



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

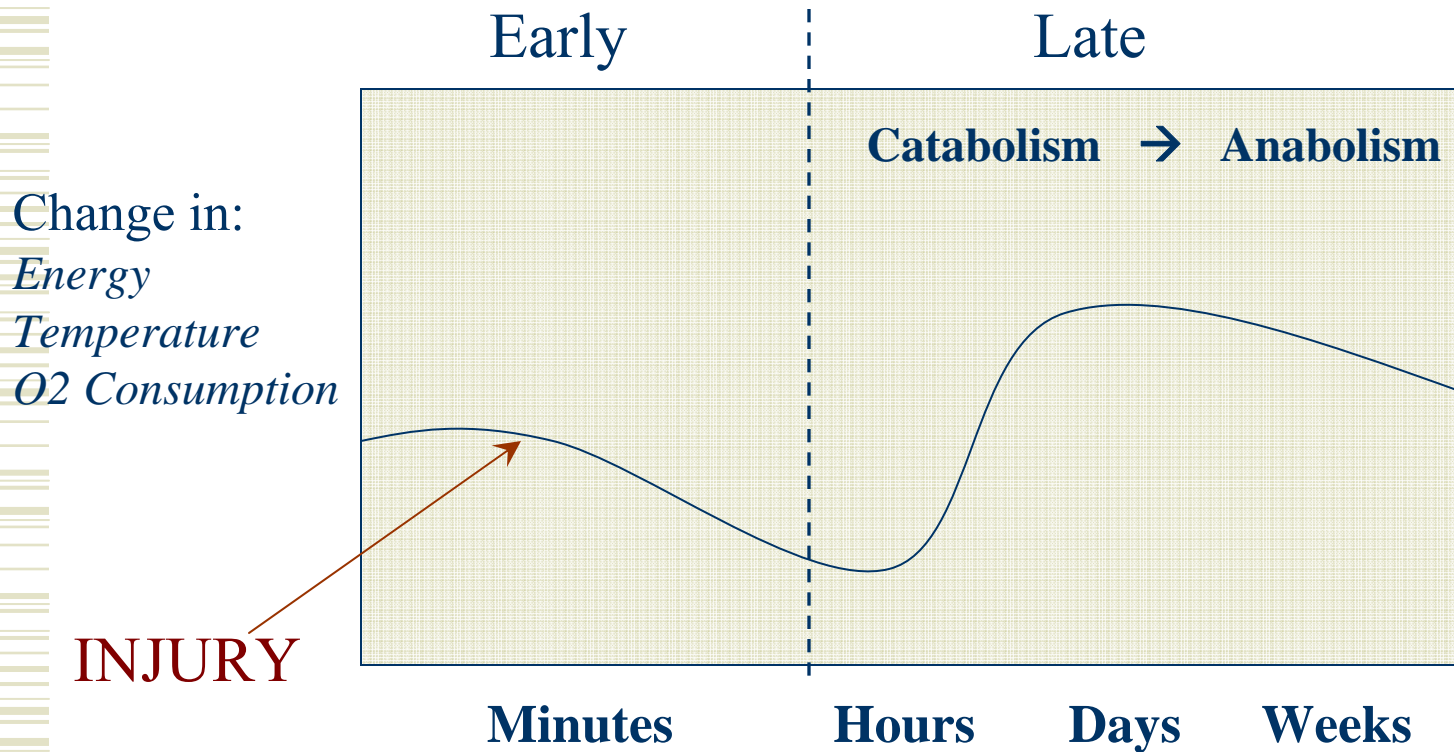
- ◆ Responses are similar regardless of cause (injury, illness, infection)
- ◆ Adaptive reactions serve to promote recovery following injury
- ◆ Costs?
 - Debility
 - Organ dysfunction syndromes
 - Death



Importance of Metabolic Response

- ◆ Treatment decisions:
 - Support?
 - Suppress?
- ◆ Goals:
 - Decrease debility
 - Promote recovery

Response to Injury





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: Hypovolemia

◆ Causes

- Hemorrhage
- Gastrointestinal loss
- Insensible loss (“third spacing”)

◆ Responses

- Sympathetic nervous system
- Hormonal response



Stress Response: Hypovolemia

- ◆ 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:
 - ◆ Atelectasis
 - ◆ 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 $> 38^{\circ}\text{C}$ (100.4°F) or $< 36^{\circ}\text{C}$ (96.8°F)
 - Heart rate > 90 beats per minute
 - Respirations > 20 per minute
 - WBC $> 12,000 / \text{mm}^3$ or $< 4,000 \text{ mm}^3$



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

SAMPLE CONDITION	CHANGE IN METABOLIC RATE
No postoperative complications	None
Fistula without infection	None
Mild peritonitis	25% above normal
Long bone fracture	25% above normal
Severe injury or infection	50% above normal
Multi-organ failure	50% above normal
Burn of 40-100% body surface	100% above normal



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 → glucose (very inefficient)
 - Gluconeogenesis
 - Alanine → 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

SEPSIS FROM:	ENTERAL FEED (%)	PARENTERAL FEED (%)
Pneumonia	11	31
Intra-abdominal abscess	2	13
Empyema	2	9
Catheter sepsis	2	13
Fasciitis	6	9



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 H₂O and FiO₂ > 0.5%)

Basic Criteria: Hepatic System

◆ Dysfunction

- High 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

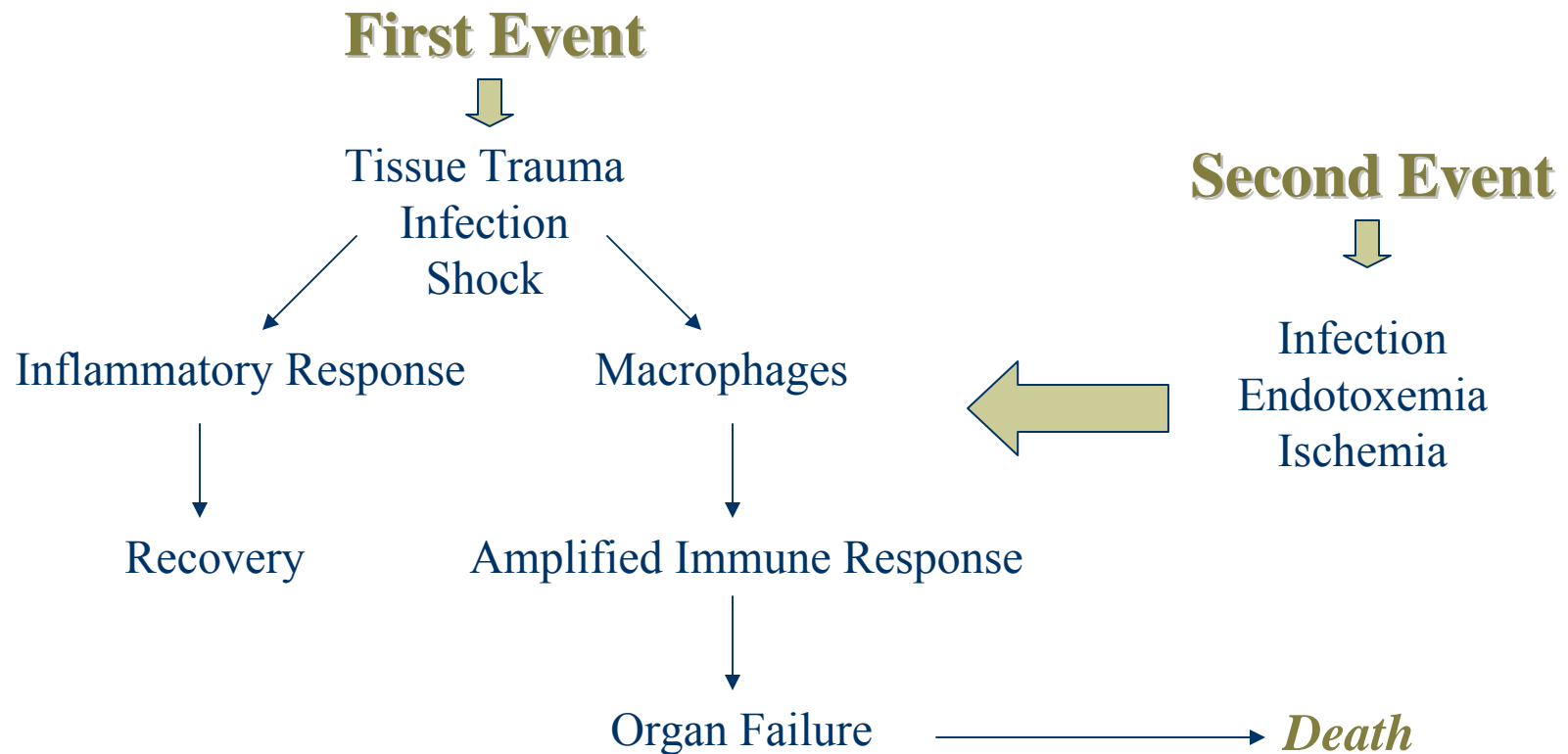
- ◆ Dysfunction

- Decreased ejection fraction

- ◆ Failure

- Refractory cardiogenic shock

What Causes Organ Failure?



Prognosis of Multiple Organ Dysfunction Syndrome

Number of failing systems	Mortality (%)
0	3
1	30
2	50-60
3	85-100
4	72-100
5	100



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