How to Write a TPN Order
How to Write a TPN Order

• Provider approved by the California Board of Registered Nursing, Provider #15200 for 1.0 contact hours.
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• Coram CVS Specialty Infusion Services is approved by The Commission for Case Manager Certification to provide continuing education credit to CCM® board-certified case managers.
• Coram CVS Specialty Infusion Services is a Continuing Professional Education (CPE) accredited provider with the Commission on Dietetic Registration (CDR), Registered Dietitians (RDs) and Dietetic Technicians Registered (DTRs) will receive 1.0 continuing professional education units (CPEUs) for completion of this program/material. CDR Provider CO100.

For Registered Dietitians
The Program Level: 3
The Learning Codes: 2090, 3000, 5030, 5440
Continuing Nursing Education and Conflict of Interest Statement

- Conflicts of interest or lack thereof
- Commercial support received
- Non-endorsement of products
Objectives

1. List and describe three areas of evaluation in a nutrition assessment.

2. Name the components of a parenteral nutrition (TPN) solution.

3. List three guidelines for safe delivery of a TPN solution.

4. Describe each step in formulating a TPN order.
Polling Question

YES / NO

As a clinician managing TPN patients, do you write a complete order (macro, micro nutrients & electrolytes?)
Getting Started Checklist

• Nutrition assessment
  – Determine macronutrients
  – Determine fluid and volume needs
  – Determine vitamins and minerals
• IV access
• Medications
• Patient additives
• Solution administration
• Line flushing protocol
• Lab orders
Nutrition Screening and Assessment

Assess for Malnutrition

3 Categories of Etiology Based Malnutrition

1. Starvation-related malnutrition (social or environmental circumstances)
2. Chronic disease-related malnutrition
3. Acute disease-or injury-related malnutrition

At least 2 characteristics must be present:

1. Inadequate food intake to meet needs over time
2. Acute or chronic unintentional weight loss
3. Changes in body composition
4. Reduced physical function measured by grip strength, walking, rising/balance, or expiratory function
Nutrition Care Plan

• A plan is a series of steps that provide guidelines for promoting positive clinical outcomes through nutrition surveillance and intervention.
Protein Needs

- **Maintenance**
  Mild stress: 0.8–1.0 g/kg/day

- **Catabolic**
  Moderate to severe stress: 1.2–2.0 gm/kg/day

- **Chronic renal failure**
  1.2–1.5 gm/kg/day

Factors to Consider:
- Disease state
- Degree of catabolism
- Wound or GI losses
- Current nutritional status
Calorie Needs

• Mifflin St-Jeor
  – Men: \( \text{REE}^* = 10 \times \text{wt in kg} + 6.25 \times \text{ht in cm} - 5 \times \text{age} + 5 \)
  – Women: \( \text{REE} = 10 \times \text{wt in kg} + 6.25 \times \text{ht in cm} + 5 \times \text{age in years} - 161 \)
  – Measured obese individuals
  – Uses ABW

• Rule of Thumb Method
  – Maintenance: 20–25 kcals/kg/day
  – Moderate stress: 25–28 kcals/kg/day
  – Severe stress: 28–35 kcals/kg/day
Fluid Needs

- 30–40 mL/kg/day maintenance
- Reduce if volume overloaded
- Increase for excessive stool, urine, vomiting, sweating, fever
## Parenteral Vitamin Requirements

<table>
<thead>
<tr>
<th>Vitamin</th>
<th>TPN Adults(^{2000})*</th>
<th>RDA Adults(^{2001})</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>3300 IU</td>
<td>2400–3000 IU</td>
</tr>
<tr>
<td>D</td>
<td>200 IU</td>
<td>200–600 IU</td>
</tr>
<tr>
<td>E</td>
<td>10 IU</td>
<td>11–15 mg</td>
</tr>
<tr>
<td>C</td>
<td>200 mg</td>
<td>75–90 mg</td>
</tr>
<tr>
<td>Folate</td>
<td>600 mcg</td>
<td>400 mcg</td>
</tr>
<tr>
<td>Niacin</td>
<td>40 mg</td>
<td>14–16 mg</td>
</tr>
<tr>
<td>Riboflavin</td>
<td>3.6 mg</td>
<td>1.1–1.3 mg</td>
</tr>
<tr>
<td>Thiamin</td>
<td>6 mg</td>
<td>1.1–1.2 mg</td>
</tr>
<tr>
<td>Pyridoxine</td>
<td>6 mg</td>
<td>1.3–1.7 mg</td>
</tr>
<tr>
<td>Cyanocobalamin</td>
<td>5 mcg</td>
<td>2.4 mcg</td>
</tr>
<tr>
<td>Pantothenic acid</td>
<td>15 mg</td>
<td>5 mg</td>
</tr>
<tr>
<td>Biotin</td>
<td>60 mcg</td>
<td>30 mcg</td>
</tr>
<tr>
<td>K</td>
<td>150 mcg</td>
<td>90–120 mcg</td>
</tr>
</tbody>
</table>

*Adapted from adult Infuvite package insert, Baxter 2013*
# Trace Element Requirements

<table>
<thead>
<tr>
<th>Trace Mineral</th>
<th>Daily Recommendations (adults)</th>
<th>Parenteral Requirements (adults) (per 1 mL concentrate)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>*AMA NAG, 1979</td>
<td></td>
</tr>
<tr>
<td></td>
<td>**Safe Practices for TPN</td>
<td></td>
</tr>
<tr>
<td>Chromium</td>
<td>10–15 mcg*</td>
<td>10 mcg</td>
</tr>
<tr>
<td>Copper</td>
<td>0.3–1.5 mg*</td>
<td>1 mg</td>
</tr>
<tr>
<td>Manganese</td>
<td>0.15–0.8 mg*</td>
<td>0.5 mg</td>
</tr>
<tr>
<td>Zinc</td>
<td>2.5–4.0 mg*</td>
<td>5 mg</td>
</tr>
<tr>
<td>Selenium</td>
<td>20–60 mcg**</td>
<td>60 mcg</td>
</tr>
</tbody>
</table>


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Additives

In home, some additives are added by patient prior to infusion

- All additives must be checked for stability in compounded solution.
- H2 Antagonist
  - Famotidine
  - Ranitidine
- Insulin
  - Need at least 10 units/L to see clinical effect
  - Average of 0.1 unit regular insulin/gm dextrose in diabetic patient
- Heparin
Additional Potential Additives

• These additives have been added with proven stability
• Vitamin C
  – 500–1000 mg/day for wound healing
• Folic Acid
  – 1 mg/day with alcohol abuse
• Thiamin
  – 100 mg/day with alcohol abuse or for refeeding risk
## Vascular Access for Parenteral Nutrition

<table>
<thead>
<tr>
<th>PERIPHERAL</th>
<th>CENTRAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peripheral catheters</td>
<td>Percutaneous non-tunneled Central Catheter (jugular, femoral, subclavian vessels)</td>
</tr>
<tr>
<td>Midline Catheters</td>
<td>Tunneled cuffed catheters (subclavian or jugular vessels)*</td>
</tr>
<tr>
<td>Midclavicular catheters</td>
<td>Peripherally inserted catheter (PICC)*</td>
</tr>
<tr>
<td><strong>Not appropriate for the infusion of PN formulas ≥900mOsm/l</strong></td>
<td>Implanted ports*</td>
</tr>
</tbody>
</table>

* Optimal for home care and long-term PN therapy
Laboratory and Line Care Orders

• Baseline CMP, phosphorus, magnesium, triglyceride
• Monitor CMP or BMP, phosphorus, magnesium, triglycerides, CBC
  – Long term PN – Iron
• Based on patients’ plan of care
• Line flushing and care protocol
Components of TPN Solution

- Amino acids
- Carbohydrates
- Lipids
- Vitamins
- Trace minerals

- Electrolytes
- Additives
- Compatible medications
- Sterile water
Amino Acids

- Nitrogen is supplied as a mixture of essential and non-essential crystalline L-amino acids
- Standard (adult and pediatric)
- Provides 4 kcalories/g and 6.25 g protein/g nitrogen
- Available in 8.5%, 10%, 15%, 20% solutions for compounding
- Percent concentration refers to grams of solute per 100 mL of solution
- Contains acetic acid as a buffer
- Acetate salts increase pH
- Some contain electrolyte additives: phosphorus
Carbohydrate

• Dextrose monohydrate
• 3.4 kcals/g
• Should provide 70-85% of non-protein calories (~55-60% of total calories) and not exceed 7g/kg/day
• Commercially available solutions of 2.5–70% for compounding
Intravenous Fat Emulsions

Provide 20–30% of daily kilocalories

1–2% of long chain fatty acids prevents EFAD

Isotonic; Egg yolk phospholipid as emulsifier; Contains vitamin K, vitamin E and phosphate

10%, 20%, 30% concentrations for compounding

Calories (lipids plus glycerol)
• 10%: 1.1 kilocalorie per mL
• 20% and 30%: 2.0 and 3.0 kilocalorie per mL respectively

Commercially available in the U.S.as:
• Soybean / safflower oil
• SMOFlipid (soybean, MCT, olive & fish oil)
• OMEGAVEN NOW FDA APPROVED!

Hang time
• Admixture (lipids/amino acids/carbohydrates): 24 hours
Three-in-One Versus Two-in-One

• Medications that are not compatible with lipids should not be added to 3-1.*

• Stability (refrigerated, without additives)
  – Per USP 797, TPN compound whether 3-1 or 2-1 or via dual-chamber bag has a 9-day beyond use or expiration date.

*Use drug information resources such as Trissel’s Handbook on Injectable Drugs before adding medications to 3-1 or 2-1 TPNs.
Electrolyte Requirements

• Average Daily Requirements
  – Repletion needs
  – Daily requirements
  – Losses

• Modification
  – Renal failure
  – Fluid retention
  – NG losses
  – Diarrhea/ostomy output
  – Fistula output
  – Refeeding
  – Medications

A.S.P.E.N.’s Daily Electrolyte Guidelines for Adult PN

<table>
<thead>
<tr>
<th>Electrolyte</th>
<th>Amount Needed</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>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>
<tr>
<td>Calcium</td>
<td>10–15 mEq</td>
</tr>
<tr>
<td>Magnesium</td>
<td>8–20 mEq</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>20–40 mmol</td>
</tr>
</tbody>
</table>
# Electrolyte Management: Not An Exact Science

<table>
<thead>
<tr>
<th>Electrolyte</th>
<th>TPN Standard Daily Requirement</th>
<th>Span of Electrolyte Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sodium</td>
<td>1–2 mEq/kg</td>
<td>100%</td>
</tr>
<tr>
<td>Potassium</td>
<td>1–2 mEq/kg</td>
<td>100%</td>
</tr>
<tr>
<td>Calcium</td>
<td>10–15 mEq</td>
<td>50%</td>
</tr>
<tr>
<td>Magnesium</td>
<td>8–20 mEq</td>
<td>150%</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>20–40 mmol</td>
<td>100%</td>
</tr>
</tbody>
</table>


**Suggested standard daily requirements for electrolytes vary.**
### Not All “Abnormal” Lab Values Are Equal

<table>
<thead>
<tr>
<th></th>
<th>Severe low</th>
<th>Adult normal range</th>
<th>Severe high</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sodium</td>
<td>&lt;115 mEq/L</td>
<td>135–145 mEq/L</td>
<td>&gt;155 mEq/L</td>
</tr>
<tr>
<td>Potassium</td>
<td>&lt;3 mEq/L</td>
<td>3.5–5 mEq/L</td>
<td>&gt;5.3 mEq/L</td>
</tr>
<tr>
<td>Bicarbonate</td>
<td>&lt;22mEq/L</td>
<td>22–26 mEq/L</td>
<td>&gt;28 mEq/L</td>
</tr>
<tr>
<td>Chloride</td>
<td>Not defined</td>
<td>95–108 mEq/L</td>
<td>Not defined</td>
</tr>
<tr>
<td>Calcium</td>
<td>Not defined</td>
<td>Total: 8.5–10.5 mg/dL</td>
<td>Total: &gt;12 mg/dL</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4.3–5.3 mEq/L</td>
<td></td>
</tr>
<tr>
<td>Magnesium</td>
<td>&lt;1 mg/dL</td>
<td>1.8–3 mg/dL</td>
<td>&gt;4 mg/dL</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.5–2.5 mEq/L</td>
<td></td>
</tr>
<tr>
<td>Phosphorus</td>
<td>&lt;1 mg/dL</td>
<td>2.5–4.5 mg/dL</td>
<td>Not defined</td>
</tr>
<tr>
<td></td>
<td>&lt;0.32 mmol/L</td>
<td>0.81–1.45 mmol/L</td>
<td></td>
</tr>
</tbody>
</table>


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Abnormal Labs

Other etiological factors should be considered

- Volume changes
  - IV fluids, fluid shift

- Medications
  - Diuretics

- Nutritional status
  - Refeeding syndrome

- GI disturbances

- Renal function

- Chronic diseases
  - Diabetes

Monitoring Electrolyte Imbalances

Some patients require more careful monitoring for electrolyte imbalances.

- **GI Surgery**
  - Reduced peristalsis, eating restrictions
  - Diuretics, insulin and glucocorticoids

- **Short Bowel Syndrome**
  - Major fluid needs
  - Potential major daily electrolyte requirements

- **Chronic Disease**
  - Diabetic ketoacidosis
  - Congestive heart failure
  - COPD

- **Renal Problems**
  - Impaired excretion of fluid and electrolytes
  - Metabolic acidosis

- **Elderly**
  - Compromised pulmonary, renal, cardiac, and GI systems
  - Co-morbidities

- **Sepsis**
  - Increased venous capacitance
  - Hypovolemia

---

Managing Electrolytes

Natural fluctuations and patient variations should be considered when managing electrolytes

- Patients’ electrolyte levels can fluctuate over time.
- Major electrolyte excretions by the kidneys are subject to circadian rhythms.
- The potential for lab error should also be considered, especially when the patient is asymptomatic.

Interventions should be based on trends over time.

Sodium Imbalances

Hyponatremia

- Causes:
  - Malnutrition / starvation
  - Water intoxication
  - Diarrhea
  - Burns

*Hormonal influences:* Increased antidiuretic hormone (ADH), decreased adrenocortical hormones

- Symptoms and Morbidities:
  - Headaches, confusion, cerebral edema, seizures
  - Muscle weakness

Hypernatremia

- Causes:
  - High-salt diet, medical interventions with 3% saline solutions
  - Renal dysfunction

*Hormonal influences:* Increased adrenocortical hormones, cortisone injections

- Symptoms and Morbidities:
  - Nausea, dry mouth, decreased appetite
  - Agitation, fever
  - Muscle twitching, heightened reflexes

Hyponatremia is one of the leading electrolyte disorders occurring in hospitalized patients.

# Potassium Imbalances

## Hypokalemia vs. Hyperkalemia

<table>
<thead>
<tr>
<th>Hypokalemia</th>
<th>Hyperkalemia</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Causes</strong></td>
<td><strong>Causes</strong></td>
</tr>
<tr>
<td>• Malnutrition / starvation / alcoholism / GI loss by diarrhea</td>
<td></td>
</tr>
<tr>
<td>• Renal dysfunction, metabolic alkalosis</td>
<td></td>
</tr>
<tr>
<td>• Traumatic injury</td>
<td></td>
</tr>
<tr>
<td><em>Hormonal influences:</em> Increased cortisone, increased aldosterone, increased insulin</td>
<td></td>
</tr>
<tr>
<td><em>Drugs effects:</em> Potassium-wasting diuretics, epinephrine, $b_2$ agonists</td>
<td></td>
</tr>
<tr>
<td><strong>Symptoms and Morbidities</strong></td>
<td><strong>Symptoms and Morbidities</strong></td>
</tr>
<tr>
<td>• Nausea, vomiting, decreased GI motility</td>
<td></td>
</tr>
<tr>
<td>• Vertigo, confusion</td>
<td></td>
</tr>
<tr>
<td>• Cardiac arrhythmias, cardiac arrest</td>
<td></td>
</tr>
<tr>
<td>• Muscle weakness</td>
<td></td>
</tr>
<tr>
<td><strong>Severe low</strong></td>
<td><strong>Severe high</strong></td>
</tr>
<tr>
<td>&lt;3 mEq/L</td>
<td>&gt;5.3 mEq/L</td>
</tr>
<tr>
<td><strong>Normal range</strong></td>
<td></td>
</tr>
<tr>
<td>3.5–5 mEq/L</td>
<td></td>
</tr>
</tbody>
</table>

**Hypokalemia is commonly acquired in the hospital due to side effects of drug therapy.**

# Bicarbonate Imbalances

## Metabolic Acidosis

<table>
<thead>
<tr>
<th>Causes</th>
<th></th>
<th>Causes</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>• Starvation, malnutrition, diarrhea, severe exercise</td>
<td></td>
<td>• Vomiting, gastric suction, peptic ulcers</td>
<td></td>
</tr>
<tr>
<td>• Renal dysfunction</td>
<td></td>
<td>• Hypokalemia</td>
<td></td>
</tr>
<tr>
<td>• Diabetic ketoacidosis</td>
<td></td>
<td>Drug effects: Bicarbonate or other acid-reducing compounds taken for the treatment of ulcers</td>
<td></td>
</tr>
<tr>
<td>• Trauma, shock, severe infection, fever</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Hormonal influences:* Hyperthyroidism

<table>
<thead>
<tr>
<th>Symptoms and Morbidities</th>
<th></th>
<th>Symptoms and Morbidities</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>• Central nervous system depression</td>
<td></td>
<td>• Central nervous system excitability</td>
<td></td>
</tr>
<tr>
<td>• Disorientation, weakness, and stupor</td>
<td></td>
<td>• Irritability, mental confusion</td>
<td></td>
</tr>
<tr>
<td>• Nausea, vomiting, abdominal pain</td>
<td></td>
<td>• Tetany-like symptoms and hyperactive reflexes</td>
<td></td>
</tr>
<tr>
<td>• Deep, rapid breathing</td>
<td></td>
<td>• Hypoventilation</td>
<td></td>
</tr>
</tbody>
</table>

## Metabolic Alkalosis

<table>
<thead>
<tr>
<th>Causes</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>• Vomiting, gastric suction, peptic ulcers</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

## Normal range

- Normal range: 22–26 mEq/L

## Severe low

- Severe low: <22 mEq/L

## Severe high

- Severe high: >28 mEq/L

---

# Calcium Imbalances

<table>
<thead>
<tr>
<th>Severe low</th>
<th>Normal range</th>
<th>Severe high</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not defined</td>
<td><strong>Total</strong>: 8.5–10.5 mg/dL; 4.3–5.3 mEq/L</td>
<td><strong>Total</strong>: &gt;12 mg/dL</td>
</tr>
<tr>
<td>Ionized: 4.25–5.25 mg/dL, 1.15–1.3 mmol/L</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

## Hypocalcemia

### Causes
- Low dietary calcium, low vitamin D
- Renal dysfunction
- Increased serum phosphate
- Severe magnesium deficit

_Hormonal influences:_ Decreased parathyroid hormone

_Drug effects:_ Steroids, loop diuretics

False low levels can be due to low albumin.

### Symptoms and Morbidities
- Tetany (involuntary muscle contractions)
- Decreased blood clotting
- Anxiety

## Hypercalcemia

### Causes
- Diet, medical interventions such as parenteral nutrition (TPN)
- Renal dysfunction
- Decreased serum phosphate

_Hormonal influences:_ Increased parathyroid hormone

_Drug effects:_ Thiazide diuretics

### Symptoms and Morbidities
- Heart block, cardiac arrest
- Kidney stones
- Depression

---

*Hypercalcemia is more common than hypocalcemia.*

- Fauci AS. *Harrison's Principles of Internal Medicine, 17th edition. Part 2. Chapter 47. Hypercalcemia and Hypocalcemia, 2008*
## Magnesium Imbalances

### Hypomagnesemia

**Causes**
- Malnutrition, starvation, alcoholism, GI losses, magnesium-poor TPN
- Increased calcium intake
- Magnesium-wasting renal diseases
- Diuresis from diabetic ketoacidosis
- Hypokalemia, hypocalcemia, and metabolic alkalosis
- Acute myocardial infarction, heart failure

**Drug effects:** Aminoglycosides, potassium-wasting diuretics, cortisone, amphotericin B, digoxin

**Symptoms and Morbidities**
- Neuromuscular excitability, increased reflexes, tetany
- Tachycardia, hypertension, cardiac dysrhythmias, ventricular fibrillation

### Hypermagnesemia

**Causes**
- Overuse of magnesium supplements, antacids or laxatives
- Severe dehydration
- Diabetic ketoacidosis
- Renal dysfunction

**Symptoms and Morbidities**
- CNS depression, loss of deep tendon reflexes
- Hypotension, heart block
- Decreased respiration, respiratory paralysis

---

**Hypomagnesemia may be the most frequently undiagnosed electrolyte deficiency.**

## Phosphorus Imbalances

<table>
<thead>
<tr>
<th>Hyperphosphatemia</th>
<th>Hypophosphatemia</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Severe low</strong></td>
<td>Causes:</td>
</tr>
<tr>
<td>&lt;1.0 mg/dL</td>
<td>• Malnutrition / starvation / alcoholism</td>
</tr>
<tr>
<td>&lt;0.32 mmol/L</td>
<td>• GI loss by diarrhea, vomiting, phosphorus-poor TPN</td>
</tr>
<tr>
<td></td>
<td>• Burns, diabetic ketoacidosis</td>
</tr>
<tr>
<td></td>
<td>• Metabolic alkalosis, respiratory alkalosis</td>
</tr>
<tr>
<td><strong>Normal range</strong></td>
<td><strong>Hormonal influences:</strong> Increased parathyroid hormone</td>
</tr>
<tr>
<td>2.5–4.5 mg/dL</td>
<td><strong>Drug effects:</strong> Aluminum-containing antacids, diuretics</td>
</tr>
<tr>
<td>0.81–1.45 mmol/L</td>
<td><strong>Causes:</strong></td>
</tr>
<tr>
<td></td>
<td>• Dietary changes, overuse of phosphate supplements</td>
</tr>
<tr>
<td></td>
<td>• Intravenous phosphate</td>
</tr>
<tr>
<td></td>
<td>• Renal dysfunction</td>
</tr>
<tr>
<td></td>
<td>• Chemotherapy</td>
</tr>
<tr>
<td></td>
<td>• Metabolic acidosis, respiratory acidosis</td>
</tr>
<tr>
<td><strong>Severe high</strong></td>
<td><strong>Hormonal influences:</strong> Lack of parathyroid hormone</td>
</tr>
<tr>
<td></td>
<td><strong>Drug effects:</strong> Phosphate-containing laxatives</td>
</tr>
</tbody>
</table>

### Symptoms and Morbidities

- **Hypophosphatemia**
  - Muscle weakness, tremors, hyporeflexia
  - Seizures
  - Tissue hypoxia, bleeding, infection
  - Myocardial dysfunction, hyperventilation
  - Anorexia

- **Hyperphosphatemia**
  - Tetany (with decreased calcium), hyperreflexia
  - Flaccid paralysis
  - Muscular weakness
  - Tachycardia
  - Nausea, diarrhea, abdominal cramps

---

Hyperphosphatemia is prevalent in patients with renal disease on dialysis.


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Solubility/Compatibility Concerns

• Formation of precipitates
• Biggest solubility concern is calcium (most reactive) and phosphorus amounts
• Influenced by temperature, pH, order by which salts are added
  – Temperature decreases solubility.
  – As pH decreases, solubility increases.
  – Use filters during compounding and infusion.
Solubility Curves

Calcium Phosphate solubility curves after 24 hours at room temperature.

A. Amino Acids 1% + Dextrose 10% (pH = 5.53)
B. Amino Acids 2% + Dextrose 20% (pH = 5.50)
C. Amino Acids 4% + Dextrose 25% (pH = 5.47)

Polling?
Ca 30Meq/L & PO4 18mMol/L
Where does this fall on the solubility curve?
Polling Question

Ca 30Meq/L & PO4 18mMol/L
Where does this fall on the solubility curve?

a) To the left of A
b) Between A and B
c) Between B and C
d) To the right of C
Polling Question

Ca 30Meq/L & PO4 18mMol/L
Where does this fall on the solubility curve?
Safe Practices Checklist

- Check clarity of the order form and labeling.
- Make sure PN meets individual nutrient needs and has been assessed for appropriateness.
- Ensure that IV fat emulsion dose is adequate to prevent essential fatty acid deficiency.
- Provide daily vitamins and standard trace elements.
- Provide lowest aluminum content solutions.
- Follow ASHP guidelines:
  - Follow safe additive compounding sequence.
  - Observe physical appearance.
  - Double-check dextrose concentration.
  - Conduct PN stability and compatibility safety checks.
TPN Order Writing Reminders

- Calcium gluconate is the preferred calcium salt.
- Phosphate can be matched with sodium or potassium.
- Potassium shifts intracellularly in alkalosis.
- Low potassium and low phosphorus levels are resistant to repletion in presence of low magnesium.
- Limit lipids to 20–30% of calories or 1 gm/kg/day.
- Maintain glycemic control.
- Do not overfeed.
- Provide AMA-NAG recommendations for vitamins and minerals.
- Follow INS, CDC line flushing and care protocols.
Errors in Hospital TPN Processes May Lead to Serious Adverse Events

In a survey conducted by A.S.P.E.N. on practices related to TPN ordering and compounding:

• ~2/3 of respondents observed 1–5 errors per month related to TPN ordering.
• 46% reported incidence of harm related to TPN.

Errors are common with TPN and can have serious consequences.

Recommendations from Safety Summit:

• Standardization of prescribing processes including electronic ordering and education of prescribers
• Standardization of order review and verification processes
• Education, competency testing, and thorough use of USP <797> processes in TPN compounding

The Safety Summit included representatives from the U.S. Food and Drug Administration, the Institute of Safe Medication Practices, the American Society of Health System Pharmacists, the National Home Infusion Association and industry representatives.
Writing the PN Order: How Do We Count the Ways

• There is more than one way to write a PN order……

• Follow a step-wise approach……
Formulating the PN Order Is Based on a Series of Step-wise Estimates

Fluid, protein, energy, and electrolyte needs are estimates based on the initial nutrition assessment.

- **Step 1**: Calculate fluid requirements.
- **Step 2**: Calculate protein.
- **Step 3**: Calculate lipids.
- **Step 4**: Calculate carbohydrate.
- **Step 5**: Calculate electrolyte requirements.
- **Step 6**: Calculate vitamin and mineral requirements.
- **Step 7**: Determine need for additives.
- **Step 8**: Determine infusion rate.
Hypothetical Patient Case

• 54 years old Male with history of Crohn’s Disease

• Admitted to the hospital for scheduled creation of an ileostomy and developed a small bowel obstruction postoperatively requiring a venting PEG tube
• Ht: 5’ 9” Wt: 73 kg  UBW: 73 kg  BMI: 23
• Nutritional needs
  • Total calories: 30 kcal/kg = ~2200 kcals
  • Protein: 1.5 gm/kg = 110 grams protein
  • Fluids needed: 3200 mL/24 hours
• Vascular access: 1 Lumen PICC with tip just proximal cavoatrial junction on Chest X-Ray
### Physician Order

#### Parenteral Nutrition Formula

<table>
<thead>
<tr>
<th>AMINO ACID:</th>
<th>AA = ml/day</th>
<th>%</th>
<th>Grams/day</th>
<th>PN ml over</th>
<th>Hrs Infused</th>
<th>d/wk</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Dextrose= ml/day</th>
<th>%</th>
<th>Grams/day</th>
<th>Pump:</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Lipids= ml</th>
<th>days/wk</th>
<th>%</th>
<th>0 Gm</th>
<th>Final % = AA % Dextrose %</th>
</tr>
</thead>
</table>

Dispensed as: 3:1 DCB

If 2:1, administer lipids over hrs.

<table>
<thead>
<tr>
<th>Access Device</th>
<th></th>
</tr>
</thead>
</table>

#### Solution Administration

<table>
<thead>
<tr>
<th></th>
<th>Flushed Volume</th>
<th>Saline</th>
<th>Heparin 10u/ml</th>
<th>Heparin 100u/ml</th>
</tr>
</thead>
</table>

Before dose: ml ml ml ml

After dose: ml ml ml ml

After Lab draw ml ml ml ml

Non TPN days: ml ml ml ml

<table>
<thead>
<tr>
<th></th>
<th>Taper Up Time:</th>
<th>Down Time:</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Electrolytes as Ions</th>
<th>mEq/L</th>
<th>mEq/bag</th>
</tr>
</thead>
</table>

Sodium 0.0 mEq/L mEq/bag

Potassium 0.0 mEq/L mEq/bag

Magnesium 0.0 mEq/L mEq/bag

Phosphate 0.0 mML mM/Bag

<table>
<thead>
<tr>
<th>Trace Metals</th>
<th>mL</th>
<th>mL</th>
<th>mL</th>
<th>mL</th>
<th>mL</th>
<th>mL</th>
<th>Misc Add</th>
</tr>
</thead>
</table>

MTE-C5 0.0 | MTE-5 0.0 | MTE-4 0.0 | PTE 0.0 | | | |

<table>
<thead>
<tr>
<th>Selenium</th>
<th>mcg</th>
<th>Cu</th>
<th>Mg</th>
<th>Cr</th>
<th>Mn</th>
<th>Zn</th>
<th>Mg</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Other:</th>
<th></th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Lab Orders</th>
<th>Additional Information</th>
</tr>
</thead>
</table>

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Day 1: Start PN (50% calories, 100% protein)

**Current Condition**
- NPO x 7 days, consult to start PN
- Venting PEG drains 2000mL/24 hours
- Abdomen distended
- CT scan shows small bowel obstruction

**Laboratory Results**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Day 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sodium (mEq/L)</td>
<td>138</td>
</tr>
<tr>
<td>Potassium (mEq/L)</td>
<td>3.6</td>
</tr>
<tr>
<td>Chloride (mEq/L)</td>
<td>103</td>
</tr>
<tr>
<td>CO2 (mEq/L)</td>
<td>26</td>
</tr>
<tr>
<td>BUN (mg/dL)</td>
<td>8</td>
</tr>
<tr>
<td>Creatinine (mg/dL)</td>
<td>0.5</td>
</tr>
<tr>
<td>Glucose (mg/dL)</td>
<td>108</td>
</tr>
<tr>
<td>Phosphorus (mg/dL)</td>
<td>2.6</td>
</tr>
<tr>
<td>Magnesium (mg/dL)</td>
<td>1.8</td>
</tr>
</tbody>
</table>

**PN Order Component**

<table>
<thead>
<tr>
<th>Component</th>
<th>Day 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>10% Amino Acid</td>
<td>110 grams</td>
</tr>
<tr>
<td>Dextrose</td>
<td>120 grams</td>
</tr>
<tr>
<td>20% Lipid</td>
<td>30 grams</td>
</tr>
<tr>
<td>Calcium Gluconate</td>
<td>10 mEq</td>
</tr>
<tr>
<td>Magnesium Sulfate</td>
<td>16 mEq</td>
</tr>
<tr>
<td>Sodium Phosphate</td>
<td>20 mmol</td>
</tr>
<tr>
<td>Potassium Chloride</td>
<td>-</td>
</tr>
<tr>
<td>Potassium Acetate</td>
<td>75 mEq</td>
</tr>
<tr>
<td>Sodium Chloride</td>
<td>150 mEq</td>
</tr>
<tr>
<td>Sodium Acetate</td>
<td>-</td>
</tr>
<tr>
<td>MVI</td>
<td>10 mL</td>
</tr>
<tr>
<td>MTE 5 Concentrate</td>
<td>1 mL</td>
</tr>
<tr>
<td>Volume</td>
<td>1200 mL*</td>
</tr>
<tr>
<td>Infusion schedule</td>
<td>50 mL/hr over 24 hours</td>
</tr>
</tbody>
</table>

*Hydration administered in addition to TPN to help meet total fluid needs due to high gastric fluid losses.
Day 2: Treat electrolytes abnormalities & Increase Calories

Intervention
- Serum phosphorus is low
- 15 mmol Potassium Phosphorus bolus is given outside of the PN
- Serum phosphorus level is redrawn after repletion

Laboratory Results | Day 2
---|---
Sodium (mEq/L) | 136
Potassium (mEq/L) | 3.7
Chloride (mEq/L) | 104
CO2 (mEq/L) | 27
BUN (mg/dL) | 26
Creatinine (mg/dL) | 0.6
Glucose (mg/dL) | 130
Phosphorus (mg/dL) | 2.2 ↓ after bolus 2.6
Magnesium (mg/dL) | 1.7

PN Order Component | Day 2
---|---
10% Amino Acid | 110 grams
Dextrose | 240 grams ↑
20% Lipid | 40 grams
Calcium Gluconate | 10 mEq
Magnesium Sulfate | 16 mEq
Sodium Phosphate | 28 mmol
Potassium Chloride | -
Potassium Acetate | 75 mEq
Sodium Chloride | 150 mEq
Sodium Acetate | -
MVI | 10 mL
MTE 5 Concentrate | 1 mL
Volume | 1800 mL*
Infusion schedule | 75 mL/hr over 24 hours

Blood sugars 128, 141, 149, 136

*Hydration administered in addition to TPN to help meet total fluid needs due to high gastric fluid losses.
Day 3: Increase to Goal Calories

Current condition
• Sips of clear liquids started
• Venting PEG output increased to 2.5L

<table>
<thead>
<tr>
<th>Labs</th>
<th>Day 2</th>
<th>Day 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sodium (mEq/L)</td>
<td>136</td>
<td>138</td>
</tr>
<tr>
<td>Potassium (mEq/L)</td>
<td>3.7</td>
<td>3.6</td>
</tr>
<tr>
<td>Chloride (mEq/L)</td>
<td>104</td>
<td>104 ▼</td>
</tr>
<tr>
<td>C02 (mEq/L)</td>
<td>27</td>
<td>26</td>
</tr>
<tr>
<td>BUN (mg/dL)</td>
<td>26</td>
<td>33</td>
</tr>
<tr>
<td>Creatinine (mg/dL)</td>
<td>0.6</td>
<td>1 ▲</td>
</tr>
<tr>
<td>Glucose (mg/dL)</td>
<td>130</td>
<td>155 ▲</td>
</tr>
<tr>
<td>Phosphorus (mg/dL)</td>
<td>2.2</td>
<td>3.2</td>
</tr>
<tr>
<td>Magnesium (mg/dL)</td>
<td>1.7</td>
<td>1.7</td>
</tr>
</tbody>
</table>

What should you do?
A. Patient requires additional fluid & potassium
B. Phosphorus is rising — compound less in the PN solution
C. Place insulin into the TPN solution
D. Continue current TPN formula and follow laboratory trends

Blood sugars 145, 148, 151

Intervention

PN Order Component | Day 3
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>10% Amino Acid</td>
<td>110 grams</td>
</tr>
<tr>
<td>Dextrose</td>
<td>370 grams ↑</td>
</tr>
<tr>
<td>20% Lipid</td>
<td>50 grams</td>
</tr>
<tr>
<td>Calcium Gluconate</td>
<td>10 mEq</td>
</tr>
<tr>
<td>Magnesium Sulfate</td>
<td>16 mEq</td>
</tr>
<tr>
<td>Sodium Phosphate</td>
<td>28 mmol</td>
</tr>
<tr>
<td>Potassium Chloride</td>
<td>20 mEq ↑</td>
</tr>
<tr>
<td>Potassium Acetate</td>
<td>75 mEq</td>
</tr>
<tr>
<td>Sodium Chloride</td>
<td>150 mEq</td>
</tr>
<tr>
<td>Sodium Acetate</td>
<td>-</td>
</tr>
<tr>
<td>MVI</td>
<td>10 mL</td>
</tr>
<tr>
<td>MTE 5 Concentrate</td>
<td>1 mL</td>
</tr>
<tr>
<td>Volume</td>
<td>2500 mL ↑</td>
</tr>
<tr>
<td>Infusion schedule</td>
<td>104 mL/hr over 24 hours</td>
</tr>
</tbody>
</table>
Day 4: Cycle PN to 18 Hours
Discharge planning coordination

<table>
<thead>
<tr>
<th>Labs</th>
<th>Day 1</th>
<th>Day 3</th>
<th>Day 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sodium (mEq/L)</td>
<td>138</td>
<td>138</td>
<td>137</td>
</tr>
<tr>
<td>Potassium (mEq/L)</td>
<td>3.6</td>
<td>3.6</td>
<td>3.9</td>
</tr>
<tr>
<td>Chloride (mEq/L)</td>
<td>103</td>
<td>104</td>
<td>103</td>
</tr>
<tr>
<td>CO2 (mEq/L)</td>
<td>26</td>
<td>26</td>
<td>27</td>
</tr>
<tr>
<td>BUN (mg/dL)</td>
<td>8</td>
<td>33</td>
<td>25</td>
</tr>
<tr>
<td>Creatinine (mg/dL)</td>
<td>0.5</td>
<td>1</td>
<td>0.6</td>
</tr>
<tr>
<td>Glucose (mg/dL)</td>
<td>108</td>
<td>155</td>
<td>168</td>
</tr>
<tr>
<td>Phosphorus (mg/dL)</td>
<td>2.6</td>
<td>3.2</td>
<td>3.2</td>
</tr>
<tr>
<td>Magnesium (mg/dL)</td>
<td>1.8</td>
<td>1.7</td>
<td>1.8</td>
</tr>
</tbody>
</table>

Blood sugars 178, 160, 173
(while on goal calories before cycle, given 12 units Sub Q insulin)

What should you do?
A. Add insulin into the PN solution
B. Compound magnesium into the PN solution
C. Place extra volume into the bag
D. Continue current PN formula & follow lab trends

Intervention
Day 5: On Goal cycle: 18 hour PN
Discharge coordination Finalized

- PEG losses remain 2.5L on clear liquids
- Abdomen still distended
- Conservative management continues
- Discharge on day 6 planned

### Laboratory Results

<table>
<thead>
<tr>
<th>Laboratory Results</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zinc (60-130 mcg/dL)</td>
<td>74</td>
</tr>
<tr>
<td>Copper (70-175 mcg/dL)</td>
<td>103</td>
</tr>
<tr>
<td>Selenium (120-300 mcg/L)</td>
<td>172</td>
</tr>
<tr>
<td>Manganese (4-14 mcg/L)</td>
<td>4</td>
</tr>
<tr>
<td>Vitamin B12 (200-100 pg/ml)</td>
<td>400</td>
</tr>
<tr>
<td>25 Hydroxy Vitamin D (30-100 ng/mL)</td>
<td>36</td>
</tr>
</tbody>
</table>

### Current condition

- Blood sugars 177, 155, 145 (18 hour cycle, 4 units Sub Q Insulin given)

### Interventions

<table>
<thead>
<tr>
<th>Laboratoray</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zinc</td>
<td>74</td>
</tr>
<tr>
<td>Copper</td>
<td>103</td>
</tr>
<tr>
<td>Selenium</td>
<td>172</td>
</tr>
<tr>
<td>Manganese</td>
<td>4</td>
</tr>
<tr>
<td>Vitamin B12</td>
<td>400</td>
</tr>
<tr>
<td>25 Hydroxy Vitamin D</td>
<td>36</td>
</tr>
</tbody>
</table>

What should you do?
A. Compound more magnesium into the bag
B. Follow laboratory trends.
C. Increase insulin delivery in PN
D. Treat the patient with a supplemental magnesium bolus
**Day 5: On Goal cycle: 18 hour PN**  
Discharge coordination Finalized

<table>
<thead>
<tr>
<th>PN Order Component</th>
<th>Day 5 PN Order</th>
</tr>
</thead>
<tbody>
<tr>
<td>10% Amino Acid</td>
<td>110 grams</td>
</tr>
<tr>
<td>Dextrose</td>
<td>370 grams</td>
</tr>
<tr>
<td>20% Lipid</td>
<td>50 grams</td>
</tr>
<tr>
<td>Calcium Gluconate</td>
<td>10 mEq</td>
</tr>
<tr>
<td>Magnesium Sulfate</td>
<td>16 mEq</td>
</tr>
<tr>
<td>Sodium Phosphate</td>
<td>28 mmol</td>
</tr>
<tr>
<td>Potassium Chloride</td>
<td>20 mEq</td>
</tr>
<tr>
<td>Potassium Acetate</td>
<td>75 mEq</td>
</tr>
<tr>
<td>Sodium Chloride</td>
<td>150 mEq</td>
</tr>
<tr>
<td>Sodium Acetate</td>
<td>-</td>
</tr>
<tr>
<td>MVI</td>
<td>10 mL</td>
</tr>
<tr>
<td>MTE 5 Concentrate</td>
<td>1 mL</td>
</tr>
<tr>
<td>Regular human Insulin</td>
<td>20 units</td>
</tr>
<tr>
<td>Volume</td>
<td>2500 mL</td>
</tr>
</tbody>
</table>

Infusion schedule:  
90 mL/hr x 1 hour  
145 mL/hr x 16 hours  
90 mL/hr x 1 hour
Questions???

• Thank you for attending.

• If you are attending a Webinar, an evaluation of this program will open in a separate browser. If you are unable to complete at this time, a ‘Thank you’ email with the link will be emailed to you shortly.

• If you are attending via teleconference or attending in a group, please email a request for the evaluation form to CEDept@coramhc.com.

• Completion of the evaluation is required for receipt of the CE certificate

• If attending a live event, please obtain the evaluation from your presenter.
References


12. LeFever Kee, J. Handbook of Fluid, Electrolyte and Acid-base Imbalances, 3rd Ed. Chapter 5, 10, Table 10-1. 2010.
References


20. Parenteral multivitamin products; drugs for human use; drug efficacy study implementation; amendment (21 CFR 5.70), Federal Register. April 20, 2000;65:21200-21201.


