Nutritional Demands of Disease and Trauma

Lecture 89
Nutritional Requirements

- Based on needs to support optimal physiological function
- Are changed by disease or injury
  - metabolism is altered
    - to prevent further cellular damage
    - to promote repair
  - metabolic priorities shift
  - collateral metabolic pathways emerge
Nutritional Status

- Reflects how well nutrient needs will be met over a range of metabolic demands
- Predictive of risk of complications
  - infection/sepsis
  - respiratory disease
  - acute renal failure
  - hepatic encephalopathy
  - congestive heart failure
  - multiple organ failure
Change in Energy Requirements Due to Disease or Injury

- Resting energy expenditure increased by 10-50% (injury factor)
  - to support increased metabolic workload
- An additional allowance is added for activity (activity factor)
  - 20 % if confined to bed
  - 30 % if ambulatory
Change in Resting Energy Expenditure in Trauma

% Above Usual Requirement

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Consequences of unmet energy needs are related to:

- **Amount of weight loss**
  - 20% loss = immune dysfunction
  - 40% loss = fatal

- **Rate of weight loss**
  - 15-20% of usual body weight
  - 10% over previous 6 months
  - 5% over previous month

- **Composition of weight loss**
  - lean body mass
Critical Nature of Loss of Lean Body Mass

- Lean body mass = cell mass
  - metabolically active compartment
- Individual tissue losses proportional to total loss
  - except brain which is primarily lipid
  - no tissue is spared
- Irreversible at some point
  - critical mass
Protein requirements are altered to accommodate:

- Immune response
- Increased metabolic activity
- Replacement of damaged cells
- Replacement of protein losses
  - perspiration, blood, exudates, renal, intestinal
  - ↑ iφ anorexia accompanies fever/infection
  - ↑ by muscle proteolysis
    - up to 35 g/day with metabolic stress
# Characteristics of Metabolic Stress

<table>
<thead>
<tr>
<th>Hormonal</th>
<th>Metabolic</th>
<th>Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td>↑ Catecholamines</td>
<td>↑ REE</td>
<td>↓ pH</td>
</tr>
<tr>
<td>↑ Glucagon</td>
<td>Hyperglycemia</td>
<td>Prostanoids</td>
</tr>
<tr>
<td>↑ Corticosteroids</td>
<td>Ketoacidosis</td>
<td>Leukotrienes</td>
</tr>
<tr>
<td>Insulin Resistance</td>
<td>Uremia</td>
<td>Cytokines</td>
</tr>
</tbody>
</table>
Causes of Muscle Proteolysis with Metabolic Stress

- Increased demand for glucose
  - by leukocytes and fibroblasts (wound)
  - elevated catecholamines and corticosteroids
- Increased rate of gluconeogenesis
  - substrates
- Elevated glucagon
- Insulin resistance
- Accelerated by insufficient energy intake
Effect of Disease and Trauma on Protein Requirements

(without dialysis) (with dialysis)
## Muscle Wasting
### Starvation vs Metabolic Stress

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Starvation</th>
<th>Metabolic Stress</th>
</tr>
</thead>
<tbody>
<tr>
<td>REE</td>
<td>Decreased</td>
<td>Increased</td>
</tr>
<tr>
<td>Muscle Catabolism</td>
<td>Energy</td>
<td>Glucose</td>
</tr>
<tr>
<td>Ketone</td>
<td>Oxidized for Energy</td>
<td>Oxidation Inhibited</td>
</tr>
<tr>
<td>Insulin Levels</td>
<td>Physiological Low</td>
<td>High/Insulin Resistance</td>
</tr>
<tr>
<td>Weight Loss</td>
<td>Fat + Protein</td>
<td>Protein</td>
</tr>
</tbody>
</table>
Vitamin and mineral requirements are altered to accommodate:

- Increased energy requirements
- Increased rate of protein synthesis
- Activation of immune system
- Increased rate of cell proliferation
- Fluid balance

and also ......
Vitamin and mineral requirements are also increased to accommodate:

- Hemostasis
  - coagulation and blood loss
- Replacement of muscle mass
- Prevention of further cellular injury
- Detoxification
  - hormones, drugs, microbial toxins
Disease-Specific Nutritional Adjustments

- Malnutrition contributes to functional deterioration of organ systems
- Disease or injury to organs affects the course of malnutrition
- Dietary adjustments allow nutrients to be processed in the absence of normal function
Nutritional Effects on Cardiovascular Function

- Protein-energy malnutrition/obesity
  - ECG abnormalities
  - Myofibrillar degeneration
  - ↓ cardiac contractility
  - Congestive myopathy
- Vitamin antioxidant deficiencies
  - Poor vascular integrity

- Protein-energy malnutrition
  - ↓ stroke volume
    - Myocardial mass
    - Hypometabolism
  - ↓ cardiac strength

- Fluid/electrolyte imbalances
  - Altered cardiac contractility
  - Abnormal BP
Nutritional Effects on Lung Function

- Stimulation of ventilatory drive
- Maintenance of respiratory muscle mass
- Influence on inflammatory response
- Influence on pulmonary vasomotor tone
Role of the Gastrointestinal Tract in Maintenance of Nutritional Status

- Release of nutrients from dietary sources
  - digestion
  - absorption
- Regulation of nutrient intake
  - appetite/satiety
- Immunological function
Nutritional Problems Associated with Gastrointestinal Disease and Injury

- Reduced digestive/absorptive capacity
- Inability or desire to consume nutrients orally
- Increased nutrient losses
- May involve inflammation
- May involve ulceration
Role of the Liver in Maintenance of Nutritional Status

- Accommodates nutrient stores
- Provides nutrient transport proteins
- Metabolizes amino nitrogen
- Critical to glucose homeostasis
- Activates/deactivates Vitamin D
- Contributes to fluid balance
Nutritional Problems Associated with Liver Disease and Injury

- **Condition-specific effects**
  - hepatitis, cirrhosis, liver failure

- **Impaired protein metabolism (cirrhosis)**
  - ↑ ammonia production and ↓ albumin synthesis

- **Abnormal vitamin/mineral metabolism**

- **Decreased nutrient availability**

- **Blood glucose and lipid abnormalities**
  - hypoglycemia and glucose intolerance
Role of the Kidney in Maintenance of Nutritional Status

- Disposal of metabolic waste
- Maintenance of blood nutrient levels
- Buffering of body fluids
- Vitamin D activation
Nutritional Problems Associated with Renal Disease and Injury

- Decreased excretion of nutrients/waste
  - ↓ GFR
- Insulin resistance
- Decreased lipoprotein lipase activity
- Fluid and electrolyte imbalances
- Loss of bicarbonate
- Abnormal calcium/phosphorus metabolism
Role of the Cardiovascular System in the Maintenance of Nutritional Status

- Delivers oxygen and nutrients
- Transports metabolic waste to disposal sites
- Contributes to fluid and electrolyte balance
- Maintains body temperature
- Influences metabolic rate
Nutritional Problems Associated with Cardiovascular Disease and Injury

- Reduces cardiac output
- Decreased oxygen delivery
  - hypometabolism
- Accumulation of metabolic waste
Role of the Respiratory System in the Maintenance of Nutritional Status

- Regulates oxygen uptake
- Regulates carbon dioxide disposal
- Contributes to acid-base balance
Nutritional Problems Associated with Lung Disease and injury

- Changes fuel source requirement
- Increases energy expenditure for respiration
- Alters acid-base balance
Adjustments in Protein Requirements

- **Restricted intake**
  - acute renal disease
  - hepatic encephalopathy

- **Increased intake**
  - acute renal disease with dialysis
  - chronic renal disease with dialysis
Adjustments in Energy Requirements

- Increased
  - metabolic stress
  - acute renal disease without dialysis

- Decreased/Unchanged
  - acute/chronic renal disease with dialysis
Adjustment in Fluid Requirements

- Increased intake
  - fever
  - metabolic stress

- Decreased intake (with sodium restriction)
  - renal disease
  - liver disease
Micronutrient intakes should be adjusted:

- When energy intakes are increased
- When protein intakes are increased
- For skeletal disease or injury
- With tissue injury
- With fluid imbalances
- With blood loss
- If immune response is activated