The Management of Shock in Pediatrics

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1. The definition of Shock:

   A syndrome which occurs because of cardiovascular dysfunction and the inability of the circulatory system to provide adequate oxygen and nutrients to meet the metabolic demands of vital organs.

   **SHOCK CAN & DOES EXIST WITHOUT HYPOTENSION!!**

Absolute hypovolemia - emesis, diarrhea, trauma, “third spacing”, peritonitis

Functional hypovolemia - vascular capacity increases ie. spinal cord injury, anaphylaxis

2. Physiology of Circulation

   a. Cardiac Output = Heart Rate x Stroke Volume

      Stroke Volume depends on pre-load, cardiac contractility, and after-load

   b. Blood Pressure = Cardiac Output x Peripheral Resistance (SVR)

3. Pathophysiology of Shock

   a. Microcirculatory Dysfunction

      Capillary blood flow decreased by precapillary smooth muscle contraction and cellular debris >>>>> endothelial cell damage (also exacerbated by complement activation >>>>> platelet and granulocyte aggregation)

   b. Tissue Ischemia - anaerobic metabolism depletes glycogen stores >>> lactic acidosis

   c. Release of Biochemical Mediators

      **Endogenous** Vasoactive and Inflammatory Mediators:

      1) Vasoactive - vasoconstriction & vasospasm, increased capillary permeability
         Examples: leukotrienes, thromboxane, prostaglandins

      2) Inflammatory mediators (cytokines) - increased permeability, inducing fever and an increased WBC count, inducing adhesion of endothelial cells
         Examples: tumor necrosis factor (TNF), interleukins, platelet-activating factor

      3) Complement Activation - vasoactive & inflammatory effects

      4) Myocardial Depressant Factor - negative inotropic effects
4. **Clinical Manifestations**

   Early (compensated) Shock

   - tachycardia may be the earliest sign (compensates for a decreased stroke volume)
   - good perfusion early (secondary to cutaneous vasodilatation when cardiac output is increased)
   - eventually delayed capillary refill secondary to peripheral vasoconstriction and decreased cardiac output
   - mild tachypnea
   - mild irritability and decreased urine output indicating decreased end-organ perfusion
   - other signs: dry mucous membranes, sunken fontanel, decreased skin turgor

   Late (uncompensated) Shock

   - increased tachycardia and tachypnea
   - capillary refill markedly delayed
   - oliguria
   - agitation progresses to coma
   - hypotension

5. **Types of Shock**

   a. Hypovolemic - decreased circulating volume, most common cause of shock in children
      - water loss from vomiting / diarrhea most common
      - others: blood loss (trauma, GI bleed), plasma loss (burns, peritonitis), and water losses (glycosuric diuresis)

   b. Distributive - pooling of blood in the peripheral vasculature
      - most commonly secondary to **sepsis**
      - others: anaphylaxis, spinal injuries, drug ingestions

   c. Cardiogenic - decreased CO as a result of decreased contractility
      - clinically: rales, hepatomegaly, JVD, gallop rhythm
      - causes: late shock, myocarditis, dysrhythmias, drug ingestions, congenital heart disease

   d. Obstructive - mechanical obstruction of ventricular outflow tract with pericardial tamponade or tension pneumothorax

6. **Initial Therapy**
a. Airway
b. Breathing (supply 100% F\textsubscript{102} via bag-valve-mask)
c. Circulation
   - must obtain vascular access and give fluids immediately
     (peripheral vein, intraosseous, central lines)
   - 20cc/kg of crystalloid 0.9% NaCl or Ringer’s Lactate
   - Packed RBCs (10cc/kg) for a low Hematocrit
d. Reassess ABCs (vital signs and physical examination)
   - May give up to 60 - 80cc/kg of fluids as needed
e. Antibiotics for septic shock or unclear etiology
f. Laboratory: ABG, CBC, Chemistries, LFTs, PT/PTT, Dstick, cultures
g. Correct acidosis: Na Bicarbonate for pH < 7.1 (ventilation & perfusion must be adequate)
h. Watch for DIC - treat with FFP (10cc/kg) and platelets (0.2 units/kg) as needed

7. Monitoring
   a. Continued reassessments
   b. Foley catheter - UOP should be maintained at least 1cc/kg/hr
c. CVP (central venous pressure)
d. End-tidal CO\textsubscript{2} monitor
e. Echocardiogram
f. Swanz-Ganz catheter

8. Continued Supportive Care
   a. Fluid boluses as indicated
   
   b. Following 60cc/kg of fluids, strongly consider positive inotropic agents:
      
      1) Dopamine
         a. 2-3 mcg/kg/min >>> dopaminergic effects (increased renal blood flow)
         b. 5-10 mcg/kg/min >>> beta effects (increased contractility, vasodilatation)
         c. 10-20 mcg/kg/min >>> alpha effects (increased BP from vasoconstriction)

   2) Dobutamine
a. Beta stimulation leading to increased cardiac output, vasodilatation
b. 2.5 - 15 mcg/kg/min
c. Indicated for cardiogenic shock

3) Norepinephrine
   a. alpha and beta 1 stimulation
   b. 0.1 - 1.0 mcg/kg/min
   c. consider in conjunction with low dose dopamine

4) Epinephrine
   a. beta effects at low dosages (0.1 - 0.2 mcg/kg/min)
   b. alpha effects (over 0.3 mcg/kg/min) increases BP

5) Milrinone
   a. decreased afterload and preload secondary to vasodilatation
   b. shorter half-life than amrinone and less risk of thrombocytopenia

9. Other
   a. Immunotherapy?
**Case #1:** A 12 month old baby is brought to the PEC with a fever of 102.5°F. He is unarousable and has a fine petechial rash across his body. The feet are cool with thready pulses.

1. What is the probable diagnosis and what type of shock would this be?

2. How would you treat this child?

3. If there is no initial response to therapy, what are your alternatives?

4. How do you monitor the child’s improvement / decline?

**Case #2**
A 4 month old is brought to the ER after 4 days of vomiting, diarrhea, and decreased intake.

1. Other history?

2. What signs of shock may be evident on physical examination?

3. What type of shock is this?

4. What is your treatment plan?

5. What options do you have for IV access?

Case #3
A 3 week old term infant was brought to the pediatrician after the mother noted difficulty breathing, poor feeding, and diaphoresis. The monitor reveals a HR of 250. He is cool and clammy, and poorly perfused.

1. What is the diagnosis and what type of shock is this an example of?

2. What other physical findings may lead to the diagnosis?

3. What would be the risk of misdiagnosis and mistreatment?

4. What would a CXR show?

5. What are other causes of this type of shock in pediatric patients?

6. Treatment?
A 6 year old boy is struck by a car while riding his bicycle. He arrives to the ER by EMS where he is obtunded, C-spine immobilized, and with initial vitals as follows:

HR 150    RR 36    BP 90/60

He has bilateral femur fractures, and no other apparent injuries?

1. What is the primary diagnosis?

2. What type of shock does he have? Is this different than case #2?

3. What is the treatment? Type of fluids?

4. What signs of improvement would you look for?