Early Detection of Shock

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Conflict of Interest Disclosure

- Bryan E. Bledsoe, DO, FACEP, FAEMS
  - No conflicts of interest to disclose

Shock

- A “rude unhinging” of the machinery of life.
  - Samuel Gross (1862)

- Shock is inadequate tissue perfusion.
  - A clinical state of acute circulatory failure with inadequate oxygen utilization and/or delivery to the cells resulting in cellular dysoxia/hypoxia.

- Shock is:
  - Cellular and tissue hypoxia:
    - Reduced oxygen delivery
    - Increased oxygen consumption
    - Inadequate oxygen utilization
  - Most commonly occurs due to circulatory failure.
  - Initially reversible if treatment provided rapidly to prevent progression to irreversible organ dysfunction.

Oxygen

Glucose
Shock

- Proteins
- Carbohydrates
- Lipids

Glucose

Shock

- Oxygen:
  - Required for the majority of cellular energy production derived from Krebs Cycle and Electron Transport Chain.
  - Metabolism with oxygen = aerobic metabolism
  - Metabolism without oxygen = anaerobic metabolism

Shock

- Oxygen Transport:
  - Hemoglobin-bound (97%)
  - Dissolved in plasma (3%)

- Monitoring:
  - Hemoglobin-bound (SpO2)
  - Dissolved in plasma (pO2)

Shock

- What factors can affect oxygen delivery to the tissues?
  - Cardiac Output (Q)
  - Available Hemoglobin (Hb)
  - Oxygen Saturation (SpO2)

Shock

- Metabolic oxygen demand (MRO2):
  - Sum total of oxygen needed to drive various tissue metabolic processes.

- Metabolic oxygen delivery (DO2):
  - Sum total of available oxygen delivery to the tissues.
  - Body approximately 20–30% effective in extracting circulating oxygen.
Shock

- Things that can adversely affect oxygen delivery:
  - Hypoxia
  - Inadequate circulation
  - Inadequate transport medium (e.g., hemoglobin)
  - Cellular toxins (e.g., cyanide)

When metabolic oxygen demands exceed oxygen supply:

- Elevated lactate levels MAY be an indicator of hemodynamic instability.
- Current lactate monitoring very non-specific.
- Numerous causes of elevated lactate levels—not all pathological.
Shock

- **Causes of Shock:**
  - Inadequate oxygen delivery:
    - Respiratory failure (mechanical, toxins)
  - Inadequate hemoglobin
  - Inadequate fluid in the vascular system
  - Impaired oxygen uptake
    - Biochemical poisoning (hydrogen cyanide)

- **Causes of Shock:**
  - Inadequate nutrient delivery:
    - Inadequate nutrient intake
    - Malnutrition, GI absorption disorder
  - Impaired nutrient (glucose) uptake:
    - Lack of insulin (Diabetes Mellitus)

- **Impaired oxygen uptake:**
  - Cyanide:
    - Inhibits metal-containing enzymes (i.e., cytochrome oxidase)
  - Carbon monoxide:
    - Binds to hemoglobin
    - Inhibits metal-containing enzymes (i.e., cytochrome oxidase)

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- Shock types:
  - Hemorrhagic
  - Respiratory
  - Neurogenic
  - Psychogenic
  - Cardiogenic
  - Septic
  - Anaphylactic
  - Metabolic

- Shock is a singular condition with multiple causes.
Primary Shock Types:

- **Distributive (66%)**
  - Septic (42%)
  - Anaphylactic and neurogenic (4%)
- **Cardiogenic (16%)**
- **Hypovolemic (16%)**
- **Obstructive (2%)**

**Distributive Shock:***
- Characterized by severe peripheral vasodilation.
- Often caused by molecules that mediate vasodilation.

**Septic Shock (most common):**
- Systemic inflammatory response syndrome (SIRS)
- Neurogenic shock
- Anaphylactic shock
- Drug and toxin-induced shock
- Endocrine shock

**Cardiogenic Shock:**
- Intracardiac cause of cardiac pump failure.
- Cardiomyopathic
- Arrhythmic
- Mechanical

**Hypovolemic Shock:**
- Reduced intravascular volume
- Hemorrhagic
- Non-hemorrhagic:
  - GI losses
  - Skin losses
  - Renal losses
  - Third-space losses

**Obstructive Shock:**
- Extracardiac issues cause cardiac pump failure (poor right ventricular output).
- Pulmonary vascular
- Pulmonary embolism
- Pulmonary hypertension
- Mechanical
- Tension pneumothorax
- Respiratory taponade
- Combined

**Obstructive Shock:**
- Pulmonary vascular:
  - Pulmonary embolism
  - Pulmonary hypertension
- Mechanical:
  - Tension pneumothorax
  - Respiratory taponade
  - Combined

The pathway to shock follows a common metabolic pattern.
Shock

- Stages of shock:
  - Pre-shock (compensated)
  - Shock (decompensated)
  - End-organ dysfunction (irreversible)

Pre-shock -> Shock -> End-organ dysfunction

Shock (Compensated): The body’s compensatory mechanisms are able to maintain some degree of tissue perfusion.

Shock ( Decompensated): The body’s compensatory mechanisms fail to maintain tissue perfusion (blood pressure falls).

Irreversible (End-organ Dysfunction): Tissue and cellular damage is so severe that the organism dies even if perfusion is restored.

<table>
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<tr>
<th>Organs/Tissues</th>
<th>Compensated Shock</th>
<th>Decompensated Shock</th>
<th>Irreversible Shock</th>
</tr>
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<tbody>
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<td>CNS</td>
<td></td>
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<tr>
<td>Heart</td>
<td>Tachycardia</td>
<td>Acute respiratory failure</td>
<td>Hypoxic/ischemic injury</td>
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<tr>
<td>Lungs</td>
<td>Tachypnea, increased work of breathing</td>
<td>Acute respiratory failure</td>
<td>Hypoxic/ischemic injury with cell necrosis</td>
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<td>Kidneys</td>
<td>Oliguria</td>
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<td>Tubular necrosis</td>
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<td>Nausea, vomiting, stress gastritis</td>
<td>Pancreatitis, acute cholecystitis, GI bleed</td>
<td>Gastric necrosis, shock liver</td>
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<tr>
<td>Liver</td>
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<td>Neurologic</td>
<td>Encephalopathy and patient agitation</td>
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<tr>
<td>Autonomic</td>
<td>Glycogenolysis, glycosgen storage, lipolysis, proteolysis</td>
<td>Glycogen depletion, hypoglycemia</td>
<td>Hypercalcemia</td>
</tr>
</tbody>
</table>

| Blood loss (mL) | Up to 750 | 750 - 1,500 | 1,500 - 2,000 | > 2,000 |
| Blood loss (% volume) | Up to 11 | 15 - 30 | 30 - 40 | > 40 |
| Pulse rate | < 100 | 100 - 120 | 120 - 140 | > 140 |
| Blood pressure | Normal | Decreased | Decreased | Decreased |
| Respiratory rate | 14 - 20 | 20 - 30 | 30 - 40 | > 35 |
| Urine output (ml/hr) | > 30 | 20 - 30 | 5 - 15 | Negligible |
| CNS/mental status | Slightly anxious | Moderately anxious | Confused | Lethargic |

Shock recognition must occur at several levels:
- Examination
- Monitoring technologies
- Response to treatments
- Experience

ITLS Primary Survey:
- Scene size-up
- Initial assessment
- Rapid trauma survey or focused exam.

ITLS Secondary Survey

ITLS Ongoing Exam
Shock

What is the first physiological factor in the development of shock?
- VO₂ < MRO₂

So, what are the first symptoms you would expect to find?
- ↑ respiratory rate
- ↑ heart rate

What is often the second physiological response to the development of shock?
- Peripheral vasoconstriction

What symptoms would you expect to see?
- Pale skin
- Cool skin
- Weakened peripheral pulses

As shock progresses, what physiological effects are seen?
- End-organ perfusion falls

What symptoms would you expect to see?
- Altered mental status
- Decreased urine output

As compensatory mechanisms fully engage, what signs and symptoms would you expect to see?
- Tachycardia
- Tachypnea
- Pupillary dilation
- Decreased capillary refill
- Pale cool skin

When compensatory mechanisms fail, what signs and symptoms would you expect to see?
- Hypotension
- Falling SpO₂
- Bradycardia
- Loss of consciousness
- Dysrhythmias
- Death

Technology:
- ECG
- Oximetry
- Capnography
- POC testing
- Lactate
- Glucose
- Non-invasive hemoglobin
- SpO₂
- Sats

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**Shock**

- **Response to treatment:**
  - Fluid responsiveness:
    - Fluid responsiveness is an increase of stroke volume of 10-15% after the patient receives 500 ml of crystalloid over 10-15 minutes.
    - Indicates preload reserve
    - Does not mean that patient needs fluid.
  - Responders are those that demonstrate physiological improvements.
  - Transient responders show an initial improvement followed by further physiological deterioration.
  - Non-responders show continued physiological deterioration despite initial fluid resuscitation.
  - Responders are those that demonstrate physiological improvements.

- **Experience:**
  - Medicine is very much pattern recognition.
  - The more patterns a provider is exposed to, the easier it is to recognize the pattern.
  - ITLS and other standardized trauma courses are designed to improve knowledge of trauma care.
  - Experience comes from patient contact and management.

- **Pornography:**
  - "I know it when I see it."
  - US Supreme Court Justice Potter Stewart (1964)

- **Shock:**
  - "I know it when I see it."
  - Every one of us!!!

- **Early recognition of shock and subsequent treatment is important in patient survival.**
  - Shock recognition:
    - Examination
    - Monitoring technologies
    - Response to treatments
    - Experience
  - You cannot treat shock until you recognize the problem!
Shock