Laboratory assessment of nutritional status in children

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Malnutrition

CHO, proteins, lipids, vitamins, mineral, and trace elements are nutrients that are crucial for human life, growth, and well-being.

Malnutrition: Inadequate intake or use of these nutrients
It is associated with risk of:
- impaired physiologic function
- increased morbidity and mortality

>50% of deaths among children < 5 years old have malnutrition

Causes of child mortality with malnutrition due to:
- diarrhea
- Infections: acute respiratory infection, measles, etc.
Malnutrition:

**Risk factors:**
- Low socio-economic status
- Malabsorption
  - Chronic diarrhea
  - Chronic liver disease
  - Pancreatic diseases
  - Parasites infestation
- Post operative state (ileus with long periods without oral intake)
- Chronic disease: AIDS, TB, chronic renal disease
- Hypermetabolic conditions:
  - major burns; septicemia; ARF; multiple organic failure

Early detection and treatment is needed to avoid morbidity and mortality:
- Increased rates of infections
- Impaired wound healing
- Extended lengths of hospital stay
- Higher mortality rates
Lab work up for malnutrition

Hematology:
- FBC and peripheral smear: anemia from nutritional deficiency such as iron, folate, and vit B12

Biochemistry:
- S-Pre-albumin and transferrin: better short term indicators of protein malnutrition
- S-Albumin: measure of long term malnutrition
- RBP
- S-BUN
- S-electrolytes and creatinine
- LFT
- Blood glucose
- CMP

Microbiology/parasitology/Serology
- Septic screening
- Stool and urine for parasites and bacteria
- HIV

Complication of PEM:
- Hypoglycemia
- Hyponatremia
- Dehydration and shock
- Infections (bacterial, viral, and trush)
- Hypothermia

Other tests:
- Trace elements: Zn, Iodine
- Creatinine/proline ratio
- Coeliac serology:
  - Screening test if family history or presence of other autoimmune diseases
  - IgA tissue transglutaminase Ab (IgA tTG)
  - IgA endomysial antibody (IgA EMA)
Ideal selection of serum proteins in malnutrition

- Proteins with a short biologic half-life reflecting changes in the serum
- Associated with an:
  - Severe infection
  - Stress injury
  - End stage liver disease
  - Renal disease

Ideal s-proteins:
- Albumin
- Transferrin
- Prealbumin
- Retinol binding protein (RBP)
- IGF-1
- Nitrogen balance

Classification of malnutrition from pl. albumin levels:
- Levels >35 g/l : normal
- Levels of 28 to 35 g/l : mild malnutrition
- Levels of 23 to 30 g/l : moderate malnutrition
- Levels < 25 g/l : severe albumin depletion
Transferrin

- Biologic half-life: 9 days
- Synthesized in the liver and binds and transports ferric iron
- High levels in iron deficiency (in proportion to deficiency)
- An early indicator in iron deficiency
- Last analyte to return to normal when iron deficiency is corrected
- More sensitive indicator of protein depletion than s-Alb
- Low levels can also be seen:
  - Nephrotic syndrome
  - Liver disorders
  - Neoplastic disease

Prealbumin

- Biological half-life: 2 days
- Each prealbumin subunit contains one binding site for RBP
- Major transport protein for thyroxin
- Better indicator of visceral protein status and positive nitrogen balance than albumin and transferrin
- Has a superior indicator for monitoring short term effects of nutritional therapy
- In protein-energy malnutrition, there is a greatly decrease levels of prealbumin and RBP complex; but levels return towards normal after nutritional replenishment
- Biologic half-life: 12 hrs
- Can be used to monitor short term changes in nutritional status
- Interacts strongly with plasma prealbumin and circulates in the plasma as a 1:1 mol/l prealbumin-RBP complex

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- Important for stimulation of growth
- Regulated by GH and nutritional intake
- Used as a nutritional marker
- Circulates in plasma bound to IGF-BP3
- IGF-BP3 modulates the biologic effect of IGF-1 in the stress response
Malnutrition

- Protein-calorie malnutrition: Kwashiorkor
- Calorie malnutrition: Marasmus
- Protein loosing enteropathy
- Stress hypermetabolism

Kwashiorkor

- Calorie-protein malnutrition
- Maladaptive response to starvation where the body utilizes proteins and conserves s/c fat
- Significant muscle and nitrogen losses from proteolysis

Clinical presentation:
- Edema
- Mental apathy
- Growth retardation
- Muscle wasting
- Desquamating patchy rash
- Hepatomegaly
- Dehydration (diarrhoea and vomiting)
- Signs of vitamin deficiencies
- Signs of infections

Lab findings:
- ↓TP; ↓Alb; ↓pre-alb
- ↓BUN; ↓Chol
- ↓transferrin; ↓ferritin
- ↓B12; ↓folate; ↓lymphocyte count with severe anemia
Marasmus (wasting)

- Inadequate intake of proteins and calories
- An adaptive response to starvation, the body utilizes all fat stores before using muscle
- Seen most commonly in the 1st yr of life due to lack of breast feeding

Clinical presentation:
- Emaciation
- Severe loss of muscle tissue due to gluconeogenetic activity
- Severe loss of adipose tissue due to increased lipolytic activity
- Severe growth retardation; child looks older than his age
- No edema or hair changes
- Alert but miserable; child appears hungry
- Dehydration (diarrhoea)
- No protein deficiency: normal serum transport proteins levels

Risk factors:
- Poverty and famine
- Diarrhea
- Ignorance and poor maternal nutrition

Protein losing enteropathy

Loss of s-protein into the lumen of GIT due to increased permeability as a result of cell damage or death

Causes:
Any condition causing serious inflammation, erosion, in the intestines such as:
- Intestinal parasite or bacteria infection
- Coeliac sprue
- Necrotizing enterocolitis
- Measles
- Whipple disease
- TB; sarcoidosis
- Lymphatic obstruction

Symptoms:
- depend on underlying disease
- Diarrhea with or without bleeding
- Fever
- Abdominal pain and/or weight loss
- Edema secondary to decreased ploncotic pressure
Lab workup of Protein loosing enteropathy

- ↓ s-alb (exclude NS, chronic liver disease, malnutrition)
- ↓ Igs and lymphocytes
- Abnormal presence of α-1 antitrypsin in stool (important in diagnostic):
  - α-1AT is an endogenous protein not present in diet, not normally actively secreted, absorbed or digested; not secreted in urine
  - α-1AT is stable in feces at 37 °C; detected by IMX
- ↓ fat soluble vitamins (ADEK) in fat malabsorption if lymphatic obstruction

Imaging Tests: MRI or CT of abdomen

Histologic findings: Biopsies for definitive diagnosis of underlying disease

Stress hypermetabolism

- Catabolic state associated with stress injury (trauma, burns and sepsis)
- Driven by cytokines release (IL-1, IL-6 and TNF-α); proportionate to the amount of injury
- Linked to the release of stress hormones such as catecholamine, glucagon, GH, cortisol and thyroid hormones
- Catecholamine and glucagon stimulate hepatic glycolysis
- Adrenal cortisol opposes the effects of insulin (insulin resistance):
  - Muscle proteolysis provides gluconeogenic precursors through alanine
  - Muscle weakness and wasting

Stress Hypermetabolism will result in:
- Hyperglycemia
- Release of FFA and associated ketosis
- Release of IGF-I
- Increase metabolic rate
- Negative nitrogen balance from gluconeogenesis due to massive proteolysis (conversion of lean body protein to a.a)
Stress hypermetabolism

- Patients may become marasmic when the gradual loss of fat tissue is associated with starvation.
- Kwashiorkor is also present in stress injury when there is visceral protein loss.