Parenteral Nutrition: An Evidence Based Practice Review

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Learning Objectives

- To identify appropriate use for TPN
- To determine correct TPN composition for different patient populations
- To recognize side effects and possible contraindications for TPN use
TPN: Indications for Use

- Non functional gastrointestinal tract/Unsuccessful EN attempt
- GI tract cannot be accessed
- NPO status for greater than 7 days in the healthy patient
- In critically ill, if EN is not possible and hypermetabolism is expected to last more than 4-5 days
- Neonates and Infants, if expected to be NPO for more than 2-3 days
- Premature Infants, within the first 24-48 hours of life
TPN: Indications for Use

- Disease State
  - Congenital Heart Disease
  - GI Disease
- Critically Ill
- ECMO – Extracorporeal Membrane Oxygenation
- Cancer – GVHD, radiation enteritis, cachexia
- High output fistulas
- Organ Transplant
TPN: Contraindications for Use

- Functioning GI tract
- Anticipated administration of TPN for < 5 days in adequately nourished patient
- No safe venous access
- No aggressive support desired
- Severe electrolyte imbalance
TPN considerations

- When possible, allow provision of oral diet or trophic enteral feedings or combined EN/PN

- If the gut works, use it!
TPN: Indications to Discontinue

- When patient is able to tolerate enteral nutrition/solid foods by mouth, greater than 60% of needs

- NICU: Decrease PN as EN/PO increases keeping total volume between 150-170 mL/kg. D/C when EN/PO is at 125 mL/kg/day

- Individualized per patient and situation
Parenteral Nutrition Access

- Peripheral
  - PIV

- Central (CVAD’s)
  - PICC
  - Broviac, Hickman, Hohn
  - Port
TPN Basic Components

- Amino Acids (protein)
- Dextrose (carbohydrate)
- Lipid emulsion (fat)
- Vitamins
- Trace minerals
- Water
- Other additives
- Electrolytes
Peripheral PN

- 900 mOsm/L
- Dextrose: 150-300g/d (5%-10%) in adults and 10-12.5% dextrose concentration in pediatrics
- Limited nutrition if fluid restriction
- Duration: 5 days to 2 weeks
- Adult Criteria: (1) good peripheral access & (2) tolerate large volumes (2.5-3L)
Macronutrients

- **Protein**
  - Crystalline amino acids – Essential and Non-Essential
  - Trophamine, Aminosyn, Premasol (Peds)
  - Travasol (Adults)
  - 4 kcal/g
  - Adults: 0.8-2 g/kg
  - Pediatrics: 2-4 g/kg
  - ~20% total kcals
Macronutrients

• Carbohydrates – Dextrose

• 3.4 kcal/g

• Needs: 50-70% of total kcals

• Maximum glucose oxidation rate (mg/kg/min)
  GIR: \[
  \frac{[\text{dextrose (g/day)} \times 1000]}{[24 \text{ (h/day)} \times 60 \text{ (min/h)} \times \text{weight (kg)}]}
  \]
Macronutrients

- **Fat** – IV Fat Emulsion (IVFE) or Lipids
  - Intralipid, Liposyn III, Nutrilipid
- 10% (1.1 kcal/mL); 20% (2.0 kcal/mL) or 30% (3.0 kcal/mL)
- ~10 kcal/g
- 12 hour hang time
- Usually ~30% of kcal
Macronutrients

Fat continued:

- 0.5-1g/kg/day to prevent EFAD
- Omega-3 and Omega-9 Fat Emulsions
- SMOF
## Initiation and Advancement of Macronutrients

### GOALS

**Infants (<1 y)**
- **Protein (g/kg/day)**: 3-4 (Preterm) - 2.5-3 (Term)
- **Dextrose (mg/kg/min)**: 6-8 (Preterm) - 6-8 (Term)
- **Fat (g/kg/day)**: 0.5-1 (Preterm) - 0.5-1 (Term)

**Term**
- **Protein (g/kg/day)**: 2.5-3
- **Dextrose (mg/kg/min)**: 3.5
- **Fat (g/kg/day)**: 2.5 (max 0.15 g/kg/h)

**Preterm**
- **Protein (g/kg/day)**: 3-4
- **Dextrose (mg/kg/min)**: 10-14 (max 14-18)
- **Fat (g/kg/day)**: 2.5 (max 0.15 g/kg/h)

**Children (1-10 y)**
- **Protein (g/kg/day)**: 1.5-2.5
- **Dextrose (mg/kg/min)**: 3-6
- **Fat (g/kg/day)**: 1-2

**Adelescents**
- **Protein (g/kg/day)**: 0.8-2
- **Dextrose (mg/kg/min)**: 2.5-3
- **Fat (g/kg/day)**: 1

Initiation and Advancement of Macronutrients

Adult Patient – individualized per assessment

- 30% of calories from fat
- 70% from dextrose and amino acid solution
- Maximum GIR: 5 mg/kg/min
- Lipids: 1-2.5g/kg
- Protein: individualized per need
- Initiate dextrose with GIR ≤ 3 mg/kg/min
Calculations of Total Calories from PN

- PN volume = PN rate (ml/hr) x hours TPN ordered

a.) Dextrose Calories: PN volume x % dextrose x 3.4 kcal/g

b.) Protein Calories: total grams protein/day x 4 kcal/g
Or grams/kg protein x weight x 4 kcal/g

c.) Fat Calories: Intralipid volume x 1.1 kcal/mL (10%) Intralipid volume x 2.0 kcal/mL (20%)

d.) Total calories = a+b+c

- Calories per kg = d/weight
Micronutrients

- Electrolytes
- Vitamins
- Trace Elements – Zinc, Copper, Chromium, Manganese and Selenium
## Parenteral Trace Elements Solutions

### Ingredient

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Adult Trace/mL&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Pediatric Trace/mL&lt;sup&gt;b&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zinc</td>
<td>5 mg</td>
<td>1.0 mg</td>
</tr>
<tr>
<td>Copper</td>
<td>1.0 mg</td>
<td>0.1 mg</td>
</tr>
<tr>
<td>Manganese</td>
<td>0.5 mg</td>
<td>25 µg</td>
</tr>
<tr>
<td>Chromium</td>
<td>10 µg</td>
<td>1 µg</td>
</tr>
<tr>
<td>Selenium</td>
<td>60 µg</td>
<td>NA</td>
</tr>
</tbody>
</table>

<sup>a</sup>Multitrace-5 Concentrate  
<sup>b</sup>Multitrace-4 Pediatric Trace Elements Injection
## Parenteral Vitamin Solutions

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Adult MVI/5mL&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Pediatric MVI/4 mL&lt;sup&gt;b&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vitamin A</td>
<td>1 mg 3300 IU</td>
<td>0.7 mg 2300 IU</td>
</tr>
<tr>
<td>Vitamin D</td>
<td>5 µg 200 IU</td>
<td>10 µg 400 IU</td>
</tr>
<tr>
<td>Vitamin E</td>
<td>10 mg 10 IU</td>
<td>7 mg 7 IU</td>
</tr>
<tr>
<td>Vitamin B&lt;sub&gt;1&lt;/sub&gt;</td>
<td>6 mg</td>
<td>1.2 mg</td>
</tr>
<tr>
<td>Vitamin B&lt;sub&gt;2&lt;/sub&gt;</td>
<td>3.6 mg</td>
<td>1.4 mg</td>
</tr>
<tr>
<td>Vitamin B&lt;sub&gt;6&lt;/sub&gt;</td>
<td>6 mg</td>
<td>1 mg</td>
</tr>
<tr>
<td>Niacin</td>
<td>40 mg</td>
<td>17 mg</td>
</tr>
<tr>
<td>Dexpanthenol</td>
<td>15 mg</td>
<td>5 mg</td>
</tr>
<tr>
<td>Folic acid (per mL)</td>
<td>600 µg</td>
<td>140 µg</td>
</tr>
<tr>
<td>Vitamin B&lt;sub&gt;12&lt;/sub&gt; (per mL)</td>
<td>5 µg</td>
<td>1 µg</td>
</tr>
<tr>
<td>Biotin (per mL)</td>
<td>60 µg</td>
<td>20 µg</td>
</tr>
<tr>
<td>Ascorbic Acid</td>
<td>200 mg</td>
<td>80 mg</td>
</tr>
<tr>
<td>Vitamin K&lt;sub&gt;1&lt;/sub&gt;</td>
<td>150 µg</td>
<td>200 µg</td>
</tr>
</tbody>
</table>
Electrolytes - Adult

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

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# Electrolytes - Pediatrics

<table>
<thead>
<tr>
<th>Electrolyte</th>
<th>Preterm Neonates</th>
<th>Infants/Children</th>
<th>Adolescents and Children &gt; 50kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sodium</td>
<td>2-5 mEq/kg</td>
<td>2-5 mEq/kg</td>
<td>1-2 mEq/kg</td>
</tr>
<tr>
<td>Potassium</td>
<td>2-4 mEq/kg</td>
<td>2-4 mEq/kg</td>
<td>1-2 mEq/kg</td>
</tr>
<tr>
<td>Calcium</td>
<td>2-4 mEq/kg</td>
<td>0.5-4 mEq/kg</td>
<td>10-20 mEq/day</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>1-2 mmol/kg</td>
<td>0.5-2 mmol/kg</td>
<td>10-40 mmol/day</td>
</tr>
<tr>
<td>Magnesium</td>
<td>0.3-0.5 mEq/kg</td>
<td>0.3-0.5 mEq/kg</td>
<td>10-30 mEq/day</td>
</tr>
<tr>
<td>Acetate Chloride</td>
<td>As needed to maintain acid base-balance</td>
<td>As needed to maintain acid base-balance</td>
<td></td>
</tr>
</tbody>
</table>

TPN- Additives

- Medications
- Carnitine
- Cysteine
TPN Solutions

- **2-in-1 Solution**
  - Dextrose and Amino Acids
  - Lipids administered separately

- **Total Nutrient Admixture (TNA)**
  - Also called 3-in-1 or all-in-one
  - Contains dextrose, amino acids and lipids together

- Premixed Formulations
Cycling TPN

- Prevent hypoglycemia, hepatotoxicity and PNALD
- 20 to 8 hours depending on patient needs
- Taper 1-2 hours on and off

**Calculation:**
A.) Total TPN volume per day
B.) Total cyclic infusion time minus 1 hour (if using 1 hr on and off taper)
C.) rate of taper

total volume (A) divided by infusion time in hours (B) = full rate of non taper time.
To obtain taper rate, divide full rate (B) by 2 = rate of taper up and down for 1 hour.

**Example:**
1. 600 mL total volume/15 hours = 40 mL/hr
2. 2. 40 mL/2 = 20 mL/hr
TPN order: total volume 600 mL cycled over 16 hours at 40 mL/hr with 1 hour taper on and off at 20 mL/hr
TPN Monitoring

- Anthropometrics and Growth
- I’s/O’s
- Electrolytes – daily then twice per week if stable
- LFT’s, Triglycerides – weekly if stable
- Glucose – individualized as needed
- Vitamins – baseline then every ~3-6 months
TPN Complications - Adults

- Refeeding Syndrome
- PNALD
- PN Associated Cholestasis (PNAC) & Gallbladder statsis
- Trace element deficiencies or toxicities
TPN Complications – Pediatrics

- Central Line-Associate Bloodstream Infections
- Aluminum Toxicity
- Iron Deficiency
- Metabolic Bones Disease
- Parenteral Nutrition Associated Liver Disease (PNALD)
TPN- Safety

- High Alert medication
- Policies, Procedures and Protocols
- PN product shortages
- A.S.P.E.N. PN safety toolkit
  http://www.nutritioncare.org/pnsafety/
TPN shortages

- A.S.P.E.N. product-shortages

- FDA Drug Shortages mobile app

Home TPN

- Stable
- Cyclic TPN

- Discharge planning – home health care company, patient/caregiver education, home assessment

- Outpatient follow up with interprofessional team (MD, RD, PA/NP, RN, Pharmacist)

- Monitor lab trends

- Daily administration of vitamins and other additives
References


Questions