PALS Pharmacology Pre-Test

PALS Written 2006 Pre-Course Self- Assessment

PALS Written 2006 Precourse Self-Assessment
Pharmacology

The PALS Pharmacology Self-Assessment is designed to test your knowledge of core drugs that will be used in the PALS Provider Course. This drug knowledge includes the indications, contraindications, and methods for administration of these agents. This exercise tests your ability to correctly use these drugs in scenarios similar to those you are likely to encounter in the PALS Provider Course teaching and testing stations. The stations are designed to simulate the knowledge you will need to care for seriously ill or injured children.

If this self-assessment shows that your knowledge of the pharmacology and indications for these drugs is deficient, we strongly suggest that you spend additional time reviewing basic resuscitation drug pharmacology before taking a PALS course. Sources of PALS drug information include the student CD, the *PALS Course Guide,* the *PALS Provider Manual,* and the *Handbook of Emergency Cardiovascular Care* (ECC Handbook).

The Pharmacology self-assessment consists of 11 multiple choice questions. Select the single best answer. Annotated answers that explain both correct and incorrect answer selections are located at the end of the self-assessments. The Pharmacology section of the student CD and other appropriate sources of further information are provided in the annotations. There are 3 self-assessment tests: ECG Rhythm Identification, Pharmacology, and Practical Application.

1. **You are called to help resuscitate an infant with severe symptomatic bradycardia associated with respiratory distress. The bradycardia persists despite establishment of an effective airway, oxygenation, and ventilation. There is no heart block present. Which of the following is the *first drug* you should administer?**

   A. Atropine
   B. Dopamine
   C. Adenosine
   D. Epinephrine

   For further information: see the PALS Provider Manual Chapter 6: Recognition and Management of Bradyarrhythmias and Tachyarrhythmias, Chapter 9: Pharmacology, and the PALS Course Guide Part 10: Pharmacology.

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2. **Which of the following statements about the effects of epinephrine during attempted resuscitation is true?**

   A. Epinephrine decreases peripheral vascular resistance and reduces myocardial afterload so that ventricular contractions are more effective
   B. Epinephrine improves coronary artery perfusion pressure and stimulates spontaneous contractions when asystole is present
   C. Epinephrine is contraindicated in ventricular fibrillation because it increases myocardial irritability
   D. Epinephrine decreases myocardial oxygen consumption

   For further information: see the PALS Provider Manual Chapter 9: Pharmacology, and the PALS Course Guide Part 10: Pharmacology.

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3. **General assessment of a 2-year-old female reveals her to be alert with mild breathing difficulty during inspiration and pale skin color. On primary assessment, she makes high-pitched inspiratory sounds (mild stridor) when agitated; otherwise her breathing is quiet. Her SpO2 is 92% in room air, and she has mild inspiratory intercostal retractions. Lung auscultation reveals transmitted upper airway sounds with adequate distal breath sounds bilaterally. Which of the following is the most appropriate initial therapy intervention for this child?**

   A. Perform immediate endotracheal intubation
   B. Administer an IV dose of dexamethasone
   C. Nebulize 2.5 mg of albuterol
   D. Administer humidified supplementary oxygen as tolerated and continue evaluation

   For further information: see the PALS Provider Manual Chapter 2: Recognition of Respiratory Distress and Failure, Chapter 3: Management of Respiratory Distress and Failure, Chapter 9: Pharmacology, and the PALS Course Guide Part 10: Pharmacology.

4. **Which of the following most reliably delivers a high (90% or greater) concentration of inspired oxygen in a toddler or older child?**

   A. Nasal cannula with 4 L/min oxygen flow
   B. Simple oxygen mask with 15 L/min oxygen flow
   C. Nonrebreathing face mask with 12 L/min oxygen flow
   D. Face tent with 15 L/min oxygen flow

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5. **Which of the following statements about endotracheal drug administration is true?**

   A. Endotracheal drug administration is the preferred route of drug administration during resuscitation because it results in predictable drug levels and drug effects
   B. Endotracheal doses of resuscitation drugs in children have been well established and are supported by evidence from clinical trials
   C. Intravenous drug doses for resuscitation drugs should be used whether you give the drugs by the IV, intraosseous (IO), or the endotracheal route
   D. Endotracheal drug administration is the least desirable route of administration because this route results in unpredictable drug levels and effects

For further information: see the PALS Provider Manual Chapter 7: Recognition and Management of Cardiac Arrest, Chapter 9: Pharmacology, and the PALS Course Guide Part 10: Pharmacology.

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6. **Which of the following statements most accurately reflects the PALS recommendations for the use of magnesium sulfate in the treatment of cardiac arrest?**

   A. Magnesium sulfate is indicated for VF refractory to repeated shocks and amiodarone or lidocaine
   B. Routine use of magnesium sulfate is indicated for shock-refractory monomorphic VT
   C. Magnesium sulfate is indicated for torsades de pointes or suspected hypomagnesemia
   D. Magnesium sulfate is contraindicated in VT associated with an abnormal QT interval during the preceding sinus rhythm

For further information: see the PALS Provider Manual Chapter 6: Recognition and Management of Bradyarrhythmias and Tachyarrhythmias, Chapter 7: Recognition and Management of Cardiac Arrest, Chapter 9: Pharmacology, and the PALS Course Guide Part 10: Pharmacology.

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7. **You enter a room to perform a general assessment of a previously stable 10-year-old male and find him unresponsive and apneic. A code is called and bag-mask ventilation is performed with 100% oxygen. The cardiac monitor shows a wide-complex tachycardia. The boy has no detectable pulses. You deliver an unsynchronized shock with 2 J/kg. The rhythm check after 2 minutes of CPR reveals VF. You then deliver a shock of 4 J/kg and resume immediate CPR beginning with compressions. A team member had established IO access, so you give a dose of epinephrine, 0.01 mg/kg (0.1 mL/kg of 1:10,000 dilution) IO when CPR is restarted after the second shock. At the next rhythm check, persistent VF is present. You administer a 4 J/kg shock and resume CPR. Based on the PALS Pulseless Arrest Algorithm, what are the next drug and dose to administer when CPR is restarted?**

A. Epinephrine 0.1 mg/kg (0.1 mL/kg of 1:1,000 dilution) IO
B. Atropine 0.02 mg/kg IO
C. Amiodarone 5 mg/kg IO
D. Magnesium sulfate 25 to 50 mg/kg IO

For further information: see the PALS Provider Manual Chapter 7: Recognition and Management of Cardiac Arrest, Chapter 9: Pharmacology, and the PALS Course Guide Part 10: Pharmacology.

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8. **Parents of a 1-year-old female phoned the Emergency Response System when they picked up their daughter from the baby-sitter. Paramedics perform a general assessment revealing an obtunded infant with irregular breathing, bruises over the abdomen, abdominal distention, and cyanosis. Assisted bag-mask ventilation with 100% oxygen is initiated. On primary assessment heart rate is 36/min, peripheral pulses cannot be palpated, and central pulses are barely palpable. Cardiac monitor shows sinus bradycardia. Chest compressions are started with a 15:2 compression-to-ventilation ratio. In the emergency department the infant is intubated and ventilated with 100% oxygen, and IV access is established. The heart rate is now up to 150/min but there are weak central pulses and no distal pulses. Systolic blood pressure is 74 mm Hg. Of the following, which would be most useful in management of this infant?**

A. Epinephrine 0.01 mg/kg (0.1 mL/kg of 1:10,000 dilution) IV
B. Rapid bolus of 20 mL/kg of isotonic fluid
C. Atropine 0.02 mg/kg IV
D. Synchronized cardioversion

For further information: see the PALS Provider Manual Chapter 6: Recognition and Management of Bradyarrhythmias and Tachyarrhythmias, Chapter 9: Pharmacology, and the PALS Course Guide Part 10: Pharmacology.

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9. **Which of the following statements about calcium is true?**

A. Routine administration of calcium is not indicated during cardiac arrest.
B. The recommended dose is 1 to 2 mg/kg of calcium chloride
C. Calcium chloride 10% has the same bioavailability of elemental calcium as calcium gluconate in critically ill children
D. Indications for administration of calcium include hypercalcemia, hypokalemia, and hypomagnesemia

For further information: see the PALS Provider Manual Chapter 9: Pharmacology, and the PALS Course Guide Part 10: Pharmacology.

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10. **An infant with a history of vomiting and diarrhea arrives by ambulance. During your primary assessment the infant responds only to painful stimulation. The upper airway is patent, the respiratory rate is 40/min with good bilateral breath sounds, and 100% oxygen is being administered. The infant has cool extremities, weak pulses, and a capillary refill time of more than 5 seconds. The infant's blood pressure is 85/65 mm Hg, and glucose concentration (measured by bedside test) is 30 mg/dL. Which of the following is the most appropriate treatment to provide for this infant?**

A. Establish IV or IO access and administer 20 mL/kg $D_5$0.45% sodium chloride bolus over 15 minutes
B. Establish IV or IO access and administer 20 mL/kg Lactated Ringer's solution over 60 minutes
C. Perform endotracheal intubation and administer epinephrine 0.1 mg/kg 1:1,000 via the endotracheal tube
D. Establish IV or IO access, administer 20 mL/kg isotonic crystalloid over 10 to 20 minutes, and simultaneously administer $D_{25}W$ 2 to 4 mL/kg in a separate infusion

For further information: see the PALS Provider Manual Chapter 4: Recognition of Shock, Chapter 5: Management of Shock, Chapter 9: Pharmacology, and the PALS Course Guide Part 10: Pharmacology.

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11. **General assessment of a 9-year-old male with increased work of breathing. reveals the boy to be agitated and leaning forward on the bed with obvious respiratory distress. You administer 100% oxygen by nonrebreathing mask. The patient is speaking in short phrases and tells you that he has asthma but does not carry an inhaler. He has nasal flaring, severe suprasternal and intercostal retractions, and decreased air movement with prolonged expiratory time and wheezing. His SpO2 is 92% (on nonrebreathing mask). What is the next medical therapy to provide to this patient?**

A. Adenosine 0.1 mg/kg
B. Amiodarone 5 mg/kg IV/IO
C. Albuterol by nebulization
D Procainamide 15 mg/kg IV/IO

For further information: see the PALS Provider Manual Chapter 3: Recognition of Respiratory Distress and Failure, Chapter 4: Management of Respiratory Distress and Failure, Chapter 9: Pharmacology, and the PALS Course Guide Part 10: Pharmacology.

Pharmacology Answer Sheet

1. **You are called to help resuscitate an infant with severe symptomatic bradycardia associated with respiratory distress. The bradycardia persists despite establishment of an effective airway, oxygenation, and ventilation. There is no heart block present. Which of the following is the *first drug* you should administer?**

   A. Atropine
   B. Dopamine
   C. Adenosine
   D. Epinephrine

   Correct answer is D. Epinephrine, a catecholamine with direct effects at the β-adrenergic receptor, is the first drug recommended for severe symptomatic bradycardia unresponsive to establishment and support of the airway, oxygenation, and ventilation. Epinephrine is preferred in this setting because it more effectively improves the heart rate in a hypoxic-ischemic myocardium, which is the most common cause of severe symptomatic bradycardia in children.

   Answer A is incorrect. Atropine is indicated only if you suspect that the bradycardia is vagally induced or associated with heart block. Note that some drug toxicities produce increased vagal tone (eg, digoxin overdose). Primary atrioventricular (AV) block is another indication for using atropine preferentially over epinephrine in the treatment of symptomatic bradycardia.

   Answer B is incorrect. Dopamine is not included in the PALS treatment algorithm for severe symptomatic bradycardia. It takes time to prepare a dopamine infusion.

   Answer C is incorrect. Adenosine blocks AV conduction and is used to treat supraventricular tachycardia. It is not recommended for the treatment of severe symptomatic bradycardia.

   For further information: see the PALS Provider Manual Chapter 6: Recognition and Management of Bradyarrhythmias and Tachyarrhythmias, Chapter 9: Pharmacology, and the PALS Course Guide Part 10: Pharmacology.

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2. **Which of the following statements about the effects of epinephrine during attempted resuscitation is true?**

   A. Epinephrine decreases peripheral vascular resistance and reduces myocardial afterload so that ventricular contractions are more effective
   B. Epinephrine improves coronary artery perfusion pressure and stimulates spontaneous contractions when asystole is present
   C. Epinephrine is contraindicated in ventricular fibrillation because it increases myocardial irritability
   D. Epinephrine decreases myocardial oxygen consumption

Correct answer is B. Epinephrine improves coronary artery perfusion pressure and myocardial oxygen delivery during CPR by increasing peripheral vascular resistance and thus aortic diastolic pressure. Recall that coronary perfusion pressure is determined by the difference between aortic end-diastolic pressure and right atrial end-diastolic pressure. Epinephrine also stimulates spontaneous cardiac contractions through its β-adrenergic agonist effects, so it may restore cardiac activity when asystole is present. Increases in heart rate, cardiac contractility, and systemic vascular resistance increase myocardial oxygen demand.

Answer A is incorrect. Epinephrine *increases* peripheral vascular resistance, ventricular afterload, and oxygen demand.

Answer C is incorrect. Epinephrine is useful in the treatment of ventricular fibrillation. It increases the coarseness of ventricular fibrillation, which likely reflects improved coronary artery perfusion, thereby enhancing the potential for termination of ventricular fibrillation by attempted defibrillation.

Answer D is incorrect. Epinephrine *increases* myocardial oxygen consumption. Although epinephrine-induced elevation of coronary artery perfusion pressure during chest compressions enhances delivery of oxygen to the heart, oxygen consumption is increased, not decreased.

For further information: see the PALS Provider Manual Chapter 9: Pharmacology, and the PALS Course Guide Part 10: Pharmacology.

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3. **General assessment of a 2-year-old female reveals her to be alert with mild breathing difficulty during inspiration and pale skin color. On primary assessment, she makes high-pitched inspiratory sounds (mild stridor) when agitated; otherwise her breathing is quiet. Her SpO2 is 92% in room air, and she has mild inspiratory intercostal retractions. Lung auscultation reveals transmitted upper airway sounds with adequate distal breath sounds bilaterally. Which of the following is the most appropriate initial therapy intervention for this child?**

   A. Perform immediate endotracheal intubation
   B. Administer an IV dose of dexamethasone
   C. Nebulize 2.5 mg of albuterol
   D. Administer humidified supplementary oxygen as tolerated and continue evaluation

Correct answer is D. This child is not in acute distress and has no clinical evidence of respiratory failure. Therefore, the most appropriate intervention is to provide humidified oxygen as tolerated and observe the child to determine if she improves, deteriorates, or stays the same.

Answer A is incorrect. This child does not meet the criteria for intubation. If you determine that the child has upper airway obstruction and cannot maintain an airway or if the child demonstrates signs of fatigue or respiratory failure, then endotracheal intubation is

indicated. Intubation of the child with upper airway obstruction can be very difficult, and it should be performed by a provider experienced in airway management.

Answer B is incorrect. Dexamethasone may be an appropriate therapeutic intervention for this child, it but would be given orally if indicated rather than IV.

Answer C is incorrect. Although this child has noisy breathing, the breathing abnormality occurs during inspiration, indicating that this is upper airway obstruction. Albuterol is not helpful for upper airway obstruction. Either nebulized racemic epinephrine or L-epinephrine (ie, IV form of epinephrine) would be appropriate if the child were more symptomatic.

For further information: see the PALS Provider Manual Chapter 2: Recognition of Respiratory Distress and Failure, Chapter 3: Management of Respiratory Distress and Failure, Chapter 9: Pharmacology, and the PALS Course Guide Part 10: Pharmacology.

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4. Which of the following most reliably delivers a high (90% or greater) concentration of inspired oxygen in a toddler or older child?

A. Nasal cannula with 4 L/min oxygen flow
B. Simple oxygen mask with 15 L/min oxygen flow
C. Nonrebreathing face mask with 12 L/min oxygen flow
D. Face tent with 15 L/min oxygen flow

Correct answer is C. With an oxygen flow of 10 to 12 L/min and a good seal between the patient's face and mask, a nonrebreathing face mask with an oxygen reservoir can provide an inspired oxygen concentration of approximately 95%.

Answer A is incorrect. A nasal cannula cannot reliably provide a high concentration of inspired oxygen to a toddler or older child. The inspired oxygen concentration provided by a nasal cannula varies based on the patient's respiratory rate, size (ie, tidal volume), and oxygen flow rate. Although a nasal cannula delivers higher inspired oxygen concentrations to infants than to older children, an oxygen concentration greater than 90% is difficult to achieve, particularly if the infant breathes through the mouth.

Answer B is incorrect. A simple oxygen mask permits entrainment of room air even when a high flow of oxygen is attached to the mask. A simple oxygen mask delivers only about 35% to 60% oxygen with a flow rate of 6 to 10 L/min.

Answer D is incorrect. A face tent still permits entrainment of room air at a rate that varies with the child's respiratory rate, respiratory effort, and size (ie, tidal volume). It can be difficult to keep the face tent in place. Even with a high oxygen flow rate of 10 to 15 L/min, stable inspired oxygen concentrations >40% cannot be reliably provided with a face tent.

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5. **Which of the following statements about endotracheal drug administration is true?**

A. Endotracheal drug administration is the preferred route of drug administration during resuscitation because it results in predictable drug levels and drug effects
B. Endotracheal doses of resuscitation drugs in children have been well established and are supported by evidence from clinical trials
C. Intravenous drug doses for resuscitation drugs should be used whether you give the drugs by the IV, intraosseous (IO), or the endotracheal route
D. Endotracheal drug administration is the least desirable route of administration because this route results in unpredictable drug levels and effects

Correct answer is D. Endotracheal (ET) drug administration is the least desirable route of resuscitation drug administration because optimal doses are unknown and this route results in unpredictable drug levels and effects. In fact, poor absorption of epinephrine by ET route may result in relatively low plasma concentration of epinephrine during resuscitation. Evidence from animal models suggests that the low epinephrine plasma concentrations following ET administration may result in preferential stimulation of β_2-adrenergic receptors (producing vasodilation) rather than the α-adrenergic receptors that would produce the vasoconstriction needed during resuscitation.

Answers A and B are incorrect. There is limited clinical evidence about optimal drug doses to be administered by the ET route to produce specific drug concentrations and effects.

Answer C is incorrect. Although evidence is limited, it is clear that higher doses than those used for IV/IO route of administration should be used when drugs are administered by ET route.

For further information: see the PALS Provider Manual Chapter 7: Recognition and Management of Cardiac Arrest, Chapter 9: Pharmacology, and the PALS Course Guide Part 10: Pharmacology.

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6. **Which of the following statements most accurately reflects the PALS recommendations for the use of magnesium sulfate in the treatment of cardiac arrest?**

A. Magnesium sulfate is indicated for VF refractory to repeated shocks and amiodarone or lidocaine
B. Routine use of magnesium sulfate is indicated for shock-refractory monomorphic VT
C. Magnesium sulfate is indicated for torsades de pointes or suspected hypomagnesemia
D. Magnesium sulfate is contraindicated in VT associated with an abnormal QT interval during the preceding sinus rhythm

Correct answer is C. Acting as an antiarrhythmic agent, magnesium sulfate is the *drug of choice* for treatment of torsades de pointes ("twisting of the point"), a distinctive form of polymorphic VT. Torsades is characterized by QRS complexes that change in amplitude and polarity with each beat so that they appear to rotate around an isoelectric line. Magnesium sulfate is also recommended for pulseless VT/VF associated with suspected hypomagnesemia.

Answer A is incorrect. Magnesium sulfate is not recommended for VF refractory to repeated shocks, amiodarone, or lidocaine. There is insufficient evidence to recommend the routine use of magnesium sulfate in the treatment of pediatric cardiac arrest.

Answer B is incorrect. Routine use of magnesium sulfate is not recommended for shock-refractory monomorphic VT. Two observational studies in adults, however, showed that magnesium alone is effective in the treatment of polymorphic VT (eg, torsades de pointes) in patients with prolonged QT interval.

Answer D is incorrect. Magnesium sulfate is indicated in VT associated with a prolonged QT interval during the sinus rhythm that preceded the development of torsades de pointes. Characteristically torsades de pointes is associated with a markedly prolonged baseline QT interval before the onset of the arrhythmia. Note that the QT interval must be evaluated during sinus rhythm and cannot be measured during an episode of ventricular tachycardia.

For further information: see the PALS Provider Manual Chapter 6: Recognition and Management of Bradyarrhythmias and Tachyarrhythmias, Chapter 7: Recognition and Management of Cardiac Arrest, Chapter 9: Pharmacology, and the PALS Course Guide Part 10: Pharmacology.

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7. **You enter a room to perform a general assessment of a previously stable 10-year-old male and find him unresponsive and apneic. A code is called and bag-mask ventilation is performed with 100% oxygen. The cardiac monitor shows a wide-complex tachycardia. The boy has no detectable pulses. You deliver an unsynchronized shock with 2 J/kg. The rhythm check after 2 minutes of CPR reveals VF. You then deliver a shock of 4 J/kg and resume immediate CPR beginning with compressions. A team member had established IO access, so you give a dose of epinephrine, 0.01 mg/kg (0.1 mL/kg of 1:10,000 dilution) IO when CPR is restarted after the second shock. At the next rhythm check, persistent VF is present. You administer a 4 J/kg shock and resume CPR. Based on the PALS Pulseless Arrest Algorithm, what are the next drug and dose to administer when CPR is restarted?**

A. Epinephrine 0.1 mg/kg (0.1 mL/kg of 1:1,000 dilution) IO
B. Atropine 0.02 mg/kg IO
C. Amiodarone 5 mg/kg IO
D. Magnesium sulfate 25 to 50 mg/kg IO

Correct answer is C. The data supporting the use of amiodarone in the treatment of life-threatening ventricular arrhythmias in children is extrapolated from adult studies showing short-term beneficial effects for treatment of shock-refractory VF or VT. In addition, amiodarone has been reported to be effective in the treatment of atrial and ventricular arrhythmias in children. Amiodarone is recommended as part of the treatment of shock-refractory or recurrent VT. Amiodarone inhibits α-adrenergic and β-adrenergic receptors, producing vasodilation and AV nodal suppression (ie, impaired conduction through the AV node). Amiodarone also inhibits the outward potassium current, thereby

prolonging the QT interval. Amiodarone slows AV conduction, prolongs the AV refractory period and QT interval, and slows ventricular conduction (widens the QRS).

Answer A is incorrect. There is no survival benefit from routine use of *high-dose* epinephrine, and it may be harmful, particularly in asphyxial arrest. High-dose epinephrine may be considered for special resuscitation circumstances, eg. calcium channel blocker overdose or β-adrenergic blocker overdose.

Answer B is incorrect. There is no evidence that atropine improves outcome from pediatric cardiac arrest. The only evidence supporting the use of atropine in cardiac arrest is from adult patients with a slow PEA. Thus, atropine is not indicated for refractory VF cardiac arrest in children.

Answer D is incorrect. Magnesium sulfate is the drug of choice for treatment of torsades de pointes and can be given for pulseless VT or VF with suspected hypomagnesemia. There is insufficient data to recommend the routine use of magnesium sulfate for pediatric cardiac arrest.

For further information: see the PALS Provider Manual Chapter 7: Recognition and Management of Cardiac Arrest, Chapter 9: Pharmacology, and the PALS Course Guide Part 10: Pharmacology.

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8. **Parents of a 1-year-old female phoned the Emergency Response System when they picked up their daughter from the baby-sitter. Paramedics perform a general assessment revealing an obtunded infant with irregular breathing, bruises over the abdomen, abdominal distention, and cyanosis. Assisted bag-mask ventilation with 100% oxygen is initiated. On primary assessment heart rate is 36/min, peripheral pulses cannot be palpated, and central pulses are barely palpable. Cardiac monitor shows sinus bradycardia. Chest compressions are started with a 15:2 compression-to-ventilation ratio. In the emergency department the infant is intubated and ventilated with 100% oxygen, and IV access is established. The heart rate is now up to 150/min but there are weak central pulses and no distal pulses. Systolic blood pressure is 74 mm Hg. Of the following, which would be most useful in management of this infant?**

   A. Epinephrine 0.01 mg/kg (0.1 mL/kg of 1:10,000 dilution) IV
   B. Rapid bolus of 20 mL/kg of isotonic fluid
   C. Atropine 0.02 mg/kg IV
   D. Synchronized cardioversion

Correct answer is B. This infant is in shock with poor perfusion, most likely secondary to inflicted trauma. The most important initial therapy is to give isotonic fluid rapidly and anticipate the need to give blood. In addition, you should consult a trauma surgeon.

Answer A is incorrect. Epinephrine is not indicated in the treatment of this patient with hypovolemic shock. The child's blood pressure is borderline acceptable but the exam confirms poor perfusion, and rather than using a vasoconstrictor, this infant needs rapid fluid resuscitation.

Answer C is incorrect. Atropine is indicated in the treatment of symptomatic bradycardia unresponsive to oxygenation and ventilation if increased vagal tone or primary AV block is suspected. This child's heart rate increased when oxygenation and ventilation were provided.

Answer D is incorrect. This child's tachycardia is a sinus tachycardia. The poor perfusion is likely the result of trauma and hypovolemia. The tachycardia should not be treated with synchronized cardioversion.

For further information: see the PALS Provider Manual Chapter 6: Recognition and Management of Bradyarrhythmias and Tachyarrhythmias, Chapter 9: Pharmacology, and the PALS Course Guide Part 10: Pharmacology.

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9. Which of the following statements about calcium is true?

A. **Routine administration of calcium is not indicated during cardiac arrest.**
B. The recommended dose is 1 to 2 mg/kg of calcium chloride
C. Calcium chloride 10% has the same bioavailability of elemental calcium as calcium gluconate in critically ill children
D. Indications for administration of calcium include hypercalcemia, hypokalemia, and hypomagnesemia

Correct answer is A. Routine administration of calcium is not recommended for the treatment of cardiac arrest because there is insufficient evidence that it improves outcome. In addition, several studies have implicated cytoplasmic calcium accumulation in the final common pathway of cell death. Calcium accumulation in cells occurs after ischemia and during reperfusion of ischemic organs. Therefore, routine administration of calcium during resuscitation of children in pulseless arrest cannot be recommended.

Answer B is incorrect. There is little high-quality data about the optimal emergency dose of calcium, but clinical experience shows that the recommended dose is approximately 20 mg/kg of calcium chloride or 5 to 7 mg/kg of elemental calcium.

Answer C is incorrect. Calcium chloride 10% (100 mg/mL) is the calcium preparation of choice in critically ill children because it provides greater bioavailability of calcium than calcium gluconate. Free calcium is released by calcium gluconate after hepatic metabolism, so it does not appear to be as rapidly effective. A dose of 0.2 mL/kg of 10% calcium chloride will provide 20 mg/kg of the salt and 5.4 mg/kg of elemental calcium. Further doses should be based on measured deficits of ionized calcium.

Answer D is incorrect. Indications for administration of calcium include hypocalcemia and hyperkalemia, and it may be considered for the treatment of hypermagnesemia and calcium channel blocker overdose. Hypokalemia and hypomagnesemia will not be aided by calcium administration. Ionized hypocalcemia is relatively common in critically ill children, particularly those with sepsis.

For further information: see the PALS Provider Manual Chapter 9: Pharmacology, and the PALS Course Guide Part 10: Pharmacology.

10. **An infant with a history of vomiting and diarrhea arrives by ambulance. During your primary assessment the infant responds only to painful stimulation. The upper airway is patent, the respiratory rate is 40/min with good bilateral breath sounds, and 100% oxygen is being administered. The infant has cool extremities, weak pulses, and a capillary refill time of more than 5 seconds. The infant's blood pressure is 85/65 mm Hg, and glucose concentration (measured by bedside test) is 30 mg/dL. Which of the following is the most appropriate treatment to provide for this infant?**

A. Establish IV or IO access and administer 20 mL/kg D50.45% sodium chloride bolus over 15 minutes
B. Establish IV or IO access and administer 20 mL/kg Lactated Ringer's solution over 60 minutes
C. Perform endotracheal intubation and administer epinephrine 0.1 mg/kg 1:1,000 via the endotracheal tube
D. **Establish IV or IO access, administer 20 mL/kg isotonic crystalloid over 10 to 20 minutes, and simultaneously administer D25W 2 to 4 mL/kg in a separate infusion**

Correct answer is D. This infant is in shock with signs of poor perfusion (cool extremities, weak pulses, and prolonged capillary refill). The history of vomiting and diarrhea suggests that hypovolemic shock is present, so immediate volume resuscitation is needed. The infant is also hypoglycemic (lowest acceptable glucose concentration for an infant is 60 mg/dL) and requires an intravenous infusion of dextrose (glucose). IV dextrose is commonly administered as $D_{25}W$ 2 to 4 mL/kg or $D_{10}W$ 5 to 10 mL/kg, both equal to 0.5 to 1 g/kg. Reassess the infant's perfusion after the bolus and reassess the serum glucose concentration after administration of dextrose.

Answer A is incorrect. You should not routinely use glucose solutions for volume resuscitation. In addition, you should use an isotonic rather than hypotonic (ie, 0.45% NaCl) fluid for volume resuscitation. Administer glucose separately if the patient has documented hypoglycemia.

Answer B is incorrect. Fluid resuscitation in an infant with signs of shock should be accomplished rapidly by administration of 20 mL/kg boluses over 20 minutes or less. Administration of fluids over 60 minutes is too slow to restore intravascular volume and improve systemic perfusion.

Answer C is incorrect. This infant's airway and breathing appear to be adequate at this time. Therefore, the first priority for resuscitation in this infant with signs of hypovolemic shock is support of circulation with volume administration. Volume administration should not be delayed to perform endotracheal intubation. Furthermore, there is no indication for epinephrine administration. This infant requires volume administration and dextrose, which should be provided without delay.

For further information: see the PALS Provider Manual Chapter 4: Recognition of Shock, Chapter 5: Management of Shock, Chapter 9: Pharmacology, and the PALS Course Guide Part 10: Pharmacology.

11. **General assessment of a 9-year-old male with increased work of breathing. reveals the boy to be agitated and leaning forward on the bed with obvious respiratory distress. You administer 100% oxygen by nonrebreathing mask. The patient is speaking in short phrases and tells you that he has asthma but does not carry an inhaler. He has nasal flaring, severe suprasternal and intercostal retractions, and decreased air movement with prolonged expiratory time and wheezing. His SpO2 is 92% (on nonrebreathing mask). What is the next medical therapy to provide to this patient?**

A. Adenosine 0.1 mg/kg
B. Amiodarone 5 mg/kg IV/IO
C. Albuterol by nebulization
D. Procainamide 15 mg/kg IV/IO

Correct answer is C. Albuterol (salbutamol outside of the United States) is a β_2-adrenergic agonist bronchodilator and an essential element of first-line therapy in status asthmaticus. Albuterol mediates bronchodilation via stimulation of β_2-adrenergic receptors in airway smooth muscle, which in turn produces smooth-muscle relaxation. Albuterol is preferred over epinephrine for its relative β_2-adrenergic selectivity, with decreased likelihood of β_1-adrenergic cardiovascular effects. Albuterol can be administered by inhaled (via nebulization or MDI) and oral routes; orally administered albuterol is ineffective in severe asthma. It is also important to recall that combined nebulized treatments with albuterol and ipratropium bromide are recommended in children with severe asthma as illustrated in this case.

Answer A is incorrect. Adenosine is not indicated in the treatment of asthma.

Answer B is incorrect. Amiodarone is not indicated in the treatment of asthma.

Answer D is incorrect. Procainamide is not indicated in the treatment of asthma.

For further information: see the PALS Provider Manual Chapter 3: Recognition of Respiratory Distress and Failure, Chapter 4: Management of Respiratory Distress and Failure, Chapter 9: Pharmacology, and the PALS Course Guide Part 10: Pharmacology.