The Critically Ill Patient: Surgical Intensive Care

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Outline

- Recognizing Critical Illness
- The Stress Response
  - Systemic Review
  - Clinical Manifestations
  - Treatment
- Multiple Organ Dysfunction and Failure
- Prevention
Metabolic Response to Critical Illness

- Responses are similar regardless of cause (injury, illness, infection)
- Adaptive reactions serve to promote recovery following injury
- Costs?
  - Debility
  - Organ dysfunction syndromes
  - Death
Importance of Metabolic Response

- Treatment decisions:
  - Support?
  - Suppress?

- Goals:
  - Decrease debility
  - Promote recovery
Response to Injury

Change in:
- Energy
- Temperature
- O2 Consumption

Early | Late
---|---
Catabolism | Anabolism

INJURY

Minutes | Hours | Days | Weeks
The Physiology of Injury: Early Phase

- Increased glucose level
- Normal glucose production
- Increased free fatty acid levels
- Low insulin concentration
- Decreased core temperature
- Increased levels of catecholamines and glucagon
- Increased blood lactate
- Decreased oxygen consumption
- Decreased cardiac output
The Physiology of Injury: Late Phase

- Increased blood glucose level
- Increased glucose production
- Normal or slightly high free fatty acid levels
- Normal or slightly high insulin levels
- Increased cardiac output

- High normal catecholamines and glucagon
- Normal blood lactate
- Increased oxygen consumption
- Increased body temperature
Stress Response: The Wound

- Source of mediators
  - Pain
  - Inflammatory cells

- Other Contributing Factors
  - Necrotic or devitalized tissues
  - Abscess
  - Inflammation
  - Foreign material
  - Drying
  - Hypoperfusion
Stress Response: Hypovoleemia

- Causes
  - Hemorrhage
  - Gastrointestinal loss
  - Insensible loss ("third spacing")

- Responses
  - Sympathetic nervous system
  - Hormonal response
Stress Response: Hypovolemic

- Resuscitation
  - Crystalloid
  - Colloid
  - Blood products

- End-points of Resuscitation
  - Clinical improvement
  - Hemodynamic stability
  - Chemical or medication maximums
Stress Response: Pain

- Pain...
  - Limits mobility causing:
    - Deep venous thrombosis
    - Ileus (silent bowel)
  - Limits cough causing:
    - Atalectasis
    - Pneumonia
Stress Response: Pain

- Treatment
  - Medications
    - Narcotics
    - Non-steroidals
    - Local anesthetic agents
  - Routes of delivery
    - Oral
    - IM
    - IV
    - Epidural
    - Patient-controlled analgesia
Stress Response: Inflammation and Infection

- Fever
  - Causes physiologic stress to patient
    - Tachycardia ➔ increased work on the heart
    - Tachypnea ➔ increased respiratory effort
    - Malaise
    - Agitation
  - Search for source
  - Treat with antipyretics
Inflammatory Syndromes

- Systemic Inflammatory Response Syndrome (SIRS)
- Sepsis
- Severe Sepsis
- Septic Shock
Systemic Inflammatory Response Syndrome

- Two or more of the following:
  - Temperature $> 38^\circ C$ (100.4°F) or $< 36^\circ C$ (96.8°F)
  - Heart rate $> 90$ beats per minute
  - Respirations $> 20$ per minute
  - WBC $> 12,000 / mm^3$ or $< 4,000 mm^3$
Sepsis and Severe Sepsis

- **Sepsis**
  - Meets criteria for SIRS
  - Clinically likely source of infection

- **Severe Sepsis**
  - Meets criteria for sepsis
  - Also has impaired cardiovascular performance requiring fluid resuscitation
Septic Shock

- Meets criteria for Severe Sepsis
- Also has impaired cardiovascular performance requiring inotropic support
Inflammation and Infection

- Types
  - Primary → related to primary injury
  - Secondary → complication of therapy
Inflammation and Infection

- Signs
  - Fever
  - Tachycardia
  - Widened pulse pressure
  - Leukocytosis
  - Glucose intolerance
  - Fluid retention
  - Hypoxemia
  - Ileus
  - Thrombocytopenia
  - Agitation
**Inflammation and Infection: Treatment**

1. **Search for source**
   - Cultures
   - X-rays
   - Endoscopies

2. **Empiric broad spectrum antibiotics**
   - Surgery
     - Drain abscess
     - Debride necrotic tissue
     - Biopsy

3. **Change all catheters**
Inflammation and Infection

- Prevention
  - Sterile technique
  - Change catheters regularly
  - Keep all access sites clean and dry
  - Prophylactic antibiotics in high risk patients
Iatrogenic Factors

- Prolonged bed rest causes:
  - Pulmonary complications
  - Deep venous thrombosis
  - Skin breakdown and ulcers
- Food deprivation
  - Starvation makes the metabolic response worse
  - Limit to 3-4 days maximum
- Invasive devices (catheters)
  - Potential source of infection
  - Limit duration of use
Iatrogenic Factors

- Sleep deprivation causes:
  - Confusion
  - Disorientation
  - Psychosis
  - Anxiety
- Treatment for sleep deprivation:
  - Reorientation
  - Sedative / hypnotic medications
Manifestations of the Stress Response

- Hypermetabolism
  - Related to severity of injury
  - Response dependent on age, sex, body size
  - Temperature sensitive but not dependent
# Alterations in Metabolic Rate

<table>
<thead>
<tr>
<th>SAMPLE CONDITION</th>
<th>CHANGE IN METABOLIC RATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>No postoperative complications</td>
<td>None</td>
</tr>
<tr>
<td>Fistula without infection</td>
<td>None</td>
</tr>
<tr>
<td>Mild peritonitis</td>
<td>25% above normal</td>
</tr>
<tr>
<td>Long bone fracture</td>
<td>25% above normal</td>
</tr>
<tr>
<td>Severe injury or infection</td>
<td>50% above normal</td>
</tr>
<tr>
<td>Multi-organ failure</td>
<td>50% above normal</td>
</tr>
<tr>
<td>Burn of 40-100% body surface</td>
<td>100% above normal</td>
</tr>
</tbody>
</table>
Manifestations of the Stress Response

- Muscle wasting
  - Accelerated protein breakdown
  - Increased urinary excretion of nitrogen
Why does skeletal muscle break down?

- Provides amino acids for protein synthesis
- Provides precursors for glucose production
  - Alanine = urea + glucose
- Provides precursors for ammonia production
- Provides fuel for rapidly dividing cells
Manifestations of the Stress Response

- Altered carbohydrate metabolism
  - Critical illness causes
    - Increased glucose production
    - Increased glucose uptake
    - Increased glucose turnover
    - Decreased glucose utilization
Altered Carbohydrate Metabolism

- Glucose production
  - Hydrolysis of glycogen stored in liver
  - Cori cycle
    - Lactate $\rightarrow$ glucose (very inefficient)
  - Gluconeogenesis
    - Alanine $\rightarrow$ glucose
Altered Carbohydrate Metabolism

- Glucose intolerance / Insulin resistance
  - High insulin levels
  - Decreased glucose utilization
  - Receptor defect
Stress Response: Mediators

- Can have good and bad effects
- Made by different types of cells
  - Endocrine, Autocrine, Paracrine
- Specific receptors
  - Alter behavior of cells
  - Affect other receptors
Types of Mediators

- Hormones
- Inflammatory mediators
- Growth factors
Injury: Hormones Released

- ACTH
- Cortisol
- Aldosterone
- Growth hormone
- Prolactin
- Histamine
- Serotonin
- Epinephrine
- Norepinephrine
- Dopamine
- Glucagon
- Renin
- Angiotensin II
Injury: Decreased Production or No Change

- Insulin
- Estrogen
- Testosterone
- Thyroxine
- T3

- Thyroid stimulating hormone
- Follicle stimulating hormone
- Luteinizing hormone
Sources and Targets of Inflammatory Mediators

- **Cytokines**
  - proteins that are secreted by a cell for the purpose of altering either its own functions (autocrine effect) or those of adjacent cells (paracrine effect)

- **Interleukins**
  - cytokines that are produced by leukocytes and other cell types
Tissue Necrosis Factor α

*Helps control local infection by:*
- Inducing acute phase proteins
- Stimulating white blood cells

Resulting in
- Removal of infectious agent
- Immunity

*Systemic release is harmful:*
- Edema
- Hypoproteinemia
- Neutropenia

Resulting in
- Multiple organ failure
- DIC
- Death
Interleukin-6

- Huge number of sources and target cells
- Primarily involved in stimulating the production of acute phase proteins in the liver
- Induces formation of antibodies and T cells
- Can inhibit the growth of some cells such as human fibroblasts and endothelial cells as well as leukemia, lymphoma and breast carcinoma cell lines
Stress Response: Central Nervous System

- Afferent (incoming) signals
  - Tell body that there is an injury
- Efferent (outgoing) signals
  - Helps to make necessary metabolic changes
Stress Response: The Gut

- Can complicate the response to critical illness
  - Source of gram negative bacteria
  - These are the predominant infective organisms in the ICU
The Normal Gut

- Has tight, intracellular junctions that do not leak contents
- Has a rich supply of immune cells
- Has (healthy?) liver and spleen as back-up if necessary
The Gut During Illness

- **↓** mucosal barrier
- **↓** immune function
- **↑** fluid and electrolyte loss
The Gut and Bacteria

- Altered permeability of cells
- ↓ host defenses
- ↑ number of bacteria

*THIS MEANS TROUBLE!*
Enteral Feedings During Severe Illness

- Preserve mucosal integrity
- Some advice on enteral feeding…
## Complication Rates

<table>
<thead>
<tr>
<th>SEPSIS FROM:</th>
<th>ENTERAL FEED (%)</th>
<th>PARENTERAL FEED (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pneumonia</td>
<td>11</td>
<td>31</td>
</tr>
<tr>
<td>Intra-abdominal abscess</td>
<td>2</td>
<td>13</td>
</tr>
<tr>
<td>Empyema</td>
<td>2</td>
<td>9</td>
</tr>
<tr>
<td>Catheter sepsis</td>
<td>2</td>
<td>13</td>
</tr>
<tr>
<td>Fasciitis</td>
<td>6</td>
<td>9</td>
</tr>
</tbody>
</table>
Multiple Organ Dysfunction or Failure?

- **Dysfunction**
  - Means the organ is incapable of maintaining homeostasis

- **Failure**
  - Means the organ cannot meet minimal demands and is not considered viable
Basic Criteria: Pulmonary System

- **Dysfunction**
  - Hypoxia requiring intubation for 3 to 5 days

- **Failure**
  - Adult respiratory distress syndrome requiring advanced ventilator settings
    (PEEP > 10 cm H$_2$O and FiO$_2$ > 0.5%)
Basic Criteria: Hepatic System

- **Dysfunction**
  - Hugh serum bilirubin
  - Liver function tests that are twice normal values

- **Failure**
  - Clinical jaundice
  - Total bilirubin > 8 – 10 mg %
Basic Criteria: Renal System

- **Dysfunction**
  - Oliguria
  - Abnormally high creatinine

- **Failure**
  - dialysis
Basic Criteria: Gastrointestinal System

- **Dysfunction**
  - Ileus
  - Intolerance of enteral feeds

- **Failure**
  - Stress ulcers
  - Acalculous cholecystitis
Basic Criteria: Hematologic System

- **Dysfunction**
  - Clotting times (PT / PTT) 125% of normal
  - Platelets < 50,000

- **Failure**
  - Disseminated intravascular coagulopathy (DIC)
Basic Criteria: Central Nervous System

- Dysfunction
  - Confusion
  - Mild disorientation

- Failure
  - Progressive coma
Basic Criteria: Cardiovascular System

- **Dysfunction**
  - Decreased ejection fraction

- **Failure**
  - Refractory cardiogenic shock
What Causes Organ Failure?

**First Event**
- Tissue Trauma
- Infection
- Shock

- Inflammatory Response
- Macrophages

- Recovery
- Amplified Immune Response

- Organ Failure

**Second Event**
- Infection
- Endotoxemia
- Ischemia

Death
# Prognosis of Multiple Organ Dysfunction Syndrome

<table>
<thead>
<tr>
<th>Number of failing systems</th>
<th>Mortality (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>1</td>
<td>30</td>
</tr>
<tr>
<td>2</td>
<td>50-60</td>
</tr>
<tr>
<td>3</td>
<td>85-100</td>
</tr>
<tr>
<td>4</td>
<td>72-100</td>
</tr>
<tr>
<td>5</td>
<td>100</td>
</tr>
</tbody>
</table>
Prevention of Multiple Organ Failure

- **Resuscitative Phase**
  - aggressive volume resuscitation in early phase

- **Operative Phase**
  - timely management of soft tissue injury and necrotic tissues
  - early fixation of long bone and pelvic fractures
Prevention of Multiple Organ Failure

- ICU Phase
  - Early nutritional support
  - Appropriate use of antibiotics
  - Specific organ support
  - Timely surgery for any ‘missed’ injuries
Other Factors That Can be Controlled

- Body oxygenation
- Tissue perfusion
- Pain, anxiety
- Body temperature
- Acid-base balance
- Nutrient supply
- Gut integrity
- Wound repair and closure