B4. PHARMACISTS
ELECTROLYTE MANAGEMENT IN ADULT PARENTERAL NUTRITION
3:15 - 4:15PM

ACPE UAN: 107-000-14-032-L01-P  0.1 CEU/1.0 hr
Activity Type: Application-Based

**Learning Objectives for Pharmacists:** Upon completion of this CPE activity participants should be able to:
1. Identify common causes of sodium, potassium, and phosphorus derangements in hospitalized adult patients on parenteral nutrition
2. Calculate sodium concentrations in parenteral nutrition solutions and relate them to sodium content of common maintenance solutions
3. Recommend appropriate doses of potassium for supplementation via parenteral nutrition
4. Predict which patients need phosphorus supplementation in parenteral nutrition
5. Devise appropriate monitoring for electrolyte supplementation in parenteral nutrition

**Speaker:** Janet Fischer, PharmD, graduated with a Doctor of Pharmacy from Creighton University. She is currently Professor of Pharmacy at South Dakota State University and Clinical Pharmacist at Sanford USD Medical Center in Sioux Falls, SD. Janet has been a member of Sanford’s Nutrition Support Team for over 25 years and serves as coordinator of their Nutrition Committee. At SDSU, Janet teaches in the areas of nutrition, acid-base and hospital practice; is co-coordinator of the P3 pharmacy practice sequence; and takes APPE students in Internal Medicine and Nutrition.

**Speaker Disclosure:** Janet Fischer reports no actual or potential conflicts of interest in relation to this CPE activity. Off-label use of medications will not be discussed during this presentation.
Electrolyte Management in Adult Parenteral Nutrition: Focus on Sodium, Potassium, and Phosphorus

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Facility Disclosure

- Janet Fischer reports she does not have actual or potential conflicts of interest associated with this presentation
- Janet Fischer has indicated that off-label use of medication will not be discussed during this presentation
Learning Objectives

Upon completion of this activity, pharmacists (or pharmacy technicians/student pharmacists) should be able to:

1. Identify common causes of sodium, potassium, and phosphorus derangements in hospitalized adult patients on parenteral nutrition (PN).
2. Calculate sodium concentrations in PN solutions and relate them to sodium content of common maintenance solutions.
3. Recommend appropriate doses of potassium for supplementation vial PN.
4. Predict which patients need phosphorus supplementation in PN.
5. Devise appropriate monitoring for electrolyte supplementation in PN.

PN Components

- Dextrose
- Amino Acids
- Fat Emulsion
- Electrolytes
- Vitamins
- Trace Minerals
- Medications
Which method of PN compounding do you use?

- A. Gravity Fill, non-automated transfers
- B. Automated compounding for large volume additives
- C. Automated compounding for small volume additives
- D. “Ready to Mix” Commercial Products

Which method of electrolyte management in PN do you use?

- A. All electrolytes added individually
- B. Base electrolytes contained in amino acids source
- C. Base electrolytes from premixed vial

A. Easy to add or reduce content
B. Easy to add, harder to reduce content
How do you order/label electrolytes in adult PN?

A. Per day  
B. Per bag  
C. Per liter  

ASPEN Statement on Parenteral Nutrition  
Standardization: amount/day is required, amount/Liter optional  

Kochevar M et al. JPEN 2007

PN Use in Adult Patients

- Critically ill patients who can’t tolerate enteral nutrition
  - Respiratory Failure
  - Renal Failure
- Surgical patients with prolonged GI recovery
  - Ileus or Obstruction
  - Fistulas
  - Short Bowel
  - Pancreatitis
- Oncology Patients with GI disorders
“Usual” Electrolyte Content of PN

- No guidelines established
- Often determined by compounding method, products used
- Must be individualized to the patient
  - Electrolyte levels
  - Concurrent IV fluids
  - Medications
  - Disease states

<table>
<thead>
<tr>
<th>Electrolyte</th>
<th>University of VA PN Handbook¹</th>
<th>Madsen and Frankel²</th>
<th>German PN Guidelines³</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sodium</td>
<td>70-100 mEq/day</td>
<td>0-200 mEq/L</td>
<td>60-150 mEq/day</td>
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<tr>
<td>Potassium</td>
<td>70-100 mEq/day</td>
<td>0-240 mEq/day</td>
<td>40-100 mEq/day</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>40-60 mEq/day</td>
<td>0-60 mMol/day</td>
<td>10-30 mMol/day</td>
</tr>
</tbody>
</table>

References:
Common Products Used

<table>
<thead>
<tr>
<th>Product</th>
<th>TPN Electrolytes</th>
<th>Amino Acids with Electrolytes (after 50% dilution)</th>
<th>CliniMix-E</th>
</tr>
</thead>
<tbody>
<tr>
<td>Na</td>
<td>35 mEq/20 ml</td>
<td>33-39 mEq/L</td>
<td>35 mEq/L</td>
</tr>
<tr>
<td>K</td>
<td>20 mEq/20 ml</td>
<td>33 mEq/L</td>
<td>30 mEq/L</td>
</tr>
<tr>
<td>Phos</td>
<td>0 – typically add 15-21 mEq/L of K</td>
<td>15 mEq/L</td>
<td>15 mM/L</td>
</tr>
</tbody>
</table>

Sodium (Na) Derangements in PN patients

- Extracellular Cation
- Normal Serum Level: 135/145 mEq/L
- Hypernatremia
- Hyponatremia
- Serum osmolality - helpful in evaluation
- Fluid status - key element
  - Hypovolemic
  - Isovolemic/Normovolemic
  - Hypervolemic
Hyponatremia

- Symptoms: N, V, HA, muscle cramps, confusion, lethargy, seizure, coma
- Severity related to rate of onset
- Most patients have low serum osmolality (hypotonic)
- Exceptions:
  - Severe hyperlipidemia (isotonic)
  - Hyperglycemia (hypertonic)
  - Exception: Calculation of Corrected Serum Na in setting of high BS:
    \[ \text{Corrected Na} = \text{Measured Na} + \left( \frac{\text{BS} - 100}{100} \times 1.6 \right) \]

Hypotonic Hyponatremia Causes

- Hypovolemic
  - Adrenal Insufficiency
  - Excessive Diuresis – thiazides and osmotic diuretics
  - Blood Loss
  - GI Losses – V, NG suction, Diarrhea
  - Skin Losses – sweat or burns
- Hypervolemic
  - Cirrhosis
  - Heart Failure
  - Nephrotic Syndrome
  - Renal Failure
Hypotonic Hyponatremia Causes

- Isovolemic
  - SIADH
    - CNS Disorders
  - Malignancy
  - Medications – carbamazepine, SSRI’s, TCA’s, NSAIDs, others
  - Pulmonary Infections
  - Pain
  - Trauma
  - Hypothyroidism

Hyponatremia Treatment

- Severe symptomatic
  - Fluid restriction
  - Hypertonic (3%) Saline – small boluses of 100 ml or slow IV infusion
  - Normal Saline (NS)
  - Loop Diuretics
    - Correct at rate 1-2 mEq/L per hour, 4-6 (not more than 9) mEq/L in 24 hours
  - Check Na levels every 2 hours
  - Treatment occurs outside of PN
Hyponatremia Treatment

- Asymptomatic
  - Hypovolemic - NS
  - Isovolemic – Fluid restriction, low dose loop diuretics if needed
  - Hypervolemic – Fluid restriction, loop diuretics
  - Correct at rate of 0.5 mEq/L per hour
  - PN Adjustments can play role

- Both
  - Identify and treat cause

PN Implications for Hyponatremia

- Patients who need fluid restriction
  - Maximize Concentration of PN to reduce fluid provisions
  - Increase dextrose to 25-30%
  - Increase amino acids to 7-10%

- Patients who need NS
  - Increase Na content of PN if low
  - Adjust Na content of PN to = NS

- Patients who need loop diuretics
  - Monitor for Hypokalemia

- Daily monitoring of Na levels
Hyponatremia Case

A 65 yo, 80 kg male is in ICU following a Whipple procedure. He has been on PN for 3 days pre-op. He is up 8 Liters of fluid since OR yesterday, and 13 liters since admit. He was extubated after surgery but is now requiring 10 L O2 per NC and complaining of SOB. CXR is consistent with pulmonary edema.

Labs: Glucose 145, Na 131, K 3.9, Cl 97, Mg 1.9, phos 3.4

Which type of Hyponatremia does he likely have?
A. Hypovolemic
B. Isovolemic
C. Hypervolemic

Hyponatremia Case

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Labs: Glucose 145, Na 131, K 3.9, Cl 97, Mg 1.9, phos 3.4

Which of the following treatments is/are preferred?
A. 3% Saline
B. Loop Diuretic
C. Normal Saline
D. Fluid Restriction
PN Adjustment with Clinimix®

His current PN is as follows:
Clinimix 4.25%AA with 20% Dextrose running 100 ml/hr to provide 2040 kcals/d with 102 gram protein/d. It has Na 35 mEq/L in it.

Which of the following would be the best adjustment to the PN?

A. Change PN to Clinimix 5% AA with 25% dextrose and reduce rate to 80 ml/hr.
B. Change PN to Clinimix 2.75% AA with 10% dextrose and increase rate to 150 ml/hr
C. Add 110 mEq/L of NaCl to = NS

PN Adjustment with Compounded PN

His current PN is as follows:
5% Amino Acids with 20% Dextrose running 85 ml/hr to provide 1795 kcals/d with 102 gram protein/d. It has Na 100 mEq/L in it.

Which of the following would be the best adjustment to the PN?

A. Decrease Na to 35 mEq/L
B. Change to 7.5% AA with 30% Dextrose and reduce rate to 55 ml/hr
C. Change to 9% AA with 33% Dextrose and reduce rate to 50 ml/hr
D. Increase Na to 145 mEq/L
A 72 kg 65 year old female presents to the hospital with N, V, and abd pain. CT scan of abd reveals a partial small bowel obstruction. NG is placed and returns 2000 ml bilious fluid. Patient is placed on an IV of D51/2NS at 100 ml/hr. On day 5, the obstruction is not resolved and PN is started. On day 7, the maintenance IV is DC’d. On day 9, the patient is still getting 1500 ml/d out of NG. PN is running at 60 ml/hr. Labs: Glucose 123, Na 129, K 3.3, Cl 98, CO2 31, Mg 2.1, phos 4.4

Which type of hyponatremia does she likely have?
A. Hypovolemic
B. Isovolemic
C. Hypervolemic

Which of the following treatments is/are preferred?
A. 3% Saline
B. Loop Diuretic
C. Normal Saline
D. Fluid Restriction
What is the Na content of NS in mEq/L?

A. 0.45 mEq/L  
B. 0.9 mEq/L  
C. 77 mEq/L  
D. 154 mEq/L  
E. 512 mEq/L

Na Addition to CliniMix®

Labs: Glucose 123, Na 129, K 3.3, Cl 98, CO2 31, Mg 2.1, phos 4.4  
PN is running at 60 ml/hr. Pharmacy uses CliniMix E which contains 35 mEq/L of Na.

How many mEq/L of Na should be added to make the bag = NS?

A. 104 mEq/L  
B. 119 mEq/L  
C. 154 mEq/L  
D. 187 mEq/L
Na Addition to CliniMix®

Labs: Glucose 123, Na 129, K 3.3, Cl 98, CO2 31, Mg 2.1, phos 4.4
PN is running at 60 ml/hr. Pharmacy uses CliniMix E which contains 35 mEq/L of Na.

How many mEq/L of Na should be added to make the bag = NS?

A. 104 mEq/L  
B. 119 mEq/L  
C. 154 mEq/L  
D. 187 mEq/L

Na Addition to Compounded PN

Labs: Glucose 123, Na 129, K 3.3, Cl 98, CO2 31, Mg 2.1, phos 4.4
PN is running at 60 ml/hr. Pharmacy makes a compounded PN bag for 24 hours that contains a total of 100 mEq of Na per day.

How many mEq of Na should be added to make the bag = NS?

A. 54 mEq  
B. 85 mEq  
C. 122 mEq  
D. 154 mEq  
E. 222 mEq
Na Addition to Compounded PN

Labs: Glucose 123, Na 129, K 3.3, Cl 98, CO2 31, Mg 2.1, phos 4.4
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A. 54 mEq  
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E. 222 mEq

Na Addition to Compounded PN

Labs: Glucose 123, Na 129, K 3.3, Cl 98, CO2 31, Mg 2.1, phos 4.4

What salt form of Na should be added to the PN formulation?

A. NaCl  
B. NaPhosphate  
C. NaAcetate  
D. NaBicarbonate
Hypernatremia

- Symptoms: Lethargy, restlessness, thirst, muscle spasticity, hyperreflexia, seizures, coma
- Severity related to rate of onset
- Generally due to loss of fluid, not excess Na
- Evaluate volume status:
  - Hypovolemic
  - Isovolemic
  - Hypervolemic

Hypernatremia Causes

- **Hypovolemic**
  - Loss of hypotonic fluids:
    - GI Loss: V, D, NG suction
    - Diuresis: loop diuretics
    - Skin loss: sweat, burns, wounds
- **Isovolemic**
  - Diabetes Insipidus
- **Hypervolemic**
  - Hypertonic (3%) saline
  - NaBicarbonate administration
  - Mineralocorticoid excess
Hypernatremia Treatment – General

- Treatment of underlying cause
- Reduce Na content of IV fluids (Hypotonic Fluids)
  - D$_{5}$1/2NS
  - D$_{5}$1/4NS
  - D$_{5}$W
- Acute (< 48 hrs) – correct 1-2 mEq/L per hour
- Chronic – correct no faster than 0.5 mEq/L per hour, max 10-12 in 24 hours

Hypernatremia Treatment

- Hypovolemic
  - Hypotonic solutions
- Isovolemic
  - Na restriction
  - D$_{5}$W
  - Desmopressin
- Hypervolemic
  - Na restriction
  - Loop or Thiazide diuretics?
  - D$_{5}$W?
PN Implications for Hypernatremia

- Patients who need Na restriction:
  - Reduce or remove Na from PN

- Patients who need diuretics:
  - Monitor for hypokalemia

- Daily monitoring of Na levels

Hypernatremia Case

A 60 yo male has been hospitalized for 3 weeks following a SB resection for ischemia that resulted in a post-op enterocutaneous fistula. He has been on a stable PN solution for the last 2 weeks. Six days ago he was noted to have pulmonary edema, was found to have an ejection fraction of 30% and was started on furosemide 40 mg IV BID. In the last 5 days he has diuresed about 10 kg and his pulmonary edema is significantly improved.

Labs today show: Glucose 132, Na 152, K 3.2, Cl 104, CO2 34, phos 4.3, Mg 1.6

Which type of hypernatremia does he likely have?
A. Hypovolemic
B. Isovolemic
C. Hypervolemic
Hypernatremia Case

A 69 yo male has been hospitalized for 3 weeks following a SB resection for ischemia that resulted in a post-op enterocutaneous fistula. He has been on a stable PN solution for the last 2 weeks. Six days ago he was noted to have pulmonary edema, was found to have an ejection fraction of 30% and was started on furosemide 40 mg IV BID. In the last 5 days he has diuresed about 10 kg and his pulmonary edema is significantly improved. Labs today show: Glucose 132, Na 152, K 3.2, Cl 104, CO2 34, phos 4.3, Mg 1.6. His PN Solution contains 75 mEq/L Na.

Which of the following treatments would be appropriate?

A. IV NS at 50 ml/hr
B. Hold furosemide
C. Reduce Na in PN
D. Desmopressin
E. IV D5W 50 ml/hr

Potassium (K) Derangements in PN Patients

- Hypokalemia
- Hyperkalemia
- Refeeding Syndrome
  - Hypokalemia
  - Hypophosphatemia
  - Hypomagnesemia
  - Seen with refeeding starved patients
Hypokalemia Causes

- Intracellular shifts
  - Metabolic alkalosis
  - Medications: Beta agonists, insulin
- K-wasting Medications
  - Diuretics
  - Corticosteroids and fludrocortisone
  - Aminoglycosides and Amphotericin B
- Magnesium Depletion
- GI loss – diarrhea and NG suction
- Refeeding Syndrome

PN Implications for Hypokalemia

- Estimate: 0.3 mEq/L decline in K level = 100 mEq total body K
- K addition to PN – 20-60 mEq/day increments
  - Kphos
  - KCl
  - K Acetate
- Use of supplements vs. adding to PN bag?
- Daily dosage in PN – is there a maximum?
  - 100 mEq/day?
  - 240 mEq/day?
PN Implications for Hypokalemia

- Monitoring
  - K, Mg, and other electrolyte levels
  - Renal function
  - Dosing of diuretics
  - Doses of K supplements given
- Magnesium Supplementation
- Safer to underdose than overdose
- When to reduce PN content?

Hypokalemia Case

A 69 yo male has been hospitalized for 3 weeks following a SB resection for ischemia that resulted in a post-op enterocutaneous fistula. He has been on a stable PN solution for the last 2 weeks. Two days ago he was noted to have pulmonary edema, was found to have an ejection fraction of 30% and was started on furosemide 40 mg IV BID.

Labs today: Glucose 123, Na 142, K 3.1, Cl 102, CO2 27, phos 3.4, Mg 1.4.

He has received 40 mEq KCl IV daily for the last 2 days per sliding scale. His PN is running at 85 ml/hr and contains K 30 mEq/L.

The provider plans to continue furosemide at this dose for at least several more days.
Hypokalemia Case

Which of the following would be the BEST approach for his hypokalemia?

A. Leave the PN K content the same and use the s/s KCl to supplement
B. Increase the PN K content from 30 mEq/L to 50 mEq/L and continue to use s/s KCl to supplement if needed.
C. Increase the PN content from 30 mEq/L to 70 mEq/L and continue to check K daily

Hyperkalemia Causes

- Renal Failure
- Medications
  - ACE Inhibitors/ARB’s
  - Potassium-sparing diuretics
  - NSAIDs
  - K supplementation
- Metabolic Acidosis
- Hemolysis – pseudo-hyperkalemia
PN Implications for Hyperkalemia

- Reduce or Remove K from PN
- May require change of other electrolytes
- Monitoring
  - K and other electrolyte levels
  - BUN/Cr
  - Urine output

Phosphorus (Phos) Derangements in PN Patients

- Hypophosphatemia
- Hyperphosphatemia
- Refeeding Syndrome
Hypophosphatemia Causes

- Malnutrition
- Alkalosis
- DKA
- Alcoholism
- Trauma
- Medications
  - Insulin
  - Diuretics
- Refeeding Syndrome
  - Estimated to occur in 1-5% of PN patients

Identifying Risk of Refeeding Syndrome

<table>
<thead>
<tr>
<th>Major Risk Factors</th>
<th>Minor Risk Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMI &lt; 16</td>
<td>BMI &lt; 18.5</td>
</tr>
<tr>
<td>Wt loss &gt; 15% in 3-6 months</td>
<td>Wt loss &gt; 10% in 3-6 months</td>
</tr>
<tr>
<td>Little-no po intake &gt; 10 days</td>
<td>Little-no po intake in &gt; 5 days</td>
</tr>
<tr>
<td>Low levels of K, phos, or Mg prior</td>
<td>Hx of ETOH, chemo, insulin, antacids, or diuretics</td>
</tr>
<tr>
<td>to feeding</td>
<td></td>
</tr>
</tbody>
</table>

Presence of 1 major or 2 minor risk factors indicate patient is at high risk

Walmsley RS. J Gastroenterol Hepatol. 2013
Refeeding Syndrome Treatment Strategies

- Correct electrolyte abnormalities before feeding
- Start feedings at 5-10 kcals/kg/d
- Advance to goal over 4-7 days
- Thiamine 200-300 mg/d x 10 days
- Higher than maintenance amounts of e-lytes:
  - Phos 0.3-0.6 mM/kg/d
  - K 2-4 mEq/kg/d
  - Mg 0.3 mM/kg/d
- Monitor levels daily

Walmsley RS. J Gastroenterol Hepatol. 2013

PN Implications for Hypophosphatemia

- Phos Supplementation in PN
  - Salt Form – K or Na
  - Incremental Dose Increases of 10-20 mM/d
  - Max dose of 0.6 – 0.7 mM/kg/d
- Daily monitoring of levels
- Supplemental doses in addition as needed
- Gradual reduction once levels stabilize
A 54 year old female with a hx of Crohn’s disease presents to the hospital with a 6 week history of abdominal pain and diarrhea. She reports minimal po intake for the last 2 weeks as her symptoms have worsened. Her current wt is 54 kg, down from her usual wt of 65 kg. Her Ht is 66 inches and her BMI is 19.2

Which of the following is true about her risk of refeeding syndrome if PN is started?
A. She is not at high risk for refeeding syndrome
B. She is at high risk due to the presence of 3 minor risk factors
C. She is at high risk due to the presence of 2 major risk factors

All of the following are true regarding use of PN in this patient EXCEPT:
A. Electrolyte abnormalities should be corrected before starting PN
B. PN should be started at a low rate and advanced to goal over 3 days
C. PN should include higher than standard amounts of K, phos, and Mg
D. Electrolytes should be monitored daily for at least the first 5 days
Hyperphosphatemia Causes

- Renal Insufficiency
- Excessive supplementation
- Phosphorus-containing laxatives
- Acidosis

Ca x Phos > 55-60: Increased risk of precipitation or deposition in soft tissues

PN Implications for Hyperphosphatemia

- Reduce or Remove from PN
- May require change of other electrolytes
- Monitoring
  - Phos and Ca levels
  - BUN/Cr
  - Urine output
References


