Parenteral Nutrition
Diamond Pharmacy Services

What is Parenteral Nutrition?
- Intravenous feeding that provides a patient with fluids and essential nutrients during a time of gastrointestinal function disruption and inability to eat

Goals of Parenteral Nutrition
- To provide essential nutrients in amounts adequate to sustain nutritional balance during periods when oral or enteral routes of feedings are not possible or are insufficient to meet patients needs
- To preserve or restore the body's protein metabolism
- To diminish weight loss and/or maintain body weight
- To promote healing and repair nutritional deficits
Indications for Parenteral Nutrition

- Trial of enteral feedings has failed
- Enteral route is contraindicated
- GI tract has severely diminished function because of underlying disease or treatment, and GI function is not expected to return within 7 days
  - Massive small-bowel resection, radiation enteritis, severe diarrhea, complete bowel obstruction

Contraindications for Parenteral Nutrition

- Functional GI tract
- Inability to obtain venous access
- Unstable clinical condition
- Terminal disease, critical illness, or metabolic derangement in which the risks outweigh the benefits

Normal Dietary Requirements

- Normal Diet
  - Protein
  - Carbohydrates
  - Fat
  - Vitamins
  - Minerals
  - Water
Types of Parenteral Nutrition...

Peripheral and Central

 Peripheral Parenteral Nutrition (PPN)
  - Short
  - Midline

 Central Parenteral Nutrition (TPN)
  - Peripherally Inserted Central Catheter (PICC)
  - Hickman or Broviac
  - Groshong Catheters
  - Femoral Lines
  - Multiple Lumen Catheters
  - Port

Peripheral vs. Central

- PPN avoids the inherent risks associated with TPN, but is not suitable unless the patient meets the following criteria:
  - Nutritional needs <1800kcal/day
  - Patient requires <10-14 days of IV nutrition
  - Peripheral venous access is available
  - Requires only one IV line with IV fat emulsion administration via piggyback infusion
  - Fluid restriction is not an issue

Peripheral Nutrition Support

- Generally intended as a supplement to oral feeding
- Limited to an osmolarity of <600-900mOsm/L
- Final concentration of Dextrose must be less than 10%
- Site should be changed every 48-72 hours
- Minimizes risk of infection and thrombophlebitis
Central Nutritional Support

- Osmolarity can be >900mOsm/L
  - Usually 1500-2000mOsm/L
- Catheter tip must be positioned in the superior vena cava
- Route of choice for:
  - Patients with fluid management issues (CHF, renal failure)
  - Patients with poor peripheral venous access
  - Patients requiring PN >10-14 days


Designing the Formulation...
Fluid Requirements

- Normal Range: 30-40mL/kg/day
  - **Use actual body weight in malnourished patients and ideal body weight in obese patients
- Special Considerations:
  - Increased requirement:
    - Fever, fistulas, diarrhea, NG suction
  - Decreased requirement:
    - Renal failure, heart failure, cirrhotic ascites, pulmonary disease


Designing the Formulation...
Calorie Requirements

- Requirement is patient specific
- Should be administered in an amount adequate to meet basal energy expenditures and provide for a level or physical activity to maintain a healthy BMI
- Predictive equations to measure energy expenditure may be valuable in healthy adults but can be problematic in obese patients
  - Harris-Benedict Equation

Designing the Formulation...

Calorie Requirements

- Normal Range: 20-35kcal/kg/day
- Usual Doses: 25-30kcal/kg/day
  **Use actual body weight in malnourished patients and ideal body weight in obese patients**
- Special Considerations:
  - Obesity (>130% IBW): Consider hypocaloric doses
  - Critically Ill (Acute): >25kcal/kg/day
  - Major thermal injury (>50% of BSA burn): up to 40kcal/kg/day


Designing the Formulation...

Macronutrients

- Protein
- Fat
- Carbohydrates

Types of Parenteral Nutrition...

2-in-1 and 3-in-1

- 2-in-1: Amino Acids + Dextrose --Fat emulsion hung separately
- 3-in-1: Amino Acids + Dextrose + Fat emulsion in same bag


2-in-1 vs. 3-in-1

Advantages of 2-in-1:
- Extended stability
- Decreased risk of contamination due to decreased manipulation
- Visual inspection possible

Disadvantages of 3-in-1:
- Decreased stability vs. 2-in-1
- Increased bacterial growth
- Visual inspection is difficult
- Cannot use 0.22 micron filter
- Limited compatibility with medications

Premixed PN Formulations

**CLINIMIX®:**
- Sulfite free (Amino Acid in Dextrose) Injections

**CLINIMIX E®:**
- Sulfite free (Amino Acid with Electrolytes in Dextrose with Calcium) Injections
- Manufactured by Baxter
- Supplied in dual chamber containers
- Admixed product is intended for IV use
- Disadvantage:
  - Less easily tailored to meet patient specific needs

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Protein

- Normal Range: 0.8-2g/kg/day
- Usual Doses: 1.1-1.5g/kg/day
- Maximum: 2g/kg/day
- Caloric contribution: 4kcal/g

Protein

- Want to achieve a positive nitrogen balance (+4-6g/day)
  - NB=nitrogen in-nitrogen out
  - Nitrogen in (grams)= grams of protein/day
  - Nitrogen out (grams)=grams of urea nitrogen excreted/day + a factor of 2 or 4 for insensible nitrogen loss
- Standard amino acids from stock solutions can be used for most patients
  - TRAVASOL 5.0%, 5.5%, 8.5%, 10%
- Special Considerations:
  - Renal and hepatic disease: modify to the lowest dose needed to achieve positive nitrogen balance


**Fat**
- Normal Range: 15-30% of non-protein calories
  - Limited benefit to fat dose >30%
- Maximum: 2.5g/kg/day
- Common dose in adults: ~1g/kg/day
- Caloric Contribution: 9kcal/g
- Manufactured as 20% intravenous fat emulsions (IVFE)
  - 20% = 2.0kcal/mL


**Lipids - Fat Emulsion**
- Opaque - creamy white solution
- Recommend infusing separate from TPN so that TPN bag can be inspected for particulates.
- Commercially available- 20% 250ml and 20% 500ml - room temp, plastic container
- Can infuse concurrently w/ TPN as separate infusion w/ its own pump.
Fat

- IVFE provides Vitamin K in varying contents depending on the manufacturer.
- Must provide at least 2-4% of total caloric intake as linoleic acid and 0.25-0.5% as alpha linolenic acid to prevent essential fatty acid deficiency (EFAD).
- Commercially available IVFE in the US contain 55-60% LA and 3-4% ALA.
- Special Considerations:
  - Hypertriglyceridemia
  - Withhold doses for TG level >400mg/dL.
  - Propofol Infusions.
  - Vehicle for propofol is 10% IVFE.


Carbohydrates (Dextrose)

- Normal Range: 70-85% of non-protein calories.
- Maximum: 4-5mg/kg/min; 7g/kg/day.
- Common dose in critically ill patients: 3-4mg/kg/min (~15-20kcal/day).
- Caloric contribution: 3.4kcal/g.


Carbohydrates - Dextrose
Designing the Formulation...

Micronutrients
- Electrolytes
- Vitamins
- Trace Elements

Custom Formulation-elements
Electrolytes

- Sodium
  - Requirement: 1-2mEq/kg/day (60-100mEq)
  - Can be provided as chloride, acetate, or phosphate salts
  - After phosphate addition, the remaining anions are added based on acid-base status
    - Acetate with metabolic acidosis
    - Chloride with metabolic alkalosis


- Potassium
  - Requirement: 1-2mEq/kg/day (60-100mEq)
  - Can be provided as chloride, acetate, or phosphate salts
  - Requirements can be increased with administration of potassium-wasting drugs (diuretics, steroids)
  - After phosphate addition, the remaining anions are added based on acid-base status
    - Acetate with metabolic acidosis
    - Chloride with metabolic alkalosis


- Magnesium
  - Requirement: 8-20mEq/day
  - Usually added as the sulfate salt
  - Higher doses needed in patients with alcoholism or large bowel losses, or in patients receiving drugs causing renal wasting of magnesium (cisplatin, amphotericin B, AMG, loop diuretics)
  - Magnesium should be decreased or removed in patients with renal failure

Electrolytes

- **Calcium**
  - Requirement: 10-15mEq/day
  - Usually added as the gluconate salt
  - Higher doses needed in patients receiving PN to help prevent metabolic bone disease
  - Addition of calcium is limited due to potential to precipitate with phosphate salts, which ultimately results in insoluble calcium phosphate


- **Phosphorus**
  - Requirement: 20-40mmol
  - Added as the sodium or potassium salt
  - Higher doses needed to prevent refeeding syndrome
  - Phosphorus should be decreased or removed in patients with renal failure
  - Addition of phosphate is limited due to potential to precipitate with calcium to form an insoluble compound


**Avoiding Ca/PO₄ precipitate**

- Use calcium gluconate instead of calcium chloride; calcium chloride is far more reactive
- Add phosphate first and calcium near the end of the compounding sequence
- Periodically agitate and check for ppt during mixing process
- A lipid emulsion in a 3-in-1 admixture obscures the presence of a ppt

Avoiding Ca/PO₄ precipitate

- Quick formula to determine if ratio is below precipitate threshold:
  - \( \frac{(2 \times \text{PO}_4) + \text{Ca}}{\text{L}} < 45 \)
- **If symptoms of acute respiratory distress, pulmonary embolus, or interstitial pneumonitis develop, infusion should be stopped immediately**

Daily Electrolyte Requirements

<table>
<thead>
<tr>
<th>Electrolyte</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sodium</td>
<td>1-2mEq/kg (60-100mEq)</td>
</tr>
<tr>
<td>Potassium</td>
<td>1-2mEq/kg (60-100mEq)</td>
</tr>
<tr>
<td>Magnesium</td>
<td>8-20mEq</td>
</tr>
<tr>
<td>Calcium</td>
<td>10-15mEq</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>20-40mmol</td>
</tr>
<tr>
<td>Acetate</td>
<td>As needed to maintain acid/base balance</td>
</tr>
<tr>
<td>Chloride</td>
<td>As needed to maintain acid/base balance</td>
</tr>
</tbody>
</table>

Vitamins

- Usually added as a commercially prepared multivitamin containing 12 or 13 vitamins
  - Vitamin K should be administered separately if the 12-vitamin preparation is used
    - Short term (<1 week) patients rarely need supplementation of Vitamin K
    - Long term (weeks to months) patients will likely require 2-4mg/week of parenteral vitamin K
- **Special Considerations:**
  - Additional thiamine and FA should be given in alcoholic patients
  - Additional FA (at least 600mcg/day) should be given in pregnant patients
### Daily Vitamin Requirements

<table>
<thead>
<tr>
<th>Vitamin</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thiamine (B1)</td>
<td>6mg</td>
</tr>
<tr>
<td>Riboflavin (B2)</td>
<td>3.6mg</td>
</tr>
<tr>
<td>Niacin (B3)</td>
<td>40mg</td>
</tr>
<tr>
<td>Folic Acid</td>
<td>400mcg</td>
</tr>
<tr>
<td>Pantothenic acid</td>
<td>15mg</td>
</tr>
<tr>
<td>Pyridoxine (B6)</td>
<td>6mg</td>
</tr>
<tr>
<td>Cyanocobalamin (B12)</td>
<td>5mcg</td>
</tr>
<tr>
<td>Ascorbic acid</td>
<td>200mcg</td>
</tr>
<tr>
<td>Vitamin A</td>
<td>3300 IU</td>
</tr>
<tr>
<td>Vitamin D</td>
<td>200 IU</td>
</tr>
<tr>
<td>Vitamin E</td>
<td>10 IU</td>
</tr>
<tr>
<td>Vitamin K</td>
<td>150mcg</td>
</tr>
</tbody>
</table>

### Trace Elements

- Usually added as a commercially prepared trace metal “cocktail”
- Special Considerations:
  - Copper and manganese should be reduced or eliminated in patients with cholestasis
  - Extra selenium should be given in homebound patients
  - Extra zinc should be given in patients with ostomy or diarrhea losses

### Daily Trace Element Requirements

<table>
<thead>
<tr>
<th>Element</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chromium</td>
<td>10-15mcg</td>
</tr>
<tr>
<td>Copper</td>
<td>0.3-0.5mg</td>
</tr>
<tr>
<td>Manganese</td>
<td>60-100mcg</td>
</tr>
<tr>
<td>Selenium</td>
<td>20-60mcg</td>
</tr>
<tr>
<td>Zinc</td>
<td>2.5-5mg</td>
</tr>
</tbody>
</table>
A variety of medications may be added to PN solutions
Insulin and H₂ antagonists have been admixed in both 2-in-1 and 3-in-1 admixtures
Other drugs shown to be stable and efficacious in 2-in-1 admixtures include heparin, aminophylline, hydromorphone, hydrochloric acid, and iron dextran

Hyperglycemia is the most common complication of TPN
Regular human insulin is added to aid in BG control
Common initial regimens:
- If BG is controlled, 0.1 units per gram of dextrose in infusion
- If BG >150mg/dL, 0.15 units per gram of dextrose in infusion
- >0.2 units of insulin per gram of dextrose is not recommended
- If blood glucose is 300mg/dL, PN should NOT be initiated until glycemic control is improved

BG levels should be monitored initially every 4 to 6 hours and supplemented with a sliding-scale coverage
Reasonable target level for blood glucose: 100-150mg/dL
Special Considerations:
- Critically ill: improved outcomes when blood glucose maintained at <110mg/dL
**H₂ Antagonists**

- Often added in patients requiring GI stress ulcer prophylaxis
- **Famotidine**
  - Stable in 3-in-1 admixtures for at least 72 hours
  - Recommended dose:
    - 40mg per 24-hour bag
    - If CrCl<50mL/min, 50% dose reduction recommended
- **Ranitidine**
  - Stable in 3-in-1 admixtures for 24 hours
  - Recommended dose:
    - 200-300mg/day NTE 400mg/day
    - If CrCl <50mL/min, recommended dose is 50mg/day

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**Designing the Formulation...**

**Example**

L.P. is a 78 year old male, who needs to be placed on TPN therapy. The patient recently had a massive bowel resection, and his GI function is not expected to return for approximately 3 weeks. L.P. is 5'8" and weighs 160 pounds.

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**Multidisciplinary**

- Physician
- Pharmacist
- Dietary
- Nursing
1. Estimate Fluid Requirements

- Fluid Requirements: 30-40mL/kg/day
  - 30mL/kg/day x 72.6 = 2178mL/day
  - 40mL/kg/day x 72.6 = 2904mL/day

2. Estimate Calorie Requirements

- Calorie Requirements: 25-30kcal/kg/day
  - 25kcal/kg/day x 72.6kg = 1815kcal/day
  - 30kcal/kg/day x 72.6kg = 2178kcal/day

3. Estimate Protein Requirements

- Protein Requirements: 1.1-1.5g/kg/day
  - 1.1g/kg/day x 72.6 = 80g/day
  - 1.5g/kg/day x 72.6 = 109g/day
  - Use 1000mL of 10% Travasol = 100g protein
  - 100g/day x 4kcal/g = 400kcal/day
3. Estimate Fat Requirements

- Fat Requirements: 30% of non-protein calories
  - 2000kcal/day - 400kcal/day = 1600kcal/day x 30% = 480kcal/day
- Use 250mL of 20% lipids = 250mL x 2 kcal/mL = 500kcal/day

4. Estimate Carbohydrate Requirements

- Total kcal/day-Protein kcal/day-Fat kcal/day
  - 2000kcal/day - 400kcal/day - 500kcal/day = 1100kcal/day
  - (1100kcal/day) / (3.4kcal/g) = 324g dextrose/day
- Use 1000mL of 35% dextrose = 350g dextrose/day
  - 350g dextrose/day x 3.4kcal/g = 1190kcal/day

5. Calculate Calorie and Fluid Totals

- Total Calories:
  - = Protein + Fat + Carbohydrates
  - = 400kcal/day + 500kcal/day + 1190kcal/day
  - = 2090kcal/day
- Total Fluid:
  - = 1000mL (protein) + 250mL (fat) + 1000mL (carbohydrate)
  - = 2250mL/day
Nursing Considerations

- Rapid discontinuation of TPN can result in Hypoglycemia - If TPN is interrupted another source of Dextrose must be available.
- Dextrose 10% should be given if TPN is not available. Need standing order from Physician upon admission.

Altered glucose metabolism

- Hyperosmolar hyperglycemic nonketonic dehydration
- Rare - caused by any hyperosmolar solution - usually glucose in PN
- Osmotic diuresis causes dehydration

Hepatic Steatosis

- Long term consequence of overfeeding
- Result of excess carbohydrate calories stored as fat in hepatocytes
- Cyclic TPN infusion may help prevent.
Hypoglycemia
- Hypoglycemia is rare in TPN patients
- Abrupt discontinuation may precipitate, but has only been reported in frail adults and children
- Taper if necessary.

Hypernatremia
- Na+ level > 145 should be evaluated for fluid volume deficiency first.
- Most common cause is decreased intravascular volume.
- Fluid replacement to all losses. (NG tubes, fistulas, loose stools)

Hyponatremia
- Na+ < 130
- Again consider fluid balance - overload
Hyperkalemia
- Can be caused by many factors.
- Consider repeat lab draw to rule out hemolysis of sample.
- Most commonly adjusted additive.

Hypokalemia
- More common than hyperkalemia.
- Replacement is needed.
- Refeeding syndrome -

TPN Nursing Considerations
- Verify placement of catheter tip in central circulation prior to administration.
- If catheter dislodged or migrates out it needs reevaluated for proper placement.
- Compare solution bag label to original Physician’s Order. (Two licensed nurses must check for accuracy)
- Keep solution refrigerated until 30-60 minutes before use.
TPN Nursing Considerations

- Except for lipid emulsions, insulin, or vitamins, no other I.V. solutions or medications, I.V. push or piggyback medications are to be added to TPN bags.
- Assure that 10% Glucose I.V. solution is available in-house at all times through duration of TPN therapy.

Nursing Considerations-Tubing

- Administration set is changed with each new solution bag.
- Filtered tubing is to be used for delivery of solution
  - A. 0.22 micron filter.
  - B. 0.5 micron or larger filter must be used when lipids have been added to solution.
- Lipids- Fat emulsion sets for Lipids - no filter

Nursing Considerations-

- Strict adherence to aseptic and sterile technique for manipulation of administration set and solution bags.
- Maintain consistent infusion rate by use of an electronic infusion device.
Nursing Considerations-
- Periodic assessment of laboratory values is essential: Serum electrolytes, serum glucose, albumin, chemistry profile, etc.
- Monitor vital signs as ordered, at least every shift, and more frequently as necessary.
- Assess urine sugar and acetone levels as ordered.
- Weigh patient daily and record.
- Record fluid intake and output.

Frequently Asked Questions...

How should PN be initiated?
- PN can be started at the goal rate for the volume to be provided
- Gradually advanced infusion rates may be beneficial in patients with diabetes or at high risk for refeeding
**When should PN be discontinued?**
- PN should be discontinued with transition to PO or enteral nutrition AS SOON AS FEASIBLE
- Tapering of PN is not necessary
  - Risk of rebound hypoglycemia is very low
- Can be restarted in 2-3 days if the patient does not continue to tolerate enteral or PO nutrition

**What happens if a patient is overfed?**
- Overfeeding occurs when maximum doses of macronutrients are exceeded
- Overfeeding can result in impaired renal, hepatic, cardiac, pulmonary, and immunologic function

**What is refeeding syndrome?**
- Refeeding results from pancreatic stimulation and insulin secretion after the introduction of a consistent nutrient source (primarily carbohydrate) in malnourished patients
- Characterized by an abrupt decrease in serum K, Mg, and/or P
- Treatment:
  - PN should be started at partial calories with appropriate supplementation of electrolytes and vitamins
How often should labs be checked?

- Daily labs are needed when initiating PN
  - First several days to >2 weeks
- Once patient is stable, most labs can be monitored weekly
  - Cr, glucose, and weight should be monitored 1-2 times/week

Questions

References