Running on Empty

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Importance

- All healthcare professionals who care for children will be faced with a child in shock
- Without appropriate intervention, death will ultimately occur
- Early recognition is imperative

Outline

- What is shock?
- Examine differences between kids and adults
- Management
- Case review

What is Shock?
Historical Definitions

- In 1872, “a rude unhinging of the machinery of life”
- “A momentary pause in the act of death”
- Most recently, “the collapse and progressive failure of the cardiovascular system.”

Complex Series of Events

Shock

- Acute process
- Complex series of events
- Reduced perfusion of vital organs ➔ inadequate oxygen and nutrients necessary for normal tissue and cellular function
- Reduction of mitochondrial oxygen ➔ anaerobic metabolism and production of lactic acid

Untreated Shock
Types of Shock

- Hypovolemic – the focus of this lecture
- Distributive – septic and neurogenic
- Cardiogenic

Common Causes

- Trauma ↔ hemorrhage
- Intracranial or GI bleed
- Vomiting and diarrhea
- Burns
- Pregnancy-related
- Peritonitis
- Sunstroke

Hypovolemic Shock

- Decreased circulating blood volume
- Most common cause of shock in children
- Due to blood, water or plasma losses

Sources of Blood Loss from Trauma

- Scene
- Chest
- Abdomen
- Retroperitoneal
- Muscle compartments
Hemorrhagic Shock

- Divided into 4 classes
- Based on signs, symptoms and estimated degree of blood loss

Pediatric Shock

- Difficult to recognize for clinicians who do not primarily care for children
- In trauma patients, assessment of circulation is often overlooked

Just One Drop

- Journal of Trauma, 2010
- Temple University, Department of Surgery
- Prospective study in adult trauma patients
- A single, isolated hypotensive event during a trauma resuscitation was indicative of severe injuries and the need for operative intervention.
- Hypotensive events should NOT be ignored
Pediatric Trauma Care

- No different than adult trauma care
- Must consider unique aspects of a child
- Many differences compared to adults
  - Anatomic
  - Physiologic
  - Psychologic

Smaller in size, but not just little adults

How are kids different?
Anatomic Differences

- Shorter neck and trachea
- Larger face to head ratio
- Large tongue and tonsils
- Anterior/superior larynx
- Narrowest point at subglottic region
- Resembles adult by age 8

Head

- Thinner calvarium
- Open sutures
- Large scalp surface area
- Weaker neck muscles

Pediatric Airway

Cervical Spine

- Fulcrum of spine is C2-C3
- Children < 14 yo have higher injuries
- Children > 14 yo have lower injuries
- Resembles adult by age 8
**Chest**
- More compliant chest wall
- More anterior position of the heart
- More mobile mediastinal structures

**Abdomen**
- Relatively larger abdomen
- Relatively larger organs
- Underdeveloped wall musculature

**Skeleton**
- More pliable bones
- Incomplete calcification
- Multiple ossification centers

**Physiologic Differences**
**Perfusion**

- Relatively larger blood volume
- Stroke volume is essentially fixed
- Cardiac output maintained by HR
- Increased sensitivity to catecholamines
- Increased arterial vascular tone

**Tachycardia**

- Most sensitive indicator in pediatric shock
- Not specific
- Complete PE necessary to rule out shock as cause of tachycardia

**Review of Cardiac Output**

- Determined by SV and HR
- SV depends on contractility, SVR, and ventricular filling volume
- Children increase HR rather than SV in times of metabolic need (shock)

\[
CO_{(l/min)} = SV_{(cubit)} \times HR_{(baselin)}
\]

**Kids are Different**

- Abundant physiologic reserve
- Demonstrate few signs of hypovolemia
- Hypotension is a late sign of shock
Take home messages

- Children can lose > 40% of their blood volume before they have a blood pressure change
- *Children can be in shock and have a normal BP*

Pediatric Blood Volume

- 80 ml/kg
- Estimating Blood Volume: Weight (kg) X 80 ml/kg
12 kg \times 80 \text{ ml/kg} = 1 \text{ L blood volume}

25 \text{ kg} \times 80 \text{ ml/kg} = 2000 \text{ ml}

12 kg \times 80 \text{ ml/kg} = 1 \text{ L blood volume}

25 \text{ kg} \times 80 \text{ ml/kg} = 2000 \text{ ml}
Estimating blood loss

- Calculate the blood volume (15 kg child)
- $15 \text{ kg} \times 80 \text{ ml/kg} = 1200 \text{ ml}$
- $30\%$ blood loss $\times 1200 \text{ ml} = 360 \text{ ml}$ of blood

$15 \text{ kg} \times 80 \text{ ml/kg} = 1200 \text{ ml} \times 30\% = 360 \text{ ml}$
Thermoregulation

- High BSA-to-mass ratio
- Increases the risk of hypothermia and dehydration
- Hypothermia increases morbidity and mortality

Psychological

- Fairly predictable based on age
- Family presence extremely important
- Caretakers can aid with assessing mental status

Psychological Differences

Management of Shock
Goals

- Restore substrate delivery, mainly oxygen to the tissues
- Preserve brain and kidney function
- Control bleeding in trauma patients

Shock Management

- Requires functioning pump
- Adequate blood volume
- Intact vascular system
- Normothermia
- Recognition

Pediatric Assessment

*80% of your pediatric evaluation is based on observation alone

Circulation

- Requires rapid, accurate assessment
- Clinical observation of 3 components:
  - Level of consciousness
  - Skin color
  - Pulses (central vs. peripheral)
- Fluid resuscitation
Responses to Resuscitation

<table>
<thead>
<tr>
<th>Table 2—Responses to Initial Fluid Resuscitation¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vital signs</td>
</tr>
<tr>
<td>-------------</td>
</tr>
<tr>
<td>Estimated blood loss</td>
</tr>
<tr>
<td>Need for more crystalloid</td>
</tr>
<tr>
<td>Need for blood</td>
</tr>
<tr>
<td>Blood preparation</td>
</tr>
<tr>
<td>Need for operative intervention</td>
</tr>
</tbody>
</table>

²200 ml Ringer’s lactate solution in adults. 20 ml/kg Ringer’s lactate in children.

Traditional Approach

- Adults: 2-3 liters of crystalloid
- Pediatrics: 40-60 ml/kg of crystalloid

Advantages of Crystalloids

- Increase circulation to the brain and kidneys
- Readily available in the pre-hospital setting
- Circulation of blood we do have in the vascular system
**Drawbacks**

- May increase hemorrhage and/or disrupt clots by increasing BP
- Do not contain the components of whole blood
- May dilute clotting factors
- No oxygen-carrying capacity

**Case 1**

- 10 year old boy riding "BMX" bicycle
- Falls while attempting aerial maneuver
- Arrives in at outside hospital complaining of vague abdominal pain
- CT scan negative
- Sent home

**Case review**

For each case:
- GOOD = rapid response
- BAD = transient response
- UGLY = no response

**Case 1 continued**

- Arrives at your hospital 2 days later
- Awake, alert, oriented
- Weight = 40 kg
- 24 hour history of vomiting
- Diffuse abdominal pain, tender
- Heart rate 120, respiratory rate 16, blood pressure 125/80, capillary refill 5 seconds
- What would you do?
Case 1 continued

- What is this patient's blood volume?
  - Roughly 3.2 liters
- What is this patient's hemodynamic status (good, bad, or ugly)
- Does this patient need a fluid bolus?
- What do you suspect is the problem?

Case 1 continued

- What is this patient's blood volume?
  - Roughly 3.2 liters
- What is this patient's hemodynamic status (good, bad, or ugly)
  - Bad (tachycardic, poor cap refill)
- Does this patient need a fluid bolus?
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### Case 1 continued
- What is this patient’s blood volume?
  - Roughly 3.2 liters
- What is this patient’s hemodynamic status (good, bad, or ugly)
  - Bad (tachycardic, poor cap refill)
- Does this patient need a fluid bolus?
  - Yes (800 ml warm Normal Saline)
- What do you suspect is the problem?

### Case 2
- 3 year old playing in yard at dusk
- Brother cutting lawn on riding mower
- Runs over child causing several leg wounds
- Local EMS unit calls for helicopter
- Wounds are wrapped

- 3 year old playing in yard at dusk
- Brother cutting lawn on riding mower
- Runs over child causing several leg wounds
- Local EMS unit calls for helicopter
- Wounds are wrapped, IV started, 150 ml bolus given, morphine 0.1 mg/kg IV
- Weight is 15 kg
**Case 2**

- On arrival, pulse is 110, BP is 90/50, he is crying softly and awake
- Because of contamination in the wounds and associated fractures, the orthopedic team wants to take the patient to the OR ASAP.

**Case 2**

What is his blood volume?
- 1200 ml

What is the correct fluid bolus?

What should you worry about when team ortho takes him to the OR?

**Case 2**

What is his blood volume?
- 1200 ml

What is the correct fluid bolus?
- 300 ml of WARM saline

What should you worry about when team ortho takes him to the OR?

Is this patient good, bad, or ugly?
<table>
<thead>
<tr>
<th>Case 2</th>
<th>Case 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>He's bad, but could become ugly due to:</td>
<td>• 15 year old girl brought to emergency</td>
</tr>
<tr>
<td>• HYPOTHERMIA</td>
<td>department by friend</td>
</tr>
<tr>
<td>• Warm IV fluids</td>
<td>• No history of trauma</td>
</tr>
<tr>
<td>• Warm O.R. (even if they complain)</td>
<td>• Distended and tender abdomen</td>
</tr>
<tr>
<td>• Forced warm air blankets</td>
<td>• Previous history of pregnancy</td>
</tr>
<tr>
<td></td>
<td>(terminated) at age 14</td>
</tr>
<tr>
<td>• BLOOD LOSS</td>
<td>• Approximate weight: 50 kg</td>
</tr>
<tr>
<td>• Difficult to calculate in ortho</td>
<td></td>
</tr>
<tr>
<td>environment</td>
<td></td>
</tr>
<tr>
<td>• Consider early transfusion</td>
<td></td>
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<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Patient extremely agitated “please help me – I'm going to die!”</td>
</tr>
<tr>
<td></td>
<td>• Heart rate 155, first blood pressure 80/45, respiratory rate 24</td>
</tr>
<tr>
<td></td>
<td>• BP 100/60, HR = 155 after 1 liter of normal saline and 2nd liter initiated</td>
</tr>
<tr>
<td></td>
<td>• Bedside ultrasound (by radiologist) shows free fluid in abdomen, enlarged uterus</td>
</tr>
</tbody>
</table>
Case 3

- Heart Rate > 150 and BP 85/45 after 2nd 1000 ml of IV fluids
- 2 units of PRBC given by rapid infuser through 18 gauge peripheral IV
- Patient remains tachycardic with BP 90/60
- Abdomen appears more distended

Case 3

- Is this patient
  - Good?
  - Bad?
  - Or Ugly?

Case 3

- Patient taken rapidly to operating room
- Well over 1000 ml of blood in abdomen
- 2 more units of PRBC given in OR
Diagnosis: ruptured ectopic pregnancy

Treatment:
- Recognition and management of shock
- Restoration of blood volume
- Operative control of bleeding

Case 3

Moral:
The skills that you develop for treating trauma patients (such as recognition of shock) can help you treat other patients

Case 3

• Diagnosis: ruptured ectopic pregnancy
• Treatment:
  • Recognition and management of shock
  • Restoration of blood volume
  • Operative control of bleeding

Conclusion

Recognition of shock is based on vital signs and physical findings

“When all else fails, examine the patient”