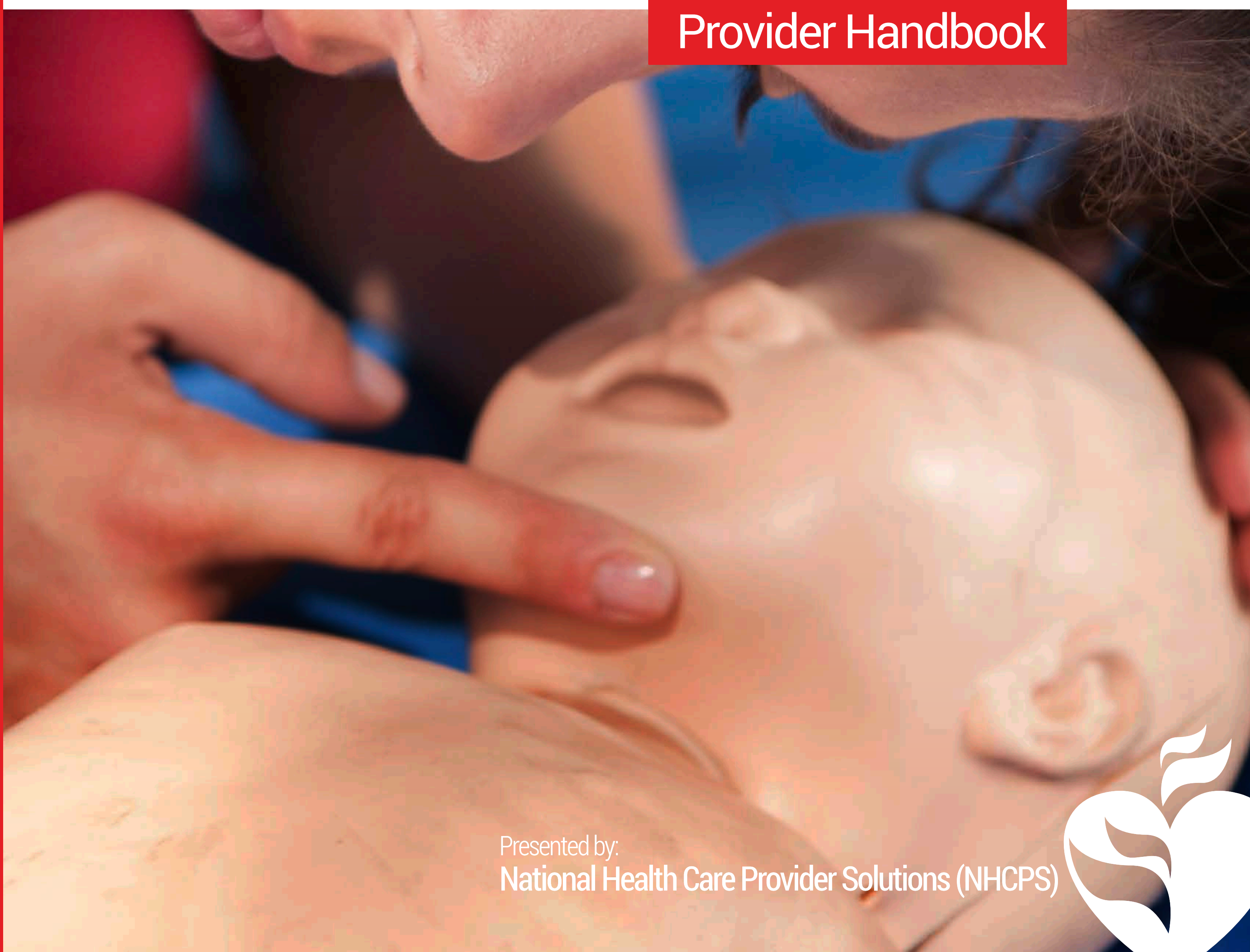
NATIONAL Health Care PROVIDER SOLUTIONS

PALS

Pediatric Advanced Life Support

Provider Handbook



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INTRODUCTION

The goal of Pediatric Advanced Life Support (PALS) is to save a life. For an infant or child experiencing serious illness or injury, your action can be the difference between life and death. PALS is a series of protocols to guide responses to life threatening clinical events. These responses are designed to be simple enough to be committed to memory and recalled under moments of stress. PALS guidelines have been developed from thorough review of available protocols, patient case studies and clinical research, and reflect the consensus opinion of experts in the field. The gold standard in the United States and many other countries is the course curriculum published by the American Heart Association (AHA). Approximately every five years the AHA updates the guidelines for Cardiopulmonary Resuscitation (CPR) and Emergency Cardiovascular Care (ECC). This handbook is based on the most recent AHA publication of PALS and will periodically compare old versus new recommendations for a more comprehensive review.[1]

IMPORTANT: **Any rescuer attempting to perform PALS is assumed to have developed and maintained competence with not only the materials presented in this document, but also certain physical skills, including Basic Life Support (BLS) interventions. Since PALS is performed on infants and children, PALS providers should be proficient in BLS for these age groups. While we review the basic concepts of pediatric cardiopulmonary resuscitation here, readers are encouraged to keep their physical skills in practice and seek additional training if needed.**

Proper utilization of PALS requires rapid, accurate assessment of the patient's clinical condition, selection and delivery of the appropriate intervention. This not only applies to the provider's initial assessment of a patient in distress, but also reassessment throughout the course of treatment utilizing PALS guidelines.

PALS protocols assume the provider may not have all of the information needed from the victim or all of the resources needed to properly use PALS in all cases. For example, if a provider is utilizing PALS on the side of the road, they will not have access to sophisticated devices to measure breathing or arterial blood pressure. Nevertheless, in such situations, PALS providers have the framework to provide the best possible care in the given circumstances. PALS algorithms are based on current understanding of best practice to deliver positive results in life-threatening cases and are intended to achieve the best possible outcome for the patient during an emergency.

[1] *American Heart Association. Pediatric Advanced Life Support Provider Manual. AHA: 2011; p 183.*

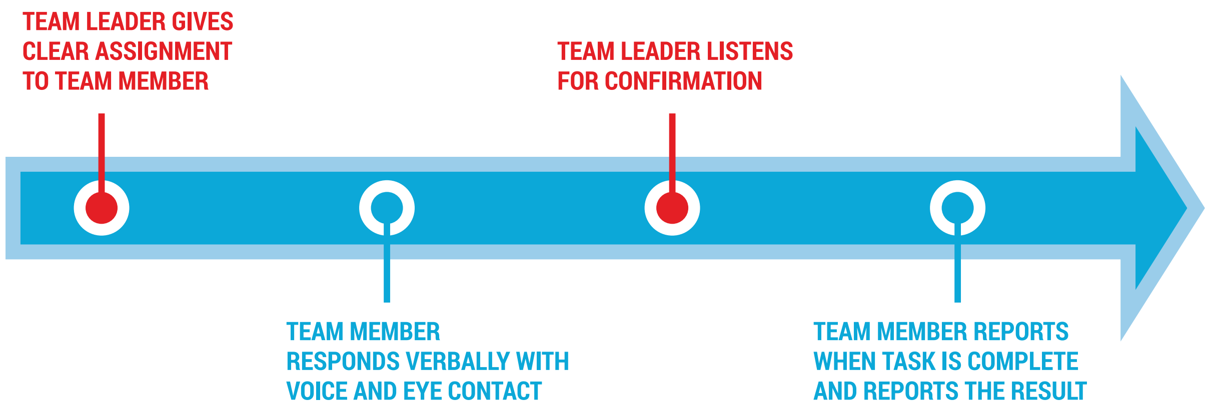
THE RESUSCITATION TEAM

The 2010 edition of the AHA PALS guidelines highlights the importance of effective team dynamics during resuscitation. In the community, the first person on the scene may be performing CPR alone; however, a pediatric arrest event in a hospital may bring dozens of people to a child's room. It is important to rapidly and efficiently organize team members to effectively participate in PALS. The AHA supports a team structure with each provider assuming a specific role during the resuscitation. This consists of a Team Leader and several Team Members.

- Clear communication between Team Leader and Team Members is essential.

TEAM LEADER	TEAM MEMBER
• Organize the group • Monitor performance • Be able to perform all skills • Direct team members • Provide critique of group performance after the resuscitation effort	• Understand their role • Be willing, able, and skilled to perform the role • Understand the PALS sequences • Be committed to the success of the team

It is important to know your own clinical limitations. Resuscitation is the time for implementing acquired skills, not trying new ones. Clearly state when you need help and call for help early in the care of the patient. Resuscitation demands mutual respect, knowledge sharing, and constructive criticism. After each resuscitation case, providers should spend time reviewing the process and providing each other with helpful and constructive feedback. Ensuring an attitude of respect and support is crucial and aids in processing the inevitable stress that accompanies pediatric resuscitation.



BASIC LIFE SUPPORT

Basic Life Support (BLS) utilizes cardiopulmonary resuscitation (CPR) and cardiac defibrillation, when an Automated External Defibrillator (AED) is available. BLS is the life support method used when there is limited access to advanced interventions such as medications and monitoring devices. In general, BLS is performed until EMS arrives to provide a higher level of care. In every setting, HIGH QUALITY CPR is the foundation of both BLS and PALS interventions. High quality CPR gives a victim the greatest chance of survival by providing circulation to the heart, brain, and other organs until return of spontaneous circulation (ROSC).

This guide covers PALS and only briefly describes BLS. All PALS providers are assumed to be able to perform BLS appropriately. It is essential that PALS providers be proficient in BLS first. High quality BLS is the foundation of PALS.

INFANTS (BIRTH – AGE 1)	CHILDREN (AGE 1 – PUBERTY)
For children and infants, if two rescuers are available to do CPR, the compression to breaths ratio is 15:2. If only one rescuer is available, the ratio is 30:2 for all age groups.	
Check the pulse in the infant using the brachial artery on the inside of the upper arm between the infant's elbow and shoulder.	Check for pulse in child using the carotid artery on the side of the neck or femoral pulse on the inner thigh in the crease between the leg and groin.
Perform compressions on a child using 2 fingers (if you are by yourself) or 2 thumbs with hands encircling the infant's chest (with 2 providers).	Perform compressions on a child using one or two handed chest compressions depending on the size of the child.
Compression depth should be 1/3 of the chest depth; for most infants, this is about 1 ½ inches.	Compression depth should be 1/3 of the chest depth; for most children, this is about 2 inches.
If you are the only person at the scene and find an unresponsive infant or child, perform CPR for 2 minutes BEFORE you call EMS or go for an AED.	
If you witness a cardiac arrest in an infant or child, call EMS and get an AED before starting CPR.	

ONE-RESCUER BLS FOR CHILDREN

If you are alone with a pediatric victim:

1. Shake and shout at the victim to determine if they are responsive.
2. Assess if they are breathing.
3. If the child does not respond and they are not breathing (or if they are only gasping), yell for help. If someone responds, send the second person to activate the Emergency Response System and get an AED.
4. Feel for the child's carotid pulse (on the side of the neck) or femoral pulse (on the inner thigh in the crease between their leg and groin) for no more than 10 seconds.
5. If you cannot feel a pulse (or if you are unsure), begin CPR by doing 30 compressions followed by 2 breaths. If you CAN feel a pulse but the pulse rate is less than 60 beats per minute, you should begin CPR. This rate is too slow for a child.
6. After doing CPR for about 2 minutes (usually about 5 cycles of 30 compressions and 2 breaths) and if other help has not arrived, leave the child to call EMS and get an AED (if you know where one is).
7. Use and follow AED prompts when available while continuing CPR until EMS arrives or child's condition normalizes.

TWO-RESCUER BLS FOR CHILDREN

If you are not alone with a pediatric victim:

1. Shake and shout at the victim to determine if they are responsive.
2. Assess if they are breathing.
3. If the child does not respond and they are not breathing (or if they are only gasping), send the second person to activate the Emergency Response System and get an AED.
4. Feel for the child's carotid pulse (on the side of the neck) or femoral pulse (on the inner thigh in the crease between their leg and groin) for no more than 10 seconds.
5. If you cannot feel a pulse (or if you are unsure), begin CPR by doing 30 compressions followed by 2 breaths. If you CAN feel a pulse but the rate is less than 60 beats per minute, begin CPR. This rate is too slow for a child.
6. When the second rescuer returns, begin doing CPR by performing 15 compressions by one rescuer and 2 breaths by the second rescuer.
7. Use and follow AED prompts when available while continuing CPR until EMS arrives or child's condition normalizes.

BLS FOR INFANTS (0 TO 12 MONTHS OLD)

BLS for both children and infants is almost identical. For example, if two rescuers are available to perform CPR, the breath to compression ratio is 15:2 for both infants and children (the ratio is 30:2 for all age groups if only one rescuer is present). The main differences between BLS for children and BLS for infants are:

- Check the pulse in the infant using the brachial artery on the inside of the upper arm between the infant's elbow and shoulder.
- During CPR, compressions can be performed on an infant using two fingers (if only one rescuer) or with two thumb-encircling hands *(Fig. 1)* (if there are two rescuers and rescuer's hands are big enough to go around the infant's chest).
- Compression depth should be 1/3 of the chest depth; for most infants, this is about 1 ½ inches.
- In infants, primary cardiac events are not common. Usually, cardiac arrest will be preceded by respiratory problems. Survival rates improve as you intervene with respiratory problems as early as possible. Remember that prevention is the first link in the Pediatric Chain of Survival!

Fig. 1

- If you witness a cardiac arrest in an infant, call EMS and get an AED just as you would in the BLS sequence for adults or children.

ONE-RESCUER BLS FOR INFANTS

If you are the lone rescuer of an infant, do the following:

1. Shake and shout at the victim to determine if they are responsive.
2. Assess if they are breathing.
3. If the child does not respond and they are not breathing (or if they are only gasping), yell for help. If someone responds, send the second person to call EMS and to get an AED.
4. Feel for the infant's femoral or brachial pulse for no more than 10 seconds. *(Fig. 2)*
5. If you cannot feel a pulse (or if you are unsure), begin CPR by doing 30 compressions followed by 2 breaths. If you CAN feel a pulse but the rate is less than 60 beats per minute, begin CPR. This rate is too slow for an infant. To perform CPR on an infant: *(Fig. 3)*
    a. Be sure the infant is face up on a hard surface.
    b. Using two fingers, perform compressions in the center of the infant's chest; do not press on the end of the sternum as this can cause injury to the infant.
    c. Compression depth should be about 1.5 inches and AT LEAST 100 per minute.
6. After performing CPR for about 2 minutes (usually about 5 cycles of 30 compressions and 2 breaths). If help has not arrived, leave the infant to call EMS and get an AED.
7. Use and follow AED prompts when available while continuing CPR until EMS arrives or patient condition normalizes.

Fig. 2

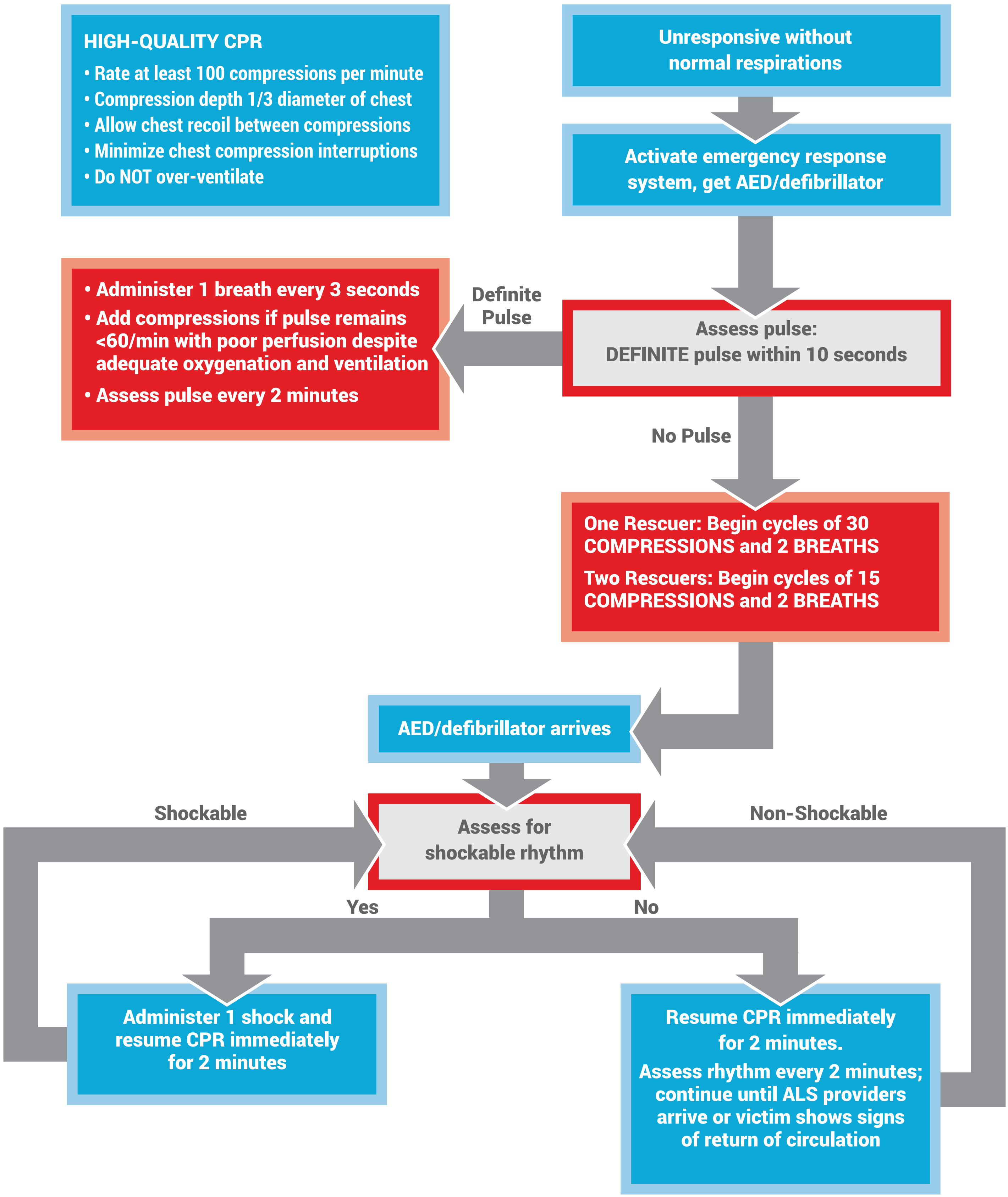
Fig. 3

TWO-RESCUER BLS FOR INFANTS

If you are not alone with the infant:

1. Shake and shout at the infant to determine if they are responsive.
2. Assess if they are breathing.
3. If the child does not respond and they are not breathing (or if they are only gasping), send the second person to call EMS and get an AED.
4. Feel for the infant's brachial pulse for no more than 10 seconds.
5. If you cannot feel a pulse (or if you are unsure), begin CPR by doing 30 compressions followed by 2 breaths. If you CAN feel a pulse but the rate is less than 60 beats per minute, begin CPR. This rate is too slow for an infant.
6. When the second rescuer returns, begin CPR by performing 15 compressions by one rescuer and 2 breaths by the second rescuer. If the second person can fit their hands around the infant's chest, perform CPR using the two thumb-encircling hands method. Do not press on the bottom end of the sternum as this can cause injury to the infant.
7. Compressions should be approximately 1.5 inches deep and at a rate of AT LEAST 100 per minute.
8. Use and follow AED prompts when available while continuing CPR until EMS arrives or patient condition normalizes.

PEDIATRIC BLS ALGORITHM



SELF ASSESSMENT BLS

1. You respond to a pediatric patient that is found down. What is the next action after determining unresponsiveness?

   A. Apply AED
   B. Tell bystander to activate emergency response
   C. Look for a parent
   D. Rescue breaths

2. Which of the following describes the brachial pulse location?

   A. Wrist - thumb side
   B. Elbow - inside near forearm
   C. Upper arm - inside
   D. Neck - either side of trachea

3. What is the primary difference between One-Rescuer and Two-Rescuer CPR for infant victims?

   A. Rate of compressions
   B. Compression: ventilation ratio
   C. Depth of compressions
   D. Volume of ventilation

4. Effective communication is key in all resuscitation attempts. Which of the following are components of effective Team communication?

   A. Knowledge sharing
   B. Clear communication
   C. Mutual respect
   D. All the above

Answers are on following page.

SELF ASSESSMENT BLS

ANSWERS

1. B

Early activation is key. Send any available bystander to summon EMS (Call 911). Many pediatric cardiac arrest situations are the result of a respiratory problem and immediate intervention can be life saving.

2. C

The brachial pulse is located in the upper arm. The radial pulse is felt on the thumb side of the wrist, but is not used during primary CPR assessment. The carotid pulse is located in the neck and the femoral pulse is located in the groin region.

3. B

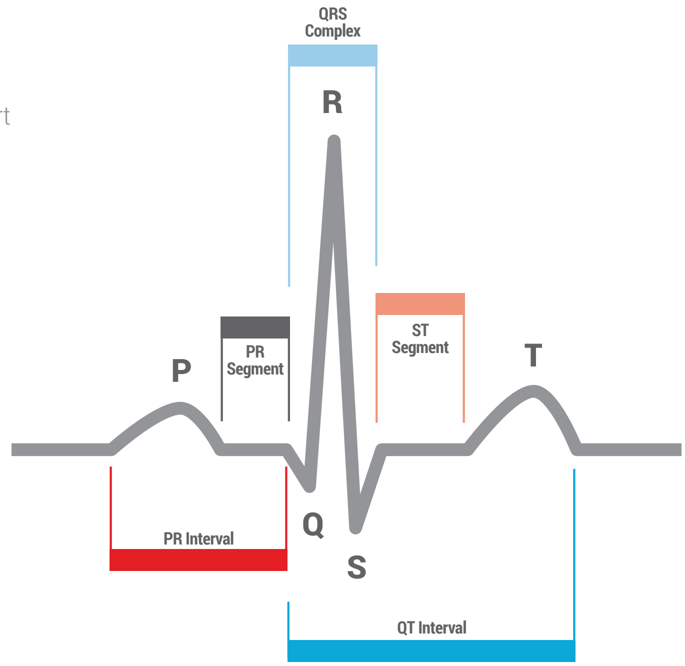
One-Rescuer CPR uses compressions at a ratio of 15:2 compressions to breaths for infants & children; Two-Rescuer CPR uses a ratio of 30:2. The volume of ventilation and depth of compression are not influenced by the number of rescuers

4. D

Additional components include: clear messages, knowing one's limitations, constructive intervention, reevaluation, and summarizing.

PEDIATRIC ADVANCED LIFE SUPPORT

NORMAL HEART ANATOMY AND PHYSIOLOGY



Understanding normal cardiac anatomy and physiology is an important component of performing Advanced Cardiac Life Support (ACLS). The heart is a hollow muscle comprised of four chambers surrounded by thick walls of tissue (septum). The atria are the two upper chambers; the ventricles are the two lower chambers. The left and right halves of the heart work together to pump blood throughout the body. The right atrium (RA) and right ventricle (RV) pump deoxygenated blood to the lungs where it becomes oxygenated. This oxygen rich blood returns to the left atrium (LA) and then enters the left ventricle (LV). The left ventricle is the main pump that delivers the newly oxygenated blood to the rest of the body. Blood leaves the heart through a large vessel known as the aorta. Valves between each pair of connected chambers prevent the backflow of blood. The two atria contract simultaneously, as do the ventricles, making the contractions of the heart go from top to bottom. Each beat begins in the RA. The LV is the largest and thickest-walled of the four chambers, as it is responsible for pumping the newly oxygenated blood to the rest of the body. The sinoatrial node (SA node) in the RA creates the electrical activity that acts as the heart's natural pacemaker. This electrical impulse then travels to the atrioventricular node (AV node), which lies between the atria and ventricles. After pausing there briefly, it moves on to the His-Purkinje system, which which acts like wiring to conduct the electrical signal into the LV and RV. This electrical signal causes the heart muscle to contract and pump blood.

By understanding the normal electrical function of the heart, it will be easier to understand abnormal functions. When blood enters the atria of the heart, an electrical impulse is sent out from the SA node that conducts through the atria resulting in atrial contraction. This atrial contraction registers on an ECG strip as the P wave. This impulse then travels to the AV node, which in turn conducts the electrical impulse through the Bundle of His, bundle branches, and Purkinje fibers of the ventricles causing ventricular contraction. The time between the start of atrial contraction and the start of ventricular contraction registers on an ECG strip as the PR interval. The ventricular contraction registers on the ECG strip as the QRS complex. Following ventricular contraction, the ventricles rest and repolarize, which is registered on the ECG strip as the T wave. The atria repolarize also, but this coincides with the QRS complex and therefore cannot be observed on the ECG strip. Together a P wave, QRS complex, and T wave at proper intervals are indicative of Normal Sinus Rhythm (NSR) (Fig. 1). Abnormalities in the conduction system can cause delays in the transmission of the electrical impulse which are detected on the ECG. These deviations from normal conduction can result in dysrhythmias such as heart blocks, pauses, tachycardias and bradycardias. blocks, dropped beats and dysrhythmias. These rhythm disturbances will be covered in more detail later in this book.

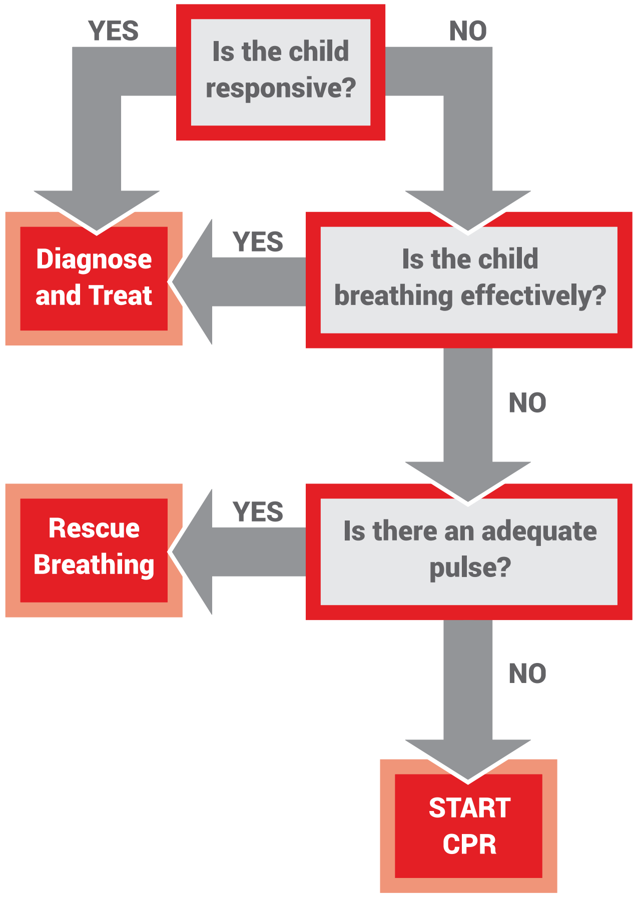
PALS—A SYSTEMATIC APPROACH

When you find an unresponsive child, it is often not possible to immediately deduce the etiology. You will want to act quickly, decisively, and apply interventions that fit the needs of the patient at that moment. In order to achieve this, PALS was designed for providers to take a comprehensive approach.

While there are various causes for a child to become unresponsive, the central issues that need to be addressed include keeping blood pumping through the vasculature (perfusion) and supplying oxygen to the lungs (oxygenation). When the child is experiencing poor perfusion and oxygenation, CPR manually takes over for the heart and lungs. If the child is still adequately maintaining perfusion and oxygenation, but unresponsive, rapid diagnosis and treatment may be possible without CPR.

It is important to differentiate normal breathing from gasping. Gasping (agonal breathing) is considered ineffective breathing.

Likewise, not all pulses are adequate. The rule of thumb is that at least 60 beats per minute is required to maintain adequate perfusion in an infant.



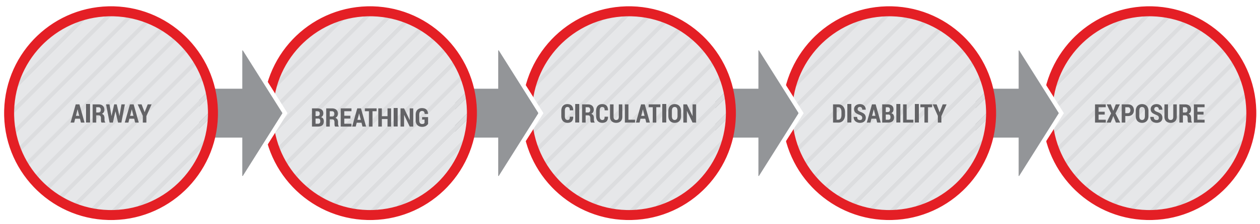
The assessment must be carried out quickly. There is a low threshold for administering ventilation and/or compressions if there is evidence that the child cannot do either effectively on their own.

If the problem is respiratory in nature (ineffective breathing with adequate pulses), then initiation of rescue breathing is warranted. If breathing is ineffective and pulses are inadequate, begin **HIGH-QUALITY CPR** immediately. It is important to understand that any case can change at any time, so you must reevaluate periodically and adjust the approach to treatment accordingly. Use CPR to support breathing and circulation until the cause has been identified and effectively treated.

INITIAL ASSESSMENT: DIAGNOSE AND TREAT

If you have reached the Diagnose and Treat phase of care, the patient is not in immediate danger of death. While this means that you likely have a brief period to find the cause of the problem and intervene with appropriate treatment; it does not mean that a life-threatening event is impossible. Always be vigilant for any indication to initiate **HIGH-QUALITY CPR** and look for life-threatening events such as respiratory distress, a change in consciousness, or cyanosis.

The AHA recommends following ***ABCDE*** when making your initial assessment.



AIRWAY

Assess the airway and make a determination between one of three possibilities.

Once an airway has been established and maintained, move on to Breathing.

Is the airway open?	• This means open and unobstructed • If yes, proceed to B
Can the airway be kept open manually?	• Jaw Lift/ Chin Thrust • Nasopharygeal or oropharygeal airway
In an advanced airway required?	• Endotracheal intubation • Cricothyrotomy, if necessary

BREATHING

If the patient is not breathing effectively, it is a life-threatening event and should be treated as respiratory arrest (detailed in a later section). However, abnormal yet marginally effective breathing can be assessed and managed.

Is breathing too fast or too slow?	• Tachypnea has an extensive differential diagnosis • Bradypnea can be a sign of impending respiratory arrest
Is there increased respiratory effort?	• Signs of increased respiratory effort include nasal flaring, rapid breathing, chest retractions, abdominal breathing, stridor, grunting, wheezing, and crackles

CIRCULATION

Assessment of circulation in children involves more than checking the pulse and blood pressure. The color and temperature of the skin and mucous membranes can help to assess effective circulation. Pale or blue skin indicates poor tissue perfusion. Capillary refill time is also a useful assessment in young patients. Adequately perfused skin will rapidly refill with blood after it is squeezed (e.g. by bending the tip of the finger at the nail bed). Inadequately perfused tissues will take longer than 2 seconds to respond. Abnormally cool skin can also suggests poor circulation.

The normal heart rate and blood pressure in children are quite different than adults and change with age. Likewise, heart rates are slower when children are asleep. Most centers will have acceptable ranges that they use for normal and abnormal heart rates for a given age. While you should follow your local guidelines, approximate ranges are listed in below.

AGE	NORMAL HEART RATE (AWAKE)	NORMAL HEART RATE (ASLEEP)	NORMAL BLOOD PRESSURE (SYSTOLIC)	NORMAL BLOOD PRESSURE (DIASTOLIC)	HYPOTENSION BLOOD PRESSURE (SYSTOLIC)
Neonate	85-190	80-160	60-75	30-45	<60
One Month	85-190	80-160	70-95	35-55	<70
Two Months	85-190	80-160	75-95	40-60	<70
Three Months	100-190	75-160	80-100	45-65	<70
Six Months	100-190	75-160	85-105	45-70	<70
One Year	100-190	75-160	85-105	40-60	<72
Two Years	100-140	60-90	85-105	40-65	<74
Child (2 to 10 years)	60-140	60-90	95-115	55-75	<70 + (age x 2)
Adolescent (over 10 years)	60-100	50-90	110-130	65-85	<90

DISABILITY

In PALS, disability refers to performing a rapid neurological assessment. A great deal of information can be gained from determining the level of consciousness on a four-level scale. Pupillary response to light is also a fast and useful way to assess neurological function.

Neurologic assessments include the AVPU Pediatric Response Scale Fig. 1, and the Glasgow Coma Scale (GCS). A specially-modified GCS is used for infants and children and takes developmental differences into account. See Fig. 2 on the next page.

AWAKE	May be sleepy, but still interactive
RESPONDS TO VOICE	Can only be aroused by talking or yelling
RESPONDS TO PAIN	Can only be aroused by inducing pain
UNRESPONSIVE	Cannot get the patient to respond

Fig. 1 AVPU Response Scale

Adapted from Gillette et al. Heart Disease in Infants, Children and Adolescents 1989:925-39; Yiallourou et al. Maturation of Heart Rate and Blood Pressure Variability during Sleep in Term-Born Infants, Sleep. 2012 February 1; 35(2): 177–186; Ngo NT, et al. Clin Infect Dis. 2001;32:204-213; Diagnosis, Evaluation, and Treatment of High Blood Pressure in Children and Adolescents, National High Blood Pressure Education Program, NIH Publication No. 05-5267, 2005.

GLASGOW COMA SCALE–INFANTS & CHILDREN

AREA ASSESSED	INFANTS	CHILDREN	SCORE
Eye opening	Open spontaneously	Open spontaneously	4
	Open in response to verbal stimuli	Open in response to verbal stimuli	3
	Open in response to pain only	Open in response to pain only	2
	No response	No response	1
Verbal response	Coos and babbles	Oriented, appropriate	5
	Irritable cries	Confused	4
	Cries in response to pain	Inappropriate words	3
	Moans in response to pain	Incomprehensible words or nonspecific sounds	2
	No response	No response	1
Motor response	Moves spontaneously and purposefully	Obeys commands	6
	Withdraws to touch	Localizes painful stimulus	5
	Withdraws in response to pain	Withdraws in response to pain	4
	Responds to pain with decorticate posturing (abnormal flexion)	Responds to pain with flexion	3
	Responds to pain with decerebrate posturing (abnormal extension)	Responds to pain with extension	2
	No response	No response	1

Figure 2: Modified Glasgow Coma Scale for Infants and Children

EXPOSURE

Exposure is classically most important when you are responding to a patient who may have experienced trauma, however it has a place in all PALS evaluations. Exposure reminds the provider to look for signs of trauma, burns, fractures or any other obvious sign that might provide a clue as to the cause of the current problem. Skin temperature and color can provide information about the patient's cardiovascular system, tissue perfusion, and mechanism of injury. If time allows, the PALS provider can look for more subtle signs such as petechiae or bruising. Exposure also reminds the provider that children lose core body temperature faster than adults do. So while it is important to evaluate the entire patient, be sure to cover and warm the patient after the diagnostic survey.

SECOND ASSESSMENT: DIAGNOSE AND TREAT

After you have progressed through ABCDE and you have discovered a treatable cause and the patient has not deteriorated to a more severe clinical (life-threatening) situation, move on to performing a more thorough survey. This includes a focused history and physical examination involving the patient, family, and any witnesses as relevant. In terms of history, you could follow the acronym SPAM.

The focused examination will be guided by the answers to the focused history. For example, a report of breathing difficulty will prompt a thorough airway and lung examination. It may also prompt a portable chest X-ray study in the hospital setting. Key point: it is best to work from head to toe to complete a comprehensive survey. Remember to make use of diagnostic tools when possible to augment the physical examination.

LIFE-THREATENING ISSUES

If at any time you determine that the patient is experiencing a life-threatening emergency, support breathing and cardiovascular function immediately. This usually means providing **HIGH-QUALITY CPR**. While it is important to recognize and respond to the particular cause of the problem, the time required to determine the problem should not interfere with perfusion and oxygenation for the patient. As you maintain breathing and circulation for the patient, determine if the patient is primarily experiencing Respiratory Distress/Arrest, Bradycardia, Tachycardia, Shock, or Cardiac Arrest. Individual PALS protocols for each of these clinical situations are provided throughout this handbook.

S: SIGNS & SYMPTOMS

- Evaluate recent events related to current problem
  - -Preceding illness, dangerous activity
- Examine patient from head to toe for the following:
  - - Consciousness, delerium
  - - Agitation, anxiety, depression
  - - Fever
  - - Breathing
  - - Appetite
  - - Nausea/vomiting
  - - Diarrhea (bloody?)

P: PAST MEDICAL HISTORY

- Complicated birth history?
- Hospitalizations?
- Surgeries?

A: ALLERGIES

- Any drug or environmental allergies?
- Any exposure to allergens or toxins?

M: MEDICATIONS

- What medications is the child taking (prescribed and OTC)?
- Could she have taken any inappropriate medication or substance?

SELF ASSESSMENT PALS

1. What is a simple mnemonic for aid in the assessment of mental status?

   A. AVPU

   B. SAMPLE

   C. ABCDE

   D. NRP

2. You are resuscitating a child and your partner suggests to follow "SPAM". What is this acronym related to?

   A. Primary survey

   B. CPR technique

   C. Secondary survey

   D. Medications to consider

3. True/False: The Glasgow Coma Scale verbal component utilizes the exact same responses for infants and adults.

ANSWERS

1. A

"Alert, responds to Verbal, responds to Pain, Unresponsive" is a simple assessment tool to assess for adequate brain perfusion.

2. C

SPAM stands for: "Signs and Symptoms, Past medical History, Allergies and Medications." SPAM refers to the history component of the more comprehensive secondary survey.

3. False

The Glasgow Coma Scale is modified for infants and children. The verbal abilities of an infant are much different from those of a child or adult.

RESUSCITATION TOOLS

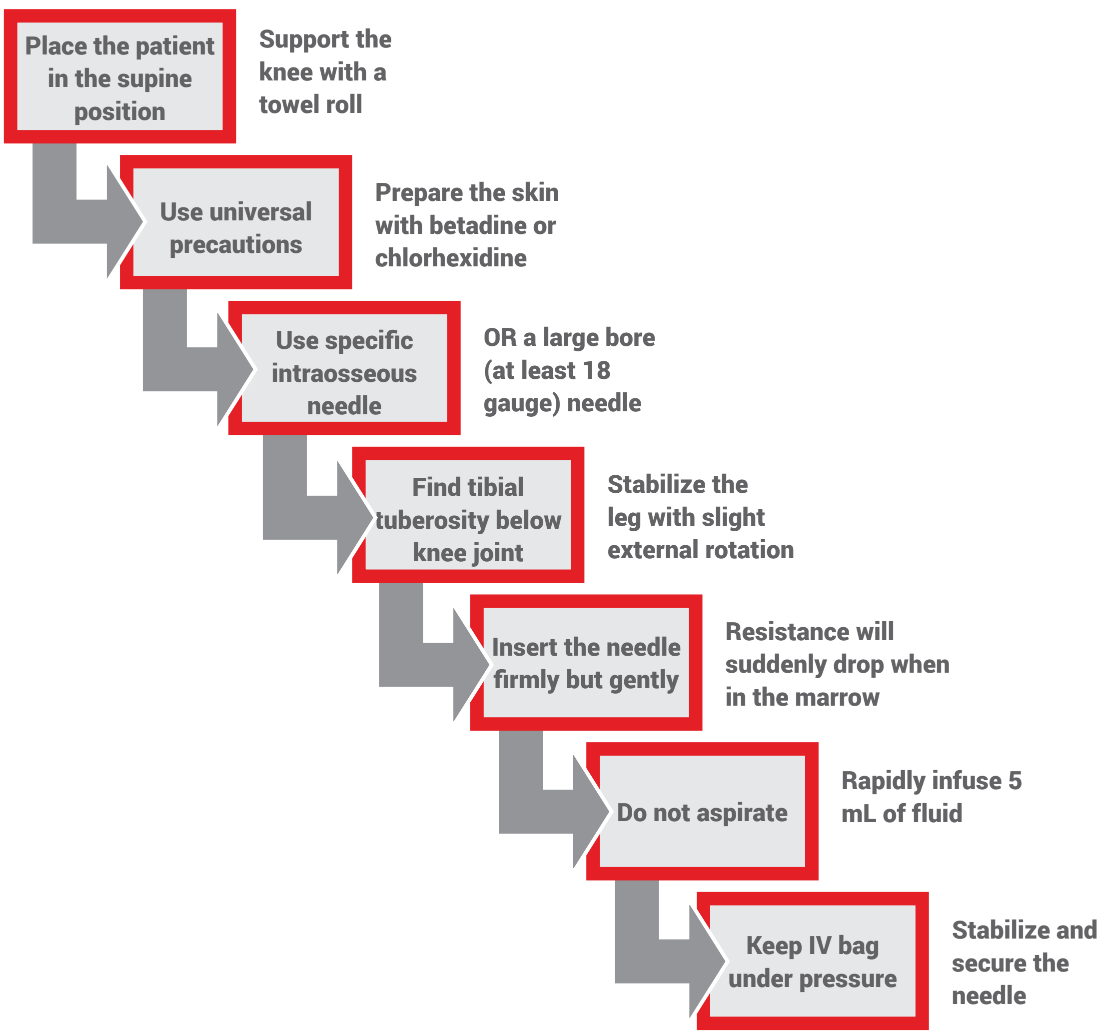
Understanding the resuscitation tools available is an essential component of PALS. These adjuncts are broken down into 2 subcategories: medical devices and pharmacological tools. A medical device is an instrument used to diagnose, treat, or facilitate care. Pharmacological tools are the medications used to treat the common challenges experienced during a pediatric emergency. It is important that thorough understanding is achieved to optimally care for a victim that needs assistance.

MEDICAL DEVICES

INTRAOSSEUS ACCESS

The relative softness of bones in young children makes intraosseous access a quick and useful means to administer fluids and medications in emergency situations when intravenous access cannot be performed quickly or efficiently. Fortunately, any medication that can be given through a vein can be administered into the bone marrow without dose adjustment. Contraindications include bone fracture, history of bony malformation, and insertion site infection.

- Intraosseous access should NOT be attempted without training.



BAG-MASK VENTILATION

When performed appropriately, bag-mask ventilation is an important intervention in PALS. Proper use requires proper fit; the child's mouth and nose should be covered tightly, but not the eyes. When possible, use a clear mask since it will allow you to see the color of the patient's lips and the presence of condensation in the mask indicating exhalation. The two most common types of bag masks are self-inflating and flow-inflating. While a self-inflating bag should be the first choice in resuscitations, it should not be used in infants or children who are spontaneously breathing.

Flow-inflating bags, on the other hand, require more training and experience to operate properly as the provider must manage gas flow, suitable mask seal, patient neck position, and proper tidal volume simultaneously. The minimum size bag should be 450 ml for infants and young children. Older children may require a 1000 ml volume bag. Proper ventilation is of utmost importance as insufficient ventilation leads to respiratory acidosis.

Proper Position

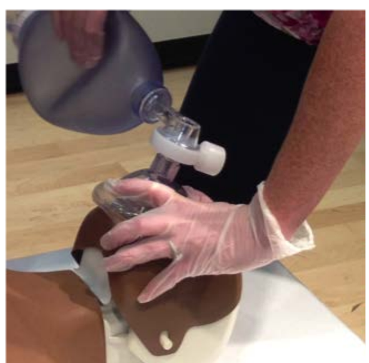
- **In the absence of neck injury, tilt the forehead back and lift the chin**

Tight Seal

- **Use the "E-C clamp," which is the letters E and C formed by the fingers over the mask**

Ventilate

- **Squeeze the bag over one second until the chest rises**
- **Do NOT over ventilate**



ENDOTRACHEAL INTUBATION

Endotracheal intubation is used when the airway cannot be maintained, bag mask ventilation is inadequate or ineffective, or when a definitive airway is necessary. Endotracheal intubation requires specialized training and a complete description is beyond the scope of this handbook.

BASIC AIRWAY ADJUNCTS

OROPHARYNGEAL AIRWAY (OPA)

The OPA is a J-shaped device fits over the tongue to hold it and the soft hypopharyngeal structures away from the posterior wall of the pharynx. It is used in patients who are at risk for developing airway obstruction from the tongue or from relaxed upper airway muscle.

The OPA is used in unconscious patients if efforts to open the airway fail to provide and maintain a clear, unobstructed airway. An OPA should not be used in a conscious or semiconscious patient because it can stimulate gagging and vomiting. The key assessment is to check whether the patient has an intact cough and gag reflex. If so, do NOT use an OPA.

NASOPHARYNEGEAL AIRWAY (NPA)

The NPA is a soft rubber or plastic uncuffed tube that provides a conduit for airflow between the nares and the pharynx. It is used as an alternative to an OPA in patients who need a basic airway management adjunct. Unlike the oral airway, NPAs may be used in conscious or semiconscious patients (patients with intact cough and gag reflex). The NPA is indicated when insertion of an OPA is technically difficult or dangerous. Use caution or avoid placing NPAs in a patient with obvious facial fractures.

SUCTIONING

Suctioning is an essential component of maintaining a patent airway. Providers should suction the airway immediately if there are copious secretions, blood, or vomit. Attempts at suctioning should not exceed 10 seconds. To avoid hypoxemia, follow suctioning attempts with a short period of 100% oxygen administration.

Monitor the patient's heart rate, pulse oxygen saturation, and clinical appearance during suctioning. If a change in monitoring parameters is seen, interrupt suctioning and administer oxygen until the heart rate returns to normal and clinical condition improves. Assist ventilation as warranted.

- Only use an OPA in unresponsive patients with NO cough or gag reflex. Otherwise, OPA can stimulate vomiting, aspiration, and laryngeal spasm.
- An NPA can be used in conscious patient with intact cough and gag reflex. However, use carefully in patients with facial trauma because of risk of displacement.
- Remember the patient is not receiving 100% oxygen while suctioning. Interrupt suctioning and administer oxygen if any change in monitoring parameters is observed during suctioning.

BASIC AIRWAY TECHNIQUE

INSERTING AN OROPHARYNGEAL AIRWAY (OPA)

STEP 1-Clear the mouth of blood or secretions with suction, if possible.

STEP 2-Select an airway device that is the correct size for the patient.

- Too large of an airway device can damage the throat.
- Too small of an airway device can press the tongue into the airway.

STEP 3-Place the device at the side of the patient's face. Choose the device that extends from the corner of the mouth to the earlobe.

STEP 4-Insert the device into the mouth so the point is toward the roof of the mouth or parallel to the teeth.

- DO NOT press the tongue back into the throat.

STEP 5-Once the device is almost fully inserted, turn it until the tongue is cupped by the interior curve of the device.

INSERTING A NASOPHARYNGEAL AIRWAY (NPA)

STEP 1-Select an airway device that is the correct size for the patient.

STEP 2-Place the device at the side of the patient's face. Choose the device that extends from the tip of the nose to the earlobe. Use the largest diameter device that will fit.

STEP 3-Lubricate the airway with a water-soluble lubricant or anesthetic jelly.

STEP 4-Insert the device slowly, moving straight into the face (not towards the brain).

STEP 5-It should feel snug; do not force the device into the nostril. If it feels stuck, remove it and try the other nostril.

TIPS ON SUCTIONING

- When suctioning the oropharynx, do not insert the catheter too deeply. Extend the catheter to the maximum safe depth and suction as you withdraw.
- When suctioning an endotracheal tube, remember the tube is within the trachea and you may be suctioning near the bronchi/lung. Therefore, sterile technique should be used.
- Each suction attempt should be for no longer than 10 seconds. Remember the patient will not get oxygen during suctioning.
- Monitor vital signs during suctioning and stop suctioning immediately if the patient experiences hypoxemia (O_2 sats less than 94%), has a new arrhythmia, or becomes cyanotic.

- OPAs too large or too small may obstruct the airway.
- NPAs sized incorrectly may enter the esophagus.
- Always check for spontaneous respirations after insertion of either device.

AUTOMATED EXTERNAL DEFIBRILLATOR (AED)

If you look around the public places you visit, you are likely to find an AED. An AED is both sophisticated and easy to use, providing lifesaving power in a user-friendly device. This makes the device useful for people who have no experience operating an AED and allows successful use in stressful scenarios. However, proper use of an AED is very important. The purpose of defibrillation is to "reset the electrical systems of the heart allowing a normal rhythm a chance to return.

CRITERIA FOR AED USE

- **No response after shaking and shouting**
- **Not breathing or ineffective breathing**
- **No carotid artery pulse detected**

AED STEPS FOR INFANTS & CHILDREN

1. Retrieve the AED (Fig. 1)

- Open the case
- Turn on the AED

2. Expose the victim's chest (Fig. 2)

- If wet, dry chest
- Remove medication patches

3. Open the Pediatric AED pads (Fig. 3) If pediatric pads not available use adult pads. Ensure pads do not touch.

- Peel off backing
- Check for pacemaker or defibrillator if present do not apply patches over the device

4. Apply the pads (Fig. 4)

- Upper right chest above breast
- Lower left chest below armpit

Fig. 1

Fig. 2

Fig. 3

Fig. 4

- If the AED is not working properly, continue giving CPR. Do NOT waste excessive time troubleshooting the AED. CPR always comes FIRST–AEDs are supplemental.
- Do NOT use AED in water.

AED Steps for Infants & Children Cont.

5. Ensure wires are attached to AED box *(fig. 1)*
6. Move away from the victim *(fig. 2)*
   - Stop CPR
   - Instruct others not to touch victim
7. Aed analyzes the rhythm
8. Message "Check Electrodes"
   - Ensure electrodes make good contact
9. Message "Shock"
   - Ensure electrodes make good contact
10. Resume CPR for 2 minutes *(fig. 3)*
11. Repeat cycle

Fig. 1

Fig. 2

Fig. 3

Fig. 3

2010 AHA GUIDELINES FOR DEFIBRILLATION

Initial dose should be 2 to 4 J/kg (4 J/kg for refractory VF). Ideal energy levels yet to be determined.

2010 AHA GUIDELINES FOR AED USE

For 1-8 year olds, an AED with a pediatric dose to attenuator system should be used (if available). For infants under 1 year old, manual defibrillation is preferred. If neither pediatric dose attenuator or manual defibrillator available, a standard adult AED may

PHARMACOLOGICAL TOOLS

Use of any of the medications in Fig. 3 should be done within your scope of practice and after thorough study of the actions and side effects. This table provides only a brief reminder for those who are already knowledgeable in the use of these medications. Moreover, the table contains only pediatric doses, indications, and routes of administration (IV/IO) for the most common PALS drugs. Although cited for reference, routine administration of drugs via an ET tube is discouraged. Rapid access and drug delivery through an IO is preferred to ET administration as drug absorption from the ET tube route is unpredictable.

Fig. 3 Pediatric Doses, Routes & Uses of Common PALS Drugs

DRUG	MAIN PALS USE	PEDIATRIC DOSE (IV/IO)	NOTES
Adenosine	Supraventricular tachycardia	First dose: 0.1 mg/kg (MAX DOSE 6 mg) Second dose: 0.2 mg/kg (MAX DOSE 12 mg)	Rapid IV/IO bolus (no ET) Flush with saline Monitor ECG
Amiodarone	Tachyarrhythmia	5 mg/kg over 20 to 60 minutes Repeat up to 15 mg/kg (MAX DOSE 300 mg)	Very long half life Monitor ECG & BP
Atropine	Bradycardia	0.02 mg/kg ET: 0.03 mg/kg Repeat once if needed (MAX single dose 0.5 mg)	Also used to treat specific toxins (e.g. organophosphate poisoning)
Epinephrine	Cardiac Arrest/Shock	IV/IO: 0.01 mg/kg [1:10,000] (MAX DOSE 1 mg) ET: 0.1 mg/kg [1:1,000] (MAX DOSE 2.5 mg)	Multiple uses, multiple routes Repeat every 3 to 5 min if needed
Glucose	Hypoglycemia	0.5 to 1 g/kg	Newborn: 5 to 10 mL/kg $D_{10}W$ Infants/Children: 2 to 4 mL/kg $D_{25}W$ Adolescents: 1 to 2 mL/kg $D_{50}W$
Lidocaine	Tachyarrhythmia	Initial: 1 mg/kg Infusion: 20 to 50 mcg/kg/min (MAX DOSE 100 mg) ET: 2 to 3 mg	
Magnesium Sulfate	Torsades de Pointes Refractory Asthma	20 to 50 mg/kg over 10 to 20 min (MAX DOSE 2 grams)	May run faster for Torsades
Milrinone	Cardiogenic Shock	Initial: 50 mcg/kg over 10 to 60 min Maintain: 0.5 to 0.75 mcg/kg/min	Longer infusion times and euvolemia will reduce risk of hypotension
Naloxone	Opioid Reversal	Less than 5 y/o OR under 20 kg: 0.1 mg/kg Over 5 y/o OR over 20 kg: 2 mg IV q 2 to 3 min prn	Decrease dose to reverse respiratory depression due to therapeutic opioid use (1 to 5 mcg/kg, titrate to effect)
Procainamide	Tachyarrhythmia	15 mg/kg over 30 to 60 minutes	Do NOT give with amiodarone Monitor ECG & BP
Sodium Bicarbonate	Metabolic Acidosis	1 mEq/kg slow bolus (MAX DOSE 50 mEq)	Monitor ABG & ECG After adequate ventilation

SELF ASSESSMENT RESUSCITATION TOOLS

1. What is the proper sequence for AED operation?

   A. Apply pads, turn on AED, shock victim, clear victim

   B. Apply pads, clear victim, shock, analyze rhythm

   C. Turn on AED, apply pads, deliver shock, resume CPR

   D. Turn on AED, analyze rhythm, CPR, shock

2. You are treating a 10 year old with a rapid pulse. The monitor is showing SVT. What drug do you consider to treat this patient?

   A. Vasopressin

   B. Lidocaine

   C. Bretylium

   D. Adenosine

3. Which of the following explains why ET delivery of drugs is not the preferred route?

   A. Unpredictable absorption

   B. Allergic reaction

   C. Difficult administration

   D. High effectiveness

ANSWERS

1. B

AED devices are equipped with instructions and may also have voice prompts making these devices operable by everyone.

2. D

Adenosine is effective for the treatment of SVT. The first dose is 0.1 mg/kg up to a maximum of 6 mg. The second dose is 0.2 mg/kg up to a maximum of 12 mg.

3. A

Delivery of medications via the endotracheal tube results in unpredictable absorption. The intravenous or intraosseous route is preferred.

RESPIRATORY DISTRESS/FAILURE

RECOGNIZE

In its simplest form, respiratory distress is a condition in which pulmonary activity is insufficient to bring oxygen to and remove carbon dioxide from the blood. Challenge arises with the recognition of respiratory distress when the patient appears to be breathing, but is not actually breathing effectively. Proper rate and depth of breathing is important to assess when evaluating whether a patient is effectively breathing. The two main actions involved in breathing are ventilation and oxygenation. Consider the signs and symptoms presented below:

VENTILATION		
Is the airway clear?	Are the muscles of the chest functioning?	Is the rate of breathing sufficient?
Ex. An obstructed airway prevents gas flow	Ex. Chest muscle fatigue can occur	Ex. CNS depression can slow/stop breathing

OXYGENATION		
Is oxygen available?	Is lung blood flow adequate?	Can gases cross the pulmonary vasculature?
Ex. High altitudes have low O_2	Ex. Vascular shunts may not send blood to lungs	Ex. Pulmonary edema or pneumonia

	RESPIRATORY DISTRESS	RESPIRATORY FAILURE
Airway	Open without support	Possibly obstructed
Respiratory Rate	Tachypnea	Slow breathing
Respiratory Effort	Increased effort	No effort
Lung sounds	Clear sounds	Abnormal sounds
Heart rate	Tachycardia	Bradycardia
Responsiveness	Agitated	Fails to respond
Appearance / capilary beds	Pale	Cyanotic
	Variable	Variable

ABNORMAL BREATH SOUNDS

STRIDOR	• Upper airway obstruction (Foreign body)
GRUNTING	• Upper airway obstruction (Swollen airway) • Pneumonia (grunting to recruit alveoli)
WHEEZING	• Lower airway obstruction (Asthma)
CRACKLES	• Fluid in lungs (Wet), Atelectasis (Dry)
ABSENT/DECREASED BREATH SOUNDS	• Collapsed lung (Air, blood) • Lung tissue disease (Pneumonia)

- In some instances, breath sounds can provide information about the source of the breathing problem.

CAUSES OF RESPIRATORY DISTRESS/FAILURE

Respiratory distress or failure generally falls into one of four broad categories: upper airway, lower airway, lung tissue disease, and CNS issues. This list is not comprehensive and specific conditions should be addressed with specific therapy, but these represent the most common causes of respiratory distress or failure in a pediatric population.

UPPER AIRWAY	LOWER AIRWAY	LUNG TISSUE DISEASE	CNS ISSUES
• Croup (swelling) • Foreign body • Retropharangeal abscess • Anaphylaxis	• Bronchiolitis • Asthma	• Pneumonia • Pneumonitis • Pulmonary edema	• Overdose • Head trauma

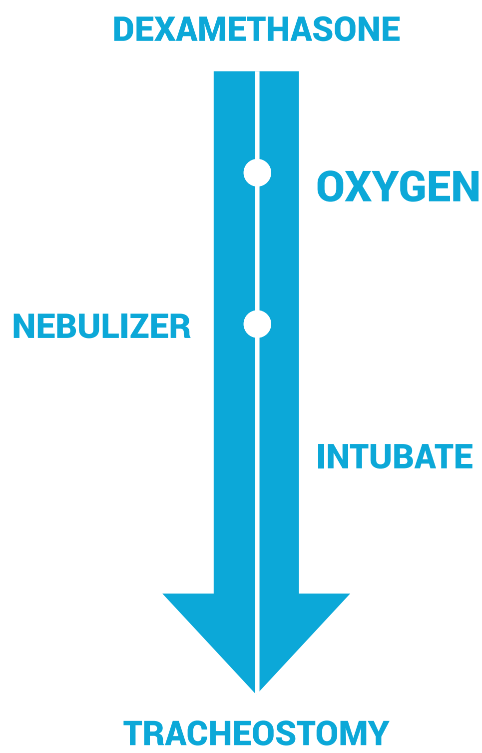
RESPOND

INITIAL MANAGEMENT OF RESPIRTORY DISTRESS/FAILURE			
AIRWAY	Open and support the airway	Suction	Consider advanced airway
BREATHING	Monitor O_2 stats	Supplemental O_2	Nebulizers
CIRCULATION	Monitor vitals	Establish vascular access	

- As an example, croup management depends on the severity of the disease.
- Dexamethasone, a corticosteroid, can cause hypertension and reduced activation of lymphocytes.

PALS management of respiratory distress/failure is adjusted based on the severity of the current condition. For example, mild asthma is treated with bronchodilator inhalers, but severe asthma (status asthmaticus) may require endotracheal intubation. The provider must continually assess the patient's current needs and adjust care accordingly.

CROUP MANAGEMENT



UPPER AIRWAY		LOWER AIRWAY		LUNG TISSUE DISEASE		CNS ISSUES	
Cause	Treatment	Cause	Treatment	Cause	Treatment	Cause	Treatment
CROUP	Dexamethasone Oxygen (Heliox) Nebulizer (epinephrine) Intubate Tracheostomy	BRONCHIOLITIS	Suctioning Nebulizers	PNEUMONIA	Antibiotics Nebulizers Support breathing	OVERDOSE	Naloxone (opioid reversal) Antidotes Support breathing
FOREIGN BODY	Back slap, abdominal thrusts (Heimlich) Suction Expert consultation Tracheostomy as needed	ASTHMA	Oxygen Nebulizers (albuterol and ipratropium bromide) Corticosteroids Magnesium sulfate Epinephrine SQ Support breathing Iteliox	PNEUMONITIS	Antibiotics (bacterial) Nebulizers Support breathing	TRAUMA	Neurosurgery Reduce intracranial pressure Support breathing
ANAPHYLAXIS	Epinephrine IM Nebulizer Diphenhydramine Methylprednisolone Other H2 Blockers			PULMONARY EDEMA	Diuretics Inotrope Support breathing		

- In general, providers commonly work from the least invasive intervention to the most invasive (top to bottom).
- If the patient presents with severe distress, proceed directly to maneuvers that are more aggressive.
- Albuterol is the most common medication used via nebulizer to cause bronchodilation.
- Common causes of acute community-acquired pneumonia include Streptococcus pneumonia, Mycoplasma pneumonia, Haemophilus influenza and Chlamydia pneumonia.
- High fever is the most common cause of quiet tachypnea.

SELF ASSESSMENT RESPIRATORY DISTRESS/FAILURE

1. Which of the following sounds suggests an upper airway obstruction?

A. Stridor

B. Burping

C. Rales

D. Apnea

2. A 5-year-old child is laughing and playing with his siblings. Moments later the child was noted to be coughing with asymmetric chest rise. What is the most likely cause?

A. Trauma

B. Airway obstruction

C. Stroke

D. Pericardial tamponade

3. A 4-month-old female infant is noted to be febrile and grunting. What underlying problem does grunting suggest?

A. Behavior problem

B. Upper airway obstruction

C. Lung tissue disease

D. Diabetes

ANSWERS

1. A

Stridor suggests an upper airway source of obstruction. Rales are a sign of lower airway disease. Burping is non-specific and apnea is an ominous sign, but in itself does not suggest the location of an obstruction.

2. B

Asymmetric chest rise in this setting is most likely a foreign body obstructing the right mainstem bronchus. Other causes include pneumothorax, hemothorax, pleural effusion and mucous plugging. Trauma is a possibility, but less likely in this scenario.

3. C

Grunting is a sign of lung tissue abnormality such as pneumonia or pulmonary contusion and acute respiratory distress, and may progress to respiratory failure.

BRADYCARDIA

RECOGNIZE

Bradycardia is defined as a heart rate that is slower than what is considered normal for a child's age. Bradycardia in children should be evaluated, but not all bradycardia needs to be medically managed. Intervention is required when bradycardia is symptomatic and compromises cardiovascular function. This commonly means that the heart is beating too slowly to maintain blood pressure, thereby causing shock, poor tissue perfusion, and/or a change in mental status. Symptomatic bradycardia may cause a number of signs and symptoms including low blood pressure, pulmonary edema/congestion, abnormal rhythm, chest discomfort, shortness of breath, lightheadedness, and/or confusion or syncope. Bradycardia most commonly becomes symptomatic when it is of new onset for the patient (acute slowing of the heart rate).

Sinus Bradycardia

- Normal rhythm with slow rate

First Degree AV Block

- PR interval is longer than 0.20 s

Type I Second Degree AV Block (Mobitz I)

- PR interval increases in length until QRS complex is dropped

Type II Second Degree AV Block (Mobitz II)

- PR interval is the same length with intermittently dropped QRS complex

Third Degree AV Block (Complete)

- PR and QRS are not coordinated with each other

RESPOND

SYMPTOMATIC BRADYCARDIA	
CHECK HEART RATE	Confirm abnormally low heart rate or a significant rate drop from previous normal
PALS SURVEY	A: Airway B: Breathing (Check O_2 stats; administer O_2 as needed) C: Circulation (Check blood pressure and rate; 12-lead ECG; IV/IO access)
CHECK FOR SIGNS/ SYMPTOMS	• Are there symptoms of shock or acute change in mental status? • Are there symptoms being caused by the bradycardia?
BRADYCARDIA SYMPTOMATIC AND SERIOUS	• Do not delay CPR • Epinephrine 0.01 mg/kg IO/IV – Can be given every 3-5 minutes • Atropine 0.02 mg/kg IO/IV – Can be repeated once
DRUGS UNSUCCESSFULL	Consider transthoracic/transvenous pacing (preferably with sedation) especially if bradycardia is the result of a complete heart block or an abnormal sinus node function Seek expert consultation

- The primary goal of symptomatic bradycardia treatment is to make sure the heart is adequately pumping blood to the body (adequate perfusion).
- Treatment is not necessarily aimed at increasing the heart rate. Treatment should continue until symptoms/signs resolve.
- If the patient stops having a pulse, move to Cardiac Arrest Protocol.
- Always consider the reversible causes of bradycardia in pediatric patients and treat if possible.
- Atropine in doses less than 0.1mg may worsen bradycardia (paradoxical bradycardia).

PEDIATRIC BRADYCARDIA WITH PULSE/POOR PERFUSION ALGORITHM

DOSES/DETAILS

EPINEPHRINE IO/IV DOSE:

0.01 mg/kg. Repeat every 3-5 minutes.
If IO/IV access not available but endotracheal (ET) tube in place, may give ET dose: 0.1mg/kg

ATROPINE IO/IV DOSE:

0.02 mg/kg. May repeat once.

- Minimum dose 0.1 mg
- Maximum single dose 0.5 mg

IDENTIFY AND TREAT UNDERLYING CAUSE

- Maintain patent airway; assist breathing if necessary
- If hypoxemic, administer oxygen
- Cardiac monitor to identify rhythm
- Monitor blood pressure and pulse oximetry
- IO/IV access
- Assess 12-Lead ECG

PERSISTENT BRADYARRHYTHMIA CAUSING:

- Hypotension?
- Acutely altered mental status?
- Signs of shock?

NO → Monitor and observe / Consider specialist consultation

YES

CPR IF HR <60/MIN

with poor perfusion despite oxygenation and ventilation

Bradycardia persists?

NO

- Monitor and observe
- Consider specialist consultation

YES

- Epinephrine
- Atropine for increased vagal tone or primary AV block
- Consider transthoracic pacing/ transvenous pacing
- Treat underlying causes

If pulseless arrest develops, go to Pediatric Cardiac Arrest Algorithm

SELF ASSESSMENT BRADYCARDIA

1. You are treating a child with a toxin ingestion, resulting in bradycardia. Atropine is advised by poison control. Why is the minimum dose 0.1 mg IV?

   A. Rebound tachycardia

   B. May worsen bradycardia

   C. Apnea

   D. Cardiac arrest

2. What is the drug of choice in managing symptomatic bradycardia?

   A. Adenosine

   B. Epinephrine

   C. Lidocaine

   D. Dopamine

3. Your team is treating a child with symptomatic bradycardia. His heart rate is 22 and you are having difficulty obtaining blood pressure. Epinephrine and atropine have had no effect. What would be the most appropriate next action?

   A. Faster CPR

   B. Transthoracic Pacing

   C. High dose epinephrine

   D. Terminate resuscitation

ANSWERS

1. B

A dose less than 0.1 mg may worsen the bradycardia. The maximum dose for a child is 0.5 mg and 1 mg in adolescent.

2. B

Epinephrine is a potent vasopressor and will also increase heart rate. The dose for bradycardia is 0.01 mg/kg IV or IO.

3. B

Transthoracic pacing is an option for treatment of symptomatic bradycardia when drug therapy fails.

TACHYCARDIA

RECOGNIZE

Tachycardia is defined as a heart rate greater than what is considered normal for a child's age. Like bradycardia, tachycardia can be life threatening if it compromises the heart's ability to perfuse effectively. When the heart beats too quickly, there is a shortened relaxation phase. This causes two main problems: 1) the ventricles are unable to fill completely, so cardiac output is lowered and 2) the coronary arteries receive less blood, so supply to the heart is decreased.

There are several kinds of tachycardia and they can be difficult to differentiate in children on ECG due to the elevated heart rate.

SIGNS AND SYMPTOMS OF TACHYCARDIA

- Respiratory distress/failure
- Poor tissue perfusion (e.g. low urine output)
- Altered mental state
- Pulmonary edema/congestion
- Weak, rapid pulse

Sinus tachycardia

- Normal rhythm with fast rate, likely non-dangerous, commonly occurring during stress or fever

Supraventricular tachycardia

- Rhythm starts above the ventricles

Atrial fibrillation

- Causes an “irregularly irregular” heart rhythm

Atrial flutter

- Causes a “sawtooth” pattern on ECG

Ventricular tachycardia

- Rhythm starts in the ventricles

Pediatric tachyarrhythmias are first divided into narrow complex or wide complex tachycardia. Measure the QRS complex on a standard ECG to assess width.

NARROW QRS COMPLEX (≤ 0.09 s)	WIDE QRS COMPLEX (> 0.09 s)
• Atrial flutter • Sinus tachycardia • Supraventricular Tachycardia (SVT)	• Ventricular tachycardia • Unusual SVT

NARROW QRS COMPLEX

Atrial flutter is an uncommon rhythm distinguished on an ECG as a "sawtooth" pattern. It is caused by an abnormal reentrant pathway that causes the atria to beat very quickly and ineffectively. Atrial contractions may exceed 300 bpm but not all of these will reach the AV node and cause a ventricular contraction.

Most often, PALS providers will have to distinguish between two similar narrow QRS complex tachyarrhythmias—sinus tachycardia and supraventricular tachycardia (SVT). SVT is more commonly caused by accessory pathway reentry, AV node reentry, and ectopic atrial focus.

SINUS TACHYCARDIA	SUPRAVENTRICULAR TACHYCARDIA
• Infant: < 220 bpm	• Infant: > 220 bpm
• Child: < 180 bpm	• Child: > 180 bpm
• Slow onset	• Abrupt start/stop
• Fever, hypovolemia	• Pulmonary edema
• Varies with stimulation	• Constant, fast rate
• Visible P waves	• Absent P waves

WIDE QRS COMPLEX

Ventricular tachycardia (VTach) is uncommon in children but can be rapidly fatal. Unless the patient has a documented wide complex tachyarrhythmia, an ECG with a QRS complex > 0.09 sec is VTach until proven otherwise. Polymorphic VTach, Torsades de pointes, and "unusual" SVT (SVT with wide complexes due to aberrant conduction) may be reversible (e.g. magnesium for Torsades), but **do not delay** treatment for VTach. Any of these rhythms can devolve into ventricular fibrillation (VFib). VTach may not be particularly rapid (simply > 120 bpm) but is regular. Generally, P waves are lost during VTach or become dissociated from the QRS complex. Fusion beats are a sign of ventricular tachycardia and are produced when both a supraventricular and ventricular impulse combine to produce a hybrid appearing QRS (fusion beat) (see Fig. 9).

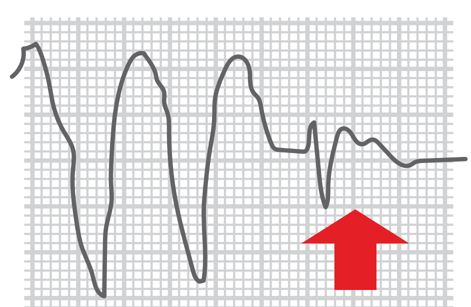
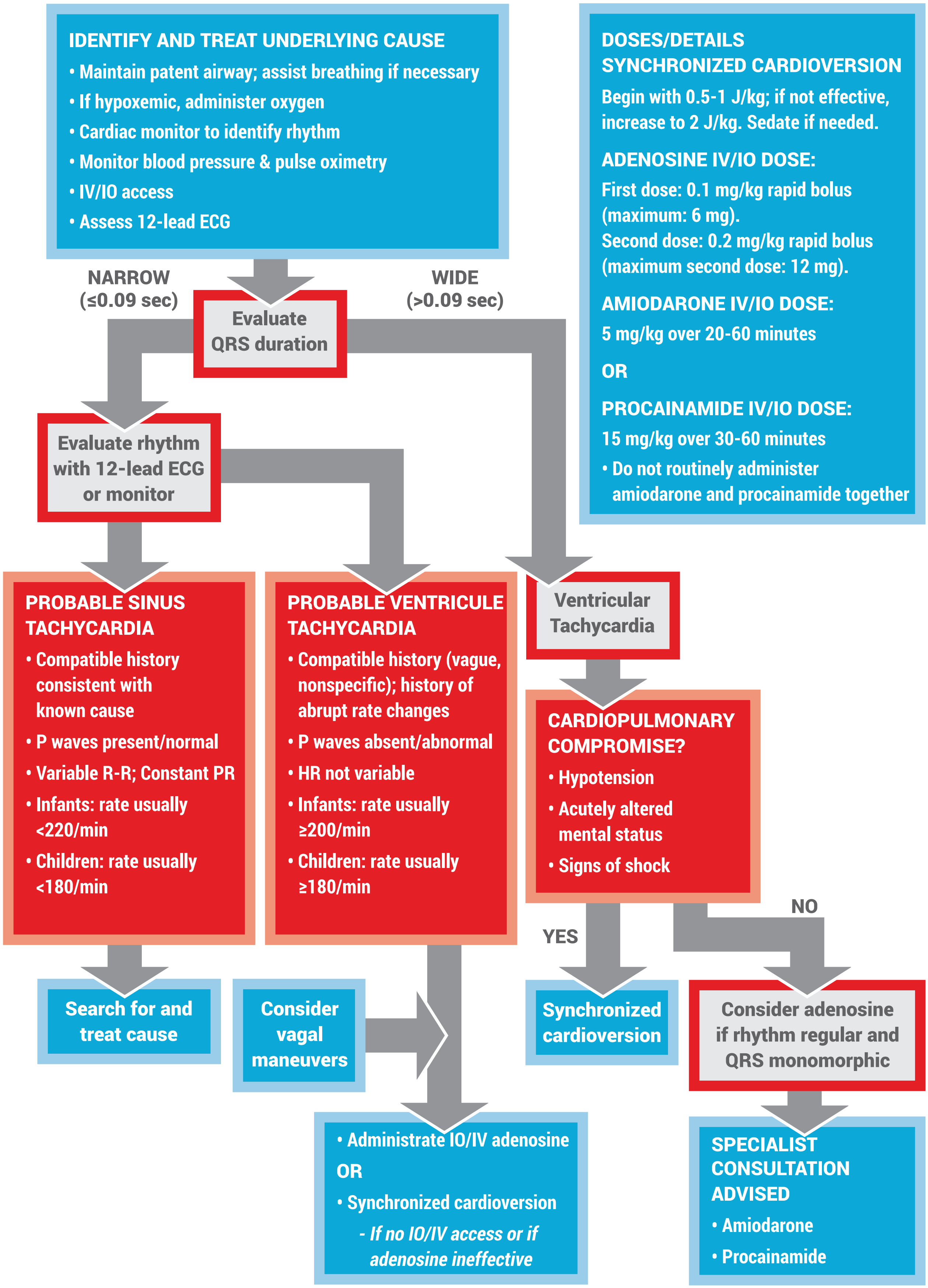


Fig. 9: Fusion Beat

RESPOND

The initial management of tachyarrhythmia is to assess PULSE and PERFUSION



SELF ASSESSMENT TACHYCARDIA

1. Which of the following is not a life threatening arrhythmias?

    A. Torsades de pointes

    B. Ventricular fibrillation

    C. Ventricular tachycardia

    D. Sinus tachycardia

2. You are treating a 13-year-old male who has a history of congenital heart disease. The monitor shows a narrow complex rhythm with a heart rate of 175 and he has a palpable pulse. Which of the following is a possible diagnosis?

    A. SVT with aberrancy

    B. Sinus tachycardia

    C. Torsades de pointes

    D. Ventricular tachycardia

3. You are treating a 10-year-old child who has SVT. What is the appropriate first dose for adenosine?

    A. 1 mg

    B. 6 mg

    C. 0.1mg/kg with a maximum dose of 6mg

    D. 12 mg

ANSWERS

1. D

Sinus tachycardia is often a response to an underlying condition such as fever, pain or stress. Blood loss and hypovolemia can also result in sinus tachycardia, but the rhythm itself is not life threatening.

2. B

Sinus tachycardia, atrial fibrillation or flutter and supraventricular tachycardia are narrow complex rhythms. The other choices are wide complex rhythms.

3. C

Pediatric drug doses are based on weight. The maximum first dose is 6mg for both adults and children. The other options are incorrect.

SHOCK

RECOGNIZE

Shock is defined as a condition in which peripheral tissues and end organs do not receive adequate oxygen and nutrients. While it is sometimes used interchangeably with severe hypotension, shock does not only occur in the setting of severely low blood pressure. Importantly, the body will attempt to compensate for shock through various mechanisms, most commonly through increased heart rate. The heart rate will increase in an attempt to increase cardiac output (stroke volume x heart rate). Blood flow will be shunted from less vital organs such as the skin, to more vital organs such as the kidneys and brain. In these cases, the child may be experiencing shock, but have high, normal, or low-normal blood pressure. This is called compensatory shock and may only persist for minutes to hours before progressing to frank uncompensated shock unless treatment is initiated. Without treatment, these compensatory systems can become overwhelmed and result in the child progressing quickly to critical hypotension and cardiac arrest. Therefore, the simple assessment of blood pressure is not a sufficient way to evaluate potential shock in pediatric patients.

TYPES OF SHOCK	
HYPOVOLEMIC	**Low blood volume, often due to hemorrhage or fluid shifting out of vasculature**
DISTRIBUTIVE	**Heart is not pumping adequately**
CARDIOGENIC	**Blood vessel dilation (e.g. septic shock)**
OBSTRUCTIVE	**Physical block of the blood flow**

HYPOVOLEMIC SHOCK

Hypovolemic shock is the most common type of shock and perhaps the easiest to understand. Hypovolemic shock results from insufficient blood in the cardiovascular system. This can be due to hemorrhage externally, or into the peritoneum or into the gastrointestinal system. Hypovolemic shock in children can also occur from water loss, perspiration, diarrhea, vomiting, or when fluid moves into the tissues ("third-spacing").

In hypovolemic shock, preload to the heart is decreased (less volume to fill the heart), though contractility is normal or increased. Likewise, afterload is increased since the vessels have constricted in an attempt to increase blood pressure.

SIGNS OF HYPOVOLEMIC SHOCK

- **Possible tachypnea**
- **Tachycardia**
- **Adequate or low blood pressure**
- **Narrow pulse pressure**
- **Slow capillary refill**
- **Weak peripheral pulses**
- **Normal central pulses**
- **Possible decreased urine output**
- **Decreased level of consciousness**

DISTRIBUTIVE SHOCK

Distributive shock is a condition in which the majority of blood is inappropriately distributed in the vasculature. A common way to conceptualize distributive shock is as a condition in which the vasculature has relaxed and dilated to the point of inadequacy. The arterial blood supply needs to maintain a certain tension in order to maintain blood pressure. Likewise, the venous system must maintain tension as well, so as not to retain too much of the total blood supply. In distributive shock, the blood is not being maintained in "useful" blood vessels. Distributive shock is most commonly caused by sepsis, anaphylaxis, or a neurological problem; all of which cause vascular dilation or loss of blood vessel tone. In distributive shock, preload, contractility, and afterload vary depending on the etiology.

SEPTIC SHOCK	ANAPHYLACTIC SHOCK	NEUROGENIC SHOCK
• Decreased preload • Normal/decreased contractility • Afterload varies	• Decreased preload • Contractility varies • Afterload is low in left ventricle and high in right ventricle	• Decreased preload • Normal contractility • Afterload is decreased

Distributive shock is difficult to recognize because the signs and symptoms vary greatly depending on the etiology. Common symptoms include tachypnea, tachycardia, low to normal blood pressure, decreased urine output, and decreased level of consciousness.

Distributive shock is further categorized into "warm" and "cold" shock. If the patient is experiencing "warm" shock, they commonly will have warm, erythematous peripheral skin and have a wide pulse pressure in the setting of hypotension. If the patient is experiencing "cold" shock, they commonly will have pale vasoconstricted skin and narrow pulse pressure hypotension. In each case, distributive shock is generally considered when a patient is likely to have one of the three main causes: sepsis, anaphylaxis, or neurological problem.

CARDIOGENIC SHOCK

Cardiogenic shock is caused by inadequate contractility of the heart. One of the key differences between hypovolemic and cardiogenic shock is the work of breathing. In both cases there will be tachypnea, but in hypovolemic shock the effort of breathing is only mildly increased. However in cardiogenic shock, the work of breathing is often significantly increased as evidenced by grunts, nasal flaring, and the use of accessory thorax muscles. Also, since the heart is pumping ineffectively, blood remains in the pulmonary vasculature. This causes pulmonary congestion and edema, which can clinically be heard as crackles in the lungs and visualized as jugular vein distension. Pulses are often weak, capillary refill is slow, extremities are cool and cyanotic, and there may be a decrease in the level of consciousness.

OBSTRUCTIVE SHOCK

Obstructive shock is similar to cardiogenic shock in that impaired heart function is the primary abnormality. In cardiogenic shock, contractility is impaired, but in obstructive shock, the heart is prevented from contracting appropriately. Common causes of obstructive shock are cardiac tamponade, tension pneumothorax, congenital heart malformations, and pulmonary embolism. Obstructive and cardiogenic shock is most easily distinguished by the contractility of the heart. In obstructive shock, heart contractility is normal though pumping function is not. Cardiac tamponade is associated with muffled heart sounds since blood is present in the pericardial space. Pulsus paradoxus (e.g. a drop in blood pressure on inspiration) may also be present. Tension pneumothorax is a clinical diagnosis. The trachea may be deviated away from the side of the lesion and there are absent breath sounds over the affected side of the chest. Consider a pulmonary embolism when the patient is cyanotic, hypotensive, experiences chest pain, and has respiratory distress without lung pathology or airway obstruction. Risk factors include obesity, hormone use, family history of abnormal clotting and coagulation factor abnormalities.

RESPOND

The goal of shock management is to get oxygen to the tissues and end organs. This requires having enough oxygen in the blood, getting the blood to the tissues, and keeping the blood within the vasculature. Thus, shock management is dedicated to achieving these three critical goals. In objective terms, this means returning the child to the correct blood pressure and heart rate for their age, restoring normal pulses, capillary refill, and mental status along with a urine output of at least 1 ml/kg/hour. Shock treatment varies according to etiology.

HYPOVOLEMIC SHOCK

The primary means of responding to hypovolemic shock is to provide additional volume. For children, an isotonic crystalloid such as normal saline or Lactated Ringers is the preferred fluid for volume resuscitation. While volume repletion is somewhat straightforward in adults, great care must be taken when administering intravenous fluids to infants and children. Careful estimates should be made concerning the amount of volume lost (e.g. blood loss), the size of the patient, and the degree of deficit. Current recommendations are to **administer 20 ml/kg of fluid as a bolus over 5-10 minutes and repeat as needed**.

In hemorrhagic shock, administer 3 ml of fluid for every 1 ml of estimated blood lost; a 3:1 ratio. If fluid boluses do not improve the signs of hypovolemic, hemorrhagic shock, consider administration of packed red blood cells without delay. Albumin can also be considered for additional intravenous volume for shock, trauma, and burns as a plasma expander.

If fluid boluses do not improve the signs of hypovolemic, non-hemorrhagic shock, re-evaluation of proper diagnosis and occult blood loss (e.g. into the GI tract) should be considered. The remaining interventions are aimed at restoring electrolyte imbalances (e.g. acid/base, glucose, etc.)

DISTRIBUTIVE SHOCK

The initial management of distributive shock is to increase intravascular volume. The intent is to provide enough volume to overcome the inappropriate redistribution of existing volume. As with hypovolemic shock, **administer 20 ml/kg of fluid as a bolus over 5 to 10 minutes and repeat as needed**. Beyond initial management, therapy is tailored to the cause of the distributive shock.

SEPTIC SHOCK

The management of septic shock is detailed and complex. A full description is beyond the scope of this handbook, though an excellent resource is Brierly et al. 2009[2]. In septic shock, aggressive fluid management is generally necessary. Broad-spectrum intravenous antibiotics are a key intervention and should be administered as soon as possible. In addition, a stress dose of hydrocortisone (especially with adrenal insufficiency) and vasopressors may be needed to support blood pressure. After fluid resuscitation, vasopressors are given if needed and according to the type of septic shock. Normotensive patients are usually given dopamine, "warm" shock is treated with norepinephrine, and "cold" shock is treated with epinephrine. Transfusing packed red blood cells to bring hemoglobin above 10 g/dl treats decreased oxygen carrying capacity. As blood cultures return, focus antibiotic therapy to the particular microbe and its resistance patterns.

ANAPHYLACTIC SHOCK

Intramuscular epinephrine is the first and most important treatment for anaphylactic shock. In severe cases, a second dose of epinephrine may be needed or intravenous administration may be required. Crystalloid fluid can be administered judiciously. Remember that in anaphylactic shock, capillary permeability may increase considerably. Thus, while it is important to support blood pressure overall, there is significant likelihood that third spacing and pulmonary edema will occur. Antihistamines and corticosteroids can also blunt the anaphylactic response. If breathing challenges arise, consider albuterol use to achieve bronchodilation. In very severe cases of anaphylactic shock, a continuous epinephrine infusion in the NICU or PICU may be required.

NEUROGENIC SHOCK

Neurogenic shock is clinically challenging because often there is limited ability to correct the insult. Injury to the autonomic pathways in the spinal cord results in decreased systemic vascular resistance and hypotension. An inappropriately low pulse or bradycardia is a clinical sign of neurogenic shock. Therefore, treatment is focused on fluids first: 20 ml/kg bolus over 5 to 10 minutes then reassess the patient for a response. If hypotension does not respond to fluid resuscitation, vasopressors are needed. This resuscitation should be done in conjunction with a broader neurological evaluation and treatment plan.

CARDIOGENIC SHOCK

Since children in cardiogenic shock have a problem with cardiac contractility, the primary goal of therapy is to restore contractility. Unlike most other types of shock, fluid resuscitation is not a primary intervention in cardiogenic shock. Often medications to support contractility and reduce afterload are first line treatments. In normotensive patients this means vasodilators and diuretics (both decrease intravascular volume). Contractility is supported with inotropes. Milrinone is often used to decrease peripheral vascular resistance. When additional volume is needed, fluid can be administered slowly and cautiously: 5 to 10 ml/kg over 10 to 20 minutes. A pediatric cardiologist or critical care specialist should manage patients with cardiogenic shock.

OBSTRUCTIVE SHOCK

Causes of obstructive shock require rapid and definitive care since they are acutely life-threatening. Cardiac tamponade requires pericardial drainage. Tension pneumothorax requires needle decompression and subsequent placement of a chest tube (tube thoracotomy). Pediatric heart surgeons can address vascular abnormalities, and ductus arteriosus can be induced to remain open by administering prostaglandin E1 analogs. Pulmonary embolism care is mostly supportive, though trained personnel can administer fibrinolytic and anticoagulant agents. Management of these complex etiologies is beyond the scope of this handbook.

[2] *Brierley J, Carcillo JA, Choong K, et al. Clinical practice parameters for hemodynamic support of pediatric and neonatal septic shock: 2007 update from the American College of Critical Care Medicine. Crit Care Med. Feb 2009;37(2):666-688.*

SELF ASSESSMENT SHOCK

1. A 7-year-old child is struck by a car and found to be hypotensive. What is the most likely cause of the low blood pressure?

   A. Anaphylactic shock
   B. Hypovolemic shock
   C. Cardiogenic shock
   D. Obstructive shock

2. What type of shock results in bounding peripheral pulses and a wide pulse pressure?

   A. Septic
   B. Cardiogenic
   C. Traumatic
   D. Hemorrhagic

3. You are treating a pediatric patient with low blood pressure. What amount of fluid is recommended for bolus therapy?

   A. 100 ml
   B. 1 liter
   C. 5 ml/kg
   D. 20 ml/kg

ANSWERS

1. B

Trauma is a leading cause of blood loss and hypovolemic shock. The other options are unlikely in this scenario.

2. A

Septic shock can result in a wide pulse pressure with low systemic resistance and normal or increased stroke volume.

3. D

Consider boluses of 20 ml/kg of isotonic crystalloid (normal saline or lactated ringers).

CARDIAC ARREST

RECOGNIZE

Unlike cardiac arrest in adults, which is very commonly due to acute coronary syndrome, cardiac arrest in pediatric patients is more commonly the consequence of respiratory failure or shock. Thus, cardiac arrest can often be avoided if respiratory failure or shock is successfully managed. Less than 10% of the time, cardiac arrest is the consequence of ventricular arrhythmia and occurs suddenly.

It may be possible to identify a reversible cause of cardiac arrest and treat it quickly. The reversible causes are essentially the same in infants and children as they are in adults.

REVERSIBLE CAUSES OF CARDIAC ARREST

THE H'S	THE T'S
Hypovolemia	Tension pneumothorax
Hypoxia	Tamponade
H^+ (acidosis)	Toxins
Hypo/Hyperkalemia	Thrombosis (coronary)
Hypoglycemia	Thrombosis (pulmonary)
Hypothermia	Trauma (unrecognized)

RECOGNIZE CARDIOPULMONARY FAILURE

AIRWAY	• May or may not be patent
BREATHING	• Slow breathing • Ineffective breathing
CIRCULATION	• Bradycardia and hypotension • Slow capillary refill • Weak central pulses (carotid) • No peripheral pulses (radial) • Skin mottling/cyanosis/coolness
DISABILITY	• Decreased level of consciousness
EXPOSURE	• Bleeding? • Hypothermia? • Trauma?

RECOGNIZE ARREST RHYTHMS

- ASYSTOLE
- PULSELESS ELECTRICAL ACTIVITY (PEA)
- VENTRICULAR FIBRILLATION (VFiB)
- PULSELESS VENTRICULAR TACHYCARDIA (VTach)

PULSELESS ELECTRICAL ACTIVITY AND ASYSTOLE

Pulseless electrical activity (PEA) and asystole are related cardiac rhythms in that they are both life threatening and **NOT** shockable. Asystole is the absence of electrical or mechanical cardiac activity and is represented by a flat-line ECG. There may be subtle movement away from baseline (drifting flat-line) but there is no perceptible cardiac electrical activity. **Make sure that a reading of asystole is not a technical error**. Ensure the cardiac leads are connected, gain is set appropriately, and the power is on. Check two different leads to confirm. Pulseless electrical activity is one of any number of ECG waveforms (even sinus rhythm), but without a detectable pulse. Pulseless electrical activity may include any pulseless waveform except VFib, VTach, or asystole. Asystole may be preceded by an agonal rhythm. An agonal rhythm is a waveform that is roughly similar to a normal waveform, but occurs intermittently, slowly, and without a pulse.

- PEA and asystole are NOT shockable rhythms.

VENTRICULAR FIBRILLATION AND PULSELESS VENTRICULAR TACHYCARDIA

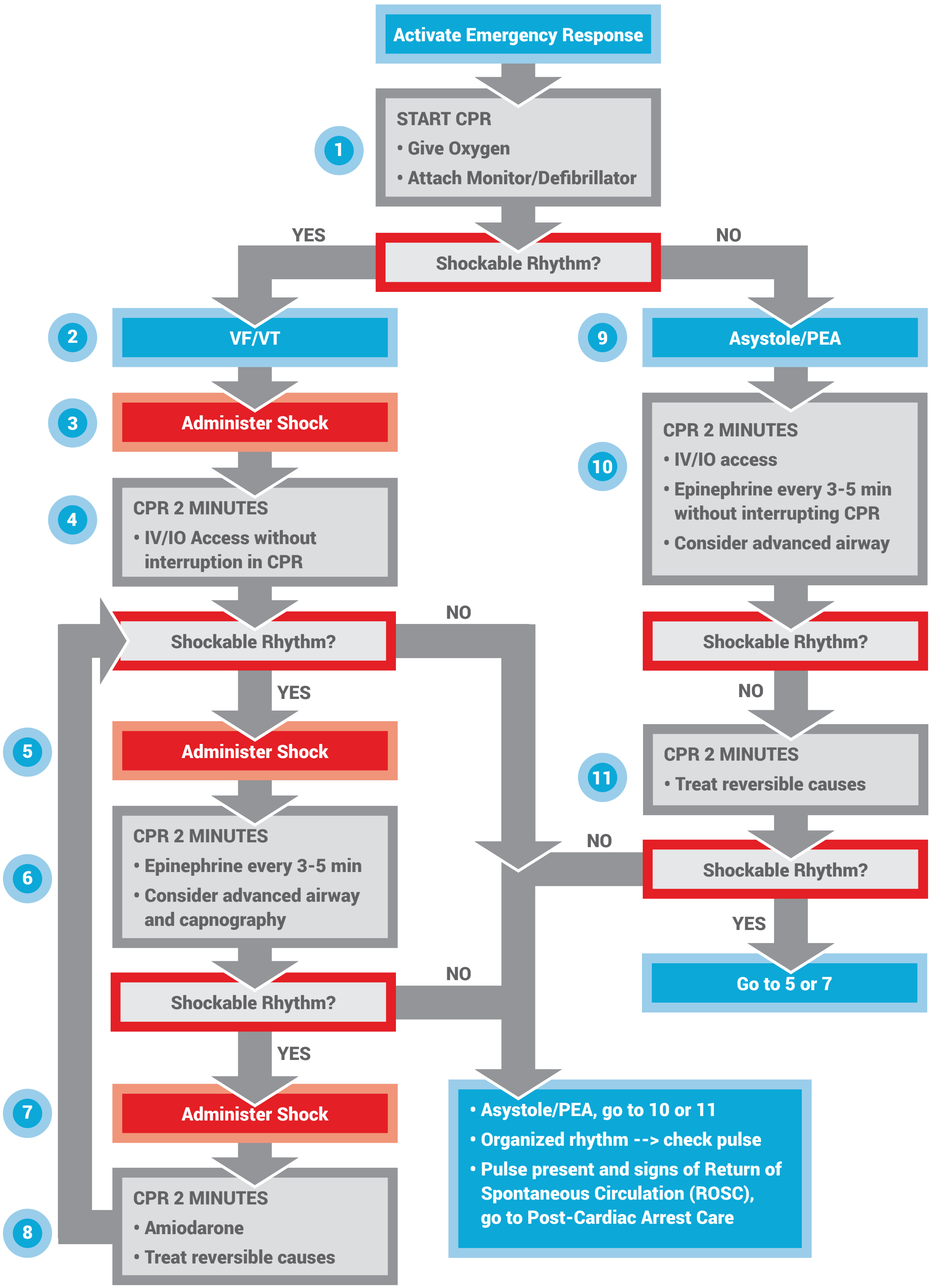
Ventricular fibrillation (VFib) and pulseless ventricular tachycardia (VTach) are life threatening cardiac rhythms that result in ineffective ventricular contractions. VFib is a rapid quivering of the ventricles instead of a forceful contraction. The ventricular motion of VFib is not synchronized with atrial contractions. Pulseless VTach occurs when the rapidly contracting ventricles are not pumping blood sufficiently to create a palpable pulse. In both VFib and pulseless VTach, patients are not receiving adequate perfusion. VFib and pulseless VTach ARE shockable rhythms.

- VFib and pulseless VTach ARE shockable rhythms.

RESPOND

The first management step in cardiac arrest is to begin **HIGH-QUALITY CPR.** (See BLS section of this Handbook for details.)

PEDIATRIC CARDIAC ARREST ALGORITHM



CPR QUALITY

- Rate at least 100 compressions per minute
- Compression depth: 1/3 diameter of chest
- Minimize interruptions
- DO NOT over-ventilate
- Rotate compressor every 2 minutes
- If no advanced airway, 15:2 compression ventilation ratio
- If advanced airway, 8-10 breaths per minute with continuous chest compressions

SHOCK ENERGY

- First shock 2 J/kg
- Second shock 4 J/kg
- Subsequent shocks ≥4 J/kg
- Maximum 10 J/kg or adult dose

RETURN OF SPONTANEOUS CIRCULATION

- Return of pulse and blood pressure
- Spontaneous arterial pressure waves with intra-arterial monitoring

ADVANCED AIRWAY

- Supraglottic advanced airway or endotracheal intubation
- Waveform capnography to confirm and monitor ET tube placement
- Once advanced airway in place, give 1 breath every 6-8 seconds (8-10 breaths per minute)

DRUG THERAPY

- Epinephrine IV/IO Dose: 0.01 mg/kg. Repeat every 3-5 minutes. If no IO/IV access, may give endotracheal dose: 0.1 mg/kg
- Amiodarone IV/IO Dose: 5 mg/kg bolus during cardiac arrest. May repeat up to 2 times for refractory VF/pulseless VT

REVERSIBLE CAUSES

- Hypovolemia
- Hypoxia
- H_+ (acidosis)
- Hypothermia
- Hypo-/hyperkalemia
- Tamponade, cardiac
- Toxins
- Tension pneumothorax
- Thrombosis, pulmonary
- Thrombosis, coronary

SELF ASSESSMENT CARDIAC ARREST

1. Your team responds to a car accident where a 14 year old is found in cardiac arrest. Which is a potentially reversible cause?

A. Aortic dissection

B. Traumatic brain injury

C. Tension pneumothorax

D. Spinal cord rupture

2. Which of the following are reversible causes of cardiac arrest?

A. Hyperthermia

B. Hypoxia

C. Tetanus

D. Theophylline Overdose

ANSWERS

1. C

Remember the "H's & T's" when evaluating cardiac arrest victims. A tension pneumothorax can be initially treated with needle decompression and subsequent chest tube placement. The other injuries are not reversible.

2. B

Hypoxia is a common precipitating factor for ***pediatric*** cardiac arrest scenarios. Hypothermia, toxins, trauma and tamponade are additional causes.

POST-RESUSCITATION CARE

If a patient has a Return of Spontaneous Circulation (ROSC), start Post-Resuscitation Care immediately. The initial PALS process is intended to stabilize a patient during a life-threatening event. Post-Resuscitation Care is meant to optimize ventilation and circulation, preserve organ/tissue function, and maintain recommended blood glucose levels. Below find a systematic approach followed by a post-resuscitation care algorithm to guide you in your treatment.

RESPIRATORY SYSTEM

- Chest X-ray to verify ET tube placement
- Arterial blood gas (ABG) and correct acid/base disturbance
- Pulse oximetry (continuously monitor)
- Heart rate and rhythm (continuously monitor)
- End-tidal CO_2 (if the patient is intubated)
- Maintain adequate oxygenation (saturation between 94% and 99%)
- Maintain adequate ventilation to achieve PCO_2 between 35-45 mm Hg unless otherwise indicated.
- Intubate if:
    - Oxygen and other interventions do not achieve adequate oxygenation
    - Needed to maintain a patent airway in the child with decreased level of consciousness
    - Ventilation is not possible through non-invasive means (e.g. CPAP)
- Control pain with analgesics and anxiety with sedatives (e.g. benzodiazepines)

CARDIOVASCULAR SYSTEM

- Arterial blood gas (ABG) and correct acid/base disturbances
- Hemoglobin and hematocrit (transfuse or support as needed)
- Heart rate and rhythm (continuously monitor)
- Blood pressure (continuously monitor with arterial line)
- Central venous pressure (CVP)
- Urine output
- Chest X-ray
- 12 lead ECG
- Consider echocardiography
- Maintain appropriate intravascular volume
- Treat hypotension (use vasopressors if needed and titrate BP)
- Pulse oximetry (continuously monitor)
- Maintain adequate oxygenation (saturation between 94% and 99%)
- Correct metabolic abnormalities (chemistry panel)

NEUROLOGICAL SYSTEM

- Elevate head of bed if blood pressure can sustain cerebral perfusion
- Temperature
    - Avoid hyperthermia and treat fever aggressively
    - Do not re-warm hypothermic cardiac arrest patient unless hypothermia is interfering with cardiovascular function
    - Treat hypothermia complications as they arise
- Blood glucose
    - Treat hypo/hyperglycemia (hypoglycemia defined as less than or equal to 60 mg/dL)
- Monitor and treat seizures
    - Seizure medications
    - Remove metabolic/toxic causes
- Blood pressure (continuously monitor with arterial line)
- Maintain cardiac output and cerebral perfusion
- Normoventilation unless temporizing due to intracranial swelling
- Frequent neurological exams
- Consider CT and/or EEG
- Dilated unresponsive pupils, hypertension, bradycardia, respiratory irregularities, or apnea may indicate cerebral herniation.

RENAL SYSTEM

- Monitor urine output
    - Infants and small children: > 1 ml/kg/hr
    - Larger children: > 30ml/hr
    - Exceedingly high urine output could indicate neurological or renal problem (diabetes insipidus)
- Routine blood chemistries
- Arterial blood gas (ABG) and correct acid/base disturbances
- Urinalysis (when indicated)
- Maintain cardiac output and renal perfusion
- Consider the effect of medications on renal tissue (nephrotoxicity)
- Consider urine output in the context of fluid resuscitation
- Toxins can sometimes be removed with urgent/emergent hemodialysis when antidotes fail or are not available

GASTROINTESTINAL SYSTEM

- Monitor NG/OG tube for patency and residuals
- Perform a thorough abdominal exam
    - Tense abdomen may indicate bowel perforation or hemorrhage
- Consider abdominal ultrasound and/or abdominal CT
- Routine blood chemistries including liver panel
- Arterial blood gas (ABG) and correct acid/base disturbances
- Be vigilant for bleeding into the bowel, especially after hemorrhagic shock

HEMATOLOGICAL SYSTEM

- Monitor complete blood count and coagulation panel
- Transfuse (as needed)
    - Correct thrombocytopenia
    - Fresh frozen plasma is to replenish clotting factors
    - Consider calcium chloride or gluconate if massive transfusion required
- Correct metabolic abnormalities (chemistry panel), especially after transfusion

PEDIATRIC POST-RESUSCITATION CARE ALGORITHM

OPTIMIZE VENTILATION AND OXYGEN

- Titrate FiO_2 to maintain oxygen saturation 94%-99%
- Consider advanced airway placement and waveform capnography

ASSESS FOR THREAT PERSISTENT SHOCK

- Identify and treat reversible causes
- Consider 10-20 mL/kg IV/IO boluses of isotonic crystalloid
- Consider inotropic and/or vasopressor support

REVERSIBLE CAUSES:

- Hypovolemia
- Hypoxia
- H^+ (acidosis)
- Hypothermia
- Hypo-/hyperkalemia
- Tamponade, cardiac
- Toxins
- Tension pneumothorax
- Thrombosis, pulmonary
- Thrombosis, coronary

HYPOTENSIVE SHOCK

- Epinephrine
- Dopamine
- Norepinephrine

NORMOTENSIVE SHOCK

- Dobutamine
- Dopamine
- Epinephrine
- Milrinone

- Monitor and treat agitation and seizures
- Monitor 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 specialist consultation and patient transport to tertiary care center

SELF ASSESSMENT PEDIATRIC POST RESUSCITATION CARE

1. Which of the following are useful to determine end-organ perfusion?

   A. Urine output

   B. Mental status

   C. Skin color

   D. All of the above

2. You have resuscitated a critically ill child. What is the goal for oxygen saturation?

   A. 100%

   B. 94 to 99%

   C. 90 to 94%

   D. Greater than 88%

ANSWERS

1. D

All of the above are useful clinical tools to assess for perfusion. Inadequate perfusion results in decreased or absent urine output, confusion, and cool or mottled skin.

2. B

Optimize oxygenation and ventilation and titrate supplementary oxygen to obtain an oxygen saturation of 94 to 99%.

PALS ESSENTIALS

- Prevention does not require advanced skills and early intervention can positively impact an emergency situation
- Remember the child's family and their response is influenced by a variety of factors and coping skills
- Mentally prepare for treating the child as you approach the scene
- Assess the appearance, work of breathing, and skin color as you approach any victim
- A child's general appearance provides an important clue to the severity of illness; alert and interactive children are rarely seriously ill
- Head bobbing is a sign of respiratory distress in infants
- A normal pulse oximetry reading does not exclude respiratory distress
- Infants and young children may become agitated when attempting to apply supplemental oxygen
- Slowing or normal respiratory rate after a period of respiratory distress can herald respiratory arrest
- Bradycardia in children is most often due to hypoxia
- SIDS is the leading cause of death for infants 1 month to 1 year of age
- An unexpected death of a child or infant is extremely stressful for the rescuer
- If a foreign body is suspected, look inside the mouth and airway before suctioning
- Nasopharyngeal airways are useful for patients having a seizure
- Do not blindly sweep the airway to avoid pushing a foreign body in further
- Pull the jaw up into the mask; do not push the mask onto the face when using bag-valve-mask
- Deliver breaths slowly over 1 second to avoid gastric distention

ADDITIONAL NHCPS TOOLS

MediCode

With MediCode, you no longer will you have to carry a set of expandable cards with you at all times while at work. You will never have to waste valuable time in an emergency situation searching through multiple algorithms until you find the right one. All of the algorithms are now accessible from the palm of your hand and you will be selecting your desired algorithm by memory in no time. Choose between multiple viewing options and easily share algorithms with co-workers and friends through email and social media.

To improve functionality and speed getting to your desired algorithm as quickly as possible in an emergency, they have been divided between BLS, ACLS and PALS. All are accessible from the main screen. The individual algorithms included within this app are:

- Basic Life Support
- Advanced Cardiac Life Support
- Pediatric Advanced Life Support

Download the app at the App Store.

CertAlert+

National Health Care Provider Solutions (NHCPS) has created CertAlert+ to minimize a potential area of stress and distraction in your life. With CertAlert+, you will have all your licenses and certifications in one place anytime you need them. We will keep track and remind you when your expiration date approaches and we will help you with your registration whenever possible.

With CertAlert+, you can:

- Compile all required licenses and certifications in one location
- Take photos (front & back) of certification cards and licenses for simple reference
- Record all expiration dates, and store with ease
- You choose when you want to be reminded of your approaching expiration dates
- Send all license or certification information directly to your email after exporting from the app.
- Easily register for NHCPS online certification and recertification courses.

Download the app at the App Store.

REVIEW QUESTIONS

1) Children have ________ metabolic rates compared to adults.

   a. Lower

   b. Higher

   c. Equal

   d. Unpredictable

2) The primary assessment includes all of the following assessments EXCEPT:

   a. Airway

   b. Breathing

   c. Choking

   d. Exposure

3) Which of the following is a sign of upper airway obstruction?

   a. Fever

   b. Stridor

   c. Nasal flaring

   d. Itching

4) The following is an indication of poor ventilation:

   a. Hypertension

   b. Hyperthyroidism

   c. Hypercarbia

   d. None of the above

5) The following cause sinus tachycardia EXCEPT:

   a. Metabolic stress

   b. Mobitz type II block

   c. Fever

   d. Acute blood loss

6) The following are included in the SAMPLE history EXCEPT:

a. Events leading up to injury

b. Past medical history

c. Medications

d. Exposure

7) Hypoxemia is a defined as a room air SpO2 reading less than ____ in a child.

a. 98%

b. 94%

c. 90%

d. 96%

8) Common causes of upper airway obstruction include all of the following EXCEPT:

a. Aspirated foreign body

b. Asthma

c. Allergic reactions

d. Peritonsillar abscess

9) The following may be used in the treatment of croup:

a. Dexamethasone

b. Nebulized epinephrine

c. Oxygen

d. All of the above

10) Which statement concerning asystole is NOT correct?

a. A state of no myocardial contractions and no cardiac output or blood flow.

b. An asystolic patient has no detectable electrical activity.

c. A flat line on an ECG always indicates asystole.

d. Asystole is one of the rhythms associated with cardiac arrest.

11) Types of shock include all of the following EXCEPT:

a. Anaphylactic shock

b. Hypovolemic shock

c. Cardiogenic shock

d. Hypothermic shock

12) When providing fluid resuscitation in children, how should intravenous fluid boluses be given?

a. 15 mL/kg bolus over 5 to 20 minutes

b. 20 mL/kg bolus over 5 to 20 minutes

c. 25 mL/kg bolus over 5 to 20 minutes

d. 30 mL/kg bolus over 5 to 20 minutes

13) Effectiveness of fluid resuscitation and medication therapy should be frequently monitored by which of the following?

a. Heart rate

b. Blood pressure

c. Mental status

d. All of the above

14) Common signs and symptoms of compensated shock include:

a. Excessive sweating

b. Increased heart rate

c. Wide pulse pressure

d. Hypertension

15) When should vasopressors be administered during the management of septic shock?

a. If the patient is responding to fluid resuscitation

b. If the patient is severely hypotensive despite proper fluid management

c. Always indicated as soon as IV access is obtained

d. Vasopressors are never used for septic shock

16) For fluid resuscitation in hypovolemic shock, give about ____ of crystalloid for every ____ of blood lost.

a. 1 mL, 2 mL

b. 3 mL, 2 mL

c. 3 mL, 1 mL

d. 2 mL, 3 mL

17) Hypoglycemia is defined as ____ in infants, children, and adolescents is:

a. Greater than or equal to 40 mg/dL

b. Greater than or equal to 50 mg/dL

c. Less than or equal to 60 mg/dL

d. Less than or equal to 70 mg/dL

18) The gold standard treatment for anaphylactic shock is:

a. Milrinone

b. Epinephrine

c. Dopamine

d. Dobutamine

19) The preferred order drug delivery routes is:

a. IV route, IO route, ET route

b. ET route, IV route, IO route

c. IO route, ET route, IV route

d. IV route, ET route, IO route

20) Which rhythm should be shocked?

a. Ventricular fibrillation

b. Pulseless ventricular tachycardia

c. Pulseless electrical activity (PEA)

d. Both A and B

REVIEW QUESTION ANSWERS

1) B. Higher
2) C. Choking
3) B. Stridor
4) C. Hypercarbia
5) B. Mobitz type II block
6) D. Exposure
7) B. 94%
8) B. Asthma
9) D. All of the above
10) C. A flat line on an ECG always indicates asystole.
11) D. Hypothermic shock
12) B. 20 mL/kg bolus over 5 to 20 minutes
13) D. All of the above
14) B. Increased heart rate
15) B. If the patient is severely hypotensive despite proper fluid management
16) C. 3 mL, 1 mL
17) C. Less than or equal to 60 mg/dL
18) B. Epinephrine
19) A. IV route, IO route, ET route
20) D. Both A and B

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