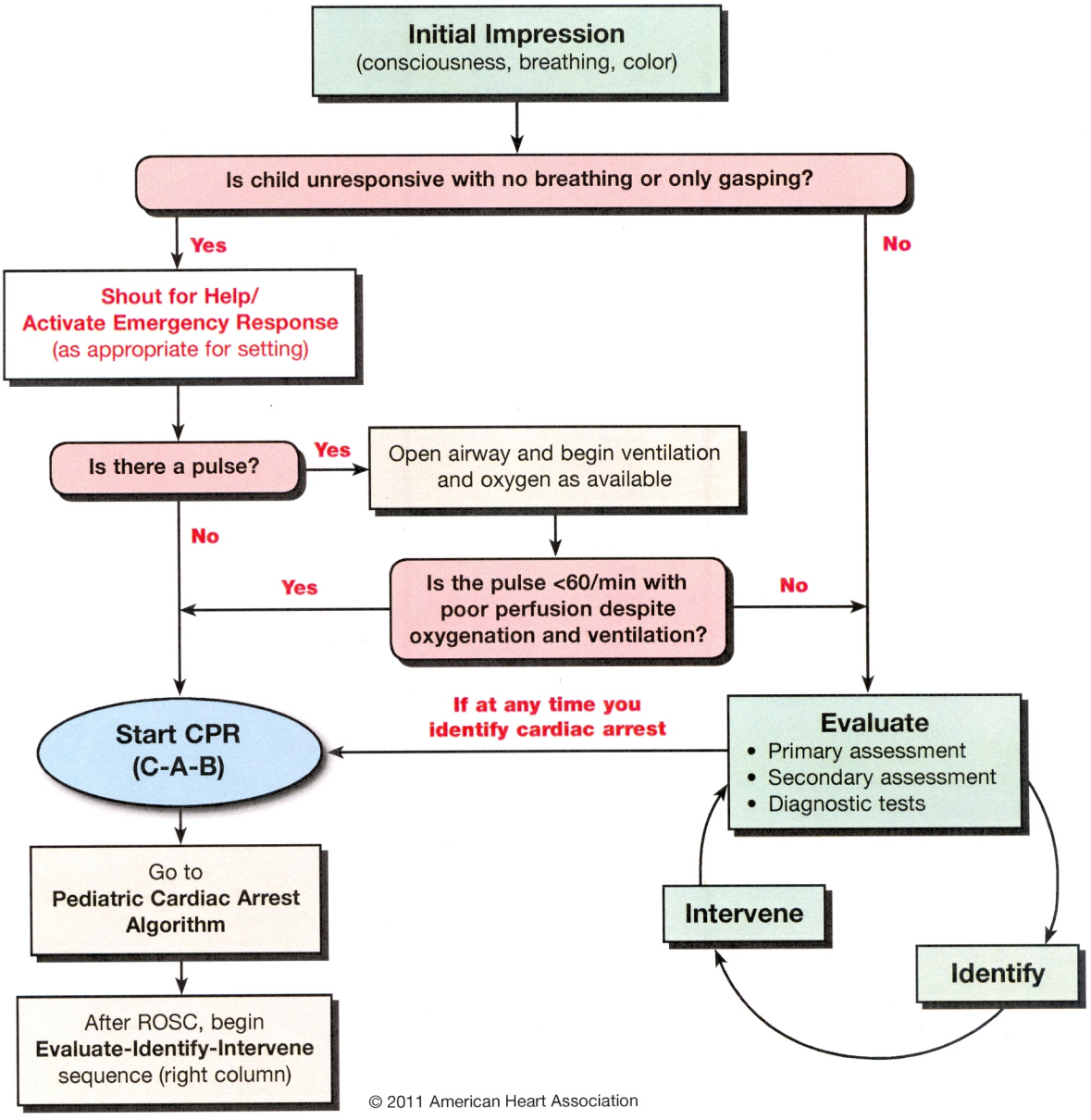
PALS Algorithms
by D.Abbas al hosainy

1. PALS Systematic Approach Algorithm
2. Management of Shock Flowchart
3. Recognition of Shock Flowchart
4. Management of Respiratory Emergencies Flowchart
5. Recognition of Respiratory Problems Flowchart
6. Pediatric Cardiac Arrest Algorithm
7. Pediatric Bradycardia With a Pulse and Poor Perfusion Algorithm
8. Pediatric Tachycardia With a Pulse and Adequate Perfusion Algorithm
9. Pediatric Tachycardia With a Pulse and Poor Perfusion Algorithm
10. Pediatric Postresuscitation Care

PALS Systematic Approach Algorithm

The PALS Systematic Approach Algorithm outlines the approach to caring for a critically ill or injured child.

American Heart Association®



Management of Shock Flowchart

American Heart Association®

Management of Shock Flowchart

- Oxygen
- Pulse oximetry
- ECG monitor
- IV/IO access
- BLS as indicated
- Point-of-care glucose testing

Hypovolemic Shock

Specific Management for Selected Conditions

Nonhemorrhagic	Hemorrhagic
• 20 mL/kg NS/LR bolus, repeat as needed • Consider colloid	• Control external bleeding • 20 mL/kg NS/LR bolus, repeat 2 or 3× as needed • Transfuse PRBCs as indicated

Distributive Shock

Specific Management for Selected Conditions

Septic	Anaphylactic	Neurogenic
Management Algorithm: • Septic Shock	• IM epinephrine (or autoinjector) • Fluid boluses (20 mL/kg NS/LR) • Albuterol • Antihistamines, corticosteroids • Epinephrine infusion	• 20 mL/kg NS/LR bolus, repeat PRN • Vasopressor

Cardiogenic Shock

Specific Management for Selected Conditions

Bradyarrhythmia/Tachyarrhythmia	Other (eg, CHD, Myocarditis, Cardiomyopathy, Poisoning)
Management Algorithms: • Bradycardia • Tachycardia With Poor Perfusion	• 5 to 10 mL/kg NS/LR bolus, repeat PRN • Vasoactive infusion • Consider expert consultation

Obstructive Shock

Specific Management for Selected Conditions

Ductal-Dependent (LV Outflow Obstruction)	Tension Pneumothorax	Cardiac Tamponade	Pulmonary Embolism
• Prostaglandin E_1 • Expert consultation	• Needle decompression • Tube thoracostomy	• Pericardiocentesis • 20 mL/kg NS/LR bolus	• 20 mL/kg NS/LR bolus, repeat PRN • Consider thrombolytics, anticoagulants • Expert consultation

Recognition of Shock Flowchart

American Heart Association®

	Clinical Signs	Hypovolemic Shock	Distributive Shock	Cardiogenic Shock	Obstructive Shock
A	Patency	Airway open and maintainable/not maintainable			
B	Respiratory rate	Increased			
	Respiratory effort	Normal to increased		Labored	
	Breath sounds	Normal	Normal (± crackles)	Crackles, grunting	
C	Systolic blood pressure	**Compensated Shock → Hypotensive Shock**			
	Pulse pressure	Narrow	Variable	Narrow	
	Heart rate	Increased			
	Peripheral pulse quality	Weak	Bounding or weak	Weak	
	Skin	Pale, cool	Warm or cool	Pale, cool	
	Capillary refill	Delayed	Variable	Delayed	
	Urine output	Decreased			
D	Level of consciousness	Irritable early Lethargic late			
E	Temperature	Variable			

Management of Respiratory Emergencies Flowchart

American Heart Association®

Management of Respiratory Emergencies Flowchart

- Airway positioning
- Suction as needed
- Oxygen
- Pulse oximetry
- ECG monitor (as indicated)
- BLS as indicated

Upper Airway Obstruction
Specific Management for Selected Conditions

Croup	Anaphylaxis	Aspiration Foreign Body
• Nebulized epinephrine • Corticosteroids	• IM epinephrine (or autoinjector) • Albuterol • Antihistamines • Corticosteroids	• Allow position of comfort • Specialty consultation

Lower Airway Obstruction
Specific Management for Selected Conditions

Bronchiolitis	Asthma
• Nasal suctioning • Bronchodilator trial	• Albuterol ± ipratropium • Corticosteroids • Subcutaneous epinephrine • Magnesium sulfate • Terbutaline

Lung Tissue Disease
Specific Management for Selected Conditions

Pneumonia/Pneumonitis Infectious Chemical Aspiration	Pulmonary Edema Cardiogenic or Noncardiogenic (ARDS)
• Albuterol • Antibiotics (as indicated)	• Consider noninvasive or invasive ventilatory support with PEEP • Consider vasoactive support • Consider diuretic

Disordered Control of Breathing
Specific Management for Selected Conditions

Increased ICP	Poisoning/Overdose	Neuromuscular Disease
• Avoid hypoxemia • Avoid hypercarbia • Avoid hyperthermia	• Antidote (if available) • Contact poison control	• Consider noninvasive or invasive ventilatory support

Recognition of Respiratory Problems Flowchart

American Heart Association®

Pediatric Advanced Life Support

Signs of Respiratory Problems

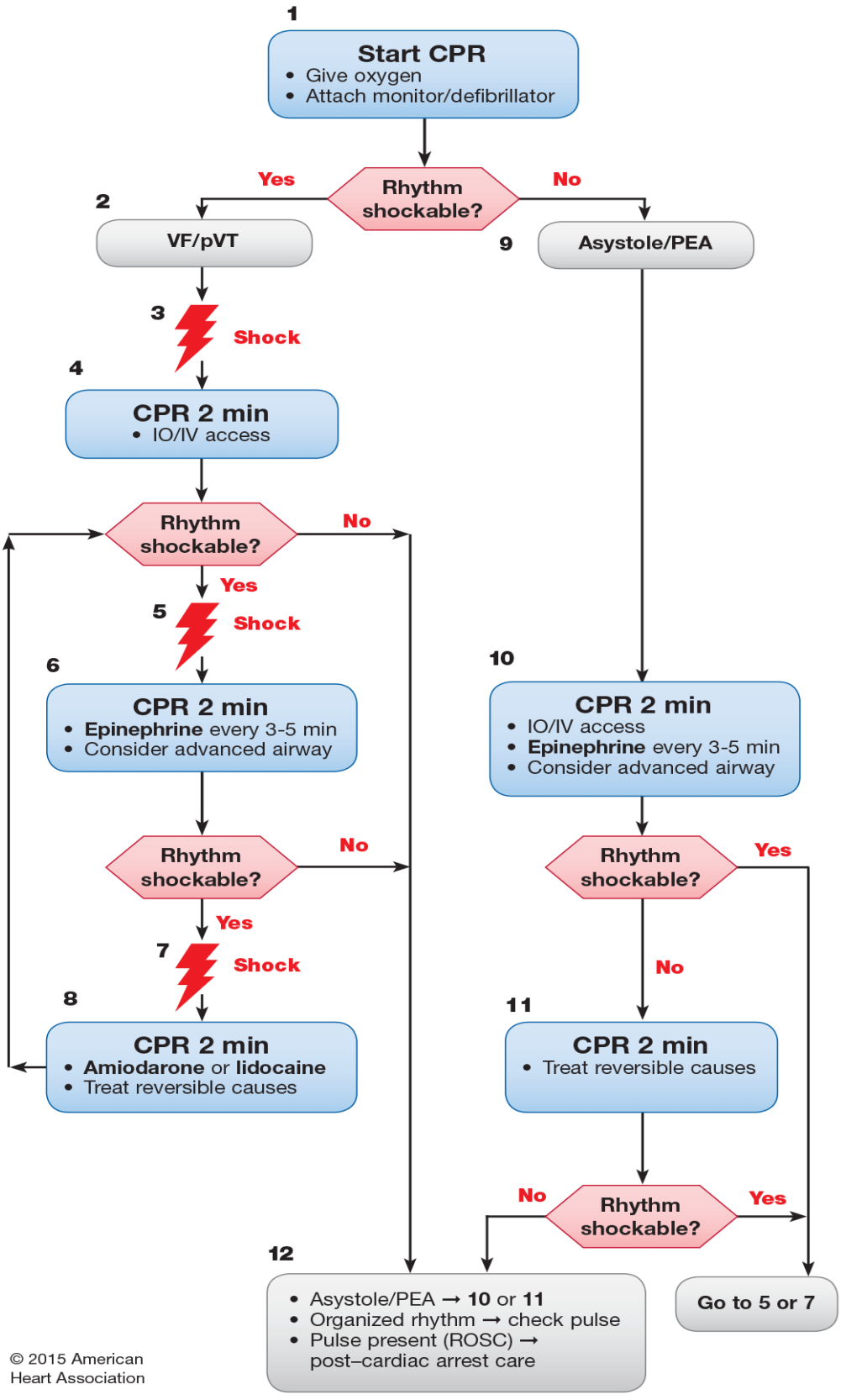
	Clinical Signs	Upper Airway Obstruction	Lower Airway Obstruction	Lung Tissue Disease	Disordered Control of Breathing
A	Patency	Airway open and maintainable/not maintainable			
B	Respiratory Rate/Effort	Increased			Variable
B	Breath Sounds	Stridor (typically inspiratory) Barking cough Hoarseness	Wheezing (typically expiratory) Prolonged expiratory phase	Grunting Crackles Decreased breath sounds	Normal
B	Air Movement	Decreased			Variable
C	Heart Rate	Tachycardia (early) Bradycardia (late)			
C	Skin	Pallor, cool skin (early) Cyanosis (late)			
D	Level of Consciousness	Anxiety, agitation (early) Lethargy, unresponsiveness (late)			
E	Temperature	Variable			

Pediatric Advanced Life Support

Identification of Respiratory Problems by Severity

	Respiratory Distress → Respiratory Failure
A	Open and maintainable ⇨ Not maintainable
B	Tachypnea ⇨ Bradypnea to apnea
B	Work of breathing (nasal flaring/retractions) Increased effort ⇨ Decreased effort ⇨ Apnea
B	Good air movement ⇨ Poor to absent air movement
C	Tachycardia ⇨ Bradycardia
C	Pallor ⇨ Cyanosis
D	Anxiety, agitation ⇨ Lethargy to unresponsiveness
E	Variable temperature

Pediatric Cardiac Arrest Algorithm—2015 Update



CPR Quality

- Push hard (≥⅓ of anteroposterior diameter of chest) and fast (100-120/min) and allow complete chest recoil.
- Minimize interruptions in compressions.
- Avoid excessive ventilation.
- Rotate compressor every 2 minutes, or sooner if fatigued.
- If no advanced airway, 15:2 compression-ventilation ratio.

Shock Energy for Defibrillation

First shock 2 J/kg, second shock 4 J/kg, subsequent shocks ≥4 J/kg, maximum 10 J/kg or adult dose

Drug Therapy

- **Epinephrine IO/IV dose:** 0.01 mg/kg (0.1 mL/kg of 1:10 000 concentration). Repeat every 3-5 minutes.
  If no IO/IV access, may give endotracheal dose: 0.1 mg/kg (0.1 mL/kg of 1:1000 concentration).
- **Amiodarone IO/IV dose:** 5 mg/kg bolus during cardiac arrest. May repeat up to 2 times for refractory VF/pulseless VT.
- **Lidocaine IO/IV dose:** Initial: 1 mg/kg loading dose. Maintenance: 20-50 mcg/kg per minute infusion (repeat bolus dose if infusion initiated >15 minutes after initial bolus therapy).

Advanced Airway

- Endotracheal intubation or supraglottic advanced airway
- Waveform capnography or capnometry to confirm and monitor ET tube placement
- Once advanced airway in place, give 1 breath every 6 seconds (10 breaths/min) with continuous chest compressions

Return of Spontaneous Circulation (ROSC)

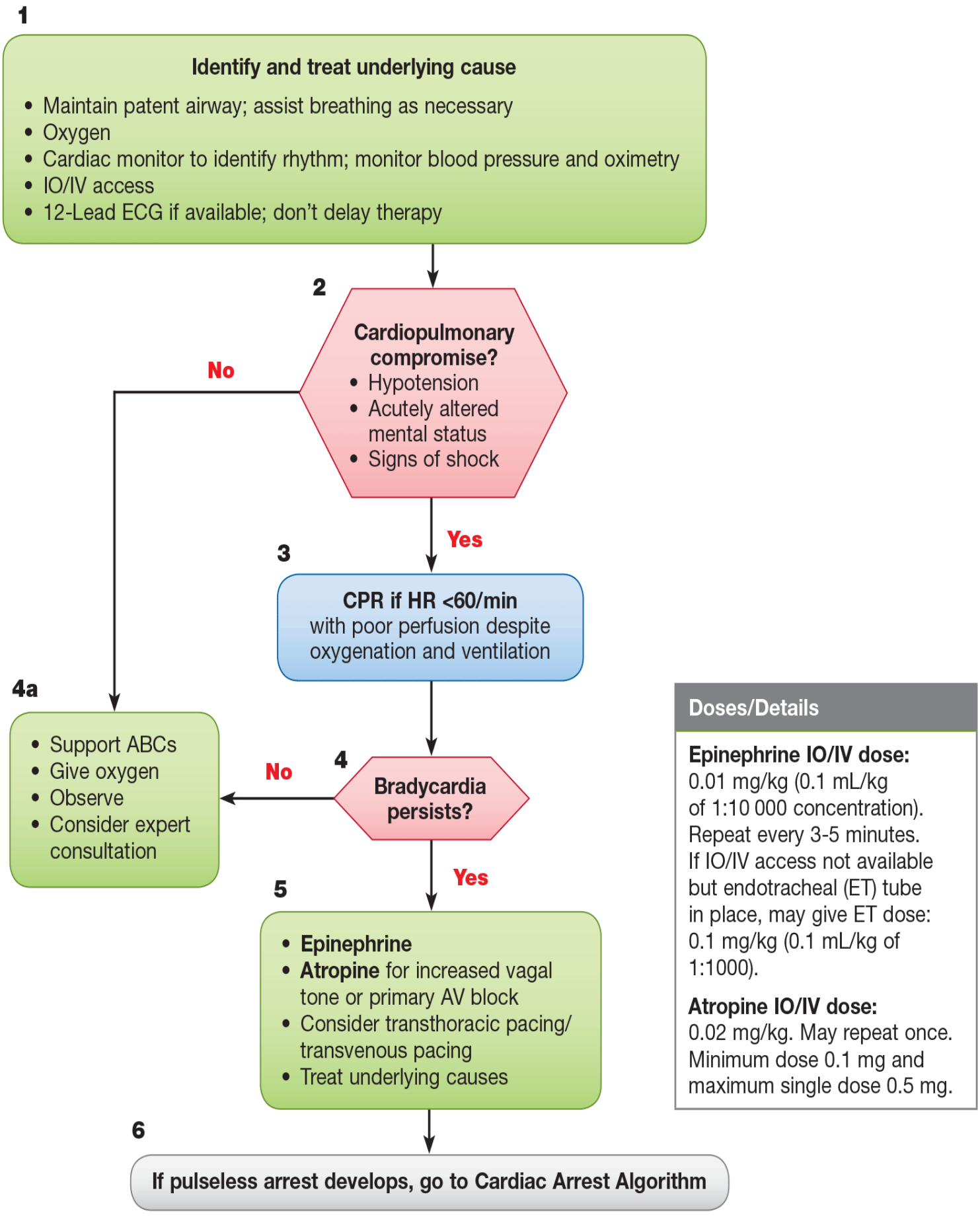
- Pulse and blood pressure
- Spontaneous arterial pressure waves with intra-arterial monitoring

Reversible Causes

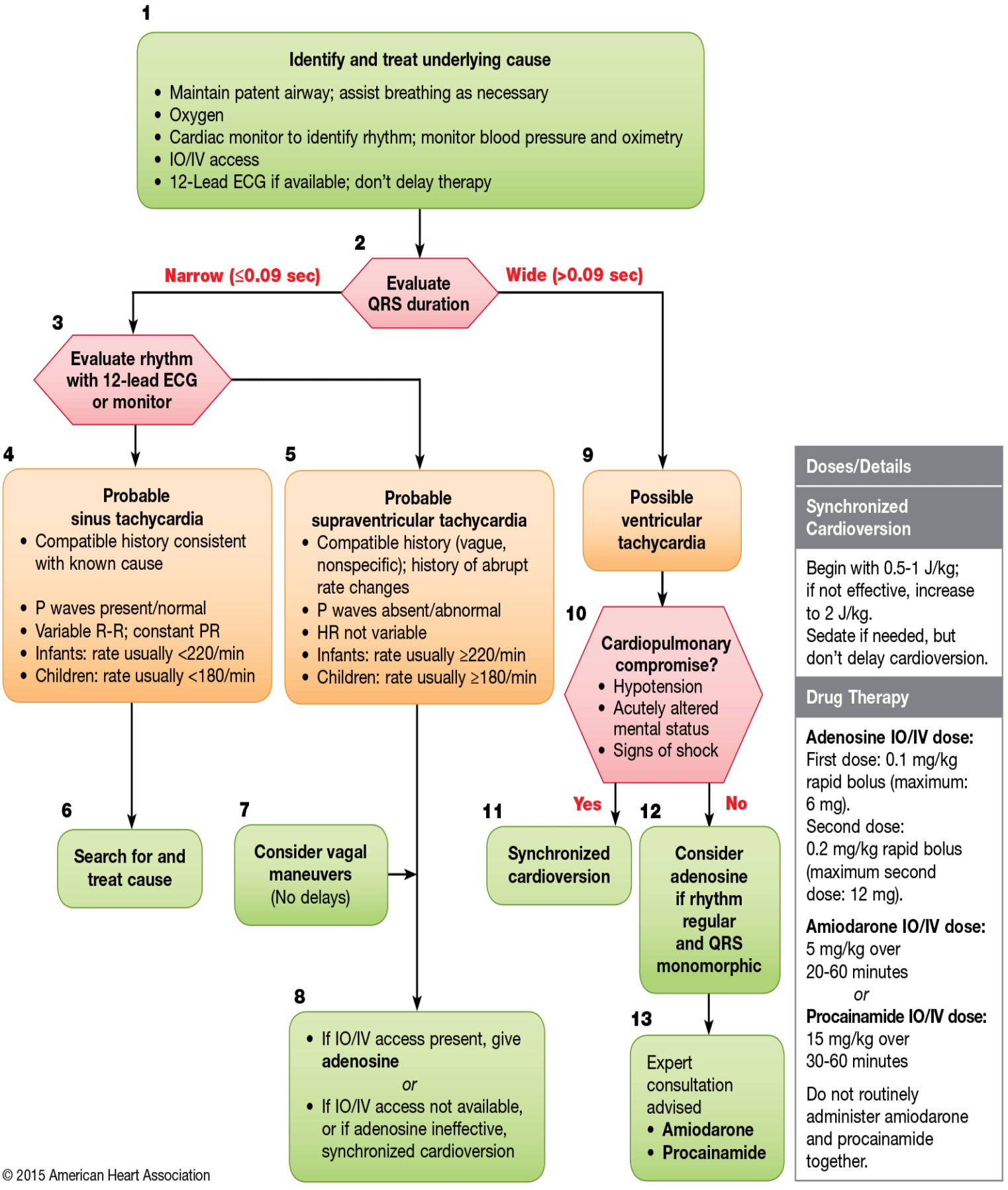
- **H**ypovolemia
- **H**ypoxia
- **H**ydrogen ion (acidosis)
- **H**ypoglycemia
- **H**ypo-/hyperkalemia
- **H**ypothermia
- **T**ension pneumothorax
- **T**amponade, cardiac
- **T**oxins
- **T**hrombosis, pulmonary
- **T**hrombosis, coronary

(Step 1) As soon as the child is found to be unresponsive with no breathing, call for help, send for a defibrillator (manual or AED), and start CPR (with supplementary oxygen if available). Attach ECG monitor or AED pads as soon as available. Throughout resuscitation, emphasis should be placed on provision of high-quality CPR (providing chest compressions of adequate rate and depth, allowing complete chest recoil after each compression, minimizing interruptions in compressions and avoiding excessive ventilation).

Pediatric Bradycardia With a Pulse and Poor Perfusion Algorithm



Pediatric Tachycardia With a Pulse and Poor Perfusion Algorithm



Pediatric Postresuscitation Care

American Heart Association®

American Academy of Pediatrics
DEDICATED TO THE HEALTH OF ALL CHILDREN™

Pediatric Advanced Life Support

Management of Shock After ROSC

Optimize Ventilation and Oxygenation
- Titrate F_{IO_2} to maintain oxyhemoglobin saturation 94%-99%; if possible, wean F_{IO_2} if saturation is 100%
- Consider advanced airway placement and waveform capnography

Assess for and Treat Persistent Shock
- Identify, treat contributing factors.*
- Consider 20 mL/kg IV/IO boluses of isotonic crystalloid. Consider smaller boluses (eg, 10 mL/kg) if poor cardiac function suspected.
- Consider the need for inotropic and/or vasopressor support for fluid-refractory shock.

***Possible Contributing Factors**

Hypovolemia
Hypoxia
Hydrogen ion (acidosis)
Hypoglycemia
Hypo-/hyperkalemia
Hypothermia
Tension pneumothorax
Tamponade, cardiac
Toxins
Thrombosis, pulmonary
Thrombosis, coronary
Trauma

Hypotensive Shock
- Epinephrine
- Dopamine
- Norepinephrine

Normotensive Shock
- Dobutamine
- Dopamine
- Epinephrine
- Milrinone

- Monitor for and treat agitation and seizures
- Monitor for and treat hypoglycemia
- Assess blood gas, serum electrolytes, calcium
- If patient remains comatose after resuscitation from cardiac arrest, consider therapeutic hypothermia (32°C-34°C)
- Consider consultation and patient transport to tertiary care center

Estimation of Maintenance Fluid Requirements

- **Infants <10 kg:** 4 mL/kg per hour

  Example: For an 8-kg infant, estimated maintenance fluid rate
  = 4 mL/kg per hour × 8 kg
  = 32 mL per hour

- **Children 10-20 kg:** 4 mL/kg per hour for the first 10 kg + 2 mL/kg per hour for each kg above 10 kg

  Example: For a 15-kg child, estimated maintenance fluid rate
  = (4 mL/kg per hour × 10 kg)
  + (2 mL/kg per hour × 5 kg)
  = 40 mL/hour + 10 mL/hour
  = 50 mL/hour

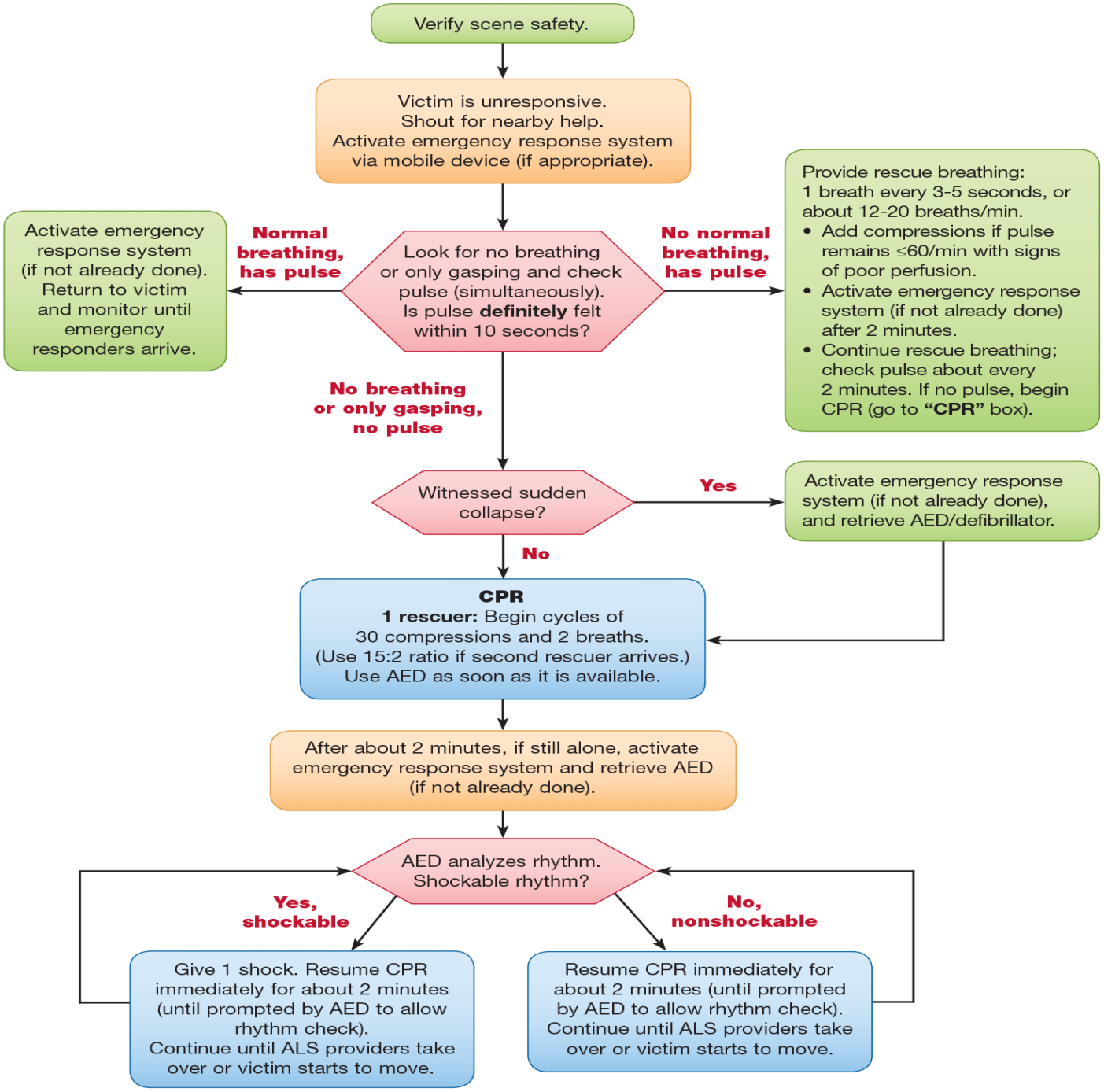
- **Children >20 kg:** 4 mL/kg per hour for the first 10 kg + 2 mL/kg per hour for kg 11-20 + 1 mL/kg per hour for each kg above 20 kg.

  Example: For a 28-kg child, estimated maintenance fluid rate
  = (4 mL/kg per hour × 10 kg)
  + (2 mL/kg per hour × 10 kg)
  + (1 mL/kg per hour × 8 kg)
  = 40 mL per hour + 20 mL per hour
  + 8 mL per hour
  = 68 mL per hour

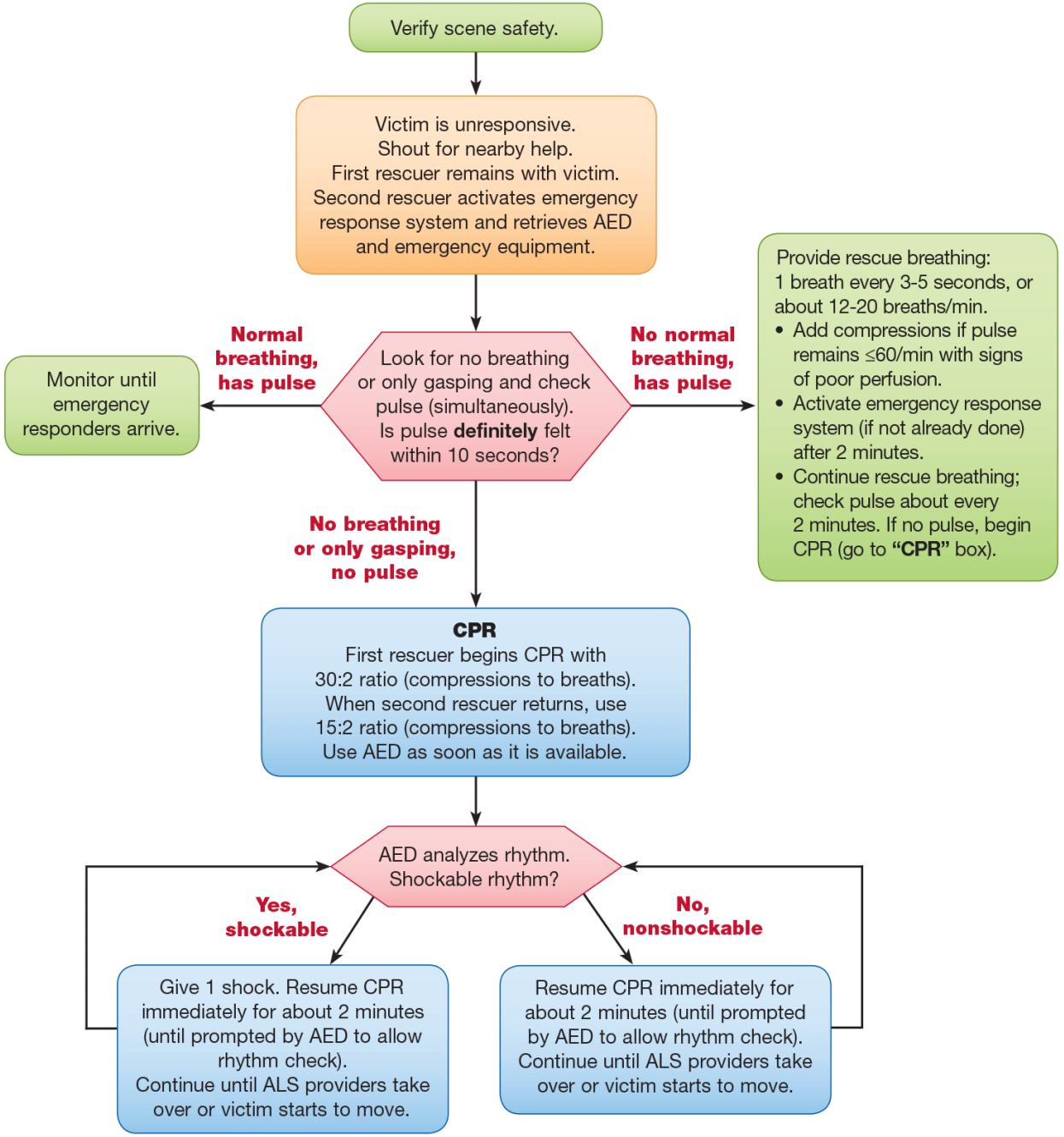
Following initial stabilization, adjust the rate and composition of intravenous fluids based on the patient's clinical condition and state of hydration. In general, provide a continuous infusion of a dextrose-containing solution for infants. Avoid hypotonic solutions in critically ill children; for most patients use isotonic fluid such as normal saline (0.9% NaCl) or lactated Ringer's solution with or without dextrose, based on the child's clinical status.

PALS

BLS Healthcare Provider
Pediatric Cardiac Arrest Algorithm for the Single Rescuer—2015 Update



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

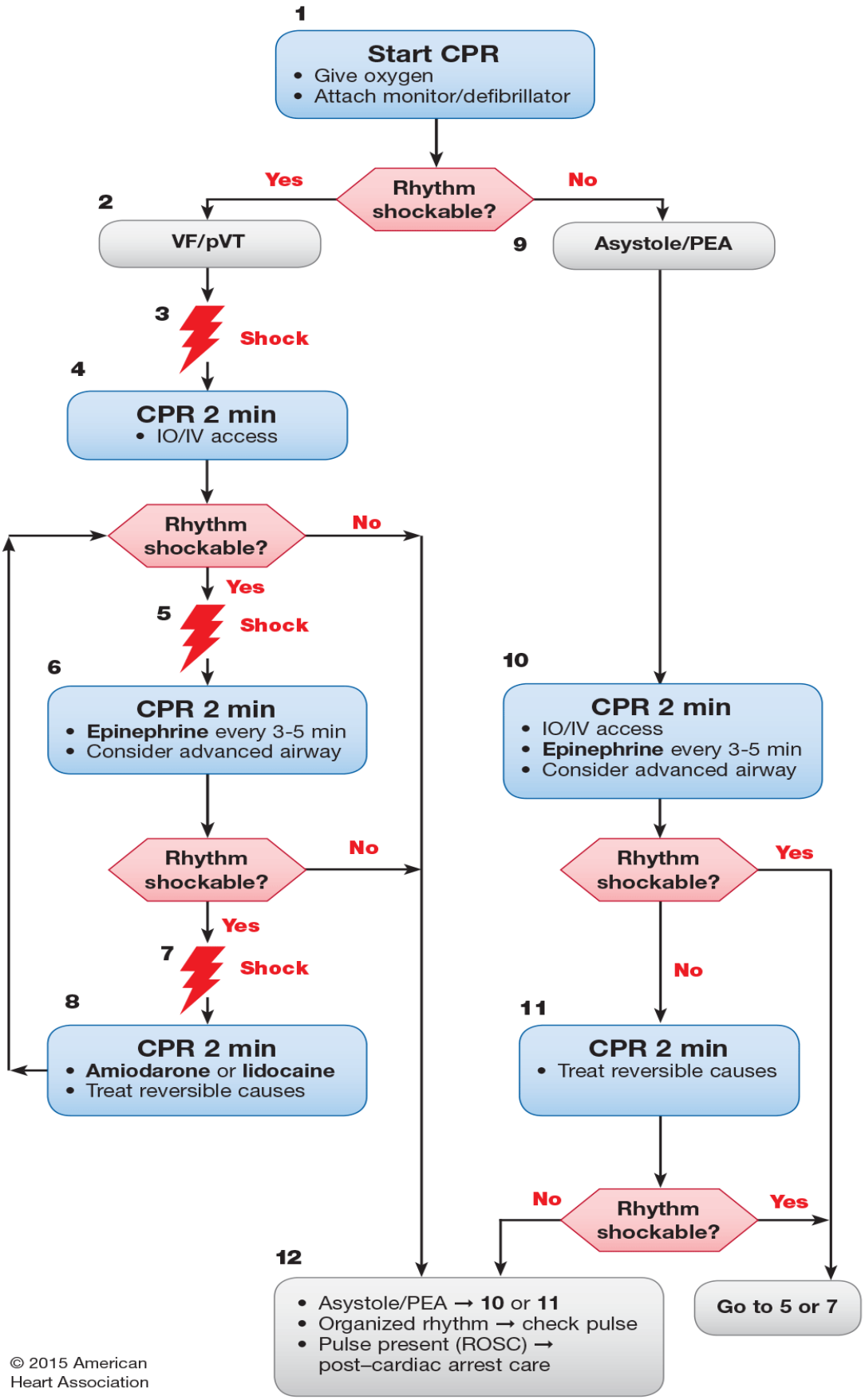


Important considerations for the greatest chance of a successful resuscitation from cardiac arrest include the following:

- Chest compressions should be immediately started by one rescuer, while a second rescuer prepares to start ventilations with a bag and mask.
- **Ventilation is extremely important in pediatrics** because of the large percentage of asphyxial arrests in which best results are obtained by a combination of chest compressions and ventilations.
- Unfortunately ventilations are sometimes delayed because equipment (bag, mask, oxygen, airway) must be mobilized. **Therefore, start CPR with chest compressions immediately**, while a second rescuer prepares to provide ventilations .

- **High-quality CPR**, requires an adequate compression rate (at least **100 - 120** compressions/min), an adequate compression depth (at least one third of the AP diameter of the chest or approximately 1.5 inches [**4 cm**] in infants and approximately 2 inches [**5 cm**] in children), allowing **complete chest recoil** after each compression, **minimizing** interruptions in compressions, and avoiding excessive ventilation.
- Reasons for not performing high-quality CPR include rescuer fatigue, and long or frequent interruptions to secure the airway, check the heart rhythm.
- While one rescuer performs chest compressions and another performs ventilations, other rescuers should obtain a monitor/defibrillator, establish vascular access, and calculate and prepare medications

Pediatric Cardiac Arrest Algorithm—2015 Update



CPR Quality

- Push hard (≥⅓ of anteroposterior diameter of chest) and fast (100-120/min) and allow complete chest recoil.
- Minimize interruptions in compressions.
- Avoid excessive ventilation.
- Rotate compressor every 2 minutes, or sooner if fatigued.
- If no advanced airway, 15:2 compression-ventilation ratio.

Shock Energy for Defibrillation

First shock 2 J/kg, second shock 4 J/kg, subsequent shocks ≥4 J/kg, maximum 10 J/kg or adult dose

Drug Therapy

- **Epinephrine IO/IV dose:** 0.01 mg/kg (0.1 mL/kg of 1:10 000 concentration). Repeat every 3-5 minutes.
  If no IO/IV access, may give endotracheal dose: 0.1 mg/kg (0.1 mL/kg of 1:1000 concentration).
- **Amiodarone IO/IV dose:** 5 mg/kg bolus during cardiac arrest. May repeat up to 2 times for refractory VF/pulseless VT.
- **Lidocaine IO/IV dose:** Initial: 1 mg/kg loading dose. Maintenance: 20-50 mcg/kg per minute infusion (repeat bolus dose if infusion initiated >15 minutes after initial bolus therapy).

Advanced Airway

- Endotracheal intubation or supraglottic advanced airway
- Waveform capnography or capnometry to confirm and monitor ET tube placement
- Once advanced airway in place, give 1 breath every 6 seconds (10 breaths/min) with continuous chest compressions

Return of Spontaneous Circulation (ROSC)

- Pulse and blood pressure
- Spontaneous arterial pressure waves with intra-arterial monitoring

Reversible Causes

- **H**ypovolemia
- **H**ypoxia
- **H**ydrogen ion (acidosis)
- **H**ypoglycemia
- **H**ypo-/hyperkalemia
- **H**ypothermia
- **T**ension pneumothorax
- **T**amponade, cardiac
- **T**oxins
- **T**hrombosis, pulmonary
- **T**hrombosis, coronary

Important considerations in pediatric arrest➔

- Provide CPR until the defibrillator is ready to deliver a shock; after shock delivery, resume CPR, beginning with chest compressions. Minimize interruptions of chest compressions.if rescuers are unwilling or unable to deliver breaths, we recommend rescuers perform compression-only CPR for infants and children in cardiac arrest.

- Ideally **chest compressions should be interrupted only for ventilations (until an advanced airway is in place), rhythm check, and shock delivery.**
- If a "shockable" rhythm is still present, continue chest compressions after a rhythm check while the defibrillator is charging (so chest compressions are delivered until shock delivery).
- **Children with VF/Pulseless VT**, an initial monophasic or biphasic dose of **2 J/kg** may be considered which can be **increased to 4 J/kg** for refractory VF.

- Higher energy levels may be considered, but not to exceed 10 J/kg or the adult maximum dose.
- If sufficient rescuers are present, obtain vascular (IO or IV) access.
- **Epinephrine Dose** is 0.01 mg/kg (0.1 mL/kg of 1:10 000 concentration), max. 1 mg every 3 to 5 minutes.
- It is helpful if a third rescuer prepares the drug doses before the rhythm is checked so epinephrine can be administered as soon as possible.
- Epinephrine should be administered during chest compressions, but the timing of drug administration is less important than the need to minimize interruptions in chest compressions

- **Once an advanced airway is in place, 2 rescuers no longer deliver cycles of CPR**. Instead, the compressing rescuer gives continuous chest compressions without pause for ventilation. The rescuer delivering ventilation provides about 1 breath every 6 seconds (10 breaths per minute).

- Rescuers should rotate the compressor role approximately every 2 minutes to prevent compressor fatigue.
- **If defibrillation successfully restores an organized rhythm, check the child's pulse to determine if a perfusing rhythm is present.**
- If a pulse is present, continue with postresuscitation care.
- If defibrillation is successful but VF recurs, resume CPR and give another bolus of amiodarone before trying to defibrillate with the previously successful shock dose.
- Search for and treat reversible causes

Defibrillators

- Defibrillators are either manual or automated (AED), with monophasic or biphasic waveforms.

Paddle Size➔

- In general, manual defibrillators have two sizes of hand-held paddles: adult and infant.
- The infant paddles may slide over or be located under the adult paddles.
- Use the largest paddles that will fit on the child's chest without touching (when possible, **leave about 3 cm between the paddles or electrodes**).
- An appropriate paddle size is➔
  - "Adult" size (8 to 10 cm) for children >=10 kg(>=1 yr)
  - "Infant" size for infants <10 kg

Interface➔

- The electrode– chest wall interface is part of the self-adhesive pad; in contrast, electrode gel must be applied liberally on manually applied paddles.
- Do not use saline-soaked pads, ultrasound gel, bare paddles, or alcohol pads.

Paddle Position➔

- Place manual paddles over the right side of the upper chest and the apex of the heart (to the left of the nipple over the left lower ribs) so the heart is between the two paddles. Apply firm pressure.

  There is no advantage in an anterior-posterior position of the paddles.

AEDs➔

- Many AEDs can accurately differentiate “shockable” from “nonshockable” Rhythms.

- A child 8 years and weighing >25 kg with sudden collapse should have an AED applied as soon as possible.
- An AED with a pediatric attenuator is ideal for a child 1 to 8 years of age, as this feature allows the delivery of a lower dose of energy in pediatric patients.
- If an AED with an attenuator is not available, use an AED with standard electrodes.
- In infants <1 year of age a manual defibrillator is preferred.
- If a manual defibrillator is not available, an AED with a dose attenuator may be used.
- An AED without a dose attenuator may be used if neither a manual defibrillator nor one with a dose attenuator is available.

Cardioversion➔

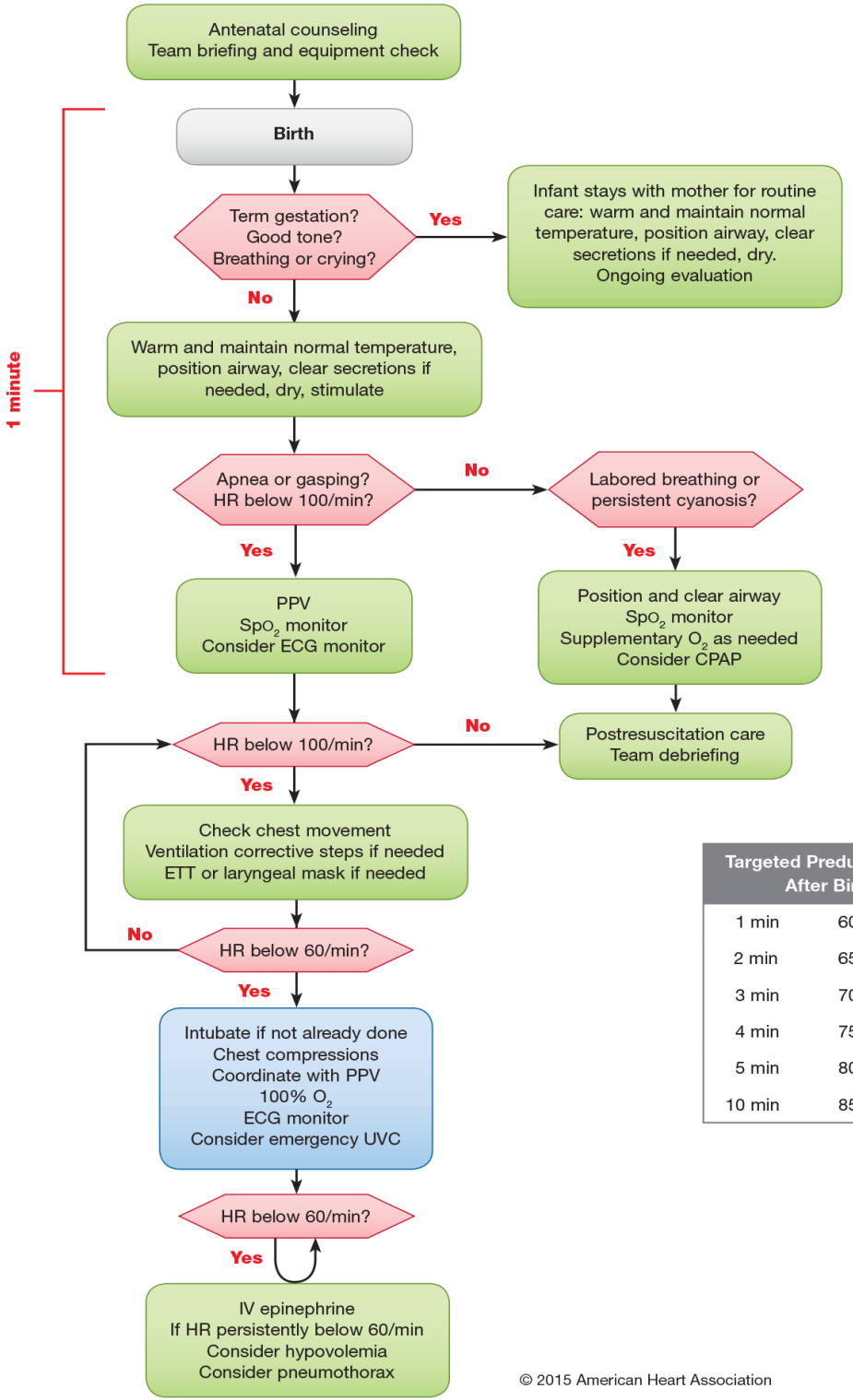
- For tachydysrhythmias **,the initial dose is 0.5 - 1 J/kg, in the synchronized mode**

- increase the dose to 2 J/kg if the first attempt is unsuccessful.
- If the device does not provide the synchronized mode, then obviously the unsynchronized mode must be used

CPR Guidelines for Newborns

- We recommend that **newborn**s (intubated or not) who require CPR in the newborn nursery or NICU receive **CPR using (3:1 compression-to-ventilation ratio with a pause for ventilation,with 90 compressions and 30 breaths per minute).**
- Newborns who require CPR in **other settings** (prehospital, ED, PICU), should receive **CPR according to infant guidelines**: 2 rescuers provide continuous chest compressions with asynchronous ventilations if an advanced airway is in place and a 15:2 ventilation-to-compression ratio if no advanced airway is in place.

Neonatal Resuscitation Algorithm—2015 Update



Targeted Preductal SpO_2 After Birth	
1 min	60%-65%
2 min	65%-70%
3 min	70%-75%
4 min	75%-80%
5 min	80%-85%
10 min	85%-95%

Airway

Oropharyngeal and Nasopharyngeal Airways➔

- Oropharyngeal and nasopharyngeal airways help maintain an open airway by displacing the tongue or soft palate from the pharyngeal air passages.
- Oropharyngeal airways are used in unresponsive victims who do not have a gag reflex.
- Make sure to select the correct size:Properly sized oral airways should reach from the corner of the mouth to the angle of the mandible. an oropharyngeal airway that is too small may push the base of the tongue farther into the airway; one that is too large may obstruct the airway.
- Nasopharyngeal airways can be used in children who do have a gag reflex.

Nasopharyngeal

Oropharyngeal

Laryngeal Mask Airway (LMA)➔

- When bag-mask ventilation is unsuccessful and when ETT is not possible, the LMA is acceptable when used to provide a patent airway and support ventilation
- LMA insertion is associated with a higher incidence of complications in young children compared with older children and adults

B

Oxygen➔

Titrate oxygen administration to maintain O2 saturation 94%.

Pulse Oximetry➔

- Monitor O2 saturation continuously with a pulse oximeter because clinical recognition of hypoxemia is not reliable.
- Pulse oximetry may be unreliable in patients with poor peripheral perfusion, CO poisoning, or methemoglobinemia.

Bag-Mask Ventilation➔

- In the prehospital setting it is reasonable to ventilate and oxygenate infants and children with BVM, especially if transport time is short
- Use only the force needed to just make the chest rise visibly avoid delivering excessive ventilation during cardiac arrest .
- Excessive ventilation during cardiac arrest increases intrathoracic pressure➔impedes venous return➔reducing cardiac output and cerebral and coronary blood flow.

- If the child is not intubated, after chest compressions (30 if 1 rescuer—15 if 2 rescuers) give 2 ventilations (mouth-to-mouth, mouth-to mask, or bag-mask).
- Deliver each breath with an inspiratory time of about 1 sec.
- If the infant or child is intubated, ventilate at a rate of about 1 breath every 6 seconds (10 times per minute) without interrupting chest compressions. It may be reasonable to do the same if an LMA is in place.
- In the victim with a perfusing rhythm but absent or inadequate respiratory effort, give 1 breath every 3 to 5 seconds (12 to 20 breaths per minute), using the higher rate for the younger child.

  One way to achieve that rate with a ventilating bag is to use the mnemonic “squeeze-release-release” at a normal speaking rate.

- A 2-person BVM ventilation technique may be preferable when personnel are available and may be more effective than1 person ventilation if the patient has significant airway obstruction, poor lung compliance, or the rescuer has difficulty in creating a tight mask-to-face seal.
- One rescuer uses both hands to maintain an open airway with a jaw thrust and a tight mask-to-face seal while the other compresses the ventilation bag.

  Both rescuers should observe the victim's chest to ensure chest rise.
- Gastric inflation may interfere with effective ventilation and cause regurgitation, aspiration of stomach contents, and further ventilatory compromise.

  The risk of gastric inflation can be decreased by:

- Giving only enough tidal volume to just achieve visible chest rise.

- Applying cricoid pressure in an unresponsive victim to reduce air entry into the stomach,Avoid excessive cricoid pressure so as not to obstruct the trachea.
- Passing NG tube to relieve gastric inflation, especially if oxygenation and ventilation are compromised.

Pass the tube after intubation because a NGtube interferes with gastroesophageal sphincter function, allowing regurgitation during intubation.

Rapid Sequence Intubation (RSI)

- To facilitate emergency intubation and reduce the risk of complications, providers may use sedatives, neuromuscular blocking agents, and other medications to rapidly sedate and neuromuscularly block the pediatric patient.
- Use RSI only if you are trained, and have experience using these medications .

- If you use RSI you must have a secondary plan to manage the airway in the event that you cannot achieve intubation.
- Actual body weight, rather than ideal body weight, should be used for some non-resuscitation medications (succinylcholine)
- Both cuffed and uncuffed endotracheal tubes are acceptable for intubating infants and children.
- The risk of complications in infants and in children is no greater with cuffed tubes than with non-cuffed tubes.
- Do not continue cricoid pressure if it interferes with ventilation or the speed or ease of intubation.

Endotracheal Tube Size➔

- Length-based resuscitation tapes (BROSLOW TAPE) are more accurate than age-based formula estimates of ETT size for children.
- If an **uncuffed ETT** is used, select a 3.5-mm ID tube for infants up to one year of age and a 4.0-mm ID tube for patients between 1 and 2 years of age.
- After age 2, uncuffed ETT size can be estimated by the following formula:

Uncuffed endotracheal tube ID (mm) =4+(age/4)

- If a **cuffed tube** is used for an infant less than 1 year of age, it select a 3.0 mm ID tube.
- For children between 1 and 2 years of age, use a 3.5 mm.
- After age 2,cuffed ETT size can be estimated by the following formula:

Cuffed endotracheal tube ID (mm)= 3.5+(age/4)

Methods for confirming correct position➔

- Listen for equal breath sounds over both lung fields, especially over the axillae.
- Listen for gastric insufflation sounds over the stomach. They should not be present if the tube is in the trachea.
- Check for exhaled CO2.
- If there is a perfusing rhythm, check O2 saturation with a pulse oximeter.

Remember that following hyperoxygenation, the O2 saturation detected by pulse oximetry may not decline for as long as 3 minutes even without effective ventilation.

- If you are still uncertain, perform direct laryngoscopy and visualize ETT to confirm that it lies between the vocal cords.
- In hospital settings, perform a chest x-ray to identify proper position in the midtrachea.

If an intubated patient's condition deteriorates, consider the following possibilities (mnemonic **DOPE**):

- Displacement of the tube
- Obstruction of the tube
- Pneumothorax
- Equipment failure

Exhaled or End-Tidal CO2 Monitoring➔

- When available, exhaled CO2 detection (capnography or colorimetry) is recommended as confirmation of tracheal tube position for neonates, infants, and children with a **perfusing rhythm** in all settings (eg, prehospital,ED, ICU ward, operating room)
- Remember that a color change or presence of capnography waveform confirms tube position in the airway **but does not rule out right mainstem bronchus intubation.**

- During cardiac arrest, if exhaled CO_2 is not detected, confirm tube position with direct laryngoscopy because the absence of CO_2 may reflect very low pulmonary blood flow rather than tube misplacement.

Esophageal Detector Device (EDD)➔

If capnography is not available, an esophageal detector device (EDD) **may be** considered to confirm ETT placement in children weighing 20 kg with a perfusing rhythm but the data are insufficient to make a recommendation for or against its use in children during cardiac arrest.

Transtracheal Catheter Oxygenation and Ventilation➔

Considered for patients with severe airway obstruction above the level of the cricoid cartilage if standard methods to manage the airway are unsuccessful.

This technique is intended for temporary use while a more effective airway is obtained.

Vascular Access

- Obtaining peripheral venous access can be challenging in infants and children during emergency; intraosseous (IO) access can be quickly established with minimal complications.

Intraosseous (IO) Access➔

- IO access is a rapid, safe, effective, and acceptable route for vascular access in children, and it is useful as the initial vascular access in cases of cardiac arrest.
- **All IV medications can be administered IO, as epinephrine, adenosine, fluids, blood products.**
- Onset of action and drug levels for most drugs are comparable to venous administration.
- IO access can be used to obtain blood samples for type and cross match and blood gases during CPR, but **ABG analysis is inaccurate** after NaHCO3 administration via IO.

Venous Access➔

- Peripheral IV access is acceptable during resuscitation if it can be placed rapidly, but placement may be difficult in a critically ill child.
- Although a central venous catheter can provide more secure long-term access, its placement requires training and experience, and the procedure can be time consuming.
- **Therefore central venous access is not recommended as the initial route of vascular access during an emergency.**
- If both central and peripheral accesses are available,give medications into the central circulation as some drugs (eg, adenosine) are more effective when given closer to the heart, and others (eg, calcium, amiodarone, procainamide, sympathomimetics) may be irritating when infused into a peripheral vein.

- The length of a central catheter can contribute to increased resistance, making it more difficult to push boluses of fluid rapidly through a multilumen central than a peripheral catheter.

Endotracheal Drug Administration➔

- Vascular access (IO or IV) is the preferred method for drug delivery during CPR, but if it is not possible, lipid-soluble drugs, as lidocaine, epinephrine, atropine, and naloxone (mnemonic “LEAN”)can be administered via ETT.
- If CPR is in progress, stop compressions briefly, give drug, and follow with a flush of at least 5 mL of N/S and 5 BVM ventilations.
- In general expert recommends doubling or tripling the dose of lidocaine, atropine or naloxone given via the ETT.
- **For epinephrine, a dose ten times the IV dose (0.1 mg/kg or 0.1 mL/kg of 1:1000 concentration) is recommended.**

- Non-lipid-soluble drugs (eg, sodium bicarbonate and calcium) may injure the airway; they should not be administered via the endotracheal route.

Emergency Fluids and Medications

Estimating Weight??

Tapes with precalculated doses printed at various patient lengths have been clinically validated and are more accurate than age-based or observer(parent or provider) estimate-based methods in the prediction of body weight.

Medications for Pediatric Resuscitation

Adenosine➔

-0.1 mg/kg (maximum 6 mg),2nd dose: 0.2 mg/kg (max.12 mg)

-Monitor ECG

-Rapid IV/IO bolus with flush

Amiodarone➔

-5 mg/kg IV/IO; may repeat twice up to 15 mg/kg

-Maximum single dose 300 mg

-Monitor ECG and blood pressure.

-IV push during cardiac arrest, more slowly–over 20–60 min. with perfusing rhythm).

-Use caution when used with other drugs that prolong QT

Atropine➔

-0.02 mg/kg IV/IO(0.04–0.06 mg/kg ET) repeat once if needed

-Minimum dose: 0.1 mg

-Maximum single dose: 0.5 mg

-Higher doses may be used with organophosphate poisoning

Calcium Chloride(10%)➔

-20 mg/kg IV/IO (0.2 mL/kg)

-Maximum single dose 2 g

-Administer slowly

Epinephrine➔

-0.01 mg/kg (0.1 mL/kg 1:10,000) IV/IO

-0.1 mg/kg (0.1 mL/kg 1:1000) ET

-Maximum dose 1 mg IV/IO; 2.5 mg ET

-May repeat every 3–5 minutes

Glucose➔

-0.5–1 g/kg IV/IO

-Newborn: 5–10 mL/kg D10W

-Infants and Children: 2–4 mL/kg D25W

-Adolescents: 1–2 mL/kg D50W

Lidocaine: Bolus: 1 mg/kg IV/IO Infusion: 20–50 mcg/kg/minute

Magnesium Sulfate➔25–50 mg/kg IV/IO over 10–20 minutes,**faster in torsades de pointes**(Max 2 g)

Naloxone Full Reversal➔

-<5 y or <20 kg: 0.1 mg/kg IV/IO/ET

->5y or >20 kg: 2 mg IV/IO/ET

Procainamide: 15 mg/kg IV/IO **Adult** Dose: 20 mg/min IV infusion to total maximum dose of 17 mg/kg.
- Monitor ECG and blood pressure; Give slowly–over 30–60 minutes. Use caution when administering with other drugs that prolong QT

Sodium bicarbonate➔
1 mEq/kg per dose IV/IO slowly After adequate ventilation

- **All ETT doses should be followed by a Flush with 5 mL of normal saline and follow with 5 ventilations.**

Shock

Shock results from inadequate blood flow and oxygen delivery to meet tissue metabolic demands.
The most common type of shock in children is hypovolemic, including hemorrhagic shock.
Shock progresses over a continuum of severity, from compensated to a decompensated state.

***Signs of compensated shock*→**

- Tachycardia
- Cool and pale distal extremities
- Prolonged (>2 seconds) capillary refill (despite warm ambient temperature)
- Weak peripheral pulses compared with central pulses
- **Normal** systolic blood pressure.

As compensatory mechanisms fail, **signs of inadequate end-organ perfusion** develop.

***Signs of decompensated shock*→**

- Depressed mental status
- Decreased urine output
- Metabolic acidosis
- Tachypnea
- Weak central pulses, weak or absent peripheral pulses
- Deterioration in color (eg, mottling,cyanosis)
- **Hypotension**

- **Tachycardia is a common sign of shock, but it can also result from other causes, such as pain, anxiety, and fever**
- Pulses are weak in hypovolemic and cardiogenic shock, but may be bounding in anaphylactic, neurogenic, and septic shock.

Hypotension is defined as a systolic blood pressure➔

- **<60 mm Hg in term neonates (0 to 28 days)**
- **<70 mm Hg in infants (1 month to 12 months)**
- **<70 mm Hg +(2 x age in years) in children 1 to 10 years**
- **<90 mm Hg in children >10 years of age**

Septic Shock

- There appears to be no clinically important difference in survival of children who are treated for septic shock with colloid compared with those who are treated with isotonic crystalloid solutions.
  It is reasonable to use isotonic crystalloid solution as the initial fluid for the treatment of septic shock.
- Monitoring the central venous (superior vena cava) oxygen saturation (ScvO2) may be useful to titrate therapy in infants and children with septic shock.
  "goal-directed" therapy, with a target ScvO2 >70% appears to improve patient survival in severe sepsis
- Early assisted ventilation may be considered as part of a Goal-directed strategy for septic shock

- Etomidate has been shown to facilitate endotracheal intubation in infants and children with minimal hemodynamic effect, **but do not use it routinely in pediatric patients with evidence of septic shock.**

Hypovolemic Shock

- **Use an isotonic crystalloid solution (R/L or N/S) as the initial fluid for the treatment of shock.**
- There is no added benefit in using colloid (eg, albumin) during the early phase of resuscitation.
- Treat signs of shock with a bolus of 20 mL/kg of isotonic crystalloid even if blood pressure is normal.
- Give additional boluses (20 mL/kg) if systemic perfusion fails to improve.

Termination of Resuscitative Efforts

- There are **no reliable predictors** of outcome to guide when to terminate resuscitative efforts in children.
- Witnessed collapse, bystander CPR, and a short interval from collapse to arrival of professionals improve the chances of a successful resuscitation.
- Intact survival has been documented after unusually prolonged in-hospital resuscitation

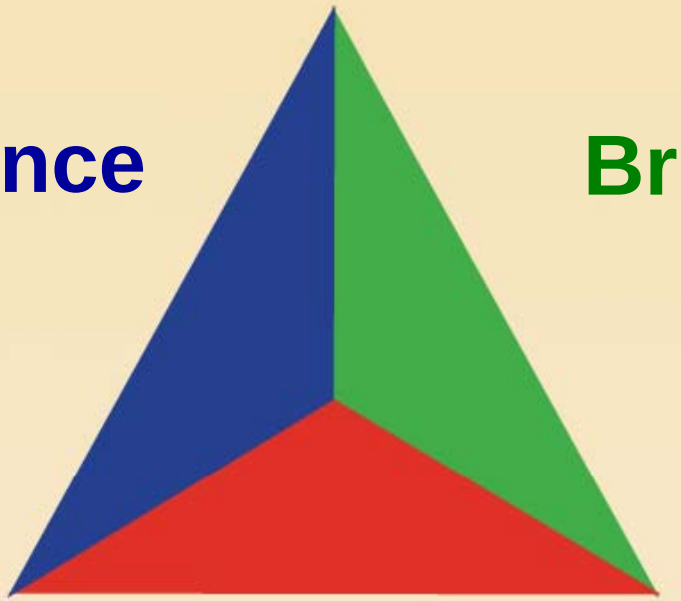
Pediatric Assessment

APLS The Pediatric Emergency Medicine Resource

Objectives

- Distinguish the three components of the PAT.
- Assess pediatric-specific features of initial assessment.
- Integrate findings to form a general impression.
- Describe the focused history and PE.

Pediatric Assessment Triangle



APLS The Pediatric Emergency Medicine Resource

Appearance

- **T**one
- **I**nteractiveness
- **C**onsolability
- **L**ook/Gaze
- **S**peech/Cry

Work of Breathing

- Abnormal airway sounds
- Abnormal positioning
- Retractions
- Nasal flaring
- Head bobbing

Circulation to Skin

- Pallor
- Mottling
- Cyanosis

Case Study 1: "Cough, Difficulty Breathing"

- One-year-old boy presents with complaint of cough, difficulty breathing.
- Past history is unremarkable. He has had nasal congestion, low grade fever for 2 days.

Pediatric Assessment Triangle

Appearance

Alert, smiling, nontoxic

Breathing

Audible inspiratory stridor at rest

Circulation

Pink

APLS The Pediatric Emergency Medicine Resource

Questions

What information does the PAT tell you about this patient?

What is your general impression?

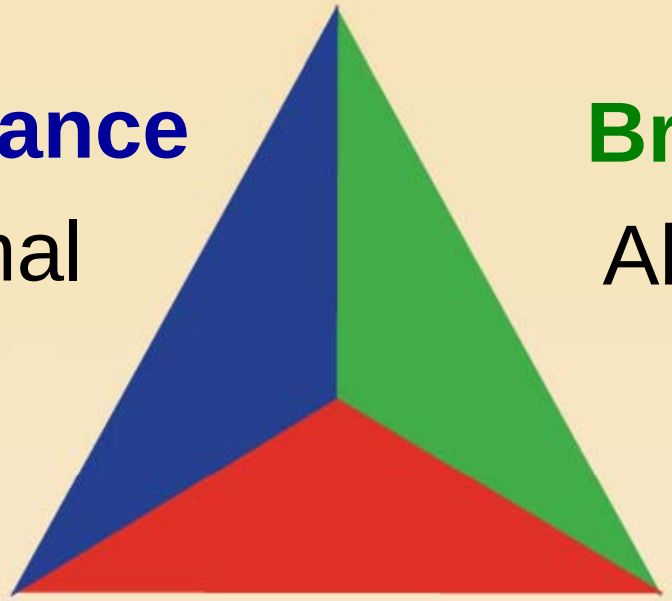
Pediatric Assessment Triangle: Respiratory Distress

Appearance

Normal

Breathing

Abnormal



Circulation

Normal

APLS The Pediatric Emergency Medicine Resource

General Impression

- Stable
- Respiratory distress
- Respiratory failure
- Shock
- Central nervous system dysfunction
- Cardiopulmonary failure/arrest

Case Progression/Outcome

- Initial assessment: Respiratory distress with upper airway obstruction
- Initial treatment priorities:
  - Leave in a position of comfort.
  - Obtain oxygen saturation.
  - Provide oxygen as needed.
  - Begin specific therapy.

Case Study 2: "Severe Difficulty Breathing"

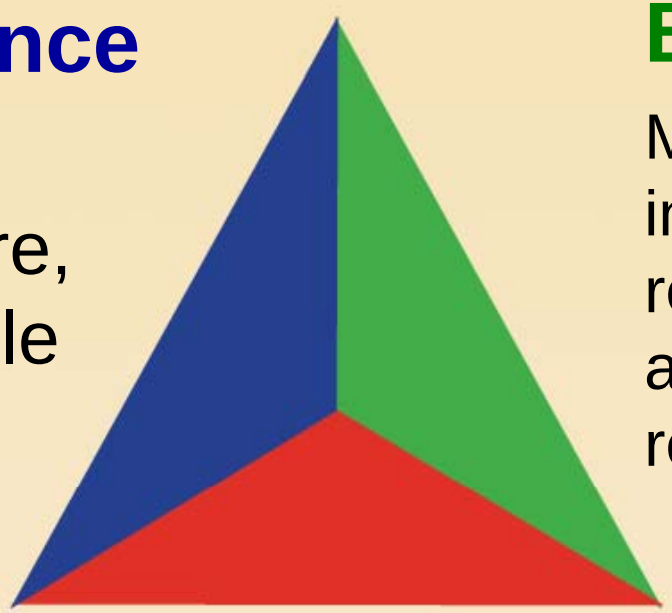
- 3-month-old girl presents with severe difficulty breathing.
- Seen in ED two days earlier; sent home with a diagnosis of bronchiolitis
- Her difficulty breathing has increased.

What further information would you like?

Pediatric Assessment Triangle

Appearance

Lethargic, glassy stare, poor muscle tone



Breathing

Marked sternal and intercostal retractions, rapid and shallow respirations

Circulation

Pale with circumoral cyanosis

Questions

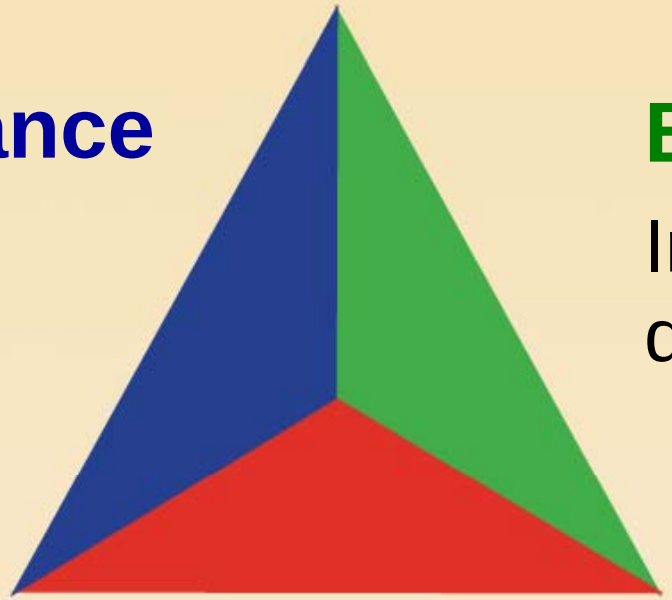
What is your general impression?

How does this impression guide your management?

Pediatric Assessment Triangle: Respiratory Failure

Appearance

Abnormal



Breathing

Increased or decreased

Circulation

Normal or abnormal

APLS The Pediatric Emergency Medicine Resource

Case Progression/Outcome

- General impression: Respiratory failure or cardiopulmonary failure
- Management priorities:
  - Support oxygenation and ventilation with bag mask; prepare for endotracheal intubation.
  - Assess cardiac function, vascular access.
  - Continually reassess after each intervention.

Case Study 3: “Vomiting”

- 15-month-old boy with 24-hour history of vomiting, diarrhea.
- Diarrhea is watery with blood and pus.
- Attempts at oral rehydration by mom were unsuccessful.
- Called ambulance when child became listless and refused feedings.

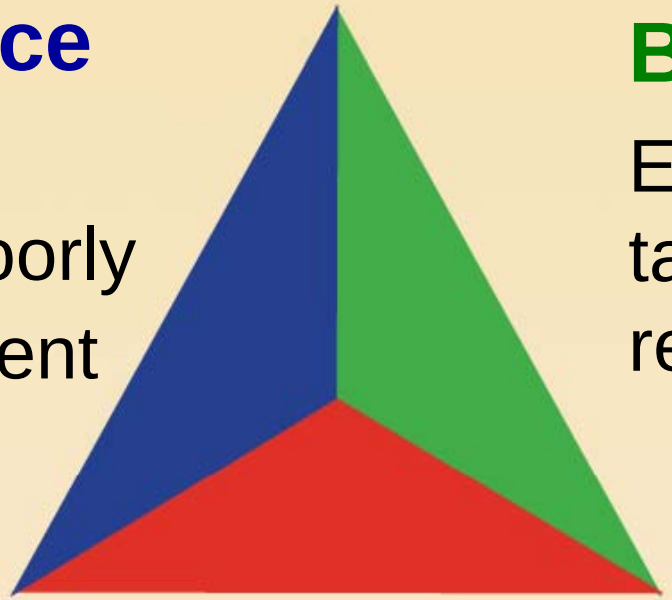
Pediatric Assessment Triangle

Appearance

Listless, responds poorly to environment

Breathing

Effortless tachypnea, no retractions



Circulation

Pale face and trunk, mottled extremities

APLS The Pediatric Emergency Medicine Resource

Case Progression/Outcome

- Initial impression: Shock
- Management considerations
  - Provide oxygen by mask.
  - Obtain quick vascular access.
  - Administer volume-expanding crystalloid (NS or LR) in 20 mL/kg increments.
  - Continuous reassessment and complete exam.

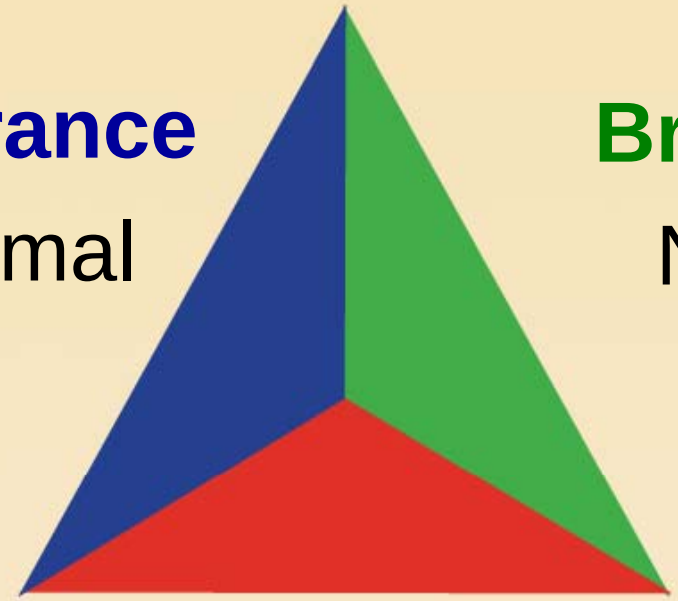
Pediatric Assessment Triangle: Shock

Appearance

Abnormal

Breathing

Normal



Circulation

Abnormal

APLS The Pediatric Emergency Medicine Resource

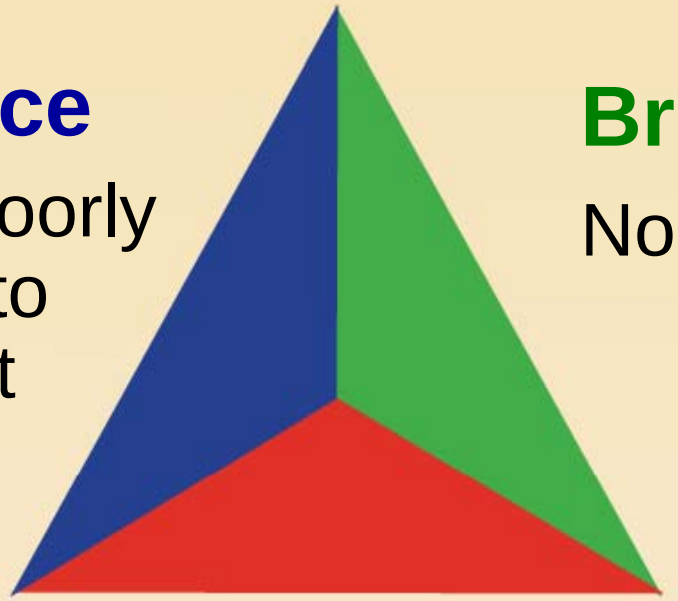
Case Study 4: “Lethargy”

- 6-month-old girl brought to ED by mother after “falling from the bed” onto carpeted floor.
- Mother states infant is “sleepy,” was worried when there was no improvement in mental status after three hours of observation.

Pediatric Assessment Triangle

Appearance

Lethargic, poorly responsive to environment



Breathing

Normal

Circulation

Normal

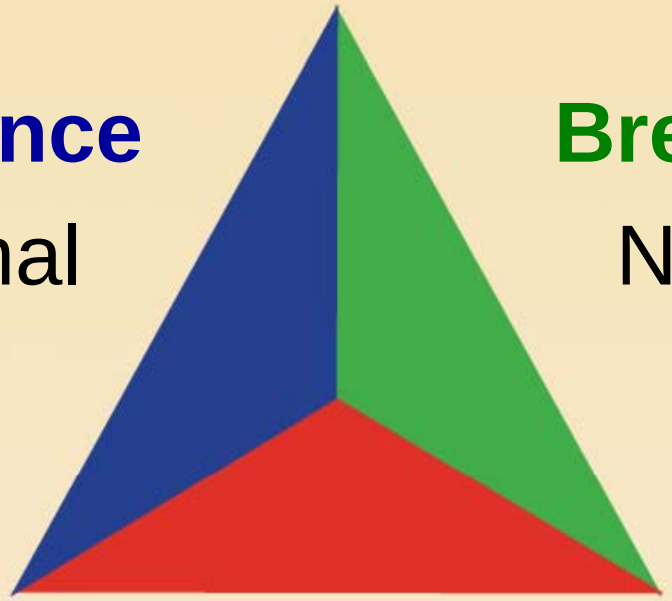
Pediatric Assessment Triangle: CNS/Metabolic Dysfunction

Appearance

Abnormal

Breathing

Normal



Circulation

Normal

Case Progression

- General impression: Primary CNS or metabolic dysfunction
- Management priorities:
  - Provide oxygen, closely monitor ventilation.
  - Obtain vascular access, rapid glucose screen.
  - Perform further physical assessment.
  - Obtain blood for labs, cultures, metabolic studies.
  - Obtain CT of head, radiographs.

General Impression

- Pediatric Assessment Triangle
- Hands-on assessment of ABCDEs
  - Pediatric differences

Airway

- Manual airway opening maneuvers: Head tilt-chin lift, jaw thrust
- Suction: Can result in dramatic improvement in infants
- Age-specific obstructed airway support:
  - <1 year: Back blow/chest thrust
  - >1 year: Abdominal thrust
- Advanced airway techniques

Breathing: Respiratory Rate

Age	Respiratory Rate
Infant	30 to 60
Toddler	24 to 40
Preschooler	22 to 34
School-aged child	18 to 30
Adolescent	12 to 16

- Slow or fast respirations are worrisome.

Breathing: Auscultation

- Listen with stethoscope over midaxillary line and above sternal notch
  - Stridor: Upper airway obstruction
  - Wheezing: Lower airway obstruction
  - Grunting: Poor oxygenation; pneumonia, drowning, pulmonary contusion
  - Crackles: Fluid, mucus, blood in airway
  - Decreased/absent breath sounds: Obstruction

Circulation: Heart Rate

Age	Normal Heart Rate
Infant	100 to 160
Toddler	90 to 150
Preschooler	80 to 140
School-aged child	70 to 120
Adolescent	60 to 100

Circulation

- Pulse quality: Palpate central and peripheral pulses
- Skin temperature: Reverse thermometer sign
- Capillary refill
- Blood pressure: Minimum BP = 70 + (2 X age in years)

Disability

- Quick neurologic exam
- AVPU scale:
  - Alert
  - Verbal: Responds to verbal commands
  - Painful: Responds to painful stimulus
  - Unresponsive
- (Pediatric) Glasgow Coma Scale

Exposure

- Proper exposure is necessary to evaluate physiologic function and identify anatomic abnormalities.
- Maintain warm ambient environment and minimize heat loss.
- Monitor temperature.
- Warm IV fluids.

Initial Assessment

- **A:** Gurgling upper airway sounds
- **B:** Irregular respirations
- **C:** Infant is pale.
- **D:** Responds to painful stimuli. Pupils are equal, but react sluggishly to light.
- **E:** Shows signs of trauma.

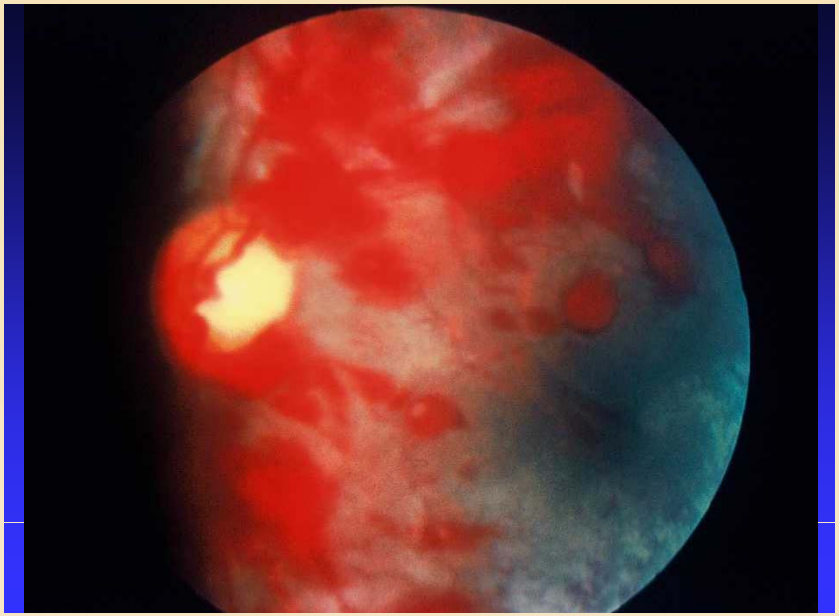
What are your management priorities?

Case Progression (2 of 4)

- Extremity exam shows pattern bruising, fingerprints suggesting forceful shaking.

Case Progression (3 of 4)

- Exam of the fundi reveals bilateral retinal hemorrhages.
- Mom admitted that she shook baby violently when baby wouldn't stop crying.



Case Progression (4 of 4)

- Vascular access is obtained, screening blood glucose is 86 mg/dL, infant is placed on oxygen by mask.

Based on the two parts of the initial assessment, what are your management priorities now?

Management Priorities

- RSI, secure airway using drugs to blunt increases in intracranial pressure.
- Deliver 100% oxygen.
- Monitor end tidal CO_2 and oxygen saturation.
- Provide intravenous volume-expanding crystalloid fluids.
- Perform CT of head and neurosurgical consultation.

Developmental Issues and the PAT

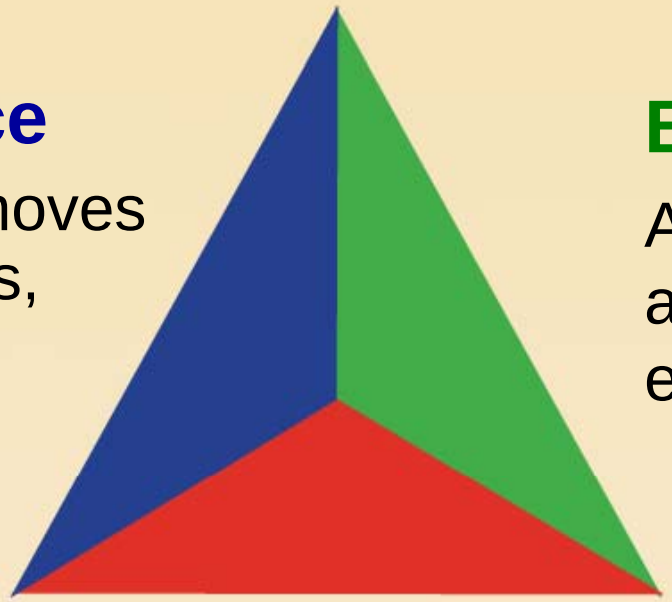
What does a normal PAT look like in a 2-week-old?

A 2-month-old?

PAT: Normal 2-Week-Old Infant

Appearance

Eyes open, moves arms and legs, strong cry



Breathing

Abdomen rises and falls with each breath

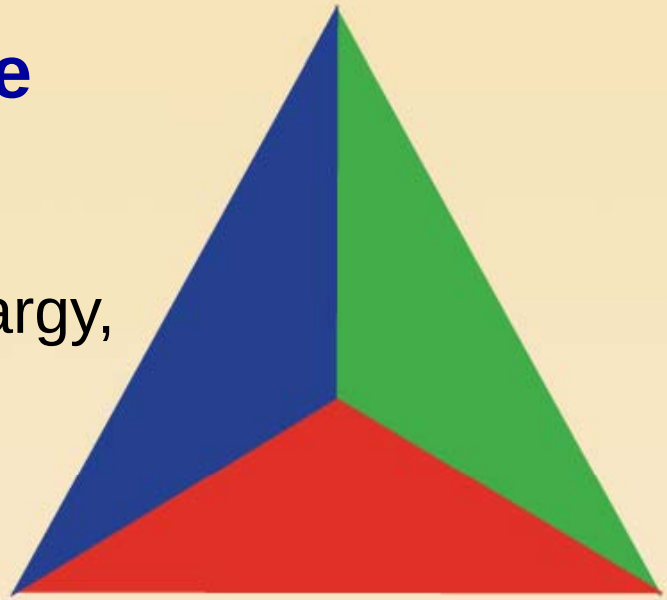
Circulation

Face and trunk normal; hands and feet blue; cutis marmorata in cool ambient environment

PAT: 2-Week-Old in Shock

Appearance

Irritable, alternating irritability/lethargy, lethargy, unresponsive



Breathing

See-saw movements of abdomen and chest; retractions, nasal flaring

Circulation

Pallor, true mottling
(patches of pallor and cyanosis or erythema)

Assessment: Less Than 2 Months Old

- Consoled when held, gently rocked
- Brief awake periods
- Little or no eye contact
- No “social smile”
- Does not recognize parents vs. strangers
- Limited behavioral repertoire

Assessment: 2-6 Months Old

- Social smile
- Recognizes caregivers
- Tracks light, faces
- Strong cry, increasing vocalization
- Rolls over, sits with support
- When possible, do much of the exam in caretaker's lap/arms.

Assessment: 6-12 Months Old

- Socially interactive, babbles
- Sits without support, increased mobility
- Everything goes in mouth
- Stranger/separation anxiety
- Sit or squat to get at eye level when examining, use “toe-to-head” approach.

Assessment: 1-3 Years Old

- “Terrible twos”
- Increased mobility
- Curious about everything, no fear
- Egocentric, very strong opinions
- Not swayed by logic
- Language comprehension is greater than expression.

Assessment: 4-10 Years Old

- Analytical, understands cause and effect
- Cooperative, “age of reason”
- But:
  - Many misconceptions about the body
  - May overestimate implications of illness/injury, and misinterpret information
  - Independence may crumble when sick.

Assessment: Adolescent

- Similar to “toddlers”:
  - Risk-takers, no fear of danger, don’t anticipate consequences. Not swayed by common sense.
  - Dependence shifts from family to peers.
- Techniques for assessment:
  - Respect privacy, provide concrete explanations.
  - Talk to the teen, not the parents.
  - Do not succumb to provocation.

Focused History

- Complete history including mechanism of injury or circumstances of illness
- Use SAMPLE mnemonic:
  - **S**igns/Symptoms
  - **A**llergies
  - **M**edications
  - **P**ast medical problems
  - **L**ast food or liquid
  - **E**vents leading to injury or illness

Detailed Physical Exam

- Establish a clinical diagnosis.
- Plan sequence of laboratory testing and imaging.

Ongoing Assessment

- Systematic review of assessment points:
  - Pediatric Assessment Triangle
  - ABCDEs
  - Repeat vital signs
  - Reassessment of positive anatomic findings, and physiologic derangements
  - Review of effectiveness and safety of treatment

The Bottom Line

- Begin with PAT followed by ABCDEs.
- Form a general impression to guide management priorities.
- Treat respiratory distress, failure, and shock when recognized.
- Focused history and detailed PE.
- Perform ongoing assessment throughout ED stay.

APLS The Pediatric Emergency Medicine Resource