Preop Evaluation/Post Operative Care (Nutrition, Pain Management)

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Topics

- Preoperative evaluation
- Post operative care
  - Pain management
  - Fluids and electrolytes
  - Nutrition
Pre Operative Evaluation

- Why is it important...
  - Abnormal physiologic and metabolic state
  - Stress
  - Establish a relationship with the patient
  - Determine the decision maker (patient or a surrogate)
  - Informed consent .... More than just a form
  - History and physical
  - Adjuncts to evaluation
Obtaining a good history

- HPI – start with open question and transition to closed, specific questions
- Family history
  - especially pertinent disease processes
- Allergies and drug sensitivities
- Medication history
  - Prescription drugs
  - OTC agents
  - Herbal remedies
- ROS – be specific!
- In emergencies…AMPLE
Adjuncts

- Laboratory studies – selective studies
  - Example: CBC only in patients at risk for anemia AND a surgery with expectations of high blood loss
  - Example: serum creat/lytes in only in patients with DM, HTN, heart/renal/hepatic disease, vomiting, patients on diuretics

- Specialty consultations
<table>
<thead>
<tr>
<th>Test</th>
<th>Incidence of Abnormalities That Change Management</th>
<th>LR+</th>
<th>LR−</th>
<th>Indications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hemoglobin</td>
<td>0.1%</td>
<td>3.3</td>
<td>0.90</td>
<td>Anticipated major blood loss or symptoms/history of anemia</td>
</tr>
<tr>
<td>White blood count</td>
<td>0.0%</td>
<td>0.0</td>
<td>1.0</td>
<td>Symptoms suggestive of infection, myeloproliferative disease, myelotoxic medications</td>
</tr>
<tr>
<td>Platelet count</td>
<td>0.0%</td>
<td>0.0</td>
<td>1.0</td>
<td>History of bleeding disorder/bruising, myeloproliferative disease, myelotoxic medications, splenomegaly</td>
</tr>
<tr>
<td>Prothrombin time</td>
<td>0.0%</td>
<td>0.0</td>
<td>1.0</td>
<td>History of bleeding disorder/bruising, chronic liver disease, malnutrition, recent or long-term antibiotic-warfarin use</td>
</tr>
<tr>
<td>Partial thromboplastin time</td>
<td>0.1%</td>
<td>1.7</td>
<td>0.86</td>
<td>History of bleeding diathesis, anticoagulant medication</td>
</tr>
<tr>
<td>Electrolytes</td>
<td>1.8%</td>
<td>4.3</td>
<td>0.80</td>
<td>Chronic renal insufficiency, CHF, diuretic use, other meds that affect electrolytes</td>
</tr>
<tr>
<td>Renal function tests</td>
<td>2.6%</td>
<td>3.3</td>
<td>0.81</td>
<td>Age 50, hypertension, cardiac disease, major surgery, medications that may alter renal function</td>
</tr>
<tr>
<td>Glucose</td>
<td>0.5%</td>
<td>1.6</td>
<td>0.85</td>
<td>Obesity, known diabetes or symptoms thereof</td>
</tr>
<tr>
<td>Liver function tests</td>
<td>0.1%</td>
<td>1.7</td>
<td>0.97</td>
<td>No indication, consider albumin measurement for major surgery or chronic illness</td>
</tr>
<tr>
<td>Urinalysis</td>
<td>1.4%</td>
<td>1.6</td>
<td>0.96</td>
<td>No indication</td>
</tr>
<tr>
<td>Electrocardiogram</td>
<td>2.6%</td>
<td>1.6</td>
<td>0.96</td>
<td>Men &gt; 40, women &gt; 50, known coronary artery disease, diabetes or hypertension</td>
</tr>
<tr>
<td>Chest x-ray</td>
<td>3.0%</td>
<td>2.5</td>
<td>0.72</td>
<td>Age &gt; 50, known cardiac or pulmonary disease or symptoms or exam findings suggesting cardiac or pulmonary disease</td>
</tr>
</tbody>
</table>

LR+, Likelihood ratio that a test will be abnormal in the absence of symptoms or signs; LR−, Likelihood ratio that a test will be normal in the absence of symptoms or signs; CHF, congestive heart failure.

Cardiac Risk

- Increased risk of MI:
  - Surge in catecholamines
  - Supression of fibrinolytic system

- Perioperative MI risk in patients with previous MI:
  5-10% (with assoc. mortality of 50%)
  - If within 3 months of MI: 30% risk of additional cardiac event → 5% if wait >6 months

- Diabetes: significantly increases cardiac risk
  - 5-10 yr history of DM: 60% have vascular disease
  - >20 h/o DM: nearly 100%

- Continue perioperative betablockers and statins!
Cardiac Risk Stratification

- Dripps - American Surgical Association Classification
- Revised Cardiac Risk Index

What are the ACC/AHA 2009 Guidelines for Preoperative Assessment?

Step 1: Need for emergency noncardiac surgery?
  - Yes (Class II, LOE B)
  - Operating room
  - Perioperative surveillance and postoperative risk stratification and risk factor management

Step 2: Active cardiac conditions?
  - Yes
  - Evaluate and treat per guidelines
  - Consider operating room

Step 3: Low risk surgery
  - Yes
  - Proceed with planned surgery

Step 4: Functional capacity ≥ 4 METs without symptoms?
  - Yes
  - Proceed with planned surgery

Step 5: ≥ 3 clinical risk factors?
  - Vascular surgery
  - Consider testing if it will change management

1-2 clinical risk factors?
  - Intermediate risk surgery
  - Proceed with planned surgery with HR control or consider noninvasive testing if it will change management

No or Unknown
  - Vascular surgery
  - Intermediate risk surgery
  - Proceed with planned surgery

* Pulmonary disease
* Renal disease
* Diabetes
* Viral hepatitis
* Systemic lupus erythematosus
* End-stage renal disease
* Cancer

Interventional lung procedures
- Apparent in 

- Possibly found in 

- Possibly found in
Pulmonary Risk

- Good H&P to identify patients at risk:
  - Smoking hx, asthma, COPD, OSA, CHF, previous pulmonary complications, exercise tolerance, etc
- ASA score
- Modifiable factors:
  - Recommend d/c smoking 6 wks preop
  - Low serum albumin (<3.5)
- Procedure related risk factors:
  - Surgical site
  - Duration of surgery
  - Anesthesia

<table>
<thead>
<tr>
<th>ASA Classification of Patient</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASA I</td>
<td>No known systemic disease</td>
</tr>
<tr>
<td>ASA II</td>
<td>Mild or well-controlled systemic disease</td>
</tr>
<tr>
<td>ASA III</td>
<td>Multiple or moderate controlled systemic disease(s)</td>
</tr>
<tr>
<td>ASA IV</td>
<td>Poorly controlled systemic diseases(s)</td>
</tr>
<tr>
<td>ASA V</td>
<td>Moribund patient</td>
</tr>
<tr>
<td>E</td>
<td>Connotes emergency</td>
</tr>
</tbody>
</table>

Table 1: American Society of Anesthesiologists classification of patients.
Pulmonary Risk

- Additional studies: PFTs
  - For patients at high risk or patients undergoing pulmonary surgery (dyspnea with minimal exertion, etc)
  - Minimum recommendations for proceeding without pre-op intervention due to increased risk of pna, death, VDRF:
    - FEV1 > 1L
    - PaO2 > 50 mmHg
    - PaCO2 < 45 mmHg

- Special considerations for patients undergoing pulmonary surgery
Renal Dysfunction

- CKD = dysfunction for > 3 months
  - Malnourishment due to derangements in nitrogen end product metabolism
  - anemia

- Periop AKI
  - Usually due to ATN (1% risk in surgical patients)
    - Risk factors:
      - Increased age
      - PMH of kidney disease
      - LVEF < 35% or CI of <1.7 L/min/m2
      - HTN
      - PVD
      - DM
      - Emergency surgery
      - High risk surgery
Renal Dysfunction Management

- Periop fluid optimization
  - Sometimes requiring invasive hemodynamic monitoring
- Close monitoring of electrolytes; at risk for
  - Hyperkalemia
  - Hypocalcemia
  - Hyperphosphatemia
  - Hypermagnesemia
- Daily weighing and accurate I/Os
- Avoid any nephrotoxins
Hepatic Dysfunction

- Increased incidence due to obesity and NASH
- Frequently asymptomatic until very progressed (regardless of etiology)
- Requires thorough evaluation of risk factors and physical exam
- Contraindications to elective surgery in patients with liver disease:
  - Acute liver failure
  - AKI
  - Acute viral hepatitis
  - Alcoholic hepatitis
  - Cardiomyopathy
  - Hypoxemia
  - Severe coagulopathy (despite treatment)

- MELD score general risk (not lap chole):
  - <8 – mortality of 5%
  - 8-11 – mortality risk of 10%
  - 12-15 – mortality risk of 25%

MELD = 3.78 x \log_e \text{serum bilirubin (mg/dL)} + 11.20 \times \log_e \text{INR} + 9.57 \times \log_e \text{serum creatinine (mg/dL)} + 6.43 (constant for liver disease etiology)

NOTES:
- If the patient has been dialyzed twice within the last 7 days, then the value for serum creatinine used should be 4.0
- Any value less than one is given a value of 1 (i.e. if bilirubin is 0.8, a value of 1.0 is used) to prevent the occurrence of scores below 0 (the natural logarithm of 1 is 0, and any value below 1 would yield a negative result)
- Why does it matter...
  - Increased risk of wound dehiscence and hernias
  - Impaired ventilation
  - Periop alcohol withdrawal and wernicke-korsakoff syndrome (give thiamine!)
  - Increased bleeding due to depleted vit K stores
  - Protein malnutrition
Diabetic Patients

- Perioperative abnormalities due to surgical stress
  - peripheral insulin resistance
  - Increased hepatic glucose production
  - Impaired insulin production
- Additional organ system involvement
  - Cardiac
  - Gastroparesis
  - Immune response (inc risk of infection)
  - Vascular disease
- MUST maintain strict glycemic control
Additional Special Considerations

- Adrenally insufficient patients
  - Generally patients who get prednisone or equivalent at 20 mg/day for >3 wks should get stress dose steroids
  - Vitamin A

- Pregnant patients
  - Multiple physiologic and anatomic alterations; for another lecture...
  - Ideally operate during 2\(^{nd}\) trimester
    - Lowest risk of precipitating spontaneous abortion or preterm labor

- Geriatric patients
  - Special attention to medications
  - Need established goals of care and family involvement
Elements of the Op Note

- GI tract tubes
- Drains
- Respiratory tubes
- Foley
- Negative pressure
- Wound dressing
Post op Care

- Wound care
  - Primary closure
  - Secondary closure

- Pain management
  - PO
  - IV
  - PCA
  - Epidural/spinal

- DVT prophylaxis
  - Periop risk of DVT = 25% if no ppx
  - Virchow's triad
    - stasis, hypercoagulability, endothelial injury
Post Op Complications

- Malignant hyperthermia
  - 1/14,000 children and 1/50,000 adults
  - Disruption of calcium metabolism
  - Symptoms:
    - Increased ETCO2
    - Temp (rise as much as 1-2 deg every 5 min)
    - Tachycardia, cyanosis, muscle rigidity
    - Compartment syndromes
    - Cardiac disturbances
  - Need early recognition (mortality now 5%, previously >70%)
  - Treatment:
    - d/c agent
    - IVF
    - Dantrolene (1 mg/kg)
Post Op Complications

- Atelectasis
  - Incentive spirometry
  - Chest physiotherapy

- Wound complications
  - Dehiscence
  - Evisceration
  - SSI (2-5% of all patients)

- Fever
  - Wind, water, wound, walking, wonder drug
  - Check out all lines/tubes
  - C.Diff
Total Body Water and Compartments

- Muscle mass = 70% water
- Fat mass = 10% water
- TBW = ~60% of weight (proportional to body composition)
  - Exceptions: elderly, morbidly obese
- **Intracellular fluid**
  - (+) potassium (high), magnesium
  - (-) phosphates, sulfates and proteins

- **Extracellular fluid (plasma and interstitial space)**
  - (+) sodium (high), potassium, calcium, magnesium
  - (-) chloride, bicarb, proteins, sulfates, organic acids

- **Colloid osmotic pressure generated by protein gradient**
Sodium

- Osmolarity =
  \[2 \times [\text{Na}^+] + \left(\frac{\text{glucose}}{18}\right) + \left(\frac{\text{BUN}}{2.8}\right)\]
- Normal osmolarity = 290 +/- 10 mOsmol/L
- Normal adult requirement 1-2 mEq/kg
- Excess excreted by kidneys
- Aldosterone: causes resorption of Na in exchange for K+ and H+ in distal tubule (RAAS)
- Antidiuretic hormone (ADH, vasopressin): reabsorption of water from cells in DCT via aquaporins
↓ Extracellular volume
  ↓
   ↑ Angiotensin II
  ↓
   ↑ Aldosterone
  ↓
  ↓ Renal blood flow
  ↓ Glomerular filtration rate
  → ↑ Na⁺ reabsorption
  ↓ Renal Na⁺ excretion
  ↓
  ↓
  ↑ Blood pressure
  → ↑ Extracellular volume

↑ Sympathetic nerve activity
  ↓
  ↑ Cardiac output
  ↑ Peripheral resistance
- **Hyponatremia**
  - HA, delirium, seizures, N/V
  - Excessive free H2O or Na loss
  - Tx: H2O restriction, then diuresis
  - Correction rate should not exceed 0.5-1mEq/hr or central pontine myelinosis can occur
  - **Na deficit = TBW x (140-Na)**

- **Hypernatremia**
  - Restlessness, irritability, ataxia, seizures
  - Excessive free H2O loss
  - Rapid correction risks cerebral edema and brain stem herniation
  - **Total free H2O deficit = TBW x ([Na-140]/140)**
Potassium

- 98% intracellular
- Normal level 3.5-5.0 mEq/L
- Normal daily requirements 0.5-0.8 mEq/kg
- Hypokalemia
  - Paralysis, ileus, EKG – flattened T waves, depressed ST segments, U waves
  - Redistribution to ICF or depletion
  - Tx: replace K, also replace Mag if low
- Hyperkalemia
  - Weakness, paresthesia, EKG – peaked T waves, flattened P waves
  - Decreased renal function, medications, crush injuries, massive blood transfusion
  - Tx: calcium gluconate, Na HCO3, 10 units regular insulin: 1amp D$_{50}$W, kayexalate, dialysis
Calcium

- 40% bound to plasma protein (albumin), 10% complexed, 50% ionized
- Ionized portion is physiologically active
- Normal levels 8-10.5 mg/dL, iCal 4.75-5.4 mg/dL
- Corrected total Ca = [0.8x(4.0-albumin)] + total serum Ca
- Hypocalcemia (<8.0)
  - Perioral tingling, muscle cramps, paresthesia, hyperactive deep tendon reflexes, Chvostek’s sign, Trousseau’s sign, EKG – prolonged QT interval
  - Hypoparathyroidism, vit D deficiency, renal failure
  - Tx: replace if symptomatic, replace Mag
  - Adjusted total Ca = [0.8 x (nl albumin – pt albumin)] + Ca
- Hypercalcemia
  - Muscle fatigue, weakness, personality d/o, confusion, depression, coma, N/V, abd pain
  - Hyperparathyroidism or malignancy
  - Tx: NSS @200-300cc/hr, lasix
Magnesium

- Important cofactor for many enzymes
- 99% intracellular, bound to ATP
- Average intake 15-30 mEq
- Absorbed in jejunum and ileum
- Excreted by kidneys
- Hypomagnesemia
  - Similar to hypocalcemia, weakness, muscle fasciculations, N/V
  - Caused by dietary deficiency, GI losses, chronic alcoholism
- Hypermagnesemia
  - Loss of deep tendon reflexes, paralysis
  - Severe burns, crush injuries, renal insufficiency
  - Tx: volume, loop diuretic, dialysis
Phosphorous

- 85% bound in bone
- Normal requirement 2-9 mg/kg
- Excretion controlled by PTH in kidneys
- Normal level 2.5-4.5 mg/dL
- Hypophosphatemia
  - Causes losses of K and mag
  - Inadequate uptake (malabsorption, GI losses, prolonged antacid use, vit D deficiency) or increased renal excretion (diuretics, SIADH, hypoparathyroidism)
  - Anorexia, dizziness, osteomalacia, severe cardiomyopathy, muscle weakness, visual defects, anemia, respiratory failure, leukocyte and erythrocyte failure
  - Treatment – identify cause, replace
- Hyperphosphatemia
  - Decreased renal excretion, increased absorption (excessive vitD, sarcoidosis)
  - No symptoms
  - Treatment: aluminum based antacids, diuretics, dialysis, does not always need to be treated
Volume Depletion

- **Causes:** acute blood loss, EDF loss, total body water reductions
  - Vomiting, diarrhea, NGT, enteric fistulas
- **Signs:** change in heart rate, pulse pressure, oliguria, elevated Hct, urinary concentration
- Urine [Na] <20 mEq/L
- BUN/creat 20:1
- Urine osmolality >400
- FeNa = \((UNa/Pcr)/(PNa/Ucr)\) x 100
  - FeNa <1% prerenal azotemia
  - FeNa >2% renal injury
# Volume losses

<table>
<thead>
<tr>
<th>Organ</th>
<th>Component</th>
<th>Average daily volume (mL)</th>
<th>Minimal daily volume (mL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Saliva</td>
<td>K</td>
<td>1L/d</td>
<td></td>
</tr>
<tr>
<td>Stomach</td>
<td>H, Cl</td>
<td>1-2L/d</td>
<td></td>
</tr>
<tr>
<td>Pancreas</td>
<td>HCO$_3$</td>
<td>1L/d</td>
<td></td>
</tr>
<tr>
<td>Bile</td>
<td>HCO$_3$</td>
<td>0.5-1L/d</td>
<td></td>
</tr>
<tr>
<td>Small intestine</td>
<td>HCO$_3$, K</td>
<td>1-2L/d</td>
<td></td>
</tr>
<tr>
<td>Colon</td>
<td>K</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Losses</th>
<th>Average daily volume (mL)</th>
<th>Minimal daily volume (mL)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sensible losses</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urinary</td>
<td>800–1,500</td>
<td>300</td>
</tr>
<tr>
<td>Intestinal/Stool</td>
<td>0–250</td>
<td>0</td>
</tr>
<tr>
<td>Sweat</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Insensible losses</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lungs and skin</td>
<td>600–900</td>
<td>600–900</td>
</tr>
</tbody>
</table>
# IVF

- **Maintenance fluid:**
  - 4-2-1 rule for cc/hr
  - 100-50-20 rule for cc/day

<table>
<thead>
<tr>
<th>Solution</th>
<th>Electrolyte(mEq/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Na⁺</td>
</tr>
<tr>
<td>0.9% NaCl</td>
<td>154</td>
</tr>
<tr>
<td>0.45% NaCl</td>
<td>77</td>
</tr>
<tr>
<td>Lactated Ringer's</td>
<td>130</td>
</tr>
<tr>
<td>3.0% NaCl</td>
<td>513</td>
</tr>
</tbody>
</table>
ACID-BASE Balance

- pH = pKa + log [HCO3]/[H2CO3]
- [H+] = 24 × PaCO2/[HCO3]
- Normal pH = 7.4 +/- 0.05
Metabolic Acidosis

- **Anion Gap** = Na – (Cl + HCO₃)  
  - Normal is 12 +/- 2 mEq/L
- Decreased HCO₃ content (consumption or loss) or decreased H excretion
- **MUDPILES** - Gap  
  - methanol, uremia, DKA, paraldehydes, isoniazid, lactic acidosis ethylene glycol, salicylates
- **HARD UP** - Nongap  
  - hyperalimentation, acetazolamide, renal tubular acidosis, diarrhea, ureteroenteric fistula, pancreaticoduodenal fistula
- Renal compensation – increase net excretion of H, takes 2-4 days
- Respiratory compensation – hyperventilation, takes 12-24 hrs  
  \[ \Delta PCO₂ = 1.2 \times \Delta HCO₃ \pm 2 \]
Metabolic Alkalosis

- Loss of HCl, inhibited renal excretion of HCO3
- Vomiting/NGT suctioning results in
  - hypochloremic, hypokalemic, metabolic alkalosis, paradoxical aciduria
  - Volume depletion triggers aldosterone production
- Respiratory compensation – hypoventilation which is limited by hypoxia, least effective compensatory mechanism
  \[ \Delta \text{PCO}_2 = 0.7 \times \Delta \text{HCO}_3 \pm 5 \]
- Tx: correct K and volume depletion with chloride containing solution
Respiratory Acid-Base Disturbances

- **Alkalosis**
  - Hyperventilation secondary to hypoxia
  - Compensatory mechanism – tissue buffering ie. RBCs, occurs in minutes
  - Renal – decreasing net acid excretion, 2-3 days
  - Tx: address underlying stimulus for hyperventilation, determine and correct hypoxemia

- **Acidosis**
  - Inadequate ventilation – CNS depression, COPD, airway obstruction
  - Compensation mechanism – tissue buffering and increased renal excretion of acid
  - Tx: correct underlying cause
  - Chronic hypercapnia – complete correction of hypoxemia may further suppress respiratory drive and worsen respiratory acidosis
Nutrition

- **Basic needs:**
  - **Kcals a person requires per day:**
    - 25-30 kcal/kg/day
  - **Fluid requirements per day:**
    - 30-40 mL/kg/day
  - **Protein requirements per day:**
    - Normal
      - 0.8-1.0 grams/kg/day
    - Surgery
      - 1.5-2.0 grams/kg/day
    - Renal patients, pts with cirrhosis will have different requirements
- **Protein**
  - 20-30% caloric intake
  - 4 kcal/g
  - Glutamine: primary fuel for small intestine enterocytes

- **Lipids:**
  - 30% daily caloric intake, 2-4% as essential fatty acids
  - 9 kcal/g

- **Carbohydrates**
  - 50-60% daily caloric intake
  - Need 120 g/day for CNS function
  - Glucose = 4 kcal/g
  - Dextrose = 3.4 kcal/g
  - Primary fuel source for brain, RBC, WBC
Nutritional Assessment

- As always...H&P
  - Medications, BMI, type of surgery, recent changes in weight, appetite, (visceral proteins)

- Options:
  - Enteral
  - parenteral

- Always try to feed enterally!
  - Avoid mucosal compromise
  - Large role in immunologic function
  - Avoid bacterial translocation
  - Supported by multiple studies from burn patients to head injury pts
## Enteral Formulations

### LEHIGH VALLEY HOSPITAL — ENTERAL NUTRITION FORMULARY

<table>
<thead>
<tr>
<th>Category</th>
<th>Isotonic</th>
<th>Isotonic With Fiber</th>
<th>High Protein With Fiber</th>
<th>Concentrated Calories</th>
<th>Calorie and Protein Dense</th>
<th>Very High Protein With Fiber</th>
<th>Renal (Dialysis)</th>
<th>Immunonutrition</th>
<th>Immunonutrition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product Name</td>
<td>Osmolite® 1 Cal</td>
<td>Jevel® 1 Cal</td>
<td>Jevel® 1.2 Cal</td>
<td>Ensure® Plus</td>
<td>TwoCare® HN</td>
<td>Promote® With Fiber</td>
<td>Neter® with Carb Steady™</td>
<td>Impact® with Fiber</td>
<td>Impact® Glutamine</td>
</tr>
<tr>
<td>Nutrient Values per</td>
<td>1 L</td>
<td>1 L</td>
<td>1 L</td>
<td>1 L</td>
<td>1 L</td>
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<td>1 L</td>
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<td>1 L</td>
</tr>
<tr>
<td>Cal/mL</td>
<td>1.06</td>
<td>1.06</td>
<td>1.2</td>
<td>1.5</td>
<td>2.0</td>
<td>1.0</td>
<td>1.8</td>
<td>1.0</td>
<td>1.3</td>
</tr>
<tr>
<td>Carbohydrate % Cal</td>
<td>54.3</td>
<td>54.3</td>
<td>52.5</td>
<td>57.0</td>
<td>43.2</td>
<td>50.0</td>
<td>34.0</td>
<td>53.0</td>
<td>46.0</td>
</tr>
<tr>
<td>Carbohydrate Source</td>
<td>Corn maltodextrin, Corn syrup solids</td>
<td>Corn maltodextrin, Corn syrup solids</td>
<td>Corn maltodextrin, Corn syrup solids, scFOS</td>
<td>Corn maltodextrin, Sugar, scFOS, Fibersol®</td>
<td>Corn syrup solids, Corn maltodextrin, Sugar, scFOS</td>
<td>Corn maltodextrin, Sugar, scFOS</td>
<td>Corn syrup solids, Sugar, Malitol syrup, Corn maltodextrin, scFOS</td>
<td>Corn maltodextrin, Sugar, scFOS</td>
<td>Maltodextrin, Maltodextrin</td>
</tr>
<tr>
<td>Protein % Cal</td>
<td>16.7</td>
<td>16.7</td>
<td>16.7</td>
<td>16.7</td>
<td>16.7</td>
<td>18.0</td>
<td>16.0</td>
<td>22.0</td>
<td>24.0</td>
</tr>
<tr>
<td>Protein Source</td>
<td>Sodium and calcium caseinates, Soy protein isolate</td>
<td>Sodium and calcium caseinates, Soy protein isolate</td>
<td>Sodium and calcium caseinates, Soy protein isolate</td>
<td>Milk protein concentrate, Soy protein concentrate, Whey protein concentrate</td>
<td>Sodium and calcium caseinates, Soy protein concentrate</td>
<td>Sodium and calcium caseinates, Soy protein concentrate</td>
<td>Calcium, magnesium, and sodium caseinates, Milk protein isolate</td>
<td>Sodium and calcium caseinates (Milk), L-Arginine</td>
<td>Wheat protein hydrolysates, Free amino acids, Sodium caseinates (Milk)</td>
</tr>
<tr>
<td>Fat % Cal</td>
<td>29.0</td>
<td>29.0</td>
<td>29.0</td>
<td>29.0</td>
<td>29.0</td>
<td>29.0</td>
<td>29.0</td>
<td>29.0</td>
<td>29.0</td>
</tr>
<tr>
<td>Fat Source</td>
<td>Canola oil, Corn oil, MCTs, Soy lecithin</td>
<td>Canola oil, Corn oil, MCTs, Soy lecithin</td>
<td>Canola oil, Corn oil, MCTs, Soy lecithin</td>
<td>Canola oil, Corn oil, Soy lecithin</td>
<td>High oleic safflower oil, MCTs, Canola oil, Soy lecithin</td>
<td>High oleic safflower oil, Canola oil, Soy lecithin</td>
<td>Palm kernel oil, Refined menhaden oil, Sunflower oil</td>
<td>Palm kernel oil, Menhaden oil, Sunflower oil</td>
<td>M. coco oil,</td>
</tr>
<tr>
<td>Carbohydrate (g)</td>
<td>143.9</td>
<td>154.7</td>
<td>168.4</td>
<td>211</td>
<td>218.5</td>
<td>188.3</td>
<td>166.8</td>
<td>140.0</td>
<td>150.0</td>
</tr>
<tr>
<td>Protein (g)</td>
<td>44.3</td>
<td>44.3</td>
<td>50.5</td>
<td>54.9</td>
<td>83.5</td>
<td>62.5</td>
<td>81.0</td>
<td>56.0</td>
<td>78.0</td>
</tr>
<tr>
<td>Fat (g)</td>
<td>34.7</td>
<td>34.7</td>
<td>30.3</td>
<td>48.1</td>
<td>90.5</td>
<td>28.2</td>
<td>96.0</td>
<td>26.0</td>
<td>43.0</td>
</tr>
<tr>
<td>Nonprotein Cal/Mg H2O Ratio</td>
<td>125.1</td>
<td>125.1</td>
<td>110.1</td>
<td>144.1</td>
<td>126.1</td>
<td>75.1</td>
<td>115.1</td>
<td>71.1</td>
<td>62.1</td>
</tr>
<tr>
<td>Sodium (mEq)</td>
<td>300</td>
<td>300</td>
<td>430</td>
<td>880</td>
<td>725</td>
<td>380</td>
<td>585</td>
<td>375</td>
<td>630</td>
</tr>
<tr>
<td>Phosphorus (mEq)</td>
<td>40.4/40.2</td>
<td>40.4/40.2</td>
<td>58.7/47.4</td>
<td>40.3/47.7</td>
<td>63.6/62.6</td>
<td>56.5/53.5</td>
<td>46.1/47.2</td>
<td>48.1/47</td>
<td>57.5/55</td>
</tr>
<tr>
<td>Mg/P (mEq)</td>
<td>25.1/49.0</td>
<td>25.1/49.0</td>
<td>32.9/77.4</td>
<td>34.7/81.9</td>
<td>36.0/67.7</td>
<td>32.9/77.4</td>
<td>17.3/46.2</td>
<td>22.5/51.1</td>
<td>33.3/77.1</td>
</tr>
<tr>
<td>ml to meet 100% RDIs*</td>
<td>1212</td>
<td>1212</td>
<td>1000</td>
<td>948</td>
<td>948</td>
<td>1000</td>
<td>948</td>
<td>1500</td>
<td>1000</td>
</tr>
<tr>
<td>% Water</td>
<td>84</td>
<td>84</td>
<td>81</td>
<td>76</td>
<td>70</td>
<td>83</td>
<td>73</td>
<td>87</td>
<td>81</td>
</tr>
<tr>
<td>Fiber (g)</td>
<td>14.4</td>
<td>14.4</td>
<td>18.0</td>
<td>12.7</td>
<td>5.0</td>
<td>14.4</td>
<td>15.6</td>
<td>10</td>
<td>10</td>
</tr>
</tbody>
</table>

### Indications for Use

- Isotonic, low-residue, can be sole nutrition source
- Isotonic, fiber-fortified, can be sole nutrition source
- Concentrated calories, high protein, fiber-fortified, can be sole nutrition source
- Volume limitation, interim sole-source feeding
- Volume limitation, hyperosmolar, can be sole nutrition source
- Very high protein, fiber-fortified, can be sole nutrition source
- Renal failure (dialysis), volume limitation, hyperosmolar, can be sole nutrition source
- High protein, fiber-fortified, protein bound and free arginine, can be sole nutrition source
- Volume limitation, high protein, fiber-fortified, protein bound and free arginine, protein peptide bound glutamine, can be sole nutrition source
Parenteral Nutrition

- IV infusion of dextrose, protein and lipids
- Need central access (TPN)
  - PPN exists but much less benefit
- Increased risk of hyperglycemia even in non-diabetics
- Basics:
  - Dextrose
    - start at 150-250 g/day and increase to goal based on pt’s weight and metabolic state
    - Monitor blood glucose for 24-48 hours (maintain 80-150)
  - Protein in surgical patients goal of 1.5-2.0 g/kg (adjust for renal/liver failure)
  - Lipids
    - Should not exceed 0.1 g/kg/hr
    - Can cause immunosuppression (omega-6 FA) and hyperlipidemia
    - Monitor triglycerides (maintain <400)
  - Add MVI and minerals
Assessing Nutritional Effectiveness

- **Nitrogen Balance:**
  - Nitrogen intake - Nitrogen output:
    - \((\text{g protein or AA intake}/6.25)-(UUN+4)\)
    - UUN = urine urea nitrogen
    - Positive balance of 2-4 g/day indicates anabolic state
    - Altered by hepatic failure, diuresis, altered creatinine clearance, fistulas, etc

- **Serum proteins**
  - Prealbumin and transferrrin
    - Not always accurate for malnutrition - down regulated with severe illness due to liver upregulating acute phase proteins)
Refeeding Syndrome

- fluid, micronutrient, electrolyte and vitamin imbalances that occurs within first few hours-days after initiating nutrient infusion in chronically malnourished patients
- Usually see hypokalemia, hypophosphatemia, hypomagnesia
- Results in:
  - Hemolytic anemia
  - Respiratory distress
  - Paresthesias
  - tetany
  - Cardiac arrhythmias
- Treatment: limit dextrose to 100-150 g/day, monitor lytes
Esophagus

Duodenum
- Calcium
- Phosphorus
- Magnesium
- Iron
- Copper
- Selenium
- Thiamin
- Riboflavin
- Niacin
- Biotin
- Folate
- Vitamins A, D, E, K

Stomach
- Water
- Ethyl alcohol
- Copper
- Iodide
- Fluoride
- Molybdenum
- Intrinsic factor

Jejunum
- Thiamin
- Riboflavin
- Niacin
- Pantothenate
- Biotin
- Folate
- Vitamin B6
- Vitamin C
- Vitamins A, D, E, K
- Calcium
- Phosphorus
- Magnesium
- Iron zinc
- Chromium
- Manganese
- Molybdenum
- Lipids
- Monosaccharides
- Amino acids
- Di-, tripeptides

Ileum
- Water
- Vitamin C
- Folate
- Vitamin B12
- Vitamin D
- Vitamin K
- Magnesium
- Bile salts and acids

Colon
- Water
- Sodium
- Chloride
- Potassium
- SCFA's
- Vitamin K
- Biotin

FIGURE 3-1. Gastrointestinal tract.
Special Nutritional Considerations

- Consider feeding tube early in treatment course
  - Head and Neck surgery
    - Often have alcohol or tobacco use
  - Esophageal surgery
- Gastric surgery
  - Dumping syndrome
  - Anemia
- Intestinal surgery
  - Short bowel syndrome
  - Absorption issues
- Pancreaticoduodenectomy
  - Delayed gastric emptying
  - Weight loss
  - Diabetes
  - Malabsorption from exocrine insufficiency
- Ileostomy and colostomy
  - Monitor output
Review Questions
Questions?