Shock in the Pediatric Patient

Initial Assessment & Interventions

Dusty Lynn RN BS CCRN CPEN NR EMT-P
RN Coordinator
University of Virginia Trauma Program
Objectives

- Compare and contrast the 4 main types of shock in the pediatric patient
- Given a case scenario, identify the type of shock based the ABC assessment, and discuss the initial treatment priorities
Response to “Pediatric unknown” Call
Kids are Special

- One size does NOT fit all!
  - Variable weight and height
  - Smaller body mass
    - Organs closer together - high risk for multi-organ injury
    - Kinetic energy has more profound impact
  - Bone are more flexible
    - Significant injuries easier to miss
  - Don’t understand cause & effect
    - Harm or risk
Children are just small adults

Know the main differences in anatomy and how they would affect responses to illness

Do not go by memory—carry a reference for:

Weight estimation
Vital signs
Equipment sizes
Medications
&
Review review review...
Definition of Shock

- Critical mismatch of the delicate balance between cellular needs (demand) and perfusion (delivery)
Pediatric Definition of Shock

Tachycardia + Poor Perfusion =

**SHOCK**

Note that Pediatric patients can be in severe shock and still have normal blood pressure!
DO2

• Its all about delivery of oxygen/ nutrients to the cell

• Oxygen delivery is the amount of oxygen transported from the pulmonary system to the microcirculation

• In healthy individuals:
  • Oxygen consumption = Oxygen delivery
SHOCK

- When the metabolic demand is greater than the metabolic delivery, shock occurs.
- If delivery is less than need, then shock occurs.
- The definition of shock does NOT depend on blood pressure.
Simply Put ........

Tachycardia + Poor Perfusion =

SHOCK

All etiologies of shock cause imbalance of metabolic demand vs. metabolic need
Cardiovascular VS

- **HR**
  - Know norms for pediatric patients
  - Know extremes
    - 180, 220
    - < 60

- **B/P**
  - Choose proper equipment
  - Recognize children can be in shock, with a WNL B/P
## Blood Pressure

<table>
<thead>
<tr>
<th>Duration</th>
<th>Lowest acceptable Systolic pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 – 28 days</td>
<td>60</td>
</tr>
<tr>
<td>1 month – 1 year</td>
<td>70</td>
</tr>
<tr>
<td>1 year+</td>
<td>70 + (2 x age in years)</td>
</tr>
</tbody>
</table>
Pediatric patients can be in severe shock and still have normal blood pressure!
Classification of Shock

• Severity
  • Compensated: Not hypotensive
    • Minimally acceptable SBP:
      • 1 year and older: $70 + 2(Age)$ up until 90 systolic BP

• Hypotensive

• Etiology
  • Hypovolemic
  • Distributive
  • Cardiogenic
  • Obstructive
Hemodynamic Compensation Factors
In Pediatric Shock

- Blood Pressure
  - Systemic Vascular resistance
- Cardiac Output
- Heart Rate
- Stroke Volume
- Pre-load
- Myocardial Contractility
- After load
General Goals of Shock Management: Improve DO2

1. Optimize O₂ content & delivery
2. Improve volume and distribution of cardiac output
3. Reduce O₂ demand
4. Correct metabolic derangements
   - Hypoglycemia
   - Hypocalcemia
   - Hyperkalemia
   - Metabolic acidosis
5. PREVENT CARDIAC ARREST
I. Hypovolemic Shock

- Intravascular Volume Loss
  - Hemorrhagic
    - Trauma
    - Surgery
    - GI bleed
  - Non Hemorrhagic
    - Intravascular
      - GI
    - Interstitial
      - Burn
      - Sepsis
      - Ascites
      - Nephrotic syndrome
Hypovolemic
Non Hemorrhagic or Hemorrhagic.

- S/S related to ▼ in preload = ▼ in DO2
  - Often tachypneic, tachycardic, compensatory increased contractility, poor perfusion/delayed cap refill, cool skin, decreased pulses, altered mental status
Hypovolemic

1. Optimize O2 content in the blood
   • High concentration of FIO2
   • Consider mechanical ventilation if needed to correct V/Q mismatch
   • Consider PRBC’s IF H/H ↓

2. Improve volume & distribution of CO
   • Give volume
     • 20cc/kg crystalloid
     • 10cc/kg PRBC’s on going hemorrhage, or poor response to 2-3 crystalloid boluses
   • Look for ongoing volume loss
Treatment Goals Cont

3. Reduce O2 demand
   • Treat fever
   • Ventilatory support if needed

4. Correct metabolic derangements
   • Hypoglycemia
   • Hypocalcaemia
   • Hyperkalemia
   • Metabolic acidosis= give volume
8-lb Newborn = 3.64-kg
Total circulating volume = 364-cc
100cc/KG
Soda can = 335 cc/ml

60-lb Child = 27-kg
TV = 2.2-L
2-L Soda bottle

125-lb Adult = 56kg
TV = 4.5 L
two 2-L Soda bottles
II: Distributive Shock

• Types of Distributive Shock
  • Septic
  • Anaphylactic
  • Neurogenic
Distributive Shock- Treatment Goals

1. Optimize O2 content in the blood
   High concentration of FIO2
   • Consider mechanical ventilation if needed to correct V/Q mismatch
   • Consider PRBC’s in H/H ↓

2. Improve volume & distribution of CO: restore hemodynamic instability
   • Give volume
   • Overcome dilated vascular space-
     • Vasopressors
     • Vasopressors- Goal- SVO2 > 70%
Treatment Goals for Distributive Shock Cont.

3. Reduce O2, metabolic demand
   - Treat fever

4. Correct metabolic derangements
   - Hypoglycemia
   - Hypocalcemia
   - Hyperkalemia
   - Metabolic acidosis
     - Volume
     - Vasopressors
     - Ventilation
     - Alkalinization

5. PREVENT CARDIAC ARREST
Distributive - Septic Shock
Definitions

SIRS = Systemic inflammatory process

Sepsis + SIRS in the presence of infection

Septic Shock = Sepsis & cardiovascular dysfunction
Systemic Inflammatory Response Syndrome “SIRS”

The presence of fever &/ or abnormal WBC and at least one of the following:

• Tachycardia

• Tachypnea

• Sepsis is SIRS + infection
Sepsis = SIRS + Infection

Mechanism

• Infectious organisms and their by-products/endotoxins trigger immune and inflammatory cascades (vasodilation)

• Vaso/venodilation caused by cytokine release damages vessel lining > increased cell permeability (capillary leak)

• DIC (which is why some septic pts need blood transfusions)

↓ in preload + ↑ vasodilatation + capillary leak = ↓ in DO2
**Treatment:**

**Distributive- Septic Shock**

1. **Optimize O2 content in the blood**
   - High concentration of FIO2
   - Consider mechanical ventilation if needed to correct V Q mismatch
   - Consider PRBC’s in H/H ↓

2. **Improve volume & distribution of CO: restore hemodynamic instability**
   - Give volume
   - Overcome dilated vascular space-
     - Vasopressors

   **Vasopressors- Goal- SVO2 > 70%**

   - Normotensive: Dopamine
   - Warm/vasodilated ↓ BP- Norepi
   - Cold/vasoconstricted hypotensive- epinephrine
Septic Shock- Treatment goals cont

3. Reduce O2 demand
   • Treat fever
   • Identify and control infection

4. Correct metabolic derangements
   • Hypoglycemia-
   • Hypocalcemia
   • Hyperkalemia
   • Metabolic acidosis

PREVENT CARDIAC ARREST
   • Continuous monitoring and frequent reassessments as sepsis can be a combination of distributive, hypovolemic, cardiogenic and obstructive (DIC) shock, all of which can lead to cardiac arrest
   • Etomidate for intubation??
Distributive Shock

Anaphylactic Shock
Distributive Anaphylaxis

• Mechanism
  • Acute severe systemic reaction to antigen

• Clinical Assessment
  – Agitation, anxiety
  – Angioedema
  – Respiratory distress
    • Stridor/ wheezing/ prolonged expiration
  – Tachycardia, hypotension
  – Uticaria
  – N/ V
  – Abdominal pain
1. Optimize O2 content & delivery
   - *Fio2*
   - *Bronchodilators*

   • Improve volume and distribution of cardiac output
     - *IM Epinephrine!*
     - Vasopressors
     - Volume

2. Reduce O2 demand & 4. Correct Metabolic derangements
   (reverse or block uncontrolled release of allergic response Mediators)

   **EPINEPHRINE**
   - Antihistamines
     - H1 blocker/ diphenhydramine
     - H2 blocker/ ranitidine, famotidine
   - Corticoid steroids
Distributive

Neurogenic

• Sudden loss of sympathetic tone of smooth muscle; spinal shock, head injury

• S/S: **Bradycardia** + **hypotension**, hypothermia

• Wide pulse pressure, low diastolic B/P, diaphragmatic breathing

• Initial tx:
  • ABC’s
  • Position pt flat or head down
  • Volume
  • Warm, or cool as needed
  • Vasopressors if needed
Neurogenic Shock

Hypotension - Decrease in Blood Pressure
Bradycardia - Slow heart rate
Warm, dry extremities
Peripheral vasodilation and venous pooling
Poikilothermia (Cold Body)
Decreased cardiac output (with cervical or high thoracic injury)
III: Cardiogenic Shock

Pump Failure
Cardiogenic Shock

\[ \downarrow SV + \downarrow CO = \downarrow DO_2 \]

- CHD, Post ischemic event, acquired HD, sepsis, cardiac tamponade, drugs, rhythm disturbances (SVT)

- **Clinical Assessment**
  - AMS
  - \( \uparrow \) RR, \( \uparrow \) WOB, crackles/rales.
  - \( \uparrow \) HR, ? Gallop/S3, narrow pulse pressure
  - Hepatomegaly, cardiomegaly
Treatment Goals: Cardiogenic Shock

1. Optimize O2 content in the blood
   - High concentration of FIO2
   - Consider mechanical ventilation if needed to correct V/Q mismatch & decrease cardiac work load
   - Consider PRBC’s in ↓ H/H

2. Improve volume & distribution of CO/ increase ventricular output and cardiac function
   - Consider **cautious** slow infusion of 5-10cc/KG observing for response
   - Expert consultation for proper selection of vasodilator/ phosphodiesterase enzyme inhibitors to improve CO with minimal increase on myocardial O2 demand
   - Consider ECLS if other methods ineffective
Treatment Goals

Cardiogenic Shock

1. Optimize O2 content in the blood
   - High concentration of FIO2
   - Consider mechanical ventilation if needed to correct V Q mismatch & decrease cardiac work load
   - Consider PRBC's in ↓ H/H

2. Improve volume & distribution of CO/ increase ventricular output and cardiac function
   - Consider cautious slow infusion of 5-10cc/KG observing for response
   - Expert consultation for proper selection of vasodilator/ phosphodiesterase enzyme inhibitors to improve CO with minimal increase on myocardial O2 demand
   - Consider ECLS if other methods ineffective
IV: Obstructive Shock

Physical Obstruction of Circulation
Obstructive Shock

- Ductal Dependent Lesions
- Tension Pneumothorax
- Cardiac Tamponade
- Pulmonary Embolism
• CHD/ Ductal Dependent Lesions:
  • ABC’s, Expert Consult, PGE, (prepare for apnea)

• Tension Pneumothorax
  • Needle Decompress
  • Chest Tube

• Cardiac Tamponade
  • Pericardiocentesis
  • Fluid boluses simultaneously

• Pulmonary Embolism
  • Fluid bolus prn, ? Thrombolytics, consult
As if it were that easy ......

• Septic can also cause....
  - Cardiogenic
  - Hypovolemic
  - Obstructive (DIC)
  - Can be viral, fungal, parasitic
  - Antibiotic resistant

• Miscellaneous
  - MSOF
As an aside....

• AHA recommendations for SATS after ROSC
• Monitoring of SVO2
• Use of ED US for determining CO
General Volume Administration Guidelines

- **Hypovolemic/ Distributive** (non DKA)
  20cc/kg over 5-10 minutes

- **Cardiogenic Shock**
  5-10 cc/kg over 10-20 minutes

- **Poisonings/ Cardio-Toxins**
  5-10cc/kg over 10-20 minutes

- **DKA** with adequate BP
  10-20cc/kg over 1 hour
Remember - It's all about supply and demand
In Summary

**Recognize** the patient in shock

– Consider the etiology based on assessment and history
– Begin treatment based on that etiology and the goal of restoration of DO2
– Reassess frequently your interventions
  – Are you on the right track?
  – Are things changing?
You want to avoid this.....
Practice

Called to a home for infant with “difficulty breathing”
AOS to find 3mth infant in crib. No one speaks English. As you approach the infant, what 3 things are you assessing?

1. Airway- patent
2. Breathing- tachypnea
3. Circulation: Pale

What next?
Hands on A- B- C

Assessment

A- ? Patent? Need Adjunct?

B- 
  • RR- 50
  • WOB- slight nasal flaring
  • BBS- clear

C- Hands on!
  • CRT- > 4 secs
  • Pulses> Central- weak, distal almost not palpable
  • Skin temp> core- WNL, peripheral > cool from knee down
  • HR> 180
  • ? B/P
  • General- foul smelling diarrhea noted.
  • ? Physiologic Status?
SHOCK!

- **Severity:**
  - Hypotensive

- **Etiology:**
  - Hypovolemic

- **Treatment**
  - ABC’s and VOLUME!

- **Reassessment after initial volume:**
  - Lethargic
  - Spontaneous RR: 40, BBS clear & =
    - HR 170, CRT > 4 sec’s
  - Priorities?
Evidence for the use of restrictive volume of intravenous fluid resuscitation, compared with unrestricted volume, by presenting illness and outcome.

<table>
<thead>
<tr>
<th>Illness</th>
<th>Studies</th>
<th>Survival to Hospital Discharge</th>
<th>Need for Transfusion or Diuretics</th>
<th>Need for Rescue Fluid</th>
<th>Mechanical Ventilation or Vasopressor</th>
<th>Time to Resolution of Shock</th>
<th>Total IV Fluids</th>
</tr>
</thead>
<tbody>
<tr>
<td>Severe sepsis/septic shock</td>
<td>Santhanam 2008; Carcillo 1991</td>
<td>No Benefit</td>
<td>No Benefit</td>
<td>No Benefit</td>
<td>No Benefit</td>
<td>No Benefit</td>
<td>No Studies Available</td>
</tr>
<tr>
<td>Severe malaria</td>
<td>Maitland 2005; Maitland 2005</td>
<td>No Benefit</td>
<td>No Benefit</td>
<td>Harm</td>
<td>No Benefit</td>
<td>No Benefit</td>
<td>No Benefit</td>
</tr>
<tr>
<td>Severe febrile illness with some but not all signs of shock</td>
<td>Maitland 2011; Maitland 2013</td>
<td>Benefit</td>
<td>No Benefit</td>
<td>No Studies Available</td>
<td>No Studies Available</td>
<td>No Benefit</td>
<td>Harm</td>
</tr>
</tbody>
</table>

Evidence for the use of noncrystalloid intravenous fluid resuscitation, compared with crystalloid, by presenting illness and outcome.

<table>
<thead>
<tr>
<th>Illness</th>
<th>Studies</th>
<th>Survival to Hospital Discharge</th>
<th>Need for Other Treatment</th>
<th>Need for Rescue Fluid</th>
<th>Mechanical Ventilation or Vaspressor</th>
<th>Time to Resolution of Shock</th>
<th>Total IV Fluids</th>
<th>Hospital Duration of Stay</th>
</tr>
</thead>
<tbody>
<tr>
<td>Severe sepsis/septic shock</td>
<td>Upadhyay 2005</td>
<td>No Benefit</td>
<td>No Benefit</td>
<td>No Studies Available</td>
<td>No Benefit</td>
<td>No Benefit</td>
<td>No Studies Available</td>
<td>No Studies Available</td>
</tr>
<tr>
<td>Dengue shock</td>
<td>Cifra 2003; Dung 1999; Ngo 2001; Wills 2005</td>
<td>No Benefit</td>
<td>No Benefit</td>
<td>No Studies Available</td>
<td>No Benefits</td>
<td>Benefit</td>
<td>No Benefit</td>
<td>No Benefit</td>
</tr>
<tr>
<td>Severe febrile illness with some but not all signs of shock</td>
<td>Maitland 2011</td>
<td>No Benefit</td>
<td>No Benefit</td>
<td>No Studies Available</td>
<td>No Benefit</td>
<td>No Benefit</td>
<td>No Benefit</td>
<td>No Studies Available</td>
</tr>
</tbody>
</table>

References

- http://www.edwards.com/eu/Products/mininvasive/Pages/venousoxime-tryoverview.aspx
- http://circ.ahajournals.org/content/112/24_suppl/IV-143.full
Thank you!

DLynnRN@virginia.edu