PARENTERAL NUTRITION

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INTRAVENOUS SOLUTIONS

- Infusion of fluid and electrolytes administered to restore and maintain normal body fluid volume and composition.
- Infused into the extracellular compartment with their distribution dependent on the content of the infusate.
- The optimal IV solution is patient specific and should imitate the composition of the fluid and electrolytes lost to re-establish and maintain homeostasis.
- Commonly prescribed IV solutions: **Normal saline solution (NSS), 5% dextrose** in water (D5W), **lactated Ringer’s solution** (LR) or a combination of these.
- **KVO**: keep the vein open (10-20 ml/hr of IVF).
NORMAL SALINE SOLUTION

- **NSS** contains 154 mEq/L of sodium and chloride (0.9% in water = 0.9 grams of sodium chloride/100ml)
- Isotonic, maintenance IV fluid: 280-300 mOsm/L
- Sodium chloride is the predominant solute of the ECF compartment
- Primary use: replace ECF volume after losses due to renal excretion of sodium chloride, hemorrhage in conjunction with blood replacement, burns and fluid losses during surgery, and a vehicle for drug administration in volumes of 500 ml or less
- ½ NSS contains 77 mEq/L of sodium and chloride (0.45% in water = 0.45 grams of sodium chloride/100 ml)
  - A hypotonic fluid replacement used for combined ECF volume depletion and dehydration
5% DEXTROSE

- Isotonic: 250 mOsm/L
- Contains **50 grams of dextrose/L** and **170 calories** (3.4 Kcal/gram of dextrose)
- Glucose moves into the cell being metabolized for fuel, leaving free water that will distribute equally into the ECF/ICF (water alone cannot be given because the osmotic pull of fluid into the RBC’s cause the cells to swell and burst)
- Used to correct water deficits. Re-hydrates after hypotonic fluid loss and indicated for treatment of hypernatremic dehydration
DEXTROSE AND SALINE COMBINATIONS

- **D5W ½ NSS**: 50 grams dextrose/L, 170 calories, 77 mEq/L of sodium and chloride, 432 mOsm/L
  Treatment of ECF volume depletion, isotonic fluid replacement, maintenance IV fluid
  The Na+ component expands or maintains the ECF compartment and the dextrose distributes into the ECF/ICF spaces

- **D5W NSS**: 50 grams of dextrose/L, 170 calories, 154 mEq/L of sodium and chloride, 585 mOsm/L
  Treatment of ECF volume depletion, isotonic fluid replacement, maintenance IV fluid

**NOTE**: The addition of potassium (Ex. 20 mEq/L) produces an effective maintenance fluid with replacement of sodium and potassium
LACTATED RINGER’S

- “Surgeon’s” IVF since it replaces some of the electrolyte and fluid losses of surgery
- Physiologic: provides electrolytes at concentrations similar to that of plasma
- One liter contains 28 mEq lactate, 130 mEq of sodium, 109 mEq of chloride, 4 mEq of potassium and 3 mEq of calcium with 270 mOsm (isotonic)
- Lactate is a bicarbonate precursor. LR is not recommended in severe acidosis or liver disease because lactate may not be converted to bicarbonate and may contribute to or worsen lactic acidosis
- Replacement or maintenance fluid
3% SALINE

- Hypertonic: 1,025 mOsm/L
- Contains: 513 mEq/L of sodium and chloride
- Used in treatment of severe, hyponatremic dehydration; change in ICF and ECF volumes dependent on degree of hyponatremia
- Often ordered in traumatic brain injury
Calculate the sodium, chloride, and potassium content of the following:

a) NSS (0.9%) at 100 ml/hr

b) \(\frac{1}{2}\) NSS (0.45%) with 20 mEq KCl at 75 ml/hr
CALCULATION # 2

Calculate the grams of dextrose, calories, sodium, chloride, and potassium content of the following:

a) D5W NSS at 100 ml/hr

b) D5W ½ NSS with 20 mEq KCl at 75 ml/hr
HISTORIC PERSPECTIVE ON PN

- 1952: Subclavian vein cannulation allowed for hypertonic infusions
- 1960’s: Stanley Dudrick successfully fed dogs with IV nutrition
- 1968: first human supported with parenteral nutrition
THE BEGINNING

PUPPIES ON PN
DEFINITION OF PARENTERAL NUTRITION

- Intravenous nutrient solution requiring cannulation of a vein
- PN is a complex nutritional therapy with potential for significant adverse effects
- Education of prescribers essential with institutional policies/procedures/protocols required to guide PN ordering and management
- Team approach: gold standard
DOES EVIDENCE-BASED MEDICINE SUPPORT THE USE OF PN?

- PN improves markers of nutritional status but prospective randomized clinical trials rarely show PN improves outcome
- Research has been critical regarding the design and validity of these studies
- Clinical practice guidelines incorporate PN research and grade levels of the recommendations to guide NSS clinicians
- Continued research is needed
GOALS OF PARENTERAL NUTRITION THERAPY

- Stabilization of weight or moving toward goal weight
- Improvement or replenishment of protein stores
- Normalization of clinical laboratory values
- Reduction in morbidity/mortality
- Improvement in quality of life
- Optimization of clinical outcomes
CHALLENGES IN PN: NATIONWIDE SHORTAGES OF PN PRODUCTS

- Acquisition issues with raw materials
- Manufacturing/production issues
- Discontinuation of components
- Consolidation of the market
- Websites: drug shortage web pages for the U.S. Food and Drug Administration, the American Society for Health-System Pharmacists, and ASPEN
Patients who are unable to meet nutrition needs with EN. Malnutrition or the risk of becoming malnourished exists.

PPN may be used to provide partial/total nutrition support for up to 2 weeks for those who cannot ingest or absorb oral or enteral tube-delivered nutrients or when CPN is not feasible.

CPN is indicated when PN feeding is needed for longer than 2 weeks, peripheral IV access is limited, nutrient needs are large, fluid limitations exist, and PN benefits outweigh the risks.

OPTIMAL CANDIDATES FOR PN

- Perioperative support in moderate to severe protein calorie malnutrition
- Gastrointestinal fistula
- Short Bowel Syndrome
- Critically ill NPO > 5-7 days
- Severe acute necrotizing pancreatitis
CLINICAL INDICATORS FOR PN

- Intractable nausea/vomiting/diarrhea
- Prolonged paralytic ileus/obstruction > 5 days
- Lower GI tract perforation/leak
- High output EC fistula > 500 ml/day
- Bowel ischemia
- Acute/necrotizing pancreatitis
- SBS/severe malabsorption/IBD
- Diffuse peritonitis/persistent GIB
- Hyperemesis Gravidarum
- Tube feeding failure/access issues/patient refusal
CAUTIOUS USE OF PN

- Hyperglycemia: BG > 200 ml/dL
- Azotemia: BUN > 80 mg/dL
- Hyperosmolality: Serum Osm > 320 mOsm/kg
- Hypernatremia: Na+ > 150 mEq/L
- Hyponatremia: Na+ < 130 mEq/L
- Hypokalemia: K+ < 3 mEq/L
- Hypomagnesemia: Mg < 1.2 mEq/L
- Hypocalcemia: Ionized Ca++ < 0.8 mmol/L
- Hyperchloremic metabolic acidosis: Cl > 115 mEq/L and HCO3 < 15 mEq/L
- Hypochloremic metabolic alkalosis: Cl < 85 mEq/L and HCO3 > 35 mEq/L
- Hypophosphatemia: < 2 mg/dL
CONTRAINDICATIONS FOR PN

- GI tract functional
- PN anticipated for < 5 days
- No venous access
- Hemodynamic instability
- Intolerance to added fluid load
- Severe electrolyte abnormalities/acid-base disturbances
- Hyperglycemia with BG > 300 ml/dL
- No lab draw orders/advanced directive to refuse PN
TYPES OF PN

- **Peripheral PN**: IV nutrient solution administered via a peripheral vein, usually the hand or forearm. It can also be administered into a central vessel.

- **Central PN**: IV nutrient solution delivered into a high flow vein, usually the superior vena cava adjacent to the right atrium. Due to its high osmolarity, it should not be administered via a peripheral vein.
INDICATIONS FOR PPN

- Mild to moderate malnutrition
- Partial/total nutrition support
- Central access not available/contraindicated
- Good peripheral veins
- Oral intake minimal/contraindicated
- Short-term nutritional support (10-14 days)
- Refusal of feeding tube for TF
PPN ACCESS DEVICES

- Peripheral catheter: defined as one whose tip position is **outside** of a central vessel (inferior vena cava or the superior vena cava)

- **Peripheral catheters**: standard peripheral cannulas, midline catheters and midclavicular catheters
Definition: the number of millimoles of liquid or solid in a liter of solution

Preferred term in PN
ESTIMATION OF OSMOLARITY FOR PARENTERAL NUTRITION

- PN solution osmolarity can be estimated by adding the osmolar contribution from each component of the PN prescription and dividing this number by the total volume (in liters) of the formulation.

- Utilize the **pharmacist** for accurate information and calculation of PN osmolarity.
CALCULATION OF ESTIMATED OSMOLARITY IN PN SOLUTIONS

- Dextrose: 5 mOsm/g
- Amino Acids: 10 mOsm/g
- 20% IVFE: 1.3 – 1.5 mOsm/g
  (Product dependent)
- Electrolytes: 1 mOsm/mEq

LIMITATIONS OF PPN

- Large fluid volume (2-3 L/day) required
- Lower nutrient concentration
- Dextrose should not exceed final concentration of 10% and AA not to exceed concentration of 4.25%
- Electrolyte manipulation difficult due to osmolarity concerns
- Final osmolarity no greater than 600 – 900 mOsm is recommended to preserve peripheral vein (site rotation every 2-3 days)
CONTRAINDICATIONS TO PPN

- Significant malnutrition
- Severe metabolic stress
- Large nutrient/electrolyte needs since potassium is a strong vascular irritant
- Fluid restriction
- Need for prolonged PN (> 2 weeks)
- Renal or liver compromise
COMPLICATIONS OF PPN

- Vein irritation is a potential problem with PPN
- Thrombophlebitis: **Hallmark** symptoms are pain, redness, tenderness or a palpable cord
- Prevention: addition of heparin 1 unit/mL, hydrocortisone 10 mg/liter or use of low dose nitroglycerine patch at the venous injection site
INDICATIONS FOR CENTRAL PN

- Nutrition support is indicated
- EN is unavailable/contraindicated
- Central venous access is available
- Therapy duration > 7-14 days
- Volume restriction may be needed
- Severe metabolic stress
- Renal or liver dysfunction
- Increased nutrient or electrolyte needs
CENTRAL PARENTERAL NUTRITION

- PN administered via a central access device
- Central access: defined by the position of the distal catheter tip, **not** by entry point of the catheter
- Central venous access: catheter whose distal tip lies in the superior vena cava or right atrium
- Should not be infused via a peripheral vein due to its high osmolarity
CPN INFUSION GUIDELINES

- Due to the high osmolarity of most PN formulations, they are limited to administration through a central venous access catheter with its tip in the superior vena cava or right atrium.
- SVC formed by the joining of the right and left brachiocephalic veins.
- Because of the high rate of blood flow (2000 ml/minute), the formula is rapidly diluted and is not harmful to the vessel.
- There is no known upper limits to solution osmolarity via a central vessel.
CENTRAL VENOUS ACCESS

- Central venous access devices are single or multilumen catheters with the distal tip located in the distal vena cava or right atrium
- Made of soft, flexible material, such as polyurethane, silicone or Teflon
- Necessary for longer term infusion therapies such as antibiotics, PN, or chemotherapy
- Provides access for infusion and blood withdrawal from the central circulation
CENTRAL VENIPUNCTURE SITES

- Subclavian vein
- Jugular vein
- Femoral vein
- Cephalic vein
- Basilic vein
CENTRAL VENOUS ACCESS DEVICES

- Non-tunneled catheters: CVC/PICC
- Tunneled cuffed catheters
- Implanted ports
PERIPHERALLY INSERTED CENTRAL CATHETERS: PICC

- **PICC**: classified as non-tunneled central venous catheter
- Inserted into one of the superficial veins of the peripheral vascular system with the tip in the superior or inferior vena cava
- Antecubital vessels: basilic, cephalic brachial veins
- Cannot lift more than 10 pounds with the cannulated arm
TUNNELED CVC’S

- Tunneled into the skin before entering the venous system
- Has an external segment, a subcutaneous segment and intravascular segment
- These access devices are utilized for home PN
- Types are the Hickman, Groshong and Broviac
IMPLANTED CATHETERS

- Consist of a silicone elastomer catheter attached to a plastic or titanium disk with a self-sealing silicone elastomer septum
- Port is placed into a subcutaneous pocket that is most often located in the anterior chest
- Access obtained by palpating the port and inserting a noncoring needle in the silicone septum (can be accessed up to 2000 times)
- Ideal for those who need infrequent IV therapies (intermittent chemotherapy)
PN COMPOSITION

- Dextrose
- Amino Acids
- Lipids
- Sterile Water
- Vitamins
- Minerals
- Trace Elements
- Electrolytes

Note: Compatible medications may be added to PN solutions if needed.
Sterile water is added to PN solutions to adjust the total volume needed to meet the patients estimated 24 hour fluid needs.

Identification of fluid losses: NG output, stool, EC fistula, chyle leak are some examples.

Average adult needs: 30 – 40 ml/kg/day with urine output goal at 0.5 – 2 ml/kg/hr.
CARBOHYDRATE IN PN

- Dextrose monohydrate
- Concentrations of 2.5% to 70%
- 3.4 Kcal/g
- Acidic: pH ranging from 3.5 to 6.5
- Glycerol: sugar alcohol providing 4.3 Kcal/g whose metabolism is independent of insulin

% concentration refers to the grams of solute per 100 ml of solution (example: a 5% solution contains 5 grams of Dextrose per 100 ml or 50 grams/Liter)
CARBOHYDRATE IN PN

- Caloric source
- Protein-sparing
- Minimum requirement: 100 grams for CNS function and drive the citric acid cycle
- Maximum oxidation:
  - Stress/critical illness: aim for less than or equal to 4-5 mg/kg/minute or 5-7 grams/kg/day
  - Ideal: < 3 mg/kg/minute
  - Non-stress: up to 6-7 mg/kg/minute
  - HPN (cyclic PN): up to 12 mg/kg/minute
DEXTROSE INFUSION RATE CALCULATION

Divide grams of Dextrose by weight in Kg - then divide by 1440 minutes in a day. Multiply this number by 1000 to convert to milligrams.

Example: 250 grams Dextrose
70 kg. male
250 divided by 70 = 3.571
3.571 divided by 1440 = 0.00248
0.00248 x 1000 = 2.5 mg/kg/min
Brain and neural tissue, erythrocytes, leukocytes, eye lens and the renal medulla use glucose as a preferential fuel.

- 50% - 60% of total calories or 70% of non-protein calories for most patients.

Be aware of other CHO sources: renal replacement therapies, IVF’s, oral diet, tube feedings, or medication delivery in dextrose.
CALCULATION # 3

a) Calculate the grams of Dextrose in 1000 ml or 1 Liter of 30% Dextrose

Calculate the calories in the above

b) Calculate the Dextrose infusion rate (mg/kg/minute) for a 50 kg female receiving 500 ml of 50% Dextrose
PROTEIN IN PN

- Crystalline amino acids: 3.5% - 20%
- AA’s commonly used PN: 8.5% - 10% - 15%
- 4 Kcal/g if oxidized for energy
- Source of essential/non-essential AA and nitrogen
- Maintains nitrogen balance: 6.25 g Protein = 1 g N2 with general assumption that AA products contain 16% nitrogen content
- The AA profiles: based on the FAO/WHO recommendations for optimal proportions of EAA’s

**Note:** Divide grams Protein by 6.25 for grams of N2 in nutrition prescription (Ex. 100 g Protein divided by 6.25 = 16 g Nitrogen)
ESSENTIAL AMINO ACIDS

- Leucine (BCAA)
- Isoleucine (BCAA)
- Valine (BCAA)
- Phenylalanine (AAA)
- Tryptophan (AAA)
- Lycine
- Methionine
- Threonine
- Histidine
DISPENABLE AMINO ACIDS

- Alanine
- Aspartic Acid
- Asparagine
- Glutamic acid
- Glycine
- Proline
- Serine
CONDITIONALLY ESSENTIAL AMINO ACIDS

- Arginine
- Cysteine
- Glutamine
- Histidine
- Taurine
- Tryosine (AAA)
DISEASE SPECIFIC PN AMINO ACID PRODUCTS

- Renal disease
- Hepatic disease
- Metabolic stress
RENAL PN AMINO ACID PRODUCTS

- Primary composition: EAA
- Theory: NEAA can be recycled from urea
- Renal PN products offer no advantages over standard products and are expensive
- Indications for use limited
- Best to use reduced amounts of standard AA products
HEPATIC PN ANIMO ACID PRODUCTS IN ENCEPHALOPATHY

- Modified AA product containing increased amounts of BCAA’s and lower amounts of AAA’s
- Hepatic failure: altered metabolism resulting in a high serum ratio of AAA to BCAA
- Imbalance results in an increased transport of AAA into the brain serving as neurotransmitters causing a change in mental status
- Expensive and limited data to support use
METABOLIC STRESS PN AMINO ACID PRODUCTS

- Higher amounts of BCAA’s
- Glutamine considered a conditionally essential AA during metabolic stress but there is no IV form of glutamine with stability and compatibility issues an issue
- Current AA products are void of glutamine
ALERT! HIDDEN COMPONENTS IN AA PRODUCTS: RD BEWARE!!

- AA solutions contain varying amounts of acetate. An acetate-free PN solution is not possible.
- AA solutions may also contain sodium, chloride and phosphorus. It is important to check with pharmacy or the supplier to determine the composition of these solutions and to take this into account when prescribing PN.
CALCULATION # 4

a) Calculate the grams of protein & nitrogen in 1000 ml or 1 Liter of 10% AA solution
   Calculate the calories in the above

b) Calculate the NPC:N ratio for a patient receiving 100 grams of protein and 1420 calories from Dextrose and Lipids
INTRAVENOUS FAT EMULSIONS

- Isotonic, aqueous solution of soybean oil, soybean and olive oil (2013 release by FDA for adults only) and fish oil (Omegaven: non-FDA approved)
- Essential fatty acid source: linoleic (omega-6) and alpha-linolenic acid (omega-3)
- Concentrated calorie source/protein sparing
- **Cannot use 9 kcal/g** since IVFE contains glycerol, a CHO source
- IVFE: 10-30% of total calories or 15-30% of non-protein calories
- Became available in the 1970’s and used as a calorie source in the 1980’s which coincided with the FDA approval of IVFE to be compounded in the same container as other IV nutrients
LONG CHAIN FATTY ACIDS

- Linolec (omega-6)
- Alpha-linolenic (omega-3)
- Oleic
- Stearic
- Palmitic
LONG CHAIN FATTY ACIDS

- Omega refers to the position of the last double bond in a fatty acid
- **Omega-3**: alpha-linolenic acid can produce eicosapentaenoic and docosahexaenoic acid, readily incorporated into cell membranes and are precursors to metabolites that enhance vasodilation, suppress inflammation, slow platelet aggregation and have immuno-stimulant and anti-arrhythmic effects
- **Omega-6**: linoleic is normally elongated to arachidonic acid- in large quantities form metabolites that up regulate vasoconstriction, inflammation, platelet aggregation and are immunosuppressive and pro-arrhythmic
INTRANAVENOUS FAT EMULSIONS

- Lipid emulsions: 10%, 20% and 30% available
- 10% IVFE: 1.1 Kcal/ml or 11 Kcal/g
- 20% IVFE: 2.0 Kcal/ml or 10 Kcal/g
- 30% IVFE: 3.0 Kcal/ml or 10 Kcal/g*
- Containers of IVFE will vary in volume, dependent upon the manufacturer
- Check with the pharmacy to determine which lipid emulsion the facility purchases (LVHN uses Nutrilipid 20%, a 100% soybean oil emulsion from Braun manufacturer)

* NOTE: 30% IVFE only approved for compounding TNA's, not for direct IV administration.
COMPOSITION OF INTRAVENOUS FAT EMULSIONS

- Egg yolk phospholipid: emulsifier
- Glycerol: adjusts osmolarity
- Sodium hydroxide: adjust final pH (range 6-9)
- Small amounts of Vitamin K, PO4, Selenium and Vitamin E (supplier dependent)
- Avoid in individuals with egg/soy allergies or history of hypertriglyceridemia
- Contains soybean oil or a combination of soybean and olive oil (safflower oil emulsions alone removed from the market due to alpha-linolenic deficiency)
ALLERGY TO INTRAVENOUS FAT EMULSIONS

- Headache
- Back pain
- Nausea
- Vomiting

- Dyspnea
- Dizziness
- Cyanosis
- Flushing/sweating
HYPERTROPHIC GYALCADYOSIS CAUTION

- Measure serum triglyceride before IVFE or lipid-containing medication if PMH of hypertriglyceridemia
- Acceptable: < 400 mg/dL
- Hold IVFE if > 500 mg/dL*
- Rare for IVFE to cause pancreatitis unless TG level is > 1000 mg/dL**
- Studied extensively in the 1980’s, IVFE’s do not stimulate the pancreas or worsen pancreatitis

- ** ASPEN 2012 Adult Nutrition Support Core Curriculum
INTRAVENOUS FAT EMULSION ADMINISTRATION

- **2 in 1** PN solution: lipids hung separately with **maximum hang time of 12 hours** per Center for Disease Control and Prevention recommendation

- **3 in 1** PN solution: lipids added to solution of dextrose and amino acids with hang time **no longer than 24 hours** per Center for Disease Control and Prevention recommendation

- IVFE can be a source of bacterial contamination
INTRAVENOUS FAT EMULSIONS

- **Maximum dose**
  1 g/kg/day or less
  - Ideal: < 0.4 – 0.75 g/kg/day (critically ill)
  - Maintain infusion rate of < 0.11 g/kg/hr (greater rate associated with infectious complications and hypertriglyceridemia)

- **To prevent EFAD**: 1-2 % of daily energy requirements from linoleic acid, about 0.5% of energy from alpha-linolenic acid & 1-2% of total calories from current IVFE

- **EFAD** can occur as early 5-14 days in critical illness with a lipid-free PN solution (4 weeks in most hospitalized patients)
CALCULATION OF LIPID INFUSION RATE

Divide grams of lipid by weight in Kg.

Example: 40 grams of lipids

80 Kg male

40 grams divided by 80 kg = 0.5 grams/kg/day
PHYSICAL SIGNS OF EFAD

- **LA deficiency**: dry, scaly, flaky skin lesions/rash that initially appears in the skin folds and becomes generalized, increased susceptibility to infection, impaired wound healing and immune dysfunction

- **ALA deficiency**: less well recognized—presents with neurological symptoms of numbness, parathesia, blurred vision and trouble walking
PREVENTION OF EFAD

- 10% IVFE: 500 ml 2x per week
- 20% IVFE: 250 ml 2x per week
- 20% IVFE: 500 ml weekly

PROPOFOL AND PN

- **Propofol** (Dripriwan): a sedative-hypotonic agent based in a 10% soybean oil IVFE
- 1.1 calories/ml
- Phosphorus content: approximately 3.75 mEq or 115 mg/250 ml
- Vitamin K: 0.3 mcg/mL
- Check the ml/hr of propofol and calculate the calories provided (Ex: if propofol is infusing at 12.8 ml/hr = 307.2 ml/day x 1.1 Kcal/ml = 337.9 calories)
- Rate will vary hour to hour in some patients
- Use a lipid-free PN until propofol stopped
- Check TG if continues > 48 – 72 hours
PROPOFOL SAMPLE CALCULATION

Order for 27 mcg/kg/min in a 70 kg male

1. 27 mcg x 70 kg = 1890 mcg
2. 1890 mcg x 60 min/hr = 113,400 mcg/hr
3. 113,400 mcg/hr divided 1,000 mcg/mg = 113.4 mg/hr
4. 113.4 mg/hr divided 10 mg/ml = 13.4 ml/hr
5. 13.4 ml/hr x 24 hr/day = 322 ml/day
6. 322 ml/day x 1.1 fat Kcal/ml = 354 fat Kcal/day

NOTE: 10 MG = 1 ML
      1 MG = 1,000 MCG

a) Calculate the grams of fat and calories in 200 ml of 20% IVFE
b) Calculate the lipid infusion rate (grams/kg/day) for a 80 kg male receiving 60 grams of lipids
c) How many calories is propofol providing at 23 ml/hr?
COMPOUNDING PN: ADMIXTURES

- **2 in 1** formulations
- **3 in 1** formulations or Total Nutrient Admixture (TNA)
2 in 1 PN ADMIXTURE

- Formulations that contain amino acids, dextrose, vitamins, minerals, trace elements, electrolytes and sterile water.
- IVFE is infused separately via the Y site below a **0.22 micron filter**. This filter is used to eliminate bacteria and particulate matter that may be in the PN solution (lipids will clog this filter).
- When MVI is in this formulation, it should be yellow in appearance.
PN 2-in-1 ADMIXTURE CALCULATION GUIDE

- **Protein**: calculate daily protein needs and calories provided from protein

- **Dextrose and lipid**:
  a) Subtract protein calories from total calories for the non-protein calories
  b) Multiple non-protein calories by 70% for the dextrose calories and 30% for the lipid calories needed (ratio 70:30)
  c) Divide dextrose calories by 3.4 Kcal for grams of dextrose per day
  d) Divide lipid calories by 1.1 (10% IVFE) or 2.0 (20% IVFE) for volume needed
3 in 1 PN ADMIXTURE

- Total Nutrient Admixture or TNA contains amino acids, dextrose, lipids, vitamins, minerals, trace elements, electrolytes and sterile water.
- Macronutrients must fall into acceptable ranges per liter due to stability issues.
- Requires less RN/RPh time and no need for 2 infusion pumps and administration sets.
- Less costly and better fat utilization.
- Visual inspection difficult due to lipids and the milky appearance of this solution (cream color from the MVI).
- **1.2 micron filter** is needed which filters out yeast and particulates.
PN 3-in-1 ADMIXTURE CALCULATION GUIDE

- **Protein**: calculate daily protein needs and calories provided from protein

- **Dextrose and lipid**:
  a) Subtract protein calories from total calories for the non-protein calories
  b) Multiply the non-protein calories by 70% for the dextrose calories and 30% for the lipid calories (ratio 70:30)
  c) Divide dextrose calories by 3.4 for the grams of dextrose per day.
  d) Divide lipid calories by 10 (20% IVFE) for the grams of lipid per day
54 year old male with peritonitis. Ht. 70”/177.8 cm., **dry** weight 176#/80 Kg.. Daily needs: 2000 Kcal, 120 g of protein, 2400 ml fluid

**Protein**: 120 grams x 4 Kcal/g = 480 cal
2000 – 480 = 1520 calories (non-protein calories)

**Dextrose**: 70% x 1520 = 1064 calories
1064 calories divide by 3.4 Kcal/g = 313 g dextrose

**Lipid**: 30% x 1520 = 456 calories

**Admixture 2-in-1**: 456 cal divide by 1.1 (10% IVFE) = 415 ml/d
456 cal divide by 2.0 (20% IVFE) = 225 ml/d

**Admixture 3-in-1**: 456 divide by 10 kcal/g = 45 grams lipid
### Goal Prescription

<table>
<thead>
<tr>
<th>Component</th>
<th>Amount</th>
</tr>
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<tbody>
<tr>
<td>Dextrose</td>
<td>313 grams</td>
</tr>
<tr>
<td>AA</td>
<td>120 grams (19 grams N2)</td>
</tr>
<tr>
<td>Lipids</td>
<td>45 grams</td>
</tr>
<tr>
<td>Volume</td>
<td>2400 ml</td>
</tr>
<tr>
<td>Rate</td>
<td>100 ml/hr/day</td>
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</tbody>
</table>

1994 total calories/day, 25 Kcal/kg/day, protein of 1.5 grams/Kg/d, dextrose infusion rate of 2.7mg/kg/minute, lipid infusion rate of 0.5g/kg/day, NPC:N ratio 80:1
CASE STUDY SAMPLE CPN
VOLUME CALCULATION

Dextrose 70%: \(313 \text{ g} \div 0.70 = 447 \text{ ml}\)
Dextrose 50%: \(313 \text{ g} \div 0.50 = 626 \text{ ml}\)
Dextrose 30%: \(313 \text{ g} \div 0.30 = 1043 \text{ ml}\)

AA 10%: \(120 \text{ g} \div 0.10 = 1200 \text{ ml}\)
15%: \(120 \text{ g} \div 0.15 = 800 \text{ ml}\)

IVFE 10%: \(45 \text{ g} \div 0.11 = 409 \text{ ml}\)
IVFE 20%: \(45 \text{ g} \div 0.20 = 225 \text{ ml}\)

Overfill: added 200 ml for electrolytes
YOUR TURN
CALCULATION # 6

35 year old female trauma patient
Dry weight: 50 Kg
Height: 64 inches
Needs: 1500 calories
75 grams protein
1750 ml/day

Calculate macronutrient goal and volume from each substrate assuming pharmacy will be using Dextrose 70%, 10% AA, and 20% IVFE
INTRAVENOUS VITAMINS IN PN

- Formulated to comply with the AMA NAG recommendations for parenteral vitamin requirements for adults
- Guidelines based on 1985 FDA recommendations
- FDA made this a “law” in 2000 for manufacturer compliance
- Individual vitamin infusions are available except for biotin, pantothenic acid, riboflavin, Vitamin A and E
- Vitamin requirements for specific disease or clinical conditions are unknown
MVI COMPOSITION

- Vitamin A: 3300 IU
- Vitamin D: 200 IU
- Vitamin E: 10 IU
- Vitamin K: 150 mcg
- Thiamin (B1): 6 mg
- Pyridoxine (B6): 6 mg
- Cyanocobalamin (B12): 5 mcg
- Pantothenic acid: 15 mg
- Biotin: 60 mcg
- Ascorbic Acid: 200 mg
- Folic Acid: 600 mcg
- Niacin: 40 mg
- Riboflavin (B2): 3.6 mg
ELECTROLYTES/MINERALS IN PN

- Sodium: extracellular cation
- Potassium: intracellular cation
- Phosphorus: intracellular anion
- Magnesium: intracellular cation
- Chloride: extracellular anion
- Calcium, iron, Acetate
ELECTROLYTE DOSING IN PARENTERAL NUTRITION

- Weight based
- Disease-specific
- Organ function
- Acid-base balance
- Degree of depletion
- Medication profile
ELECTROLYTE DOSING IN PN

- **Milliequivalent** (mEq): concentration of electrolytes in a certain volume of solution, usually expressed as mEq/L. It is calculated by multiplying the milligrams/L by the valence of the chemical and dividing by the molecular weight of the substance.

- **Millimole**: defined as one atomic weight of a molecule.
ELECTROLYE DOSING IN PN

- Sodium, potassium, calcium and magnesium are expressed in mEq units.
- Phosphorus is expressed as millimoles (1 mmol = 1.8 mEq of PO4).
- 1 mmol of sodium phosphorus = 1.33 mEq of Na+.
- 1 mmol of potassium phosphorus = 1.47 mEq K+.
ASPEN GUIDELINES FOR DAILY ELECTROLYTE DOSING IN PN

- Sodium: 1-2 mEq/kg
- Potassium: 1-2 mEq/kg
- Phosphorus: 20-40 mmole
- Magnesium: 8-20 mEq
- Calcium: 10-15 mEq
- Chloride and Acetate: as needed as dictated by acid-base balance (usual Cl PN dose 35 – 50 mEq/L)
ELECTROLYTE COMPOUNDING IN PN: SALT FORM

- Sodium: chloride, acetate, phosphate
- Potassium: chloride, acetate, phosphate
- PO4: sodium or potassium
- Magnesium: sulfate preferred
- Calcium: gluconate preferred
- Acetate/chloride: sodium or potassium (usually provided in a 1:1 ratio in the absence of acidosis or alkalosis)
CALCIUM AND PHOSPHORUS COMPATIBILITY IN PN

- Solid precipitates can develop when an incompatible combination of calcium and phosphate salts are added to a PN formulation.
- Calcium salts are one of the most reactive compounds and can form insoluble products, which can result in embolic death when infused.
Increased temperature increases the likelihood of a precipitate forming because of increased dissociation of calcium from gluconate, and potassium and sodium from phosphate.

Increased pH of the PN solution increases the likelihood of precipitation because the amount of dibasic phosphate is increased. An acidic pH is more favorable to calcium phosphate solubility.

Increased amounts of calcium and phosphorus favor precipitation. Pharmacy is diligent when reviewing PN formulations regarding this issue.
TRACE ELEMENTS IN PN

- Intravenous trace element requirements are based on the AMA NAG recommendations established in 1979
- ASPEN 2004 recommendations included SE
- Nearly 20 trace elements are thought to be essential to man but only 5 are commonly added to PN
- Trace elements include zinc, chromium, copper, selenium, manganese, iodine, and molybdenum
- Available as “package” of trace elements or as individual ones
- Trace element requirements in specific diseases or clinical conditions are unknown
ASPEN GUIDELINES FOR DAILY TRACE ELEMENTS IN PN

- Zinc: 2.5 – 5.0 mg
- Copper: 0.3 – 0.5 mg
- Chromium: 10-15 mcg
- Manganese: 60 – 100 mcg
- Selenium: 20 – 60 mcg

Note: Parenteral products are contaminated with Manganese, Copper, Chromium and Aluminum
LVHN TRACE ELEMENT DOSE

Multitrace 5: dose 3 ml/day

- Zinc: 3 mg
- Copper: 1.2 mg
- Manganese: 0.3 mg
- Selenium: 60 mcg
- Chromium: 12 mcg
ZINC AND CHROMIUM IN PN

- Stable adults: 2.5 – 5.0 mg/d
  Additional 2 mg/d for hypermetabolic states
- GI losses:
  NG losses: add 10 mg/L
  SB losses: add 12 mg/L
  Stool/ileostomy losses: add 17 mg/L
- Excessive zinc, as little as 25 mg, may alter copper status and may be immunosuppressive
- GI losses: Added 20 mcg/d chromium
COPPER AND MANGANESE IN PN

- May need to **delete or reduce** dose in Wilson’s disease, biliary obstruction, intrahepatic cholestasis, biliary cirrhosis and hepatic compromise
- 80% of Cu excreted via bile/20% urine
- Consider deletion of Cu and Mn if total bilirubin is > 5.0 due to potential for becoming bound in the liver (identify cause– bilirubin may be elevated due to reabsorption of a hematoma/sepsis, etc)
- GI losses: Added 500 mcg/d
SELENIUM IN PN

- Should be added to all PN
- Se supplementation of 20 – 60 mcg/d is recommended
- Se toxicity has not been reported in PN patients
- Se excretion is primarily via the urine with some losses in the intestinal secretions
- Se deficiency is well-documented in HPN patients without added Se and demonstrated as cardiomyopathy and skeletal myopathy
IRON IN PN

- Iron is not routinely added to PN
- Iron **should not be added** to TNA since it can destabilize the IVFE
- Iron dextran can be added to non-IVFE PN solutions but requires caution due to compatibility limitations
- During sepsis or infectious states, iron is redistributed from the circulating compartment into the liver under the influence of leukocyte endogenous mediation (combination of cytokines, TNF and interleukin 1)
- **Avoid iron in sepsis** (bacteria feed off iron)
ACID-BASE BALANCE

- Describes the ability of the body to equilibrate acids and bases
- The lung and kidneys work together to maintain acid-base balance
- **Acid**: substance that donates hydrogen ions
- **Base**: substance that accepts or combines with hydrogen
- The free hydrogen concentration determines the acidity of body fluids and is represented by the pH
ACID-BASE BALANCE

- Acid-base disturbances can affect plasma concentrations of electrolytes as they shift between the ICF and ECF spaces to accommodate the disorder.
- GI losses or certain renal disorders may also affect acid-base balance.
- Bicarbonate (unstable in PN): principal extracellular buffer in the body – changes pH and forms insoluble precipitates with calcium and magnesium.
- Acetate (stable in PN): converts to bicarbonate in the liver.
ACID-BASE BALANCE TERMINOLOGY

- **PCO2**: pressure exerted by dissolved CO2 gas in the blood
- **HCO3-**: plasma bicarbonate concentration
- **H+**: hydrogen ion
ACID-BASE DISORDERS

- Metabolic Acidosis
- Metabolic Alkalosis
- Respiratory Acidosis
- Respiratory Alkalosis
ACID-BASE BALANCE

- If pH < 7.35 – acidemia
- If pH > 7.45 – alkalemia
- Respiratory component: PCO2 > 45 (respiratory acidosis) and PCO2 < 35 (respiratory alkalosis)
- Metabolic component: HCO3- > 26 (metabolic alkalosis) and HCO3- < 22 (metabolic acidosis)
- **Respiratory** event is primary if pH and PCO2 move in different directions and **metabolic** event is primary if pH and PCO2 move in the same direction
REMEMBER ACRONYM: ROME

R = Respiratory
O = Opposite
M = Metabolic
E = Equal

Remember: if one value is up, and the other is down, then it is respiratory. If both are going in the same direction, then it is metabolic.
METABOLIC ACIDOSIS

- Results from an increase in acids other than carbonic acid which causes a decrease in the plasma bicarbonate concentration
- There is either a gain of acid or loss of bicarbonate
METABOLIC ACIDOSIS

- **Gains of acid** occur from excessive ingestion of acid, excessive endogenous acid production (lactic acidosis, DKA, rhabdomyolysis), excessive provision of acidifying salts, inability to excrete acid loads (renal failure) or overfeeding protein in the presence of decreased ability to excrete the acid load.

- **Bicarbonate is lost** via the GI tract with severe diarrhea, pancreatic or SB fistulas, biliary drainage, ureterosigmoidostomy or from renal losses in type 3 renal tubular acidosis. Metabolic concerns arise because serum K+ increases due to a shift of H+ into cells and K+ out of cells.
ANION GAP AND METABOLIC ACIDOSIS

- **AG**: concentration of unmeasured anions in the blood
- **AG**: difference between the measured cations and anions in the body
- **Anion gap** = (Na+) – (Chloride + HCO3-)
- AG: helps to determine type of metabolic acidosis. Normally, there is a 1:1 ratio with AG of 6-12 mEq/L normal. Hypoalbuminemia decreases the AG by 3mEq/L for every 1 g/dL decrease in serum albumin (albumin is an unmeasured anion). If the AG is > 26 mEq/L, metabolic acidosis is likely.
TREATMENT OF METABOLIC ACIDOSIS

- Provision of exogenous bicarbonate for severe cases (pH < 7.1). In PN, acetate is utilized as either sodium or potassium acetate.
- If due to organic acid production, bicarbonate replacement is recommended if the pH is < 7.1 and bicarbonate is < 10mEq/L.
METABOLIC ALKALOSIS

- Occurs with an increase in the plasma bicarbonate concentration. This is due to either a loss of hydrogen or a gain of bicarbonate and abnormal renal retention of bicarbonate.

- Metabolic alterations usually include decreased plasma K+, with hydrogen leaving the cell and K+ entering the cell in an attempt to maintain electron neutrality.
CAUSES OF METABOLIC ALKALOSIS

- ECF volume depletion due to vomiting/NG suction, diuretic therapy, chronic diarrhea, fistula drainage, secondary hyperaldosteronism, renovascular disease, malignant HTN, CHF, cirrhosis with diuretic therapy and renal failure due to inability of the kidney to excrete bicarbonate

- Excess bicarbonate can be gained with oral or IV bicarbonate administration
TREATMENT OF METABOLIC ALKALOSIS

- Most cases in hospitalized patients are chloride-responsive. Chloride is replaced with isotonic fluid and chloride (0.9% NS)
- Bicarbonate (acetate) may need to be reduced in the PN
NUTRITIONAL ASSESSMENT FOR PN PATIENTS

- Calculate fluid, calorie and protein needs
- Review laboratory data
- Review medication profile
- Assess volume status
- Assess access site available
- Evaluate other sources of IVF/nutritional support (oral diet/TF)
- ASPEN PN guidelines
SUGGESTED NUTRIENT INTAKES FOR ADULTS ON PN

Critical Illness
Protein: 1.5 – 2 g/kg/d
CHO: \( \leq 4 \) mg/kg/minute
IVFE: \( \leq 1 \) g/kg/d
Kcal: 25 – 30 cal/kg/d
Fluid: As needed to deliver nutrients in PN

Stable
Protein: 0.8 – 1 g/kg/d
CHO: \( \leq 7 \) mg/kg/minute
IVFE: 1 g/kg/d
Kcal: 20 – 30 cal/kg/d
Fluid: 25 – 40 ml/kg/d (age and disease specific)
COMMERCIAL PREMIXED PN PRODUCTS

- Used in small hospitals or SNF’s where PN is used on an irregular basis
- Need to add MVI
- 24 hour stability only
- PPN or CPN solutions with or without electrolytes available
- Glycerol based product available
- Major disadvantage: unable to prescribe patient specific/individualized PN
FLUID REQUIREMENTS IN PN

- Use established standards for fluid needs
- Look for other sources of fluid, such as IV’s, medications, tube feedings, oral intake, etc.
- IV fluids with dextrose will contribute calories and contribute to the CHO load
- Some renal replacement therapies will contribute dextrose, such as PD
- Propofol will provide lipid calories depending upon the infusion rate
WRITING A PN PRESCRIPTION: DEXTROSE

- Begin with 150 – 200 grams of dextrose or half of the dextrose requirements.
- Begin with 100 – 150 or less in the presence of diabetes, glucose intolerance or risk of refeeding syndrome.
- In critical illness, do not exceed 4-5 mg/kg/minute or 5-7 grams/kg/day. Infusion rate at < 3 mg/kg/minute is recommended, maintaining BG between 90-140mg/dL.
- Stable: 140 – 180 mg/dl.
WRITING A PN PRESCRIPTION: AMINO ACIDS

- AA should be dosed based on the patients clinical status
- Generally, standard AA solutions should be used. Specialized AA solutions lack solid evidence to support their use and are costly
- Maximum amount of protein first day of PN: 60 – 70 grams
- Protein should comprise 10 – 25% of total calories, dependent on the patients protein requirements.
- At LVHN, protein is counted in with total calories
WRITING A PN PRESCRIPTION: IVFE

- Start with 40 grams of lipids if fasting Tg is < 250 mg/dL
- In critical illness, do not exceed a lipid infusion rate of > 1 gram/kg/day due to the omega-6 fatty acid composition of IVFE which is immunosuppressive
- Keep fat at ≤ 30% of total calories
- IVFE maximum infusion rate: 0.11 gm/kg/hour
INITIAL PN PRESCRIPTION

- Initial PN start with 50% of needs
- Concentrate PN using Dextrose 70%, 15% AA and 20% IVFE if volume is an issue (central access only)
- Do not start PN in the presence of severe hyperglycemia (> 300 mg/dL) azotemia with a BUN > 100 mg/dL, severe fluid problems and severe electrolytes abnormalities
MONITORING PN

- Weight, intake and output
- Glucose, BUN, Creatinine, Na+, K+, Chloride, Ionized calcium, CO2, magnesium, phosphorus daily until stable
- Triglyceride weekly
- Liver function studies
- Prealbumin/C-reactive protein
- 24 hour UUN as needed
- Measured EE with indirect calorimetry
- PN at goal, NPC:N ratio, appropriate infusion rates for dextrose and lipids
- Introduction of EN (tube feedings or oral diet)
- Other calorie sources (RRT, IVF, Med delivery)
VISCERAL PROTEIN MARKERS

- **Albumin, prealbumin and transferrin** are negative acute phase proteins and are poor indicators of nutritional status or adequacy of nutrition support in critical illness (decreased)

- More a **marker of inflammation** than response to nutrition therapy
NITROGEN BALANCE

- Calculate the grams of protein from PN
- Divide this number by 6.25 for the grams of nitrogen (6.25 grams of protein contain 1 gram of nitrogen)
- PN nitrogen minus nitrogen in 24 hour urine sample plus 3-4 grams for other losses of N2 such as feces, skin, sweat, etc
- **Ex:** 24 grams N2 in PN – 16 grams N2 in urine + 3-4 grams = N2 balance of positive 4-5 grams
PN COMPLICATIONS

- Catheter-related
- Gastrointestinal
- Metabolic
CATHETER-RELATED PN COMPLICATIONS

- Pneumothorax
- Air embolism, venous thrombosis
- Phlebitis
- Catheter embolization
- Catheter occlusion/tip misplacement
- Sepsis/infections
COMPLICATIONS OF PARENTERAL NUTRITION

- **Fatty liver**: cause unclear though may be due to EFAD, excess CHO, calories or protein, carnitine or choline deficiency
- **Cholestasis**: cause not clear though may be due to excess CHO/fat, impaired biliary flow or absence of luminal nutrients
- **GI atrophy/gastric hyperacidity**
COMPLICATIONS OF PARENTERAL NUTRITION

- Hepatobiliary: **steatosis** (hepatic fat accumulation) usually seen in adults. Increase in serum aminotransferases, bilirubin, and alkaline phosphatase seen 1 to 2 weeks after PN start (etiology unclear but benign and reversible)

- **GGT** (gamma glutamyl transpeptidase) most specific to the liver
Steatosis: may be due to decreased fatty acid transport from the liver or increased hepatic lipid synthesis due to continuous glucose and/or excess caloric load that maintains high blood insulin levels.
COMPLICATIONS OF PARENTERAL NUTRITION

- **Cholestasis**: defined as an impaired bile secretion or biliary obstruction which is seen mostly in children
  - Prime indicator: elevated conjugated (direct) bilirubin defined as > 2 mg/dL
  - May be due to lack of EN, overfeeding or excess CHO
  - Try to correct with cyclic PN and early EN
COMPLICATIONS OF PARENTERAL NUTRITION

- **GI atrophy** due to lack of enteral stimulation with reduction of small bowel or colon mass
- Bowel shortens, villi are thinner and closer together
- **Gallbladder stasis**: gallstones or gallbladder sludge develops with cholecystitis. Due more to lack of EN than PN (little or no EN results in decreased CCK release with impaired bile flow and gallbladder contractions)
REFEEDING SYNDROME IN PN

- Refers to the metabolic and physiological shifts of fluid, electrolytes and minerals (potassium, magnesium and phosphorus) that results from aggressive nutrition support.
- Occurs within a few days after refeeding an acutely/chronically malnourished adult.
- Trigger: increase in insulin: glucagon ratio in the transition from the fasted to fed state.
- A potentially life-threatening event if not recognized and treated promptly.
REFEEDING SYNDROME IN PN

- Shift from **fat to CHO** metabolism as a primary fuel source
- Insulin levels rise and stimulate cellular uptake of potassium, magnesium, phosphorus and glucose
- Fat mobilization as a fuel source is inhibited by insulin, an anabolic hormone
REFEEDING SYNDROME IN PN

- **Complications**: severe hypophosphatemia, hypokalemia, hypomagnesemia, tachycardia, respiratory distress and cardiac decompensation

- **Symptoms**: generalized fatigue, lethargy, muscle weakness, edema, cardiac arrhythmia and hemolysis
PREVENTION OF REFEEDING SYNDROME WITH PN

- Replete serum potassium, magnesium and phosphorus before initiating PN
- Provide adequate amounts of potassium, magnesium, phosphorus and vitamins (thiamin is an important coenzyme for CHO metabolism) in initial PN
- Limit initial Dextrose to 100 – 150 g/day and fluid to 800 ml/day with Dextrose goal not to exceed 200 g/day
- Start with 50% of calculated energy needs or 15 calories/kg
- Since the effect of glycolysis is not as concerning as Dextrose, some have recommended starting at the goal dose of protein less than or = to 1.5 g/kg/day
HYPERGLYCEMIA WITH PN

- Increase loss of water and electrolytes
- Impairs immune function as glucose binds to the biochemically active site of complement and inhibits the complement attachment to the microbial surface
- BG > 200 mg/dL may increase infectious complications
- Evidence indicates that a BG of < 140 mg/dL is associated with decreased mortality, LOS and infectious complications in critically ill
- Tight BG control is a controversial issue
- Most clinicians aim for 140 – 180 mg/dL or less
Initial dextrose dose: 100 – 150 g
Slow increase by 50 – 70 g/day if BG is under control (avoid increasing dextrose if BG is > 140 – 150 mg/dL)
If insulin is needed, only regular human insulin is compatible with PN
5% - 15% of insulin in PN may adhere to the bag and tubing if made form ethyl vinyl acetate or PVC
A separate insulin infusion is recommended in critically ill
INSULIN DOSING IN PN

- Initial dose: 0.05 or 0.1 unit per gram of dextrose (5 - 10 units per 100 grams of dextrose)
- Increase by 0.05 – 0.1 units per gram of dextrose per day
- 0.15 to 0.2 units of insulin per gram of dextrose in hyperglycemic patients
- Two-thirds of the total amount of sliding scale insulin needed over 24 hours can be added to the next day’s PN formulation
- If 0.3 units of insulin per gram of dextrose is exceeded, an insulin drip should be considered
HYPERLIPIDEMIA WITH IVFE

- Associated with a removal defect of TG (lipoprotein lipase)
- May contribute to pancreatitis
- May contribute to altered pulmonary hemodynamics and decreased pulmonary diffusion capacity (ability of the lungs to transfer gas across the alveolar surface)
IVFE MONITORING

- Tg < 250 mg/dL 4 hours after lipid infusion for piggybacked lipids (2-in-1)
- Tg < 400 mg/dL for 24 hour IV lipid infusions (3-in-1)
- Tg levels should not be drawn during the lipid infusion (2-in-1)-always check what time the blood was drawn
- Hold IVFE if TG > 400 – 500 mg/dL with a 3-in-1 solution (24 hour infusion) or in the presence of lipemic serum
HYPONATREMIA IN PN

- Serum sodium < 135 mEq/L
- Potential causes: administration of excessive hypotonic fluid, nephritis, adrenal insufficiency, CHF, SIADH and cirrhosis with ascites
- Symptoms: confusion, hypotension, irritability, lethargy, seizures
- Treatment: depending on the cause, correct with fluid restriction or diuretics
- If Na+ intake is inadequate and the clinical condition warrants, sodium may be increased in the PN solution
HYPERNATREMIA IN PN

- Serum sodium > 145 mEq/L
- **Causes**: inadequate free water administration, excessive water loss or excessive sodium intake
- **Symptoms**: thirst, decreased skin turgor, irritability
- **Treatment**: increasing fluid intake usually corrects hypernatremia and less often, reducing sodium content in PN solution may be needed
HYPOKALEMIA IN PN

- Serum potassium < 3.6 mEq/L
- **Causes:** inadequate K+ intake, refeeding syndrome or excessive losses with diarrhea or intestinal fluids. Drugs, such as loop and thiazide diuretics, cathartics and some antibiotics and antifungals may increase urinary K+ losses. Hypomagnesemia may cause hypokalemia and should be corrected first to facilitate correction of the hypokalemia.
- **Symptoms:** nausea, vomiting, confusion, arrhythmias, respiratory depression and cardiac arrest.
- **Treatment:** Replace K+ or add/increase to PN solution.
HYPERKALEMIA IN PN

- Serum potassium > 5.0 mEq/L
- **Causes**: renal dysfunction, administration of excessive K+, metabolic acidosis or potassium-sparing medications
- **Symptoms**: diarrhea, paresthesia, tachycardia, oliguria and cardiac arrest
- **Treatment**: Reduce or delete K+ in PN and other sources, or if severe, by using K+ exchange resins, insulin and dextrose, inhaled beta agonists or dialysis
HYPOCALCEMIA IN PN

- Total serum calcium < 8.6 mg/dL
- **Causes**: decreased Vitamin D intake, hypoparathyroidism, citrate binding of calcium with blood product administration or hypoalbuminemia. Hypomagnesemia may also contribute to hypocalcemia.

- **Symptoms**: tetany, irritability, seizures and ventricular arrhythmias

- **Treatment**: Hypocalcemia independent of hypoalbuminemia may be treated with calcium supplementation
HYPERCALCEMIA IN PN

- Total serum calcium > 10.2 mg/dL
- **Causes:** renal failure, tumor lysis syndrome, bone cancer, excessive Vitamin D administration, prolonged immobilization and stress or hyperparathyroidism
- **Symptoms:** confusion, dehydration, muscle weakness, nausea, vomiting and coma
- **Treatment:** administration of isotonic saline, inorganic phosphate, corticosteroids, bisphosphonates or mithramycin
HYPMAGNESEMIA IN PN

- Serum magnesium < 1.8 mg/dL
- **Causes**: refeeding syndrome, alcoholism, diuretic use, prolonged NG suction, increased stool output, DKA, or magnesium-wasting medications such as thiazide and loop diuretics, cisplatin, cyclosporine, amphotericin B, aminoglycosides and foscarnet
- **Symptoms**: cardiac arrhythmias, tetany, convulsions and muscular weakness
- **Treatment**: magnesium replacement or add/increase in PN solution
HYPERMAGNESEMMIA IN PN

- Serum magnesium > 2.3 mg/dL
- **Causes**: excessive magnesium intake in renal insufficiency
- **Symptoms**: respiratory paralysis, hypotension, premature ventricular contractions, lethargy, coma, liver dysfunction and cardiac arrest
- **Treatment**: decrease or eliminate magnesium in PN or other sources or start RRT if severe
HYPOPHOSPHATEMIA IN PN

- Serum phosphorus < 2.7 mg/dL
- **Causes**: refeeding syndrome, long term alcoholism and inadequate phosphorus intake
- **Symptoms**: CHF, arrhythmias, nausea, vomiting, altered RBC morphology, hemolytic anemia, leukocyte dysfunction, ataxia, short-term paralysis, lethargy, confusion, coma, acute respiratory failure, ATN and bicarbonate/glucose wasting
- **Treatment**: administration of IV phosphorus or add/increase in PN
HYPERPHOSPHATEMIA IN PN

- Serum phosphorus > 4.5 mg/dL
- **Causes**: administration of excess phosphate or with renal insufficiency
- Tissue calcification may occur with prolonged elevated levels
- **Symptoms**: parenthesis, flaccid paralysis, mental confusion, HTN and cardiac arrhythmias
- **Treatment**: decrease sources of phosphorus or decrease/delete in PN or other sources (remember that IVFE may contain small amount of phosphorus)
CONTAMINANTS IN PN

- Aluminum and manganese appear to be the most clinically relevant contaminants in PN.
- FDA developed regulations that require manufacturers to disclose aluminum content on its label.
- The safe limit of aluminum is 5 mcg/kg/day.
WHEN TO STOP PN

○ Once oral intake is > 500 calories, begin to decrease macronutrients in PN

○ Once 60% of needs are met by either an oral diet or tube feeding, discontinue PN—no need to taper PN if patient is eating or on tube feedings

○ If more than 25% of calorie needs are met by PN, reduced oral intake can be seen (Gil IM et al. Parenteral nutrition and oral intake: effect of glucose and fat infusions. JPEN. 1991;15;426-432.)
REFERENCES

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