Chapter 26

Parenteral Nutrition

Perhaps we should say, "You are what's infused into you!" for this chapter.
--A horrible attempt at humor from this book's author.

A simple definition of parenteral nutrition (PN) would be a method of acquiring nutrition in a route other than through the digestive tract. It is intended for patients that are unable to obtain an adequate quantity of nutrients through their digestive tract. Indications for parenteral nutrition may include diseases and conditions associated with a nonfunctional gastrointestinal tract (bowel obstruction, severe pancreatitis, severe malabsorption), cancer therapy (radiation therapy, antineoplastic drugs, bone marrow transplantation), organ failure, hyperemesis during pregnancy, severe eating disorders (anorexia nervosa) when the patient cannot tolerate enteral nutrition, or failure when a patient attempted a trial of enteral nutrition.

This chapter will present the following concepts related to parenteral nutrition:

- various terms used to refer to parenteral nutrition,
- macronutrients and micronutrients commonly used,
- quantities and concentrations of nutrients in PN,
- precipitation concerns,
- osmolarity and implications involving infusion options,
- determining appropriate PN volume for a patient, and
- calculating calorie requirements for patients.

Commonly used terms for parenteral nutrition

Parenteral nutrition is referred to by many different names including:

- **total parenteral nutrition** (TPN) – As the name implies, it involves a patient receiving all of their nutritional needs parenterally
- **partial parenteral nutrition** (PPN) – This is when a patient is receiving part of their dietary needs through their digestive tract, but it is insufficient for all their needs, so they also receive a portion of their dietary needs parenterally
- **hyperalimentation** (HAL) or **intravenous hyperalimentation** (IVH) – This term may be defined in the same broad way as parenteral nutrition. The name itself is referring to the idea that the patient is receiving something outside of their alimentary canal.
- **total nutrient admixture** (TNA) – This is a term that could be used interchangeably with total parenteral nutrition.
- **3-in-1 admixture** or **all-in-one admixture** – This name is intended to inform the medical staff and caregivers that all three major bases (dextrose, amino acids, and lipids) along with micronutrients are included directly in the parenteral nutrition, as sometimes the lipids are infused separately from the rest of the PN.
- **centrally infused parenteral nutrition** (CPN) – Parenteral nutrition is always infused either centrally or peripherally. This name ensures that everyone knows the proper route of

administration, which is important when looking at the osmolarity.

- **peripherally infused parenteral nutrition** (PPN) – Parenteral nutrition is always infused either centrally or peripherally. This name ensures that everyone knows the proper route of administration, which is important when looking at the osmolarity. It is important to know whether the term PPN is being used to refer to a partial parenteral nutrition or a peripherally infused parenteral nutrition.

Macronutrients and micronutrients

Many people are used to looking at the nutrition labels on the foods they buy. You will notice that there are usually major items like carbohydrates, protein, and fat followed by other items like vitamins and minerals. Parenteral nutrition still functions on the same concepts but often uses different terms for the nutrients. The table below provides a comparison of these items between what we traditionally call them when dealing with a typical diet compared to the terms we'll use to prepare PN therapy.

enteral nutrition	***parenteral nutrition***	***function/purpose***
Macronutrients		
water	water	Water is the most necessary substance for life as it forms the solution base for all metabolic processes and makes up around 50 – 60% of body weight.
protein	amino acids	Amino acids form proteins and provide the major structural building blocks of the body and are needed for the daily activities of living.
carbohydrates	dextrose	Carbohydrates are the primary source of cellular energy. Dextrose, a simple sugar, provides this role in PN.
fat	lipids	Fatty acids perform important physiological functions.
Micronutrients		
vitamin	multivitamin injection (MVI)	Vitamins are important for biochemical processes within the human body. MVI typically includes fat soluble (A,D,E, and K) and water soluble (thiamine, riboflavin, niacin, pantothenic acid, pyridoxine, ascorbic acid, folic acid, B12, and biotin) vitamins.
trace elements	trace elements	These are elements that you only require small quantities of. MTE7 includes Zinc (Zn), copper (Cu), manganese (Mn), chromium (Cr), selenium (Se), iodine (I), and molybdenum (Mo). Other trace elements include Cobalt (Co), Vanadium (V), Nickel (Ni), and Flouride (F).
electrolytes	electrolytes	Electrolytes are necessary for optimal physiological fuction. Common electrolytes include sodium (na), potassium (K), chloride (Cl), magnesium (Mg), phosphate (PO_4), calcium (Ca), etc. There is a potential concern of the calcium and phosphate electrolytes forming a precipitate (discussed further later).
N/A	drug additives	While not technically a nutrient, PN will often include drug additives such as regular insulin, H2 antagonists, heparin, etc.

Quantities and concentrations of nutrients in parenteral nutrition

Now that we have introduced the most common ingredients of parenteral nutrition, let's take a moment and look at a PN that has been ordered and determine the quantities and concentrations of its nutrients.

Example

The pharmacy receives a request for a partial parenteral nutrition to be infused through a central line over 16 hours. On the left are the requested quantities/concentration and on the right are the available components.

Requested PN	*Source components*
amino acids 2.125%	8.5% amino acid solution
dextrose 20%	50% dextrose solution
sodium chloride 15 mEq	14.6% sodium chloride (2.5mEq/mL, 146 mg/mL)
potassium phosphate 15 mMol	potassium phosphate 3 mMol/mL
calcium gluconate 2.5 mEq	10% calcium gluconate (4.65 mEq/10 mL)
MVI 10 mL	MVI 10 mL vial
trace elements 1 mL	trace elements 1 mL vial
regular insulin 15 units	Humulin R U-100 (100 units/mL)
SWFI qs 1000 mL	Sterile Water for Injection

$$\text{amino acids}$$
$$\frac{2.125\text{ g}}{100\text{ mL}} = \frac{\text{N}}{1000\text{ mL}}$$
$$\text{N} = 21.25\text{ g}$$
$$\frac{21.25\text{ g}}{\text{N}} = \frac{8.5\text{ g}}{100\text{ mL}}$$
$$\text{N} = \mathbf{250\text{ mL of }8.5\%\text{ amino acid}}$$

$$\text{dextrose}$$
$$\frac{20\text{ g}}{100\text{ mL}} = \frac{\text{N}}{1000\text{ mL}}$$
$$\text{N} = 200\text{ g}$$
$$\frac{200\text{ g}}{\text{N}} = \frac{50\text{ g}}{100\text{ mL}}$$
$$\text{N} = \mathbf{400\text{ mL of }50\%\text{ dextrose}}$$

$$\text{sodium chloride}$$
$$\frac{15\text{ mEq}}{1} \times \frac{\text{mL}}{2.5\text{ mEq}} = \mathbf{6\text{ mL sodium chloride}}$$

$$\text{potassium phosphate}$$
$$\frac{15\text{ mM}}{1} \times \frac{\text{mL}}{3\text{ mM}} = \mathbf{5\text{ mL potassium phosphate}}$$

$$\text{calcium gluconate}$$
$$\frac{2.5\text{ mEq}}{1}\times\frac{10\text{ mL}}{4.65\text{ mEq}}=\mathbf{5.4\,mL\,calcium\,gluconate}$$

$$\text{MVI}$$
$$\mathbf{10\,mL\,MVI}$$

$$\text{trace elements}$$
$$\mathbf{1\,mL\,trace\,elements}$$

$$\text{regular insulin}$$
$$\frac{15\text{ units}}{1}\times\frac{\text{mL}}{100\text{ units}}=\mathbf{0.15\,mL\,regular\,insulin}$$

$$\text{sterile water}$$
$$\begin{array}{rl} 1000 & \text{mL} \\ -250 & \text{mL} \\ -400 & \text{mL} \\ -6 & \text{mL} \\ -5 & \text{mL} \\ -5.4 & \text{mL} \\ -10 & \text{mL} \\ -1 & \text{mL} \\ -0.15 & \text{mL} \\ \hline \mathbf{322.45} & \mathbf{mL\ sterile\ water} \end{array}$$

Calcium and phosphate solubility

Another thing to look at briefly is the solubility of phosphate and calcium in a parenteral nutrition admixture. These two ions have a strong affinity for each other and they may form a solid that precipitates out of solution. The following factors affect it including: order of mixing, pH, dextrose concentration, calcium salt form, storage temperature and time, amino acid profile, and drug additives. There is a formula that many institutions employ to estimate whether or not a solution is likely to form a precipitate.

calcium-phosphate solubility estimate

$$\frac{\left(\frac{2\text{ mEq}}{1\text{ mMol}}\times\text{phosphate mMol}\right)+\text{calcium mEq}}{\text{volume in liters}}\ <\ \mathbf{46\,mEq/liter}$$

As various factors in PN may affect the nature of the phosphates (monobasic vs dibasic) you automatically double the millimoles of phosphates when converting them to milliequivalents, treating them as all being in the dibasic form. While this formula does not claim to be perfect, it does provide a good estimate. Typically if the phosphate values and the calcium values total to less than 46 mEq per liter, you expect your PN to be stable for its intended purpose. It is also noteworthy that there are other variations on this formula along with visual charts. Familiarize yourself with the tools used wherever you practice. Let's go back and look at the PPN in the previous example and make sure that the calcium and phosphates should be stable.

Example

Using the numbers from the previous example problem, determine if the PPN should precipitate.

There were 15 mMol of potassium phosphate and 2.5 mEq of calcium gluconate in a total volume of 1 liter.

$$\frac{\left(\frac{2\text{ mEq}}{1\text{ mMol}} \times 15\text{ mMol of phosphate}\right) + 2.5\text{ mEq of calcium}}{1\text{ liter}} = \mathbf{32.5\,mEq/liter}$$

It should not precipitate, as 32.5 mEq/liter is less than 46 mEq/liter.

A lot of material has already been covered in this chapter. Attempt a practice problem to help ensure that all the concepts make sense so far.

Practice Problem

A patient is to receive a 2000 mL all-in-one TPN admixture infused through a central line infused over 24 hours. On the left are the requested quantities/concentration and on the right are the available source components. Answer the following questions (the answers are on the next page):

a) What is the infusion rate in mL/hr?
b) Determine the quantity of each ingredient required.
c) Using the information here determine whether or not the calcium and phosphate is likely to precipitate.

Requested PN	*Source Components*
4% amino acid	8.5% amino acid solution
19% dextrose	70% dextrose solution
250 mL of 20% lipid emulsion	250 mL of 20% lipid emulsion
sodium chloride 100 mEq	14.6% sodium chloride (2.5mEq/mL, 146 mg/mL)
potassium acetate 80 mEq	potassium acetate 2 mEq/mL
calcium gluconate 9.4 mEq	10% calcium gluconate (4.65 mEq/10 mL)
magnesium sulfate 16 mEq	50% magnesium sulfate (4.06 mEq/mL)
sodium phosphate 30 mMol	sodium phosphate 3 mMol/mL
MVI 10 mL	MVI 10 mL vial
trace elements 1 mL	trace elements 1 mL
famotidine 40 mg	famotidine 20 mg/2 mL
SWFI qs 2000 mL	Sterile Water for Injection

a) 83.3 mL/hr b) 941 mL of 8.5% amino acid; 543 mL of 70% dextrose; 250 mL of 20% lipid emulsion; 40 mL of 14.6% sodium chloride; 40 mL of potassium acetate 2 mEq/mL; 20.2 mL of 10% calcium gluconate; 3.9 mL of 50% magnesium sulfate; 10 mL of sodium phosphate 3 mMol/mL; 10 mL of MVI; 1 mL of trace elements; 4 mL of famotidine 20 mg/2 mL; 137 mL of SWFI c) Since the calculations come out to 34.7 mEq/L, it is not likely to precipitate.

Worksheet 26-1

Name:

Date:

Solve the following problems involving parenteral nutrition using the source components listed on this page. Be aware that even though most institutional facilities offer various concentrations of amino acid bases and lipid emulsions, the orders on this worksheet will specify which ones to use.

Source Components

Macronutrients

- 10% amino acid solution
- 8.5% amino acid solution
- 5.2% amino acid solution (renal formula)
- 70% dextrose
- 10% lipid emulsion
- 20% lipid emulsion
- sterile water for injection

Micronutrients

- potassium chloride 2 mEq/mL
- sodium chloride 14.6% (2.5 mEq/mL)
- calcium gluconate 10% (4.65 mEq/10 mL)
- magnesium sulfate 50% (4.06 mEq/mL)
- sodium acetate 2 mEq/mL
- sodium phosphate 3 mMol/mL (4 mEq/mL)
- potassium acetate 19.6% (2 mEq/mL)
- potassium phosphate 3 mMol/mL (4.4 mEq/mL)
- multivitamin injection (MVI) – standard 10 mL
- trace elements – standard 1 mL
- vitamin C 250 mg/2 mL
- folic acid 5 mg/mL
- insulin regular U-100 (100 units/mL)
- famotidine 20 mg/2 mL

1) Answer the questions pertaining to the hyperalimentation ordered below:

Additive	*Ordered Quantity*	*Volume*
Macronutrients		
Amino Acid 10%	1000 mL	
Dextrose 70%	1000 mL	
Sterile Water for Injection	qs 2500 mL	
Micronutrients		
sodium chloride	50 mEq	
potassium chloride	60 mEq	
magnesium sulfate	24 mEq	
potassium phosphate	30 mMol	
calcium gluconate	46.5 mEq	
MVI	10 mL	
trace elements	1 mL	
vitamin C	250 mg	
regular insulin	55 units	
folic acid	5 mg	
sodium acetate	80 mEq	
potassium acetate	28 mEq	
sodium phosphate	6 mMol	

a) What is the appropriate volume of each ingredient? List them on the chart above.

b) If this is to be infused over a 24 hour period, what is the infusion rate?

c) What are the final concentrations of amino acid and dextrose?

d) Based on the calcium-phosphate solubility estimate, is this HAL likely to precipitate?

2) Answer the questions pertaining to the parenteral nutrition ordered below:

Additive	*Ordered Quantity*	*Volume*
Macronutrients		
Amino Acid 5.2%	800 mL	
Dextrose 70%	700 mL	
Sterile Water for Injection	qs 2000 mL	
Micronutrients		
sodium chloride	24 mEq	
potassium chloride	40 mEq	
magnesium sulfate	40 mEq	
potassium phosphate	17.6 mEq	
calcium gluconate	1.4 g	
MVI	10 mL	
trace elements	1 mL	
vitamin C	500 mg	
regular insulin	95 units	
folic acid	7.5 mg	
sodium acetate	70 mEq	
potassium acetate	40 mEq	
sodium phosphate	40 mEq	

a) What is the appropriate volume of each ingredient? List them on the chart above.

b) If this is to be infused over a 24 hour period, what is the infusion rate?

c) What are the final concentrations of amino acid and dextrose?

d) Based on the calcium-phosphate solubility estimate, is this PN likely to precipitate? (*Hint: Be careful to convert both of your phosphates into mMol prior to plugging them into the formula.*)

3) Answer the questions pertaining to the parenteral nutrition admixture ordered below:

Additive	*Ordered Quantity*	*Volume*
Macronutrients		
Amino Acid 8.5%	1000 mL	
Dextrose 70%	1000 mL	
Sterile Water for Injection	qs 3000 mL	
Micronutrients		
sodium chloride	60 mEq	
potassium chloride	40 mEq	
magnesium sulfate	4 g	
potassium phosphate	30 mMol	
calcium gluconate	5 g	
MVI	10 mL	
trace elements	1 mL	
vitamin C	250 mg	
regular insulin	40 units	
folic acid	2 mg	
sodium acetate	60 mEq	
potassium acetate	28 mEq	
sodium phosphate	15 mMol	

a) What is the appropriate volume of each ingredient? List them on the chart above.

b) If this is to be infused over a 24 hour period, what is the infusion rate?

c) What are the final concentrations of amino acid and dextrose?

d) Based on the calcium-phosphate solubility estimate, is this parenteral nutrition admixture likely to precipitate?

Osmolarity of parenteral nutrition

Osmolarity is the measure of osmoles of solute per liter of solution (osmol/L). Osmoles are only looking at the moles of chemical compound that contribute to the osmotic pressure of a solution. When looking at the constituents of parenteral nutrition, dextrose and amino acids are the primary contributors to osmolarity. Lipids do not contribute to the solution's osmolarity, but electrolytes do. You can usually use the concentrations of dextrose and amino acid to estimate the osmolarity of PN. When looking at IV infusions, we traditionally measure the osmolarity in milliosmoles per liter (mOsmol/L).

Extracellular fluid generally has an osmolality of approximately 285-295 mOsmol/kg[1]. A challenge is that parenteral nutrition has a much higher concentration making it hypertonic and therefore potentially irritating to the veins it is being infused through, this despite its slow infusion rate. While institutions may have varying policies, a common practice is if a PN has an osmolarity less than a 1000 mOsmol/L it can be infused peripherally, versus an osmolarity of 1000 mOsmol/L or more is infused through a central line (an IV line that feeds into the superior vena cava). You can quickly estimate the osmolarity of PN by multiplying the grams of dextrose per liter by 5 and adding it to the grams of amino acid per liter multiplied by 10. Let's look at a quick example problem.

Example

If a TNA has a final concentration of 10% dextrose and 2.75% amino acid, what is the estimated osmolarity and could it be infused peripherally?

dextrose

$$\frac{10\ \text{g}}{100\ \text{mL}} = \frac{\text{N}}{1000\ \text{mL}}$$

$$\text{N} = 100\ \text{g}$$

$$\frac{100\ \text{g}}{\text{L}} \times \frac{5\ \text{mOsmol}}{\text{g}} = 500\ \text{mOsmol/L}$$

amino acid

$$\frac{2.75\ \text{g}}{100\ \text{mL}} = \frac{\text{N}}{1000\ \text{mL}}$$

$$\text{N} = 27.5\ \text{g}$$

$$\frac{27.5\ \text{g}}{\text{L}} \times \frac{10\ \text{mOsmol}}{\text{g}} = 275\ \text{mOsmol/L}$$

$$500\ \text{mOsmol/L} + 275\ \text{mOsmol/L} = \mathbf{775\ mOsmol/L}$$

This TNA could be infused peripherally.

Now attempt a practice problem.

Practice Problem

If a TPN has a final concentration of 15% dextrose and 4% amino acid, what is the estimated osmolarity and could it be infused peripherally?

The estimated osmolarity is 1150 mOsmol/L, therefore this TPN could not be infused peripherally.

1 Extracellular fluids are generally measured in osmolality (mOsmol/kg) as opposed to IV fluids measuring osmolarity (mOsmol/L). The two numbers are typically very close, as a liter of water weighs 1 kilogram. The mass of the dissolved solutes makes a slight difference.

Fluid requirements

The fluid requirements for parenteral nutrition are usually calculated as either 30 mL/kg of body weight, 1500 mL per m^2 of BSA, or 1 mL/kcal of nutrition required. These are just guidelines and may be adjusted for various reasons such as dehydration or fluid restriction. Let's look at these guidelines with an example.

Example

Use all three methods for determining PN fluid volume for a 6'1" patient weighing 168 pounds (BSA of 2 m^2) if they are receiving 2400 kilocalories per day.

$$\frac{168\,\text{lb}}{1} \times \frac{1\,\text{kg}}{2.2\,\text{lb}} \times \frac{30\,\text{mL}}{\text{kg}} = \mathbf{2291\,mL}$$

$$\frac{2\,\text{m}^2}{1} \times \frac{1500\,\text{mL}}{\text{m}^2} = \mathbf{3000\,mL}$$

$$\frac{2400\,\text{kcal}}{1} \times \frac{1\,\text{mL}}{\text{kcal}} = \mathbf{2400\,mL}$$

You will notice a a range of answers using the above guidelines. It is a good practice to learn which guidelines are used at the institution where you practice.

Practice Problem

Use all three methods for determining PN fluid volume for a 5'4" patient weighing 125 pounds (BSA of 1.6 m^2) if they are receiving 1800 kilocalories per day.

1705 mL when based on weight; 2400 mL when based on BSA; 1800 mL when based on caloric intake.

Caloric requirements

The kilocalorie (kcal, or Calorie, C, or Cal) is the basic unit used for quantifying the amount of energy that is in a potential sustenance. A patient's energy requirements may vary based on their body type/size, medical condition (called stress factors), and activity level. While there are other ways to determine a patient's Calorie needs, the Harris-Benedict equation is a very common methodology taking the patient's basal energy expenditure (BEE) multiplied by an activity factor and multiplied again by a stress factor. On the next page we will look at this equation.

Harris-Benedict equation

$$\text{BEE} \times \text{activity factors} \times \text{stress factors} = \text{Total Daily Energy Expenditure}$$

Basal Energy Expenditure is determined the following way:

for males

$$66.67 + (13.75 \times \text{weight in kg}^{*}) + (5 \times \text{height in cm}) - (6.76 \times \text{age in years}) = \text{BEE}$$

for females

$$655.1 + (9.56 \times \text{weight in kg}^{*}) + (1.86 \times \text{height in cm}) - (4.68 \times \text{age in years}) = \text{BEE}$$

*If a patient is obese, their ideal body weight (IBW) will be used instead.

Activity factors:
- Confined to bed: 1.2
- Ambulatory: 1.3

Stress factors:
- Surgery 1.2
- Infection 1.4-1.6
- Trauma: 1.3-1.5
- Burns: 1.5-2.1

This provides the total daily energy expenditures for a patient, but does not account for the make-up of amino acids, dextrose, and lipids. Traditionally, you determine how many calories the patient needs from amino acids and lipids, and whatever is left is provided by the dextrose.

Amino acid requirements

Use the following guidelines to estimate the patient's amino acid needs (use IBW if obese):
- 0.8 g/kg in an unstressed patient
- 0.8 to 1 g/kg for a mildly stressed patient
- 1.2 g/kg for a renal dialysis patient
- 1.1 to 1.5 g/kg for a moderately stressed patient
- 1.5 to 2 g/kg for a severely stressed patient
- 3 g/kg for a severely burned patient

Amino acid provides 4 kcal/g, therefore 50 g of amino acid would provide 200 kilocalories.

Lipid requirements

The proportion of calories provided by lipids are in the 30 to 40% range of the patient's total caloric intake. Many people will simply split the difference and base it on 35%. Each gram of lipids provides 9 kilocalories, therefore a patient that requires 900 kilocalories of lipids would only need 100 g of lipids.

Dextrose quantity

After the kcal from both the amino acids and the lipids have been subtracted from the total daily expenditure, the rest is provided by dextrose. Each gram of dextrose given parenterally provides 3.4 kilocalories. Therefore, if a patient receiving 2800 kcal per day had 200 calories of amino acids and

900 kcal of lipids, they would need 1700 kcal of dextrose or 500 g of dextrose.

Micronutrients

A patient will ordinarily receive a standard quantity of multivitamins and trace elements every day. There are also standard quantities of electrolytes in each liter of PN (35 mEq of sodium, 30 mEq of potassium, 5 mEq of magnesium, 3 mEq of calcium, 15 mM of phosphorous, and a 1:1 ratio of acetate to chloride). The quantity of various electrolytes may be adjusted based on disease state and lab values. Physician's may choose to add additional vitamins, electrolytes, elements, and drug additives to the bag.

Let's do a practice problem to emphasize all these ideas. This problem will be broken into many steps so you can review each concept.

Practice Problem

The 6'1", 165 lb author of this text is severely burned (use a stress factor of 2) in a fire at the age of 35 and the medical staff at the burn center where he is hospitalized has confined him to bed and is initiating parenteral nutrition on him using an all-in-one admixture that is to be infused over 24 hours.

a) Determine his BEE.

1788.42 kcal

b) Determine his total daily energy expenditure.

4292 kcal

c) How many grams of amino acid does he require and how many kcal does that translate into?

225 g; 900 kcal

d) If the facility decides 35% of his kcal should come from lipids, how many kcal does he require and how many grams of lipids does that translate into?

166.9 g; 1502 kcal

e) How many kcal should he receive from dextrose and how many grams does that translate into?

1890 kcal; 555.9 g

f) If they decide to base the fluid volume of his PN on 1 mL/kcal of nutrition, how many mL will this entire admixture need to be?

4292 mL

g) How many mEq or mMol of each electrolyte will the patient require if his electrolytes are ordered as follows: sodium chloride 35 mEq/L , potassium acetate 20 mEq/L , calcium gluconate 4.5 mEq/L , potassium phosphate 15 mMol/L , and magnesium sulfate 5 mEq/L?

sodium chloride 150.2 mEq; potassium acetate 85.8 mEq; calcium gluconate 19.3 mEq; potassium phosphate 64.4 mMol;
magnesium sulfate 21.5 mEq

h) Using the concentrations of the source components you've already calculated along with a vial of MVI and a vial of trace elements, fill in the ordered quantities and determine the appropriate volume of each ingredient to make this PN.

Source Components	*Fill in the Ordered Quantity*	*Volume Required*
Macronutrients		
Amino Acid 10%		
Dextrose 70%		
Lipid Emulsion 20%		
Sterile Water for Injection		
Micronutrients		
sodium chloride 23.4% (4 mEq/mL)		
potassium acetate 2 mEq/mL		
calcium gluconate 4.65 mEq/10 mL		
potassium phosphate 3 mMol/mL		
magnesium sulfate 50% (4.06 mEq/mL)		
MVI 10 mL/vial		
trace elements 1 mL/vial		

This is what the chart on the previous page should look like when completed.

Source Components	*Fill in the Ordered Quantity*	*Volume Required*
Macronutrients		
Amino Acid 10%	225 g	2250 mL
Dextrose 70%	555.9 g	794.1 mL
Lipid Emulsion 20%	166.9 g	834.5 mL
Sterile Water for Injection	q.s. 4292 mL	253.6 mL
Micronutrients		
sodium chloride 23.4% (4 mEq/mL)	150.2 mEq	37.6 mL
potassium acetate 2 mEq/mL	85.8 mEq	42.9 mL
calcium gluconate 4.65 mEq/10 mL	19.3 mEq	41.5 mL
potassium phosphate 3 mMol/mL	64.4 mMol	21.5 mL
magnesium sulfate 50% (4.06 mEq/mL)	21.5 mEq	5.3 mL
MVI 10 mL/vial	1 vial	10 mL
trace elements 1 mL/vial	1 vial	1 mL

i) What will the infusion rate be in mL/hr?

178.8 mL/hr

j) If the tubing being used has a drop factor of 20, what will the drip rate be?

60 gtt/min

k) Use the calcium-phosphate solubility formula to check whether or not this solution is likely to precipitate.

The formula works out to 34.5 mEq/L; therefore it is not likely to precipitate.

l) What are the final percentage strengths of both the dextrose and the amino acid of this admixture?

13% dextrose; 5.2% amino acid

m) Based on the estimated osmolarity of this bag, could it be infused peripherally?

The estimated osmolarity is 1170 mOsmol/L; therefore this bag must be infused centrally.

Worksheet 26-2

Name:

Date:

Review the patient case and determine the correct quantities for preparing parenteral nutrition for the patient. Your answers should be based on the Harris-Benedict Equation.

Pt Case: An obese patient with a GI obstruction due to complications from a gastric bypass has developed severe pneumonia, and her care team has decided she should be placed on parenteral nutrition using a 3-in-1 admixture as opposed to a starvation diet. The patient is a 5'6”, 290 lbs, 40 year old female and is to continue to be ambulatory. She does not have an allergy to eggs, as an allergy to eggs would impact her ability to receive the lipid emulsion.

1) Since this patient is obese, you will need to use her ideal body weight (IBW) for determining her BEE and her amino acid requirements. Use the Devine formula for determining her IBW (it is on page 531 if you need to look it up).

2) Using her IBW, calculate her basal energy expenditure.

3) Determine her total daily energy expenditure now that she is ambulatory after her recent surgery, but has has developed pneumonia. With these factors in mind, treat her as having a stress factor of 1.6.

4) How many grams of amino acid does she require, and how many kcal does that translate into remembering to use her IBW? She is considered a moderately stressed patient, so her amino acids should be calculated as 1.3 g/kg.

5) If the facility decides 30% of her kcal should come from lipids, how many kcal does she require and how many grams of lipids does that translate into?

6) How many kcal should she receive from dextrose and how many grams does that translate into?

7) What is her BSA? Remember to use her actual body weight. You may need to refer to the nomogram on page 523. (Your answer may vary depending on method used, but for consistency, with the answer key, use 2.34 m^2.)

8) If they decide to base the fluid volume of her PN on 1500 mL per m^2 of BSA, how many mL will this entire admixture need to be?

9) How many mEq or mMol of each electrolyte will the patient require if her electrolytes are ordered as follows (according to her lab values her sodium was a little high and her potassium was a little low): sodium chloride 25 mEq/L , potassium chloride 10 mEq/L, potassium acetate 20 mEq/L , calcium gluconate 4.5 mEq/L , potassium phosphate 15 mMol/L , and magnesium sulfate 5 mEq/L?

10) Using the concentrations of the source components you've already calculated, along with 5 mg of folic acid, a vial of MVI, a vial of trace elements, and 40 mg of famotidine, fill in the ordered quantities and determine the appropriate volume of each ingredient on the chart on the next page.

Source Components	*Fill in the Ordered Quantity*	*Volume Required*
Macronutrients		
Amino Acid 8.5%		
Dextrose 70%		
Lipid Emulsion 20%		
Sterile Water for Injection		
Micronutrients		
sodium chloride 23.4% (4 mEq/mL)		
potassium chloride 2 mEq/mL		
potassium acetate 2 mEq/mL		
calcium gluconate 4.65 mEq/10 mL		
potassium phosphate 3 mMol/mL		
magnesium sulfate 50% (4.06 mEq/mL)		
folic acid 5 mg/mL		
MVI 10 mL/vial		
trace elements 1 mL/vial		
famotidine 20 mg/2 mL		

11) What will the infusion rate be in mL/hr if the facility wants to infuse it over 24 hours?

12) If the tubing being used has a drop factor of 20, what will the drip rate be?

13) Use the calcium-phosphate solubility formula to check whether or not this solution is likely to precipitate.

14) What are the final percentage strengths of both the dextrose and the amino acid of this admixture?

15) Based on the estimated osmolarity of this bag, could it be infused peripherally?

Worksheet 26-3

Name:

Date:

Answer/solve the following questions/problems.

1) What are the various names and corresponding acronyms for parenteral nutrition?

2) Are lipids always mixed directly into a parenteral nutrition admixture?

3) List several reasons for placing a patient on parenteral nutrition.

4) What are the macronutrients used in parenteral nutrition and what are the corresponding designations of a traditional enteral diet?

5) Which two ions commonly used in parenteral nutrition raise a concern about precipitation?

6) Is PN hypertonic, isotonic, or hypotonic?

7) What is the common cut off for when PN can be infused peripherally or centrally?

8) Pt. Case: A patient's estimated nutritional requirements have been assessed at approximately 95-105 grams protien/day and 1800-2100 nonprotien kcal/day. The patient has no history of hyperlipidemia or allergy to eggs and is not fluid restricted. The PN solution will be compounded as an individualized regimen using a single bag, 24-hour infusion of amino acid/dextrose/intravenous lipid emulsion combination. All lab values for vitamins and electrolytes are within normal ranges.

a) Determine the appropriate volume for each ingredient.

Source Components	*Ordered Quantity*	*Volume Required*
Macronutrients		
Amino Acid 8.5%	4% final conc.	
Dextrose 70%	19% final conc.	
Lipid Emulsion 10%	250 mL	
Sterile Water for Injection	q.s. 2000 mL	
Micronutrients		
sodium chloride 14.6% (2.5 mEq/mL)	50 mEq/L	
potassium acetate 2 mEq/mL	40 mEq/L	
calcium gluconate 4.65 mEq/10 mL	4.7 mEq/L	
sodium phosphate 3 mMol/mL	15 mMol/L	
magnesium sulfate 50% (4.06 mEq/mL)	8 mEq/L	
MVI 10 mL/vial	1 vial	
trace elements 1 mL/vial	1 vial	
famotidine 20 mg/2 mL	40 mg	

b) What is the appropriate infusion rate in mL/hr?

c) Are the calcium and phosphate ions likely to precipitate?

d) Could this bag be infused peripherally?

9) Pt Case: Patient's first attempt at enteral feeding has failed as patient is unable to attain a sufficient quantity of nutrition through their GI tract. Physician has decided to place patient on a PPN during the night.

a) Determine the appropriate volume for each ingredient.

Source Components	*Ordered Quantity*	*Volume Required*
Macronutrients		
Amino Acid 8.5%	4% final conc.	
Dextrose 70%	5% final conc.	
Sterile Water for Injection	q.s. 1000 mL	
Micronutrients		
sodium chloride 14.6% (2.5 mEq/mL)	50 mEq/L	
potassium acetate 2 mEq/mL	40 mEq/L	
calcium gluc. 10% (4.65 mEq/10 mL)	1 g/L	
sodium phosphate 3 mMol/mL	15 mMol/L	
magnesium sulfate 50% (4.06 mEq/mL)	2 g/L	
MVI 10 mL/vial	1 vial	
trace elements 1 mL/vial	1 vial	

b) What is the appropriate infusion rate in mL/hr if the physician requests this admixture to be infused over 8 hours?

c) Are the calcium and phosphate ions likely to precipitate?

d) Could this bag be infused peripherally?

10) Pt Case: A 58 year old female who is 5' 3” tall and weighs 140 lbs has been determined to have the following nutritional requirements for her TPN (the Harris-Benedict equation was employed to derive these numbers).

a) Determine the appropriate volume for each ingredient.

Source Components	*Ordered Quantity*	*Volume Required*
Macronutrients		
Amino Acid 8.5%	50.91 g	
Dextrose 70%	186.65 g	
Lipid Emulsion 10%	41.03 g	
Sterile Water for Injection	q.s. ad 30 mL/kg	
Micronutrients		
sodium chloride 14.6% (2.5 mEq/mL)	35 mEq/L	
potassium acetate 2 mEq/mL	35 mEq/L	
calcium gluconate 4.65 mEq/10 mL	9.6 mEq/L	
potassium phosphate 3 mMol/mL	6.7 mMol/L	
magnesium sulfate 50% (4.06 mEq/mL)	8 mEq/L	
folic acid 5 mg/mL	1.7 mg	
MVI 10 mL/vial	1 vial	
trace elements 1 mL/vial	1 vial	
regular insulin U-100	40 units	

b) What is the appropriate infusion rate in mL/hr if the physician requests this admixture to be infused over 24 hours?

c) Are the calcium and phosphate ions likely to precipitate?

d) Could this bag be infused peripherally?