SURGICAL NUTRITION

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Six Basic Questions

Does the patient need nutritional support?
Is the gut available?
How many calories needed?
How much protein required?
Is there a fluid restriction?
Is the patient responding?
Body Composition

Lean body mass

Total body water/0.73

Components

Body cell mass

- 60% skeletal muscle
- 20% visceral cell mass
- 20% red cells and connective tissue
- Linearly related to total body potassium

Extracellular mass

- Plasma, collagen, fascia, skeleton
- Correlated with total body sodium
Body Composition

- Effect of catabolic stress or malnutrition
  - Contracted body cell mass
  - Expanded extracellular mass
  - Increase in \( \frac{\text{Na}_e}{\text{K}_e} \) ratio \((N = 1.0)\)

- TPN-excess feeding leads to increased body fat without change in body cell mass
Starvation

- Fat primary energy source in unstressed pts
- 0.5 kg/day weight loss in adults
- Survival rare when losses greater than 30-40%
- Lean body mass generally preserved
- Increased utilization of FA with adaption
- Hepatic glucose stores good for 24 hrs
- Muscle stores 3-4 times store of liver glycogen
Endocrine/Protein Changes in Starvation

- Decreased insulin
- Increase due to decreased clearance then decrease due to decreased secretion
- GH increased then decrease after 10 days
- TSH reduced after 10 days
- Increase free plasma cortisol
- Decreased ability to synthesize antibodies
- Decrease in complement proteins (except C4)
- Lymphoid atrophy
- Motility defects in PMNs
**Protein-Calorie Malnutrition**

- **Marasmus** - simple starvation from inadequate nutrients
  - Loss of subcutaneous fat, decreased muscle mass, weight loss

- **Kwashiorkor** - inadequate protein but adequate calories
  - Reduced visceral mass and muscle bulk, edema, hair loss

- **Mixed picture**
  - Most common in hospitalized patients
"She had waffles for breakfast and anorexia for lunch"
Metabolic Response to Trauma and Infection

- Neuroendocrine response
  - Sympathetics primary mediator of stress response
  - Increased secretion of NE and epi
  - Decreased insulin, increased glucagon
  - GH increased for 2-3 days
  - TSH and T4 remain normal
  - Increased ACTH
Metabolic Response to Trauma and Infection

- Na and fluid retention
- Mild metabolic alkalosis
- Metabolic rate increases with magnitude of injury
- Increased protein catabolism
- AA’s mobilized for energy synthesis
- 2-3 fold increase in hepatic glucose production
- Lypolysis is predominant fuel in trauma
- Lipid infusions not protein sparing, unlike glucose
Basic Principles: Nutritional Components

- Carbohydrates
- Fats
- Proteins
- Vitamins
- Trace Metals
- Fiber
Carbohydrates

- 4 kcals/gm (IV solutions-3.4)

Simple sugars

- **Monosaccharides** - glucose, fructose, mannose
  - Absorbed directly in intestines

- **Disaccharides** - sucrose, lactose
  - Cleaved by disaccharidases and absorbed intestinally
Carbohydrates

- Complex polysaccharides
  - Starch, dextrins, glycogen
  - Salivary and pancreatic amylases required
- Not all saccharides can be absorbed
  - Lactulose
  - Fermented in intestines to fatty acids, lactate
CHO Digestion

- Converted to glucose and metabolized as an energy source
- Metabolized as fructose directly
- Erythrocytes, brain, adrenal medulla dependent on glucose alone
- Excess glucose stored as glycogen in muscle and liver cells
- Also converted to pyruvate and acetyl CoA and then stored as fat
Carbohydrates (con’t)

- Intestinal brush border crucial for absorption
- Starvation, stress can lead to atrophy, and poor absorption
- Glycogen acts as a storage depot but good for only 18-24 hours at best (1000-1500 kcal)
“One horsepower is the amount of energy required to drag a horse 500 feet in one second.”
Fats

- 9 kcals/gm
- Body’s principal form of energy storage
- Tolerated up to 2-4 gm/kg/day (25% of total calories)

Avoid fat overload syndrome
- Hyperlipidemia
- Coagulopathy
- Respiratory distress
Fats

- Essential fatty acids - Linoleic and Linolenic
- Essential fatty acid deficiency manifests as dermatitis and alopecia
  - Usually seen in patients on TPN without lipid supplement
- Omega 3 fatty acids participate in synthesis of prostaglandins and cell membranes
Protein

- Should not be considered a source of calories
- Hydrolyzed in GI tract - pepsin, trypsin, chymotrypsin, intestinal proteases
- Enter portal circulation as free amino acids
- Branched-chain amino acids catabolized in muscle
- All other essential AA’s catabolized in liver
Protein (con’t)

¬ Body’s protein exists in dynamic state with constant synthesis, degradation, and resynthesis

¬ Must have adequate calories or AA’s are used as energy substrate

¬ Essential AA’s are:
  ¬ Leucine, Isoleucine
  ¬ Valine, lysine
  ¬ Methionine, Phenylalanine
  ¬ Threonine, Tryptophan
Glutamine

- Non essential AA but essential in times of stress
- Major AA stored in muscle protein
- Released in high quantities after stress and injury
- Specific fuel for enterocyte
- Missing from TPN—may explain loss of gut microvilli
- Available in most enteral solutions
Arginine

- Semi essential AA
- Shown to increase wound healing and immunologic reactivity in animal models
- Increased wound healing and T-cell response in humans
- Available in small amounts in TPN and large amounts in enteral solutions
- Potent secretagogue - stimulates GH, insulin, glucagon, prolactin, somatostatin
Vitamins

- Fat soluble-A, D, E, and K
- Water soluble- B complex, biotin, folic acid, C
- Vitamin A
  - Most stored in liver
  - Useful for wound healing, preventing stress gastritis in hospitalized patients
Vitamins

- **Vitamin D**
  - Hospitalized pt must rely on exogenous sources
  - Most important role is absorption of dietary calcium

- **Vitamin K**
  - Dependent clotting factors-II, VII, IX, X
  - Deficient in broad spectrum antibiotic therapy, obstructive jaundice, malnutrition
Kids talk science...

“There are 26 vitamins in all, but some of the letters are yet to be discovered. Finding them all means living forever.”
Fiber

- Delays gastric emptying
- Absorbs bile acids which increases fat soluble absorption and decreases destruction of bile acids by bacteria
- Increases stool weight
- Decrease diarrhea—not clinically proven
Nutritional Assessment

- **Somatic profile**
  - Midarm circ., triceps skin fold
  - Not reliable in individuals

- **Creatinine height index**
  - Correlates Cr Excretion and muscle mass
  - Better in chronic malnourished patients
  - Altered by dietary meat and renal function
Visceral Proteins

- Albumin (1/2 life = 17 days)
  - Changes with stress and hydration
  - Better in chronic states

- Transferrin (1/2 life = 8 days)
  - More sensitive than albumin
  - May be altered by iron deficiency
Visceral Proteins

- Retinol binding protein and pre-albumin
  - 12 hours and 2 days ½ life
  - Both decrease in liver disease

- Immunologic profile
  - DH skin tests
    - Correlates with sepsis and mortality
  - Total lymphocyte count
    - Normal: > 1500/ml; nonspecific
Prognostic nutritional assessment
- Complications increase in linear correlation to PNI
- \[ PNI(\%) = 158 - 16.6(Alb) - 0.78(TSF) - 0.2(Trnsfrn) - 5.8(DH) \]

Dynamic nutritional assessment
- Nitrogen excretion and balance
  - Best measured by 24 hr urine for urea N
  - < 5 gm urea N in unstressed starvation state
  - 10-30 gms lost following injury or infection
  - Can underestimate due to losses through skin, wounds, fistulas
Assessment (Con’t)

- Dynamic nutritional assessment
  - 3-methylhistidine
    - Liberated from breakdown of actin and myosin
    - Increased with refeeding in starved patients
    - No better than nitrogen balance
- Body weight
- Indirect Calorimetry
Energy Expenditure Calculations

- Harris-Benedict equation
  - (Men) 66 + (13.7 x wt) + (5 x ht) - (6.8 x age)
  - (Women) 655 + (9.6 x wt) + (18 x ht) - (4.7 x age)

- Metabolic cart-excellent with ICU patients on ventilators
  - determines respiratory quotient
  - RQ for CHO is 1.0, fat 0.7

- Nitrogen balance determination—"Gold
Nutritional Support

- Parenteral Feeding
  - Used when gut is unavailable or unsuitable

- Enteral Feeding
  - Associated with fewer complications than TPN
    - Preserves gut mucosal integrity better

- Requirements
  - 20-25 Kcal/kg/day in most pts
  - 150:1 Kcal:N ratio in most surgical pts
Enteral Support
“*If the Gut works use it*”

• Lack of enteral stimulus leads to
  ▶ Gut atrophy
  ▶ Decreased villous height and mass
  ▶ Decreased “good” bacteria
  ▶ Increased translocation of bacteria
  ▶ Increased absorption of endotoxin
“She stated that she had been constipated for most of her life, until she got a divorce.”
Enteral Solutions

- Calorie-volume ratio
  - most are 1.0 kcal/ml

- Osmolality
  - major determinant of diarrhea

- Carbohydrate source
  - most are lactose free

- Protein content
  - most commonly mixed proteins and amino acids
Enteral Solutions

- Pure elemental (Vivonex, Vital, Immunaid) designed for efficient absorption, unpalatable
- Standard Polymeric (Ensure, Promote)
- Fiber enriched (Jevity)
- Specialty (Nepro, Impact, Alitraq)
Route of Administration

- **Oral**
  - Palatable, awake patient with intact gag reflex

- **Gastric** - nasogastric tube vs gastrostomy
  - Risk of aspiration, monitor gastric residuals

- **Jejeunal** - nasoenteric or J tube
  - Least risk of aspiration, can begin early
Complications of Enteral Feeding

- Gut necrosis associated with feeding an under resuscitated patient
- Aspiration
- Diarrhea
- Hyperosmolar, hyperglycemic dehydration
- Tube complications
- Intolerance to tube feedings
Parenteral Feeding

❖ To be used only when the gut doesn’t work
❖ Requires central venous access
❖ PIC lines make peripheral TPN obsolete
❖ Generally 1.0 kcal/ml with a 25% dextrose and 10% lipid solution
❖ Protein 1.5 gm/kg/day—most AA’s except glutamine
Total Parenteral Nutrition

Ingredients

- Protein: essential AA’s, need adequate calories to fully utilize
- Carbohydrates: all converted to glucose
- Fat: prevent essential FA deficiency, 2-4 gm/kg/day (25% of total calories)
- Vitamins: water soluble daily; A, D, E, K twice weekly

Trace minerals

- Zinc 3-6 mg/day, deficiency: dermatitis around ala, lips, decreased wound healing
- Copper 0.5 mg/day, deficiency: neutropenia, megaloblastic anemia
- Chromium 15 mcg/day, deficiency: diabetic state, neuropathy
Indications for TPN

- Small bowel resection/disease
- Radiation enteritis
- Intractable vomiting/diarrhea
- Chemo/radiation therapy
- Severe pancreatitis
- Malnutrition with nonfunctional GI tract
- Severely catabolic pts with nonfunc. GI tract
From patients charts...

“The patient was to have a bowel resection. However, he took a job as a stock broker instead.”
Contraindications to TPN

- Pts with functional GI tract
- TPN needed < 5 days
- Poor prognosis patients
- Risks outweigh benefits
Complications of TPN

- **Technical (most common, <5% incidence)**
  - Pneumothorax, arterial laceration, venous thrombosis, arrhythmias, thoracic duct injury

- **Infection**
  - Catheter sepsis (2-30% incidence), Staph aureus or epidermidis, Candida
  - Most occur > 2 weeks after insertion
  - Electrolyte disturbances
Complications of TPN

- Metabolic
  - K, PO₄, Mg imbalance
  - Trace element deficiencies (Zinc, Cu, Chromium)
  - Essential fatty acid deficiency
    - Decreased levels of linoleic and arachidonic acid
    - Impaired wound healing, dry, flaky rash, platelet dysfunction, anemia, respiratory distress
    - Occurs within two weeks

- Vitamins
Complications of TPN

Glucose

▲ Hypoglycemia (slowing of infusion, excess insulin)

▲ Hyperglycemia (most dangerous)
   ▶ Sudden intolerance -- sepsis
   ▶ Hypertonic hyperglycemic nonketotic coma
      • Fever, obtundation, osmotic diuresis
      • Blood glucose: 700-1400
      • Tx: insulin, hypotonic salt solutions
Specific Organ Support

- Hepatic encephalopathy
  - 1.0 - 1.4 gm protein good with higher BCAA/AAA ratio
  - No survival benefit seen in studies

- Renal Failure
  - Restrict volume, increase caloric density
  - Nephramine-expensive and not worth it
  - Once dialysis begins use standard solutions and amounts

- Respiratory failure
  - Excess CHO leads to increased R/Q and CO2 production
  - During weaning may need to increase calories due to increased work of breathing
Monitoring Nutritional Support

- Blood tests
  - Glucose, electrolytes
  - Triglycerides
  - Albumin, transferrin, prealbumin

- Measure nitrogen balance
  - Nitrogen In = Gms of Protein/6.25
  - Nitrogen out = 24 hr UUN + 4 (fudge factor for non-urea nitrogen losses)
Special Problems

- Pancreatitis
  - TPN affords pancreatic rest but benefit not proven
  - Enteral route is best if able to place a tube past the pylorus

- Stress Gastritis
  - Addition of food to stomach is most efficient means of preventing stress gastritis
  - H2 blockers or carafate are useful in head injured, burn or ventilator dependent patients
Special Problems

- **Head Injury**
  - Increased nitrogen losses-peaking at 10th day
  - Hyperglycemia must be avoided

- **Burns**
  - Severely stressed
  - Daily calories = 25 kcal/kg + 40 kcal/%BSA burn
  - Increased protein needs (2-3 gm/kg/day)
  - Increased Vit A, Vit C, folic acid, zinc
Overfeeding

- Respiratory quotient (RQ) is 1.0 for CHO and 0.7 for fat
- RQ > 1.0 leads to lipogenesis
- Excess calories can lead to fatty liver
- Increased CO2 production makes weaning difficult
“Patient’s past medical history has been remarkably insignificant with only a 40 pound weight gain in the past three days”