Pediatric Advanced Life Support Overview

2010 American Heart Association Guidelines for CPR and ECC

The following is not meant to replace AHA printed materials. It is meant to be used in conjunction with the PALS textbook and other printed materials.

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Change is about the only constant in medicine. Lucky for us medicine moves forward at exciting speed allowing us to heal injuries, conquer illness and prolong life more efficiently with each step forward. For those of us who have been in healthcare for a period of time change can be frustrating at least. After all, have we really been killing people with the way we’ve been doing things all these years??? Resistance to change is resistance to forward movement. If everyone resisted change we would still be riding donkeys as everyone knows it is impossible to train a horse for anything of any values. Those young kids.....the ones that insist on chopping off the corners of the stones we are trying to pull up the hill....they say it will be easier if it is rounded at the edges.....but we’ve always done it this way. Get the idea?

This overview is based on the 2010 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care – Supplement to Circulation – Volume 122 – Issue 18 – Supplement 3 – November 2, 2010. It is not meant to take the place of AHA publications or textbooks. It is meant to be use as an study adjunct to those publications.

The Pediatric Chain of Survival emphasizes that multiple things must come together to enhance survival in cardiac arrest. The biggest impact on pediatric survival is had when bystander CPR is performed quickly and effectively. There have been up to 70% neuro intact survival reported when everything goes perfectly. However only 1/3 to ½ of infants and children who have cardiac arrest actually receive bystander CPR. The survival rates for infants and children not changed substantially in over 20 years.

- Infants – 4% survival in out of hospital arrest
- Children 10% survival in out of hospital arrest
- Adolescents – 13% survival in out of hospital arrest

In hospital survival numbers are better at 27%. Infants and children who are not permitted to completely arrest (with a pulse but poor perfusion and bradycardia) who required CPR had the best in hospital survival rate of 64% to discharge. Children are more likely to survive in hospital cardiac arrest than adults and infants have a higher survival rate than children.
The change from ABC to CAB applies to infants and children as well as adults.

- High quality compressions are essential to generate blood flow to vital organs
- Beginning CPR with 30 compressions rather than 2 ventilations leads to shorter delays to first compression
- All rescuers should be able to deliver compressions almost immediately. Positioning the head and attaining a seal for ventilation takes time and delays the initiation of CPR
- Hypoxic arrest is more common than VF in infants and children and ventilations are extremely important in pediatric resuscitation.
- Starting with compressions only delays ventilations by approximately 18 seconds for a lone rescuer and even shorter for two rescuers
- CAB simplifies training with the hope that more victims will receive bystander CPR

**Age Definitions**

- Infant = under one year of age
- Child = children approximately 1 year to puberty
  - Defined as breast development in girl
  - Presence of armpit hair in the boy
- Adult = applies to all beyond puberty

**BASIC LIFE SUPPORT FOR LAY RESCUERS**

**ASSESSMENT** – the lay rescuer simply checks for responsiveness and absence of NORMAL breathing. It is very important to emphasize NORMAL breathing as many mistaken agonal gasps for breathing and therefore do not intervene. If normal breathing is not present and the patient is not responsive CPR should be started.

- If the patient is found to be unresponsive but breathing – leave the child and summon medical assistance immediately
- Children respiratory distress often assume a position in which they can breathe the easiest. Allow the child to assume this position of comfort.

**CHEST COMPRESSIONS** – immediately begin chest compressions (30 compressions)

- “Push Hard, Push Fast” at a rate of at least 100/minute
- Depress the chest at least one third the anterior-posterior diameter of the chest (approx. 1½ inches in infants and 2 inches in children)
  - Inadequate chest compression is common both in the lay rescuer and the healthcare professional
  - There is no data to show that one or two hand method produces better compressions or outcomes
- Chest recoil must be complete. This is the time during which the heart fills with blood and the coronary arteries are perfused. It is acceptable to come slightly off the chest wall in between compressions to ensure complete chest recoil. Remember that this can also be a function of tiring. As the rescuer gets fatigued he/she tends to lean on the
chest wall and not allow complete recoil. This is the reason for the recommended switch of compressors that occurs every 2 minutes of the resuscitation

- Minimize interruptions of chest compressions. Some studies show that compressions may only be performed half of the time during resuscitations. Given that adequate compressions are the single most determinant of survival; this is unacceptable. Care must be taken to minimize interruptions that are not absolutely necessary.
- Avoid hyperventilation – many studies have shown that patients are hyperventilated. This is bad for a number of reasons; but the most basic is that when the chest cavity is filled with air, no gradient occurs with chest recoil and the heart or the coronary arteries do not fill with blood.

AIRWAY AND VENTILATIONS – for the lone rescuer the compression to ventilation ratio is 30:2 for all age groups.

- Open the airway – use the head tilt chin lift maneuver for both injured and non-injured victims. The jaw thrust method should not be taught or used for lay rescuers.
- Use mouth to mouth and nose technique to give breaths to an infant
- Use mouth to mouth to give breaths to a child
- Each breath should take approximately 1 second and result in chest rise
  - If the chest fails to rise, reposition the head, attempt a better seal and attempt ventilation again. It may be necessary to move the patient’s head to a range of positions to provide optimal airway patency and effective breathing
- Mouth to nose or mouth to mouth may also be used if difficulty is encountered
- The lone rescuer should immediately begin compressions following 2 breaths. This cycle of 30:2 should be continued for approximately 2 minutes before leaving the victim to activate the Emergency Response System and obtain an automated external defibrillator (AED) if one is nearby.

ACTIVATE THE EMERGENCY RESPONSE SYSTEM

- If two rescuers, one should start CPR immediately and the other should activate the EMS system and get the AED if available
- Because most infants and children have a respiratory cause of arrest, not a cardiac one, 2 minutes of CPR are recommended before leaving the child to activate the EMS system if there is only one rescuer at the scene.

BASIC LIFE SUPPORT FOR THE HEALTHCARE PROVIDER

Healthcare providers most often work in teams, such as in a hospital, or on an ambulance. Therefore the steps of CPR do not have to be sequential, but can be accomplished simultaneously by a healthcare team.

Healthcare providers are able to tailor the sequence of resuscitation actions to the most likely cause of arrest.
• If the arrest is sudden in an adolescent or child identified at high risk for arrhythmia or during an athletic event, the provider may assume the victim has suffered a sudden VF arrest and proceed accordingly.

ASSESSMENT
• If the victim is unresponsive and not breathing assume the need for CPR and begin immediately.
• Healthcare providers may take 10 seconds to check for a pulse. If after 10 seconds you do not feel a pulse or are not sure, begin CPR
  o Brachial in an infant
  o Carotid or femoral in a child
• If there is a pulse, but no or inadequate breathing, rescue breaths are provided at a rate of 12-20 breaths per minute (1 every 3-5 seconds)

BRADYCARDIA WITH POOR PERFUSION
• Pulse less than 60 with poor perfusion despite support of oxygenation and ventilation, begin chest compressions
  o Cardiac output in infancy and childhood is dependent upon heart rate
  o Cardiac arrest is imminent and beginning CPR prior to full cardiac arrest results in increased survival
  o These patients have the highest survival rate among in hospital patients

CHEST COMPRESSIONS – the only difference between healthcare professionals and lay persons is in compressions for infants
• The lone rescuer should use the 2 finger chest compression technique for infants
• If not a lone rescuer – the two thumb encircling hands technique is recommended when CPR is provided by 2 rescuers. Encircle the chest with both hands; spread your fingers around the thorax, and place your thumbs together over the lower third of the sternum
  o Preferred because it provides higher coronary artery perfusion pressures and more consistently results in appropriate depth or force of compressions
  o May generate higher systolic and diastolic pressures.
VENTILATIONS

- Ventilation to Compression Ratio 30:2 if single rescuer
  - 15:2 if two rescuers
- Airway is opened with head tilt – chin lift unless there is evidence of trauma
  - If trauma use the jaw thrust method to open the airway – IF IT IS DIFFICULT TO MAINTAIN A PATENT AIRWAY WITH THIS METHOD – USE THE HEAD TILT – CHIN LIFT because airway is of utmost importance in infants and children
- Coordinate ventilations with chest compressions until there is an advanced airway in place
  - After advanced airway placement (intubation, supraglottic airway) cycles of compressions and ventilations are no longer performed
  - Compressions are performed at a rate of at least 100 per minute
  - Ventilations are performed at a rate of 8-10 breaths per minute (one every 6-8 seconds)

DEFIBRILLATION USING AUTOMATED EXTERNAL DEFIBRILLATOR (AED)

- AEDs have high specificity in recognizing pediatric shockable rhythms
- Some are equipped to attenuate the delivered energy to make them suitable for infants and children
- In infants a manual defibrillator is preferred when a shockable rhythm is identified by a healthcare provider
- Recommended first dose energy is 2 joules/kg
  - Second dose is 4 joules per kg
  - At least 4 joules/kg for subsequent doses and higher energy levels may be considered not to exceed 10 joules/kg
- AED equipped with a pediatric attenuator (pediatric pads) is preferred for infants and children. If it is not available and an AED without a dose attenuator is available it should be used on both infants and children with shockable rhythms.
- The time between the last compression and the shock delivery should be minimized as much as possible

HANDS ONLY (COMPRESSION ONLY) CPR – most arrests in infants and children are of a respiratory nature and rescue breathing is more effective than compressions alone when this is the case and the arrest was from a non cardiac etiology. In some studies survival when hands only CPR was used in infants and children were no better than when no CPR was done at all. Optimal CPR in infants and children includes both compressions and ventilations, but compressions alone are preferable to no CPR.

BREATHING DEVICES

- Barrier devices have not reduced the low risk of transmissions of infection and some increase the resistance to flow
- If there is any delay in obtaining a barrier device or ventilation equipment, give mouth to mouth ventilations or continue chest compressions alone
Bag Valve Mask ventilation is an essential CPR technique for healthcare providers
- Self inflating bag of at least 450-500ml for infants and young children
- 1000ml for children or adolescents
- Not recommended for the lone rescuer – two person technique with one person sealing the mask and the other depressing the bag is more effective in providing adequate ventilation

HYPERVENTILATION is harmful because
- Intra-thoracic pressure is increased and venous return to the heart is decreased. Therefore, cardiac output, cerebral blood flow and coronary perfusion pressure are all compromised.
- Air is trapped and barotrauma can occur
- Increases the risk of regurgitation and aspirations in patients without an advanced airway in place
- Ventilation should stop when chest rise is noted.
- Patients with airway obstruction or poor lung compliance may require higher pressures to ventilate properly. Be sure that your BVM allows the use of high pressures.

OXYGEN DELIVERY – it is reasonable to use 100% oxygen during resuscitation
- Once perfusion returns, monitor systemic oxygen saturation and titrate oxygen to maintain an oxygen saturation of 94% or greater.
- Since an oxygen saturation of 100% may correspond to a PaO2 anywhere between 80-500 mmHg, it is appropriate to wean FiO2 for a saturation of 100% provided the oxyhemoglobin saturation can be maintained at 94% or greater.
- Whenever possible oxygen should be humidified.

CPR ADJUNCTS – there is insufficient data in infants and children to recommend for or against the use of mechanical devices to compress the chest, active compression-decompression CPR, interposed abdominal compression, the impedance threshold device, or pressure sensor accelerometers.

FOREIGN BODY AIRWAY OBSTRUCTION – 90% of childhood deaths from foreign body aspiration occur in children less than 5 years old. Liquids are the most common cause of choking in infants. Balloons, small objects and foods (hot dogs, round candies, nuts and grapes) are the most common causes in children.

**Sudden** onset of respiratory distress with coughing, gagging, stridor or wheezing;
- If mild, do not interfere. Allow the victim to clear by coughing
- If victim unable to make sound
  - Perform subdiaphragmatic abdominal thrusts (Heimlich maneuver) until the body is expelled in children
  - For INFANT deliver repeated cycles of 5 back blows and 5 chest compressions until the object is expelled or victim becomes unresponsive
• If victim becomes unresponsive, start CPR with chest compressions (do not perform a pulse check)
  o After 30 compressions – open the airway. If you see a foreign body remove it; but do not perform blind finger sweeps because they may push the obstructing objects farther into the pharynx and may damage oropharynx

SPECIAL RESUSCITATION SITUATIONS

**Advanced Directives** – the MD must write an order clearly detailing the limits of any attempted resuscitation. A separate order must be written for the out of hospital setting. Regulations vary by state.

**Ventilation with a Tracheostomy or Stoma** – Everyone involved in the child’s care should know how to assess patency, clear the airway, change the tube, and perform CPR using the artificial airway.
  • Observe for chest rise with ventilation
  • If not effective, suction the tube
  • If not effective following suctioning, the tube should be replaced
  • If still unable to ventilate, remove the tube and attempt alternative ventilation methods such as mouth to stoma ventilation of bag mask ventilation through the nose and mouth (while you or someone else occludes the tracheal stoma)

**Trauma**
  • Anticipate airway obstruction by dental fragments, blood or other debris
  • When the mechanism of injury is compatible with spinal injury, minimize the motion of the cervical spine and movement of the head and neck.
  • Professional rescuers should open and maintain the airway using the jaw thrust and try not to tilt the head, however if this is not effective, use the head tilt – chin lift method.

**DROWNING** – outcome is determined by the duration of submersion, the water temperature, and how promptly and effectively CPR is done.
  • If able, without delaying removal from the water, mouth to mouth should be started while still in the water. Chest compressions should not be attempted in the water.
  • Five cycles of CPR should be completed before activated the EMS system if you are a lone rescuer
Adults most often experience cardiac arrest via ventricular fibrillation caused by either an ischemic event or sudden arrhythmic death. Children on the other hand more often experience cardiac arrest as a result of respiratory failure or shock. Instead of a sudden event as in adults, cardiac arrest in infants and children is usually a progressive failure that ends in cardiac arrest. Thus we have the opportunity to catch and reverse the progression prior to cardiac arrest.

Ventricular Tachycardia and Ventricular Fibrillation is the initial rhythm in only 5 to 15% of cardiac arrests in infants and children. However, ventricular fibrillation is present at some time during the resuscitation of in patients in 27% of cases so it is imperative that healthcare providers become proficient at its treatment.

Despite the fact that in the 1980s survival from in hospital arrest in pediatrics was 9% and has since increased to 27%, out of hospital cardiac arrest survival rates have not changed substantially in 20 years and remains at about 6%. (3% for infants and 9% for children and adolescents) Even in those children who survive a large number are incapacitated.

**Basic Life Support:** the highest success rate will occur when there is an organized response in an advanced healthcare environment.

- Multiple responders are rapidly mobilized and capable of simultaneous action
- Have access to invasive patient monitoring

The problem is maintaining the efficiency of the team in an organized fashion.

1. Chest compressions should be started immediately.
2. At the SAME TIME ventilations should be started with a BVM by another rescuer. Ventilations are important in the infant and child because most cardiac arrests are the result of respiratory failure and therefore require proper oxygenation.
   a. At least 100/min
   b. 1 ½ inches in infants and 2inches in children
   c. Avoid hyperventilation
3. Other rescuers should obtain vascular access and calculate and prepare medications for administration

If available, arterial monitoring should be utilized to adjust compressions to obtain the best arterial waveform. It is also useful in determining ROSC early in the resuscitation.

The secret to treating pediatrics and preventing cardiac arrest is to recognize and treat problems before the progress. **Respiratory Failure** is one of the most common and important
ones to recognize. Respiratory failure can be secondary to inadequate ventilation, insufficient oxygenation or both. Be on the lookout for respiratory failure if any of the following are present:

- Increased work of breathing
  - Rate
  - Effort – nasal flaring, retractions, seesaw breathing or grunting
- Inadequate respiratory rate, effort or chest excursion
  - Diminished breath sounds or gasping
  - Decreased mental status
- Cyanosis with abnormal breathing despite oxygen administration

**Shock** is the second most common cause of cardiac arrest and healthcare providers must be prepared to recognize it and intervene as necessary. **Shock** is defined as inadequate blood flow and oxygen delivery to meet the metabolic demands of tissue. There are several types of shock, but the most common in children is hypovolemic.

Shock is a progressive state. In its early stages the body compensates for shock by increasing heart rate and using vascular resistance to maintain blood pressure. Decompensation occurs when compensatory mechanisms fail and the patient becomes hypotensive.

The key to early treatment of shock and therefore prevention of progression to cardiac arrest is to recognize the early signs and symptoms which are related to the body’s attempt to compensate for inadequate tissue perfusion. They include:

- Tachycardia
- Cool and pale distal extremities caused by the body using vasoconstriction to push blood from extremities toward central circulation
- Prolonged (>2 seconds) capillary refill (despite warm temperatures)
- Weak peripheral pulses compared with central pulses
- Normal systolic blood pressure

The problem is that as adult care providers we are used to many of these conditions being present at baseline in many of our patients. For example in the elderly it is common to have diminished distal pulses or delayed capillary refill due to peripheral vascular disease. We have to change our mind set in infants and children and realize that they are brand new and remain under warranty so all of their systems work normally. There should be NO abnormalities at baseline, so when we find them they must be investigated.

As these compensatory mechanisms fail, signs of inadequate tissue perfusion develop. These can include:

- Depressed mental status
- Decreased urine output
- Metabolic acidosis
- Tachypnea
• Weak central pulses
• Deterioration in color such as mottling
• Hypotension

Hypotension

<table>
<thead>
<tr>
<th>Age</th>
<th>Hypotensive Systolic Blood Pressure</th>
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<tbody>
<tr>
<td>0-28 days</td>
<td>&lt;60mmHg in term neonates</td>
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<tr>
<td>1-12 months</td>
<td>&lt;70mmHg in Infants</td>
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<tr>
<td>1-10 years</td>
<td>&lt;70mmHg + (2x age in years) in children 1-10</td>
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<tr>
<td>Greater than 10 yrs</td>
<td>&lt;90mmHg in children older than 10</td>
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AIRWAY MANAGEMENT

It is important that each and every healthcare provider who is going to assess or treat infants and/or children be proficient at airway management at whatever level is within the scope of practice of the individual. Proper airway management can and will save many pediatric lives.

Airways

Sizing of both oropharyngeal and nasopharyngeal airways is of the utmost importance. Oral airways are used in patients who are deeply unconscious. However one that is too small can actually obstruct the airway by pushing the base of the tongue farther into the airway. If it is too large, the airway itself may obstruct.

Nasopharyngeal airways work well in children who have an intact gag reflex. However, an airway that is too short may not work to maintain the airway and one that is too long may obstruct it. They may become easily obstructed because of the small diameter and require frequent suctioning.

Laryngeal Mask Airway (LMA) The LMA is the only supraglottic airway that has been studied in infants and children. It is acceptable to utilize it when BVM ventilation is not working or difficult and intubation is not possible. It is associated with a higher incidence of complications in young children compared with older children and adults.

Oxygen – can be used at 100% during CPR but once ROSC oxygen should be titrated to maintain 94% or greater oxygen saturation. Hyperoxia should be avoided. Adequate oxygen delivery requires not only arterial oxyhemoglobin saturation but also adequate hemoglobin concentration and cardiac output.
Pulse oximetry must be monitored continually in perfusing patients, however keep in mind that it may be unreliable in patients with poor perfusion, carbon monoxide poisoning or several other condition.

**Bag Valve Mask Ventilation** – can be as effective and may be safer than intubation for short periods during out of hospital resuscitation.

- Tidal volumes must be limited to the amount needed to cause chest rise
- Hyperventilation should be avoided
- If not intubated a pause should take place after every 30 compressions for ventilation.
- If two rescuers then the patient should be ventilated at a rate of 15:2
- If perfusion rhythm one can use the mnemonic “squeeze-release-release” at a normal speaking rate to deliver a breath every 3-5 seconds or 12-20 times per minute
- May be more effective to utilize the BVM with two people when there are enough rescuers available. One to seal the mask and one to push the bag

Gastric inflation can be avoided by:

- Avoiding excessive peak inspiratory pressure by ventilating slowly and limiting tidal volume.
- Cricoid pressure by a third rescuer. Avoid excessive cricoids pressure so as not to obstruct the trachea
- Nasogastric or orogastic tube to relieve gastric inflation

**INTUBATION**

Intubation of infants and children requires special training. The pediatric airway differs from that of the adult. Complications are directly related to experience and training of the provider.

**Rapid Sequence Intubation (RSI)** – may be used by skilled, experienced providers to facilitate emergency intubation and reduce the incidence of complications. If RSI is being used, a secondary plan must be in place for airway management should intubation attempts fail.

**Cuffed vs Uncuffed Tubes** – either tube is acceptable. In the operating room, the use of cuffed tubes is associated with correct tube size selection more often. In intensive care units the number of complications from intubation were not affected by whether a cuffed or uncuffed tube was used.
Endotracheal Tube Size – the use of resuscitation tapes is more accurate than age based formulas for children up to 35kg. There should always be a tube 0.5mm larger and 0.5mm smaller available when intubation is being attempted.

Uncuffed tube size (ID) = 4 + (Age/4)

Cuffed Tube ID = 3.5 + (Age/4)

Verification of Tube Placement – no single method is reliable so both clinical assessment and confirmatory devices should be used to verify placement. Tube placement should be verified immediately after intubation, during transport and each time the patient is moved.

- Bilateral chest movement and equal breath sounds
- Listen for gastric insufflations sounds over the stomach
- Check for exhaled CO2
- If perfusing rhythm, check saturation
- If uncertain, direct laryngoscopy and visualize the endotracheal tube to confirm that it lies between the vocal cords
- In hospital perform a chest xray.

Endotracheal tubes in infants and children are very easy to dislodge. If at any time after intubation, the patient’s condition worsens the intubation should be evaluated based on the mnemonic DOPE.

D – displacement of the tube

O – obstruction of the tube

P – pneumothorax

E – equipment failure

Exhaled or End Tidal CO2 Monitoring – recommended as confirmation of tube position for neonates, infants and children with perfusing rhythms in all settings. Color change or presence of capnography waveform confirms tube placement in the airway but does not rule out right mainstem intubation. The absence of CO2 may reflect very low pulmonary flow during cardiac arrest rather than tube misplacement.
Colormetric Detectors may be inaccurate because of:

- Contamination with gastric contents
- IV bolus of Epinephrine which may reduce pulmonary blood flow
- Severe airway obstruction and pulmonary edema may impair CO2 elimination below what can be detected
- Large glottis air leak may reduce exhaled tidal volume through the tube and dilute CO2 concentration

**Resuscitation of the Newly Born** – is different than the resuscitation of infants. The compression to ventilation rate is 3:1. Newborns who require resuscitation outside of the hospital setting should receive CPR according to infant guidelines. It is reasonable to resuscitation newborns with a primary cardiac etiology arrest, regardless of location, according to infant guidelines with emphasis on chest compressions.

**Extracorporeal Life Support (ECLS)** – modified form of cardiopulmonary bypass that prolongs delivery of oxygen to tissues. If it is to be used in resuscitation it must be instituted early in the resuscitation. Outcome is better for children with underlying cardiac disease.

**Monitoring the Cardiac Arrest Patient**

Obviously, arrhythmia monitoring should begin at the earliest possible time and continue into and beyond the post arrest period. There may be limited indications for the use of echocardiography during arrest, but science does not support it either way.

**End Tidal CO2 (PETCO2)**

If available, can be very helpful in monitoring the efficiency of cardiac compressions. If PETCO2 remains <10-15mmHg, the efficacy of chest compressions must be evaluated and improved. It is also helpful in noting the return of spontaneous circulation (ROSC), so that a large increase in PETCO2 is a reliable indicator of ROSC and therefore repetitive interruptions in chest compressions for pulse checks are not necessary if end tidal CO2 is monitored.

**Vascular Access** – is obviously a very important part of resuscitation. Given the difficulty of obtaining IV access in pediatrics, especially infants, little time should be wasted attempted IV access. Intraosseous (IO) access is easy and safe to achieve and should be used immediately if there is any concern about the ability to achieve vascular access. Following resuscitation the IO needle can be replaced by IV peripheral or central access. All medications that can be given IV can be given via the IO route. In many cases blood samples can be drawn for laboratory analysis by this route.
Central venous access is NOT recommended during resuscitation due to the training and time required to place it. There is no scientific evidence that drugs or fluids given centrally during arrest are any more efficient than those given via the IO route.

If vascular access is not possible, lipid soluble medications may be given via the endotracheal tube, although not recommended unless this is the only possible route. Given the ease of placement of the IO needle, the ET route will rarely if even be necessary.

**EMERGENCY MEDICATIONS AND FLUID RESUSCITATION**

The child’s weight can be very difficult to approximate and may be unknown particularly in the out of hospital setting. Tapes such as the Broslow tape is more accurate basing medications on body weight approximation using body length. When available they should be used rather than “approximating” the patient’s weight. If the patient’s weight is known, then drug doses should be calculated based on known weight. It is unknown whether drug doses must be adjusted when using length base tapes in obsess children.

The following medications are routinely used during infant and pediatric resuscitation and the healthcare provider should be familiar with all of them.

**Adenosine** works by blocking the conduction through the AV node. It has an extremely short half life (seconds) and therefore is a very safe drug. Because of its short half life it must be administered rapid bolus and followed with a bolus of saline. The result will be a prolonged pause in the rhythm followed by conversion to sinus rhythm if the rhythm being treated involves the AV node. It is used in the treated of narrow complex tachycardias.

**Dosage:**
- 0.1mg/kg (maximum of 6mg)
- Second Dose: 0.2mg/kg (maximum of 12mg)

**Amiodarone** works on a number of levels within the heart to terminate arrhythmias. It slows AV nodal conduction, prolongs the QT interval, slows ventricular conduction. Unless absolutely impossible it is recommended that expert consultation be sought prior to using Amiodarone in the perfusing pediatric patient.

The patient can become severely hypotension, therefore BP and rhythm must be monitored closely. The rate must be decreased if the QRS complex widens by 50% or if heart block is noted. Because it prolongs QT interval, Amiodarone should not be combined with other medications that may cause QT prolongation such as procainamide.

**Dosage:**
- 5mg/kg (may repeat twice) up to 15mg/kg
- Maximum dose: 300mg
**Atropine** – accelerates sinus or atrial pacemakers by blocking the influence of the parasympathetic system. It should be administered rapid IV/IO bolus as slow administration may result in a slowing of heart rate.

**Dosage:** 0.02mg/kg Minimum dose of 0.1mg and maximum single dose of 0.5mg.

**Epinephrine** – is both alpha and beta and therefore increases diastolic pressure and coronary perfusion pressure. It is a drug which is critical to the success of resuscitation. If used to control bradycardia or blood pressure in the perfusing patient, the patient should be monitored for arrhythmias or signs of ischemia as a common side effect is tachycardia.

**Dosage:** 0.01mg/kg (0.1ml/kg) 1:10,000 IV/IO Dose may be repeated every 3-5 minutes

**Glucose** – infants have a high demand for glucose and low store of glucose so glucose levels must be monitored closely in infants and children who have or are experiencing critical injury or illness. Hypoglycemia should be treated promptly.

**Dosage:**
- Newborn: 5-10ml/kg D10W
- Infant and Children: 2-4ml/kg D25W
- Adolescents: 1-2ml/kg D50W

**Lidocaine** – depresses automaticity and ventricular arrhythmias. As such it can have a negative effect on left ventricular function. It is not as effective as Amiodarone for improving return of spontaneous circulation or survival to hospital admission. Therefore, Lidocaine is only recommended if Amiodarone is unavailable for use during cardiac arrest resuscitation.

**Dosage:** 1mg/kg IV/IO

**Magnesium** has a limited indication. It is indicated if the patient is documented hypomagnesemia or if the patient with known prolonged QT interval then goes into polymorphic ventricular tachycardia (torsades de pointe)

**Dosage:** 25-50mg/kg over 10-20 minutes (faster if in torsades de pointe)

**Sodium Bicarbonate** – is not recommended during resuscitation (Class III, potentially harmful) Blood gases that are drawn during arrest are inaccurate for acid base balance and do not reflect tissue or venous acidosis. Excessive bicarbonate may impair oxygen delivery, cause hypokalemia, hypocalcemia, hypernatremia, and hyperosmolality. In addition, it may decrease the VF threshold and impair cardiac function. Acid base correction should not be done until perfusion has returned and accurate blood gases can be obtained.
Vasopressin – there is insufficient evidence for or against the routine use of vasopressin in infants and children in cardiac arrest. A large case series suggested that vasopressin is associated with lower ROSC and trend toward lower 24 hour and discharge survival than Epinephrine.

Algorithms

The goal of pediatric resuscitation will always be to avoid cardiac arrest at all costs by recognizing the signs and symptoms of respiratory distress, respiratory failure, compensated and decompensated shock. When arrest occurs the resuscitation team must work together in an organized methodical manner to assure that all resuscitation steps are taken and that the patient is continually re-assessed for change in condition. Assessment is paramount to successful resuscitation and must occur frequently. The team must be ready to change interventions based on changes in the condition of the patient.
PULSELESS ARREST IN THE PEDIATRIC PATIENT

1. Immediately call for help and send for a defibrillator or AED
2. Start CPR (with oxygen if available)
3. Attach ECG electrodes or AED pads as soon as they become available
4. Emphasis should be placed on high quality CPR. The quality of CPR should be monitored closely throughout resuscitation and corrected if efficiency is less than optimal
   a. Ensure adequate depth and rate of compressions
   b. Ensure complete chest recoil
   c. Minimize interruptions
   d. Eliminate hyperventilation
5. Determine the child’s rhythm to determine if it is “shockable” or not. Although VF is not common in infant and pediatric arrest it is not unheard of. It is more common the older the child. However, VF may develop at any time during the resuscitation and if it does, it should be defibrillated promptly.

NON-SHOCKABLE RHYTHM – Pulseless Electrical Activity or Asystole

1. Continue CPR with as few interruptions as possible
2. Obtain vascular access and administer Epinephrine 0.01mg/kg (0.1ml/kg) of 1:10,000 solution to a maximum of 1mg (10ml) This dose can be repeated every 3-5 minutes throughout the resuscitation
   a. High dose Epinephrine is NOT recommended and may be associated with harm. It can be considered in the rare case of beta blocker overdose only
3. Once a definitive airway is in place, compressions are delivered at a rate of 100/min without interruption for ventilations which are delivered every 6-8 seconds.
4. Check the rhythm every 2 minutes for the presence of a shockable rhythm
5. Search for and treat reversible causes

SHOCKABLE RHYTHM – Ventricular Fibrillation or Ventricular Tachycardia

The earlier defibrillation occurs, the greater than chance of survival. There is an overall survival rate of 17% - 20% in pediatrics. Survival is higher for primary rather than secondary (ventricular fibrillation that occurs as the result of another injury or illness and is not the primary cardiac arrest rhythm), for example ventricular fibrillation that develops after resuscitation from PEA.

- Minimizing the time between the last compression and the defibrillation is very important because coronary perfusion pressures drop to zero very quickly. Compressions should begin immediately after defibrillation no matter what the result of the shock.

1. Provide CPR until the defibrillator becomes available.
2. Deliver one shock at 2 joules/kg and immediately resume CPR. Minimize time from end of compressions to shock and from shock to resumption of compressions.
3. Continue CPR for 2 minutes. Obtain vascular access.
4. After 2 minutes recharge the defibrillator and deliver shock at 4 joules/kg
5. If a shockable rhythm exists, give another shock (4 joules/kg or higher) followed by immediate CPR
6. After two minutes of CPR give Epinephrine .01mg/kg of 1:10,000 to a maximum of 1mg. This is repeated every 3-5 minutes during the resuscitation
7. After two minutes of CPR, check the rhythm. If the rhythm is shockable, deliver at shock at 4joules/kg or higher and immediately resume CPR.
8. Administer Amiodarone or Lidocaine if Amiodarone is not available.

- If defibrillation is successful as evidenced by an abrupt rise in PETCO2 or visible pulsations on an arterial waveform, or palpable pulses, continue with post resuscitation 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 reversible causes of cardiac arrest.

**DEFIBRILLATION**

The use of paddles and self adhesive pads appear to be equally effective. The largest pad or paddle should be used that can be placed on the patient’s chest without touching. Usually an infant of one year of age is large enough to use adult pads or paddles. If pads are used, nothing need be applied to the chest. If paddles are used and electrode gel must be applied liberally. Do not use saline soaked pads, bare paddles or alcohol pads.

Follow the package instructions for placement of adhesive pads. Paddles are placed with one over the right side of the upper chest and the other to the left of the nipple over the left lower ribs. Firm pressure must be applied so that there is no air between the chest wall and the paddle when the shock is delivered. There is no advantage to anterior-posterior placement in the pediatric patient.

The correct energy dose for pediatric defibrillation is unknown. It is reasonable to start with a dose of 2 joules/kg, doubled to 4 joules/kg for the second shock. For refractory ventricular fibrillation it is reasonable to increase to higher energy doses to a maximum of 10joules/kg which is the adult dose. If an AED is being used it is best to utilize the pediatric pads as an energy attenuator is locating in the line of the pads. However, if pediatric pads or a manual defibrillator is not available, the adult combination pads from the AED may be used on both children and infants.
SYMPTOMATIC BRADYCARDIA

Treatment of bradycardia is necessary when it results in hemodynamic compromise. Infants and children do not tolerate bradycardia. It is often a terminal rhythm and is most often caused by hypoxia in infants and children.

2. Reassess the patient to determine if bradycardia persists and is still causing cardiac or respiratory compromise.
3. If pulses, perfusion and respirations are adequate, no emergency treatment is necessary.
4. If heart rate is less than 60 with poor perfusion despite oxygenation and ventilation CPR should be started.
5. After two minutes the patient should be re-evaluated for perfusion status.
6. If bradycardia persists, administer Epinephrine 0.01mg/kg 1:10,000 solution.
7. If you are suspicious that the bradycardia is caused by increased vagal tone or primary AV conduction block give Atropine 0.02mg/kg.
8. Emergency Transcutaneous pacing may be lifesaving if the bradycardia is due to complete heart block or sinus node dysfunction unresponsive to ventilation.
9. Pacing is not useful for Asystole or bradycardia due to post arrest hypoxic ischemic myocardial insult or respiratory failure.
Tachycardia in the Pediatric Patient

If signs and symptoms of poor perfusion are present, then emergency treatment must begin immediately. If pulses are not present, proceed with the Pulseless Arrest Algorithm. If the patient is stable and has adequate perfusion;

1. Assess and support airway, breathing and circulation
2. Attach monitor/defibrillator
3. Obtain vascular access
4. Evaluate 12 lead ECG and assess QRS duration to determine wide or narrow complex tachycardia
Narrow Complex Tachycardia (QRS <0.9 seconds) use the history of the patient and an electrocardiogram to determine sinus tachycardia vs Supraventricular tachycardia. The history of the patient with sinus tachycardia will include a reason for the child to be compensating with heart rate. Common presentations of sinus tachycardia include, hypovolemia from trauma or vomiting and diarrhea, sepsis, high fever, etc. If the rhythm is determined to be sinus tachycardia then it is treated by finding the cause and fixing it.

Supraventricular Tachycardia

1. Monitor for the effect of intervention. Treatment is determined by the stability of the patient.
2. Attempt vagal stimulation first. In infants and small children ice can be applied to the face. In the older child having them blow bubbles through a straw and reaching over and kinking off the straw will usually cause a vagal. In older children carotid sinus massage is safe.
3. Pharmacological intervention includes Adenosine which is the first drug of choice. It is safe as it has a very short half life and is very efficient in rhythms that involve the AV node for conduction. 0.1mg/kg is administered as fast as possible and followed immediately with a bolus of saline.
4. Verapamil 0.1 to 0.3mg can be effective in older children but should not be used in infants because of potential myocardial depression, hypotension and cardiac arrest.
5. If the patient is or becomes hemodynamically unstable he/she must be electrically cardioverted. Start with a dose of 0.5 joules/kg to 1 joule/kg. The dose can be increased to 2 joules/kg if necessary. If a second shock is unsuccessful or if the rhythm quickly recurs, a dose of Amiodarone 5mg/kg should be given prior to a third shock. Amiodarone must be infused slowly over 20-60 minutes depending on the urgency of the patient. Rhythm and blood pressure must be monitored carefully during administration.

Wide Complex Tachycardia

Not all wide complex tachycardia originates in the ventricle. Many are Supraventricular in origin. All therapies for arrhythmias have the potential for serious side effects. For this reason if possible expert consultation should take place before they are administered to infants or children.

1. Adenosine may be given to differentiate SVT from VT and converting wide complex tachycardia that is Supraventricular in origin. It should be given only if the rhythm is regular and the QRS is monomorphic. Do not use Adenosine in WPW.
2. Consider cardioversion after sedation with a starting dose of 0.5 joules/kg – 1.0 joules/kg with an increase to 2 joules/kg if the first is unsuccessful.
3. Consider pharmacologic conversion with Amiodarone over 20-60 minutes (5mg/kg) or Procainamide 15mg/kg over 30-60 minutes.
SPECIAL RESUSCITATION SITUATIONS

SEPTIC SHOCK
- No difference in survival if treated with colloid or isotonic crystalloid solutions
- Monitoring central venous oxygenation saturation (SVC) is useful to titrate therapy in infants and children. Target Scv02 >70% associated with improved survival in severe shock
- Early assisted ventilation
- Etomidate has been shown to facilitate endotracheal intubation in infants and children without effecting hemodynamics

HYPOVOLEMIC SHOCK
- Isotonic crystalloid for resuscitation
- 20ml/kg even if blood pressure is normal.
- Additional boluses of 20ml/kg if systemic perfusion fails to improve
- Insufficient evidence in infants and children to make a recommendation about the best timing of volume resuscitation for children with hypovolemia following trauma

TRAUMA – improperly performed resuscitation is a major cause of preventable pediatric deaths
Common errors include failure to provide appropriate fluid resuscitation, manage and maintain airway and failure to recognize internal bleeding

Involve a qualified surgeon early in the treatment of a child with trauma. When possible transport the child to a multisystem trauma center with pediatric experience.

1. If mechanism of injury is compatible with cervical spine injury, restrict motion and avoid traction or movement of the head and neck. Open the airway with a jaw thrust and do not tilt the head.
2. If airway cannot be open with the jaw thrust, use a head tilt chin lift because you must establish a patent airway
3. Do not routinely hyperventilate even in the case of head injury.
4. Suspect thoraco-abdominal trauma even in the absence of external injuries.
5. If the patient has maxillofacial trauma or skull fracture, insert an orogastric rather than Nasogastric tube.

POST RESUSCITATION STABILIZATION
Reassessment is key. The goal is to optimize perfusion to prevent organ injury and to preserve neurologic function. The cause of arrest must be diagnosed and treated.
Respiratory

- Data suggests that hyperoxemia (high PaO2) is associated with organ injury. The goal following arrest is to decrease the FiO2 to the lowest level that will maintain an oxyhemoglobin saturation of 94% or greater.
- Evaluate acid base balance and treat imbalances.
- Assist ventilation if significant respiratory compromise. If already intubated, verify tube placement and position. Consider arterial blood gases 10-15 minutes after establishing ventilator settings.
- Control pain and discomfort with analgesics and sedatives. Neuromuscular blocking agents with analgesia or sedation may improve oxygenation and ventilation.
- Monitor exhaled CO2, especially during transport and diagnostic procedures.
- Insert a gastric tube to relieve and help prevent gastric inflation.

Cardiovascular

- Monitor heart rate and blood pressure. Consider monitoring urine output with catheter. 12 Lead ECG may be helpful in discovering cause of cardiac arrest.
- Remove IO access if used for resuscitation and establish venous catheters.
- Monitor electrolytes, glucose and blood gases.
- Drugs used to maintain cardiac output:
  - Epinephrine
  - Dopamine
  - Dobutamine Hydrochloride
  - Sodium Nitroprusside
  - Inodilators (inamrinone and milrinone)

Neurologic

- Do not routinely provide excessive ventilation or hyperventilation. Has no benefit and may impair neurologic outcome by adversely affecting cardiac output and cerebral perfusion.
- Therapeutic hypothermia may be considered for children who remain comatose after resuscitation from cardiac arrest.
  - The ideal method for cooling and re-warming is not known.
- Treat post ischemic seizures aggressively; search for a correctable cause.

Inter-hospital Transport should be done by a specially trained team from a pediatric tertiary care facility. The team should be contacted as early as possible in the resuscitation to decrease waiting time. The team should be supervised by a pediatric emergency medicine or critical care specialist.
NEONATAL RESUSCITATION

Newborn, Neonate – applies to infants during the initial hospitalization. Newly Born is intended to apply to an infant at time of birth.

Only 10% of newborns require some assistance to begin breathing. Less than 1% require extensive resuscitation. Those that do not require resuscitation can be easily identified by the following characteristics:

1. Term gestation
2. Crying or breathing?
3. Good muscle tone?

If the answer to all three is yes, the baby does not require resuscitation and it should not be separated from the mother.
If the answer to any is no the infant should receive one or more of the following 4 categories of action in sequence:

1. Initial steps in stabilization (warming, clear airway, if necessary, dry, and stimulate)
2. Ventilation
3. Chest Compressions
4. Administration of epinephrine and/or volume expanders

Approximately 60 seconds are allotted for completely the initial steps, reevaluating and beginning ventilation if required. The decision to progress beyond the initial steps is determined by simultaneous assessment of respirations and heart rate (>100)

Assessment of heart rate should utilize the Precordial pulse. If detectable, palpation of the umbilical pulse can be used.