Pediatric Shock
Recognition / Resuscitation

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Shock
Oxygen Delivery can not support Metabolic Demands of the Body
Is the child in shock?

- Mental status, general appearance, response to stimulation (AVPU)
- Heart rate, central and distal pulse character
- Skin temperature, capillary refill, end organ function, blood pressure, urine output
Decompensated Shock

- Neonate SBP < 60 mm Hg
- Infant SBP < 70 mm Hg
- Child SBP < 70 mm Hg + (2 x age in years)
- Child > 10 years of age: SBP < 90 mm Hg
Acute Blood Loss

- 15% or less (Class I)
- 15-30% (Class II)
- 30-40% (Class III)
- >40 % (Class IV)
Dehydration

• Mild: 4%-5% BW loss or 40-50 ml/kg fluid deficit
• Moderate: 6%-9% BW loss or 60-90 ml/kg fluid deficit
• Severe: >10%BW loss or 100-110 ml/kg fluid deficit
Myocardial Dysfunction

• Dyspnea, cough, tachypnea, wheeze, rales

• Tachycardia, gallop rhythm, hypotension

• Cyanosis, cold extremities, diaphoresis, weak peripheral pulses

• Edema, neck vein distention, hepatomegaly
Sepsis

- Documented or suspected infection
- Fever, hypothermia
- Leukocytosis, leukopenia
- Hypotension
- Oliguria, coagulopathy
- Prolonged capillary refill, mottling
Septic Shock

- Cold or warm shock
- Fluid-refractory/dopamine resistant shock
- Catecholamine resistant shock
- Refractory shock
Blood Pressure

Blood Pressure =

Cardiac Output
x
Systemic Vascular Resistance
Cardiac Output

• Stroke volume x heart rate

• Stroke volume depends on
  – Preload
  – Contractility
  – Afterload
Oxygen Content
CaO2

- Hbg gm/dl x 1.36 x SaO2 + PaO2 x .003

- 1.36 is the estimate of mean volume of O₂ that can be bound by 1 gram of normal hemoglobin when fully saturated

- .003 is the solubility coefficient of O₂ in human plasma
Oxygen Delivery

- Oxygen delivery = cardiac output \times \text{ arterial O}_2 \text{ content (CaO}_2\text{)}

- Oxygen consumption = cardiac output \times (\text{CaO}_2 - \text{CvO}_2)

- Oxygen extraction = oxygen consumption / oxygen delivery
Re-perfusion Injury

- Reperfusion of injured cells with oxygen = Superoxide anion radicals
- Microvascular disruption, inflammatory cascade, pro-coagulant, cytokine release
- Multiple organ system dysfunction
Etiologies of Shock

• Insufficient cardiac filling

• Impaired ejection of blood

• Inadequate heart rate

• Increased demand for blood flow
Insufficient Cardiac Filling

- Intravascular volume depletion
- Increased vascular capacity
- Impedance to venous return
Impaired Ejection of Blood

- Impedance to outflow
  - Obstructive lesions

- Decreased contractility
  - Cardiac
    - Congenital
    - Acquired
  - Non Cardiac
Inadequate Heart Rate

- Disorder of pulse formation
- Disorder of impulse conduction
Increased Demand for Blood Flow

- Reduced arterial oxygen saturations
- Impaired nutrient utilization
- Maldistribution of flow
- Increased metabolic demand
Treatment for Shock

- Airway & C-spine stabilization
- Breathing (Oxygenation / Ventilation)
- Circulation (First 15 minutes)
- Ongoing shock
  - General
  - Specific insult
Circulatory Support
The First 15 Minutes

- Access (IO, peripheral or central IV)
- Isotonic crystalloid solution 20ml/kg bolus
- Control external hemorrhage
- Chest compressions
- AED
- EKG
- Treat THAID
Fluids

- Isotonic crystalloid solution (normal saline or Ringer’s lactate), 20ml/kg fluid bolus IO/IV push over 5 minutes
- Isotonic crystalloid solution or colloid 20ml/kg fluid bolus IO/IV push over 5 minutes
- After the third fluid bolus, if suspected hemorrhage, PRBC 10-15 ml/kg or Whole blood 20 ml/kg
AED

- Prehospital setting
- Children > 8 yrs old, weight ≥ 25 kg who have sudden collapse cardiac arrest
- **Power ON** the AED
- **Attach** AED electrode pads to chest
- **Clear** patient and **analyze** rhythm
- If indicated, **Clear** patient, deliver **Shock**
EKG

- Asystole and PEA
- Ventricular tachycardia / fibrillation
- Bradycardia (Heart rate < 60 and poor systemic perfusion)
- Tachycardia and poor perfusion
  - Narrow Complex
  - Wide Complex
Treat THAID

- Tension pneumothorax, Tamponade, Thromboembolism, Toxin,
- Hypoxemia, Hypovolemia, Hypothermia, H+ (metabolic, K, Ca, Mg, glucose), Head, Heart
- Adrenal insufficiency
- Infection
- Ductal dependent cardiac lesion
Circulatory Support
Ongoing Shock

• Maximize oxygen delivery to tissues
  • Cardiac output, Hemoglobin, $O_2$ saturation
• Correct precipitating problem (THAID)
• Address re-perfusion and inflammatory injury
• Provide multiple organ system support.
Hemorrhage

- Continue Isotonic crystalloid solution / colloid / PRBC until surgical intervention has controlled internal bleeding and shock resolved
- Monitoring - consider central venous and urinary catheter
Hypovolemia (fluid losses)

- Continue Isotonic crystalloid solution or colloid 20ml/kg fluid bolus IO/IV push over 5 to 20 minutes based on child’s clinical condition until shock is resolved.
- Monitoring - consider central venous and urinary catheter
Myocardial Dysfunction

- Optimize preload: 10 ml/kg boluses may be used and given slowly over 10-20 minutes
- Inotropes, vasodilators, inhaled NO
- Maintain ductal opening if appropriate
- Correct anatomic lesions, dysrhythmias
- IVIG / Steroids (myocarditis)
- Ventricular Assist Device / ECMO
Septic Shock

- Fluid Refractory Shock
  - Dopamine 10 mcg/kg/min IV
  - Establish central venous and arterial catheters for monitoring

- Fluid refractory-dopamine resistant shock
  - Epinephrine 0.1 mcg/kg/minute IV and titrate for cold shock
  - Norepinephrine 0.1 mcg/kg/minute IV and titrate for warm shock
Septic Shock

- Catecholamine-resistant shock
  - At risk of adrenal insufficiency?
    - Give hydrocortisone
    - Stress coverage - Hydrocortisone 1-2 mg/kg IV
    - Shock coverage - Hydrocortisone 50 mg/kg IV followed by same dose as a 24 hour infusion
Septic Shock

- Normal BP, cold shock, SVC 02 Sat < 70%
  - Vasodilator & Volume loading
- Low BP, cold shock, SVC 02 sat < 70%
  - Epinephrine & volume loading
- Low BP, warm shock
  - Norepinephrine & volume loading
  - Vasopressin or angiotensin?
Septic Shock

• Persistent Catecholamine-resistant shock
  – Direct fluid, inotropes, vasopressor, vasodilator and hormonal (thyroid) therapies using pulmonary artery catheter to attain normal MAP-CVP and C.I. > 3.3 and < 6.0 L/min/m²

• Refractory Shock
  – Consider ECMO
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Circulatory Support
Ongoing Shock

- Consultation with pediatric critical care physician

- Consider transfer to a pediatric ICU, pediatric trauma center or primary trauma center with pediatric expertise.