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This handout outlines the fundamental approach to recognizing the infant or child at risk for a cardiopulmonary arrest and preventing the progression to full arrest. This outline supplements, but does not replace the PALS manual.

RAPID CARDIOPULMONARY ASSESSMENT

The Rapid Cardiopulmonary Assessment is the PALS approach to identifying the infant or child at risk for a Cardiopulmonary Arrest and preventing the Arrest by recognizing and treating the pre-arrest conditions of Respiratory Failure, Shock and Cardiopulmonary Failure. This approach also facilitates recognition and resuscitation of a Cardiopulmonary Arrest. The Rapid Cardiopulmonary Assessment focuses on the respiratory and circulatory status of the infant or child and is executed in 3 phases.

THE STEPS OF THE RAPID CARDIOPULMONARY ASSESSMENT

- 1) Physical examination: a rapid, cursory yet focused assessment of the infant's or child's **Airway, Breathing, and Circulation**.
- 2) Cardiopulmonary ("Physiologic") Status: the infant or child's condition with respect to respiration and circulation based on the physical exam and categorized as **Shock, Respiratory Failure, Cardiopulmonary Failure or Cardiopulmonary Arrest**.
- 3) Initial Management Priorities: the treatment tasks that are the most important to address, immediately, as dictated by the Cardiopulmonary Status. These interventions take priority over all other diagnostic and therapeutic tasks.

Continual phase: Reassessment-Intervention-Reassessment-Intervention-Reassessment-etc.

- a) repeat the physical examination focusing on Airway, Breathing and Circulation;
- b) revise the Cardiopulmonary Status including both an assessment of the infant or child's response to the initial therapy and the appearance of additional respiratory or circulatory compromise;
- c) proceed to next Management Priority, as dictated by the revised Cardiopulmonary Status

Repeat the entire sequence until the infant or child is stable, with respect to airway, ventilation and circulation.

FOCUSED ASSESSMENT RESPIRATION & CIRCULATION

*1st phase: **Physical Examination***

The physical exam is cursory yet focused, only addressing the issues of Airway, Breathing and Circulation and allowing a rapid assessment of the infant or child's respiratory and circulatory status:

Observation allows a quick determination of:

- 1) **Respiratory Status** can be rapidly and effectively assessed by observing the respiratory rate (tachypnea or apnea); effort and work-of-breathing (presence or absence of Respiratory Distress); chest excursion (air-entry); and color (presence or absence of cyanosis).*
- 2) **General Demeanor and Responsiveness** including activity and muscle tone offer clues to the severity of respiratory or circulatory compromise. An alert, interactive, comforted infant with good neuromuscular tone cannot have any more than very mild respiratory or circulatory compromise. Conversely, a floppy, unresponsive infant suggests neurologic depression and raises the possibility of severe circulatory or respiratory compromise although there may be other explanations. An infant may be irritable, restless and inconsolable because of impending Respiratory Failure, as a prelude to becoming unresponsive, although again there be other explanations.*

*Palpation provides a rapid and complete assessment of **Circulation** by determining heart rate; the strength of the central and peripheral pulses; and assessing perfusion of the extremities by temperature and capillary refill.*

Focusing on these items of the physical exam can rapidly and accurately determine if the infant has Respiratory Failure, Shock or Cardiopulmonary Failure. Other data can be obtained to clarify or substantiate the preliminary impression, including: auscultation of lungs to assess air entry and measuring vital signs (heart rate, respiratory rate and blood pressure).

CATEGORY OF RESPIRATORY OR CIRCULATORY COMPROMISE

*2nd phase: **Cardiopulmonary (Physiologic) Status***

The focused physical exam allows the infant or child to be categorized according to their respiratory and circulatory status:

Stable

No, or at most a questionable compromise of respiration or circulation.

Mild Respiratory Failure

*A compensated compromise of airway or breathing. Usually an infant or child with some degree of **Respiratory Distress** who is able to achieve adequate air entry and is therefore compensated.*

Severe Respiratory Failure

An uncompensated compromise of airway or breathing presenting either as 1) severely depressed respiratory effort (periodic, irregular breathing or apnea) or 2) severe respiratory distress with inadequate air entry (uncompensated).

Physical exam alone may not conclusively distinguish between Mild and Severe Respiratory Failure. Further monitoring, with repeat Rapid Cardiopulmonary Assessments, or laboratory testing, especially blood gas measurements, may be necessary. However, blood gas measurements must be interpreted considering the infant or child's respiratory status, in particular the degree of respiratory distress. Relatively normal arterial oxygen (P_aO_2) and carbon dioxide (P_aCO_2) in the face of severe distress and tachypnea may still indicate impending if not actual Respiratory Failure. Laboratory tests supplement or assist, but never replace, the physical exam for respiratory assessment.

Shock

*Early, compensated Shock presents with tachycardia, weak pulses and poor peripheral perfusion but normal blood pressure. Hypotension indicates late, potentially irreversible shock. The mechanism of circulatory failure may be either inadequate vascular volume ("**hypovolemic**") or depressed pumping performance of the heart ("**Cardiogenic**"). Cardiogenic Shock is suggested by the additional findings of fluid overload including hepatomegaly, respiratory distress and a chest x-ray showing cardiomegaly and pulmonary edema. The combination of Shock and Respiratory Failure, from pulmonary edema, is particularly suggestive of Cardiogenic Shock. (Hyperpnea, increased rate and depth of breathing, may result from shock as a manifestation of the respiratory compensation for metabolic acidosis.)*

Cardiopulmonary Failure

The result of progressive Shock or Respiratory Failure presenting simple with agonal breathing or apnea and bradycardia, with poor perfusion. Indicates need for aggressive and expeditious resuscitation to prevent progression to full Cardiopulmonary Arrest.

Cardiopulmonary Arrest

*A Pulseless, apneic and unresponsive infant or child. The types of arrest differ only in the type of rhythm, all of which do not generate spontaneous circulation and are "non-perfusing": **Asystole, Ventricular Fibrillation and Pulseless Electrical Activity (PEA)**. Cardiopulmonary Arrest is a clinical diagnosis not a rhythm identification. Rhythm identification is required only to guide therapy, in particular the need for defibrillation. Usually, cardiopulmonary arrest is the culmination of progressive Shock or Respiratory Failure.*

PRINCIPLES OF MANAGEMENT

3rd phase: **Priorities of Initial Management**

The infant or child's condition with respect to respiration and circulation, ie) their "Cardiopulmonary Status", dictates the priorities for management. These actions and interventions should be performed before any other diagnostic or therapeutic tasks until a stable respiratory and circulatory condition is achieved. Nothing should interfere nor defer these priorities, except for the rapid delivery of antibiotics in suspected sepsis, anticonvulsant for sustained seizures and glucose for hypoglycemia. The general principles of our initial management are:

Stable:

No intervention is required to support respiration or circulation and efforts can address a more complete diagnostic evaluation and specific therapy is required. If the infant or child is "questionable stable" then proceed to obtain laboratory data to help clarify the infant or child's respiratory and circulatory status with the provision that careful and frequent reassessment of respiration and circulation be performed. If at any time, respiratory and/or circulatory compromise becomes more evident then intervene according to the category of the compromise. A complete diagnostic evaluation and specific therapy should be usually deferred until respiration and circulation are stable.

Mild Respiratory Failure:

Mild failure indicates a need for careful and repeated reassessment for deterioration of respiratory function and for supporting the infant or child's efforts at compensation. This support includes providing supplemental oxygen, comforting the patient and allowing them to assume a position of comfort. (For selected infants or children with bronchospasm ("reactive airways disease"), bronchodilators are important at this stage to prevent the progression to Severe Respiratory Failure.)

Severe Respiratory Failure:

Severe failure indicates a need for maximum respiratory support by establishing a secure and patent airway, insuring adequate ventilation with positive pressure, and providing maximal supplemental oxygen.

During the initial treatment of Respiratory Failure manual ventilation with a bag / mask allows continual adjustment of tidal volume in response to changing lung compliance. Use of mechanical ventilation should be deferred until the respiratory status is stable.

Adequate ventilation is expeditiously provided with mask ventilation under almost all circumstances with proper head positioning and mask seal. Endotracheal intubation allows more effective ventilation, and oxygenation, than mask ventilation because of: 1) more complete delivery of the tidal volume from the bag to the trachea, rather than the esophagus; 2) less gastric distension to inhibit diaphragmatic movement and lung expansion; and 3) the ability to provide positive end-expiratory pressure (PEEP). Mask ventilation may be sufficient for ventilation during temporary depression of breathing due to seizures or brief sedative-induced apnea. However, for the treatment of more prolonged Respiratory Failure endotracheal intubation is mandatory. Mask ventilation is critical to establish ventilation and oxygenation before intubation. Mask ventilation is also critical between intubation attempts if intubation proves to be prolonged or difficult.

(Bronchodilators are required with intubation for the relief of severe lower airway obstruction due bronchospasm.)

Shock:

Severe circulatory compromise indicates a need for either volume expansion (repletion) or vasoactive support, and in either case requires vascular access:

If the physical exam suggests Hypovolemic Shock then large fluid boluses are rapidly administered, either as isotonic crystalloid or colloid solutions, in the amount of 10 - 20 ml / Kg. Hypovolemic Shock represents a massive fluid deficit of at least 15% to 20%, and not simply 5% - 10% dehydration, so that large volumes are not only indicated in this setting, but mandatory. Hypotonic fluids, such as D₅¹/₄NS or ¹/₂NS, should not be used in these large volumes since they may result in hyponatremia, and possible seizures.

If the type of Shock is initially unclear then proceed as if the infant has Hypovolemic Shock using smaller fluid boluses (10 ml/Kg), with careful attention to the development or worsening of Respiratory Failure. If Cardiogenic Shock becomes more evident then withhold further fluid boluses and start vasoactive support of the circulation.

The danger of giving excessive fluid, especially in the face of Cardiogenic Shock, is the development of Respiratory Failure from pulmonary edema. This respiratory failure can be effectively treated with support of ventilation and oxygen, if quickly recognized.

Fluid boluses should therefore be repeated until: 1) the Shock is corrected as evidenced by return of peripheral perfusion and urine output; or 2) Respiratory Failure develops or worsens in response to fluids.

If the physical exam suggests Cardiogenic Shock then a continuous infusion of an adrenergic agent is required to augment contractility. Vasopressors are most effective when preload has been maximized by insuring complete restoration of vascular volume. In mixed forms of shock both fluid volume and vasopressor support may be required. Only a rapid acting, adrenergic agonist is appropriate for the treatment of cardiogenic shock, which in practice requires a continuous infusion. Dopamine in doses of 10 to 20 ug/kg/min is the most generally useful of the available agents because it provides cardiac stimulation without peripheral vasodilation. [The type of receptor stimulation and kind of hemodynamic response to Dopamine is dose dependent. Lower doses of dopamine do not provide sufficient cardiac stimulation and the primary effects sought of dopamine in this setting is improvement in cardiac output and not renal vasodilation.] Continuous Epinephrine infusion in the dose of 0.05 to 0.1 ug/kg/min may be effective if the response to high doses of Dopamine (20 ug/Kg/min) is inadequate. Dopamine may have a limited cardiovascular effect because of depletion of epinephrine stores, especially in young infants with long-standing circulatory compromise. [Neither Dobutamine or isoproterenol offer any significant advantage over Dopamine and their vasodilator effects are potentially harmful. Blood pressure is maintained in the face of vasodilation by augmented cardiac output. However, the ability to increase output with cardiogenic shock, the cardiac reserve, is unknown and possibly limited, so that hypotension may result.]

STAGES CARDIOPULMONARY ARREST

CardioPulmonary Failure:

The management of Cardiopulmonary Failure proceeds in 3 stages:

- 1) **Support Respiration:** *Airway and Breathing should be provided in the same manner as for severe Respiratory Failure. Respiratory support usually results in ready correction of the bradycardia.*
- 2) **Correct Bradycardia and Support Circulation:** *For young infants, if the bradycardia does not quickly resolve with respiratory support, or adequate respiratory support is delayed, and the bradycardia is profound and unstable (poor perfusion), then chest compressions may need to be performed to assist circulation while interventions are taken to correct the bradycardia. With sustained bradycardia, respiratory support remains the major priority and efforts should be redoubled at providing an Airway and adequate Breathing. Drug therapy is a distant, secondary priority but may be needed for profound, sustained bradycardia associated with poor perfusion, especially if the bradycardia persists despite effective respiratory support.*
- 3) **Reassess Circulation:** *After the respiratory failure is adequately controlled and bradycardia is corrected, attention is turned to reassessing the infant or child's circulatory status. Shock may have been the cause of the Cardiopulmonary Failure. If Shock is present then treatment proceeds accordingly.*

CardioPulmonary Arrest:

Resuscitation proceeds in 2 stages:

- 1) *The 1st step is **Recognition** that the infant or child is suffering a Cardiopulmonary Arrest. The immediate and automatic response is to start "**Advanced CPR (Basic CPR with adjuncts)**," assemble a resuscitation team and equipment, and attach the patient to a cardiac monitor, without any further delay for further assessment. The priorities of CPR are: ventilation (briefly with mask and bag); chest compressions; intubation; vascular access; and Epinephrine, as soon as a route is established.*
- 2) *Subsequent actions are dictated by the underlying collapse rhythm identified on the monitor: For **Asystole** no specific therapy is available, except for CPR. For **PEA** no specific therapy is available, unless an etiology such as pneumothorax, hemorrhage or pericardial tamponade, can be identified and corrected. Only **Ventricular Fibrillation** has an effective therapy, namely defibrillation. Electrical defibrillation is the only therapy that will convert fibrillation into a pulse generating rhythm. If a defibrillator is available, defibrillation becomes the primary priority, even before starting CPR, with ventricular fibrillation. Drug therapy is primarily used to prevent recurrence of fibrillation after successful conversion, and secondarily to facilitate electrical therapy.*

MANAGEMENT SUMMARIES

("Algorithms")

The following protocols are offered as flexible guidelines to assist in the management of a wide-range of pediatric patients. These guidelines should be applied according to discretion of the pediatric care-provider responsible for the well being of the patient. No claim that these guidelines are totally comprehensive is made nor should be inferred. Deviation from these sequences and the use of these protocols for other than the listed scenarios may be warranted depending on the circumstances.

MILD RESPIRATORY FAILURE

RECOGNITION

- ◀ *respiratory distress with good air entry (compensated).*
 - *alert, good neuromuscular tone, no circulatory compromise.*
- ◀ *obtunded patient with intact respiratory effort and maintainable airway.*

TREATMENT

- ◀ *allow infant or child to assume position of maximum comfort.*
- ◀ *allow parent to provide care, with guidance and assistance.*
- ◀ *provide maximum supplemental oxygen, in nonthreatening manner.*
- ◀ *attach to heart rate monitor to assist, not replace, re-assessment using the physical exam.*
- ◀ **Reassess frequently** *(repeat Rapid Cardiopulmonary Assessment) for deterioration of status.*
 - *if the infant or child develops uncompensated Respiratory Failure proceed according to the management priorities for severe Respiratory Failure.*

SEVERE RESPIRATORY FAILURE

RECOGNITION *should be suspected in 2 situations:*

- 1) *severe respiratory distress with diminished air entry,*
 - *accompanied by poor perfusion and/or diminished consciousness.*

or

- 2) *inadequate respiratory effort (apnea, erratic or shallow breathing),*
 - *depressed, poorly responsive infant with floppy neuromuscular tone.*
 - *prior respiratory distress with the development of respiratory fatigue.*

TREATMENT

- ◀ *establish stable and patent **Airway**:*
 - *head position, chin-lift or jaw-thrust maneuvers.*
 - *(endotracheal intubation will assist in maintaining the Airway.)*

- ◀ *insure adequate **Breathing**:*
 - *positive-pressure ventilation with ventilation bag (self-inflating).*
 - *by mask initially to stabilize.*

- ◀ *delivery maximum, supplemental oxygen ($F_iO_2 = 1.0$).*
- ◀ *attach to heart rate monitor, to assist, not replace, reassessment using the physical exam.*

- ◀ *assess **Airway** and **Breathing** interventions by observing chest excursion, air entry and improvement in cyanosis.*
 - *if unable to adequately ventilate, then check adequacy of initial intervention by repositioning the head, repeating jaw-thrust and resetting the face mask. (2 providers may be needed for adequate mask ventilation.)*
 - *if still unable to ventilate, then proceed to expeditious endotracheal intubation, or check for obstructed airway due to a foreign body.*

- ◀ *proceed to endotracheal intubation for persistent apnea, persistent severe respiratory distress or inability to ventilate by mask.*

- ◀ ***Repeat Rapid Cardiopulmonary Assessment** until patient stable, with or without respiratory support.*
 - *assess circulation to insure that patient does not have Shock in addition to Respiratory Failure.*

- ◀ *if the infant develops bradycardia at any point continue to address support of ventilation and oxygenation with intubation, bag ventilation and 100% F_iO_2 if not used already and proceed according to protocol for Cardiopulmonary Failure.*

SHOCK

RECOGNITION

- ◀ tachycardia, diminished central pulses and poor peripheral perfusion with absent or thready distal pulses, cold extremities and delayed capillary refill
 - depressed, poorly responsive infant with floppy neuromuscular tone.
- ◀ recognition of Shock not dependent on blood pressure, which may be normal or depressed,
 - blood pressure does identify the stage of the Shock, with hypotension indicating late Shock, and indicates the degree of urgency for correcting.
- ◀ mechanism of shock usually **Hypovolemic** but may also be **Cardiogenic**.
 - presentation of Shock is same in either case, but treatment need to be modified.
- ◀ **Cardiogenic Shock** suggested by evidence of fluid overload:
 - combination of **Respiratory Failure** and Shock, in particular the development of **Respiratory Failure** after fluid bolus.
 - hepatomegaly,
 - CXR showing cardiomegaly and pulmonary edema or shunt vascularity.

TREATMENT

- ◀ obtain vascular access
- ◀ deliver supplemental oxygen.
- ◀ attach to heart rate monitor, to assist, not replace, re-assessment using the physical exam.
- ◀ large fluid bolus (20 ml/Kg of isotonic or colloid solution) given rapidly (<10 minutes), if definitely Hypovolemic Shock.
 - smaller bolus (10 ml/Kg) if assessment unclear whether Hypovolemic or Cardiogenic Shock.
- ◀ repeat **Rapid Cardiopulmonary Assessment**:
 - reassess respiration for development or progression of **Respiratory Failure**.
 - assess change in circulation and peripheral perfusion with initial intervention.
- ◀ if **Respiratory Failure** develops then treat according to management priorities for severe **Respiratory Failure**, being more aggressive with the combination of Shock and **Respiratory Failure**.
 - if **Respiratory Failure** develops, then assess for **Cardiogenic Shock** by checking liver span and obtaining chest x-ray: if cardiomegaly and pulmonary edema/shunt vascularity present proceed according to management of **Cardiogenic Shock**.

- ◀ if Shock uncorrected or only partially corrected and Respiratory Failure has not developed, then repeat fluid bolus.
 - repeat sequence of Rapid Cardiopulmonary Assessment and fluid bolus until either Shock corrected or fluid overload becomes evident, especially the development of respiratory distress.
- ◀ if at any point, there is evidence for a cardiogenic etiology, then:
 - treat Respiratory Failure aggressively according to protocol for Severe Respiratory Failure
 - with-hold further fluid bolus, or be less aggressive with fluid (10 ml/Kg bolus) if vascular volume expansion still required for adequate perfusion.
 - start infusion of adrenergic agent with both vasoconstrictor and inotropic actions (dopamine).

CARDIOPULMONARY FAILURE

RECOGNITION

- ◀ poorly responsive, floppy infant with apnea or agonal respirations and bradycardia.

typical scenarios include, but are not limited to:

- ◀ an infant or child with fluctuating level of consciousness who becomes more depressed and apneic.
- ◀ an infant or child with respiratory distress whose respiratory effort becomes ineffective because of either fatigue or obtundation.
- ◀ a monitored infant or child who suddenly becomes profoundly bradycardia and cyanotic, in particular an intubated patient being mechanically ventilated.
- ◀ check central pulse to insure that patient has spontaneous pulse and determine general heart rate.
 - if pulse is not palpable, and presumed absent, patient is suffering **Cardiopulmonary Arrest** and proceed accordingly.

MANAGEMENT - 1st treat Respiratory Failure

1) *correct the Respiratory Failure:*

◀ if infant is intubated and mechanically ventilated, then remove from ventilator, ventilate with self-inflating bag and maximum oxygen ($F_iO_2 = 100\%$) and proceed as outlined under "**Failure to Improve with Intubation and Ventilation**."

◀ establish a stable and patent Airway:

- head position, chin-lift or jaw thrust maneuvers to establish ventilation and oxygenation.

◀ insure adequate Breathing:

- positive-pressure ventilation with a ventilation bag, with tidal volume determined by the adequacy of chest excursion.
- delivery maximum, supplemental oxygen ($F_iO_2 = 100\%$).

expeditious endotracheal intubation if continued ventilation is needed, after an initial period of ventilation and oxygenation by face mask.

- ◀ assess **Airway and Breathing** interventions by observing chest excursion, air entry and improvement in cyanosis.
 - if unable to adequately ventilate, then check adequacy of initial intervention by repositioning the head, repeating jaw-thrust and resetting the face mask. (2 providers may be needed for adequate mask ventilation.)
 - if still unable to ventilate, then proceed to expeditious endotracheal intubation, or check for obstructed airway due to a foreign body.
- ◀ proceed to endotracheal intubation for persistent apnea, persistent severe respiratory distress or inability to ventilate by mask.
- ◀ attach to heart rate monitor to aid, not replace, clinical reassessment with physical exam.

MANAGEMENT - correct Bradycardia

2) correct profound, sustained bradycardia and support circulation:

- ◀ if bradycardia is not readily corrected then efforts should continue to be directed, and even intensified, at respiratory support.
 - other interventions may be required to supplement, but not replace, respiratory support.
- ◀ perform chest compression for profound sustained bradycardia, especially for infants with a weak pulse, if heart rate does not quickly improve with attempts at ventilation and oxygenation:
 - warranted if the pulse < 60/minute in an infant with poor perfusion or hypotension.
 - compressions not beneficial nor warranted if pulse rate > 80, even though circulation is not optimum.
 - continue to pursue efforts to support respiration and increase heart rate in either circumstance.
- ◀ if profound, sustained bradycardia persists despite good ventilation and oxygenation, and perfusion is compromised, then drug therapy is indicated:
 - epinephrine IV/IO = 0.01 mg/kg (1:10,000 solution) or via ET = 0.1 mg/kg (1:1000 solution)
 - * NOTE that epinephrine is considered before atropine in symptomatic bradycardia that is unresponsive to adequate airway and ventilation management. Remember that adequate ventilation will almost always correct bradycardia in children! So recheck airway and ventilation to be sure.
 - atropine 0.02 mg/Kg IV, IO or ET (0.1 mg, minimum dose - 0.5 mg, low adult dose), is generally satisfactory for bradycardia persisting after correction of Respiratory Failure. Give Atropine before Epinephrine if bradycardia due to suspected increased vagal tone or primary AV block.
- ◀ if patient loses spontaneous pulse then management should proceed according to the Cardiopulmonary Arrest protocol for asystole or PEA with the use of epinephrine.

3) when Respiratory Failure is corrected, and heart rate is corrected then reassess for Shock (as possible cause or residual compromise):

- ◀ recognition and treatment according to protocol for **Shock**,
- ◀ Cardiogenic Shock may present as Cardiopulmonary Failure:
 - suggested by hepatomegaly or CXR showing cardiomegaly and pulmonary edema/shunt vascularity.

FAILURE TO IMPROVE WITH INTUBATION and VENTILATION

Improperly set-up or malfunctioning equipment, a misplaced or obstructed endotracheal tube or certain patient conditions may prohibit adequate ventilation of an intubated infant or child dependent on mechanical ventilation. When a patient with Respiratory or Cardiopulmonary Failure either fails to improve or deteriorates with positive pressure ventilation by means of an endotracheal tube, then the following problems should be addressed:

EQUIPMENT

- ◀ *inadequate ventilation or oxygenation can result: if any of the myriad of ventilatory tubing becomes accidentally disconnected, allowing an air leak in what is supposed to be a closed circuit; if air flow from the source or supply of gas may be interrupted because of disconnected tubing or depletion of a tank; from an inappropriate ventilator setting; or rarely, from a malfunction of a mechanical ventilator.*
 - *removing the patient from the ventilator and using bag ventilation eliminates the ventilator as a potential problem while sorting out the cause of the malfunction.*
- ◀ *check all tubing for improper or disrupted connection, especially the oxygen source.*
 - *failure to use oxygen reservoir with self-inflating ventilation bag may result in insufficient supplemental oxygen.*
 - *anesthesia type ventilation bags require a continuous flow of air or oxygen in order to generate any positive pressure and will not provide any ventilation if gas flow is interrupted.*
 - *check that the oxygen source is turned-on at an adequate rate.*
- ◀ *check chest excursion and air-entry to determine if the delivered tidal volume is adequate, especially a problem with poorly compliant lungs.*
 - *a pop-off valve may limit tidal volume because ventilation pressures are exceeded, especially in infants with poorly compliant lungs.*
 - *if unable to ventilate then depress valve or use bag without valve.*
- ◀ *check that the manometer port is occluded and that the manometer tubing is not detached, both of which will result in loss of tidal volume.*
- ◀ *insure that the seal of the adapter of either the ventilation bag or ventilator tubing with the endotracheal tube is tight so that no tidal volume is lost.*

ENDOTRACHEAL TUBE

- ◀ *check endotracheal tube for obstruction from kinking or secretions.*
- ◀ *check for displacement of the ET tube into right main stem bronchus, suggested by poor aeration of left lung.*
- ◀ *assess for esophageal intubation, probably the most common reason for the acute deterioration of intubated infants:*
 - *suggested by gastric distension and abdominal air sounds (which may also be transmitted to chest in small infants).*
 - *esophageal displacement of the endotracheal tube can result from just head movement (neck extension and flexion) in infants.*
- ◀ *check for an excessive air leak, suggesting that the endotracheal tube size is too small to form an effective seal with the cricoid ring.*

PATIENT COMPLICATIONS

- ◀ check for gastric distension which may limit diaphragm movement, especially a problem with infants because of poor chest expansion.
 - a frequent problem after mask ventilation but easily relieved with a nasogastric tube.
- ◀ assess for tension pneumothorax, as the final and last cause:
 - suggested by sudden onset of Cardiopulmonary Failure in previously stable patient receiving positive pressure ventilation.
 - suggested by refractory Cardiopulmonary Failure despite appropriate treatment with proper technique and absence of other possible causes.
 - characteristic deviation of trachea, loss of breath sounds, etc. may be absent in infant.

ACUTE DETERIORATION IN INTUBATED PATIENT??? REMEMBER TO SEARCH FOR DOPE:

Displaced tube, Obstructed Tube, Pneumothorax, Equipment Problems.

CARDIOPULMONARY ARREST

[The following steps should be followed in sequence proceeding to the next action if the patient continues to be in asystole, PEA or fibrillation. If a rhythm and pulse are generated at any step, these guidelines do not apply and management should proceed according to the patient's current circulatory or respiratory status.]

RECOGNITIONS AND INITIAL RESPONSE

- ◀ central pulse is absent (apneic, unresponsive infant or child).
 - proceed with all infants or children when there is any chance of recovery, except those with a prospective decision not to resuscitate because of terminal illness and that decision has been explicitly stated.
- ◀ initiate advanced CPR (basic CPR with adjuncts) with chest compressions, BVM ventilation and maximal oxygen.
 - rapidly intubate after initial period of ventilation and oxygenation by mask.
- ◀ establish appropriate vascular access, as soon as possible, limiting attempts at peripheral vascular access to 3 attempts or 90 seconds, whichever comes first, before resorting to intraosseous insertion:
 - proximal antecubital, central or femoral vein.
 - temporary use of endotracheal tube for certain drugs until IV or IO routes established.
 - use intraosseous as direct substitute for intravenous.
 - interrupt chest compressions only for endotracheal intubation and defibrillation.
 - coordinate and pause chest compressions with ventilation by mask, only until endotracheal intubation confirmed.

BASIC CPR

Infant (< 1 yr old)

airway:

- ◀ appropriate size mask to seal nose and mouth
- ◀ appropriate size uncuffed ET tube

breathing:

- ◀ initially 2 slow breaths (1-2 sec each)
- ◀ 20 breaths minute
- ◀ synchronize with chest compression only with mask ventilation
 - compression to ventilation ratio of 5:1

circulation:

chest compression with 2 fingers placed 1 finger-breadth below intermammary line (one rescuer) or thumbs encircling chest with thumbs over lower sternum (two professional rescuers).

- rate at least 100/minute
- depth 1/2 to 1 inch - this is approximate; the chest of an infant or child is compressed approximately one third the dept of the chest: enough to generate a pulse.

Young Child (1 - 8 yr old)

airway:

- ◀ appropriate size mask to seal nose and mouth
- ◀ appropriate size uncuffed (<8 yrs) ET tube

breathing:

- ◀ initially 2 slow breaths (1-2 sec each)
- ◀ 20 breaths minute
- ◀ synchronize with chest compression only with mask ventilation
 - compression to ventilation ratio of 5:1

circulation:

- ◀ chest compression with heel of hand placed 1 finger-breadths above costal margin (xiphoid)
- ◀ rate at 100/minute
- ◀ depth 1 to 1 1/2 inch or one third the depth of the chest: enough to generate a pulse

Older Child (>8 yr old): Adult standards

airway:

- ◀ appropriate size mask to seal nose and mouth
- ◀ appropriate size cuffed (>8 yrs) ET

breathing:

- ◀ initially 2 slow breaths (1-2 sec each)
- ◀ 15 breaths minute
- ◀ synchronize with chest compression only with mask ventilation
- ◀ compression to ventilation ratio of 15:2 until airway secured then asynchronous.

circulation:

- ◀ chest compression with heel of hand placed 2 finger-breadths above costal margin (xiphoid)
- ◀ rate at 100/minute
- ◀ depth 1 1/2 to 2 inch

SPECIFIC THERAPY

- ◀ attach to cardiac monitor, as soon as possible.
 - proceed according to underlying rhythm.

ASYSTOLE

RECOGNITION

- ⚡ *rhythm monitor shows no significant electrical activity ("flat line")*
 - *check that monitor is properly connected.*
- ⚡ *check another lead to insure fine fibrillation is not present*
 - *occasional agonal beats confirm asystole (incompatible with fibrillation)*

TREATMENT

- ⚡ *epinephrine*
 - *IV/IO dose - 0.01 mg/kg (1:10,000 solution)*
 - *ET dose - 0.1 mg/kg (1:1000 solution)*
 - repeat epinephrine every 3 to 5 minutes while patient remains pulseless.*
- ⚡ *effective ventilation is the primary therapy for the acidosis during Cardiopulmonary Arrest, correcting the respiratory component and compensating for the metabolic component.*
 - *consider bicarbonate only for prolonged resuscitation with severe acidosis but only if able to adequately ventilate to the point of hypocapnia (pCO₂).*
- ⚡ *the use of calcium may be warranted with a young infant for presumptive hypocalcemia.*
- ⚡ *defibrillation initiated early if fine ventricular fibrillation suspected.*
- ⚡ *continue resuscitation until spontaneous rhythm with palpable pulse is generated or until "cardiovascular unresponsiveness" obvious (ability to produce a pulse generating rhythm is hopeless).*

<i>PULSELESS ELECTRICAL ACTIVITY (PEA)</i>

RECOGNITION

cardiac rhythm present without pulse.

- ⚡ *rhythm usually slow and often junctional or idioventricular*

TREATMENT

epinephrine

- *IV/IO dose - 0.01 mg/kg (1:10,000 solution)*
- *ET dose - 0.1 mg/kg (1:1000 solution)*
- repeat epinephrine every 3 to 5 minutes while patient remains pulseless.*

PEA (continued)

- ⚡ *consider possible etiology and correct if possible*
 - *hypoxemia, pneumothorax, hemorrhage, pericardial tamponade, or profound hypothermia.*
 - *inability to generate pulse with chest compressions suggest depletion of vascular volume (from*

hemorrhage) or inhibition of cardiac filling (from pericardial tamponade or pneumothorax)

- ◀ effective ventilation is the primary therapy for the acidosis during Cardiopulmonary Arrest.
 - consider bicarbonate only for prolonged resuscitation with severe acidosis but only if able to adequately ventilate to the point of hypocapnia.
 - ◀ the use of calcium may be warranted with a young infant for presumptive hypocalcemia.
- continue resuscitation until spontaneous rhythm with palpable pulse is generated or until "cardiovascular unresponsiveness" is obvious (ability to produce a pulse generating rhythm is hopeless).

VENTRICULAR FIBRILLATION

RECOGNITION

- ◀ rhythm monitor shows the characteristic sinusoidal, disorganized pattern.
 - ventricular tachycardia should be treated the same as fibrillation if there is no pulse.

TREATMENT

- ◀ initiate CPR, until defibrillator available.
 - immediately interrupt CPR when defibrillator available, including attempts at intubation and vascular access.
- ◀ defibrillate for documented fibrillation.
- ◀ defibrillate 2 J/Kg ASAP, as 1st priority
 - check rhythm, proceed if fibrillation persists
 - if the lower energy dose is successful in converting fibrillation but the fibrillation recurs, the lower dose should be repeated rather than proceeding to a higher dose.
- ◀ immediately defibrillate 4 J/Kg, without resuming CPR
 - check rhythm, proceed if fibrillation persists
- ◀ immediately defibrillate 4 J/Kg, without resuming CPR
 - check pulse, check rhythm, proceed if fibrillation persists
- ◀ resume CPR and attempts at intubation and vascular access
- ◀ epinephrine
 - IV/IO dose - 0.01 mg/kg (1:10,000 solution)
 - ET dose - 0.1 mg/kg (1:1000 solution)
 - repeat epinephrine every 3 to 5 minutes while patient remains pulseless.

V-FIB (continued)

- ◀ defibrillate 4 J/Kg (for sustained fibrillation, after drug circulated).
 - check pulse, check rhythm, proceed if fibrillation persists

- ◀ *resume CPR*
 - *continue attempts at IV or IO access if previously unsuccessful*

Drug-Defibrillation sequence:

Amiodarone 5mg/kg bolus IV, IO

OR Lidocaine 1mg/kg bolus IV, IO, ET

OR Magnesium 25-50mg/kg IV or IO for torsades de pointes or hypomagnesemia (maximum: 2 grams).

- ◀ *defibrillate 4 J/Kg (for sustained fibrillation) after drug circulates*
- ◀ *check pulse, check rhythm, proceed if fibrillation persists*
- ◀ *resume CPR*
- ◀ *always alternate drugs with electricity*
- ◀ *if patient develops asystole (or profound bradycardia) or PEA in response to defibrillation at any point in the treatment sequence for fibrillation, then proceed according to the appropriate sequence with the continue use of epinephrine.*