. D. Procainamide is used for a wide range of atrial and ventricular dysrhythmias, including supraventricular and ventricular tachycardia. Procainamide must be infused slowly (over 30 to 60 minutes) while continuously monitoring the patient's electrocardiogram and blood pressure. Epinephrine (not procainamide) is the drug of choice in the management of symptomatic bradycardia. The infusion of procainamide should be stopped or slowed if the QRS lengthens by more than 50% of its original width or if hypotension occurs.

OBJ: Discuss the pharmacology of medications used while managing a tachycardia.

26. D. Vagal maneuvers may be tried in the stable but symptomatic child in supraventricular tachycardia or during preparation for cardioversion or drug therapy for this dysrhythmia. When indicated, vagal maneuvers should be tried before administration of adenosine. The application of a cold stimulus to the face (e.g., a washcloth soaked in iced water, crushed ice mixed with water in a small plastic bag or glove) for 15 to 20 seconds is often effective in infants and young children. Application of pressure to the eye should not be performed in a patient of any age because this can damage the retina. Vagal maneuvers are not indicated in the treatment of any cardiac arrest rhythm.

OBJ: Discuss the types of vagal maneuvers that may be used in the pediatric patient.

27. A. When infused at low doses, dopamine increases renal and mesenteric flow, thereby improving perfusion to these organs. At medium doses, dopamine increases cardiac contractility and thereby increases cardiac output, with little effect on vascular resistance. Dopamine acts as a vasopressor, causing arteriolar vasoconstriction when infused at higher doses. This medication is administered as a continuous IV/IO infusion at 2 to 20 mcg/kg per minute.

OBJ: Discuss the pharmacology of medications used during shock.

28. A. Obstructive shock occurs when low cardiac output results from an obstruction to ventricular filling or to the outflow of blood from the heart. The patient's initial clinical presentation may be identical to hypovolemic shock. Possible causes of obstructive shock include cardiac tamponade, tension pneumothorax, ductal-dependent congenital heart lesions, and massive pulmonary embolism. Hypovolemic shock is caused by a sudden decrease in the circulating blood volume relative to the capacity of the vascular space. Arrhythmogenic cardiogenic shock results from a heart rate that is either too fast or too slow to sustain a sufficient cardiac output despite a normal stroke volume. With hypovolemic shock, emergency care is directed toward controlling fluid loss and restoring vascular volume. With obstructive shock, emergency care focuses on supporting oxygenation and ventilation, and maintaining effective circulation.

OBJ: Discuss the physiologic types of shock.

29. D. Amiodarone may cause hypotension, bradycardia, and prolongation of the QT interval. Amiodarone should be administered over 20 to 60 minutes via IV push during cardiac arrest in a patient with a perfusing rhythm. Amiodarone should not be administered with procainamide without first seeking expert consultation because each drug may cause QT prolongation.

OBJ: Discuss the pharmacology of medications used while managing a tachycardia.

30. A. Adult pads may be used if pediatric pads are unavailable. If defibrillation of an infant is indicated, use of a manual defibrillator is preferred. If a manual defibrillator is not available, an AED equipped with a pediatric attenuator is desirable. If neither are available, use a standard AED. It is acceptable to use an initial energy dose for pulseless VT or VF of 2 J/kg. If the dysrhythmia persists, it is reasonable to increase the dose to 4 J/kg. If the dysrhythmia persists, subsequent energy levels should be at least 4 J/kg. Higher energy levels may be considered but should not exceed 10 J/kg or the adult dose, whichever is lower.

OBJ: Discuss defibrillation and identify the indications and recommended energy levels for this procedure.

31. C. Because an oral airway does not isolate the trachea, it does not protect the lower airway from aspiration. An oral airway is not used in responsive or semi-responsive patients with a gag reflex because insertion may stimulate vomiting in these patients. Proper airway size is determined by holding the device against the side of the patient's face and selecting an airway that extends from the corner of the mouth to the angle of the lower jaw or to the earlobe. A nasopharyngeal airway, not an oropharyngeal airway, is placed in one nostril and advanced until the bevel-shaped distal tip lies in the posterior pharynx just below the base of the tongue and above the epiglottis, while the proximal tip rests at the external nasal opening.

OBJ: Describe the method of correct sizing, insertion technique, and possible complications associated with the use of the oropharyngeal airway and nasopharyngeal airway.

32. D. Examples of conditions that may disrupt control of ventilation include increased intracranial pressure, neuromuscular disease, and acute poisoning or drug overdose. Asthma and bronchiolitis are common causes of lower airway obstruction in children. Causes of upper airway obstruction include secretions that block the nasal passages, airway swelling (e.g., croup, epiglottis, anaphylaxis), the presence of a foreign body, and congenital airway abnormalities. Cystic fibrosis and cardiogenic pulmonary edema are among the many causes of lung tissue disease.

OBJ: Describe the pathophysiology, assessment findings, and treatment plan for the child who has lung tissue disease or disordered ventilatory control.

33. B. Because epinephrine is supplied in different dilutions, it is important to ensure selection of the correct concentration before administering this medication. The intravenous dosage of epinephrine for an infant or child is 0.01 mg/kg (0.1 mL/kg of 1:10,000 solution). If vascular access is not available and the patient is intubated, epinephrine may be given by means of an endotracheal (ET) tube: 0.1 mg/kg (0.1 mL/kg of 1:1,000 solution). The maximum ET dose 2.5 mg.

OBJ: Discuss the pharmacology of medications used while managing a symptomatic bradycardia.

34. C. Bag-mask ventilation in this situation should be provided at a rate of 12 to 20 breaths per minute (1 breath every 3 to 5 seconds). Each breath should be given over 1 second.

OBJ: Discuss positive-pressure ventilation using a bag-mask device and troubleshoot for ineffective bag-mask ventilation.

35. D. Synchronized cardioversion is used to treat rhythms in the unstable patient who has a clearly identifiable QRS complex and a rapid ventricular rate such as supraventricular tachycardia (SVT) that is caused by reentry, atrial flutter, and monomorphic ventricular tachycardia (VT) with a pulse. It is not used in the management of sinus tachycardia. Synchronized cardioversion may be used in the management of the stable patient with SVT, atrial flutter, and monomorphic VT with a pulse under the direction of a pediatric cardiologist. Synchronized cardioversion is not used to treat disorganized rhythms (such as polymorphic VT) or those that do not have a clearly identifiable QRS complex (such as ventricular fibrillation). An energy dose of 0.5 to 1 J/kg is used for the initial shock. The energy dose may be increased to 2 J/kg for the second and subsequent attempts if necessary. Defibrillation, not synchronized cardioversion, is used in the management of *pulseless* ventricular tachycardia.

OBJ: Discuss synchronized cardioversion and identify the indications and recommended energy levels for this procedure.

Glossary

Afterload The pressure or resistance against which the ventricles must pump to eject blood
Anaphylaxis A severe allergic response to a foreign substance with which the patient has had prior contact
Apnea The cessation of breathing for more than 20 seconds with or without cyanosis, decreased muscle tone, or bradycardia
Asthma A disease of the lower airway characterized by chronic inflammation of bronchial smooth muscle, hyperreactive airways, and episodes of bronchospasm that limit airflow

Bilevel positive airway pressure (BPAP) The delivery of positive pressure during inspiration and a lesser positive pressure during expiration
Bradypnea A slower than normal rate of breathing for the patient's age
Bronchiolitis An acute infection of the bronchioles, most commonly caused by respiratory syncytial virus
Bronchopulmonary dysplasia (BPD) A chronic lung disease characterized by persistent respiratory distress

Capnograph A device that provides both a numeric reading and a waveform of carbon dioxide concentrations in exhaled gases
Capnography The process of continuously analyzing and recording carbon dioxide concentrations in expired air
Capnometer A device that measures the concentration of carbon dioxide at the airway opening at the end of exhalation
Capnometry A numeric reading of exhaled CO2 concentrations without a continuous waveform
Cardiac Output (CO) The amount of blood pumped into the aorta each minute by the heart
Cardiopulmonary (cardiac) arrest The absence of cardiac mechanical activity, which is confirmed by the absence of a detectable pulse, unresponsiveness, and apnea or agonal, gasping breathing; also called *cardiac arrest*
Cardiopulmonary failure A clinical condition identified by deficits in oxygenation, ventilation, and perfusion
Continuous positive airway pressure (CPAP) The delivery of a continuous, fixed pressure of air throughout the respiratory cycle by means of a medical device through a soft mask worn over the nose or over the mouth and nose
Crackles Abnormal breath sounds produced as air passes through airways containing fluid or moisture (formerly called *rales*)
Cystic fibrosis (CF) A hereditary disease of the exocrine glands characterized by production of viscous mucus that obstructs the bronchi

Defibrillation The therapeutic delivery of unsynchronized electrical current through the myocardium over a very brief period to terminate a cardiac dysrhythmia
Defibrillator Device used to administer an electrical shock to terminate a cardiac dysrhythmia

Extravasation The inadvertent administration of a vesicant (irritating to human tissue) solution or medication into surrounding tissue because of catheter dislodgment

Fontanels Membranous spaces formed where cranial bones intersect

Grunting A short, low-pitched sound heard as the patient exhales against a partially closed glottis; it is a compensatory mechanism to help maintain the patency of the alveoli and prolong the period of gas exchange
Gurgling A bubbling sound that occurs when blood or secretions are present in the upper airway

Head bobbing An indicator of increased work of breathing in infants; the head falls forward with exhalation and comes up with expansion of the chest on inhalation
Hypovolemic shock A state of inadequate circulating blood volume relative to the capacity of the vascular space

Infiltration The inadvertent administration of a nonvesicant (nonirritating to human tissue) solution or medication into surrounding tissue because of catheter dislodgment

Minute volume The amount of air moved in and out of the lungs in one minute, determined by multiplying the tidal volume by the ventilatory rate

Nasal flaring Widening of the nostrils on inhalation; an attempt to increase the size of the nasal passages for air to enter during inhalation

Noninvasive positive pressure ventilation (NPPV) The delivery of mechanical ventilatory support, typically by means of a snug fitting nasal or facial mask, without using an endotracheal or tracheostomy tube

Pediatric assessment triangle (PAT) A rapid, systematic approach to forming a general impression of the ill or injured child that focuses on three main areas: (1) appearance, (2) work of breathing, and (3) circulation to the skin

Perfusion The circulation of blood through an organ or a part of the body

Preload The volume of blood in the ventricle at the end of diastole

Petechiae Reddish-purple nonblanchable discolorations in the skin less than 0.5 cm in diameter

PQRST An acronym used when evaluating patients in pain: Precipitating or provoking factors, Quality of pain, Region and radiation of pain, Severity, and Time of pain onset

Primary assessment A hands-on assessment that is performed to rapidly find and treat life-threatening conditions by evaluating the nervous, respiratory, and circulatory systems; also called a *primary survey, initial assessment*, or *ABCDE assessment*

Pulse oximetry A noninvasive method of monitoring the percentage of hemoglobin that is saturated with oxygen

Purpura Red-purple nonblanchable discolorations greater than 0.5 cm in diameter; large purpura are called *ecchymoses*

Respiratory distress A clinical condition characterized by increased work of breathing and a rate of breathing outside the normal range for the patient's age

Respiratory failure A clinical condition in which there is inadequate oxygenation, ventilation, or both to meet the metabolic demands of body tissues

Retractions Sinking in of the soft tissues above the sternum or clavicle, or between or below the ribs during inhalation

SAMPLE Acronym used when obtaining a patient history; Signs and symptoms (as they relate to the chief complaint), Allergies, Medications, Past medical history, Last oral intake, and Events surrounding the illness or injury

Seesaw breathing An ineffective breathing pattern in which the abdominal muscles move outward during inhalation while the chest moves inward; a sign of impending respiratory failure

Septic shock A physiologic response to infectious organisms or their by-products that results in cardiovascular instability and organ dysfunction

Shock Inadequate tissue perfusion that results from the failure of the cardiovascular system to deliver sufficient oxygen and nutrients to sustain vital organ function; also called hypoperfusion or circulatory failure

Sniffing position A position in which the patient sits upright and leans forward with the chin slightly raised, thereby aligning the axes of the mouth, pharynx, and trachea to open the airway and increase airflow

Snoring Noisy, low-pitched sounds usually caused by partial obstruction of the upper airway by the tongue

Sudden cardiac arrest The abrupt and unexpected loss of heart function

Stridor A harsh, high-pitched sound heard on inhalation that is associated with inflammation or swelling of the upper airway often described as a high-pitched "seal bark" sound; caused by disorders such as croup, epiglottitis, the presence of a foreign body, or an inhalation injury

Synchronized cardioversion The delivery of a shock to the heart to terminate a rapid dysrhythmia that is timed to avoid the vulnerable period during the cardiac cycle

Tachypnea A rate of breathing that is more rapid than normal for the patient's age

TICLS A mnemonic developed by the American Academy of Pediatrics that is used to recall the areas to be assessed related to a child's overall appearance; Tone, Interactivity, Consolability, Look or gaze, and Speech or cry

Tidal volume The volume of air moved into or out of the lungs during a normal breath

Toxidrome A constellation of signs and symptoms useful for recognizing a specific class of poisoning

Tripod position A position in which the patient attempts to maintain an open airway by sitting upright and leaning forward supported by his or her arms with the neck slightly extended, chin projected, and mouth open

Vascular resistance The amount of opposition that the blood vessels give to the flow of blood

Wheeze High- or low-pitched sound produced as air passes through airways that have been narrowed because of swelling, spasm, inflammation, secretions, or the presence of a foreign body

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Note: The letters '*f*' and '*t*' following locators refer to figures and tables respectively