Practice Cases

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Introduction

The purpose of the Practice Cases is to illustrate the systematic approach to patient assessment and application of the “assess-categorize-decide-act” model.

Please note that some of the case discussions contain information that is more advanced than the level of knowledge required for core PALS course completion. This information is included to illustrate the approach to patient assessment and intervention and to highlight the category of respiratory and circulatory conditions that may be encountered by a wide variety of PALS providers. Elements of the cases that are for advanced providers (or for those who would like to learn more) are noted using italic blue font for the questions and the answers to those questions.

As you read through each case, stop and try to answer the questions in each section before continuing to the next section. Check your answers by referring to the annotated answers in the appendix. Working through these questions will give you a deeper understanding of the approach to pediatric assessment and the significance of signs and symptoms in categorization and management.

The questions in these cases are linked to their correct answers, which appear at the end of this document. To see the answer and explanation for a question, click on the question. Click the "Return" icon in the answer section to return to the question and case discussion.

If there are elements of the cases or annotated answers that you do not understand, refer to the PALS Provider Manual. You will find the following chapters particularly helpful: Chapter 1: Pediatric Assessment; Chapter 2: Recognition of Respiratory Distress and Failure; Chapter 3: Management of Respiratory Distress and Failure; Chapter 4: Recognition of Shock; and Chapter 5: Management of Shock.

Contents

The practice cases are grouped as follows:

- 4 respiratory distress cases
- 4 shock cases
- 4 cardiac cases
Respiratory Distress Cases

Case 1

Introduction
A 2-year-old is brought to the emergency department with a history of labored breathing for the past 2 days that has progressively worsened. Initially the child had symptoms of an upper respiratory infection. Yesterday he began to have a barky cough, and today he is making a high-pitched sound on inspiration. Although the child was playful earlier today and took fluids well, he now seems very anxious. His breathing is clearly different than earlier. His parents are concerned.

General Assessment
As you enter the room, you see an anxious toddler who is sitting on his mom’s lap and working hard to breathe. He has obvious nasal flaring and intercostal and suprasternal retractions. His breathing is labored but not rapid. You hear a high-pitched inspiratory sound with each breath. He has an occasional harsh, barky cough. His mucus membranes and skin color appear pale.

1A What are the 3 elements of the general assessment?

1B What is your initial impression of the child's condition based on your general assessment? Does the child need immediate intervention? If so, what intervention is indicated?

1C What are the elements of the next assessment step, the primary assessment?

Primary Assessment
The toddler’s heart rate is 165/min, respiratory rate is 22/min, blood pressure is 115/75 mm Hg, and temperature (axillary) is 99.2°F (37.3°C). On blow-by oxygen his oxyhemoglobin saturation (SpO₂) is 97%. The airway and lung exam are notable for transmitted high-pitched, inspiratory upper airway sounds heard centrally and diminished air entry heard over the axillary regions bilaterally. You don’t hear rales or wheezes. The heart sounds are normal with a regular rhythm. His pulses are brisk with warm extremities. Capillary refill in his fingers is <2 seconds. He is clinging to his mother and watching you carefully as you perform your exam. The skin and mucus membranes now appear pink with oxygen administration. No rashes are noted.

1D What is your categorization of the patient’s condition now?
1E What are your next decision and action steps?

1F Does a normal SpO₂ rule out respiratory failure? If not, why not?

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**Case Progression**

After helping the child’s mother administer oxygen by a high-flow device and 3 mL of racemic epinephrine, you reassess the patient. The child appears less distressed and is more interactive with his parents. His retractions have diminished, and there is better air entry in the distal lung fields with minimal inspiratory stridor. His SpO₂ rises to 99% to 100% while the heart rate decreases to 130/min.

1G What other conditions cause upper airway obstruction?

Based on the examination, the child has clearly improved, but he still requires careful observation. His symptoms may recur as the therapeutic effects of the epinephrine subside. If not already given, a dose of oral dexamethasone is appropriate in this setting.

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**Summary**

In summary, *upper airway obstruction* causes respiratory distress that is most apparent during inspiration. Remember that if endotracheal intubation is needed in a patient with respiratory failure due to upper airway obstruction that is thought to be at or below the vocal cords, an endotracheal tube smaller than the normally predicted size is appropriate secondary to anticipated narrowing of the airway. Other children with upper airway obstruction may improve with simple maneuvers to extend the head and move the jaw forward or with placement of a nasopharyngeal airway. See Chapter 3: Management of Respiratory Distress and Failure in the *PALS Provider Manual*.

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**Case 2**

**Introduction**

You are an advanced EMS provider called to the home of a 7-year-old with breathing difficulty. Her mother says the child has had a cold for the last 2 days with increasing coughing. She is now having trouble catching her breath.

**General Assessment**

You see a thin child who is sitting upright and using her accessory muscles. She appears worried and alertly watches you approach her.
She is working hard to breathe with increased inspiratory and expiratory effort. She appears to be forcing the air out during exhalation, which appears prolonged. Her color appears somewhat pale.

2A What is your initial impression of the child's condition based on your general assessment? Does the child need immediate intervention? If so, what intervention is indicated?

2B What is the significance of the prolonged, forced expiratory effort?

As you talk to the patient and ask questions, you note that she is unable to say more than one word at a time. She has marked intercostal and suprasternal retractions during inspiration with a forced, prolonged expiratory phase and occasional grunting. By auscultation, air entry is markedly decreased over her distal lung fields, and you hear high-pitched wheezing centrally throughout exhalation. Her heart rate is 144/min. Respiratory rate is 24/min. Her heart sounds are normal although they sound somewhat distant. Her pulses are weak distally.

You note that her radial pulse disappears and reappears in a somewhat rhythmic manner every few heart beats in association with her breathing; her pulse disappears during inspiration and reappears with exhalation. Her distal extremities are cool with capillary refill of approximately 2 seconds. She is alert with good muscle tone. No rash is noted. Her blood pressure is 126/78 mm Hg. The pulse oximeter is not consistently reading, but when it does show a value, the displayed SpO₂ is 84% to 88%.

2C What is your categorization of the child's condition based on the primary assessment? Based on your current impression, does the child need immediate intervention now? If so, what intervention is indicated?

2D What conditions are associated with wheezing and a prolonged, forced expiratory phase in infants and children?

2E What is the significance of the variability in radial pulse volume in this patient? Why does this variability occur?

While allowing the child to remain in the position most comfortable for her, you provide high-flow oxygen using a face mask and begin a...
nebulizer treatment with 2.5 mg of albuterol. In response to these interventions her SpO₂ increases to 95% to 98%. You place ECG leads for monitoring and reassess the child’s respiratory effort. You obtain additional history using the SAMPLE mnemonic.

<table>
<thead>
<tr>
<th>2F</th>
<th>What are the elements of the SAMPLE mnemonic? What specific history questions are you interested in knowing about this child?</th>
</tr>
</thead>
<tbody>
<tr>
<td>2G</td>
<td>What are your treatment priorities now?</td>
</tr>
</tbody>
</table>

**Case Conclusion**

You continue high-flow oxygen administration and repeat a nebulized albuterol treatment during transport to the emergency department. Reassessment shows that the child is breathing more easily with less effort. She is now able to answer questions using several words at a time.

| 2H | What other conditions cause lower airway obstruction? |

**Summary**

In summary, this child had acute, severe asthma requiring urgent therapy. She was at significant risk of deterioration in view of the clinical evidence for severe lower airway obstruction manifested by her inability to speak more than one word at a time and the significant pulsus paradoxus detected by simple palpation of her pulse. If respiratory failure develops, remember that effective bag-mask ventilation may require the use of a 2-person bag-mask ventilation approach: 1 rescuer performs a head tilt–chin lift and seals the mask to the face while the 2nd rescuer compresses the ventilation bag. Avoid rapid ventilation rates since air trapping and further impairment of cardiac output will occur with overventilation.

The treatment of lower airway obstruction from asthma typically consists of bronchodilator therapy (nebulized albuterol and ipratropium bromide and intravenous (IV) magnesium in severe cases) along with systemic corticosteroid therapy. When lower airway obstruction is caused by a viral infection (eg, RSV bronchiolitis), treatment is largely supportive with oxygen. Nebulized albuterol or epinephrine may be helpful. The role of steroids in bronchiolitis remains controversial.

In more severe cases of asthma or bronchiolitis, positive airway pressure support in the form of CPAP in infants or BiPAP in children may be helpful and may reduce the need for mechanical ventilation. For more information on these treatments, see Chapter 3: Management of Respiratory Distress and Failure in the *PALS Provider Manual* and Pharmacology on the student CD.
### Case 3

#### Introduction
You are examining a 2-year-old patient who was brought to the ED by EMS providers. They report that the child demonstrated increasing respiratory distress. The child was previously well and was found at home with a bottle of lamp oil that he had apparently opened. The mother called EMS immediately when she noted that the toddler was “breathing funny” and appeared in distress. While receiving high-flow oxygen by face mask, his $\text{SpO}_2$ during transport and on ED arrival was in the mid to high 80s.

#### General Assessment
You see a tachypneic, anxious toddler who is sitting up and grunting with nasal flaring and signs of increased respiratory effort, specifically intercostal and suprasternal retractions. His color appears normal. He is alert and watching you anxiously.

<table>
<thead>
<tr>
<th>3A</th>
<th>What is your initial impression of the child’s condition based on your general assessment? Does the child need immediate intervention? If so, what intervention is indicated?</th>
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<tbody>
<tr>
<td>3B</td>
<td>What is the significance of the child’s grunting?</td>
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</table>

#### Primary Assessment
He is placed on a cardiac monitor and pulse oximeter. His heart rate is 145/min, respirations are 50/min, blood pressure is 115/75 mm Hg, and temperature is 97.8°F (36.5 °C) axillary. His $\text{SpO}_2$ is 85% on high-flow oxygen. On auscultation you hear moist crackles throughout his lung fields with decreased air entry over his axillary lung fields; there are coarse breath sounds centrally. He has good distal perfusion with readily palpable pulses and brisk capillary refill.

<table>
<thead>
<tr>
<th>3C</th>
<th>How would you categorize this child’s condition?</th>
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<tbody>
<tr>
<td>3D</td>
<td>What are your initial decisions and actions?</td>
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<tr>
<td>3E</td>
<td>What conditions are associated with the signs and symptoms seen in this child?</td>
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</table>

In view of his marked distress, poor response to oxygen, and the fact that his symptoms are severe so early after the aspiration event, the child’s respiratory condition is likely to worsen. As a result he will need to be electively intubated.
While the equipment is being gathered for intubation and mechanical ventilation, you obtain a SAMPLE history, learning that he rapidly developed breathing symptoms after being found with the lamp oil bottle. Other than the signs noted in the primary assessment, there are no other relevant findings when examining his skin, abdomen, back, or neck. You note that his jaw and mouth appear normal. He has no allergies. He is not receiving any medications, and his past medical history is unremarkable. He last ate about 2 hours before this event. You do learn a few more details about the event. The toddler’s father was refilling several lamps in the garage and left the bottle of lamp oil on the garage floor. The child has no history of other ingestions or unexplained injuries.

<table>
<thead>
<tr>
<th>3F</th>
<th>What equipment do you need to gather in preparation for intubation? Does the likelihood of lung tissue disease change your thoughts about the intubation equipment needed?</th>
</tr>
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<tbody>
<tr>
<td>3G</td>
<td>What is the significance of the time he last ate?</td>
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<tr>
<td>3H</td>
<td>In addition to gathering equipment, what other preintubation activity should you consider?</td>
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</tbody>
</table>

The child is intubated with a 4.5 mm cuffed endotracheal tube. Tube position is confirmed. You provide mechanical ventilation with 100% oxygen and a PEEP of 6 cm H$_2$O. A nasogastric tube is inserted to decompress his stomach. The SpO$_2$ initially was 91%, and following an increase in the PEEP to 10 cm H$_2$O, it improved to 100%. You hear equal breath sounds with bilateral moist crackles but improved air entry over the lateral lung fields. Heart rate is 160/min with blood pressure of 118/78 mm Hg. Pulses remain strong distally with good capillary refill. The child is not moving because a neuromuscular blocking agent was used to facilitate intubation.

| 3I | What tertiary assessment studies are appropriate now?                                                                                   |

A chest x-ray is obtained, but immediately after the x-ray plate is removed from under the child, his SpO$_2$ and heart rate suddenly fall.

| 3J | What do you think happened? How would you manage this situation?                                                                     |
Following appropriate intervention, tube position is reconfirmed by clinical examination and capnography. An arterial blood gas is obtained with the following results on 100% oxygen: pH 7.32, $\text{PCO}_2$ 52, $\text{PO}_2$ 95, base deficit – 0.5.

He is transferred to the pediatric intensive care unit with capnography and pulse oximetry monitoring during transport.

This child had acute lung tissue disease secondary to airway and alveolar injury associated with aspiration of lamp oil into the lungs and resulting lung inflammation. The important point in this case is that when severe, this type of injury is likely to require more therapy than oxygen administration alone. Effective therapy often requires mechanical ventilation with the use of positive end-expiratory pressure. Good teamwork is essential to successful intubation and optimal patient outcome.

An 11-year-old boy is in the intermediate care unit pending surgical resection of a newly diagnosed brain tumor in the morning. He presented to the emergency department earlier today with vomiting and double vision. A CT scan revealed the diagnosis. He was treated with steroids and admitted to the hospital and was clinically improved several hours later. You are called to his room the night before surgery because his mother is concerned that the boy is demonstrating what she describes as “funny breathing.”

You see a somnolent adolescent who has his eyes closed and does not respond as you enter the room. His breathing is characterized by periods of several slow, deep breaths followed by pauses. His color appears pale.

What is your initial impression based on your general assessment?

Does the child require immediate intervention? If so, what intervention is appropriate at this time?

You note that the patient intermittently makes an inspiratory effort, but there does not appear to be air movement with these efforts. He has
suprasternal retractions. His heart rate is irregular and averages around 60/min. His respiratory rate is around 12/min but is irregular as noted. You hear intermittent transmitted upper airway inspiratory snoring sounds. His lung sounds are otherwise unremarkable. His radial pulse is readily palpable. Capillary refill is brisk. Heart sounds are normal. You firmly pinch his finger, which results in grimacing and rigid extension of his arms and legs. His pupils are 4 to 5 mm in diameter and appear to be sluggishly reactive to a bright light. Blood pressure is 135/90 mm Hg. A pulse oximeter reveals an SpO₂ that fluctuates between 88% and 98% on room air.

| 4C | How would you categorize this child’s condition? |
| 4D | What decisions and actions are appropriate at this time? |

In response to bag-mask ventilation with 100% oxygen, the patient begins to resist intervention and reaches up to push away your hands holding the mask to his face. His SpO₂ is 100%.

| 4E | Should you stop providing bag-mask ventilation? Should you intubate this patient? |
| 4F | If you decide to intubate, what are important considerations in planning to intubate this child? |

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**Case Progression**

The child receives bag-mask ventilation, and his SpO₂ is 100% by pulse oximetry. The most experienced healthcare provider successfully intubates the child's trachea with a 6.5 mm cuffed tracheal tube using a rapid sequence technique.

| 4G | What are the next appropriate steps? |

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**Case Progression**

Tube position in the trachea is confirmed by clinical examination and detection of exhaled CO₂. The child's heart rate is 88/min and blood pressure is 110/65 mm Hg following endotracheal intubation and mild hyperventilation. A chest x-ray is ordered to confirm depth of tube insertion. He is ventilated at 20 breaths per minute. A post-intubation arterial blood gas shows: pH 7.49, PCO₂ 30, PO₂ 589, base excess + 0.2. End-tidal CO₂ by capnography is 28 mm Hg.

A more detailed history is obtained. He was doing well during the evening until he got sleepy. His breathing changed while he slept (sign). He has no allergies. His only medications are dexamethasone...
and ranitidine. His past medical history was unremarkable. His last meal was lunch (more than 6 hours ago). There are no additional relevant details about this most recent breathing event. The mother did not observe any seizure activity prior to the change in breathing.

Case
Conclusion

The child is transported to the CT scanner with continuous ECG, exhaled CO₂, and pulse oximetry monitoring. His CT scan shows new bleeding in his tumor with increased edema surrounding the tumor. He is rapidly transported to the operating room for tumor resection.

This child had respiratory failure secondary to disordered control of breathing. In general, treatment of this condition requires immediate bag-mask support of oxygenation and ventilation followed by endotracheal intubation and mechanical ventilation.

| 4H | In addition to increased intracranial pressure, what other conditions can cause disordered control of breathing? |
Case 5

Introduction
You enter the room of a 3-month-old girl who was brought to the emergency department with a history of vomiting and diarrhea with poor PO intake.

General Assessment
You see an infant who appears listless. She is lying on the bed and does not respond to her parents. She is breathing rapidly without retractions or respiratory distress. Her color appears mottled.

5A What is your initial impression of the child's condition based on your general assessment?
5B Does this infant require immediate intervention? If so, what intervention is indicated?

Primary Assessment
You administer high-flow oxygen and proceed with your primary assessment. The child's heart rate is 210/min, respiratory rate is 50/min, blood pressure is 60/43 mm Hg, and axillary temperature is 97°F (36.1°C). The pulse oximeter is not picking up the pulse consistently—when a reading is obtained it is 99% to 100%. You palpate weak brachial and femoral pulses, but you cannot palpate distal pulses. Heart sounds are normal. The extremities are cool and mottled below the elbows and knees. Capillary refill time in the foot is >5 seconds. Auscultation reveals clear lungs with good distal air entry bilaterally. During the exam the child moans occasionally but otherwise has little response to verbal or painful stimulation.

5C How would you categorize this infant's condition? Is the infant hypotensive?
5D What decisions and actions are appropriate at this time?
5E What is the definition of shock?
5F What elements of the secondary assessment would you like to know?

Your colleagues try to establish vascular access while you obtain additional history information. The infant's parents report her signs and
symptoms: she has had “nearly continuous vomiting and diarrhea” during the previous 8 hours. They are uncertain if she has urinated during this time because her diapers have been filled with watery diarrhea. She has no allergies and is not receiving any medications. Her past medical history is unremarkable. She took an ounce of fluid about an hour ago (last meal). Events leading to the presentation are as follows: The infant was well until yesterday when she initially started having episodes of vomiting and then a few hours later began having watery diarrhea. Her vomiting is better, but she is not taking clear liquids well and her diarrhea is worse today. There is no history of fever, and no one else in the family is ill.

The infant has reduced skin turgor without skin rash except for erythema of the diaper area. The abdomen is soft with the liver at the costal margin. Her fontanel is sunken.

Initial attempts at establishing IV access are unsuccessful.

<table>
<thead>
<tr>
<th>5G</th>
<th>What would you do now?</th>
</tr>
</thead>
<tbody>
<tr>
<td>5H</td>
<td>After vascular access is obtained, what fluid and how much would you give? How quickly should you administer the fluid bolus? What bedside laboratory test is critically important?</td>
</tr>
</tbody>
</table>

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**Case Progression**

The bedside glucose is 40 mg/dL. You give an initial fluid bolus of isotonic crystalloid (20 mL/kg over about 10 minutes) and a bolus of 25% dextrose (0.5 gm/kg). You reassess the infant: heart rate is 195/min to 200/min, respiratory rate remains at 50/min, blood pressure is 66/42 mm Hg, and pulse oximetry reveals an SpO₂ of 100%. The infant appears a bit more responsive, but the distal pulses are still not palpable. Capillary refill remains prolonged.

<table>
<thead>
<tr>
<th>5I</th>
<th>What are your decisions and actions now?</th>
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<tbody>
<tr>
<td>5J</td>
<td>What additional tertiary studies would you like to obtain?</td>
</tr>
</tbody>
</table>

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**Case Progression**

The infant receives additional fluid. The infant appears more responsive after the subsequent fluid with heart rate down to 180/min. Distal pulses are now palpable. The pulse oximeter currently shows a consistent waveform on the monitor. A catheter is inserted into the bladder, and 30 mL of dark yellow urine is obtained. The infants’ initial laboratory studies were as follows: sodium 136 mEq/L, potassium 3.9 mEq/L, chloride 110 mEq/L, total CO₂ 11 mEq/L, BUN 29 mg/dL, creatinine 0.9 mg/dL, and lactate is 4.4 mmol/L. White blood cell count is 7,600/mm³ with a normal differential, hemoglobin is 10.9 g%,
hematocrit is 32.5%, and platelet count is 335,000/ mm³. Repeat rapid bedside glucose is 50 mg/dL.

<table>
<thead>
<tr>
<th>5K</th>
<th>How does the laboratory data and urine output help you categorize this infant’s condition?</th>
</tr>
</thead>
<tbody>
<tr>
<td>5L</td>
<td>What are your decisions and actions now?</td>
</tr>
</tbody>
</table>

Case Conclusion

The infant is placed on IV replacement and maintenance fluids of dextrose in normal saline with 20 mEq/L of potassium chloride. She is now much more vigorous with palpable distal pulses, so she is admitted to the pediatric ward for further therapy. This infant demonstrated the clinical history and signs of hypovolemic shock, the most common type of shock in infants and children. The clinical signs are tachycardia, quiet tachypnea, a narrow pulse pressure with cool extremities, prolonged capillary refill, and weak distal pulses. Changes in level of consciousness depend on the severity of hypovolemia. Depressed level of consciousness is a relatively late manifestation of hypovolemic shock because in infants and children intense vasoconstriction may initially maintain perfusion to the brain and heart.

Case 6

Introduction

A mother brings her 4-year-old girl to the pediatrician’s office. The child has a history of increasing lethargy, fever, and “dizziness” when she tries to stand up. There is no history of vomiting or diarrhea. Her intake has been poor over the last 12 hours. Typical chickenpox lesions developed 5 days ago. Over the last 18 hours several lesions on her abdomen have become red, tender, and swollen.

General Assessment

As you enter the room to obtain the child’s vital signs, you note that the child is lying supine and appears listless. She is breathing rapidly and quietly. Her skin is mottled.

| 6A | What is your initial impression of the child’s condition based on your general assessment? Does the child need immediate intervention? If so, what intervention is indicated? |
After calling for help and administering high-flow oxygen, you begin to obtain vital signs and attach a pulse oximeter and cardiac monitor. You note that the child is confused. She responds to your voice and tries to answer questions, but she does not know where she is and does not seem to understand what people are saying.

Her heart rate is 165/min, respiratory rate is 60/min, rectal temperature is 39.4°C (103°F), and blood pressure is 90/30 mm Hg. Auscultation reveals clear lungs with good distal air entry. You hear a regular, rapid heart beat with a short systolic ejection murmur. Extremities are warm and bright red; central pulses are full and bounding; and peripheral pulses are palpable but feel thready. The skin is warm to mid forearms and mid calves. Capillary refill is about 2 seconds. The skin lesions on her abdomen are bright red and tender. Pulse oximetry shows an SpO₂ of 100% while the child is receiving the high-flow oxygen.

<table>
<thead>
<tr>
<th>6B</th>
<th>How do you categorize the child’s condition? What decisions and actions are indicated now?</th>
</tr>
</thead>
<tbody>
<tr>
<td>6C</td>
<td>What is the significance of the pulse pressure and the elevated respiratory rate?</td>
</tr>
<tr>
<td>6D</td>
<td>What other conditions result in a wide pulse pressure?</td>
</tr>
<tr>
<td>6E</td>
<td>What additional assessment studies are indicated?</td>
</tr>
</tbody>
</table>

After vascular access is obtained, you administer an isotonic crystalloid fluid bolus (20 mL/kg). Your repeat assessment reveals a heart rate of 155/min, respiratory rate is still approximately 60/min, and blood pressure is 85/30 mm Hg. You can still palpate weak distal pulses with capillary refill <2 seconds. The skin is now warm to the child’s wrists and ankles. A targeted history reveals the following:

- Her mother reports that the child’s dizziness started about an hour ago (signs and symptoms).
- There is no history of allergies.
- She received acetaminophen for fever and is not receiving other medications.
- The child was healthy up until this recent illness with chickenpox (past medical history and events leading to presentation).

| 6F  | What would you do now?                                                                    |
You begin to administer a second isotonic crystalloid bolus. You perform a bedside glucose test in the office that reveals a glucose concentration of 140 mg/dL. EMS providers arrive and transport the child to the emergency department of the nearest healthcare facility. In response to the second fluid bolus, the child becomes more alert. In the emergency department blood cultures are obtained, and IV antibiotics are given along with another 20 mL/kg bolus of normal saline (total of 60 mL/kg normal saline administered in an hour).

Despite the fluid boluses the child’s condition deteriorates. She becomes unresponsive to voice and barely responsive to painful stimulation. Her distal pulses are no longer palpable. Her extremities are cold. Her heart rate ranges from 170/min to 180/min, and her blood pressure decreases to 70/25 mm Hg. She remains tachypneic on a nonrebreathing oxygen mask. Her lung fields are clear, but pulse oximetry is not picking up her pulse accurately.

**Questions 6H through 6K and responses are intended for advanced providers.**

<table>
<thead>
<tr>
<th>Question</th>
<th>Response</th>
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<tbody>
<tr>
<td><strong>6H</strong></td>
<td>Why is she deteriorating despite fluid administration?</td>
</tr>
<tr>
<td><strong>6I</strong></td>
<td>When would you add vasoactive drug support?</td>
</tr>
<tr>
<td><strong>6J</strong></td>
<td>What are the indications for giving “stress-dose” corticosteroids?</td>
</tr>
<tr>
<td><strong>6K</strong></td>
<td>When would you intubate this child and provide mechanical ventilation? Are there any special risks of the intubation procedure in this patient?</td>
</tr>
</tbody>
</table>

A central line is placed and vasoactive drug support is initiated. The child’s blood pressure improves to 90/36 mm Hg with better distal perfusion. An arterial catheter is also placed for continuous blood pressure monitoring. She is receiving 40% oxygen by face mask. An arterial blood gas shows the following: pH 7.37, Pco₂ 32, Po₂ 245, base deficit – 5.5; a venous blood gas from the central venous cannula had a Po₂ of 42 mm Hg with oxygen saturation of 78%. Lactate was 3.3 mmol/L. The laboratory values show that oxygen extraction by the tissues is normal to reduced, which is typical in septic shock patients with adequate fluid resuscitation. For more information on the interpretation of venous oxygen saturation and lactate, see Chapter 5:

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<thead>
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<tbody>
<tr>
<td><strong>6L</strong></td>
<td>Can you give vasoactive drugs through a peripheral IV catheter?</td>
</tr>
<tr>
<td><strong>6M</strong></td>
<td>In addition to sepsis, what are other causes of distributive shock?</td>
</tr>
</tbody>
</table>

**Summary**

This child had septic shock complicating varicella (chickenpox) infection. This is commonly caused by streptococci or staphylococci. The clinical course may be complicated by the toxin release from these organisms, leading to a greater risk of hemodynamic instability and organ injury. The key to successful outcome from septic shock is early recognition and aggressive early fluid resuscitation (typically 60 to 80 mL/kg in the first hour and 240 mL/kg in the first 8 hours of therapy in children with shock) with frequent reassessment. Early activation of the EMS system and transfer of the patient to a center with expertise in the management of pediatric septic shock are also important.

**Case 7**

**Introduction**

A 3-month-old girl is brought to the emergency department because of poor feeding and listless behavior that has worsened over the past hours. She had a several-day history of vomiting and watery diarrhea, but those symptoms had resolved yesterday. Despite the improved diarrhea and no vomiting, she is still not taking liquids well.

**General Assessment**

As you enter the room you note that the infant appears listless. She is breathing rapidly with increased effort as exhibited by mild to moderate retractions. Her color appears mottled.

| **7A** | What is your initial impression of the infant’s condition based on your general assessment? Are any interventions indicated to treat a life-threatening condition? If so, what are the interventions? |

**Primary Assessment**

After calling for help, you provide high-flow oxygen and attach her to the monitor and pulse oximeter. Her heart rate is 210/min with a regular rhythm, respiratory rate is 50/min, blood pressure is 55/40 mm
Hg, and axillary temperature is 97°F (36.1°C). On examination the infant has little response to verbal or painful stimulation. There is increased respiratory effort with mild to moderate retractions. Auscultation reveals reduced distal air entry and scattered inspiratory moist crackles at both lung bases. The cardiac rhythm is rapid and regular without identifiable murmur, but heart sounds are difficult to hear secondary to her breathing noises and rapid heart rate. Her brachial and femoral pulses are weakly palpable, but the distal pulses are not palpable. The extremities are cool and mottled below the elbows and knees. Capillary refill time in the foot is >6 seconds. The skin is mottled without rash.

7B How would you categorize the infant’s condition now?
7C What are your decision and actions now?

---

**Case Progression**

After obtaining vascular access and administering a fluid bolus of isotonic crystalloid, you repeat your examination and obtain a focused history:

- Her most recent illness began with vomiting and diarrhea (signs).
- She was a term newborn and had done well until the present illness.
- She has no allergies, is not on any medications.
- Her past medical history is otherwise unremarkable.
- The vomiting lasted about 1 day, and then she had 5 to 6 loose bowel movements a day. She was wetting her diaper well until the last 24 hours, when her parents noted that she was more fussy and irritable and would not take her bottle well. Her older brother also had gastroenteritis symptoms last week, and he is now recovered (event).

After the fluid bolus the infant appears to have an increased work of breathing with grunting respirations. Moist crackles remain bilaterally. Auscultation of the heart is unchanged. Her heart rate fluctuates between 200/min and 210/min. Respiratory rate ranges from 50/min to 60/min. Blood pressure is 60/45 mm Hg with no improvement in her pulses. Pulse oximeter is reading intermittently with displayed SpO₂ of 92% to 95% on 100% high-flow oxygen. The infant’s liver is firm and palpable 3 cm below the costal margin. A bedside glucose test is 80 mg%.

7D What do you think is happening? Why is there no improvement after the fluid bolus?
7E What are your decisions and actions now?
What laboratory and radiographic studies (tertiary assessment) would be helpful now?

Following appropriate interventions, a colleague places a femoral venous line. Laboratory studies were sent. The venous blood gas was pH 7.25, PCO₂ 39, PO₂ 23, HCO₃⁻ 13, base deficit – 10.5, oxygen saturation 44%. Venous lactate is 7.5 mmol/L.

The white blood cell count, platelet count, and hemoglobin are all unremarkable. Sodium is 135 mEq/L, potassium 4.4 mEq/L, chloride 97 mEq/L, total CO₂ 12 mEq/L, BUN 23 mg/dL, and creatinine 1.1 mg/dL. A chest x-ray shows bilateral diffuse alveolar infiltrates with an increased cardiac silhouette size. An ECG shows a narrow-complex tachycardia with small QRS complexes across all the limb leads.

How do you interpret the laboratory data?

In view of the laboratory findings, the patient is started on milrinone (a loading dose followed by a continuous infusion). (Note: The approach to vasoactive drug support is complex, and you should seek consultation. Sometimes catecholamine support with agents such as dobutamine may be indicated. But in general, a vasodilator is preferred in this setting if blood pressure is adequate. See Chapter 5: Management of Shock and Chapter 8: Postresuscitation Management in the PALS Provider Manual for more information on the management of cardiogenic shock).

An esophageal temperature was 39.9°C whereas the rectal temperature was only 37.5°C. A nasogastric tube is placed, and 50 mL of iced saline is instilled and then removed every 5 minutes to reduce core temperature. To eliminate the work of breathing, you provide mechanical ventilation with sedation. An arterial line is placed for monitoring blood pressure and obtaining blood samples for repeat laboratory studies. The infant’s distal pulses are now palpable with blood pressure of 75/45 mm Hg and heart rate of 175/min. To improve oxygenation, the PEEP is set to 7 cm H₂O.

This case illustrates the clinical manifestations of cardiogenic shock. Initial presentation in some infants and children may be consistent with hypovolemic or septic shock. The presence of grunting in a child with poor perfusion suggests the presence of pulmonary edema and is most consistent with cardiogenic rather than hypovolemic or septic
shock. Cardiogenic shock is characterized by marked tachycardia and tachypnea with increased work of breathing. The presence of moist crackles along with marked tachycardia, poor perfusion, and increased size of the liver are typical findings in patients with cardiogenic shock.

The treatment approach for cardiogenic shock is focused on interventions that increase tissue perfusion and reduce metabolic demand. Thus attention to temperature control and reducing the work of breathing are important.

Note that cardiogenic pulmonary edema results in a clinical picture of lung tissue disease requiring the same approach to intervention as when there is a primary respiratory process. Mechanical ventilation with increased PEEP is often needed following intubation to reopen collapsed alveoli and maintain adequate oxygenation and ventilation.

For more detailed management information see Chapter 5: Management of Shock in the PALS Provider Manual.

Case 8

Introduction

Note that the elements of this case are advanced, but the case illustrates one of the causes of shock in children. All PALS providers are encouraged to review the general and primary assessment in this case and the review of “Causes and Presentation of Shock” review at the end of the answers to this case.

You are called to see a 15-year-old patient on the pediatric ward who has developed acute onset of respiratory distress and chest pain. He was admitted 3 days earlier after being struck by a car. His injuries include a fracture of his left femur and multiple contusions and abrasions. His femur fracture was stabilized with external fixation. He was doing well on the ward until he complained of shortness of breath.

General Assessment

As you enter the room you see an adolescent who appears anxious. He has obvious tachypnea and appears diaphoretic. He is alert with mottled skin color.

| 8A | What is your initial impression of the child's condition based on your general assessment? Are any interventions required at this time? If so, what are they? |
Primary Assessment

His respiratory rate is 32/min with somewhat deep respirations and mild retractions. Heart rate is 135/min with thready distal pulses and weak central pulses. You attach a cardiac monitor, which displays a regular sinus rhythm with no arrhythmias. His blood pressure is 88/62 mm Hg by automated cuff. Temperature is 37.7°C, and pulse oximetry shows an SpO₂ of 92% on room air. There are scattered wheezes and a few moist crackles noted with a rapid regular rhythm. His skin is cool and clammy without rash. He is alert and obviously anxious; he answers questions appropriately and tells you that he does not feel well.

8B How do you categorize this patient’s condition? What do you think is causing this patient’s respiratory distress?

8C What are your decisions and actions now?

Case Progression

In response to high-flow oxygen administration by a nonrebreathing mask (nearly 100% oxygen), the patient remains in distress and anxious. His SpO₂ increases to 98%, and heart rate is 130/min. Respiratory rate remains increased at approximately 30/min. After he receives 10 mL/kg of normal saline IV, his blood pressure is 90/65 mm Hg with weak but improved distal pulses. He tells you the following when you ask him for more details about not feeling well:

- He says he feels as if he can’t breathe but has no pain with breathing; he says he feels scared (signs and symptoms).
- He is not allergic to any medications.
- He is receiving codeine and acetaminophen for pain (medications).
- The rest of his past medical history is unremarkable.
- He ate lunch about an hour ago.
- He reports that the onset of respiratory distress was sudden and that he had been breathing OK prior to this event.

His abdomen is soft with his liver about 1 cm below the right costal margin. His neck veins appear somewhat distended.

8D What would you do now? What laboratory and nonlaboratory studies would help you determine the cause of this patient’s condition and necessary treatment?

8E What conditions may cause this type of shock?

Case Progression

An arterial blood gas obtained while the patient is receiving 100% high-flow oxygen by nonrebreathing mask shows: pH 7.37, PCO₂ 34,
PO₂ 277, base deficit – 5.8, bicarbonate 17.5 mmol/L, lactate 3.2 mmol/L. Glucose is 178 mg/dL. His WBC count is 11,600 with a normal differential, hemoglobin is 12.2 g/dL, and platelet count is 233,000/mm³. A chest x-ray shows a hazy infiltrate in the right lower lobe area; heart size appears mildly enlarged. In response to a second fluid bolus, his perfusion is better. An echocardiogram shows a distended right ventricle and an underfilled left ventricle with increased left ventricular contractility.

The child’s diagnosis of a pulmonary embolism is confirmed by a high resolution CT scan. Treatment consists of heparin administration since he is not hemodynamically unstable after his fluid resuscitation.
Cardiac Cases

Case 9

Introduction
You are a paramedic and arrive with your partner at the home of a 6-year-old who suddenly collapsed. The mother is performing CPR as you enter the home.

General Assessment
You see a lifeless child who is small for his age lying on the floor in the living room. His mother is performing chest compressions, and his brother, who let you into the house, is crying. The child is not responding to the chest compressions and is flaccid with mottled skin color.

9A What are your initial decisions and actions?

Case Progression
You confirm that the child is in cardiac arrest. You and your partner take over CPR from the mother. You give 2 breaths but have difficulty achieving chest rise. While your partner is performing a series of compressions, you turn on and attach the AED using a pediatric dose-attenuator system (child pads). You ask the mother what happened. The mother reports that her son had a kidney transplant 4 years ago. But his transplant kidney has been failing, and he is on the transplant list again. He had not felt well for the past few days and missed his dialysis treatment 2 days ago. He is scheduled to go in for dialysis today. She says his last weight was 20 kg.

The following rhythm is seen on the monitor:

9B What is the rhythm? What would you do now?

9C When you provide CPR, what compression-ventilation ratio are you providing?

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| 9D | How can you or your partner improve ventilation during CPR? |
| 9E | What is the significance of the history? |
| 9F | Why is a primary assessment not performed in this case progression? |

---

**Case Progression**

You give a shock and then restart CPR. After about one minute your partner attempts endotracheal intubation with a 5 mm endotracheal tube. You listen and can hear breath sounds over both lungs and do not hear breath sounds over the abdomen. At this time another EMS team arrives to assist.

| 9G | How else should you confirm endotracheal tube placement? |
| 9H | When would you give a drug to this child? |
| 9I | What drug would you use first? |
| 9J | What would you ask the new team members to do? |

---

**Case Progression**

A colorimetric exhaled CO₂ detector is attached, but there is no color change after 6 ventilations while you are providing chest compressions. It is now about 2 minutes after you gave the first shock. You look at the rhythm and it is unchanged from before.

| 9K | Would you remove the endotracheal tube? If not, why not? |
| 9L | What should you do now? If you were using a manual defibrillator rather than an AED, what shock energy dose would you use for the second and subsequent shocks? |

---

**Case Progression**

After giving a shock you resume CPR (beginning with compressions). Your colleagues have achieved IO access, and epinephrine is delivered during compressions. You continue compressions and ventilation for about 2 minutes. During CPR a member of the new team obtains the following information:

- The onset of the collapse was sudden and unexpected; the patient had complained of not feeling well for several days and had not been taking his medications because of nausea (signs and symptoms).
- He is reportedly allergic to morphine with a rash.
- He is taking a blood pressure medicine (amlodipine), calcitriol (vitamin D formulation), an antacid to bind phosphate, and
cyclosporine (immunosuppressant).

- The mother reports that her son had a kidney transplant because of a congenital blockage of his urethra leading to chronic kidney failure (past medical history).
- She reports that he ate a small breakfast about 2 hours ago (last meal).
- She said that when her son collapsed, he simply slumped over while sitting on the sofa (events leading to presentation).

After about 2 minutes of CPR following the second shock, the AED prompts you to check the rhythm. The following is seen on the monitor:

9M What should you do now?

9N How does the focused SAMPLE history help you?

---

**Case Progression**

The patient now has a perfusing rhythm. Exhaled CO₂ is observed by the colorimetric detector after you transfer the patient into the ambulance. You ventilate him at a rate of about 15 breaths per minute and closely monitor his pulse during transfer to the emergency department. During transport you note that he has weak central pulses and barely palpable peripheral pulses. His IO remains in place. You insert another IV into his right arm, noting that he has a shunt fistula for dialysis in his left upper arm.

9O What tertiary assessments would you obtain on this child after ED arrival?

---

**Case Progression**

His laboratory studies are notable for the following: pH 7.28, Pco₂ 32, Po₂ 427, base deficit – 13 on 100% oxygen. Electrolytes are sodium 135 mEq/L, potassium 6.9 mEq/L, chloride 97 mEq/L, bicarbonate 12 mEq/L, glucose 165 mg/dL, BUN 65 mg/dL, and creatinine 5.6 mg/dL. Phosphorus is 7.8 mmol/L, and magnesium is 2.3 mg/dL. His hemoglobin is 7.8 g/dL.
What would you do based on these laboratory data?

What are the potentially reversible conditions that can cause failure to respond to CPR?

If this child had failed to respond to the second shock, what medication would you have given? What energy dose would you have used for subsequent shocks?

---

The child receives a dose of calcium and a dose of sodium bicarbonate, then an infusion of glucose and insulin. The dialysis team is called to initiate dialysis. An arterial catheter is inserted for continuous blood pressure monitoring. He is transported to the pediatric ICU for subsequent care, where his temperature is closely monitored and his blood pressure and perfusion continue to improve. He wakes up about 2 hours after PICU admission and responds appropriately to questions.

This child had hyperkalemia-induced sudden ventricular fibrillation (VF). In children an underlying cause for VF is more likely than the sudden coronary ischemic events that cause sudden cardiac arrest in adults. The underlying causes can range from chronic cardiomyopathy and acute myocarditis to toxin or metabolic induced causes. VF may also develop during resuscitation of cardiac arrest, particularly in the in-hospital setting, where frequent administration of epinephrine may contribute to the development of VF.

In addition, it is likely that many of the hospitalized children who develop VF during a resuscitation have a predisposition to do so based on underlying heart disease. The important point is that healthcare providers should always think about possible reversible conditions that may require specific treatment in order to achieve successful outcome.

---

Case 10

Introduction

An ALS (paramedic) EMT service brings an 18-month-old child to the emergency department with CPR being performed. The child was found in the backyard pool after being out of sight "for just a few minutes." When the EMTs arrived, he appeared lifeless. After they delivered 2 breaths, they could not palpate a pulse, so they provided cycles of chest compressions with bag-mask ventilation. The paramedics placed an endotracheal tube, obtained IO access, and
gave a dose of epinephrine.

**General Assessment**

On arrival you see a flaccid, pale toddler with an oral endotracheal tube; chest compressions are being performed. A monitor is attached, and you can see only CPR artifact.

<table>
<thead>
<tr>
<th>10A</th>
<th>What are your assessment and treatment priorities at this time?</th>
</tr>
</thead>
<tbody>
<tr>
<td>10B</td>
<td>What medication would you give this child if cardiac arrest is confirmed?</td>
</tr>
</tbody>
</table>

**Case Progression**

When you look at the monitor, you see the rhythm below. No pulses are detected with this rhythm. An exhaled CO$_2$ monitoring device is attached to the endotracheal tube and fails to detect exhaled CO$_2$. Chest compressions are resumed. You use a laryngoscope to examine the airway, finding that the endotracheal tube is in the esophagus.

<table>
<thead>
<tr>
<th>10C</th>
<th>What are your treatment priorities now?</th>
</tr>
</thead>
<tbody>
<tr>
<td>10D</td>
<td>How should you coordinate compressions and ventilations once the endotracheal tube is correctly placed?</td>
</tr>
<tr>
<td>10E</td>
<td>What medications are indicated in the treatment of this child?</td>
</tr>
</tbody>
</table>

**Case Progression**

The child’s endotracheal tube is placed with position confirmed by the presence of exhaled CO$_2$ indicated by a slight color change in the colorimetric CO$_2$ detector. CPR is continued and a dose of epinephrine is given. The parents arrive at the emergency department and the mother wants to come in to see her son.
Case Progression

The child has return of an organized rhythm about 1 minute after a dose of epinephrine, but pulses are difficult to palpate. His central pulses are barely palpable. His temperature is 35.5°C rectally. Heart rate is now about 80/min. There is no respiratory effort, and blood pressure is 88/65 mm Hg by automated blood pressure device. His bedside glucose is 185 mg/dL. Arterial blood gas results are as follows: pH 7.07, PaCO₂ 33, PaO₂ 135 (on 100% oxygen), base deficit – 18, lactate 8.8 mmol/L.

Sodium 136 mEq/L, potassium 4.7 mEq/L, chloride 101 mEq/L, total CO₂ 9 mEq/L, BUN 11 mg/dL, creatinine 0.6 mg/dL. WBC is 18,300/mm³, hemoglobin 12.8 mg/dL, platelets 321,000/mm³.

A focused history reveals the following:

• The child was found lifeless in a pool (sign).
• The child has no known allergies.
• He is not on any medications.
• He was full term and had been healthy with no medical problems (past medical history).
• He last ate about 3 hours ago.
• His parents thought that he was playing in the family room when the mom discovered the door to the pool was open. She thinks he was out of her sight for not more than 10 minutes (events leading to presentation).

| 10 F | Would you let the mother enter the resuscitation room? |
| 10G | What information do you want from the family? |
| 10H | What secondary and tertiary assessment data would you like to obtain now? |
| 10I | When would you use high-dose epinephrine? |
| 10J | How do you interpret the laboratory results? |
| 10K | Why do you think the child is poorly perfused? Do you trust the blood pressure readings obtained by the automated blood pressure device? How would you treat this child in view of his current findings? |
| 10L | Would you rewarm this child? |
The child receives 5 mL/kg of normal saline over a few minutes and is started on an epinephrine infusion through the IO line. A second peripheral IV is inserted. In response to the epinephrine infusion at 0.15 μg/kg per minute, his heart rate increases to 125/min. His pulses are more readily palpable centrally with weak distal pulses now palpable. His neurologic examination shows pupils that are 5 mm and unreactive to light. He has no breathing and no response to suctioning of his endotracheal tube. There is also no response to noxious stimulation in the head and neck region. A chest x-ray shows bilateral streaky infiltrates with a normal heart size. The radiologist indicates that this appearance is consistent with aspiration. He is transported to the pediatric ICU after a report is given to the ICU nursing team and the ICU attending physician.

10M What are your postresuscitation priorities?

Case 11

Introduction

A 3-month-old is admitted to the hospital with a history of respiratory distress following a 2-day history of coldlike symptoms. He was on 2 L/min nasal oxygen with 96% to 99% SpO2 earlier today. But now you are called to evaluate him because his alarm has gone off several times for bradycardia with low oxygen saturations.

General Assessment

As you enter the room, you see the nurse applying a blood pressure cuff to a vigorous, pink, tachypneic infant who is crying loudly. You note that the nasal cannula is in place and the pulse oximeter displays 98%.

11A What is your initial impression of this infant's condition based on your general assessment?

11B What are your decisions and actions now?

Primary Assessment

You hear bilateral air movement with diffuse moist crackles and scattered wheezes. Distal air entry is decreased. He has a rapid, regular heart rhythm with a soft systolic ejection murmur. Distal pulses are 2+ with brisk capillary refill. Heart rate is 178/min, respiratory rate is 60/min, blood pressure is 98/60 mm Hg, temperature is 37.7°C (axillary), and SpO2 is 97% to 99%. He is vigorous with good muscle tone and seems appropriately responsive during your examination. His
skin is pink, warm, and dry. Anterior fontanel is soft.

<table>
<thead>
<tr>
<th>11C</th>
<th>How do you categorize the infant’s condition now?</th>
</tr>
</thead>
<tbody>
<tr>
<td>11D</td>
<td>What are your actions now?</td>
</tr>
</tbody>
</table>

Secondary Assessment

Your SAMPLE history reveals the following:

- The infant started to have nasal congestion 2 days ago. Last night he was taking oral fluids poorly. This morning he was admitted to the ward with a diagnosis of respiratory syncytial virus (RSV) bronchiolitis. His older sister had a cold last week. (signs and symptoms).
- He has no allergies.
- He is receiving intermittent nebulized doses of racemic epinephrine; otherwise he is not receiving any medication.
- His past medical history includes the fact that he was born prematurely at 32 weeks. He spent several days in the nursery for mild respiratory distress and jaundice. Since being home he has been growing well and has been healthy with no history of apnea.
- His heart rate has averaged 168/min since admission with no bradycardia noted until this recent event. The nurse was in the room during the last monitor alarm and saw the slowing of the pulse oximetry waveform. But by the time she moved to the bedside, all monitor numbers had returned to normal, and the infant was breathing at a rate of 60/min. His admission laboratory studies were unremarkable.

A more complete examination does not reveal any abnormalities except for fluid behind both tympanic membranes without erythema. After completing your examination, you observe the infant for several minutes without any stimulation and note that when he falls asleep, his monitor alarms within a minute for bradycardia into the 70/min to 80/min range and \( \text{SpO}_2 \) into the low 80s.

<table>
<thead>
<tr>
<th>11E</th>
<th>How do you categorize this infant’s condition now?</th>
</tr>
</thead>
<tbody>
<tr>
<td>11F</td>
<td>Why do you think this infant is developing bradycardia?</td>
</tr>
<tr>
<td>11G</td>
<td>What are your actions now?</td>
</tr>
</tbody>
</table>

Case Progression

In response to stimulation, the infant’s heart rate and oxygen saturation rapidly improve, and he begins to cry and move spontaneously. When you leave him alone, within a few minutes he becomes flaccid and stops breathing and his heart rate and oxygen
saturation rapidly fall.

11H How would you manage this infant’s bradycardia?

11I Would a medication help correct the bradycardia? Which medications are indicated for the treatment of bradycardia, and when are they indicated?

11J What are common causes of bradycardia in infants and children?

11K How do you decide if an infant or child with bradycardia needs intervention? When would you provide CPR in an infant or child with bradycardia?

---

**Case Conclusion**

The nurse continues to stimulate the infant until he arrives in the pediatric ICU. There he is electively intubated and ventilated with resolution of the bradycardia. After several days of ventilation, the infant was extubated and subsequently did well.

Infants, particularly those who are born prematurely, sometimes develop apnea as part of the clinical manifestation of RSV bronchiolitis. These infants often respond readily to stimulation, with improvement in their oxygenation and ventilation, but when they are not stimulated, they stop breathing. This leads to hypoxemia and bradycardia. In general the only effective treatment is to prevent the apnea by supporting ventilation until the viral infection runs its course. This case illustrates the common association between respiratory-induced hypoxemia and bradycardia in infants.

---

**Case 12**

**Introduction**

You are seeing a 6-week-old infant who was brought to the emergency department because the mother noted breathing difficulty, poor feeding, and vomiting today.

**General Assessment**

You see an obviously tachypneic infant with occasional grunting respirations who appears irritable and is not consoled by her mother. Her color appears mottled and grayish.

12A Based on your general assessment, what is your impression of this infant’s condition?
12B Does the child need immediate intervention? If so, what intervention is indicated?

**Primary Assessment**

After you provide oxygen and place the infant on a monitor, the infant appears to be breathing adequately, so you proceed with your primary assessment. The pulse rate displayed by the pulse oximeter is 275/min with SpO₂ of 99% on a high-flow oxygen delivery system. Blood pressure is 72/55 mm Hg. Auscultation of the lungs reveals bilateral scattered crackles at the lung bases with fair air entry. Occasional grunting respirations are still heard. You hear a very fast, regular rhythm; the rate is so fast you are unable to tell if there is a murmur. You do not hear a gallop rhythm. The infant has weak central pulses, and you cannot feel definite peripheral pulses. The extremities are cool, with capillary refill of at least 5 seconds. The infant remains fussy with good muscle tone and vigorous crying. The skin appears less mottled with oxygen administration. The rhythm on the monitor is seen below:

12C How do you categorize this infant’s condition now?

12D Is this a narrow-complex or wide-complex rhythm? Why is that distinction important?

12E What is your decision and action for this infant?

12F What would be your action(s) if the infant had readily palpable distal pulses with this rhythm?

**Case Progression**

A high-flow oxygen delivery system is continued, and the infant has an IV cannula inserted. The infant remains irritable and agitated.

12G What should you do now and why?
The infant’s heart rate transiently decreased with the dose of adenosine but then went back up to 275/min again. A second (larger) adenosine dose was also ineffective, so after a small dose of midazolam, you provide synchronized cardioversion at a dose of 0.5 J/kg. Following the shock, the monitor shows the rhythm seen below at a rate of about 165/min. On reassessment the infant continues to have tachypnea with some grunting. Color is improved and SpO₂ is 100%. Blood pressure is 82/58 mm Hg. Pulses can now be felt distally but are weak. Central pulses are improved.

![ECG rhythm](image)

12H | How do you categorize this infant’s condition now?
---|---
12I | What are your actions now?
12J | What are other causes of narrow-complex tachycardia?
12K | What are causes of wide-complex tachycardia in infants and children?

You consult a pediatric cardiologist. The infant is admitted to the pediatric ICU for careful monitoring. An arterial blood gas is obtained, and it shows that the infant had mild metabolic acidosis. Once the blood pressure is stabilized and perfusion is improved, you give the infant a dose of lasix. The infant has a good urine output response and improved respiratory examination within a few hours. The pediatric cardiologist recommends that you administer propranolol (a β-adrenergic blocker). This infant had supraventricular tachycardia, most likely from an accessory pathway in the heart.
# Appendix

## Introduction

The appendix contains the answers to the questions posed in the practice cases.

## Contents

The answers for the questions in the practice cases are grouped as follows:

- Respiratory distress cases 1 to 4
- Shock cases 5 to 8
- Cardiac cases 9 to 12
Respiratory Distress Cases

Case 1 Answers

1A What are the 3 elements of the general assessment?

The general assessment consists of your observation (auditory and visual) of the child made during the first few seconds of a patient encounter and focuses on the child’s appearance, work of breathing, and circulation (color).

1B What is your initial impression of the child’s condition based on your general assessment?

The child is in respiratory distress with increased work of breathing. The main breathing difficulty occurs during the inspiratory phase of the respiratory cycle, which suggests upper airway obstruction. His anxious appearance and pale skin color may indicate significant hypoxemia or hypercarbia, or both.

Does the child need immediate intervention?

You should be worried about this child. He is not clearly in respiratory failure but is at risk. Treatment should begin quickly while you complete your primary assessment.

If so, what intervention is indicated?

The most appropriate immediate interventions are to

- provide oxygen in a nonthreatening manner (remember: increased agitation worsens upper airway obstruction)
- place a pulse oximeter
- begin appropriate therapy with nebulized epinephrine or racemic epinephrine

Allow the child to remain in a position of comfort (such as on the mother’s lap) rather than place the child on a stretcher to minimize agitation.

Although the PALS course suggests a linear approach to patient evaluation and treatment (Assess → Categorize → Decide → Act),
providing care for the patient often involves a mixture of these interventions.

Your initial actions should focus on life-saving or stabilizing interventions. Your later actions will likely be more focused on specific treatment. Base subsequent treatment on further assessment and categorization of the patient’s condition with consideration of the likely etiology. These assessments and revised approaches to therapy occur continuously during your patient encounter.

1C What are the elements of the next assessment step, the primary assessment?

The primary assessment comprises an ABCDE (Airway, Breathing, Circulation, Disability, and Exposure) evaluation with vital signs (including pulse oximetry).

1D What is your categorization of the patient’s condition now?

This toddler has upper airway obstruction. Based on the history, it is most likely from a viral infection leading to croup. You should consider that a foreign-body airway obstruction (FBAO) may be present, but the history of relatively slow onset and gradual worsening of symptoms makes an FBAO unlikely. The high-pitched upper airway sounds also suggest that the upper airway obstruction is at a level just below the vocal cords (subglottic). Because the child is now watching you and does not appear as anxious, you note that his respiratory function and clinical condition have improved in response to oxygen administration.

1E What are your next decision and action steps?

Appropriate next steps include administration of nebulized epinephrine or racemic epinephrine to reduce upper airway obstruction. Administration of oral dexamethasone would also be appropriate. You should carefully observe this child for worsening symptoms and possible need for additional intervention. You can now obtain a more complete history and perform a more thorough exam. The exam (secondary assessment) may be deferred until the child is breathing more comfortably after the epinephrine inhalation treatment.
Relevant history questions include asking if the child was premature, was mechanically ventilated (which increases the risk of upper airway injury, predisposing to upper airway obstruction with subsequent infections), or has had episodes of croup in the past. A history of croup suggests an underlying airway problem (eg, subglottic stenosis, an airway hemangioma, or laryngeal papillomatosis). At present there is little indication for laboratory studies, such as an arterial blood gas (tertiary assessment).

1F Does a normal SpO2 rule out respiratory failure? If not, why not?

Respiratory failure is defined as inadequate oxygenation, ventilation, or both. Pulse oximetry does not evaluate the effectiveness of ventilation (ie, elimination of carbon dioxide). Children may develop hypoventilation with significant hypercarbia, yet if they are receiving supplementary oxygen they may maintain normal SpO2. Although a normal SpO2 is somewhat reassuring, the child still needs careful assessment to determine if ventilation is adequate.

1G What other conditions cause upper airway obstruction?

Many conditions can cause upper airway obstruction. The child’s symptoms can give clues to the site of the obstruction. For example, high-pitched inspiratory stridor is seen with croup; snoring inspiratory sounds are heard with a floppy pharynx and tongue occlusion. Prominent retractions and intermittent complete upper airway obstruction can be seen in a sleeping infant or child with enlarged tonsils and adenoids. Foreign bodies, peritonsilar and retropharyngeal abscess, laryngomalacia, and airway hemangiomas and polyps are other examples of conditions causing upper airway obstruction.

Case 2 Answers

2A What is your initial impression of the child's condition and your general assessment?

The initial appearance is worrisome in view of the child’s anxiety and labored breathing with prolonged, forced expiratory effort. The child is still alert, which suggests she is not in respiratory failure, but you should be worried by the child’s general assessment.
Does the child need immediate intervention? If so, what intervention is indicated?

Essentially you should **give oxygen** to all children with significant respiratory effort and distress while you **rapidly proceed to your primary assessment**.

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**2B**

What is the significance of the prolonged, forced expiratory effort?

The prolonged, forced expiratory effort and the significance of the child's overall respiratory effort are the most striking elements of the child's physical examination. The presence of prolonged, forced exhalation strongly **suggests that the child has lower airway obstruction**. When the lower airway obstruction is severe, as seen in this child, an increase in both inspiratory and expiratory effort is required to overcome the small airway obstruction. An increased effort throughout the breathing cycle is always more worrisome than an isolated increase in expiratory effort.

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**2C**

What is your categorization of the child's condition based on the primary assessment?

This child has **marked respiratory distress due to lower airway obstruction**. The inability to speak using more than one word at a time is very worrisome and confirms that this child's tidal volume is limited.

**Based on your current impression, does the child need immediate intervention now?**

This child requires urgent therapy to improve oxygenation.

**If so, what intervention is indicated?**

**Administer oxygen while directly treating the cause of the lower airway obstruction.** In children the initial specific treatment is typically nebulized albuterol therapy combined with corticosteroid therapy. Parenteral corticosteroids are indicated only in children with severe distress who cannot safely take oral therapy (eg, oral therapy is commonly used in the ED). Given this child's severe distress, if medical control or protocol allows, IV administration of corticosteroids
would be reasonable. Once the child arrives in the ED, inhaled ipratropium bromide should be used in children with severe asthma. See Chapter 2: Management of Respiratory Distress and Failure in the PALS Provider Manual and Pharmacology on the student CD for more details on medications for the treatment of asthma.

2D What conditions are associated with wheezing and a prolonged, forced expiratory phase in infants and children?

In *infants* wheezing and a prolonged expiratory effort are most commonly seen with *bronchiolitis*, a viral infection of the small airways. In *older children* these signs are most commonly seen in association with *asthma*.

2E What is the significance of the variability in radial pulse volume in this patient?

The variability in this child’s palpable pulse volume is a sign of *pulsus paradoxus*. Note that this pulse volume variation may result in inaccurate pulse oximetry readings.

**Why does this variability occur?**

Severe air trapping in the lower airways causes *hyperinflation*. With each inspiratory effort the heart is squeezed by the overinflated lungs and by the pericardium. The pericardial compression develops because the pericardium attaches to the diaphragm, and the diaphragm is flattened in patients with severe asthma. Each time the patient breathes in, the *diaphragm moves downward*. This adds additional tension to the pericardium and impedes filling of the heart. Thus stroke volume is decreased during inspiration, resulting in pulsus paradoxus. See the Figure.
Figure 1. Chest x-ray of a child with asthma illustrates the relationship between the lungs and heart. As the lung volume increases, the heart is compressed. In addition, the parietal pericardium is attached to the diaphragm. As the child inhales, the diaphragm flattens further and pulls the pericardium more tightly around the heart. Both of these actions impede venous return and thus impair stroke volume during inspiration, leading to the pulsus paradoxus.

2F

What are the elements of the SAMPLE mnemonic?

- Signs and symptoms
- Allergies
- Medications
- Past medical history
- Last meal
- Events leading to presentation

What specific history questions are you interested in knowing about this child?

The answers to the SAMPLE mnemonic questions for this child include the following:

- Signs and symptoms began 2 days ago with a cold that progressed to more coughing today. At times the child’s coughing resulted in emesis, and she has not been able to take much orally.
- She has a history of allergic rhinitis but no other allergies.
- The only medications her mother gave was a cough syrup, which has not helped.
- Her past medical history is notable for a history of coughing with previous colds, but she has never been this ill before. She also coughs frequently at night and has complained of tightness in her chest and coughing after she runs.
• Her last oral intake was several hours ago.
• There was no event leading to this illness other than the recent cold.

2G What are your treatment priorities now?

The child has clinically improved in response to your interventions. You need to maintain vigilance, however, since her respiratory distress may worsen as the initial effects of the albuterol treatment fade. You should monitor and reexamine the child frequently during transport to the emergency department. Ideally, continuous pulse oximetry should be maintained during transport.

2H What other conditions cause lower airway obstruction?

In addition to asthma, viral or mycoplasma infection may cause inflammation of the small airways. In infants this presents as bronchiolitis, with respiratory syncytial virus (RSV) being the most common cause. In older children (≥5 years) mycoplasma is the most common cause of wheezing-associated lower respiratory tract infection. Inhalation injury and anaphylaxis may also cause bronchospasm, leading to wheezing and signs of lower airway obstruction.

Case 3 Answers

3A What is your initial impression of the child’s condition based on your general assessment?

This child’s condition is very worrisome because he has significant tachypnea and respiratory distress and he is not responding well to oxygen administration (his pulse oximetry is still in the mid 80s despite oxygen administration).

Does the child need immediate intervention?

He needs rapid interventions to try to improve his oxygenation.

If so, what intervention is indicated?
The first intervention is to provide high-flow, high-concentration oxygen delivery using a nonrebreathing mask. At the present time you cannot determine if he is ventilating adequately—more information will be obtained by a careful primary assessment with an evaluation of the quality of the child’s breath sounds. You should anticipate the need to provide mechanical ventilatory support in this child.

3B What is the significance of the child’s grunting?

Grunting is always a worrisome sign. In the setting of respiratory distress, it almost always means the child is trying to keep alveoli and small airways open by increasing end-expiratory pressure. When grunting and hypoxemia are seen together, there is a high likelihood that the child has respiratory failure and will need ventilatory support.

3C How would you categorize this child’s condition?

This child has respiratory distress that is most likely caused by lung tissue (parenchymal) lung injury. This categorization is based on the presence of grunting and hypoxemia that is poorly responsive to oxygen administration. The lack of oxygen responsiveness suggests that the alveoli are not participating in gas exchange because they are collapsed or full of fluid (such as edema fluid or blood). In this case aspirated lamp oil can injure lung tissue, disrupt surfactant, and stimulate an acute inflammatory reaction, leading to hypoxemia, pulmonary edema, and decreased lung compliance. The degree of respiratory distress and lack of response to oxygen indicate that the child has respiratory failure.

It is difficult to estimate the degree of hypercarbia in this situation—some children may maintain adequate ventilation even when they have significant hypoxemia. An arterial blood gas is the only way to quantify the adequacy of ventilation. But your clinical exam is often sufficient to recognize when the child is not moving air adequately.

3D What are your initial decisions and actions?

The lack of response to high-flow oxygen indicates that this child’s oxygenation will improve only with the application of positive end-
expiratory pressure (PEEP) to help recruit collapsed alveoli. This may be delivered **noninvasively (eg, BiPAP)** or through an **endotracheal tube** during mechanical ventilation.

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### 3E

**What conditions are associated with the signs and symptoms seen in this child?**

*Lung tissue disease* is caused by a range of conditions producing alveolar collapse or obstruction. The alveoli are filled with inflammatory exudate in children with infectious pneumonia. They may also be filled with edema fluid and varying degrees of inflammatory cells in children with acute respiratory distress syndrome. Children with **left heart failure** may have alveoli filled with a transudate (low protein-containing fluid) produced from high pulmonary capillary pressures. Other less common causes include **aspiration**, such as in this case, and acute alveolar hemorrhage.

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### 3F

**What equipment do you need to gather in preparation for intubation?**

In addition to the monitoring that is in place, you will need to gather the following:

- Oxygen supply, equipment for connections to airway adjunct device
- Exhaled CO\(_2\) detector device
- Suction equipment (large bore suction catheter or tonsil-tipped suction as well as a catheter that can pass through the endotracheal tube)
- Bag-mask connected to high-flow oxygen source
- Face mask (correct size)
- Endotracheal tubes, proper size (ie, the estimated size and the size 0.5 mm above and below that size)
- Endotracheal tube stylet
- Laryngoscope blade (correct size), curved or straight, with working bulb
- Laryngoscope handle with connector and battery
- Backup light source (another laryngoscope handle and blade)
- Medications
- Commercial endotracheal tube holder/tape
- Towel or pad to place under the patient's head (to align the airway)
- NG tube (correct size)
• Oropharyngeal airway (correct size)

A length-based resuscitation tape or other reference is helpful to estimate the correct equipment sizes for the child.

**Does the likelihood of lung tissue disease change your thoughts about the intubation equipment needed?**

When selecting an endotracheal tube for this child, you should consider that he will need increased end-expiratory pressures (ie, positive end-expiratory pressure [PEEP]) and relatively high peak inspiratory pressures, so a cuffed tube would be appropriate if available. If a cuffed tube is used, remember that you must monitor the cuff pressure and maintain it <20 cm H₂O to avoid airway injury.

To improve oxygenation prior to intubation, a flow-inflating bag with a tight mask seal may be useful since you can easily provide continuous positive airway pressure (CPAP) with this setup. Alternatively, a PEEP valve may be attached to a self-refilling bag. You should anticipate the need for PEEP following intubation.

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**3G**

**What is the significance of the time he last ate?**

You must assume that this child’s stomach is full. Therefore he is at risk for regurgitation and aspiration of stomach contents. In addition, he may have some of the lamp oil still in his stomach, and you want to avoid a second lamp oil aspiration episode during intubation. To minimize the risk to this child, the provider with the greatest experience in intubation should perform or closely supervise the intubation procedure. You should use a rapid sequence intubation (RSI) protocol. (For more information, see RSI in the appendix of Respiratory Management Resources on the student CD.) Once the sedative/paralytic has taken effect (and the child loses cough and gag reflexes), a team member should maintain cricoid pressure during attempted intubation.

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**3H**

**In addition to gathering equipment, what other preintubation activity should you consider?**

Successful resuscitation of this child requires good teamwork. It is important that all members of the team know their roles and that the team leader clearly communicate requests. It is a good idea to assign roles before intubation. Clear communication is important so that the team leader knows what medication has been given and when. For
more information on team dynamics, see Resuscitation Team Concept on the student CD and Part 5 in the PALS Course Guide. It is also essential that you assess the patient’s airway anatomy. You should know or have confidence that you can provide effective bag-mask ventilation if needed before giving a neuromuscular blocker as part of a rapid sequence intubation approach.

3I What tertiary assessment studies are appropriate now?

Following intubation you should obtain a chest x-ray to assess endotracheal tube depth of insertion and to evaluate the extent of the child’s lung disease and the degree of lung inflation. An arterial blood gas is also indicated to objectively assess the adequacy of ventilation and to compare the child’s arterial PaCO₂ with his end-tidal CO₂ reading if capnography is being used. For more information on capnography, see Respiratory Management Resources on the student CD.

3J What do you think happened?

In this setting consider causes of sudden deterioration in an intubated child. These can be recalled by the DOPE mnemonic (see Endotracheal Intubation on the student CD). On examination it is clear that the endotracheal tube was displaced from the trachea.

How would you manage this situation?

You remove the tube and team members provide 2-person bag-mask ventilation using a flow-inflating manual resuscitator with a pressure manometer. You then successfully reintubate the trachea and confirm correct placement with clinical examination and detection of exhaled CO₂. The child’s oxygenation and ventilation improve immediately following reintubation.
Case 4 Answers

4A What is your initial impression based on your general assessment?

This child’s clinical condition is very worrisome because the respiratory pauses indicate disordered control of breathing.

4B Does the child require immediate intervention?

In view of his history, you have to be concerned about increased intracranial pressure or some other neurologic emergency (eg, subclinical seizures or a postictal state from an unobserved seizure). You should immediately activate the emergency response team—shout for help if necessary.

If so, what intervention is appropriate at this time?

Begin mouth-to-mask ventilation with a mask and 1-way valve until a ventilation bag is available for you to provide bag-mask ventilation with oxygen. Ask a colleague to place the patient on a cardiac monitor and pulse oximeter.

You should anticipate the need for airway intervention.

4C How would you categorize this child’s condition?

This child demonstrates disordered control of breathing characterized by intermittent pauses in ventilation. In addition, the child has decreased responsiveness and decreased upper airway tone, resulting in intermittent upper airway obstruction. Hypoventilation is present and is likely causing hypercarbia and hypoxia.

4D What decisions and actions are appropriate at this time?

In this patient the major concern is that the hypercarbia and hypoxia are further increasing his intracranial pressure, resulting in impending brain herniation. Noxious stimulation caused decerebrate (ie,
extensor) posturing. Since either hypercarbia or hypoxemia can contribute to increased intracranial pressure, you should attempt to correct both. He also has a relatively slow and irregular heart rate with increased blood pressure, both of which are consistent with increased intracranial pressure and impending herniation. This represents an emergent condition requiring immediate intervention.

Appropriate interventions include initiation of ventilation with oxygen. You should be using a mask with a 1-way valve if needed until a bag-mask device with oxygen is available. Your goal is to provide modest hyperventilation to help acutely reduce the PaCO₂ and raise the PaO₂ to reduce intracranial pressure (ICP). Note that hyperventilation is discouraged for routine ventilation of patients with cardiopulmonary failure or brain injury. Hyperventilation, however, is appropriate when there are signs of impending cerebral (brain or brainstem) herniation, as in this patient. Inadequate or abnormal central control of respiratory drive is a cause of respiratory failure that may not present with symptoms of respiratory distress but still can result in respiratory failure. Because there is no respiratory distress, it sometimes is more difficult to recognize that the patient requires urgent intervention.

You will also improve ventilation by properly opening the child's airway. He is unresponsive, so his tongue is probably causing upper airway obstruction. IV administration of either mannitol or 3% normal saline would be appropriate to help reduce ICP acutely. (See Pharmacology on the student CD.) If necessary an oropharyngeal airway may be inserted, provided the child remains poorly responsive to stimulation and has no cough or gag reflex.

4E Should you stop providing bag-mask ventilation?

No, you should continue providing assisted ventilation. The patient’s initial improvement in neurologic status likely reflects the effectiveness of your ventilation in reducing his increased intracranial pressure.

Should you intubate this patient?
Yes, you should proceed with insertion of an advanced airway.

4F If you decide to intubate, what are important considerations in planning to intubate this child?
You should *use medications to help reduce intracranial pressure* during endotracheal intubation. It is important to ensure that all of the necessary equipment is present before you begin the procedure. The *provider who is most skilled in endotracheal intubation* should perform or closely supervise the intubation procedure. We recognize that teaching institutions have an obligation to provide experience and education to help new providers learn essential skills.

**4G**

What are the next appropriate steps?

The next steps are to *use clinical assessment and exhaled CO$_2$ detection to confirm endotracheal tube placement*. The tube should be *secured in place*. Confirm correct depth of tube position with clinical assessment and by chest x-ray. *Record the endotracheal tube depth* marker (usually in centimeters) that sits at the lip or teeth when the tube position is confirmed. Since many of the agents used to facilitate endotracheal intubation are short-acting, the *patient should receive additional sedation agents* to maintain sedation and thus help reduce intracranial pressure.

**4H**

In addition to increased intracranial pressure, what other conditions can cause disordered control of breathing?

Other conditions include *drug overdose, metabolic conditions causing coma* (eg, hyperammonemia), *head trauma*, subclinical *seizures*, or *vascular events* such as stroke or subarachnoid hemorrhage.
## Causes and Presentation of Respiratory Failure or Arrest

### Introduction

In summary, there are 4 general types of respiratory problems leading to respiratory failure or arrest, as illustrated in the previous cases:

- Upper airway obstruction
- Lower airway obstruction
- Lung tissue (parenchymal) disease
- Disordered control of breathing

These are recognized by specific signs and symptoms.

### Upper Airway Obstruction

The major clinical signs of upper airway obstruction occur during the *inspiratory* phase of the respiratory cycle. The child may have stridor, hoarseness, or a change in voice or cry. There are inspiratory retractions, use of accessory muscles, and nasal flaring. The respiratory rate is often only mildly or moderately elevated, because rapid respiratory rates tend to increase the relative severity of the upper airway obstruction.

### Lower Airway Obstruction

The major clinical signs of lower airway obstruction occur during the *expiratory* phase of the respiratory cycle. The child often has wheezing and a prolonged expiratory phase requiring increased expiratory effort. The respiratory rate is usually elevated, particularly in infants whose respiratory rates commonly exceed 60/min. When lower airway obstruction impairs both inspiration and exhalation, increased inspiratory effort is required, and it will produce prominent inspiratory retractions.

### Lung Tissue (Parenchymal) Disease

With lung tissue (parenchymal) disease, the child’s lungs become stiff, requiring increased respiratory effort during inspiration. Therefore retractions and increased respiratory effort are common. Hypoxemia is often marked. It can be caused by alveolar collapse or pulmonary edema fluid and inflammatory debris in alveoli that reduces oxygen diffusion, or both. Tachypnea is common and often quite marked. The patient frequently tries to counteract alveolar and small airway collapse by increased efforts to maintain an elevated end-expiratory pressure; this is usually manifested by grunting respirations.
In disordered control of breathing, the breathing pattern is abnormal. Often the parent will state that the child is “breathing funny.” There may be periods of increased rate or effort followed by decreased rate or effort, including respiratory pauses (apnea), or the child’s respiratory rate and/or effort may be continuously inadequate. The net effect is hypoventilation. This clinical state results from a host of conditions such as injury to the brain or brainstem, or both, or drug overdose.
Case 5 Answers

5A What is your initial impression of the child's condition based on your general assessment?

This infant has a worrisome clinical picture with tachypnea and decreased response to her parents and her environment. Based on the history of vomiting and diarrhea, she likely had a viral gastroenteritis and now has hypovolemia secondary to fluid loss. The infant’s appearance with decreased responsiveness suggests that this infant is in shock.

5B Does this infant require immediate intervention?

Yes.

If so, what intervention is indicated?

Based on your general assessment, it is appropriate to provide oxygen and call for help to obtain vascular access and get assistance in providing care for this infant.

This infant appears to have an open airway and is breathing adequately, so ventilation is not needed. To obtain more objective data about the infant’s condition, you should rapidly proceed to the primary assessment and place the infant on a cardiac monitor and pulse oximeter. Once vascular access is established, begin rapid fluid resuscitation.

5C How would you categorize this infant’s condition?

The vital signs confirm your initial clinical impression that the infant is in shock.

Is the infant hypotensive?

Lower limits of systolic blood pressures that are considered to define
hypotension are
• <60 mm Hg in infants during the first month of life
• <70 mm Hg for infants from 1 month to 12 months of age
• <70 mm Hg + (2 × age in years) for children from 1 to 10 years of age

If a blood pressure measurement device is not readily available, the absence of detectable distal pulses is consistent with hypotensive shock. Indeed, if peripheral pulses are difficult to palpate, you should interpret the results of automated blood pressure devices cautiously because they are not highly reliable in this situation. (For more information, see Chapter 4: Recognition of Shock in the PALS Provider Manual.) The failure of a pulse oximeter to detect the pulse when placed on the extremities should raise your concern that the child has poor distal perfusion and is in shock.

5D What decisions and actions are appropriate at this time?

Since this infant is in hypotensive shock, you must quickly establish vascular access to enable administration of one or more isotonic crystalloid fluid boluses. Brief attempts to gain peripheral venous access are appropriate. But if they are not rapidly successful, then place an IO needle because the infant is in hypotensive shock.

Laboratory studies will be helpful to objectively determine the severity of shock. You should obtain a bedside glucose determination as soon as possible because infants in shock are at high risk for hypoglycemia (see answer 5H below).

5E What is the definition of shock?

Shock is a clinical condition in which tissue perfusion is inadequate to meet metabolic demand. In this infant global cardiac output is apparently reduced, but remember that in some forms of shock, cardiac output may be increased (eg, septic shock). For a more detailed discussion on the types of shock, see Chapter 4: Recognition of Shock in the PALS Provider Manual.

5F What elements of the secondary assessment would you like to know?

Obtain a focused history while you implement the above interventions. The duration of the child’s symptoms, allergies, use of any
medications, past medical history, last feeding, and any events leading up to the infant’s presentation are important history elements. The infant most likely has a viral gastroenteritis based on the history, but you should carefully look for the presence of signs suggesting a different cause, such as sepsis. Look for the presence of a skin rash or bruising. Assess the abdomen (ie, is the abdomen distended and tender?) for signs of a potential surgical problem, such as an acute abdomen.

**5G What would you do now?**

In this infant with hypotensive shock, it is inappropriate to make multiple attempts to insert a peripheral IV catheter. A highly skilled provider may elect to attempt central venous catheter placement, but the most appropriate next step for most providers is to place an IO catheter.

**5H After vascular access is obtained, what fluid and how much would you give?**

As soon as the needle is placed, you should deliver 20 mL/kg of isotonic crystalloid, such as normal saline. Remember to use a 3-way stopcock or pressure bag to rapidly deliver the fluid since it will generally not flow rapidly through a small peripheral IV or IO needle.

How quickly should you administer the fluid bolus?

The fluid should be given as rapidly as feasible, ideally over less than 15 minutes.

What bedside laboratory test is critically important?

If blood is aspirated at the time the IO access is confirmed, you should perform a bedside glucose determination.

**5I What are your decisions and actions now?**

When you reassess the infant, she is slightly improved, but she
remains very tachycardic and her distal pulses are still not palpable. These findings indicate that another isotonic crystalloid fluid bolus is indicated.

5J

What additional tertiary studies would you like to obtain?

The following tertiary studies may help assess the severity of acidosis and the presence of hyponatremia or hypernatremia:

- Blood sample to evaluate serum electrolytes
- Repeat bedside glucose test
- Complete blood count will help determine if the infant is anemic, and the white blood cell count may help identify if the infant is at increased risk of bacterial sepsis (either a high or low white blood cell count); it will also confirm whether the infant has adequate oxygen-carrying capacity (ie, hemoglobin concentration)
- Blood and urine cultures if sepsis is considered a risk based on the history and examination
- Urine analysis

It is helpful to place a bladder catheter both to monitor the volume of urine produced and to obtain a urine sample for analysis. Remember that the initial volume of urine in the bladder does not determine the current urine output since you don’t know how long the urine has been in the bladder. An indwelling bladder catheter will permit ongoing assessment of urine production, which provides indirect evidence of effectiveness of renal perfusion.

5K

How does the laboratory data and urine output help you categorize this infant’s condition?

The infant’s normal white blood cell count and platelet count suggests that the infant does not have bacterial sepsis. The hemoglobin concentration is adequate, so the infant is not anemic.

The advanced care provider will calculate the anion gap at 23 mEq/L (including potassium in the calculation); this is an elevated anion gap. It is, however, not as wide as expected by the child’s clinical condition. The chloride is relatively high and the bicarbonate is low. It is likely that this infant has a mixed anion gap and non-anion gap acidosis with the latter caused by the loss of bicarbonate in the watery diarrhea. This is
important to recognize since it will be more difficult to correct the metabolic acidosis without the administration of bicarbonate or a substance that can be readily converted to bicarbonate (eg, acetate). Thus, some advanced providers may change the child’s IV fluid to use potassium acetate rather than potassium chloride in this setting. There are different approaches that may be used in this situation, such as adding sodium bicarbonate to half-normal saline or using potassium acetate in the IV maintenance fluids.

5L What are your decisions and actions now?

The glucose concentration remains low, so you should administer another bolus of glucose and begin a maintenance glucose infusion. The electrolytes show that the infant’s serum sodium concentration is normal, so administration of an isotonic IV fluid such as normal saline or lactated Ringer’s solution is appropriate.

Case 6 Answers

6A What is your initial impression of the child’s condition based on your general assessment?

This child’s appearance is very worrisome because she demonstrates decreased response to her environment. Her history of chickenpox with these clinical changes suggests sepsis since the skin rash in children with chickenpox provides a portal for bacterial superinfection.

Does the child need immediate intervention?

Once septic shock is considered, it is important to activate the appropriate emergency response system to obtain additional help in treating shock and stabilizing the child.

If so, what intervention is indicated?

In the short term this child appears to be breathing adequately, but oxygen should be administered in all children with shock to maximize oxygen delivery to the tissues. For any child with possible sepsis or septic shock, you should
• complete your **primary assessment**
• direct appropriate help to **place the child on a cardiac monitor and pulse oximeter**
• **establish vascular access**
• **administer rapid fluid bolus** with isotonic crystalloid (eg, normal saline or lactated Ringer’s)
• **conduct clinical reassessment**

While you complete your primary and secondary assessments, other providers can obtain appropriate laboratory studies, including a rapid bedside glucose test and blood cultures.

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6B How do you categorize the child’s condition?

The child has **significant tachycardia with adequate distal perfusion** and an **acceptable (low normal) systolic blood pressure** on examination. These findings are consistent with compensated septic shock.

**What decisions and actions are indicated now?**

*As soon as vascular access is established, administer a rapid fluid bolus* with isotonic crystalloid (eg, normal saline or lactated Ringer’s) followed by clinical reassessment.

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6C What is the significance of the pulse pressure and the elevated respiratory rate?

One of the characteristics of sepsis is a wide pulse pressure. (The pulse pressure is the difference between the systolic and diastolic blood pressures. See Chapter 5: Management of Shock in the PALS Provider Manual for more information). The advanced provider will remember that if the diastolic blood pressure is less than or equal to half of the systolic blood pressure, the pulse pressure is clearly increased or widened. This is a finding consistent with a reduced systemic vascular resistance. The most likely cause of this vasodilated state is sepsis.

The child is tachypneic without increased work of breathing. This is characteristic of shock with the **increased respiratory rate representing a compensatory response to create a respiratory**
alkalosis to counteract the metabolic acidosis that characterizes shock.

6D What other conditions result in a wide pulse pressure?

In addition to sepsis, a wide pulse pressure is seen in children with spinal (neurogenic) and anaphylactic shock (see Chapter 4: Recognition of Shock in the PALS Provider Manual). A wide pulse pressure is also seen in children with significant anemia, such as the child with sickle cell anemia, and in children with high fever, especially when the temperature is coming down (ie, when they are vasodilated as they attempt to eliminate heat).

In both situations the vasodilation represents the need for low systemic vascular resistance to maintain a high cardiac output state. In sepsis the vasodilation results from the effects of the inflammatory mediators. With anemia the reduced oxygen-carrying capacity and oxygen content are compensated by a high cardiac output to maintain tissue oxygen delivery. Similarly, the increased metabolic demand produced by fever requires a high cardiac output to maintain adequate oxygen delivery. Other less common clinical conditions that cause a vasodilated state occur in children with chronic or acute liver failure and thyrotoxicosis.

6E What additional assessment studies are indicated?

During the secondary assessment you should look for evidence of cardiac dysfunction (listen for a gallop, assess hepatic size, and look for venous distention in neck veins). Also look for evidence of purpura and petechia suggestive of disseminated intravascular coagulation or other coagulopathies that can complicate sepsis. During the focused history obtain any further information about the child, including

- the child’s recent signs and symptoms
- if the child has any allergies to the antibiotics that you plan to administer
- if the child is receiving any medications
- if the child’s past medical history is relevant to her current condition
- the time of the child’s last meal in anticipation of the need for intubation
- additional details about this event or most recent change in responsiveness.

A bedside glucose test is important because children with sepsis are at increased risk for hypoglycemia. Blood samples for other studies,
such as electrolytes and blood counts (tertiary assessment), will provide additional information to help you determine the severity of shock and identify the etiology as well as identify complications resulting from shock or its cause.

Advanced providers will find it helpful to obtain an arterial or venous blood gas and measurement of serum lactate concentration. These results will help objectively determine the severity of shock. (These results are discussed further in the case presentation.) It is unlikely that arterial blood gases will be available in the physician’s office, however.

6F What would you do now?

The repeat assessment shows a slight improvement in the child’s heart rate. Monitoring the change in heart rate is an important element of shock assessment. If the correct interventions are provided and are effective, the heart rate and systemic perfusion will improve. The child remains quite tachypneic, and the pulse pressure is still wide with a fall in the systolic blood pressure. It is important to recognize that sepsis is a dynamic clinical state and that frequent reassessment and aggressive fluid resuscitation are commonly required. Therefore, this child requires another rapid fluid bolus with isotonic crystalloid (eg, normal saline or lactated Ringer’s) followed by clinical reassessment. If available, administer appropriate antibiotics.

In this patient staphylococcal sepsis is possible because the skin is the likely source for the infection. The advanced provider will know that vancomycin is appropriate in view of the increasing frequency of methicillin-resistant Staphylococcus aureus.

This child requires urgent transport as soon as possible to the nearest tertiary care center with pediatric critical care capability.

6G How would you categorize this child’s condition now?

Despite a total of 60 mL/kg administered in 3 fluid boluses in less than an hour, this child’s systolic blood pressure indicates that she has hypotensive shock that is fluid refractory.
What decisions and actions are indicated?

Based on the PALS Management of Septic Shock Algorithm (see Chapter 5: Management of Shock in the PALS Provider Manual), she requires vasoactive drug support.

If possible, providers should establish a central venous line to safely administer a potent vasoconstrictor such as norepinephrine, high-dose dopamine, or vasopressin. If a central venous line cannot be established, a secure peripheral venous line or IO line may be used. This requires a second access site because fluid boluses should not be given through the same site as the vasoactive drug infusion.

6H Why is she deteriorating despite fluid administration?

The child has vasodilated septic shock. Severe septic shock is a complex physiologic state with hypotension typically resulting from a combination of profound arterial and venous vasodilation combined with variable impairment of cardiac contractility and increased capillary permeability. The venodilation results in pooling of blood in the venous circulation with reduced venous return to the heart and therefore reduced cardiac output. Impaired cardiac contractility may reduce the ejection fraction, contributing to a fall in cardiac output. Increased capillary permeability contributes to the relative hypovolemia despite fluid administration. Sepsis is a form of distributive shock because it is characterized by a maldistribution of blood flow. There is often excessive blood flow to the skeletal muscle and inadequate blood flow to the intestines, liver, and kidney.

6I When would you add vasoactive drug support?

If the patient does not adequately respond to aggressive fluid resuscitation, you should administer vasoactive drugs. Potent vasoconstrictor agents may be helpful to maintain effective perfusion of the brain and heart and to reduce the excessive skeletal muscle flow and redirect blood flow to the splanchnic circulation.

6J What are the indications for giving “stress-dose” corticosteroids?

If the child requires potent vasoactive agents, many experts now recommend the addition of a stress-dose of hydrocortisone. Note that this is a small dose of steroids compared with the larger doses that
were used in the treatment of sepsis in years past—typically only 2 mg/kg of hydrocortisone is given as a loading dose. Some experts recommend obtaining a blood sample to determine cortisol concentration or performing an ACTH stimulation test before administration of hydrocortisone. Because many labs do not have a sufficiently rapid turnaround on cortisol concentrations, hydrocortisone may be started empirically.

6K When would you intubate the child and provide mechanical ventilation? Are there any special risks of the intubation procedure with this patient?

The decision to intubate and place the child on mechanical ventilation requires that you weigh the need to maintain good oxygenation and ventilation and reduce the metabolic demand from the work of breathing against the potential detrimental effects of positive-pressure ventilation on intrathoracic pressure and potential reduction in venous return and cardiac output. Moreover, sedative agents are typically needed to permit endotracheal intubation, but these agents may reduce the child’s endogenous stress hormone response and result in sudden cardiovascular collapse. You may not realize how much the child depends on her intrinsic catecholamine response until a sedative agent is given.

Thus it is important that you provide adequate fluid resuscitation and, if possible, begin a vasopressor drug infusion (eg, norepinephrine, epinephrine, or dopamine) before intubation. Sedative agents should be titrated by giving small doses to achieve just the level of sedation required for intubation.

6L Can you give vasoactive drugs through a peripheral IV catheter?

Although peripheral venous administration is not ideal when the child has fluid-refractory shock, vasoactive drug support may be given through a peripheral venous catheter or IO catheter. You should closely monitor the vascular infusion site to detect early signs of infiltration. You should infuse vasoactive medications through a central line when one is inserted.

As a detail for the advanced provider, when a central venous infusion site is established after beginning a peripheral venous vasoactive drug infusion, it is often preferable to start a second vasoactive infusion...
through the central line and then stop the peripheral infusion when additional drug effect is seen. If you simply switch the infusion tubing from the peripheral to a central line, the patient’s blood pressure may rapidly fall because whenever a vasoactive infusion is added to an infusion catheter, it will take several minutes for the vasoactive infusion to infuse through the tubing to reach the patient.

6M

In addition to sepsis, what are other causes of distributive shock?

Distributive shock is characterized by a maldistribution of blood flow due to inappropriate vasodilation. The latter is clinically characterized by a wide pulse pressure, as previously noted, and some evidence of organ ischemia.

In addition to sepsis, distributive shock is seen in children with profound anemia, such as a child with new onset leukemia, who may present with a hemoglobin as low as 3 g/dL or lower. In this case even though cardiac output is high, the low hemoglobin concentration reduces arterial oxygen content, so there is inadequate oxygen delivery to the tissues, leading to anaerobic metabolism and defining shock. Distributive shock may also be seen in a child with spinal cord injury interrupting the sympathetic innervation to the vasculature, resulting in profound vasodilation and hypotension (also called “spinal shock”).

Anaphylaxis may also produce histamine release that causes profound vasodilation and hypotension. The cardiac output in anaphylaxis is also compromised by an elevation of pulmonary vascular resistance, which may cause acute right heart strain and impaired delivery of blood from the right heart through the pulmonary circulation and to the left ventricle.

Case 7 Answers

7A

What is your initial impression of the infant’s condition based on your general assessment?
The general assessment suggests there is poor perfusion, *altered mental status, and increased work of breathing*. It is not immediately clear if the infant requires bag-mask ventilation.

**Are there any interventions indicated to treat a life-threatening condition?**

Yes.

**If so, what are the interventions?**

This infant requires intervention with at least *oxygen administration* and a rapid primary assessment to determine if the clinical problem is respiratory, circulatory, or both. You will need additional help, so you should *activate the emergency response system* appropriate for your work environment. You (or colleagues) should *place the infant on a cardiac monitor and pulse oximeter* and *administer high-flow oxygen*.

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7B How would you categorize the infant’s condition now?

This infant has hypotensive shock.

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7C What are your decision and actions now?

This infant *requires urgent intervention* including *administration of high-flow oxygen* (if not already started) and *rapid establishment of vascular access*. If peripheral or central venous access cannot be rapidly obtained, IO access is appropriate in this infant with hypotensive shock. The cause of the patient’s condition is not clear, and you should consider hypovolemic shock because of the history of vomiting and diarrhea.

The severity of the infant’s clinical condition, however, is not consistent with the history, which should suggest that something else is causing this child’s hypotensive shock state. The 2 common types of shock that can result in this more severe clinical condition are septic and cardiogenic shock. The *narrow pulse pressure is more consistent with cardiogenic shock* rather than septic shock, especially since there is an increased work of breathing with moist bilateral crackles.
In view of these considerations, the decision is how to begin therapy. To treat the hypotension, a fluid bolus is indicated, but with the possibility of cardiogenic shock, an appropriate approach is to give a rapid bolus of 5 to 10 mL/kg of an isotonic crystalloid with careful assessment during the fluid bolus and reassessment after the bolus.

The advanced provider may determine that it is appropriate to take over the work of breathing through intubation and mechanical ventilation. But this is a high-risk procedure in patients with cardiogenic shock because their blood pressure and cardiac output may be very dependent on the intrinsic stress hormone response. If sedation is given, the patient’s blood pressure may fall precipitously, leading to cardiac arrest. Thus you should anticipate the need for vasoactive drug support and use only the minimal amount of sedation required to permit intubation. If there is time before intubation, you should request preparation of an epinephrine infusion.

7D What do you think is happening? Why is there no improvement after the fluid bolus?

The history of a prior gastroenteritis leading to this clinical illness suggests an acute viral myocarditis in view of the poor response to a fluid bolus. This case illustrates the importance of reassessment and maintaining a willingness to reconsider your initial clinical impression based on the patient’s response to interventions. This infant appeared to have gastroenteritis, but the response to fluid suggests that this diagnosis is incorrect. Instead, the likelihood of cardiogenic shock is increased considering the described response.

7E What are your decisions and actions now?

This infant requires urgent interventions to improve cardiac output and support adequate oxygenation and ventilation. In children with hypotensive cardiogenic shock the first priority is to increase the blood pressure to provide adequate perfusion of the heart and help restore adequate perfusion to the brain and other organs. In the short term an inotrope and vasopressor agent such as epinephrine may be started.

Subsequent therapy is focused on reducing myocardial work, so a vasodilator is often used with or without additional inotropic support.
For more information on the treatment of cardiogenic shock see Chapter 5: Management of Shock in the PALS Provider Manual. In addition, treatment of cardiogenic shock includes interventions to reduce metabolic demand by taking over the work of breathing and reducing temperature if the patient is febrile.

7F

What laboratory and radiographic studies (tertiary assessment) would be helpful now?

As in all children (especially infants) with shock, you should evaluate the serum glucose to determine if the child is hypoglycemic (a bedside glucose test is appropriate). The advanced provider will use additional objective measures of the adequacy of cardiac output to meet metabolic demand by measuring the degree of metabolic acidosis with evaluation of an arterial or venous blood gas. A venous blood gas from a central venous line also provides objective information on the degree of oxygen extraction by noting the venous oxygen saturation and the difference between the arterial and venous oxygen saturation (see "Tertiary Assessment" in Chapter 1: Pediatric Assessment in the PALS Provider Manual). Normal venous oxygen saturation should is about 70% to 75%.

Evidence for end-organ dysfunction includes evaluation of the BUN and creatinine as well as liver function studies. A chest x-ray will help assess cardiac size, which will help confirm whether the heart is enlarged or underfilled and will demonstrate if there is x-ray evidence of pulmonary edema consistent with the clinical examination. An ECG will help determine if there is an arrhythmia, and it may show findings (eg, enlarged cardiac silhouette) consistent with myocarditis or a pericardial effusion. An echocardiogram helps objectively evaluate cardiac function and heart chamber size.

7G

How do you interpret the laboratory data?

The advanced provider will know that the venous blood gas confirms the presence of a significant metabolic acidosis with an increased lactate concentration. The low venous oxygen saturation also indicates that there is increased oxygen extraction because of low cardiac output and tissue oxygen delivery. The elevated BUN and creatinine are evidence of renal dysfunction, most likely due to inadequate renal perfusion. The chest x-ray confirms an enlarged heart size. The ECG is consistent with myocarditis (small QRS complexes).
Summary
In summary, this infant has cardiogenic shock. The characteristics of cardiogenic shock include marked tachycardia with tachypnea and often an increased work of breathing. The presence of grunting in a child with poor perfusion suggests the presence of pulmonary edema secondary to cardiogenic shock. Note that cardiogenic pulmonary edema results in a clinical picture of lung tissue disease requiring the same approach to intervention as when there is a primary respiratory process. Mechanical ventilation with increased PEEP is often needed following intubation to recruit (reopen) collapsed alveoli and maintain adequate oxygenation and ventilation.

Case 8 Answers
Note: This case is primarily for experienced providers, although the general and primary assessment information and the review of “Causes and Presentation of Shock” at the end of the answers to this case will be helpful to all PALS providers.

8A What is your initial impression of the child's condition based on your general assessment?

The child has signs of respiratory distress with obvious anxiety and mottled skin. The mottled skin may be caused by shock or poor oxygenation. It is difficult to tell on visual observation, but his alert mental state suggests that he is still perfusing his brain adequately and that his SpO₂ is not too low.

Are any interventions required?

Yes.

If so, what are they?

At the least, you need to call for help, activate the emergency response system, start oxygen, and place him on a cardiac monitor and pulse oximeter while you continue with your primary assessment.
8B

How do you categorize this patient’s condition?

He has clinical signs of respiratory distress with hypoxemia and signs of shock with poor perfusion. The sudden onset of this combination of signs and symptoms suggests an acute process that is affecting both his circulatory and pulmonary function.

What do you think is causing this patient’s respiratory distress?

Although pneumonia is possible, the sudden onset is not typical of pneumonia. Instead, this combination of findings in a patient who is immobilized in bed following a femur fracture is most consistent with a pulmonary embolus.

8C

What are your decisions and actions now?

A new PALS provider may not be familiar with acute pulmonary embolism. It is a relatively uncommon condition in children that may be under recognized. It causes an acute, variable reduction in cardiac output due to the obstruction of blood flow going from the right heart to the pulmonary circulation and ultimately to the left heart. The magnitude of obstruction depends on the size of the embolus. Intrapulmonary shunting and resultant hypoxemia are also common, but adequate ventilation, as documented by arterial PaCO₂, is usually maintained. In this form of obstructive shock the treatment depends on the severity of symptoms. Often the patient will respond to an increase in preload (ie, a fluid bolus; see Chapter 5: Management of Shock in the PALS Provider Manual for a more complete explanation of preload).

Therapy designed to dissolve the clot may be used (ie, thrombolytic therapy, but it is associated with higher risk of hemorrhage when the patient has had recent surgery or trauma (as in this child). Instead, treatment is often supportive, consisting of bolus fluid therapy and the acute administration of heparin designed to prevent further clot formation.
8D

What would you do now?

The patient responded to 10 mL/kg of isotonic crystalloid with some improvement in his clinical condition, so *administration of another small fluid bolus* would be appropriate.

What laboratory and nonlaboratory studies would help you determine the cause of this patient’s condition and necessary treatment?

An *arterial blood gas* would help the experienced provider determine the degree of ventilation-perfusion mismatch and the degree of metabolic acidosis, which would help quantify the magnitude of the compromise in tissue perfusion. A *chest x-ray* would be appropriate to rule out pneumonia and to evaluate the patient’s heart size.

An *echocardiogram* can help identify the presence of a pulmonary embolism by showing increased volume in the right ventricle and atrium and decreased blood volume in the left ventricle. An echocardiogram also helps rule out the presence of a pericardial effusion. To confirm the diagnosis of a pulmonary embolism, the most common diagnostic test is a *spiral CT scan* with IV contrast.

8E

What conditions may cause this type of shock?

The 3 common causes of obstructive shock are *pulmonary embolism, pericardial tamponade*, and *tension pneumothorax*. All 3 are characterized by an obstruction of blood flow. Pulmonary embolism causes the right heart to be distended because the obstruction is in the pulmonary artery; the other 2 causes result in impaired filling of the right and left ventricle, so the heart will appear small on echocardiogram. With pericardial tamponade the heart size may be normal or enlarged on chest x-ray. The chest x-ray is also helpful in confirming the diagnosis of a tension pneumothorax. Ideally the PALS provider should suspect and treat tension pneumothorax based on clinical exam rather than await radiographic confirmation.

*A less common cause of obstructive shock is seen in neonates with some congenital heart lesions. Neonates with a congenital cardiovascular obstruction, such as severe coarctation of the aorta, may present clinically when the patent ductus arteriosus begins to close, usually within the first 2 weeks of life.*
Causes and Presentation of Shock

In summary, there are 4 types of shock, as illustrated in the previous cases:

- Hypovolemic shock
- Distributive shock
- Cardiogenic shock
- Obstructive shock

These types of shock are recognized by the following signs and symptoms.

### Hypovolemic Shock

Hypovolemic shock is characterized by tachycardia with a narrow pulse pressure. The child typically has quiet tachypnea (ie, tachypnea without an increased work of breathing). The degree of perfusion abnormality (ie, severity of compromise in systemic perfusion) and the severity of symptoms depend on the magnitude of hypovolemia, but in children intense vasoconstriction often maintains the blood pressure and perfusion to the brain. Severe (eg, profound dehydration) or sudden (eg, hemorrhagic shock) hypovolemic shock is typically accompanied by hypotension. The history is very important in the recognition of hypovolemic shock, although children with nonaccidental trauma (child abuse) often do not have a reported history consistent with their clinical signs.

### Distributive Shock

The most common cause of distributive shock is sepsis, but this form of shock may also occur as part of anaphylaxis or spinal shock. The characteristic finding in this form of shock is an abnormal distribution of blood volume and flow due to inappropriate vasodilation. Inappropriate vasodilation leads to the characteristic clinical finding that should suggest distributive shock: a wide pulse pressure. Similar to other forms of shock, children in distributive shock have tachycardia and tachypnea. Tachypnea may be quiet or there may be increased work of breathing. Tachypnea with increased work of breathing is likely to be present if sepsis is caused by pneumonia, if there is bronchospasm as part of anaphylaxis, or if there is pulmonary edema as part of the acute respiratory distress syndrome complicating sepsis.

Children with sepsis often have vasodilation, so they may appear to have good color and their capillary refill may or may not be prolonged. Some children with certain types of septic shock have delayed capillary refill because of vasoconstriction (cold shock) whereas others
have very brisk capillary refill while still in shock (warm shock). If their blood volume is adequate, they may have good pulses despite low blood pressure, even when they are overtly hypotensive.

**Cardiogenic Shock**

Children with cardiogenic shock often appear severely ill with poor perfusion and altered mental status. Unlike hypovolemic shock, increased vasoconstriction tends to further reduce cardiac output even though it may help to maintain blood pressure. Indeed, vasoconstriction may compromise perfusion to vital organs by further reducing cardiac output. These patients may have marked hypoxemia and increased work of breathing due to pulmonary edema from an elevated left ventricular end-diastolic pressure.

One of the common characteristics in these children is the combination of poor perfusion, tachypnea, and grunting respirations. The central pulses are often very weak, and they typically have marked tachycardia. They also may have occult hyperthermia. The experienced provider will recognize this finding. The core temperature is elevated, but the axillary or even rectal temperature may not be elevated because distal perfusion is so severely compromised that the patient is not perfusing the skin or rectal mucosa. This creates a difference between the core body temperature and the peripheral temperature measurements. The poor skin perfusion means the patient is unable to lose heat; this causes further elevation of the core temperature, which further increases oxygen demand and taxes the patient’s poor cardiac function. Tachypnea is common and often quite marked.

**Obstructive Shock**

Knowledge of events leading to presentation of the condition is critical to the recognition of most children with obstructive shock. Pulmonary embolism occurs as an acute process, most often in older children who have been immobile or in children with an underlying disorder that makes them prone to coagulation (clot development).

Tension pneumothorax and cardiac tamponade should be considered in patients with significant trauma, particularly when they fail to improve with fluid administration. Children with a tension pneumothorax typically have decreased breath sounds on the affected side; children with a cardiac tamponade typically have diminished heart sounds and distended neck veins.

As with hypovolemic and cardiogenic shock, these children have a narrow pulse pressure with tachycardia. The quality of the pulses may fluctuate with the respiratory cycle in children with cardiac tamponade...
and a pneumothorax: the pulse volume decreasing during inspiration and improving during expiration. Cardiac tamponade can be quickly confirmed with an echocardiogram.
Cardiac Cases

Case 9 Answers

9A  What are your initial decisions and actions?

You should not perform a complete primary assessment at this time. The child appears to be in cardiac arrest. If you confirm the cardiac arrest, the most important interventions you can provide are performing high-quality CPR and attaching the child to a monitor/defibrillator as soon as feasible. If VF or pulseless VT is present, the child will require attempted defibrillation. As you begin CPR in this setting, it is helpful to gather further information from the child’s mother about the events leading up to the arrest.

9B  What is the rhythm?

The rhythm is ventricular fibrillation.

What would you do now?

Once a shockable rhythm (VF or pulseless VT) is identified, rapid shock delivery is indicated. In the out-of-hospital setting for sudden witnessed collapse, the guidelines note that 2 minutes of CPR before defibrillation may improve survival if the EMS providers did not witness the arrest and the EMS call-to-response interval is >5 minutes. Ideally the medical director will determine whether CPR first or shock first should be provided for victims of sudden witnessed collapse. If a child is found to be unresponsive (ie, no one witnessed a sudden collapse), 2 minutes of CPR is recommended before you attach an AED.

9C  When you provide CPR, what compression-ventilation ratio are you providing?

The appropriate ratio for 2-person CPR in a child is 15 compressions to 2 ventilations with each breath delivered over about 1 second.

9D  How could you or your partner improve ventilation during CPR?
This common problem of difficulty producing chest rise may be improved by

- **better patient positioning**—trying to move the head and neck into a **sniffing position**
- **being sure to lift the chin or jaw into the mask** rather than pushing the mask down onto the face

**Insertion of an oropharyngeal airway** is also helpful to maintain airway patency. If you continue to have difficulty, you might be more inclined to proceed to **early endotracheal intubation.**

9E What is the significance of the history?

Since this child has a history of chronic renal failure with worsening kidney function and he missed a dialysis treatment, **he may have a significant metabolic disturbance, especially hyperkalemia.** Since he had a kidney transplant, **he is likely to be immunosuppressed,** so you should also suspect sepsis.

9F Why is a primary assessment not performed in this case progression?

You must interrupt the assessment approach **whenever you recognize a life-threatening condition.** Since this child is in cardiac arrest, management of the arrest takes precedence over the performance of a detailed assessment.

9G How else should you confirm endotracheal tube placement?

Use an **exhaled CO₂ detector** to confirm tube placement. There is insufficient information to recommend for or against the use of an esophageal detector device for confirmation of tube placement for children in cardiac arrest. The data available has been reported from studies of children >20 kg weight with perfusing rhythms.

9H When would you give a drug to this child?
You should anticipate the need to give epinephrine if the child is still in cardiac arrest after 2 minutes of CPR following attempted defibrillation.

9I What drug would you use first?

Epinephrine is the vasoactive drug given when cardiac arrest persists at the next rhythm check. If VF is present and IV/IO access is in place, you will ideally give the drug during chest compressions and as soon as possible after the rhythm check (ie, either before or shortly after the second shock). Recall that IV or IO drug administration rather than endotracheal drug administration is the preferred route. Drug administration should not delay a second shock. Be sure to follow the IV/IO drug with a bolus of normal saline (5 to 10 mL) and continue CPR during drug administration to circulate the drug.

9J What would you ask the new team members to do?

They should be directed to obtain vascular access. Since this child is in cardiac arrest, little time should be spent on obtaining peripheral access. They should rapidly insert an IO cannula unless peripheral vascular access can be obtained quickly. A team member should also draw up the doses of medication likely to be needed so that they are ready for administration. Finally, it would be helpful to obtain additional history and to check a bedside glucose.

9K Would you remove the endotracheal tube? If not, why not?

The endotracheal tube should not be removed. Since the tube appeared to be in place by clinical examination, confirm the tube position by direct observation of the tube passing between the vocal cords. During cardiac arrest cardiac output and pulmonary blood flow may be too low to generate sufficient exhaled CO₂. If tube position is confirmed, then you should carefully assess that good quality chest compressions are being performed at a rate of at least 100/min with good compression depth and complete relaxation of the chest after each compression.

9L What should you do now?
Since the child is still in VF, another shock is indicated. It is appropriate to give a dose of epinephrine: 2 mL (0.1 mL/kg) of 1:10,000 epinephrine IV/IO if vascular access is available. If vascular access is not available, a dose of 0.1 mg (0.1 mL of 1:1000 epinephrine) can be given through the endotracheal tube. IV or IO administration is preferred to endotracheal drug administration. Endotracheal drug administration is less desirable because it produces unpredictable drug levels and effects.

If you were using a manual defibrillator rather than an AED, what shock energy dose would you use for the second and subsequent shocks?

The appropriate energy dose is 4 J/kg for this and all subsequent shocks if a manual defibrillator is used. If an AED is used, you should use a pediatric dose-attenuator system (pads and cable) if available.

What should you do now?

An organized sinus rhythm is seen. You should check to see if there is a pulse with this rhythm. If there is no pulse, then the patient has pulseless electrical activity. Resume CPR and give a second dose of epinephrine if cardiac arrest persists at the next rhythm check (you just gave epinephrine 2 minutes ago at the last rhythm check). Recall that all IV/IO epinephrine doses in this setting should be standard doses; high-dose epinephrine is not routinely indicated.

How does the focused SAMPLE history help you?

The history raises concern about either an electrolyte problem (particularly hyperkalemia) causing the VF or that the child has sepsis. The sudden onset of the event suggests that VF resulted from a metabolic problem and that treatment for hyperkalemia is indicated. In this case administration of epinephrine may reduce the potassium concentration and contribute to reversing the cause of the arrest. You may also consider administration of calcium, sodium bicarbonate, glucose plus insulin, and possibly a dose of albuterol.
What tertiary assessments would you obtain on this child after ED arrival?

In view of his history, measurement of electrolytes, phosphate, and magnesium is important. An arterial blood gas will help define the degree of metabolic acidosis, which is likely to be of mixed etiology from his renal failure and from lactic acidosis associated with global ischemia. A complete blood count may be helpful to document the adequacy of his oxygen-carrying capacity since patients with renal failure are often anemic. A chest x-ray should be obtained to confirm correct tube depth of insertion.

What would you do based on these laboratory data?

This child needs urgent treatment for hyperkalemia. Give calcium to protect or stabilize the myocardium from the effects of hyperkalemia and to reduce the chance of another rhythm disturbance. Sodium bicarbonate is typically administered to raise the serum pH and encourage a shift of potassium from the vascular to the intracellular space. But sodium bicarbonate may not be very effective, particularly in patients with chronic renal failure. The most effective therapy is an infusion of glucose and insulin. A dose of nebulized albuterol may also be effective in reducing serum potassium, but its effects are unpredictable.

The advanced provider may know that if the patient needs vasoactive drug support, an epinephrine infusion would be a good choice since the β-adrenergic effect will cause potassium to move into muscle cells, lowering the plasma concentration.

What are the potentially reversible conditions that can cause failure to respond to CPR?

The potentially reversible causes of cardiac arrest are recalled as the 6 H’s and 5 T’s:

- Hypovolemia, Hypoxia (or ventilatory problem), Hydrogen ion excess (acidosis), Hypo-/Hyperkalemia, Hypoglycemia, and Hypothermia
- Toxins, Tamponade (cardiac), Tension pneumothorax, Thrombosis (cardiac or pulmonary, with the latter more common in children), and Trauma (hypovolemia, increased intracranial pressure)
9R If this child had failed to respond to the second shock, what medication would you have given?

If the child had remained in VF, amiodarone (5 mg/kg) would have been the next medication administered. If VF persists and hyperkalemia is likely to be present, you should consider empiric treatment of the hyperkalemia (ie, calcium, sodium bicarbonate, glucose plus insulin).

What energy dose would you have used for subsequent shocks with a manual defibrillator?

Shock doses with a manual defibrillator will be 4 J/kg for the second and subsequent shocks, whether you are using a monophasic or biphasic defibrillator. See Chapter 7: Recognition and Management of Cardiac Arrest in the PALS Provider Manual. If VF persisted after amiodarone and another shock and 2 minutes of CPR, then a shock and epinephrine would be given again. This would be followed by an additional shock and a second dose of amiodarone if at the 2 minute rhythm check following epinephrine, the patient remained in VF arrest.

Case 10 Answers

10A What are your assessment and treatment priorities at this time?

The initial approach to the management of this child requires a team effort. To ensure that the team works effectively, as soon as you learn that a child is arriving in cardiac arrest, the team leader should identify roles and expectations. Examples of team roles include the following:

• One team member performs compressions.
• Another team member provides ventilations.
• An additional team member (if available) is assigned to relieve the compressor; if this additional rescuer is not available, the team members performing compressions and ventilations can switch roles when the rhythm is checked every 2 minutes.
• One team member obtains vascular access and draws the necessary laboratory studies; this team member will typically administer medications.
• Another team role is attaching the patient to a cardiac monitor and pulse oximeter (this team member often then draws up medications).
• Another team role is to document what is done (this team member can also serve as a timer).
• The team leader should also designate someone to be available to remain with the family; you may want to call someone from pastoral care or a social worker to ask that person to be available when the family members arrive.

Early after the child’s arrival you should confirm that the endotracheal tube is in the correct position. During transport, especially into or out of the transport vehicle, the endotracheal tube may become displaced even if it was initially confirmed to be in the correct position. You should also confirm that the child is in cardiac arrest.

During resuscitation the compressors should deliver high-quality chest compressions, allowing complete chest recoil and minimizing interruptions. If an organized rhythm is seen on the monitor, check to see if the child has detectable perfusion with that rhythm. If CPR is resumed after the rhythm check, request preparation of a dose of epinephrine along with syringes of normal saline to flush drug doses. Be sure to check the child’s core temperature and obtain a bedside glucose concentration. Finally, ask that someone obtain a history of what happened if possible.

10B What medication would you give this child if cardiac arrest is confirmed?

The initial medication indicated in cardiac arrest is epinephrine in an IV/IO dose of 0.01 mg/kg (0.1 mL/kg of the 1:10,000 solution).

10C What are your treatment priorities now?

You must remove the existing endotracheal tube and place a new one in the trachea. When you remove the existing tube, it is generally a good idea to first provide oxygenation and ventilation with a bag-mask device while preparing the necessary equipment for endotracheal intubation. This will help better oxygenate the lungs and ultimately the blood flow to the heart and brain. It may take a few minutes to prepare intubation equipment, including a suction setup.
with an adequate-sized suction catheter or tonsillar suction device. Because ventilation was delivered into the esophagus, the child is likely to have gastric distention and is at high risk for regurgitation and aspiration during the intubation.

*Use cricoid pressure during bag-mask ventilation* and *insert a nasogastric tube* as soon as feasible after the intubation because relieving gastric distention will often improve ventilation.

**10D** How should you coordinate compressions and ventilations once the endotracheal tube is correctly placed?

Once the endotracheal tube is confirmed to be placed in proper position in the trachea, *chest compressions are delivered continuously at a rate of at least 100/min while ventilations are given at a rate of about 8 to 10 breaths/min*. Rescuers will *not longer give “cycles”* of compressions with pauses for ventilations.

**10E** What medications are indicated in the treatment of this child?

The only medication likely to be effective in this child is *epinephrine*. There is no data supporting the routine use of atropine, calcium, or bicarbonate in this setting.

**10F** Would you let the mother enter the resuscitation room?

The *2005 guidelines encourage rescuers to give family the option of being present during CPR* provided there is someone available who can dedicate attention to the needs of the family. Data does not show that the experience is harmful to the parent. Indeed, most parents report that it was helpful to them in their grief response if the resuscitation attempt was unsuccessful.

**10G** What information do you want from the family?

You would like to obtain at least a *SAMPLE history*, being certain to identify any important information about *signs* and symptoms before the event, any *allergies*, use of *medications*, past medical history, and last meal taken. The *events* leading up to the drowning, including an estimate of how long the child was not observed, may be helpful, but...
the parental recall is often inaccurate in estimating the possible submersion time interval.

10H What secondary and tertiary assessment data would you like to obtain now?

You should **assess the child for evidence of trauma**. Once there is a perfusing rhythm, you would like to **assess his neurologic status**, with particular attention to his pupil size and pupil response to light and his motor response to noxious stimulation.

The laboratory data includes an **arterial blood gas and lactate concentration** measurement. Most drowning patients do not have clinically important electrolyte abnormalities or immediate abnormalities of organ systems such as the kidney or liver, but laboratory results are typically obtained to document baseline values. A **CBC** is also often obtained, but it is usually not remarkable other than showing an elevated white blood cell count with left shift. **The experienced provider will know that this is typically caused by the action of epinephrine**. It would be appropriate to obtain **coagulation studies** since diffuse endothelial injury occurs with prolonged arrest, often leading to at least laboratory evidence of disseminated intravascular coagulopathy.

10I When would you use high-dose epinephrine?

Although high-dose epinephrine was recommended in guidelines published prior to 2005, a **recent study** in children showed no benefit and **suggested there is harm from the use of high-dose epinephrine in pediatric cardiac arrest**, especially in the setting of asphyxia. High-dose epinephrine may be indicated in specific clinical circumstances characterized by poor responsiveness to catecholamines. Cardiac arrest conditions characterized by poor catecholamine responsiveness include β-blocker ingestion and calcium channel blocker ingestion.

10J How do you interpret the laboratory results?

The laboratory data confirms a **severe metabolic acidosis with elevated lactate concentrations consistent with marked anaerobic metabolism**. In addition, the **PaO₂ is relatively low** considering that
the child is being ventilated with 100% oxygen. In this child the etiology of his hypoxemia is likely from a combination of lung tissue insult (hypoxic insult) and lower airway obstruction from particulate material that was likely aspirated during the resuscitation (For a discussion of aspiration pneumonia, see Chapter 3: Management of Respiratory Distress and Failure in the PALS Provider Manual). After hemodynamic stability is achieved, the child may require mechanical ventilation with increased PEEP to help improve oxygenation.

**10K**

Why do you think the child is poorly perfused?

*After a cardiac arrest the heart function is often poor.* On echocardiogram the heart is often not contracting effectively. Essentially the patient often has a clinical picture of cardiogenic shock, which is consistent with the injury to the heart from hypoxia-ischemia. Some investigators call this a “stunned myocardium” since recovery of cardiac function often occurs with appropriate support.

Do you trust the blood pressure readings obtained by the automated blood pressure device?

In the setting of poor perfusion with the absence of detectable distal pulses, *automated blood pressure devices are unreliable.*

How would you treat this child in view of his current findings?

You should *treat the child as being in hypotensive shock.* In this case, however, a large volume fluid bolus is not indicated because the child likely has cardiogenic shock. Instead, you may *give a small fluid bolus (5 to 10 mL/kg) of isotonic crystalloid and repeat the bolus if there is clinical improvement without adverse effect.* Adverse effects could include worsening of respiratory status. In addition, a *potent inotropic agent* is indicated. An epinephrine infusion is often used in this setting.

**10L**

Would you rewarm this child?

There is substantial data showing that fever harms the cardiac arrest survivor. In addition, data in both adults and neonates suggests that induced hypothermia for victims who remain comatose following resuscitation from cardiac arrest may improve survival and neurologic outcome. Therefore, *this child should not be actively rewarmed* unless you think his cardiac function is adversely affected by the
hypothermia. Typically as long as the core temperature is at least 33°C, the cardiac function will not be adversely affected except that the heart rate may be slower because of the effects of hypothermia on the sinus node pacemaker rate.

10M What are your postresuscitation priorities?

In addition to avoiding fever and maintaining a reduced core temperature, you need to confirm that the endotracheal tube is at the proper depth of insertion by checking a chest x-ray. Placement of an arterial catheter is indicated to enable continuous monitoring of blood pressure and provide a method for frequent evaluation of arterial blood gases. Adjust vasoactive drug support as necessary to maintain adequate perfusion pressure. If the child has adequate perfusion, you should see the lactate concentration decrease and the degree of metabolic acidosis steadily improve. You should maintain the child’s glucose concentration in a normal range. Seizures may develop and careful neurologic monitoring is indicated. Place a bladder catheter to monitor urine output and assess the adequacy of renal function.

A team member should discuss the child's condition and prognosis with the family and assess their knowledge and wishes regarding the child’s therapy. Management of a child following cardiac arrest is complex. The child ideally should be referred to a medical center with pediatric critical care expertise if the resources are not available in your institution. For more detailed information on postresuscitation care, see Chapter 8 in the PALS Provider Manual.

Case 11 Answers

11A What is your initial impression of this infant's condition based on your general assessment?

This infant appears to have respiratory distress and is requiring oxygen, but he is quite vigorous with adequate oxyhemoglobin saturation and heart rate.
11B What are your decisions and actions now?

Since you were called to see this infant for bradycardia, you can ask to see a rhythm strip to confirm that the bradycardia episode was real and not a problem with the monitor. Whether a rhythm strip is available or not, it is important to carefully assess this infant since someone was concerned enough to call you to see the baby. Since no intervention is required immediately, you should proceed with your primary assessment.

11C How do you categorize the infant’s condition now?

Based on your clinical examination, this infant has findings consistent with lung tissue disease and lower airway obstruction. Both conditions are common in infants with viral bronchiolitis.

11D What are your actions now?

Complete a primary assessment and proceed to a secondary assessment. The infant is well perfused and his oxygen saturation is adequate, so the reason for his reported bradycardia is not apparent.

11E How do you categorize this infant’s condition now?

In addition to lung disease, this infant has disordered control of breathing. The apnea is described as central apnea because he is not making efforts to breathe. This differs from obstructive apnea, where the infant attempts to breathe but there is severe or complete airway obstruction (usually upper airway).

11F Why do you think this infant is developing bradycardia?

In infants, unlike older children and adults, hypoxemia often leads to apnea rather than tachypnea or hyperpnea (deep rapid breaths). In this setting the central apnea occurs first and results in hypoxemia, which is the likely cause of the infant’s bradycardia.
The advanced provider may note that on a rhythm strip this bradycardia usually has a narrow complex and sometimes does not have a P wave before the QRS, indicating that the sinus node is suppressed by increased vagal tone and a different pacemaker is producing the heart rate (see Chapter 6: Recognition and Management of Bradyarrhythmias and Tachyarrhythmias in the PALS Provider Manual).

11G What are your actions now?

The treatment of bradycardia in this setting requires stimulating the infant to breathe. If the infant does not rapidly respond to stimulation, then you should begin bag-mask ventilation.

11H How would you manage this infant’s bradycardia?

This infant responds to stimulation, but when the infant is left alone, apnea and bradycardia recur. Treatment consists of endotracheal intubation with mechanical ventilation to maintain ventilation and oxygenation. You may try using nasal CPAP since sometimes the stimulation from the nasal prongs and the CPAP are sufficient to prevent the apnea episodes. If this approach is used, the infant needs to be carefully observed for recurrent apnea.

11I Would a medication help correct the bradycardia?

Although atropine may reverse the bradycardia in this setting, it will not prevent the hypoxemia and hypercarbia that develop with central apnea.

Which medications are indicated in the treatment of bradycardia and when are they indicated?

Atropine is indicated in conditions where the bradycardia is caused by heart block or is caused by increased vagal tone and can be reversed with an anticholinergic agent. This may be seen in some children with congenital cardiac lesions and may be seen in clonidine or digoxin overdose.

Epinephrine is the alternative medication used to treat symptomatic
bradycardia. Symptomatic bradycardia is defined as poor perfusion in association with the slow heart rate. The initial approach to bradycardia is to provide adequate oxygenation and ventilation. If the heart rate is 60/min with signs of poor perfusion despite adequate oxygenation and ventilation, you should provide chest compressions with the ventilation. If these interventions are not effective, then you may give epinephrine to increase the heart rate. The dose of epinephrine for symptomatic bradycardia that is unresponsive to respiratory interventions is the same as used in cardiac arrest (ie, 0.01 mg/kg).

11J What are common causes of bradycardia in infants and children?

Bradycardia often results from hypoxemia, hypercarbia, or both. Hypoxemia is the more common cause. Another relatively common cause of bradycardia in children is cardiac ischemia. This often results from severe shock or may be seen in the postarrest setting when a rhythm is restored but the heart has been stunned and is poorly responsive to endogenous or exogenous catecholamine stimulation. Bradycardia may be seen in children with cardiac disease, such as a cardiomyopathy or congenital heart disease with injury to the conduction system after heart surgery. In the setting of primary bradycardia in children with heart disease (see Chapter 6 in the PALS Provider Manual), atropine is often helpful and less likely to cause arrhythmias than epinephrine.

Less common causes of bradycardia are conditions that increase vagal tone as previously noted, such as drug toxicity from agents such as narcotics, clonidine, and high serum concentrations of digoxin along with increased vagal tone accompanying brain injury or increased intracranial pressure.

11K How do you decide if an infant or child with bradycardia needs intervention?

The PALS Pediatric Bradycardia With a Pulse Algorithm for treatment of an infant or child with bradycardia recommends that you base your interventions on the severity of symptoms as defined by clinical signs of the child’s perfusion in association with the bradycardia.

When would you provide CPR in an infant or child with bradycardia?
Some patients with chronic bradycardia adapt to the bradycardia quite well and maintain adequate perfusion and do not need intervention even when their heart rate is less than 60/min. Infants are particularly dependent on their heart rate to maintain adequate cardiac output, however, and they often tolerate bradycardia poorly. Thus if the infant or child with poor perfusion (ie, absent distal pulses, cool extremities, prolonged refill, and altered mental status) does not improve in response to ventilatory support with 100% oxygen, you should provide chest compressions with the ventilation and prepare to administer epinephrine.

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**Case 12 Answers**

12A Based on your general assessment, what is your impression of this infant’s condition?

You should be very worried by this infant’s appearance. She has respiratory distress with grunting respirations and mottled color with irritability. This clinical picture suggests lung tissue disease, which is often complicated by hypoxemia.

12B Does the child need immediate intervention?

Yes, the child is in severe respiratory distress. If so, what intervention is indicated?

Your first actions are to call for additional help so that you can quickly place the infant on high-flow oxygen, a cardiac monitor and pulse oximeter, and establish vascular access. The infant has good respiratory effort, so there is no obvious need to provide ventilatory support at this time.

12C How do you categorize this infant’s condition now?

This infant has a tachycardia (>200/min) with poor perfusion.
12D  Is this a narrow-complex or wide-complex rhythm?

Since the heart rate is well in excess of 200/min and the history does not suggest a cause for shock producing tachycardia (ie, a sinus tachycardia), this is most likely a supraventricular tachycardia (SVT). Once you see a fast rhythm on the monitor, your next decision is to determine if the rhythm is narrow or wide.

Why is that distinction important?

A narrow rhythm (≤0.08 sec) is supraventricular, whereas a wide rhythm (>0.08 sec) may be either a supraventricular rhythm with aberrant conduction or ventricular tachycardia (VT). Since this discrimination is often difficult, you should treat wide-complex tachycardia as VT unless the child is known to have aberrant conduction. When the patient is poorly perfused with a wide-complex tachycardia, early synchronized cardioversion is indicated. If the child has narrow-complex tachycardia, you may attempt pharmacologic conversion if IV or IO access is readily available.

12E  What is your decision and action for this infant?

In this case recommendations for management are based on the Algorithm for Pediatric Tachycardia With Pulses and Poor Perfusion (see Chapter 6 in the PALS Provider Manual). With poor perfusion the infant will likely require synchronized cardioversion. But if you have vascular access established (or it can be readily established), you may first attempt to convert the rhythm with a dose of adenosine, using 0.1 mg/kg (maximum first dose 6 mg) by rapid IV infusion. You may also attempt to convert the rhythm with a vagal maneuver by placing iced water in a bag or glove on the infant’s face (without obstructing the infant’s nose), provided the vagal maneuvers do not delay pharmacologic or electrical cardioversion. For more information on treatment of a SVT, see Chapter 6 in the PALS Provider Manual.

This infant is irritable and fairly vigorous despite the poor perfusion. In this setting the experienced provider may consider the use of sedation prior to cardioversion. Provide sedation agents cautiously using a small dose of a benzodiazepine (midazolam, 0.05 mg/kg is a reasonable choice) to provide amnesia for the shock (see Pharmacology on the student CD).
12F What would be your action(s) if the infant had readily palpable distal pulses with this rhythm?

The presence of good pulses indicates that this infant has adequate perfusion and does not need immediate cardioversion. Instead you may attempt vagal maneuvers and adenosine after IV/IO access is established. In addition, you should seek consultation with a pediatric cardiologist or other knowledgeable providers to help with management.

12G What should you do now and why?

Since the infant has vascular access available, giving a dose of adenosine (0.1 mg/kg) is reasonable. Remember that this drug requires a 2-syringe method of rapid administration. A 3-way stopcock is often used so that the drug can be given quickly and followed immediately by a flush of normal saline to help deliver the drug to the central circulation. If the initial dose is not effective, you can double the dose and give that dose once.

12H How do you categorize this infant’s condition now?

The infant has improved perfusion following successful cardioversion to a sinus rhythm. The infant still has evidence of lung tissue disease, which is likely secondary to pulmonary edema from congestive heart failure induced by the tachycardia.

12I What are your actions now?

At this time the best approach is often careful observation rather than administration of a vasoactive drug. Recall that SVT may be induced by catecholamines, so giving a catecholamine may re-initiate the SVT. You should obtain an ECG to analyze the rhythm. The experienced provider may look for the presence of delta waves or other abnormalities. In addition, if not already obtained, consultation with a pediatric cardiologist is indicated.
What are other causes of narrow-complex tachycardia?

The initial decision making (differential diagnosis) of the causes of a narrow-complex tachycardia is between SVT versus sinus tachycardia. The child with sinus tachycardia typically has a history compatible with a cause of the tachycardia, such as shock, sepsis, a high fever, or vomiting and diarrhea leading to serious dehydration. SVT is typically associated with an extra conduction pathway for impulse conduction in the heart (see Chapter 6 in the PALS Provider Manual). Other cardiac causes of narrow-complex tachycardia include atrial flutter and atrial fibrillation, but these are uncommon rhythms in infants unless they have underlying congenital heart disease.

What are causes of wide-complex tachycardia in infants and children?

As previously noted, wide-complex tachycardia may result from aberrant conduction of an SVT, but you should treat a wide-complex tachycardia as VT unless the child is known to have aberrant conduction. Wide-complex tachycardia is a relatively uncommon rhythm in children, but it can be seen in children with cardiomyopathy, myocarditis, congenital heart disease, drug ingestions (particularly tricyclic antidepressants), and electrolyte disturbance, particularly hyperkalemia. In children with abnormal heart function or anatomy from any of the reasons noted above, hypomagnesemia or hypocalcemia may predispose to the development of VT.