# **General nutrition information**

What are the things patients will need to receive in a TPN solution? These are the things that patient would normally receive as part of their normal daily diet (unless that diet consists primarily of potato chips and diet soda...). Let's take time to look at the building blocks of nutritional intake and how these are addressed with TPN.

**Water**. This needs to be listed first because it is *the* most necessary element for life. Water forms the solution base for all metabolic processes and makes up around 50-60% of our body weight. About 40% of our body water is inside our cells and 20% is extracellular – either in the blood (5% of body weight) or between the cells (called interstitial fluid). The water in the blood is vitally important for maintaining the pressure that allows oxygen and other nutrient delivery to all the tissues of the body. If someone's blood volume gets too low (this is called "volume depletion" in the medical field) then that person will not be able to deliver enough oxygen to his or her tissues and tissue death will result. I remember two particularly tragic cases of children who died from vascular collapse after only a couple of days of the stomach flu – fairly severe vomitting and diarrhea, depleting their intravascular volume. As pharmacists, we need to ensure that our patients are educated about the value of adequate daily free water intake (unless they have a medical need for water restriction) and we need to ensure that our patients don't get too much fluid, which can lead to increased blood pressure (and all its complications) and extravascular (outside the blood vessels) leakage of fluid into the lungs ("pulmonary edema"), which interferes with blood oxygenation.

**Carbohydrates**. These provide the main source of cellular energy. The standard source of carbohydrate in TPN is a simple sugar, dextrose, which is the dextrorotary form of glucose. In order for sugars to work effectively in the body, there needs to be adequate supply of and adequate response to insulin. Insulin is a cellular gatekeeper for carbohydrates: it facilitates glucose transfer across the membrane into the intracellular milieu. The actions of insulin allow the glucose that can be measured in the blood to remain within a surprisingly narrow concentration range, even after consumption of a fairly sugary substance. This is highly desirable because sustained high glucose concentrations can lead to deposition of glucose on tissue (this is called glycosylation) and eventual tissue damage. If the blood concentration of glucose gets too low, patients become confused and can even faint. This can be very scary if the person is engaged in a potentially dangerous activity that requires a lot of concentration, like driving a car. Pharmacists very carefully monitor the blood glucose concentrations of patients receiving TPN and make adjustments to the TPN dextrose concentration or insulin regimen in order to maintain the blood glucose in as narrow a range as possible.

Carbohydrates are metabolized by the liver. Similar to you and homework, the liver can only handle just so much carbohydrate at any given time. Pharmacists need to take this saturability into consideration when calculating the amount of dextrose that goes into the TPN. Excess carbohydrate administration can also lead to increased  $CO_2$  production, which will make a patient acidotic (i.e., lower physiologic pH – bad for proper cellular functioning). These are two good reasons to limit the amount of calories provided as carbohydrates.

**Proteins**. Proteins are the body's structural building blocks. TPN protein products are called amino acids, so named because every protein contains an *amine* ( $NH_2$ ) group and a carboxylic *acid* (COOH) group. In addition to the usual amount of protein that patients need for the activities of daily living, certain conditions can increase their protein requirements. Surgery involves tissue repair, usually a small amount, and so increases the need slightly (except major surgery, which is more similar to major trauma). Substances released when a patient has an infection can cause mild tissue breakdown over a larger area of the body compared to standard surgery, so patients with severe infections need a bit more protein than post-surgery patients. Patients with major trauma or burns will require more protein than those with infection or after surgery. Each of these conditions places a certain amount of stress on the body's metabolic system and so in your calculations of amino acid amount for a patient, you will need to factor in the level of metabolic stress placed on the patient.

**Fats**. We've all been told to stay away from these, but they actually do perform some important physiologic functions. They serve as a fuel source when the body isn't getting enough energy from carbohydrates, and they are the building blocks for many of the hormones involved in the inflammatory process. That said, many people eat more fat than they need in order to produce an adequate amount of inflammatory mediators. Pharmacists will try to keep the amount of energy given as fat calories to the minimum necessary to ensure adequate provision of calories.

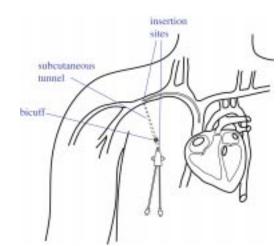
**Electrolytes**. The electrolytes necessary for optimal physiologic function in the body include sodium, potassium, phosphate, magnesium, and calcium. The phosphate is usually given as a potassium salt and the rest of the potassium and the sodium is usually given as the chloride salt. If the patient is acidotic, however, the acetate salt of these agents can be used. To ensure that the calcium and phosphate do not combine (forming chalk) and precipitate

out of solution, a standard "rule of thumb" is to add the calcium amount in mEq/L to the phosphate amount in mEq/L. Remember that 1 mMol of phosphate = 2 mEq. If the resulting number is greater than 45 mEq/L then there is an increased chance of these precipitating. Using the low to medium portions of the dosing guidelines will maximize your chance of avoiding precipitation. Higher dextrose concentrations will be a bit protective against precipitation since dextrose is somewhat acidic and will thus increase the solubility of the calcium and phosphate. If the physician wants the patient to receive extra calcium or phosphate beyond the recommended amounts, it would be best for those to be given via a separate infusion and *not into the same IV line* as the TPN. It is unknown whether or not it is safe to administer the phosphate or calcium salts into one lumen of a double or triple lumen catheter while TPN is infusing through another lumen and so it is best not to take any chances. People can (and have) died as a result of precipitated calcium phosphate infusion into the body. Remember when you are mixing not to add calcium gluconate right after the phosphate! Localized concentrations of each could precipitate within the bag.

**Vitamins and trace elements**. The use of these need no explanation. In general, pharmacies will use a pre-mixed vial of vitamins and the whole vial (10ml) to one bag of TPN daily. The trace elements usually given are zinc, copper, manganese, and chromium and the volume given will depend upon the product concentration. Most institutions also add 10mg of vitamin K to the TPN once a week. Finally, in an effort to minimize the development of stomach ulcers due to stress, many institutions will also place a standard IV dose of a histamine-2 ( $H_2$ ) receptor antagonist in the preparation.

Why might someone need TPN? The most common reason is that a person has undergone surgery of some sort in their bowel and the surgeons want that bowel to rest and heal, which would be difficult if there were food going through it. In this case, TPN will be temporary, and the cutoff for decision to provide TPN is usually if the patient is expected to be unable to eat for more than 7 days. Other reasons for temporary TPN include bowel obstruction (don't want to add to the problem!), temporary inability to swallow (e.g., trauma to the face or throat), and a host of other reasons too numerous to list. A few individuals may require long-term TPN. For example, if someone has had a large amount of their small intestine removed, they will not be able to absorb food adequately enough to avoid starvation unless they receive some or all calories from TPN.

**Osmolarity**. Most TPN solution osmolarity will be 600 or more mOsm/L – easily enough to irritate the cells lining the veins commonly used for IV access. How do they deal with this issue? By infusing TPNs into the largest vein in the body: the superior vena cava.



Let's do some calculations.

**Patient #1**: An 85yo female is admitted with an intestinal obstruction. She has been experiencing nausea and vomitting for 2 days along with severe abdominal pain. The standard treatment for this condition (called "ileus" if you care) is bowel rest. TPN is ordered and pharmacy is asked to dose it. She is 5'2" and weighs 160 pounds. Her labs are:

sodium	132 mEq/L	normal range 135 – 150 mEq/L
potassium	3.6 mEq/L	normal range 3.5 – 5.0 mEq/L
chloride	98 mEq/L	normal range 100 – 106 mEq/L
bicarbonate	27 mEq/L	normal range 24 – 30 mEq/L
BUN	12 mg/dL	normal range 8 – 20 mg/dL
creatinine	0.7 mg/dL	normal range 0.6 – 1.2 mg/dL
glucose	149 mg/dL	normal range 70 – 110 mg/dL, fasting
calcium	8.3 mEq/L	normal range 8.5 – 10 mEq/L
phosphate	1.6 mg/dL	normal range 2.6 – 4.5 mg/dL
magnesium	1.8 mEq/L	normal range 1.8 – 2.5 mEq/L
albumin	2.7 g/dL	normal range $3.5 - 5 \text{ g/dL}$

**Patient #2**: A 79yo female is admitted with acute pancreatitis. She is to be treated with bowel rest and intravenous pain medication until her symptoms resolve. She is 5'2" and weighs 88 pounds. Her labs are:

pain metication	i unun nei symptoi	and weights of pour
sodium	146 mEq/L	normal range 135 – 150 mEq/L
potassium	3.7 mEq/L	normal range 3.5 – 5.0 mEq/L
chloride	111 mEq/L	normal range 100 – 106 mEq/L
bicarbonate	32 mEq/L	normal range 24 – 30 mEq/L
BUN	8 mg/dL	normal range 8 – 20 mg/dL
creatinine	0.6 mg/dL	normal range 0.6 – 1.2 mg/dL
glucose	132 mg/dL	normal range 70 – 110 mg/dL, fasting
calcium	7.8 mEq/L	normal range 8.5 – 10 mEq/L
phosphate	2.0 mg/dL	normal range 2.6 – 4.5 mg/dL
magnesium	1.7 mEq/L	normal range 1.8 – 2.5 mEq/L
albumin	2.0 g/dL	normal range 3.5 – 5 g/dL

# Some calculations you may do when looking at a patient's labs

For any patient with a serum creatinine above the normal range, you will want to use the Cockroft-Gault equation to check creatinine clearance and make sure that their kidneys are not impaired (if they are, then fluid restriction may be needed and the electrolyte excretion may be impaired). You will also want to make sure that the are not retaining water or have other disease states that would cause them to retain water and so be in danger of pulmonary edema (if they are, then fluid restriction and possibly sodium restriction may be needed). Unfortunately, there is no rule-of-thumb calculation you can use to determine how much to restrict fluid by. That is a judgement call and something you will determine after discussion with the patient's health care team

Another thing you will want to do is look carefully at the patient's albumin. If the patient has not been eating well for a long period of time, the serum albumin concentration will be decreased. This will have a number of effects. First, less albumin means fewer particles in the bloodstream, meaning that the colloidal pressure which keeps the fluid inside the blood vessels will be lower than normal and the patient may be more likely to leak fluid out into scary places like the lung. Fluid restriction may be needed. Second, calcium is transported on albumin. Only a fraction of it is not attached to albumin, and this is the fraction available to the body for physiologic purposes. If the patient's albumin is decreased, there will be less albumin to bind to calcium and thus more circulating unbound calcium available for physiologic use. Some institutions measure unionized calcium (unionized so it can cross membranes and have pharmacologic effect!), which is in essence the unbound calcium, but many institutions do not. If you don't have an unionized calcium available, you can "correct" the serum calcium for a low albumin by the following method:

 $[(4.0 - \text{serum albumin concentration})(0.8)] + [\text{serum calcium concentration}] = Ca_{\text{corrected}}$ If this corrected number is within the normal range, then you will not need to add extra calcium to your TPN, just the standard amount.

It is traditional in many institutions to limit the number of calories that the patient receives on the first day of TPN so as not to "overwhelm"

TPN Worksheet	age:	sex:	
height:cm ABW:kg	IBW:	_kg feed weight:	kg
<b>Targets:</b> <b>1. Daily fluid needs.</b> >20 kg: 1500ml + (20 ml)(W - 20 kg), or 30 - 35 ml/kg/day	calculated target:	ml/day	
<b>2. Protein requirements.</b> normal, unstressed individual: 0.8g/kg/day hospitalized patient: 1-1.2g/kg/day stressed patient: 1.5-2g/kg/day	calculated target:	g protein/d	ay
3. Non-protein calories $BEE_{men} = 66.67 + 13.75(W) + 5.0(H) - 6.76(A)$ $BEE_{women} = 665.1 + 9.56(W) + 1.86(H) - 4.68(A)$ activity factors: confined to bed: 1.2, out of bed: stress factors: surgery: 1.2; infection: 1.4; trauma TDE = (BEE) (activity factor) (stress factor)	1.3	kcals/day	
Amounts:         4. Total TPN volume        ml/day; vol	ume for each TPN:	ml/bag; # bags/day	:
5. Protein Volume choose one:           27.5g in 500ml 5.5% AA         42.5g in 500	ml 8.5% AA	50g in 500ml 10% AA or	
10% AA calculated volume: ml			
6. Dextrose volume (3.4 kcals/g)choose one100g in D20W 500ml250g in D50	W 500ml	3.5 mg/kg/min = g 350g in D70W 500ml or	
D70W calculated volume: ml			
7. Fat volume (9 kcals/g)         choose one:           550kcals/500ml 10% lipid         900kcals/ 50	0ml of 20% lipid	or	
20% lipid calculated volume: ml	plus sterile w	ater volume: n	ป
amt/1000 calories (am	ll amount of kcals/day f ht)(# daily cals)/1000_	rom fat and dextrose: amount/bag	
$m_{a}$ $q_{1}$ $m_{Eq}$			
<b>9. Calculate the volume of each electrolyte solu</b> sodium chloride 23.4% (4mEq/ml) sodium acetate 16.4% (2mEq/ml) potassium phosphate: 3mMol phosphate/ml, 4.4 potassium chloride 2mEq/ml magnesium sulfate 4mEq/ml calcium gluconate 10% (0.465mEq/ml) <b>infusion rate:</b> ml/hr		l <u>volume to add</u> n n n n n n	1 1 1 1

**Patient #1**: An 85yo female is admitted with an intestinal obstruction. She has been experiencing nausea and vomitting for 2 days along with severe abdominal pain. The standard treatment for this condition (called "ileus" if you care) is bowel rest. TPN is ordered and pharmacy is asked to dose it. She is 5'2" and weighs 160 pounds. Her labs are:

sodium	132 mEq/L	normal range 135 – 150 mEq/L
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albumin	2.7 g/dL	normal range $3.5 - 5 \text{ g/dL}$

In this case I am going to assume that I work in a pharmacy where they get the protein and dextrose in fixed 500ml volumes (scenario #2 from the self-study text).

## **TPN Worksheet using scenario #2**

age: <u>85</u> sex: <u>F</u> height: <u>157</u> cm

ABW: <u>73</u> kg ABW means actual body weight

IBW: 50 kg ideal body weight as you hopefully know by now is [(2.3)(# inches over 5 ft)] + 45 kg for woman and 50 kg for a male

feed weight: <u>55</u> kg feed weight is the weight that you are going to use in your calculations. You can choose to use IBW or if a person is overweight, you could use a weight that is 10 or 20% above IBW, assuming that some of the patient's "overweight" is extra muscle and not all fat. Just for giggles, I will use a feed weight of 120% IBW. I will now use the weight of 55kg in all of my weight-based computations.

# **Targets:**

1. Daily fluid needs.

>20 kg: 1500ml + (20 ml)(W - 20 kg), or 30 - 35 ml/kg/day calculated target: <u>1700 - 2200</u> ml/day

Using the first method you would get 2200ml and using the second you should get 1650-1925ml/day. I combine these to get an acceptable range. If the patient is at risk for being easily overhydrated (e.g., has a weak heart or kidney disease) then I will go with the lower end. Otherwise, as long as her kidneys are in good shape, she should be able to pee out any excess fluid that she doesn't need so I will choose a number that makes my computations easy. In this case, the woman's kidneys are fine (you can check that yourself by determining her creatinine clearance!) and my calculations and mixing will be easiest if I choose that she gets 2 L/day.

# 2. Protein requirements.

normal, unstressed individual: 0.8g/kg/day hospitalized patient: 1-1.2g/kg/day stressed patient: 1.5-2g/kg/day calculated target: 55 - 66 g protein/day

She is hospitalized but probably isn't metabolically too stressed (no surgery, trauma, burns), so I will choose the range of 1-1.2g/kg/day. This means she will need around 55 - 66g of amino acid daily.

# 3. Non-protein calories

$$\begin{split} &\text{BEE}_{\text{men}} = 66.67 + 13.75(\text{W}) + 5.0(\text{H}) - 6.76(\text{A}) & \text{calculated target: } \underline{1302 - 1432} \text{ kcals/day} \\ &\text{BEE}_{\text{women}} = 665.1 + 9.56(\text{W}) + 1.86(\text{H}) - 4.68(\text{A}) \\ &\text{activity factors: confined to bed: } 1.2, \text{ out of bed: } 1.3 \\ &\text{stress factors: surgery: } 1.2; \text{ infection: } 1.4; \text{ trauma: } 1.5; \text{ burns: } 1.7 \\ &\text{TDE} = (\text{BEE}) \text{ (activity factor) (stress factor)} \end{split}$$

Running the numbers through for a woman, I get a BEE of 1085 kcals/day (note: I use the terms kcals and calories interchangeably here, as does everyone in the profession. Yes, I know that it is technically incorrect.) Multiply that by 1.2 since she is confined to bed, for a total of 1302 calories. Now for a stress factor, I will choose 1.0, since she doesn't really meet any of the listed criteria for metabolic stress. It would be equally OK if you wanted to hedge and say she has a metabolic stress factor of 1.1 and thus ended up with 1432 kcals/day.

## Amounts:

**4. Total TPN volume** <u>2000</u> ml/day; volume for each TPN: <u>1000</u> ml/bag; # bags/day: <u>2</u>

This is where the method your pharmacy uses to mix TPNs comes into play. If you use the 500ml preset volume solutions, then you will send up more than one bag every day, and each bag will contain 1000ml. If your pharmacy uses a pump with stock solutions, then you will send up one bag every day with more than 1000ml in that bag. For this example I will be assuming that we use the preset 500ml volume solutions of dextrose and amino acids, so you will only see me working with the first row of numbers for the protein and dextrose volumes, plus the fat will be infused separately and no sterile water will be added. If the patient needed fluid restriction, you would include the lipid volume in the total TPN volume. Since the patient's kidneys are fine, we will not include it in the total TPN volume, just to make things easier.

**5. Protein Volume** choose one: 27.5g in 500ml 5.5% AA

42.5g in 500ml 8.5% AA

50g in 500ml 10% AA

or

or

Looking at my protein target range above (55-66g/day) and knowing that the total amount of protein I will need will need to be divided over 2 liters, I choose the 5.5% strength because I know that it will give her 27.5g protein in each of her two bags for a total of 55g of protein daily. Had I chosen the 8.5% of 10% amino acid products, she would end up receiving 85g and 100g of protein, respectively, both of which are farther away from my target of 55-66kg when compared to the 5.5% amino acid strength.

10% AA calculated volume: \_\_\_\_\_ ml I disregard this row since it is used when mixing the big ingredients using the pump, and we are not.

**6. Dextrose volume** (3.4 kcals/g)

3.5 mg/kg/min = 277 g/day

Now I need to determine the maximum amount of sugar this patient's liver can handle in a day. I know that I cannot exceed 4 mg/kg/minute, so I choose a number that's a bit lower: 3.5 mg/kg/min. Multiply this by her feed weight to get 192.5 mg/minute, then by 60 minutes/hr to get 11,550 mg/hr, then by 24 hours to get 277,200 mg/day. This is equal to 277.2 g/day, which is a comfortable amount of sugar for her liver to deal with. You could choose a different target: anything up to 316.8 g/day, which is 4 mg/kg/minute. I always round to whole numbers and so my chosen target will be 277 g/day, rather than 277.2g/day.

## 100g in D20W 500ml

250g in D50W 500ml

350g in D70W 500ml

I know that we can give up to around 300 g/day of sugar without stressing her liver, so I know that my maximum amount of sugar in each bag is 150g (300g/day divided by 2 bags/day). Therefore I know that the 250g in the D50W and the 350g in the D70W are way too much sugar for this woman. I am forced to choose the D20W option.

She will thus receive 200g of dextrose/day. There are 3.4 kcals/g of dextrose, so the sugar will provide 680 kcals/day. But she needs more than that. My computations above showed a target number of 1300-1400 kcals/day. We will give the remainder of the calories as fat.

D70W calculated volume: \_\_\_\_\_ ml *I* disregard this row since it is used when mixing the big ingredients using the pump, and we are not.

**7. Fat volume** (9 kcals/g) choose one: 550kcals/500ml 10% lipid

900kcals/ 500ml of 20% lipid

or

She needs around 1300 kcals/day and is getting 680 kcals from the dextrose. 1300 – 680 kcals means that she needs around 620 kcals from fat. The closest product to this is the 10% lipid. We are forced to choose this product.

20% lipid calculated volume: \_\_\_\_\_ ml plus sterile water volume: \_\_\_\_\_ ml *I disregard this row since it is used when mixing the big ingredients using the pump, and we are not.* 

#### **Electrolytes:**

8. Daily electro	lyte needs to	total amount of kcals/day from fat and dexttrose: $550 + 680 = 1230$ kcals/day	
	amt/1000 calories	(amt)(# daily cals)/1000	<u>amount/bag</u>
sodium	40-50 mEq	<u>49 – 62 mEq/day</u>	<u>30 mEq/bag</u>
potassium	40mEq	<u>49 mEq/day</u>	<u>25 mEq/bag</u>
magnesium	8-12mEq	<u>10 – 15 mEq/day</u>	<u>6mEq/bag</u>
calcium	2-5 mEq	<u>2.5 - 6 mEq/day</u>	<u>2 mEq/bag</u>
phosphate	15-25mMol	<u>18 - 31 mMol/day</u>	<u>15 mMol/bag</u>

Remind yourself of the total number of kcals the patient is receiving daily. In the first fill-in column, take this amount, multiply it by the number from the column to the left, then divide it all by 1000. This gets rid of the "/1000 calories" part of the electrolyte guidelines and makes it easy to see the total amount of electrolyte you will need to give for each substance. Then just divide by the number of bags/day to get the amount of electrolyte to add to each bag. Rounding up or down a bit is fine. In this patient's case I used the higher end of the phosphate range since her phosphate serum concentration is low; otherwise, if I have a range, I just choose something in the middle that looks handy. Notice that your calcium and phosphate addition number is 32 [2 + (15)(2) = 32] in each liter and so you should not have precipitation.

9. Calculate the volume of each electrolyte solution that you will add	volume to add
sodium chloride 23.4% (4mEq/ml)	<u>7.5</u> ml
sodium acetate 16.4% (2mEq/ml)	<u>0</u> ml

I will only give sodium as the acetate salt if the patient is acidotic (high chloride, low bicarb lab values). I would never expect you to know how to do this at your point in school, so if I wanted you to do this on an exam, I would tell you bluntly that the patient was acidotic and therefore would need half or all of the sodium as the acetate salt.

potassium phosphate: 3mMol phosphate/ml, 4.4 mEq potassium/ml	<u>5.0</u> ml
potassium chloride 2mEq/ml	<u>1.5</u> ml

It is traditional to give phosphate as the potassium salt. Figure this out first. 15 mMol phos divided by 3mMol K phos/ml means you will place 5ml of potassium phosphate in the bag. This 5ml of K phos will contain 15 mMol of phosphate and 22 mEq of potassium (because each ml of K phos contains 4.4mEq of potassium). But you need more potassium than that. You will give the remaining potassium as the chloride salt. Subtract the potassium give as the phosphate salt from your total desired potassium/bag (25mEq - 22mEq) to get the amount you will add as KCl (3mEq = 1.5 ml KCl).

magnesium sulfate 4mEq/ml	<u>1.5</u> ml
calcium gluconate 10% (0.465mEq/ml)	<u>4.3</u> ml

infusion rate: 83 ml/hr

2000ml/24 hours means the infusion rate will be 83 ml/hr.

On the next page, I have noted what the TPN worksheet would look like for this patient.

TPN Worksheet, patient #1, using pre-set volumes	age: <u>85</u> sex: <u>F</u>
height: <u>157</u> cm ABW: <u>73</u> kg IBV	W: <u>50</u> kg feed weight: <u>55</u> kg
<b>Targets:</b> <b>1. Daily fluid needs.</b> >20 kg: 1500ml + (20 ml)(W - 20 kg), or cal- 30 - 35 ml/kg/day	culated target: <u>1700 - 2200</u> ml/day
<b>2. Protein requirements.</b> normal, unstressed individual: 0.8g/kg/day cal- hospitalized patient: 1-1.2g/kg/day stressed patient: 1.5-2g/kg/day	culated target: <u>55 – 66 g</u> protein/day
<b>3. Non-protein calories</b> $BEE_{men} = 66.67 + 13.75(W) + 5.0(H) - 6.76(A)  \text{cal-BEE}_{women} = 665.1 + 9.56(W) + 1.86(H) - 4.68(A)$ activity factors: confined to bed: 1.2, out of bed: 1.3 stress factors: surgery 1.2; infection 1.4; trauma 1.5; burns TDE = (BEE) (activity factor) (stress factor)	culated target: <u>1302 – 1432</u> kcals/day s 1.7 <i>I used a stress factor of 1.0 – 1.1 for this range</i>
Amounts:4. Total TPN volume2000 ml/day;volume for end	each TPN: <u>1000</u> ml/bag; # bags/day: <u>2</u>
5. Protein Volume/bag choose one:           27.5g in 500ml 5.5% AA         42.5g in 500ml 8.5%	AA 50g in 500ml 10% AA or
10% AA calculated volume: ml	
6. Dextrose volume/bag         (3.4 kcals/g)           100g in D20W 500ml         250g in D50W 500ml	3.5 mg/kg/min = $277.2$ g/day 350g in D70W 500ml or
D70W calculated volume: ml	
7. Fat volume (9 kcals/g) choose one:550kcals/500ml 10% lipid900kcals/ 500ml of 20	1300 kcals – 680 kcals = 620 needed from fat 0% lipid or
20% lipid calculated volume: ml plu	s sterile water volume: ml
	25 mEq/bag       q/day     6mEq/bag       /day     2 mEq/bag
<b>9. Calculate the volume of each electrolyte solution tha</b> sodium chloride 23.4% (4mEq/ml) sodium acetate 16.4% (2mEq/ml) potassium phosphate: 3mMol phosphate/ml, 4.4 mEq pot potassium chloride 2mEq/ml magnesium sulfate 4mEq/ml calcium gluconate 10% (0.465mEq/ml) <i>note: one bag daily will contain 10ml of a standard vitame and insulin</i> <b>infusion rate:</b> 83 ml/hr	$ \begin{array}{c}                                     $

Now let's look at the same patient using scenario #1

TPN Worksheet	age: <u>85</u>	sex: <u>F</u>	
height: <u>157</u> cm ABW: <u>73</u> kg	IBW: <u>50</u> kg	feed weight: <u>55</u> kg	
<b>Targets:</b> <b>1. Daily fluid needs.</b> >20 kg: 1500ml + (20 ml)(W - 20 kg) = 2200ml 30 - 35 ml/kg/day =1650 - 1925 ml	calculated target	: <u>1700 - 2200</u> ml/day	
<b>2. Protein requirements.</b> normal, unstressed individual: 0.8g/kg/day hospitalized patient: 1-1.2g/kg/day = 55-66g/day stressed patient: 1.5-2g/kg/day	calculated target:	: <u>55 – 66 g</u> protein/day	
<b>3. Non-protein calories</b> $BEE_{men} = 66.67 + 13.75(W) + 5.0(H) - 6.76(A)$ calculated target: $1302 - 1432$ kcals/day $BEE_{women} = 665.1 + 9.56(W) + 1.86(H) - 4.68(A) = 1085 \ kcals/day$ activity factors: confined to bed: 1.2, out of bed: $1.3 = 1302 \ kcals/day$ stress factors: surgery: 1.2; infection: 1.4; trauma: 1.5; burns: 1.7TDE = (BEE) (activity factor) (stress factor) (1085)(1.2)(1.0-1.1) = 1302-1432 \ kcals/day			
Amounts:4. Total TPN volume2000 ml/day;volume	e for each TPN: <u>20(</u>	00 ml/bag; # bags/day: <u>1</u>	
Notice that this is where the calculations begin to deviate from the previous method. Although I chose the same amount, everything will be placed in one large bag.			
5. Protein Volume choose one:27.5g in 500ml 5.5% AA42.5g in 500ml 8.5% AA50g in 500ml 10% AAorI disregard this row since it is used when mixing the set ingredient volume method, and we are not.or			
10% AA calculated volume: 600 ml			
Here I can comfortably choose a number within my r	ange of 55-66g/da	y. I will choose 60g since it is a whole	

Here I can comfortably choose a number within my range of 55-66g/day. I will choose 60g since it is a whole number and easy to deal with. Using dimensional analysis:

 $\frac{100ml}{10g} x \ 60g = 600ml \ of \ 10\% \ amino \ acids$ 

2000ml - 600ml = 1400ml remaining. I will give the rest of this as dextrose, fat, water, and electrolytes/vitamins/trace elements

6. Dextrose volume (3.4 kcals/g)

3.5 mg/kg/min = 277.2 g/day

Similar to the previous method, I now need to determine the maximum amount of sugar this patient's liver can handle in a day. I know that I cannot exceed 4 mg/kg/minute, so I choose a number that's a bit lower: 3.5 mg/kg/min. Multiply this by her feed weight to get 192.5 mg/minute, then by 60 minutes/hr to get 11,550 mg/hr, then by 24 hours to get 277,200 mg/day. This is equal to 277.2 g/day, which is a comfortable amount of sugar for her liver to deal with. You could choose a different target: anything up to 316.8 g/day, which is 4 mg/kg/minute.

100g in D20W 500ml250g in D50W 500ml350g in D70W 500mlI disregard this row since it is used when mixing the set ingredient volume method, and we are not.

D70W calculated volume: 400 ml

Using this method, it is much easier to give this woman the amount of carbohydrates I calculated that I would feel comfortable using, because I am not constrained by volume. Again, I use dimensional analysis to calculate the volume.

100ml x 277g = 395.7ml 
$$\approx$$
 400ml of 70% amino acids  
70g

1400ml - 400ml = 1000ml remaining. I will give the rest of this as fat, water, and electrolytes/vitamins/trace elements.

Now I need to figure out the remaining calories that need to be given as fat. To do this, I need to first know how many are being given as sugar. Using dimensional analysis:

 $\frac{277g \text{ CHO}}{day} \times \frac{3.4 \text{ kcals}}{g \text{ CHO}} = 941.8 \approx 942 \text{ kcals/day given as CHO}$ 

I need to choose a target amount of calories within the range of 1302-1432 kcals/day. I will arbitrarily choose1367 kcals/day since it's right in the middle.

1367 kcals/day – 942 kcals CHO = 425 kcals left to give as fat

7. Fat volume (9 kcals/g) choose one:550kcals/500ml 10% lipid900kcals/ 500ml of 20% lipidI disregard this row since it is used when mixing the set ingredient volume method, and we are not.

I use the computation above to determine the number of grams of lipid that will give her 425 kcals.  $425 \text{ kcals } x \text{ } \underline{1 \text{ g}} = 47.2 \text{ g lipid}$ 9 kcals

47 g lipid x  $\underline{100 \text{ ml}} = 235 \text{ ml} 20\%$  lipids to add to the TPN 20 g lipid

1000ml – 235ml = 765 ml remaining. I will give the rest of this as water and electrolytes/vitamins/trace elements.

20% lipid calculated volume: 235 ml plus sterile water volume: 665 ml

You have two choices here as to how you will deal with the electrolyte portion of the remaining volume. One choice would be to do your electrolyte volume calculations first, add up the volume of all electrolytes, subtract that volume from 765 ml, and then give the remaining volume as sterile water. The more common choice is to guestimate that total electrolyte and vitamins and trace elements will total approximately 100ml, and so just give 765 ml – 100 ml = 665 ml of sterile water. It is not wrong to do this, since you need to remember that you're working with volume ranges and that if you are off on volume by 10, 15, or even 20 ml, it will not adversely affect the patient. Since this is a common method of dealing with volumes from electrolytes, I will choose this method and give 665 ml sterile water.

### **Electrolytes:**

8. Daily electrol	electrolyte needs total amount of kcals/day from fat and dextrose: $942 + 425 = 1367$ kcal		
	amt/1000 calories	(amt)(# daily cals)/1000	<u>amount/bag</u>
sodium	40-50 mEq	<u>55 – 68 mEq/day</u>	<u>60 mEq/bag</u>
potassium	40mEq	<u>55 mEq/day</u>	<u>55 mEq/bag</u>
magnesium	8-12mEq	<u>11 – 16 mEq/day</u>	<u>12 mEq/bag</u>
calcium	2-5 mEq	<u>3 - 7 mEq/day</u>	<u>5 mEq/bag</u>
phosphate	15-25mMol	<u>20 - 34 mMol/day</u>	<u>30 mMol/bag</u>

This part is easier than the previous method, because you only have 1 bag/day. Notice how the amount of electrolytes you give is a bit higher, since the patient's caloric intake using this method will be slightly higher. Again, I go with a phosphate dose at the higher end of the dosing scale. The patient's calcium and phosphate product is 65 [(30)(2) + 5), but this case it is in 2 liters, so is 33 mEq/L: below the precipitation threshold of 45 mEq/L.

9. Calculate the volume of each electrolyte solution that you will add	volume to add
sodium chloride 23.4% (4mEq/ml)	<u>15.0</u> ml

sodium acetate 16.4% (2mEq/ml)	<u>0</u> ml
potassium phosphate: 3mMol phosphate/ml, 4.4 mEq potassium/ml	<u>10</u> ml
potassium chloride 2mEq/ml	<u>5.5</u> ml

It is traditional to give phosphate as the potassium salt (although it can be given as the sodium salt if the patient's serum potassium concentration is too high). Figure this out first. 30 mMol phos divided by 3mMol K phos/ml means you will place 10.0 ml of potassium phosphate in the bag. This 10.0 ml of K phos will contain 30 mMol of phosphate and 44 mEq of potassium (because each ml of K phos contains 4.4mEq of potassium). But you need more potassium than that. You will give the remaining potassium as the chloride salt. Subtract the potassium give as the phosphate salt from your total desired potassium/bag (55mEq - 44mEq = 11 mEq) to get the amount you will add as KCl (11 mEq = 5.5 ml KCl).

magnesium sulfate 4mEq/ml	<u>3.0</u> ml
calcium gluconate 10% (0.465mEq/ml)	<u>10.8</u> ml

Note: you will also add 10 ml of standard vitamins to each TPN and possibly trace elements, insulin, an  $H_2$ antagonist and/or vitamin K in some or all of the bags. Protocols vary between institutions.

infusion rate: 83 ml/hr

2000ml/24 hours means the infusion rate will be 83 ml/hr.

On the next page, I have noted what the TPN worksheet would look like for this patient, using this method.

TPN Workshee	t, patient	t #1, using pum	þ	age:	<u>85</u>	sex: <u>F</u>
height: <u>157</u>	_cm	ABW: <u>73</u>	kg	IBW:	<u>50</u> kg	feed weight: <u>55</u> kg
<b>Targets:</b> <b>1. Daily fluid n</b> >20 kg: 1500ml 30 - 35 ml/kg/da	+ (20 ml		2200ml	calcul	lated target	:: <u>1700 - 2200</u> ml/day
<b>2. Protein requi</b> normal, unstress hospitalized pati stressed patient:	ed individent: 1-1.	dual: $0.8g/kg/day$ 2g/kg/day = 55-		calcu	lated target	:: <u>55 – 66 g</u> protein/day
BEE <sub>women</sub> = 665. activity factors: stress factors: su	+ 13.75(N) 1 + 9.56(C) confined rgery: 1.2	W) + 1.86(H) - 4 to bed: 1.2, out o 2; infection: 1.4;	A.68(A) = 1 of bed: 1.3 trauma: 1	1085 kcd = 1302 5; burn	als/day kcals/day ns: 1.7	:: <u>1302 – 1432</u> kcals/day 02-1432 kcals/day
Amounts: 4. Total TPN vo	olume	<u>2000</u> ml/day;	volume	e for eac	ch TPN: <u>20</u>	<u>00</u> ml/bag; # bags/day: <u>1</u>
<b>5. Protein Volu</b> 27.5g in 500ml			in 500ml	8.5% A	A	50g in 500ml 10% AA or
10% AA calcula	ted volun	ne: <u>600</u> ml				
<b>6. Dextrose volu</b> 100g in D20W 5			in D50W 5	500ml	3.5 mg/	/kg/min = <u>277.2</u> g/day 350g in D70W 500ml
D70W calculated	d volume	: <u>400</u> ml				
<b>7. Fat volume</b> (9 550kcals/500ml			900kca	ıls/ 500r	nl of 20% 1	lipid or
20% lipid calcul	ated volu	me: <u>235</u> ml	plus	sterile	e water volu	ume: <u>665</u> ml
Electrolytes: 8. Daily electrol sodium potassium magnesium calcium phosphate 9. Calculate the sodium chloride sodium acetate potassium phosp potassium chlori magnesium sulfa calcium glucona	amt/100 40-50 r 40mEq 8-12mF 2-5 mE 15-25m volume 23.4% 16.4% (2 hate: 3m de 2mE ate 4mEq	00 calories nEq Eq A Mol of each electrol (4mEq/ml) 2mEq/ml) nMol phosphate/n q/ml	$\frac{(\text{amt})(\frac{4}{55} - 68)}{55 - 68}$ $\frac{55 - 68}{55 - 68}$ $\frac{11 - 16}{3 - 7 - 10}$ $\frac{3 - 7 - 10}{20 - 34}$ yte solution	# daily c 3 mEq/d q/day 5 mEq/d nEq/day 4 mMol 4 mMol n that y	als)/1000 ay ay /day /day /ou will ad	dextrose: $\frac{942 + 425 = 1367}{amount/bag}$ kcals/day $\frac{60 \text{ mEq/bag}}{55 \text{ mEq/bag}}$ $\frac{12 \text{ mEq/bag}}{30 \text{ mMol/bag}}$ d volume to add $\frac{15.0 \text{ ml}}{0 \text{ ml}}$ $\frac{10.0 \text{ ml}}{5.5 \text{ ml}}$ $\frac{3.0 \text{ ml}}{10.8 \text{ ml}}$
infusion rate:	83	ml/hr				

pain medication	until her symptom	s resolve. She is 5'2" and weighs 88 pour
sodium	146 mEq/L	normal range 135 – 150 mEq/L
potassium	3.7 mEq/L	normal range 3.5 – 5.0 mEq/L
chloride	111 mEq/L	normal range 100 – 106 mEq/L
bicarbonate	32 mEq/L	normal range 24 – 30 mEq/L
BUN	8 mg/dL	normal range 8 – 20 mg/dL
creatinine	0.6 mg/dL	normal range 0.6 – 1.2 mg/dL
glucose	132 mg/dL	normal range 70 – 110 mg/dL, fasting
calcium	7.8 mEq/L	normal range 8.5 – 10 mEq/L
phosphate	2.0 mg/dL	normal range 2.6 – 4.5 mg/dL
magnesium	1.7 mEq/L	normal range 1.8 – 2.5 mEq/L
albumin	2.0 g/dL	normal range 3.5 – 5 g/dL

**Patient #2**: A 79yo female is admitted with acute pancreatitis. She is to be treated with bowel rest and intravenous pain medication until her symptoms resolve. She is 5'2" and weighs 88 pounds. Her labs are:

In this case I am going to assume that I work in a pharmacy where they get the protein and dextrose in fixed 500ml volumes (scenario #2 from the self-study text).

**TPN Worksheet using scenario #2** 

age: <u>79</u> sex: <u>F</u> height: <u>157</u> cm

ABW: 40 kg ABW means actual body weight

IBW: 50 kg ideal body weight as you hopefully know by now is [(2.3)(# inches over 5 ft)] + 45 kg for woman and50 kg for a male

feed weight: <u>45</u> kg Since she is malnourished and below ideal body weight (called "cachectic" in medical terminology), we will want to feed her with enough to build tissue, not just maintain current tissue. Therefore I have chosen a feed weight that is halfway between her actual and her ideal body weight.

# **Targets:**

**1. Daily fluid needs.** >20 kg: 1500ml + (20 ml)(W - 20 kg), or 30 - 35 ml/kg/day

calculated target: 1350 - 2000 ml/day

Using the first method you would get 2000ml and using the second you should get 1350-1575ml/day. I combine these to get an acceptable range. If the patient is at risk for being easily overhydrated (e.g., has a weak heart or kidney disease) then I will go with the lower end. Otherwise, as long as her kidneys are in good shape, she should be able to pee out any excess fluid that she doesn't need so I will choose a number in the middle of the range: 1.6 L/day

# 2. Protein requirements.

normal, unstressed individual: 0.8g/kg/day hospitalized patient: 1-1.2g/kg/day stressed patient: 1.5-2g/kg/day calculated target: <u>54 - 68 g protein/day</u>

She is hospitalized and it is debatable whether or not she is stressed. Since this is the case, I will choose a range of 1.2 - 1.5 g/kg/day since this is between those two criteria. It's a conservative approach. This gives me an acceptable range of 54 - 68 g/day of protein.

# 3. Non-protein calories

$$\begin{split} &\text{BEE}_{\text{men}} = 66.67 + 13.75(\text{W}) + 5.0(\text{H}) - 6.76(\text{A}) & \text{calculated target: } \underline{1465 - 1710} \text{ kcals/day} \\ &\text{BEE}_{\text{women}} = 665.1 + 9.56(\text{W}) + 1.86(\text{H}) - 4.68(\text{A}) \\ &\text{activity factors: confined to bed: } 1.2, \text{ out of bed: } 1.3 \\ &\text{stress factors: surgery: } 1.2; \text{ infection: } 1.4; \text{ trauma: } 1.5; \text{ burns: } 1.7 \\ &\text{TDE} = (\text{BEE}) \text{ (activity factor) (stress factor)} & (1018)(1.2)(1.2-1.4) = 1465 - 1710 \text{ kcals/day} \end{split}$$

Running the numbers through for a woman, I get a BEE of 1018 kcals/day. Multiply that by 1.2 since she is confined to bed, for a total of 1221 calories. A stress factor is a bit tricky in acute pancreatitis. Sometimes it is caused by a mechanical or chemical factor and sometimes it is infectious in origin. It might be easiest, then, to choose a stress factor that falls in between surgery and infection, since there is tissue building that needs to occur. In my computations, I will choose something in the middle, so I will arbitrarily choose 1600 kcals/day as a goal for her energy intake.

### Amounts:

**4. Total TPN volume** <u>1600</u> ml/day; volume for each TPN: <u>1000</u> ml/bag; # bags/day: <u>1.6</u>

This is where the method your pharmacy uses to mix TPNs comes into play. If you use the 500ml preset volume solutions, then you will send up more than one bag every day, and each bag will contain 1000ml. If your pharmacy uses a pump with stock solutions, then you will send up one bag every day with more than 1000ml in that bag. For this example I will be assuming that we use the preset 500ml volume solutions of dextrose and amino acids, so you will only see me working with the first row of numbers for the protein and dextrose volumes, plus the fat will be infused separately and no sterile water will be added. If the patient needed fluid restriction, you would include the lipid volume in the total TPN volume. Since the patient's kidneys are fine, we will not include it in the total TPN volume, just to make things easier.

How does that extra 0.6 of a liter work in? Basically, the extra 400ml in the bag will infuse during the next day of TPN. You don't actually mix 1.6 liters of TPN per day.

5. Protein Volume choose one:

27.5g in 500ml 5.5% AA

42.5g in 500ml 8.5% AA

50g in 500ml 10% AA or

*Here I will need to take my target protein range* (54 - 68 g/day) *and figure out how much I am targeting per liter. Using dimensional analysis, it works out thus:* 

$$\frac{54-68 \ g}{day} \ x \ \frac{1 \ day}{1.6 \ L} = \frac{34-42.5 \ g}{L}$$

The closest amino acid product would be the 8.5% amino acids, since this will give us a protein intake within our target range.

10% AA calculated volume: \_\_\_\_\_ ml *I disregard this row since it is used when mixing the big ingredients using the pump, and we are not.* 

# 6. Dextrose volume (3.4 kcals/g)

3.5 mg/kg/min = 277 g/day

Now I need to determine the maximum amount of sugar this patient's liver can handle in a day. I know that I cannot exceed 4 mg/kg/minute, so I choose a number that's a bit lower: 3.5 mg/kg/min. Multiply this by her feed weight to get 158 mg/minute, then by 60 minutes/hr to get 9,480 mg/hr, then by 24 hours to get 227,520 mg/day. This is equal to 227 g/day, which is a comfortable amount of sugar for her liver to deal with. You could choose a different target: anything up to 259 g/day, which is 4 mg/kg/minute.

250g in D50W 500ml

350g in D70W 500ml or

At 227 g/day target to 259 g/day maximum, you would do the following to see how much you could place in each liter:

$$\frac{227 - 259 \text{ g CHO}}{day} x \frac{1 \text{ day}}{1.6 \text{ L}} = \frac{142 - 162 \text{ g CHO}}{L}$$

Unfortunately, none of the available products provide the amount within the given range, so we will have to choose the 20% dextrose, since her liver couldn't handle the 50% dextrose.

The 100 g CHO in each bag will provide a total of 160g CHO daily (100 g/L x 1.6 L/day). Now you need to see how many kcals she will get from the carbohydrate.

 $\frac{160 \text{ g CHO}}{day} \quad x \quad \frac{3.4 \text{ kcals}}{\text{g CHO}} = \frac{544 \text{ kcals}}{L}$ 

D70W calculated volume: \_\_\_\_\_ ml *I* disregard this row since it is used when mixing the big ingredients using the pump, and we are not.

# **7. Fat volume** (9 kcals/g) choose one: 550kcals/500ml 10% lipid

## 900kcals/ 500ml of 20% lipid or

The target daily calorie range was 1600 kcal/day. She will get 544 of these kcals from carbohydrate, so the remaining 1056 kcals will need to come from fat (lipids). In your choice of product above, you could give 2 bags of 10% lipid, for a total of 1100 kcals. You could also give one bottle of 20% for a total of 900 kcals. How do you choose between? The guidelines are that the total dose should not exceed 2.5 g/kg/day or 60% of total calories. Using the 2.5 g/kg/day guideline, both methods would provide around 2.2 g/kg/day. Using the 60% cutoff, we can see that the 20% lipid bottle would provide 62% of the total and that the two bottles of 10% would provide67%, so the 20% lipid is probably the lesser of the two risks. In a perfect world, we would prefer that her lipid contribution to total calories not exceed 30-40%/day. This is one of the problems with using the set amount preparation method.

20% lipid calculated volume: \_\_\_\_\_ ml plus sterile water volume: \_\_\_\_\_ ml *I disregard this row since it is used when mixing the big ingredients using the pump, and we are not.* 

# **Electrolytes:**

8. Daily electro	lyte needs tota	al amount of kcals/day from fat and o	dextrose: $544 + 900 = 1444$ kcals/day
	amt/1000 calories	(amt)(# daily cals)/1000	<u>amount/bag</u>
sodium	40-50 mEq	<u>58 – 72 mEq/day</u>	<u>40 mEq/bag</u>
potassium	40mEq	<u>58 mEq/day</u>	<u>36 mEq/bag</u>
magnesium	8-12mEq	<u>12 – 17 mEq/day</u>	<u>10 mEq/bag</u>
calcium	2-5 mEq	<u>3 - 7 mEq/day</u>	<u>3 mEq/bag</u>
phosphate	15-25mMol	<u>22 - 36 mMol/day</u>	<u>20 mMol/bag</u>

Remind yourself of the total number of kcals the patient is receiving daily. In the first fill-in column, take this amount, multiply it by the number from the column to the left, then divide it all by 1000. This gets rid of the "/1000 calories" part of the electrolyte guidelines and makes it easy to see the total amount of electrolyte you will need to give for each substance. Then just divide by the number of bags/day to get the amount of electrolyte to add to each bag. Rounding up or down a bit is fine. If I have a range, I just choose something in the middle that looks handy. I chose a phosphate on the high end of the range because you will notice that this patient's phosphate was low. I did not, however, go on the high end of the calcium because if you use the calcium correction factor noted earlier in this lesson, you will see that her calcium corrects to 9.4 - well within the normal range. Notice that your calcium and phosphate addition number is 43 [3 + (20)(2) = 43] in each liter and so shouldn't precipitate (do visually inspect your TPN after addition of these elements, however!).

9. Calculate the volume of each electrolyte solution that you will add	volume to add
sodium chloride 23.4% (4mEq/ml)	<u>7.5</u> ml
sodium acetate 16.4% (2mEq/ml)	<u>0</u> ml

I will only give sodium as the acetate salt if the patient is acidotic (high chloride, low bicarb lab values). I would never expect you to know how to do this at your point in school, so if I wanted you to do this on an exam, I would tell you bluntly that the patient was acidotic and therefore would need half or all of the sodium as the acetate salt.

potassium phosphate: 3mMol phosphate/ml, 4.4 mEq potassium/ml	<u>6.6</u> ml
potassium chloride 2mEq/ml	<u>3.5</u> ml

It is traditional to give phosphate as the potassium salt. Figure this out first. 20 mMol phos divided by 3mMol K phos/ml means you will place 6.6 ml of potassium phosphate in the bag. This 6.6 ml of K phos will contain 20 mMol of phosphate and 29 mEq of potassium (because each ml of K phos contains 4.4mEq of potassium). But you need more potassium than that. You will give the remaining potassium as the chloride salt. Subtract the potassium give as the phosphate salt from your total desired potassium/bag (36mEq - 29mEq = 7mEq) to get the amount you will add as KCl (7mEq = 3.5 ml KCl).

magnesium sulfate 4mEq/ml	<u>1.5</u> ml
calcium gluconate 10% (0.465mEq/ml)	<u>4.3</u> ml

**infusion rate:** 83 ml/hr 2000ml/24 hours means the infusion rate will be 83 ml/hr. On the next page, I have noted what the TPN worksheet would look like for this patient.

TPN Worksheet, patient #2, using pre-set	volumes age: <u>79</u>	sex: <u>F</u>
height: <u>157</u> cm ABW: <u>40</u>	kg IBW: <u>50</u> kg fe	ed weight: <u>45</u> kg
<b>Targets:</b> <b>1. Daily fluid needs.</b> >20 kg: 1500ml + (20 ml)(W - 20 kg), or 30 - 35 ml/kg/day	calculated target: <u>13</u>	<u>350 - 2000</u> ml/day
<b>2. Protein requirements.</b> normal, unstressed individual: 0.8g/kg/day hospitalized patient: 1-1.2g/kg/day stressed patient: 1.5-2g/kg/day	calculated target: <u>54</u>	<u>↓ – 68 g</u> protein/day
<b>3.</b> Non-protein calories $BEE_{men} = 66.67 + 13.75(W) + 5.0(H) - 6.76(A)$ $BEE_{women} = 665.1 + 9.56(W) + 1.86(H) - 4.68$ activity factors: confined to bed: 1.2, out of b stress factors: surgery 1.2; infection 1.4; traum TDE = (BEE) (activity factor) (stress factor)	5(A) bed: 1.3 ma 1.5; burns 1.7 <i>I used a stre</i>	
Amounts:4. Total TPN volume1600ml/day;	volume for each TPN: <u>1000</u> n	nl/bag; # bags/day: <u>1.6</u>
	$\frac{54-68g/day \div 1  day/1.6L}{500\text{ml} \ 8.5\% \text{ AA}} = 50$	<i>34 – 42.5 g/L</i> Og in 500ml 10% AA or
10% AA calculated volume:	_ml	
6. Dextrose volume/bag(3.4 kcals/g)100g in D20W 500ml250g in l		5 mg/kg/min = <u>277.2</u> g/day 50g in D70W 500ml or
D70W calculated volume:	_ml	
7. Fat volume (9 kcals/g) choose one:550kcals/500ml 10% lipid900kcals	<i>1300 kcals</i> 500ml of 20% lipid or	$-680 \ kcals = 620 \ needed \ from \ fat$
20% lipid calculated volume:	ml plus sterile wate	er volume: ml
Electrolytes:8. Daily electrolyte needstotal amountamt/1000 caloriessodium40-50 mEqpotassium40mEqmagnesium8-12mEqcalcium2-5 mEqphosphate15-25mMol	ount of kcals/day from fat and (amt)(# daily cals)/1000 49 – 62 mEq/day 49 mEq/day 10 – 15 mEq/day 2.5 - 6 mEq/day 18 - 31 mMol/day	dextrose: $550 + 680 = 1230$ kcals/day <u>amount/bag</u> <u>30 mEq/bag</u> <u>5 mEq/bag</u> <u>3 mEq/bag</u> <u>20 mMol/bag</u>
<b>9. Calculate the volume of each electrolyte</b> sodium chloride 23.4% (4mEq/ml) sodium acetate 16.4% (2mEq/ml) potassium phosphate: 3mMol phosphate/ml, potassium chloride 2mEq/ml magnesium sulfate 4mEq/ml calcium gluconate 10% (0.465mEq/ml) <i>note: one bag daily will contain 10ml of a stat and insulin</i> infusion rate: 83 ml/hr	4.4 mEq potassium/ml	volume to add 7.5 ml Q ml <u>6.6</u> ml <u>3.5</u> ml <u>1.5</u> ml <u>4.3</u> ml <i>ll also occasionally add trace elements</i>

Now let's look at the same patient using the pump method

TPN Worksheet	age: <u>79</u>	sex: <u>F</u>	
height: <u>157</u> cm ABW: <u>40</u> kg	IBW: <u>50</u> kg	feed weight: <u>45</u> kg	
<b>Targets:</b> <b>1. Daily fluid needs.</b> >20 kg: 1500ml + (20 ml)(W - 20 kg) = 2000ml 30 - 35 ml/kg/day =1350 - 1575 ml	calculated target	: <u>1350 - 2000</u> ml/day	
<b>2. Protein requirements.</b> normal, unstressed individual: 0.8g/kg/day hospitalized patient: 1-1.2g/kg/day <i>upper end</i> = 54 g stressed patient: 1.5-2g/kg/day <i>lower end</i> – 68 g/day	U	: <u>54 – 68 g</u> protein/day	
<b>3. Non-protein calories</b> $BEE_{men} = 66.67 + 13.75(W) + 5.0(H) - 6.76(A)$ calculated target: $1465 - 1710$ kcals/day $BEE_{women} = 665.1 + 9.56(W) + 1.86(H) - 4.68(A) = 1018 \ kcals/day$ activity factors: confined to bed: 1.2, out of bed: $1.3 = 1221 \ kcals/day$ stress factors: surgery: 1.2; infection: 1.4; trauma: 1.5; burns: 1.7       TDE = (BEE) (activity factor) (stress factor)			
Amounts: 4. Total TPN volume <u>1600</u> ml/day; volume	for each TPN: <u>16</u>	00 ml/bag; # bags/day: <u>1</u>	
Notice that this is where the calculations begin to devamount, everything will be placed in one large bag.	viate from the prev	ious method. Although I chose the same	

### 5. Protein Volume choose one:

27.5g in 500ml 5.5% AA 42.5g in 500ml 8.5% AA 50g in 500ml 10% AA or *I disregard this row since it is used when mixing the set ingredient volume method, and we are not.* 

10% AA calculated volume: 600 ml

Here I can comfortably choose a number within my range of 55-66g/day. I will choose 60g since it is a whole number and easy to deal with. Using dimensional analysis:

 $\frac{100ml}{10g} x \ 60g = 600ml \ of \ 10\% \ amino \ acids$ 

1600ml – 600ml = 1000ml remaining. I will give the rest of this as dextrose, fat, water, and electrolytes/vitamins/trace elements

# 6. Dextrose volume (3.4 kcals/g)

3.5 mg/kg/min = 227 g/day

Similar to the previous method, I now need to determine the maximum amount of sugar this patient's liver can handle in a day. I know that I cannot exceed 4 mg/kg/minute, so I choose a number that's a bit lower: 3.5 mg/kg/min. Multiply this by her feed weight to get 157.5 mg/minute, then by 60 minutes/hr to get 9,450 mg/hr, then by 24 hours to get 226,800 mg/day. This is equal to  $\approx$ 227 g/day, which is a comfortable amount of sugar for her liver to deal with. You could choose a different target: anything up to 260 g/day, which is 4 mg/kg/minute.

100g in D20W 500ml250g in D50W 500ml350g in D70W 500mlI disregard this row since it is used when mixing the set ingredient volume method, and we are not.

D70W calculated volume: 325 ml

Using this method, it is much easier to give this woman the amount of carbohydrates I calculated that I would feel comfortable using, because I am not constrained by volume. Again, I use dimensional analysis to calculate the volume.

100ml 
$$x$$
 227 $g$  = 324ml  $\approx$  325 ml of 70% amino acids 70 $g$ 

1000ml - 325ml = 675ml remaining. I will give the rest of this as fat, water, and electrolytes/vitamins/trace elements.

Now I need to figure out the remaining calories that need to be given as fat. To do this, I need to first know how many are being given as sugar. Using dimensional analysis:

 $\frac{227g \ CHO}{day} x \frac{3.4 \ kcals}{g \ CHO} = 772 \ kcals/day \ given \ as \ CHO$ 

I need to choose a target amount of calories within the range of 1465 – 1710 kcals/day. I will arbitrarily choose1600 kcals/day since it's right in the middle.

1600 kcals/day – 772 kcals CHO = 828 kcals left to give as fat

 7. Fat volume (9 kcals/g) choose one:

 550kcals/500ml 10% lipid
 900kcals/ 500ml of 20% lipid
 or

 *I disregard this row since it is used when mixing the set ingredient volume method, and we are not.*

I use the computation above to determine the number of grams of lipid that will give her 425 kcals.  $828 \text{ kcals } x \text{ } \underline{1 g} = 92 \text{ g lipid}$ 9 kcals

92 g lipid x 100 ml = 460 ml 20% lipids to add to the TPN 20 g lipid

675ml - 460ml = 215 ml remaining. I will give the rest of this as water and electrolytes/vitamins/trace elements.

20% lipid calculated volume: 460 ml plus sterile water volume: 115 ml

You have two choices here as to how you will deal with the electrolyte portion of the remaining volume. One choice would be to do your electrolyte volume calculations first, add up the volume of all electrolytes, subtract that volume from 215 ml, and then give the remaining volume as sterile water. The more common choice is to guestimate that total electrolyte and vitamins and trace elements will total approximately 100ml, and so just give 215 ml - 100 ml = 665 ml of sterile water. It is not wrong to do this, since you need to remember that you're working with volume ranges and that if you are off on volume by 10, 15, or even 20 ml, it will not adversely affect the patient. Since this is a common method of dealing with volumes from electrolytes, I will choose this method and give 665 ml sterile water.

## **Electrolytes:**

8. Daily electrol	yte needs total ar	nount of kcals/day from fat and dext	rose: $772 + 828 = 1600$ kcals/day
	amt/1000 calories	(amt)(# daily cals)/1000	<u>amount/bag</u>
sodium	40-50 mEq	<u>64 – 80 mEq/day</u>	<u>72 mEq/bag</u>
potassium	40mEq	<u>64 mEq/day</u>	<u>64 mEq/bag</u>
magnesium	8-12mEq	<u>13 – 19 mEq/day</u>	<u>16 mEq/bag</u>
calcium	2-5 mEq	<u>3 - 8 mEq/day</u>	<u>5 mEq/bag</u>
phosphate	15-25mMol	<u>24 - 40 mMol/day</u>	<u>30 mMol/bag</u>

This part is easier than the previous method, because you only have 1 bag/day. Notice how the amount of electrolytes you give is a bit higher, since the patient's caloric intake using this method will be slightly higher. The patient's calcium and phosphate product is 65 [(30)(2) + 5), but is in 1.6 L, which works out to 41 mEq/L so is below the precipitation threshold of 45.

9. Calculate the volume of each electrolyte solution that you will add	volume to add
sodium chloride 23.4% (4mEq/ml)	<u>18.0</u> ml
sodium acetate 16.4% (2mEq/ml)	<u>0</u> ml

potassium phosphate: 3mMol phosphate/ml, 4.4 mEq potassium/ml	<u>10.0</u> ml
potassium chloride 2mEq/ml	<u>10.0</u> ml

It is traditional to give phosphate as the potassium salt (although it can be given as the sodium salt if the patient's serum potassium concentration is too high). Figure this out first. 30 mMol phos divided by 3mMol K phos/ml means you will place 10.0 ml of potassium phosphate in the bag. This 10.0 ml of K phos will contain 30 mMol of phosphate and 44 mEq of potassium (because each ml of K phos contains 4.4mEq of potassium). But you need more potassium than that. You will give the remaining potassium as the chloride salt. Subtract the potassium give as the phosphate salt from your total desired potassium/bag (64mEq - 44mEq = 20 mEq) to get the amount you will add as KCl (20 mEq = 10 ml KCl).

magnesium sulfate 4mEq/ml	<u>4.0</u> ml
calcium gluconate 10% (0.465mEq/ml)	<u>10.8</u> ml

Note: you will also add 10 ml of standard vitamins to each TPN and possibly trace elements, insulin, an  $H_2$ antagonist and/or vitamin K in some or all of the bags. Protocols vary between institutions.

infusion rate: <u>83</u> ml/hr

2000ml/24 hours means the infusion rate will be 83 ml/hr.

On the next page, I have noted what the TPN worksheet would look like for this patient, using this method.

TPN Worksheet, patient #2, using pump	age: <u>79</u> sex: <u>F</u>		
height: <u>157</u> cm ABW: <u>40</u> kg	IBW: <u>50</u> kg feed weight: <u>45</u> kg		
<b>Targets:</b> <b>1. Daily fluid needs.</b> >20 kg: 1500ml + (20 ml)(W - 20 kg) = 2000ml 30 - 35 ml/kg/day =1350 - 1575 ml	calculated target: <u>1350 - 2000</u> ml/day		
<b>2. Protein requirements.</b> normal, unstressed individual: 0.8g/kg/day hospitalized patient: 1-1.2g/kg/day = 55-66g/day stressed patient: 1.5-2g/kg/day	calculated target: <u>54 – 68 g</u> protein/day		
<b>3. Non-protein calories</b> $BEE_{men} = 66.67 + 13.75(W) + 5.0(H) - 6.76(A) \qquad \text{calculated target: } \underline{1465 - 1710} \text{ kcals/day}$ $BEE_{women} = 665.1 + 9.56(W) + 1.86(H) - 4.68(A) = 1085 \text{ kcals/day}$ activity factors: confined to bed: 1.2, out of bed: 1.3 = 1302 kcals/day stress factors: surgery: 1.2; infection: 1.4; trauma: 1.5; burns: 1.7 $TDE = (BEE) \text{ (activity factor) (stress factor) } (1085)(1.2)(1.0-1.1) = 1302-1432 \text{ kcals/day}$			
Amounts:4. Total TPN volume1600 ml/day;volume	for each TPN: <u>1600</u> ml/bag; # bags/day: <u>1</u>		
<b>5. Protein Volume</b> choose one: 27.5g in 500ml 5.5% AA42.5g in 500ml	8.5% AA 50g in 500ml 10% AA or		
10% AA calculated volume: <u>600</u> ml			
6. Dextrose volume (3.4 kcals/g)           100g in D20W 500ml         250g in D50W 5	$\begin{array}{c} 3.5 \text{ mg/kg/min} = \underline{227} \text{ g/day} \\ 00\text{ml} & 350\text{g in D70W 500ml} \end{array}$		
D70W calculated volume: <u>325</u> ml			
7. Fat volume (9 kcals/g) choose one:550kcals/500ml 10% lipid900kcals/200ml 10% lipid	ls/ 500ml of 20% lipid or		
20% lipid calculated volume: <u>460</u> ml plus	sterile water volume: <u>115</u> ml		
amt/1000 calories $(amt)(#)$ sodium40-50 mEq $64 - 80$ potassium40mEq $64$ mEqmagnesium8-12mEq $13 - 19$ calcium2-5 mEq $3 - 8$ m	ccals/day from fat and dextrose: $772 + 828 = 1600$ kcals/dayc daily cals)/1000amount/bagmEq/day72 mEq/bagu/day64 mEq/bagmEq/day16 mEq/baguEq/day5 mEq/bag0 mMol/day30 mMol/bag		
<b>9. Calculate the volume of each electrolyte solution</b> sodium chloride 23.4% (4mEq/ml) sodium acetate 16.4% (2mEq/ml) potassium phosphate: 3mMol phosphate/ml, 4.4 mE potassium chloride 2mEq/ml magnesium sulfate 4mEq/ml calcium gluconate 10% (0.465mEq/ml) vitamins infusion rate: <u>83</u> ml/hr	<u>18.0</u> ml <u>0</u> ml		