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

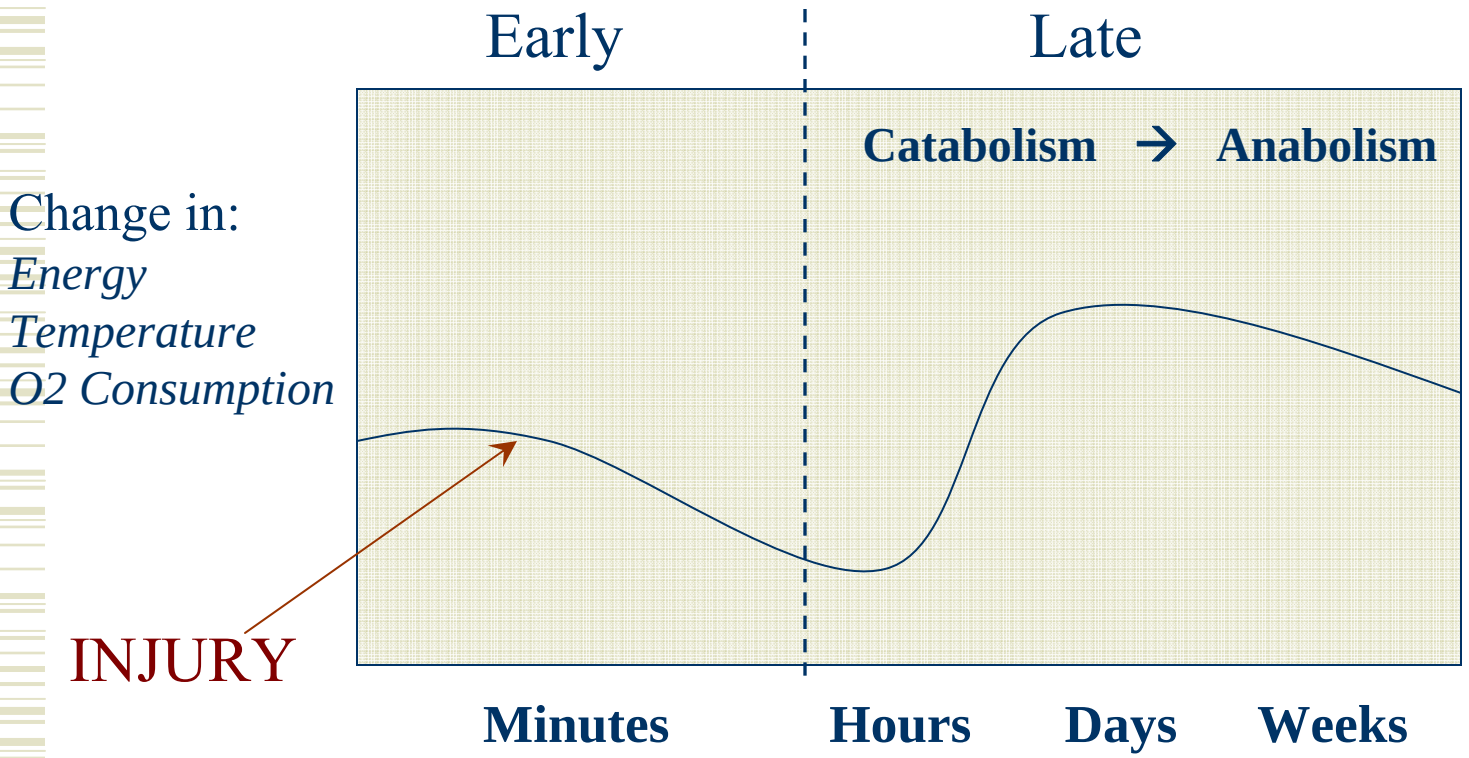
Metabolic Response to Critical Illness

- 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:
    - 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°C (100.4°F) or < 36°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

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 H_20 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)

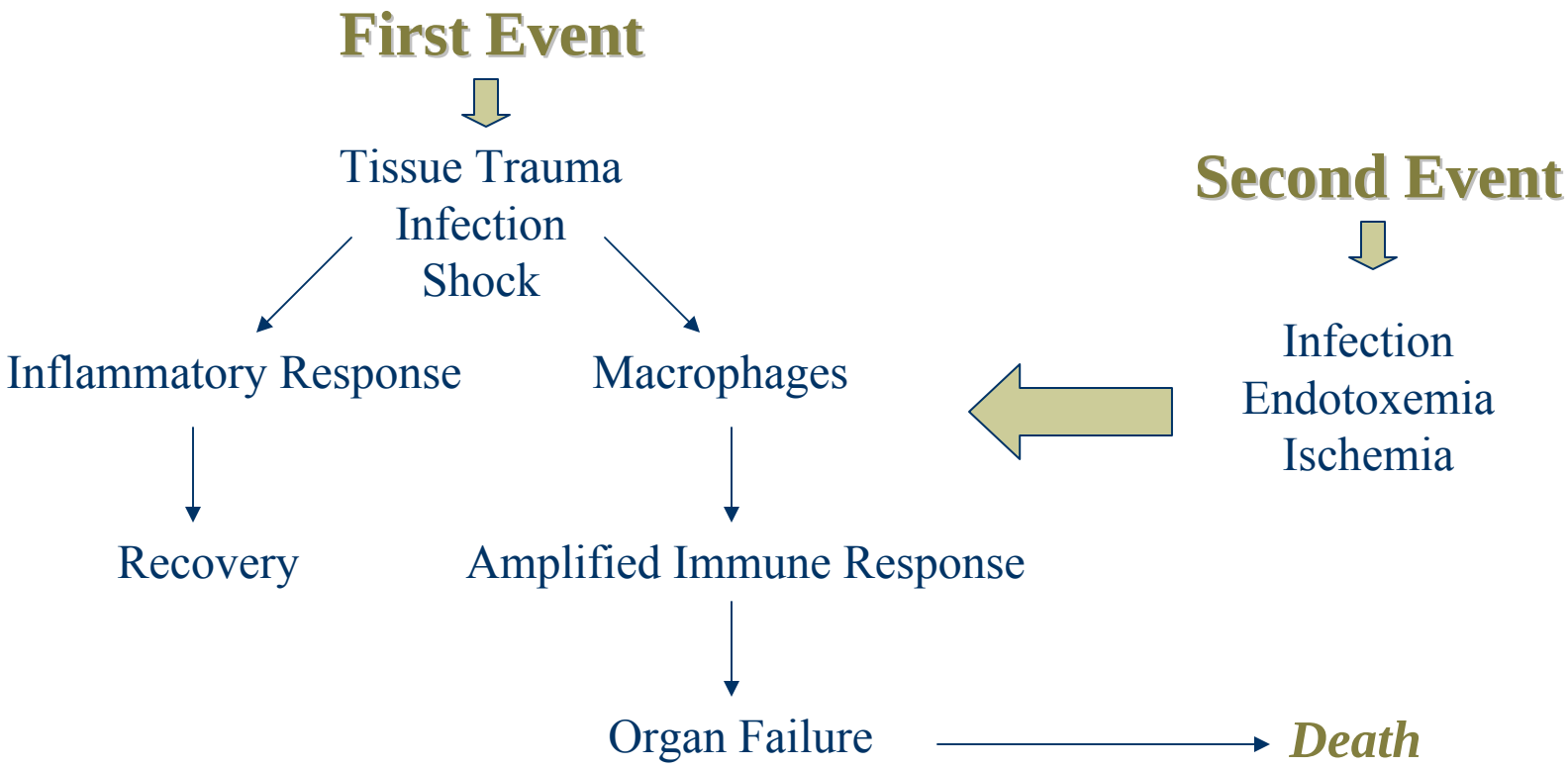
Basic Criteria: Central Nervous System

- Dysfunction
  - Confusion
  - Mild disorientation
- Failure
  - Progressive coma

Basic Criteria: Cardiovascular System

- Dysfunction
  - Decreased ejection fraction
- Failure
  - Refractory cardiogenic shock

What Causes Organ Failure?



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