

# What's Really in that TPN

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## Objectives

- Discuss macro and micronutrients and their role in parenteral nutrition
- Review the role of trace elements and discuss deficiencies
- Describe issues regarding safe use of parenteral nutrition

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## Adult Caloric Needs

- 25-35kcal/kg
- Harris-Benedict
- Indirect Calorimetry
  - RQ
  - BEE

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### Adult Protein Needs

- 0.8g/kg normal
- 1-1.5g/kg stressed
- 2-3g/kg burn/hypermetabolic
- 0.8g-1g/kg RF Non Dialysis
- 1-1.2g/kg RF Dialysis

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### Energy Needs Peds

- 0-1 years 90-120kcal/kg
- 1-7 years 75-90kcal/kg
- 7-12 years 60-75kcal/kg
- 12-18 years 30-60kcal/kg
- >18 years 25-35kcal/kg

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### Protein Requirements Peds

- Low birth/kg/d wt 3-4g/kg/d
- Full term 2-3g/kg/d
- 1-10 years 1-1.2g/kg/d
- Adolescence
  - Boys 0.9g/kg/d
  - Girls 0.8g/kg/d
- Critically Ill 1.5g/kg/d

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### Patient Selection Indications for Parenteral Nutrition

- Cannot eat adequately or should not eat to maintain adequate nutrition status.
- Malnourished or at risk of malnutrition from inadequate nutrient intake for  $\geq 7$  days or weight loss  $\geq 10\%$  preillness weight.
- Enteral feedings have failed or are contraindicated.
- Have severely diminished intestinal function due to underlying diseases (obstruction, short bowel syndrome, ileus, peritonitis).

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### Patient Selection Peripheral vs. Central

#### Peripheral

- Short-term ( $< 2$  weeks)
- Adequate peripheral venous access
- Central venous access not feasible
- Moderate nutrient needs
- No fluid restrictions

#### Central

- Required for  $\geq 2$  weeks
- Limited peripheral venous access
- Large nutrient needs
- Require fluid restrictions

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### Amino Acid Products


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### Caloric Density of Intravenous Nutrients

Nutrient/Product	kcal/g	kcal/mL
Amino Acids	4	
Amino Acids 5%		0.2
Amino Acids 10%		0.4
Dextrose	3.4	
Dextrose 10%		0.34
Dextrose 70%		2.38
Fat	10	
Fat emulsion 10%		1.1
Fat emulsion 20%		2
Fat emulsion 30%		3
Glycerol	4.3	
Medium Chain Triglycerides	8.3	

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### Guidelines for Daily Adult Electrolyte Requirements

Electrolyte	SDR
Sodium	1-2 mEq/kg
Potassium	1-2 mEq/kg
Calcium	10-15 mEq
Magnesium	8-20mEq
Phosphorus (phosphate)	20-40 mmol
Acetate/Chloride	as needed

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### Electrolytes

- Sodium
  - Chloride (1:1)
  - Acetate (1:1)
  - Lactate (avoid)
  - Bicarbonate (avoid)
- Potassium
  - Chloride (1:1)
  - Acetate (1:1)
- Phosphate
  - Potassium (3:4.4)
  - Sodium (3:4)
- Magnesium
  - sulfate
  - chloride
- Calcium
  - gluconate
  - chloride (avoid)
  - gluceptate (avoid)

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## Electrolytes Acetate vs. Chloride

- Depends on acid-base status
- Generally, approximate equal amounts of chloride and acetate (1:1 ratio)
- Metabolic acidosis - maximum acetate, minimum chloride
- Metabolic alkalosis - maximum chloride, minimum acetate

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## Vitamins

- AMA/NAG recommendations (1975)
  - some products with this profile available
  - this profile will be eliminated
- FDA revised doses (2000)
  - based on 1985 AMA/NAG recommendations
  - some products available with 13 vitamin profile
  - all manufacturers converting to this profile

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## Recommendations for Daily IV Vitamins

Vitamin      AMA/NAG      USP  
6 mg  
0.64 mg  
20 mg  
50 mcg

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## Vitamins

- Vitamin K
  - not in 12-vitamin products
  - included in the new 13-vitamin products
  - some in IV lipids-amount not standardized
    - 10% - 13-30 mcg/100 mL
    - 20% - 27-68 mcg/100 ml
  - if using 12-vitamin profile must supplement
    - 2-4 mg/week
    - 250-500 mcg/d IV

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## Recommended Daily Intake of Intravenous Trace Minerals

<u>Trace Element</u>	<u>Dose</u>
Chromium	10-15 mcg
Copper	0.3-0.5 mg
Manganese	60-100 mcg
Zinc	2.5-5.0 mg

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## Trace Minerals

- Combination products; single entities
- Other trace minerals
  - Selenium 20-60 mcg/d
  - Iron
  - Molybdenum
  - Iodine

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## Chromium

- 1-5 mcg/L
- Component of GTF
- Potentates action of insulin
- Tissue levels may be higher than plasma
- Hyperglycemia & peripheral neuropathy

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## Copper

- 75-150 mcg/dl
- First trace element deficiency associated with TPN 1972
- Erythropoiesis, leucopoiesis, bone mineralization, catecholamine metabolism
- Anemia, neutropenia, Menke's
- Biliary excretion

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## Manganese

- 2-3 mcg/L
- Homeostasis of proteins, CHO, lipids
- Biliary Excretion
- Deficiency
  - Weight loss
  - Dermatitis
  - Growth Retardation
- Manganese Madness

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## Selenium

- 100-130 mg/ml
- Component of glutathione peroxidase (antioxidant)
- Role in prostate cancer
- Keshan's Disease/Cardiomyopathy

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## Zinc

- 70-130 mcg/dl
- Component in ~230 enzymes
- Deficiency
  - Decreased appetite
  - Loss of smell
  - Decreased taste sensitivity
  - Impaired wound healing
- 90% excretion in stools

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## L-Glutamine

- Not included in commercially available AA products - ? need; instability in solution
- Mixed with other AA
- Not commercially available
- Provided by few home infusion companies
- Doses 0.18-0.57 g/kg/d; usually  $\leq$  40 g/d

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## L-Cysteine

- Essential for neonates
- Mixed with other AA; 40 mg/g AA
- Decreases pH and improves  $\text{CaPO}_4$  solubility

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## Standard Parenteral Formulations

### Peripheral

- Low nutrient density
- Dextrose  $\leq 10\%$ , 30-40% kcals
- AA 3-5%
- Lipid 60-70% kcals
- Osmolarity  $< 900$

### Central

- Increased nutrient density
- Dextrose 15-30%, 60-70% kcals
- AA 5-10%
- Lipids 30-40% kcals
- Osmolarity  $\geq 1800$

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## Parenteral Formulations Macronutrient Mixtures



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**Advantages of TNA vs.  
Dextrose/amino acids +lipids**

- Decreased pharmacy preparation time
- Decreased compounding supplies
- Potentially decreased rate of contamination
- Decreased growth of micro-organisms vs. lipid alone
- Improved lipid oxidation of lipids
- One infusion pump vs. two

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**Disadvantages of TNA vs.  
Dextrose/amino acids + lipid**

- Difficult to detect particulate matter
- Microbial growth greater than dextrose/amino acids
- Cannot filter with 0.22 micron filter
- Risk of lipid emulsion instability
- Macronutrients may be limited to one manufacturer

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**Stability of PN Formulations  
General Considerations**

- Temperature
- pH
- Exposure to light
- Time
- Composition
- Order components are admixed

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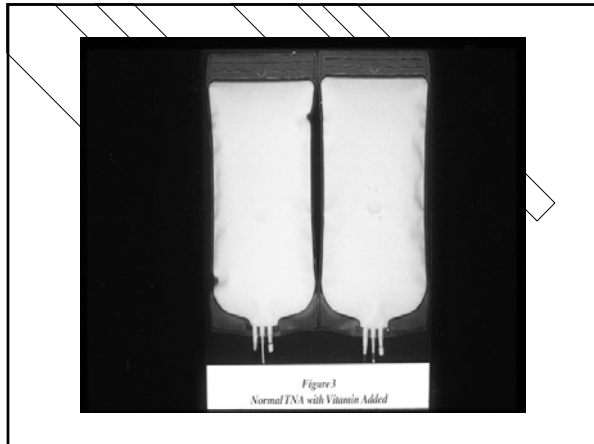
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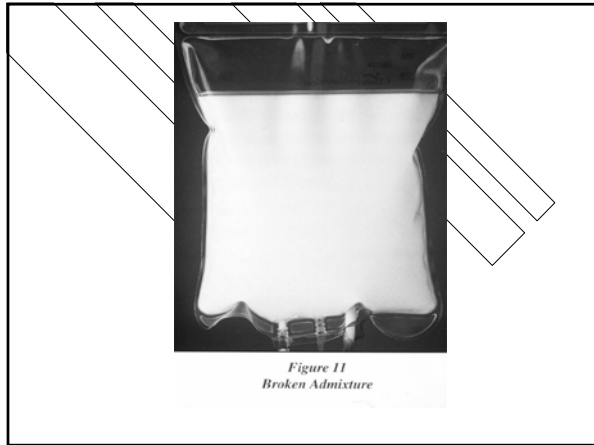
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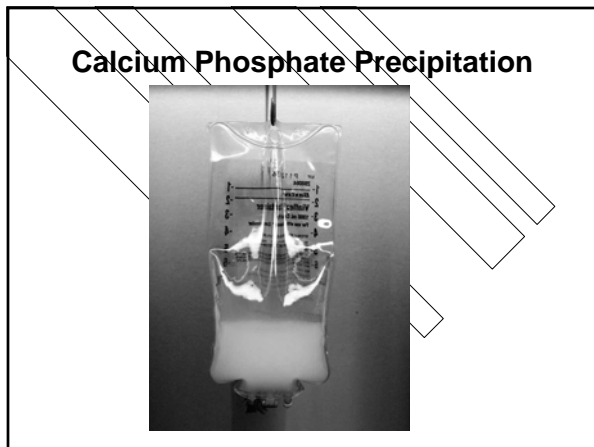
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## Factors Enhancing Calcium Phosphate Solubility

- Low molar calcium and phosphate salt concentrations
- Low pH (acidic) of formulation
- Higher amino acid concentration
- Cool environmental temperature
- Addition of phosphate before calcium
- Avoid prolonged standing time or slow infusions
- Use calcium gluconate (avoid chloride)

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## Calcium/Phosphate Equation

To calculate must determine Ca/Phos/Liter  
 510 cc 10% A.A., 214cc D70W, 153cc 20% Lipids  
 9mEq/bag Ca Gluconate & 10mM/bag Potassium Phosphate  
 Total Volume=877cc

Ca <u>9mEq</u>	$\frac{X}{1000cc}$	Phos <u>10mM</u>	$\frac{X}{1000cc}$
877cc		877cc	
X=10.26mEq		X=11.4mM x 2 =22.8mEq	

Total=10.26mEq + 22.8mEq = 33.06mEq  
 DO NOT EXCEED 40mEq

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## Order of Mixing/Manual Compounding

- Combine dextrose, amino acids and sterile water for injection
- Add phosphate
- Add sodium, potassium and magnesium (in any order)
- Add trace minerals
- Agitate the solution well

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## Order of Mixing/Manual Compounding

- Add calcium (or calcium containing multi-electrolyte solution) and agitate
- Observe for precipitates
- If TNA, add IVFE next, gently agitate and observe for signs of emulsion cracking
- Add vitamins last
- TNA-Dextrose and IVFE should NEVER be added directly to one another

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### Standard PN Label Template Adult Patient

Institution/Pharmacy Name, Address and Pharmacy Phone Number		
Name	Dosing Weight	Location
Administration Date/Time		Expiration Date/Time
Base Formula	Amount/day	(Amount/L)
Dextrose	g	(g/L)
Amino acids*	g	(g/L)
Lipid*	g	(g/L)
Electrolytes		
Sodium chloride	mEq	(mEq/L)
Sodium acetate	mEq	(mEq/L)
Potassium chloride	mEq	(mEq/L)
Potassium acetate	mEq	(mEq/L)
Potassium phosphate	mmol of P (mEq of K)	(mmol/L) (mEq/L)
Sodium phosphate	mmol of P (mEq of Na)	(mmol/L) (mEq/L)
Calcium gluconate	mEq	(mEq/L)
Magnesium sulfate	mEq	(mEq/L)
Vitamins, trace elements and medications		
Multiple vitamins*	mL	
Multiple trace elements*	mL	
Insulin	Units	(Units/L)
H <sub>2</sub> - antagonists*	mg	
Rate ____ mL/hr	Volume ____ mL	Infuse over 24 hours
Admixture contains ____ mL plus ____ mL overfill		
***Central Line Use Only***		

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## Co-Administration of Medications

- Avoid admixture as drug delivery vehicle, if possible
- Plethora of data with many variables and difficult to compare to specific clinical circumstance
- Lists of compatible and incompatible medications
- Lipid-based medications - consider caloric contribution

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## Drugs Incompatible with PN (2:1)

- Acyclovir
- Amphotericin B
- Cefazolin
- Ciprofloxacin
- Cyclosporin
- Furosemide
- Midazolam
- Metoclopramide
- Minocycline
- Phenytoin
- Promethazine
- Sodium Bicarbonate

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## Drugs Incompatible with TNA (3:1)

- Acyclovir
- Amphotericin B
- Cyclosporine
- Dopamine
- Doxycycline
- Erythromycin
- Haloperidol
- Hydromorphone
- Iron Dextran
- Lorazepam
- Midazolam
- Minocycline
- Morphine (15mg/ml)
- Phenytoin

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## Administration Safety Issues

- Filtration
  - 0.2 micron filter for dextrose/AA formulations
  - 1.2-5 micron filter for TNA formulations
  - 1.2 micron filter for all formulations
- IV administration set changes
  - 72 hours for dextrose/AA
  - 48 (?24) hours for TNA
  - 24 hours for lipids alone
- Administration "hang" times
  - 24 hours for dextrose/AA or TNA
  - 12 hours for IV lipids

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### Discontinuing the PN Infusion

- Institution and patient-specific need to “taper” vs. abrupt discontinuation vs. administer dextrose 5% or 10% in water
- “Rebound” hypoglycemia uncommon
- Patients at risk of hypoglycemia
  - patients requiring large doses of insulin
  - concern for patient on cyclic PN

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### Essential Fatty Acid Deficiency

- PN regimens without IV lipids for weeks to months
- Clinical Signs
  - Observed in 1-3 weeks
  - Dermatitis, hair loss
  - Thrombocytopenia
- Biochemical evidence
  - occurs in 1 week
  - Triene:tetraene ratio  $\geq 0.4$
- Prevent by giving 2-5% calories as IV lipid

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### Aluminum Toxicity

- More problematic in infants and small children; renal insufficiency
- Aluminum contamination of parenteral products
- Signs and symptoms
  - microcytic anemia
  - bone disease
  - dementia
  - impaired neurologic development

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## Aluminum Toxicity

- Monitor aluminum concentrations (?)
- Minimize aluminum intake in patients at risk
- Consider all parenteral products, not just TPN
  - calcium
  - phosphate

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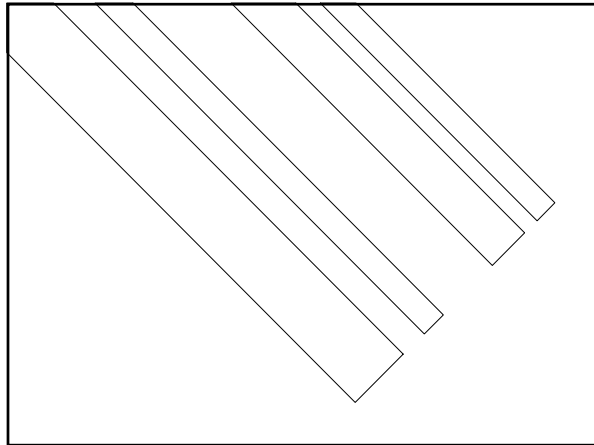
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