Malnutrition: The Skeleton in the Closet Revisited

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I. Objectives

A. What is malnutrition?
B. Identification of persons at nutritional risk
C. Determination of appropriate requirements
D. Monitor response to therapy

II. Suggested Reading

- Jensen GL. Use and Abuse of Visceral Proteins: A Critical Appraisal of their Meaning and Application. (on reserve at library)
- Jensen GL. Clinical guidance from the American College of Physicians. Available at: http://pier.acponline.org (hard copy on reserve at library)

III. What is malnutrition?

A. Etiology for malnutrition

1. Diminished intake
2. Malabsorption / maldigestion
3. Increased utilization
4. Excessive losses
5. Altered metabolism

B. Settings for malnutrition

1. Child abuse
2. Substance disorders
3. Eating disorders
4. Elderly
5. Surgery, injury, or disease

C. Prevalence and recognition

1. Prevalence - hospital or chronic care - 33% or greater
2. Community - less than 10%
3. Physician recognition poor

D. Body composition

1. Lean body mass - 99% of body's metabolic processes
   a. Body cell mass - skeletal muscle (30,000 kcal), visceral protein
   b. Extracellular - basement membrane, bone, tendon, etc.
2. Fat mass - energy storage (100,000 kcal)
3. Female - 32% body fat, Male 18% body fat
4. Aging - decline in lean body mass (sarcopenia)
5. Human body has highly resilient responses to starvation and injury.
6. Methodologies for assessment - anthropometrics, densitometry, bioelectrical impedance, air plethysmography, isotope dilution, imaging - CT, MRI, and DEXA

E. Response to starvation

1. Rapidly deplete glycogen stores
2. Catabolize lean body mass, especially carcass protein, through gluconeogenesis
3. Utilize fat in the form of ketone bodies and free fatty acids
4. Decrease energy expenditure
5. Synthesize only essential proteins
6. Anemia
7. Decrease in insulin concentration

F. Spectrum of malnutrition

1. Marasmus - starvation
   a. Decline in skeletal muscle and SQ fat - evidenced by weight loss
   b. Simple screen 10 lbs over 6-months
   c. Weight loss 10-20% moderate, >20% severe, 33% or greater is life-threatening
   d. Typical disease states - anorexia nervosa, malabsorption, esophageal cancer, anything causing starvation
2. Hypoalbuminemia
   a. Classic Kwashiorkor
      - Diet deficient in quality protein but with abundant carbohydrate.
      - Stressor often a parasitic or infectious condition.
      - Characteristic edema, hypoalbuminemia, and fatty liver.
   b. "Kwashiorkor-like" malnutrition
      - Poor quality protein intake generally not a concern.
      - High prevalence of low albumin observed in hospitalized patients.
      - Common feature is stress response.
   c. Acute phase response
      - Cytokine mediated response to injury, illness, or inflammatory disease (IL-1, IL-6, TNF).
      - Alter hormone secretion and target organ functions favoring a catabolic state.
      - Elevation of resting energy expenditure.
      - Export of amino acids from muscle to liver.
      - Increase in gluconeogenesis.
      - Expansion of extracellular fluid.
      - Shift toward production of positive acute phase reactants (albumin falls).
   d. Disease states impact albumin synthesis / losses
      - Liver disease
      - Nephrotic syndrome
      - Protein-wasting enteropathy
      - Inflammatory diseases
c. Adverse outcomes associated with low albumin
   - Hospital - increased complications, length of stay, re-admissions, mortality
   - Chronic care - increased mortality
   - Community - increased functional limitations, mortality, and risk of hospital admission
3. Spectrum of protein-calorie malnutrition
   a. Can have pure marasmus or stress response syndromes.
   b. Where you fall on the continuum depends upon how long you are starved and the degree of underlying stress.

IV. Identification of persons at nutritional risk

A. Clinical assessment

1. History
   a. Medical history - disease, injury, or surgery
   b. Body weight - loss, gain, dieting
   c. Dietary habits - supplement use, therapeutic diets
   d. Socioeconomic - resources, mobility
2. Physical examination
   a. Marasmus - weight loss
   b. Hypoalbuminemia - edema
   c. Example of specific deficiencies
      - Pellagra - niacin - 4 D's - dermatitis, diarrhea, dementia, death, also Casal's necklace, glossitis
      - Scurvy - vitamin C - perifillicular petechiae, cork-screw hairs, bleeding gums, anemia, thrombocytopenia, poor wound healing
      - Osteomalacia - vitamin D - bone pain and tenderness, proximal weakness, skeletal deformity, waddling gait

B. Anthropometrics

1. Weight - relative to ideal reference tables
2. Weight for height - body mass index (BMI, kg/m2)
   a. BMI < 18.5 - underweight
   b. BMI 25 - 29 - overweight
   c. BMI 30 or greater - obese
3. Skin folds and circumferences - require training

C. Biochemical and metabolic

1. Plasma proteins
   a. Albumin \( (t_{1/2} - 18 \text{ days}) \)
   b. Transferrin \( (t_{1/2} - 8 \text{ days}) \)
   c. Prealbumin \( (t_{1/2} - 2 \text{ days}) \)
   d. Retinol binding protein \( (t_{1/2} - 12 \text{ hours}) \)

2. Other biological markers
   a. Cholesterol – also falls with inflammatory response or underlying disease
   b. C-reactive protein – increases with inflammatory response
Inroduction to Clinical Nutrition
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c. Cytokines
d. Research is needed to validate new indicators of nutritional status.

3. Urine
   a. Creatinine height index - correlates with muscle mass
      \[ \text{CHI} = \frac{\text{measured 24-hr urinary Cr}}{\text{ideal Cr for height and gender}} \times 100 \]
   b. 3-methylhistidine - quantitatively excreted in urine as indicator of muscle catabolism

D. Functional assessments

1. Immunologic
   a. Lymphocyte count - relative lymphopenia < 1000 mm\(^3\)
   b. Skin testing - delayed hypersensitivity - skin test anergy
   c. Lymphocyte subsets, mixed lymphocyte culture, and mitogen response
2. Muscle
   a. Dynamometry - hand grip
3. Wound healing

E. Risk stratification

1. Prognostic Nutritional Index
   \[ \text{PNI} (\%) = 158 - 16.6 (\text{Alb}) - 0.78 (\text{TSF}) - 0.20 (\text{Tfn}) - 5.8 (\text{DH}) \]
   (Alb-albumin, TSF-triceps skin fold, Tfn-transferrin, DH-delayed hypersensitivity)
   Elevated PNI correlates with increased morbidity and mortality in elective gastrointestinal and oncologic surgeries.
2. Subjective Global Assessment
   a. Weight change
   b. Dietary intake
   c. Gastrointestinal symptoms
   d. Functional capacity
   e. Disease
   f. Physical exam

F. Diagnosis as a risk indicator

1. Severe acute pancreatitis
2. Enterocutaneous fistula
3. Mesenteric ischemia
4. Complications of inflammatory bowel disease
5. Short bowel syndrome

V. Determination of appropriate requirements

A. Protein

1. Normal persons - 0.75 - 0.90 gm/kg/day
2. Stressed persons - 1.5 - 2.0 gm/kg/day

B. Energy
1. 25-35 kcal / kg / day for most patients
2. Harris-Benedict Equations
   a. Men: BEE = 66.47 + 13.75 (W) + 5.00 (H) - 6.76 (A)
   b. Women: BEE = 655.10 + 9.56 (W) + 1.85 (H) - 4.68 (A)
      \( W = \) weight in kg; \( H = \) height in cm; \( A = \) age in years
   c. Stress correction factor
      Maintenance energy needs = BEE X 1.2
      Anabolic energy needs = BEE X 1.76
3. Indirect calorimetry - The difference between inspired and expired gas volumes
   is used to determine the quantity of oxygen consumed and CO\(_2\) produced.
   a. Resting energy expenditure (REE) is calculated with the modified Weir equation.
   b. Respiratory quotient (RQ) = VCO\(_2\) / VO\(_2\)
   c. RQ > 1.0 suggests overfeeding
   d. RQ < 0.7 suggests ketosis

VI. Monitor response to therapy

A. Nitrogen balance - reflects catabolism and protein replacement
   1. Protein intake (gm) / 6.25 - [24 hr urinary urea nitrogen (gm) + 4]
   2. Will be negative in highly stressed individuals

B. Anthropometrics
   1. Marasmus - positive nitrogen balance 2-6 gm corresponds to 60-180 gm lean tissue per day
   2. Stressed, hypoalbuminemia - weight is water (edema)

C. Protein markers
   1. Albumin will remain low as long as patient is stressed
   2. Albumin should slowly improve over several weeks once stress is alleviated
   3. Markers with shorter half-life may improve more quickly (like prealbumin)

D. Immune function
   1. Most highly stressed patients will be anergic
   2. Variety of disease states and medications will adversely impact immune assessment
   3. Skin test response may be restored with 2-3 weeks of adequate nutrition if anergy was secondary to malnutrition

VII. Conclusion

A. Practical nutrition assessment
   1. Weight loss or underweight
   2. Albumin or prealbumin as inflammatory indicators
   3. Clinical judgment
B. Key take home points

1. Prevalence of malnutrition in hospital setting
2. Adaptive response to starvation
3. Malnutrition syndromes - marasmus and hypoalbuminemia (stress response)
4. Assessment indicators - weight loss, body mass index, and visceral proteins (albumin / prealbumin)

VIII. Selected references


Electronic Media

IX. Review Questions

1. Marasmus is characterized by ________.
   a. Excess fluid consumption.
   b. Marked peripheral edema.
   c. Weight loss.
   d. Preservation of SQ fat.

2. Life threatening malnutrition occurs when weight loss approximates ________ percent of usual body weight.
   a. 10%
   b. 20%
   c. 25%
   d. 33%

3. Hypoalbuminemia may represent which of the following?
   a. Response to injury / inflammation
   b. Underlying liver disease
   c. Protein wasting enteropathy
   d. Nephrotic syndrome

4. Energy needs may be estimated using ________.
   a. Harris-Benedict Equations
   b. 25-35 kcal/kg/day
   c. Indirect calorimetry
   d. Blayton-Smyth Algorithm

5. Weight gain in a critically ill patient is most likely to represent ________.
   a. Water
   b. Muscle
   c. Fat
   d. Surgical hardware and dressings

Answers: 1-c, 2-d, 3-a,b,c,d, 4-a,b,c, 5-a
Table 1. History and Physical Examination Elements for Nutrient Deficiencies (adapted from reference 24)

<table>
<thead>
<tr>
<th>Category</th>
<th>Element</th>
<th>Notes</th>
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<tbody>
<tr>
<td>History</td>
<td>Chronic disease; medical and surgical conditions</td>
<td>Look for chronic disease or medical or surgical conditions that can place one at nutritional risk like: critical illness, major abdominal surgery or trauma, previous gastrointestinal surgery, severe gastrointestinal hemorrhage, enterocutaneous fistula, gastrointestinal obstruction, mesenteric ischemia, severe acute pancreatitis, chronic exocrine pancreatic insufficiency, inflammatory bowel disease, celiac disease, bacterial overgrowth, malignancy, bone marrow transplant, acquired immune deficiency syndrome, organ failure / transplant - kidney, liver, heart, lung or gut.</td>
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<tr>
<td>History</td>
<td>Constitutional signs / symptoms</td>
<td>Fever, sweats, or chills can indicate active disease or inflammatory response. Anorexia is common with cachexia and is also often a side effect of treatments and medications.</td>
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<tr>
<td>History</td>
<td>Medication use</td>
<td>Many medications can adversely affect nutrient intake or assimilation. Review potential drug – drug and drug – nutrient interactions. A pharmacist consultant can be helpful.</td>
</tr>
<tr>
<td>History</td>
<td>Eating difficulties / gastrointestinal complaints</td>
<td>Poor dentition or problems swallowing can compromise oral intake. Vomiting, abdominal pain abdominal distension, diarrhea, constipation, and gastrointestinal bleeding, can be signs of gastrointestinal pathology that may place one at nutritional risk.</td>
</tr>
<tr>
<td>History</td>
<td>Dietary practices and supplement use</td>
<td>Look for dietary practices including therapeutic, weight reduction, vegetarian, macrobiotic, and fad diets. Also record use of dietary supplements, including vitamins, minerals, and herbals. Ask about dietary intake. Recall, record, and food frequency tools are available. It is estimated that 50% of adults take dietary supplements.</td>
</tr>
<tr>
<td>History</td>
<td>Body weight</td>
<td>Ask about usual weight, peak weight, and deliberate weight loss. A 10-lb weight loss over 6 months is noteworthy and a weight loss of &gt;10% of usual body weight is prognostic of clinical outcomes. Use medical records, family, and caregivers as information resources.</td>
</tr>
<tr>
<td>History</td>
<td>Eating disorders</td>
<td>Look for distorted body image, compulsive exercise, amenorrhea, vomiting, tooth loss, dental caries, and use of laxatives, diuretics or Ipecac.</td>
</tr>
<tr>
<td>History</td>
<td>Influences on nutritional status</td>
<td>Ask about factors such as living environment, functional status (activities of daily living and instrumental activities of daily living), dependency, caregiver status, resources, dentition, alcohol or substance abuse, mental health (depression or dementia), and lifestyle.</td>
</tr>
<tr>
<td>History and Physical Exam</td>
<td>Subjective Global Assessment (SGA)</td>
<td>Subjective Global Assessment combines scored parameters of medical history and physical examination that include weight change, dietary intake, gastrointestinal symptoms, functional capacity, disease, and physical signs of undernutrition. It requires trained practitioners and gives a validated measure of nutritional risk.</td>
</tr>
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| Physical Exam | Body mass index (BMI) | BMI = weight in kg / (height in meters)^2  
BMI <18.5 kg/m^2 proposed screen for undernutrition per NIH guidelines. BMI ≤15 kg/m^2 or less is associated with mortality. Comparison with ideal body weight for stature can also be determined from reference tables. Note hydration status and edema at the time body weight is determined. |
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<tr>
<td>Physical Exam</td>
<td>Weight loss</td>
<td>Look for loss of muscle mass and subcutaneous fat. Temporal and neck muscle wasting may be readily observed. Anthropometrics including skin-folds and circumferences can be useful but require training to achieve reliability.</td>
</tr>
<tr>
<td>Physical Exam</td>
<td>Weakness/ loss of strength</td>
<td>Decreased hand-grip and leg extensor strength have been related to loss of muscle mass in undernourished states. Lower extremity weakness may be observed in thiamine deficiency.</td>
</tr>
<tr>
<td>Physical exam</td>
<td>Peripheral edema</td>
<td>Peripheral edema may confound weight measurements and is often observed with reduced visceral proteins. Edema may also be observed with thiamine deficiency.</td>
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</table>
| Physical Exam | Hair exam              | Hair findings are indicative of certain nutrient deficiencies. Loss: protein, B12, folate  
Brittle: biotin  
Color change: zinc  
Dry: vitamins A & E  
Easy pluckability: protein, biotin, zinc  
Coiled, corkscrew: vitamins A & C  
Alopecia is common in severely undernourished persons. Ask about excessive hair loss on pillow or when combing hair. |
| Physical Exam | Skin exam              | Skin findings are indicative of certain nutrient deficiencies. Desquamation: riboflavin  
Petechiae: vitamins A & C  
Perifollicular hemorrhage: vitamin C  
Ecchymosis: vitamins C & K  
Xerosis, bran-like desquamation: essential fatty acid  
Pigmentation, cracking, crusting: niacin  
Acneiform lesions, follicular keratosis, xerosis: vitamin A  
Acro-orificial dermatitis, erythematous, vesiculbullous, and pustular: zinc  
Characteristic nutritional dermatitis and skin findings may be observed with a number of nutrient deficiencies. Wounds and pressure sores should also be noted as indicators of compromised nutritional status. |
| Physical Exam | Eye exam               | Ocular findings are indicative of certain nutrient deficiencies. Bitot's spots: vitamin A  
Xerosis: vitamin A  
Angular palpebritis: riboflavin  
Also ask about difficulties with night vision/night blindness; indicates vitamin A deficiency. |
### Physical Exam

#### Perioral exam

Perioral findings are indicative of certain nutrient deficiencies. Angular stomatitis and cheilosis: B complex, iron, & protein
Glossitis: niacin, folate, & vitamin B12
Magenta tongue: riboflavin
Bleeding gums, gingivitis, tooth loss: vitamin C

Angular stomatitis, cheilosis, and glossitis are associated with vitamin and mineral deficiencies. Note poor dentition, caries, and tooth loss. Difficulty swallowing and impairment of gag should also be recognized.

#### Extremity exam

Extremity findings indicate certain nutrient deficiencies.
Arthralgia: vitamin C
Calf pain: thiamine
Extremities may also exhibit loss of muscle mass and/or peripheral edema in undernourished patients. Neurological findings in the extremities may also result from deficiencies described below.

#### Mental status / nervous system exam

Mental and nervous system findings indicate certain nutrient deficiencies.
Ophthalmoplegia and foot drop: thiamine
Paresthesia: thiamine, vitamin B12, and biotin
Depressed vibratory and position senses: vitamin B12
Anxiety, depression, and hallucinations: niacin
Memory disturbance: vitamin B12
Hyporeflexia, loss of lower extremity deep tendon reflexes: thiamine and vitamin B12

Conduct formal cognitive and depression assessments are appropriate. Dementia and depression are common causes of undernutrition among older persons. Wernicke-Korsakoff syndrome may be observed with severe thiamine deficiency.

#### Functional assessment

Observe and test functions as indicated: gait, chair stands, stair steps, and balance. These provide complex measures of integrated neurological status, coordination, and strength.