Nutrition for the Surgical Resident

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Hamilton Health Sciences
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I Wish I Had Known
More About Nutrition
Nutrition

- Serves two basic functions
  - Provide substrate for energy production through intermediary metabolism
  - Provide necessary nutrients that act as co-factors, signalers, electrolytes, etc.
Nutritional Requirements

- Energy substrate is obviously required. In general, glucose is the preferred substrate
  - Fat is the primary storage substrate, but neural cells still require glucose
- Essential fatty acids
  - Linoleic and linolenic required for cellular structure and as precursors for prostaglandins, prostacyclins, leukotrienes, etc.
Nutritional Requirements

- **Essential amino acids**
  - These cannot be synthesized by humans (leucine, isoleucine, valine, lysine, threonine, methionine, phenylalanine, tryptophan, histidine)

- **Semi-essential Amino Acids**
  - Cysteine and tyrosine can be synthesized from methionine and phenylalanine
  - Conditionally essential In times of stress – Glutamine, Arginine

- **0.8 mg/kg/day is usually sufficient, but more may be required during growth, stress, etc.**
Vitamins

- Required in small amounts
  - Fat soluble (A, D, E, K)
  - Water soluble (thiamine (B1), riboflavin (B2), niacin (B5), B6, biotin (B7), folate (B9), cyanocobalamin (B12), pantothenic acid, C)

- Function as precursors for co-enzymes, processors of genetic information, electron-transport, and antioxidants
Minerals

- 19 required minerals
- Serve as structural components (bone), cellular signals (Ca++, Mg++), charged ions (Na+, K+, Cl-), metalloproteins, and metalloenzymes
- The trace minerals include Fe++, Zn++, Cu++, Se, Mg, Mb, Co, I, Cr
Nutritional Deficiencies

- **Marasmus**
  - Caloric and protein deficiency
    - These folks look severely emaciated and cachectic

- **Kwashiorkor**
  - Just protein deficiency
    - Can be obese and hard to identify
    - May have thin extremities and temporal wasting
    - Liver enlargement and ascites
Nutritional Deficiencies

- Neurological changes can be indicative of vitamin and trace mineral deficiency
  - Niacin – pica (also 4 D’s)
- Vitamin C – scurvy
- Thiamin deficiency -
- Vitamin A deficiency -
- B12 and folate – megaloblastic anemia
  - Watch out for the folate trap
Surgery & Nutrition
Why do we care?

- Well documented that severe protein-calorie malnutrition contributes to increased postoperative morbidity and mortality
- Hypoalbuminemia is associated with higher surgical morbidity and mortality
- Infectious complications are increased with malnutrition
Surgery & Nutrition
Why do we care?

- Underweight patients
  - are predisposed to respiratory failure
  - Are less likely to be weaned from ventilatory support

- Hypercatabolism that occurs following multiple trauma, shock, sepsis
  - leads to severe lean body mass wasting
  - impaired organ function, and decrease in reparative and immune processes even in previously healthy individuals
Surgery & Nutrition

Why do we care?

- Nutrition support alone cannot stop the ongoing protein catabolism
  - lean body mass wasting seen in acute injury or illness

- The bedridden septic or injured patient cannot be expected to increase or even maintain lean body mass until the source of hypermetabolism resolves and physical therapy or ambulation is initiated
Metabolic Rate

![Graph showing metabolic rate changes over time for different conditions: major burn, major trauma or surgery with critical illness, major surgery (uncomplicated), and normal range. Time is measured in days (d).]
Starvation vs. Injury

Nitrogen Dynamics

- Major Burns
- Skeletal Trauma
- Severe Sepsis
- Infection
- Elective Operation
- Partial Starvation
- Total

Nitrogen Excretion

g/day

Days

Normal Range
Metabolic Effects of Starvation

- Adaptive response activated
- Decreased metabolic rate
- Decreased glucose production
- Reduced protein synthesis & catabolism
- Efficient use of fat for energy (i.e., fatty acids, ketones & glycerol)

Energy Production
Mainly from fat sources

Lean Mass Preserved
Normal visceral proteins & glucose

Net Protein Loss

Liver

Gluconeogenesis
Glycogenesis
PEM Induced by Catabolic Insult

- No adaptive response activated
- Increased metabolic rate
- Increased glucose production
- Increase use of Protein for fuel
- Inefficient use of fat for energy

**Energy Production**
Mainly from glucose
And amino acids

**Lean Mass Catabolism**
Protein for glucose production

**Net Protein Loss**

**LIVER**

Gluconeogenesis

Amino Acids
Complications of Catabolism

Negative consequences associated with erosion of body mass

<table>
<thead>
<tr>
<th>% Lost</th>
<th>Altered Physiology</th>
<th>% Mortality</th>
</tr>
</thead>
<tbody>
<tr>
<td>-10%</td>
<td>Impaired immune function</td>
<td>10%</td>
</tr>
<tr>
<td>-20%</td>
<td>Decreased wound healing</td>
<td>30%</td>
</tr>
<tr>
<td>-30%</td>
<td>Pneumonia, pressure sores</td>
<td>50%</td>
</tr>
<tr>
<td>-40%</td>
<td>Death (pneumonia)</td>
<td>100%</td>
</tr>
</tbody>
</table>

Chang, DeSanti, Demling. SHOCK. 1998
Nutrition Assessment

- Parameters often examined:
  - Anthropometrics
  - Biochemical
  - Diagnosis, PMH\(_x\) and Surgical H\(_x\)
  - Physical assessment
  - Medications
  - Diet H\(_x\)
  - Bowel function
“Energy” Metabolism

- Basal energy expenditure in a healthy adult male is 20 kcal/kg/day
  - ...so about 1600 kcal/day for you and me
- Normal activity increases needs to 30-40 kcal/kg/day
  - ...so about 2400-3600 for you and me IF active
- This does not account for growth, etc.
Determining Nutrition Requirements

- Indirect calorimetry is the gold standard
  - AKA “metabolic cart”
  - Measures $O_2$ consumption and $CO_2$ production
  - A more accurate method to determine energy requirements and substrate utilization
  - Reduces the incidence of overfeeding
  - Usually performed by a Nutrition Assistant in a non-ICU setting or a RT in an ICU setting
Determining Calorie Requirements

- **Harris-Benedict Equation (HBE):**
  - Estimates basal energy expenditure
  - Multiply by activity and stress factors
  - Overestimates energy for critically ill
  - Use actual wt for morbidly obese unless BMI ≥ 30

- 25 – 35 kcal/kg provides an estimate for most hospital patients
  - For example, a 60 kg person requires 1500 – 1800 kcal/d
  - Adjust kcals to 15-21 kcal/kg if BMI>30
Elwyn DH, Kinney JM, Surgical Clinics of North America, 1981
Energy Metabolism

- Basal energy expenditure (BMEE) can be estimated using Harris-Benedict equations
  - Men: $655 + (9.6)W + (1.8)H - (4.7)A$
  - Women: $66 + (13.7)W + (5)H - (6.8)A$

- Nitrogen balance
  - $NB = \text{protein delivery/6.25} - (\mu\text{UN} + 4)$
Determining Protein Requirements

- Protein requirements (g/kg/d): (ideal wt if obese)
  - Healthy adults: 0.8
  - Trauma: 1.5 – 2.0
  - Pancreatitis (acute): 1.5
  - General surgery: 1.0 – 1.5
  - Sepsis: 1.5 – 2.0
  - HD: 1.2 – 1.4
  - Transplant (acute phase): 1.5 – 2.0
  - IBD (active): 1.3 – 2.0
  - For example, a 60 kg surgical patient requires 60 – 90 g protein/d (assuming normal organ function)
Determining Fluid Requirements

- Fluid requirements (H₂O):
  - Young athletic adult: 40 ml/kg
  - Most adults: 35 ml/kg
  - Older adults (55 to 65 y): 30 ml/kg
  - Elderly adults (> 65 y): 25 ml/kg

- Or 1 ml/kcal energy expenditure
  - Fluid requirements increase with pregnancy, infants, fever, high altitude, low humidity, profuse sweating, diarrhea, vomiting, hemorrhage, fistula drainage, surgical drains, and loss of skin integrity
  - For example, a 58 y old weighing 60 kg requires 1800 ml fluid/d
# Anthropometrics - Weight

<table>
<thead>
<tr>
<th>UBW-BW x 100 UBW</th>
<th>Significant Wt loss</th>
<th>Severe Wt loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 week</td>
<td>1-2%</td>
<td>&gt;2%</td>
</tr>
<tr>
<td>1 month</td>
<td>5%</td>
<td>&gt;5%</td>
</tr>
<tr>
<td>3 months</td>
<td>7.5%</td>
<td>&gt;7.5%</td>
</tr>
<tr>
<td>6 months</td>
<td>10%</td>
<td>&gt;10%</td>
</tr>
</tbody>
</table>
## Anthropometrics - Weight

<table>
<thead>
<tr>
<th>Malnutrition Risk</th>
<th>BW/UBW x 100</th>
<th>BW/IBW x 100</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mild</td>
<td>85-90%</td>
<td>80-90%</td>
</tr>
<tr>
<td>Moderate</td>
<td>75-84%</td>
<td>70-79%</td>
</tr>
<tr>
<td>Severe</td>
<td>0-74%</td>
<td>0-69%</td>
</tr>
</tbody>
</table>
Albumin

- Best simple estimate of protein reserve
  - Half-life 20 days
- Others with shorter half-lives may be more indicative of acute changes
  - Transferrin 9 days
  - Prealbumin 1 day
  - Retinol-binding protein 0.5 days
The Albumin-Nutrition Connection: myth or fact?

- Kwashiorkor is the only instance where albumin has nutritional diagnostic implications
- Hypoalbuminemia is indicative of impaired nutritional status, specifically protein nutriture
The Albumin-Nutrition Connection: myth or fact?

- Albumin is an indicator of nutritional status in the marasmic and critically ill pt population
- Serum albumin is a prognostic indicator for morbidity and mortality
Case Scenario #1
- Labs on admission: Alb 40, Hgb 150, Cr 87
- 60 y old woman with 2 mon Hx of N & V, diarrhea and 8 kg wt loss
- Dx: gastric CA
- After 2 d of IV hydration: Alb 28, Hgb 110, Cr 48
- Does your Alb level match the patient in question?
Feeding the Surgical Patient - Is there a need for a clear fluids diet?

- CF → DAT
- Traditionally, patients progress over 2 to 3 d from clear to full fluids and then to solids
- Is this necessary?
Clear Fluids
400 - 500 kcal/d
Full Fluids
900 - 1000 kcal/d
Feeding the Surgical Patient - Is there a need for a clear fluids diet?

- Not a necessity for routine postoperative surgical patients
- Literature shows that early post-operative feeding is safe and in some studies beneficial
  - Decreased infections and LOS
  - Regular diet also provides better nutrition
- Should patients be allowed to select from a “diet as tolerated”?
- Concept of energy deficit and LOS
Feeding the Surgical Patient
- Nutrition supplementation

- Trial nutrition supplementation & MedPass
  - Ensure Plus 1 can: 355 kcal and 13.3 g protein
  - Resource 2.0 1 box: 475 kcal and 21.3 g protein
  - Carnation Breakfast Anytime: 300 kcal and 15.5 g protein
Therapeutic Diets
Postgastrectomy & Dumping Syndrome

- Gastrectomy, esophagojejunostomy, Whipple
- 6 – 8 small meals; eat slowly, chew food well
- Drink fluids 30 – 60 min before or after meals
- Complex carbohydrates are preferred
- Simple sugars should be avoided
- Protein at every meal
- $B_12$ and Fe supplementation as needed
- Pancreaticoduodenectomy: gastroparesis
Low Residue

- Diverticulitis, bowel resection,
- stricture, ostomies
- Avoid high fibre foods, stringy foods and foods with skins and seeds
- Nuts, corn, bean sprouts, mushrooms, popcorn, coconut are not recommended
- Cooked veggies vs. raw
- No dried fruit, trail mix, pickles, olives
- Return to high fibre diet when surgeon OKs
Pancreatitis

- 80% of patients with acute pancreatitis recover with a few days of IV fluids and bowel rest
- Begin an oral diet when abdominal pain is controlled
- Most patients resume eating within 5-7 days
- Clear fluids to a low fat diet
- Chronic pancreatitis: high calorie, high protein, moderate fat (.7-1.0 g/kg) (MCT), low fibre, pancreatic enzymes, fat-soluble vitamins
- Enterally feed past Ligament of Treitz
**Lap Fundo**

- Fundoplication for GERD, hernia
- Esophagus and stomach swollen
- Soft / Minced diet for the next 2 weeks
- Then slowly return to usual diet
- No steak, corn, salad, bread for 1 mon
- No straws, gum, smoking, carbonated beverages
- Centrum Select chewable
Before Starting Nutrition Support

- Nutrition assessment
  - Baseline investigations
- Gastrointestinal/venous access evaluation
  - If the gut works, use it
Enteral Nutrition

If the gut works…use it!!
EN: Indications

- For patients with access to a functional GI tract and whose oral intake is insufficient to meet estimated nutrition requirements
Malfunctioning GI tract or conditions requiring extended bowel rest:
- SBS
- Mechanical obstruction or GI motility disorder
- Prolonged ileus
- Severe GI bleeding, diarrhea or vomiting
- High output fistula (> 500 ml/d)
- Severe inflammation or enteritis
- GI ischemia
- Severe pancreatitis
Enteral Access

- OG, NG, ND, NJ, G-tube, PEG-tube, GJ-tube, J-tube, TEF-tube
- Consider diagnosis and duration
  - EN required < 6 weeks, suggest temporary NG or “Dobbhoff” / Flexiflo feeds

![Diagram of enteral access methods](image-url)
Standard tube feeding formulas are like your “DAT” of tube feeds:
- Assume normal organ function
- No allergies
- No fluid restrictions
- May contain fibre
- 1.0 – 1.2 kcal/ml; isotonic
- All feeds are gluten and lactose free
- Examples: Jevity 1.2, Ensure, Ensure HP
Volume-restricted/nutrient dense formulas:
- Generally 1.5 – 2.0 kcal/ml
- 400 – 700 mOsm/kg
- Useful for CHF, renal failure, home tube feeds (less time)
- Examples: Jevity 1.5, Resource 2.0, TwoCal
Disease specific formulas:

- Useful for diabetes without large doses of insulin (less CHO), renal failure (less Na, K, PO₄, Mg)
- Used with ARDS/ALI/Septic pts
- Often higher in fat
  - Gastric emptying is slower for high fat formulas
- 375 – 700 mOsm/kg
- Examples: Glucerna, Nepro, Oxepa
Enteral Formulas

- Chemically defined formulas (semi-elemental and elemental):
  - “Promote” rapid absorption of nutrients for patients with GI impairment
  - Contain free a.a., hydrolyzed whey, casein, short chain peptides, MCT f.a.
  - 460 – 650 mOsm/kg
  - Useful for pancreatic disorders, malabsorption syndrome, Crohn’s
  - Examples: Peptamen, Peptamen 1.5, Vital, Optimental, Peptamen AF1.2
Supplements

- Glutamine – 0.3-.5 g/kg bw - use 10 g packs at present
- Beneprotein – whey protein – 6 g packs
- Centrum Select
- Centrum Forte, Penta 3B, Replevit
Ordering EN

- Initiate full strength formula at 20 – 40 ml/h
- Increases of 20 ml/h are OK if feeds tolerated
- Continue to progress feeds until goal reached
  - For example, Jevity 1.2 @ 25 ml/h x 6 h
  - If tolerated, increase 25 ml/h q 6 h to goal of 75 ml/h
  - ~ 24 h to get to goal rate
EN: Flushes

- Don’t forget your H₂O or saline flushes
- Flushes help meet fluid requirements
- Maintain tube patency
- Minimum of 50 ml H₂O qid
- Flushes can be Δ’d to NS with hyponatremia or add salt to feeds
- All water flushes must be with sterile water in critically ill/immunocompromised pts.
Transitioning Enteral Feeds

- To change to overnight feeds:
  - Increase flow rate
  - Decrease infusion duration
  - For example, 80 ml/h x 24 h → 105 ml/h x 18 h → 130 ml/h x 15 h → 160 ml/h x 12 h

- Bolus feeds:
  - 2 cans infused over 3 hours qid
  - Gradually decrease infusion time
  - Do not bolus into the jejunum
Monitoring EN

- Monitoring parameters vary with patient acuity, duration of feeds and institutional practice
- Weekly weights
- Bowel function
- Fluid and electrolyte balance
- Visceral protein (albumin, prealbumin)
  - Consider half-life, change in fluid status, organ function and presence of infection
Complications of EN

- **Diarrhea:** 2 – 63 % incidence
  - Formula responsible for diarrhea ~ 20% of cases
- **Constipation**
- **Aspiration:** 0.8 – 95 % incidence
  - Clinically significant aspiration resulting in pneumonia 1 – 4 %
- **GI intolerance:** N & V, abdo discomfort
- **Clogged tubes – enzymes/bicarb**
- **Procedure related complications**
Corporate bowel protocol

- Prune juice
- Dulcolax
- Senna
- M of Magnesia
- Supps......

Bristol Stool Chart

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type 1</td>
<td>Separate hard lumps, like nuts (hard to pass)</td>
</tr>
<tr>
<td>Type 2</td>
<td>Sausage-shaped but lumpy</td>
</tr>
<tr>
<td>Type 3</td>
<td>Like a sausage but with cracks on its surface</td>
</tr>
<tr>
<td>Type 4</td>
<td>Like a sausage or snake, smooth and soft</td>
</tr>
<tr>
<td>Type 5</td>
<td>Soft blobs with clear-cut edges (passed easily)</td>
</tr>
<tr>
<td>Type 6</td>
<td>Fluffy pieces with ragged edges, a mushy stool</td>
</tr>
<tr>
<td>Type 7</td>
<td>Watery, no solid pieces. Entirely Liquid</td>
</tr>
</tbody>
</table>
Gastric residual policy

Gastric Residual Check
(Every 4 hours or before each feed for intermittent and bolus feedings)

< 200 cc
- Return aspirated feed
  - Yes: Increasing abdominal distension/girth &/or tenderness, or
  - Emesis, or
  - Clinically detected aspiration, or
  - No BM x 3 days
  - No: Do not return residual
    - > 200 cc: Hold Feeds
    - < 200 cc: Return Feed Flush with 30 cc warm tap water
    - > 200 cc: Check residual in 1 hour

> 200 cc
- Return aspirated feed
  - Presence of:
    - Increasing abdominal distension/girth &/or tenderness, or
    - Emesis, or
    - Clinically detected aspiration, or
    - No BM x 3 days
  - No: Continue feeding

* Continue feeding
** Contact MD/RD

* Continue to monitor abdomen – girth, tenderness, absence, vomiting, etc.
** Consider promotility agent &/or small bowel feeds (if abdominal X-ray normal)

Note: Long-term, well-established tube feeds do not need gastric residuals checked.
Parenteral Nutrition (TPN)
TPN

- TPN is similar to \( \frac{2}{3} + \frac{1}{3} \)
  - Only with amino acids, lipid and additives (Na, K, Ca, Mg, PO\(_4\), etc.)
TPN Composition – Electrolytes & minerals

- Cater for maintenance & replacement needs
- Na: 1 – 2 mmol/kg
- K: 1 – 2 mmol/kg
- Mg: 0.13 – 0.18 mmol/kg or 4 – 10 mmol/d
- Ca: 0.1 – 0.15 mmol/kg or 5 – 7.5 mmol/d
- PO₄: 15 to 30 mmol/d
TPN Composition – Additives

- MVI – 12
- Trace + 4 elements (Zn, CU, Mn, Cr)
- Vitamin $K_1$:
  - If patient on Warfarin and difficulty reaching therapeutic INR, may remove vitamin K from TPN
TPN Composition – Other additives: medications

- **Insulin**
  - Monitor sliding scale requirements q 4 – 6 h
  - Once stable, give ~ 70 – 100 % total requirements in TPN & review daily
  - Insulin drip – add 2/3 of the total insulin infused during the previous TPN administration
  - Alternate regimes
    - 0.1 unit/g dextrose
    - 10 unit/l TPN initial dose

- **Ranitidine**
TPN 3 in 1

- Dextrose
- Lipids
- Amino acids
- Electrolytes & minerals
- Vitamins
- Trace elements
Who Benefits from TPN?

- Nonfunctioning or inaccessible GI tract
- Anticipated duration of TPN is at least 7 days

"It's your four basic food groups."
Clinical Settings
Where TPN is Routine Care

- Inability to absorb adequate nutrients via GI tract (SBS, diarrhea, intractable vomiting, prolonged ileus)
- Complete BO or intestinal pseudo-obstruction
- CA: when treatment causes GI toxicities that prevent PO intake and make EN unsuccessful
- Pancreatitis (mod-severe): when EN unsuccessful (abdo pain, serum lipase, or pancreatic fistula drainage increases)
- Critically ill: hypermetabolic/catabolic and EN unsuccessful
Clinical Settings where TPN is Usually Beneficial

- Preoperative TPN (7 – 10 d) for severely malnourished patients
- Bowel obstructions unlikely to resolve in 7 d
- IBD not responding to medical therapy
- Enterocutaneous fistula
- Vascular event & diminished perfusion to gut
- Eating disorders: where severe malnutrition and GI or emotional intolerance to EN exist
- Hyperemesis gravidarum (EN unsuccessful)
Home TPN Criteria

- Non-functional GI tract
- Required > 1 month
- Valid Ontario Health Card
- Primary Care Physician
- CVAD
- CCAC acceptance
- Primary care giver & a support network
- No compliance issues
- Pt/family capable of learning proper techniques of caring for CVAD/equipment and TPN administration
- Agreeable to monthly F/U at McMaster
TPN: Contraindications

- Functional GI tract
- TPN less than 1 week in a well-nourished Pt.
- Prognosis does not warrant aggressive nutrition support
- Pt. or POA decline nutrition support
- Risks exceed potential benefits
- Pending surgery delayed to accommodate the initiation of TPN
TPN Access - Peripheral vs. central

Venous Access

Blood flow
>1000 ml/min.

~2000 mOsm/L

Blood flow
<100 ml/min.

~800 mOsm/L
The higher the osmolarity, the larger the vein needed to accommodate the solution.
A solution with high osmolarity infused into a small peripheral vein will cause irritation, pain, damage to the vessel, which requires frequent changes to the IV site.
- Peripheral TPN not recommended > 7 d
- Peripheral TPN < 1100 mOsmol/l
- PICC preferred
Where does TPN come from?

- RD or MD writes TPN order before 1300 h
- TPN is made in the pharmacy sterile room
- TPN is started between 1800 to 2000 h
- 24 h hang time for each TPN bag
- Label reflects nutrients per d
Ordering TPN

- Nutrition assessment
- Peripheral or central access?
- Complete form
- Critically ill/septic patients are started on lipid free solutions for first 5-7 days
  - Why???
- Forms must be signed by MD
Ordering TPN

- Case scenario #2
  - 30 y old male surgical resident
  - TPN consult for lack of sleep and unable to prepare diet/administer tube feeds
  - wt: 80 kg    ht: 182.9 cm
  - Labs normal, except K 6.0
  - central line inserted by his staff surgeon
  - BMI?
  - TPN order?
TPN -
To change or not to change

- Labs: K 3.0  PO₄ 0.58
- Consult to Δ TPN
- Try to adjust IV prior to changing TPN
- Chasing electrolytes time consuming & not always appropriate
Transitioning TPN

- Oral/enteral feeds may be initiated when the patient has GI function
- A swallowing evaluation may be required
- Calorie counts may be useful
- Decrease the volume of TPN as oral/enteral intake increases
  - For example, if enteral feeds ½ way to goal rate, decrease volume of TPN in ½ (a new TPN order form should be completed when changing rate) – consult Dietitian
Monitoring TPN

- Weekly weights
- Daily fluid balance, vital signs
- Visceral protein (albumin, prealbumin)
  - Consider half-life, change in fluid status, organ function and presence of infection
- Electrolyte and acid-base balance
## Monitoring TPN Labs

<table>
<thead>
<tr>
<th></th>
<th>Initiation and q Mon</th>
<th>q Mon and Thurs</th>
<th>After 2 months</th>
<th>As needed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bun, Creatinine, Electrolytes, Glucose</td>
<td>×</td>
<td>×</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CBC, Alb, Ca, Mg, PO&lt;sub&gt;4&lt;/sub&gt;, LFTs, Chol, TG, INR, PTT</td>
<td>×</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cr, Mn, Se</td>
<td></td>
<td></td>
<td>×</td>
<td></td>
</tr>
<tr>
<td>Zn, Fe panel</td>
<td></td>
<td></td>
<td></td>
<td>×</td>
</tr>
</tbody>
</table>
Complications of TPN

- Mechanical
- Infectious
- Metabolic
Mechanical Complications of TPN

- Related to vascular access technique
  - Pneumothorax
  - Air embolism
  - Arterial injury
  - Bleeding
  - Catheter misplacement
  - Catheter embolism
  - Thoracic duct injury
Mechanical Complications of TPN

- Related to catheter in situ
  - Venous thrombosis
  - Catheter occlusion
  - Dislodgement or breakage
Infectious Complications of TPN

- Insertion site contamination
  - Catheter contamination
  - Improper insertion technique
  - Use of catheter for non-feeding purposes
  - Contaminated TPN solution
  - Contaminated tubing

- Secondary contamination
  - Septicemia
Metabolic Complications of TPN

- Abnormalities related to excessive or inadequate administration:
  - Hyper and/or hypoglycemia
  - The refeeding syndrome
  - Electrolyte/acid-base disorders
  - Hyperlipidemia
  - Hepatic complications
  - Metabolic bone disease
Metabolic Complications of TPN – hyperglycemia

- Promotes inflammation and sepsis
- Increased risk of infection when BG > 11.1
- Poor glucose control is associated with dysfunction of leukocytes
- Risk factors: DM, obesity, older age, pancreatitis, sepsis, cirrhosis, renal failure, steroids
  - Van den Bergh vs. NICE Sugar studies

Intensive versus Conventional Glucose Control in Critically Ill Patients
The NICE-SUGAR Study Investigators*, NEJM, March 26, 2009, pages 1283-1297
Metabolic Complications of TPN – Hypoglycemia

- Usually occurs when TPN is suddenly interrupted
- Reactive hypoglycemia may occur 15 – 60 minutes after TPN is stopped
  - Monitor glucose
- Decreasing the TPN volume by one-half for 1 to 2 hours before discontinuing may minimize the risk when cycling TPN
- Capillary glucose levels may be measured ½ to 1 hour after stopping TPN
Metabolic Complications of TPN - Electrolyte/acid-base disorders

- May be related to underlying condition
- Excess chloride salts can cause metabolic acidosis
- Excess acetate salts can cause metabolic alkalosis
- Acetate converted to bicarbonate: high acetate in TPN can help correct bicarb losses from diarrhea and fistulas
- Chloride may help correct metabolic alkalosis that occurs with gastric fluid losses
Metabolic Complications of TPN – Hyperlipidemia

- Excessive fatty acid synthesis from dextrose
- Impaired lipid clearance
- Predisposing factors: sepsis, MSOF, obesity, DM, liver disease, renal failure, alcohol misuse, Hx of hypertriglyceridemia and pancreatitis
- Medications: cyclosporine, corticosteroids, propofol (10% lipid emulsion, 1.1 kcal/ml)
- Stop IV lipids if TG > 4.0
Hepatic steatosis and steatohepatitis
- Most common early hepatic abnormality
- 1 – 4 weeks after initiation
- Reversible
- Can progress to fibrosis, cirrhosis in long term use
- Excessive dextrose infusion
- Overfeeding of lipids: maximum recommended lipid dose is 1g/kg/day
- Specific nutrient deficiencies: choline, carnitine, essential fatty acids
Metabolic Complications of TPN - Hepatic complications

- Cholelithiasis and Cholestasis
  - Result of decreased gallbladder contractility during fasting
  - Present after 6 – 12 weeks
  - 19 – 35 % develop gallstones
  - ~ 15 % on long term TPN (1 – 20 y) develop ESLD with 100 % mortality within 10.8 +/- 7.1 months after the initial elevated bili *Chan, Surgery 1999*
  - SBS: increased risk for cholelithiasis and biliary sludge
  - Other factors: long-term TPN, bacterial overgrowth, frequent sepsis, opioid therapy
Metabolic Complications of TPN - Hepatic complications

- **Management strategies:**
  - Exclude other causes: biliary obstruction, viral hepatitis, drug toxicity, herbal supplements
  - Avoid excess glucose and fat infusion
  - Cycle TPN (10 – 16 h)
  - Avoid or treat sepsis
  - Trial of ursodeoxycholic acid (URSO)
  - Oral antibiotics (flagyl, gentamycin, neomycin) to reduce intestinal bacterial overgrowth
  - Remove copper and manganese
  - Oral/enteral feedings to stimulate gallbladder contraction
Metabolic Complications of TPN - Metabolic bone disease

- Osteomalacia, osteopenia, osteoporosis
- Reported in long term TPN use
- Deficiencies of Ca, PO₄, vitamin D
- Aluminum toxicity
- Non-TPN related factors: corticosteroids, underlying disease
The Refeeding Syndrome
The Refeeding Syndrome - What is it?

- The physiological alterations that are observed when an individual is refed after a period of starvation,
- either parenterally, enterally or orally
The Refeeding Syndrome - Who is at risk?

- **Reduced food intake**
  - Anorexia nervosa
  - Alcoholism
  - Hunger strike
  - Prolonged periods of “nil by mouth” as an inpatient
  - Oncology patients undergoing chemotherapy
  - After bariatric surgery

- **Malabsorption of nutrition**
  - Inflammatory bowel disease
  - Celiac disease

- **Increased metabolic demands**
  - Malignancy
  - Recent major surgery

- **Other**
  - Prolonged diarrhea and vomiting
Patients at high risk

- **One or more of:**
  - Body mass index <16
  - >15% unintentional weight loss in the past 3-6 months
  - Little or no nutritional intake for more than 10 days
  - Low concentrations of potassium, phosphate, or magnesium before refeeding

- **Or two or more of:**
  - Body mass index <18.5
  - >10% unintentional weight loss in the past 3-6 months
  - Little or no nutritional intake for more than 5 days
  - History of alcohol abuse or drugs, including insulin, chemotherapy, antacids, or diuretics
The Refeeding Syndrome

- The sudden provision of adequate or excess calories causes the body to convert to CHO metabolism as an energy source.
- This precipitates a surge in the release of insulin.
- Metabolic rate increases, as does O$_2$ consumption and CO$_2$ production.
- Insulin stimulates the shift of PO$_4$, K and Mg from the serum into the cells as these minerals are required for energy metabolism.
The Refeeding Syndrome

- As body stores are depleted, minerals that have moved from the serum into the cells cannot be replaced.
- Critical levels of hypophosphatemia, hypokalemia, and hypomagnesemia may develop with resulting cardiac and/or neuromuscular compromise.
- Arrhythmia, CHF, acute respiratory failure and even sudden death may result.
- Thiamine deficiency and intolerance of the glucose and fluid load administered contribute to the adverse results.
The Refeeding Syndrome - How to feed patients at risk

- Do not attempt to immediately meet estimated energy and fluid goals
- Malnutrition does not develop over night and cannot be corrected in a matter of days
- Rapidly switching from a catabolic starved state to an anabolic refed state can overwhelm the functional capacity of the body
The Refeeding Syndrome

- Case scenario #3
  - 80 y old gentleman with rectal CA pending Surg
  - TPN consult for preop nutrition support
  - wt: 59.1 kg (130 lb)  ht: 172.7 cm (5 ft 8 in)
  - BMI: 19.8
  - 11.4 kg (25 lb) wt loss over 3 mon
  - Labs: Alb 25, K 2.9, Mg 0.50, PO₄ 0.80, BUN 1.5, Cr 26
  - TPN order?
The Refeeding Syndrome - How to feed patients at risk

- Replete serum $\text{PO}_4$, K and Mg before initiating EN/PN
  - Hypomagnesemia may also result in hypokalemia
- Goal to meet requirements over a few days
- Use a “starter” solution which provides less calories and dextrose
- Progress volume of EN/PN after assessment of labs, ability to tolerate fluid volume, etc.
Questions?

- Thank you

“I really should consult a dietician. My idea of preparing healthy food is to blow the sugar off a donut.”