Shock in Pediatric Patients

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Objectives

- Describe the epidemiology of shock in pediatric patients
- Define shock and describe the types of shock
- Discuss treatment of shock in the prehospital setting
- Case presentations and discussion
Epidemiology

- Shock is seen in many settings
  - Traumatically injured patient
  - Infection
  - Dehydration
  - Heart failure
Take Home Point

Shock is the most *reversible* cause of death in children
# Leading Causes of Mortality in Children

<table>
<thead>
<tr>
<th>Infants</th>
<th># of deaths</th>
<th>Age 1-14yrs</th>
<th># of deaths</th>
</tr>
</thead>
<tbody>
<tr>
<td>Congenital anomalies</td>
<td>6,554</td>
<td>Accidents</td>
<td>5,824</td>
</tr>
<tr>
<td>Prematurity-related</td>
<td>3,933</td>
<td>Severe sepsis</td>
<td>1,570</td>
</tr>
<tr>
<td>SIDS</td>
<td>3,397</td>
<td>Cancer</td>
<td>1,514</td>
</tr>
<tr>
<td><strong>Severe sepsis</strong></td>
<td>2,135</td>
<td>Congenital anomalies</td>
<td>1,144</td>
</tr>
<tr>
<td>Resp distress syndrome</td>
<td>1,454</td>
<td>Homicide</td>
<td>1,024</td>
</tr>
<tr>
<td>Maternal pregnancy complications</td>
<td>1,309</td>
<td>Diseases of the heart</td>
<td>545</td>
</tr>
<tr>
<td>Accidents</td>
<td>787</td>
<td>HIV</td>
<td>399</td>
</tr>
</tbody>
</table>

Watson et al. Am J Respir Crit Care Med 2003;167:695-701
Sepsis causes more deaths in children than CANCER!!
Epidemiology

Shock leads to thousands of children being admitted to intensive care settings per year.

Shock can lead to significant morbidity and death in many cases.
Epidemiology

Shock costs U.S. hospitals more than $1.9 billion annually
Epidemiology

- Death rates from shock in children are decreasing in the United States
  - Early recognition
  - Aggressive prehospital management
How we used to transport patients!!
How we transport now !!
Transport of Septic Shock

- Nine-year study of pediatric patients in septic shock
- 91 children
- 29% died, 54% within 48 hours
- 73% still in shock when transport team arrived at referring facility
- Only 25% of patients had received appropriate therapy as recommended by PALS

Fluid, Fluid, Fluid !!!

Appropriate resuscitation at the initial presentation improved survival!!
Role of EMS in Pediatric Shock

EMS personnel are essential in the management of children with shock!

- First on the scene
- Decisions and management affect immediate and long-term outcomes
Decision-Making: Discomfort Zone

The obvious is easy…
- Cardiac arrest → CPR

Approach to trauma in children is similar to adults and protocolized nationally

Until recently, no widely accepted guidelines for treatment of shock in children
Back to Basics: Definition of Shock

An acute syndrome that occurs in the state of cardiovascular dysfunction which leads to inadequate oxygen delivery to meet the metabolic demands of the body’s organs. In other words…
Clinical Presentation

History
- Traumatic injury
- Bleeding
- Vomiting and diarrhea

- Infection/ Fever
- Heart disease
- Inadequate immune system
Stages of Shock

1. Compensated
2. Uncompensated
3. Irreversible
Vital Signs: Early Shock

- Tachycardia
- Mild tachypnea
- Orthostatic hypotension

Early Shock → Increased HR → Maintain Perfusion
WARNING!!!

- Blood pressure may be normal in early, compensated shock
- Low blood pressure does not occur until LATE shock
- Tachycardia is a non-specific sign of distress
Exam Findings: Early Shock

- Dry mucous membranes
- Skin warm or cool
- Palpable central pulses
- Slightly delayed capillary refill (3 seconds)
Take Home Point

Blood Pressure has little to do with early shock recognition!
KEYS to Early Shock Recognition

**ALTERED MENTAL STATUS**
- Irritable, inconsolable
- Does not interact with parent
- Stares into space
- Poor response to pain

**ABNORMAL PERFUSION**
- Decreased or bounding peripheral pulses
- Poor capillary refill
- Decreased urine output
Take-Home Point

It is NOT OK to sit on a patient who has compensated shock!
Vital Signs: Late Shock

- Tachycardia
- Tachypnea
- **Hypotension**

LATE SHOCK = UNCOMPENSATED SHOCK

UNABLE TO MAINTAIN PERFUSION
What is Normal Heart Rate?

### Table 7. Heart rate (HR) changes (beats/min) by percent increase

<table>
<thead>
<tr>
<th>Age</th>
<th>Basal HR</th>
<th>20% Increase</th>
<th>50% Increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Newborn</td>
<td>145</td>
<td>174</td>
<td>218</td>
</tr>
<tr>
<td>6 months</td>
<td>120</td>
<td>144</td>
<td>180</td>
</tr>
<tr>
<td>1 year</td>
<td>115</td>
<td>138</td>
<td>173</td>
</tr>
<tr>
<td>5 years</td>
<td>95</td>
<td>114</td>
<td>143</td>
</tr>
<tr>
<td>10 years</td>
<td>75</td>
<td>90</td>
<td>113</td>
</tr>
<tr>
<td>Adult</td>
<td>70</td>
<td>84</td>
<td>105</td>
</tr>
</tbody>
</table>
What is a Normal Blood Pressure?

An easy rule of thumb:

Minimal acceptable SBP = $70 + 2 \times \text{age}$
Exam Findings: Late Shock

- Agitated, confused, decreased level of consciousness
- Poor tone
- Tacky mucous membranes
- Cool, mottled extremities
- Decreased pulses
- Delayed capillary refill, >4 seconds
Late Shock is a Pre-arrest State!!

A pediatric patient in LATE SHOCK may decompensate quickly!!
Irreversible Shock

- Complete failure of compensatory mechanisms
- Death even in the presence of resuscitation
Responses to Shock

- Progressive vasoconstriction
- Increased blood flow to major organs
- Increased cardiac output
- Increased respiratory rate and volume
- Decreased urine output
Types of Shock

- Hypovolemic shock
- Distributive shock
- Cardiogenic shock
- Obstructive shock
Hypovolemic Shock

- Most common cause of shock in children
- “Not enough fluid to fill the tank”
  - Vomiting and diarrhea
  - Blood losses: trauma
  - Water losses: heat stroke, burns
**Figure 15-3** Pathophysiological sequence of events in hypovolemic shock.

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Distributive Shock

- Due to vasodilation and pooling of blood
- “Tank failure”
  - Anaphylaxis
  - Sepsis
  - Drug ingestion
  - Spinal cord injury (Neurogenic)
Cardiogenic Shock

“Pump failure”
- Congenital heart disease
- Abnormal heart rhythm
- Heart infection: myocarditis
- Drug ingestion
Clinical Features of Cardiogenic Shock

- Low blood pressure
- Cold, white or cyanotic periphery
- Sweatiness
- Tachycardia
- Low volume thready pulse
  - There may be additional signs
    - third or fourth heart sounds or a "gallop"
Cardiogenic Shock

- Not very common in children
- Rarely diagnosed in the prehospital setting, unless they have a history of congenital heart disease
- Fluid administration should be more cautious
- 10 cc/kg boluses then reassess
Obstructive Shock

- Blood flow to/from the heart is obstructed
  - Cardiac Tamponade
  - Tension Pneumothorax

- May occur following penetrating trauma to the chest.

- Fortunately, rare in children
How do I tell the difference?

- Take a good history
- Clues to congenital heart disease
  - Baseline status (are sats usually in 80’s??)
  - Cyanosis
  - Cardiac meds
  - Surgical history
  - Sweating during feeds
Initial Assessment

- Initial assessment may detect shock, but the cause may be uncertain.
- In most cases it does not matter, as the early treatment is the same.
- When in doubt, treat as hypovolemic shock.
Shock Management: Where to Start

#1

Recognize that a patient is in shock.
Know your ABC’s: Airway

- Oxygen delivery to tissues is a primary goal in children with shock
  - 100% O2 for ALL shock
  - Chin-lift, jaw thrust
  - Bag-valve-mask if needed
Breathing: Indications for Advanced Airway Management

- Unable to maintain airway
  - Includes inability to handle secretions
- Able to maintain airway but BVM ventilation is needed
- Sats <95% or cyanotic on non-rebreather mask
- Irregular respirations or periods of apnea
- No cough or gag reflexes
- Severe retractions or use of accessory muscles
Circulation

- Fluid administration is key in shock management!
- Most common error is TOO LITTLE
Take Home Point

The majority of shock is fluid responsive!
Survival of Septic Patients

Every hour without appropriate resuscitation and restoration of capillary refill < 2 s and normal blood pressure increases mortality risk by 40%!
Vascular Access

- Large-bore IV catheter in peripheral vein is ideal
  - Peripheral extremities may be cool and poorly perfused
- Consider an intraosseous needle early
Intraosseous Access

- Access marrow space
- Medial proximal tibia, 1-2 inches below the tibial tuberosity
- Children >5 years, 1-2 inches above the medial malleolus
Intraosseous Access

- EZ-IO PD 15 mm Needle Set
- EZ-IO AD 25 mm Needle Set
- EZ-IO LD 45 mm Needle Set
Fluid Administration

- **What fluids?**
  - 0.9% Normal saline or Ringer’s Lactate

- **How much?**
  - 20mL/kg to start

- **How fast?**
  - As rapidly as possible
How Much is Too Much?

- Significantly greater survival when > 40 cc/kg given in first hour of presentation

- Pulmonary edema not associated with fluid volume or ↓ survival
Specific Situations

In addition to aggressive fluid resuscitation, in some types of shock, specific therapies may be necessary:

Some examples of these include:

- Anaphylaxis: Epinephrine, Albuterol
- Drug ingestions: Epi, Calcium
- Dysrhythmias: Adenosine, Cardioversion
- Cardiogenic: Earlier use of vasopressors
Glucose Check

- Hypoglycemia = glucose < 60

- Treatment
  - D25 2-4 ml/kg
  - D10 5-10 ml/kg
Parameters of Improvement

- Capillary refill brisk
  - Goal <2s
- Warm extremities
- Improving mental status
  - More alert and interactive
Parameters of Improvement

- Normal pulses with no differential between peripheral and central pulses
- Increasing blood pressure
- Decreasing heart rate
Take Home Point

Reassess, reassess, reassess!!
Further Management in Hospital

- Antibiotics
- Vasoactive medicines
  - Epinephrine
  - Dopamine
- Inotropes
- Hydrocortisone
- Hemorrhage control
Case #1

- 4 mo old male, previously well
- Parents state he has had fever, vomiting and diarrhea for the past two days
- Today, extremely fussy and refusing feeds
- One wet diaper over the past 12 hours
Case #1: Physical Exam

- Toxic-appearing infant, irritable, does not console
- T-103.1 HR-206 RR-66 BP-129/109
- Sat probe is not picking up well
- Tacky mucous membranes
- Sunken fontanel
- Palpable femoral pulse, thready peripheral pulses
- Extremities cool and mottled
Case #1

- What history is concerning?
- What exam findings are concerning?
- What stage of shock is this infant in?
- What type of shock?
- How do you start management?
Case #1

- You place the baby on oxygen
- You are able to insert a peripheral IV
  - What fluids and how much?
  - What if you can’t get an IV?
Reassessment

- You estimate the baby is 5 kg and give NS 100ml rapidly
- Infant still fussy and mottled
- You give a second NS bolus of 100mL
- On reassessment, somewhat fussy, alert
  HR-180  RR-30  BP-130/100  O2sat 100% on 100% O2
  Femoral pulses 2+, cap refill 2s
Case #2

- 5yo male, history of sickle cell disease
- Flu-like symptoms for 5 days
- Now with fever to 102, rapid respiratory rate
- Parents called 911 because pt was difficult to arouse
Case #2: Physical Exam

- Lethargic and difficult to arouse, moderate respiratory distress
- T-102.5  HR-162  RR-60  BP-107/52
  O2sat-85% on room air
- Tachypneic, retracting
- Tachycardic, soft heart murmur
- Cap refill 3-4s, thready peripheral pulses
Case #2

- What history is concerning?
- What exam findings are concerning?
- What stage of shock is this child in?
- What type of shock?
- How do you start management?
Case #2

- You place the child on oxygen
- You place a peripheral IV and push NS 20ml/kg rapidly
- Cap refill is still >3s and pt still unarousable to deep sternal rub

What are your next steps?
Putting It All Together

- Shock is a major cause of morbidity and mortality in pediatric patients
- Early and aggressive management leads to improved outcomes
  - Recognition of shock is key!
- EMS personnel are essential to early management of patients in shock
Take Home Points

- Shock is the most reversible cause of death in children
- BP has little to do with early shock recognition
- It is NOT OK to sit on a patient who has compensated shock
Take Home Points

- Late shock is a pre-arrest state
- The majority of shock is fluid-responsive
- Reassess, reassess, reassess
Questions???