Pediatric Sepsis “A Tankless Job”

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Disclosure

• I have no disclosures
Pediatric Sepsis

• Mom calls 911 because her 13 month has fever, coughing and “breathing funny”. Once you arrive the patient is awake, alert, crying but comforted by mom. The patient has a fever of 103.2 F but is in his pajamas and bundled up. No medications given. The patient has a wet diaper. As EMS, what do you do:
  – A. Transport the patient to the hospital
  – B. Start an IV and give 20 ml/kg bolus
  – C. Administer Rocephin IV/IM and transport
  – D. Encourage the mother use of antipyretics and no transport needed at this time
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Pediatric Sepsis

• 13 month presents to the ED after 2 days of fever. The mother had been giving tylenol recommended by EMS last night. Vitals are 104.2 F, HR 165, RR 40, Pulse Ox 95% on room air. He is grunting and lethargic. What is the next step:
  • A: Encourage oral hydration
  • B: Transport patient to ER
  • C: IV and give a bolus (20mg/kg)
  • D: Encourage the patient to f/u with PCP tomorrow
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Definition

- Infection
  - Inflammatory response of tissue to a microbe
- Bacteremia
  - Bacteria in the blood
- SIRS
  - At least 2 criteria
    - Fever/Hypothermia
    - Tachycardia/bradycardia for age
    - Tachypnea/respiratory failure
    - Leukopenia/bandemia
# SIRS Criteria

**Pediatric systemic inflammatory response syndrome criteria**

<table>
<thead>
<tr>
<th>Age group</th>
<th>Heart rate (beats/minute)</th>
<th>Respiratory rate (breaths/minute)</th>
<th>Leukocyte count (leukocytes x 10^3/mm^3)</th>
<th>Systolic blood pressure (mmHg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Newborn (0 days to 1 week)</td>
<td>&gt;180 Tachycardia, &lt;100 Bradycardia</td>
<td>&gt;50</td>
<td>&gt;34</td>
<td>&lt;59</td>
</tr>
<tr>
<td>Neonate (1 week to 1 month)</td>
<td>&gt;180 Tachycardia, &lt;100 Bradycardia</td>
<td>&gt;40</td>
<td>&gt;19.5 or &lt;5</td>
<td>&lt;79</td>
</tr>
<tr>
<td>Infant (1 month to 1 year)</td>
<td>&gt;180 Tachycardia, &lt;90 Bradycardia</td>
<td>&gt;34</td>
<td>&gt;17.5 or &lt;5</td>
<td>&lt;75</td>
</tr>
<tr>
<td>Toddler and preschool (&gt;1 to 5 years)</td>
<td>&gt;140 Tachycardia, NA Bradycardia</td>
<td>&gt;22</td>
<td>&gt;15.5 or &lt;6</td>
<td>&lt;74</td>
</tr>
<tr>
<td>School age (&gt;5 to 12 years)</td>
<td>&gt;130 Tachycardia, NA Bradycardia</td>
<td>&gt;18</td>
<td>&gt;13.5 or &lt;4.5</td>
<td>&lt;83</td>
</tr>
<tr>
<td>Adolescent (&gt;12 to &lt;18 years)</td>
<td>&gt;110 Tachycardia, NA Bradycardia</td>
<td>&gt;14</td>
<td>&gt;11 or &lt;4.5</td>
<td>&lt;90</td>
</tr>
</tbody>
</table>

NA: not applicable.

Pediatric Sepsis

• Sepsis
  – SIRS in the presence of suspected or proven infection

• Severe Sepsis
  – Sepsis with one at least 1
    • Cardiovascular dysfunction
    • Acute respiratory distress syndrome
    • >2 other organ dysfunction

• Septic Shock
  – Sepsis and cardiovascular dysfunction with hypotension and indicators of hypoperfusion
    • Metabolic acidosis
    • Lactic acidosis
    • Oliguria
    • Prolonged capillary refill
    • Core-to-peripheral temperature gap
# Normal Vitals

## Table 3. Normal Vital Signs For Age Of Pediatric Patients.

<table>
<thead>
<tr>
<th>Age</th>
<th>Heart Rate (bpm)</th>
<th>Respiratory Rate (bpm)</th>
<th>Systolic Blood Pressure (mm Hg)</th>
<th>Diastolic Blood Pressure (mm Hg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Newborn</td>
<td>90-180</td>
<td>30-50</td>
<td>60 ± 10</td>
<td>37 ± 10</td>
</tr>
<tr>
<td>1-5 months</td>
<td>100-180</td>
<td>30-40</td>
<td>80 ± 10</td>
<td>45 ± 15</td>
</tr>
<tr>
<td>6-11 months</td>
<td>100-150</td>
<td>25-35</td>
<td>90 ± 30</td>
<td>60 ± 10</td>
</tr>
<tr>
<td>1 year</td>
<td>100-150</td>
<td>20-30</td>
<td>95 ± 30</td>
<td>65 ± 25</td>
</tr>
<tr>
<td>2-3 years</td>
<td>65-150</td>
<td>15-25</td>
<td>100 ± 25</td>
<td>65 ± 25</td>
</tr>
<tr>
<td>4-5 years</td>
<td>65-140</td>
<td>15-25</td>
<td>100 ± 20</td>
<td>65 ± 15</td>
</tr>
<tr>
<td>6-9 years</td>
<td>65-120</td>
<td>12-20</td>
<td>100 ± 20</td>
<td>65 ± 15</td>
</tr>
<tr>
<td>10-12 years</td>
<td>65-120</td>
<td>12-20</td>
<td>110 ± 20</td>
<td>70 ± 15</td>
</tr>
<tr>
<td>13+ years</td>
<td>55-110</td>
<td>12-18</td>
<td>120 ± 20</td>
<td>75 ± 15</td>
</tr>
</tbody>
</table>

*Adapted from: Silverman BK. Practical Information. In: Textbook of Pediatric Emergency Medicine, ©2006. Also: Jorden RC. Multiple Trauma. In: Emergency Medicine: Concepts and Clinical Practice, ©1990. All rights reserved. See References 94 and 95, respectively.*
Definitions

- Multiple Organ System Failure
  - Alterations in function of multiple organs
- Cold Shock
  - Decreased perfusion,
  - Altered mental status
  - Delay capillary refill > 2-3 sec
  - Diminished peripheral pulses
  - Mottle cool extremities
  - Decreased urine output (1ml/kg/h)
- Warm Shock
  - Decreased perfusion
  - Altered mental status
  - Flash capillary refill
  - Bounding peripheral pulses
  - Decreased urine output (<1ml/kg/h)
Definitions

• Fluid-refractory/dopamine-resistant shock
  • Shock persists despite 60ml/kg fluid resuscitation in the first hour
  • Dopamine infusion of 10 mcg/kg/min
• Catecholamine-resistant shock
  • Shock persist despite use of catecholamine
    • Epinephrine
    • Norepinephrine
• Refractory Shock
  • Shock persist despite goal-directed use
    • Inotropic agents
    • Vasopressors
    • Vasodilators
    • Maintenance of metabolic (glucose and calcium)
    • Maintenance of hormonal (thyroid and hydrocortisone)
Triage

• Emergency Severity Index
  – Five-level triage system
  – Patient Acuity (vital signs, degree of distress, expected resource intensity and timeliness
  – Level 1-most urgent to level 5 least urgent
Triage

– Level 1: unresponsive, apneic, intubated, etc
– Level 2: Confused or lethargic, severe pain, respiratory distress, unstable vital signs
– Level 3: Multiple resources needed (X-ray, exam, consultation, etc.)
– Level 4: Single resource needed (X-ray exam, consultation, etc)
– Level 5: History/physical exam only
<table>
<thead>
<tr>
<th>Level 1</th>
<th>Level 2</th>
<th>Level 3</th>
<th>Level 4</th>
<th>Level 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cardiac arrest</td>
<td>Seizures</td>
<td>Multiple resources needed</td>
<td>Single resource needed</td>
<td>Only history/physical exam required</td>
</tr>
<tr>
<td>Respiratory arrest</td>
<td>Sepsis, severe dehydration</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Severe respiratory distress</td>
<td>Diabetic ketoacidosis</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SpO₂ &lt; 90</td>
<td>Child abuse, burns</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Critically injured and unresponsive trauma patient</td>
<td>Head trauma</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Severe respiratory distress with agonal or gasping-type respirations</td>
<td>Vitamins/iron or other overdoses/ingestions</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Severe bradycardia or tachycardia with signs of hypoperfusion</td>
<td>Infant less than 28 days of age with a fever of 100.4 °F or 38 °C, or greater</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hypotension with signs of hypoperfusion</td>
<td>1-3 months of age: with a fever of 100.4 °F or 38 °C, or greater may be considered up to II</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trauma patient who needs resuscitation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anaphylactic reaction</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baby who is flaccid</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hypoglycemia with a change in mental status</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Difficulties in Triage

- Approx 2 minutes to triage
- Crying
- Overcrowding
- Poor historian
Epidemiology

- 75,000 Children hospitalized yearly for Sepsis
- Incidence 1 per 1600
- Increase in incidence
- 4.4% of all admissions
- 2/3 of cases are respiratory and blood stream
- Mortality due to shock in critically ill children is highly associated with multiple organ dysfunction syndrome
Etiology

• Most causes are not identified
• Rise in bacteremia and sepsis
  – Invasive devices
  – Mechanical ventilation
  – Central venous lines
  – Overuse of antibiotics
Differential Diagnosis

- Child Abuse (head injury)
- Hypoglycemia
- Environmental hyperthermia
- Seizures
- Congenital heart disease
- Cardiac arrhythmias
- Myocarditis
- Inborn errors of metabolism
- Congenital adrenal hyperplasia
- Malrotation with volvulus
- Intussusception
- Baclofen withdrawal syndrome

- Pyloric stenosis
- Posterior urethral valves
- Necrotizing enterocolitis
- Gastroenteritis with dehydration
- Water intoxication
- Toxin exposure (cocaine, bath salts, meth, carbon monoxide)
- Acute bilirubin encephalopathy
- Serotonin syndrome
- Neuroleptic malignant syndrome
- Malignant hyperthermia
- Kawasaki disease
Risk Factors for Sepsis

- < 1 month of age
- Serious injury (major trauma, burns, or penetrating wounds)
- Chronic debilitating medical conditions
- Immunosuppression
- Large surgical incisions
- In-dwelling vascular catheters or invasive devices
- Urinary tract abnormalities with frequent infections
Pathogens-Bacteria

- *Staphylococcus aureus* (MRSA)
- Coagulase-negative Staphylococcus (neonates and in-dwelling catheters)
- *Streptococcus pneumoniae*
- *Streptococcus pyogenes*
- Group B streptococcus in neonates
- *Pseudomonas aeruginosa*
- *Escherichia coli*
- Enterococcus species
- Klebsiella species
Pathophysiology of Sepsis

- Cellular level—decreased glucose and oxygen—anaerobic metabolism—increased lactic acid
- Decreased energy—loss of cellular integrity—cellular swelling—cell death
- Organ Dysfunction—decreased perfusion pressure—cells swell—organ swell—organ failure
- Endothelial cells of vasculature—cytokines and immunomodulators release-SIRS-hypo/hyperthermia, tachycardia, tachypnea and abnormalities in white blood cell counts
Pathophysiology of Sepsis

- Liver failure—deficiency of clotting substrates
- Kidney Failure—increased intravascular and extravascular volume
- Lung Failure—decreased compliance and increased work of breathing
- Heart Failure—decreased contractility and increased risk of dysrhythmias
- Increased hyperkalemia (kidney failure)—dysrhythmias
- Increased BUN—decreased platelet function
Pathophysiology of Sepsis

• Increased cardiac output—decreased systemic vascular resistance—wide pulse pressure—hypotension “warm shock”

• Decreased cardiac output—systemic resistance increased—metabolic acidosis—worsening hypotension—“cold shock” –Multi-organ system failure
Evaluation of Patient

- Rapid blood glucose
- Arterial blood gas
- Complete blood count
- Blood lactate
- Serum electrolytes
- Blood urea nitrogen
- Serum creatinine
- Serum calcium
- Serum total bilirubin
- Alanine aminotransferase
- Urinalysis

- Prothrombin time
- Partial thromboplastin time
- International normalized ratio
- Fibrinogen and D-dimer
- Blood culture
- Urine culture
- Culture (wound, trach, etc.)
- CRP
- Procalcitonin
- Chest Xray
Evaluation of Patient

- Lactic acidosis >3.5 mmol/L
- Age-specific leukocytosis or leukopenia
- Platelet count < 80,000/microL
- Disseminated intravascular coagulopathy
  - Decreased fibrinogen
  - Increase D-dimer, INR, PT, and PPT
- Serum creatinine >2 times upper limit of age
Treatment/Management

• Provide ventilation and oxygen
• Vascular access
• Fluid resuscitation
• Antibiotics
• Caution with decreased cardiac function
Treatment/Management

• Respiratory support
• Maintain sats >92% (pO2) >65mmHg
  – Face mask
  – High-flow nasal cannula
  – Mechanical ventilation
Treatment/Management

• Medications for Rapid Sequence Intubation
• RSI
  – Atropine, Midazolam, Fentanyl
  – Ketamine
    • Does not inhibit respiratory
    • Increased blood pressure
    • Prolonged stress state can lead to decreased noradrenalin and lead to hypotension
  – Etomidate
    • Rapid onset (30-60 secs)
    • Short duration (5-15 mins)
    • Typically avoided because of adrenal suppression

*Few cardiovascular and respiratory effects
## Treatment/Management

<table>
<thead>
<tr>
<th>Age</th>
<th>Uncuffed ETT ID (mm)</th>
<th>Cuffed ETT ID (mm)</th>
<th>Initial ETT depth</th>
<th>Central Line Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Newborn</td>
<td>3.0-3.5</td>
<td>3.0</td>
<td>9-10</td>
<td>5-8 cm/4 Fr</td>
</tr>
<tr>
<td>1-5 months</td>
<td>3.5</td>
<td>3.0-3.5</td>
<td>10</td>
<td>5-8 cm/4 Fr</td>
</tr>
<tr>
<td>6-11 months</td>
<td>3.5-4.0</td>
<td>3.5</td>
<td>11</td>
<td>8-12 cm/4-5 Fr</td>
</tr>
<tr>
<td>1 year</td>
<td>4.0-4.5</td>
<td>4.0</td>
<td>12</td>
<td>8-12 cm/4-5 Fr</td>
</tr>
<tr>
<td>2-3 years</td>
<td>4.5-5.0</td>
<td>4.0-4.5</td>
<td>12-13</td>
<td>8-12 cm/4-5 Fr</td>
</tr>
<tr>
<td>4-5 years</td>
<td>5.0-5.5</td>
<td>4.5-5.0</td>
<td>13-15</td>
<td>8-12 cm/5.5-6.0 Fr</td>
</tr>
<tr>
<td>6-9 years</td>
<td>5.5-6.0</td>
<td>5.0-5.5</td>
<td>15</td>
<td>8-12 cm/5.5-6.0 Fr</td>
</tr>
<tr>
<td>10-12 years</td>
<td>6.5-7.0</td>
<td>6.0-6.5</td>
<td>17</td>
<td>12-15 cm/6.0+ Fr</td>
</tr>
<tr>
<td>13+ years</td>
<td>7.0-7.5</td>
<td>6.5-7.0</td>
<td>19</td>
<td>12-15 cm/6.0+ Fr</td>
</tr>
</tbody>
</table>
Treatment/Management

• Determining Volume status
  – Extremely difficult
  – Capillary refill
  – Blood pressure
  – Normal pulses (no difference between peripheral and central pulses)
  – Warm extremities
  – Urine output >1ml/kg/hr
  – Normal mental status
# Volume Status

Physical findings of volume depletion in infants and children

<table>
<thead>
<tr>
<th>Finding</th>
<th>Mild (3 to 5 percent)</th>
<th>Moderate (6 to 9 percent)</th>
<th>Severe (≥10 percent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pulse</td>
<td>Full, normal rate</td>
<td>Rapid</td>
<td>Rapid and weak OR absent</td>
</tr>
<tr>
<td>Systolic pressure</td>
<td>Normal</td>
<td>Normal to low</td>
<td>Low</td>
</tr>
<tr>
<td>Respirations</td>
<td>Normal</td>
<td>Deep, rate may be increased</td>
<td>Deep, tachypnea OR decreased to absent</td>
</tr>
<tr>
<td>Buccal mucosa</td>
<td>Tacky or slightly dry</td>
<td>Dry</td>
<td>Parched</td>
</tr>
<tr>
<td>Anterior fontanelle</td>
<td>Normal</td>
<td>Sunken</td>
<td>Markedly sunken</td>
</tr>
<tr>
<td>Eyes</td>
<td>Normal</td>
<td>Sunken</td>
<td>Markedly sunken</td>
</tr>
<tr>
<td>Skin turgor</td>
<td>Normal</td>
<td>Reduced</td>
<td>Tenting</td>
</tr>
<tr>
<td>Skin</td>
<td>Normal</td>
<td>Cool</td>
<td>Cool, mottled, acrocyanosis</td>
</tr>
<tr>
<td>Urine output</td>
<td>Normal or mildly reduced</td>
<td>Markedly reduced</td>
<td>Anuria</td>
</tr>
<tr>
<td>Systemic signs</td>
<td>Increased thirst</td>
<td>Listlessness, irritability</td>
<td>Grunting, lethargy, coma</td>
</tr>
</tbody>
</table>
Treatment/Management

• Vascular Access
  – Peripheral IV
  – Ultrasound guided IV
  – Central line
  – Intraosseous catheter
    • Proximal tibia (2-3cm below tibial tuberosity)
    • Contraindications (previous attempts, fractures)
    • Distal Femur (3-4 cm above medical condyle)
Treatment/Management

- Fluid Resuscitation
  - Lactated Ringer’s
  - Normal Saline
  - 20ml/kg (rapid)
  - 60ml/kg (<60 minutes)
  - Fluids need to be administered by a push and not an electric pump
    - Saline-filled syringes
    - Use of single syringe connected to a 3-way stopcock which can pull fluid from a saline bag and “push” it into the patient
    - Rapid infuser or pressure bag
Treatment/Management

• Urine output
  – Foley catheter
  – 1mL/kg/h
• >40 mL/kg in first hour
  – Decreased risk of pulmonary edema
• Inotropic and vasoactive agents
Treatment/Management

• Inotropic and vasoactive agents
  – Alpha-receptors
    • Smooth muscle contraction in arterioles and bronchiole
  – Beta-receptors
    • Beta 1 – increased contractility (inotropy) and rate (chronotropy)
    • Beta 2 – smooth muscle relaxation – arteriole and bronchiole dilation
  – Dopaminergic-receptors – kidney, increase perfusion
Treatment/Management

• Dopamine
  – First-line agent
  – 10mcg/kg/min (max dose 20 mcg/kg/min)
  – Beta-adrenergic causing increase heart rate and contractility
  – High doses leads to alpha-adrenergic
  – Improves blood pressure, cardiac output, urine production, and extremity perfusion

• Epinephrine
• Milrinone
• Norepinephrine and Vasopressin
Treatment/Management

• Epinephrine
  – Severe shock
  – Max dopamine
  – 0.05 mcg/kg/min
  – >0.2-0.3 mcg/kg/min – increased alpha—vasoconstriction
  – >1 mcg/kg/min—severe peripheral vasoconstriction
Treatment/Management

• Milrinone
  – Low cardiac output
    • Echocardiography
    • Extreme delay cap refill
    • Nonpalpable peripheral pulses with normal blood pressure
  – Increased systemic vascular resistance
  – Increase inotropy
  – Increase lusitropy (diastolic relaxation)
  – Peripheral vasodilation
  – 0.25mcg/kg/min (max 0.75 mcg/kg/min)
Treatment/Management

• Norepinephrine and Vasopressin
  – Vasoconstriction
  – Alpha and Beta (more alpha therefore vasoconstriction)
  – “Warm shock”
Treatment/Management

• Antibiotics
  – Administered quickly
  – Removing infected tissue
  – Removing infected source
  – Depends on age and past medical history

• Corticosteroids
## Treatment/Management

<table>
<thead>
<tr>
<th></th>
<th>Ampicillin</th>
<th>Vancomycin</th>
<th>Cefotaxime (or Ceftriaxone if Age &gt; 4 weeks)</th>
<th>Acyclovir</th>
<th>Piperacillin/Tazobactam</th>
<th>Clindamycin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age &lt; 1 month</td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age &gt; 4 weeks</td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Concerns for intra-abdominal source</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Concerns for toxic shock syndrome</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Treatment/Management

• Special Consideration
  – Immunodeficiency
  – Central venous catheter – Vancomycin
  – Antifungal agents – Patients taking broad spectrum antibiotics
Treatment/Management

• Corticosteroids
  – 25% with septic shock have relative or absolute adrenal insufficiency
  – Choices: methylprednisolone, hydrocortisone, and dexamethasone
    • Hydrocortisone is the treatment of choice
    • Stress doses in patients with fluid-refractory and catecholamine-refractory shock
    • Cortisol level < 18 mg/dL
    • Dose 1mg/kg q6h, or 50mg/m2/24h as infusion
Disposition

- Transfer
- PICU
Thank-You

• Questions?