

TOTAL PARENTERAL NUTRITION

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Definition of nutrition

- **Nutrition** (also called **nourishment** or **aliment**) is the provision, to cells and organisms, of the materials necessary (in the form of food) to support life.

Types of nutrition

Enteral Nutrition (Definition)

- Nutritional support via placement through the nose, esophagus, stomach, or intestines (duodenum or jejunum)
 - Tube feedings
 - Must have functioning GI tract
 - **IF THE GUT WORKS, USE IT!**
 - Exhaust all oral diet methods first.

Parenteral Nutrition (Definition)

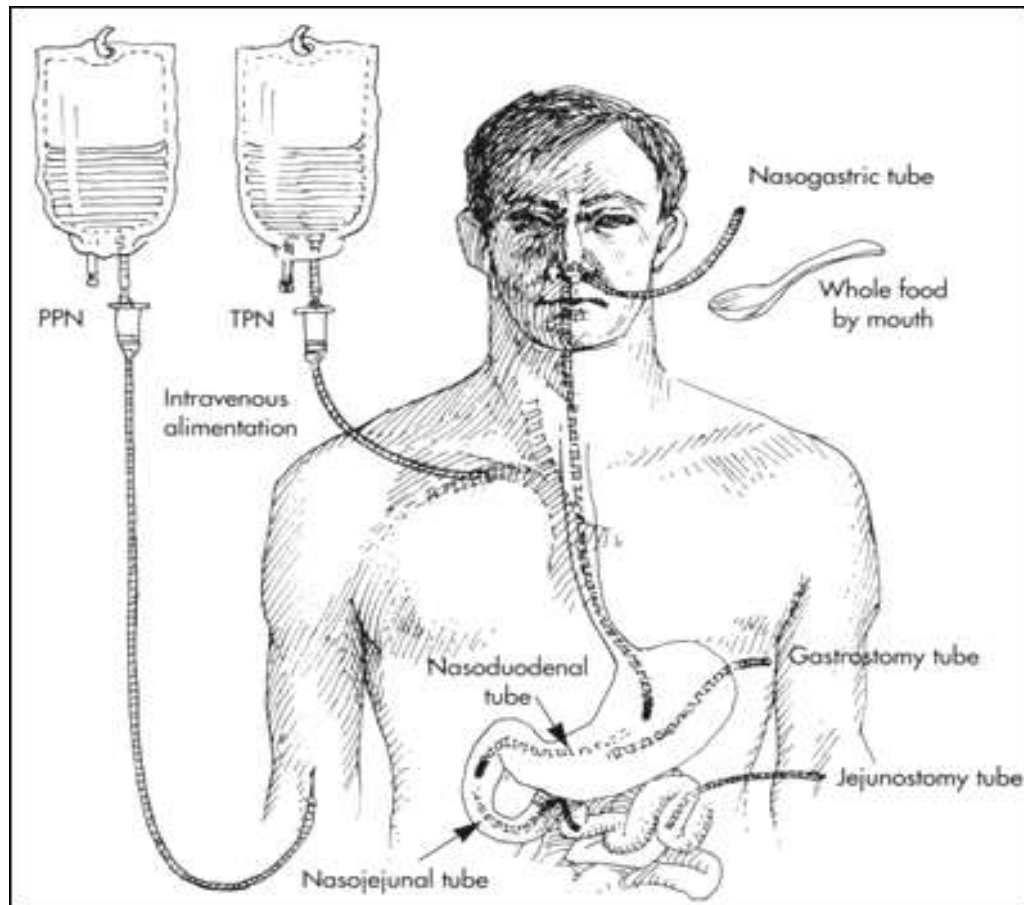
- Components are in elemental or “pre-digested” form
 - Protein as amino acids
 - CHO as dextrose
 - Fat as lipid emulsion
 - Electrolytes, vitamins and minerals

Indications

Conditions that often require nutrition support

RECOMMENDED ROUTE OF FEEDING	CONDITION	TYPICAL DISORDERS
Enteral nutrition	<p>Impaired nutrient ingestion</p> <p>Inability to consume adequate nutrition orally</p>	<p>Neurologic disorders</p> <p>HIV/AIDS</p> <p>Facial trauma</p> <p>Oral or esophageal trauma</p> <p>Congenital anomalies</p> <p>Respiratory failure</p> <p>Cystic fibrosis</p> <p>Traumatic brain injury</p> <p>Hyperemesis of pregnancy</p> <p>Hypermetabolic states such as with burns</p> <p>Comatose states</p> <p>Anorexia in congestive heart failure, cancer, COPD, ED</p> <p>Congenital heart disease</p> <p>Impaired intake after orofacial surgery or injury</p> <p>Spinal cord injury</p>

RECOMMENDED ROUTE OF FEEDING	CONDITION	TYPICAL DISORDERS
Parenteral nutrition	Gastrointestinal incompetency	<ul style="list-style-type: none"> Short bowel syndrome—major resection Severe acute pancreatitis Severe inflammatory bowel disease Small bowel ischemia Intestinal atresia Severe liver failure
	Critical illness with poor enteral tolerance or accessibility	<ul style="list-style-type: none"> Major gastrointestinal surgery Multiorgan system failure Major trauma or burns Bone marrow transplantation Acute respiratory failure with ventilator dependency and gastrointestinal malfunction Severe wasting in renal failure with dialysis Small bowel transplantation, immediate postoperatively



Parenteral Nutrition (Types)

- Delivery of nutrients intravenously, e.g. via the bloodstream.
 - **Central Parenteral Nutrition:** often called Total Parenteral Nutrition (TPN); delivered into a central vein
 - **Peripheral Parenteral Nutrition (PPN):** delivered into a smaller or peripheral vein

Evidence for PN (ASPEN)

- When Specialized Nutrition Support (SNS) is indicated, EN should generally be used in preference to PN. (B)
- When SNS is indicated, PN should be used when the gastrointestinal tract is not functional or cannot be accessed and in patients who cannot be adequately nourished by oral diets or EN. (B)
- The anticipated duration of PN should be ≥ 7 days

ASPEN Board of Directors. JPEN 26;19SA, 2002.; ASPEN Nutrition Support Practice Manual, 2005, p. 108

Common Indications for PN

- Patient has failed EN with appropriate tube placement
- Severe acute pancreatitis
- Severe short bowel syndrome
- Mesenteric ischemia
- Paralytic ileus
- Small bowel obstruction
- GI fistula unless enteral access can be placed distal to the fistula or where volume of output warrants trial of EN

Adapted from Mirtallo in ASPEN, The Science and Practice of Nutrition Support: A Case-Based Core Curriculum. 2001.

Contraindications

- Functional and accessible GI tract
- Patient is taking oral diet
- Prognosis does not warrant aggressive nutrition support (terminally ill)
- Risk exceeds benefit
- Patient expected to meet needs within 14 days

Enteral nutrition

Considerations in Enteral Nutrition

- 1. Applicable**
- 2. Site placement**
- 3. Formula selection**
- 4. Nutritional/medical requirements**
- 5. Rate and method of delivery**
- 6. Tolerance**

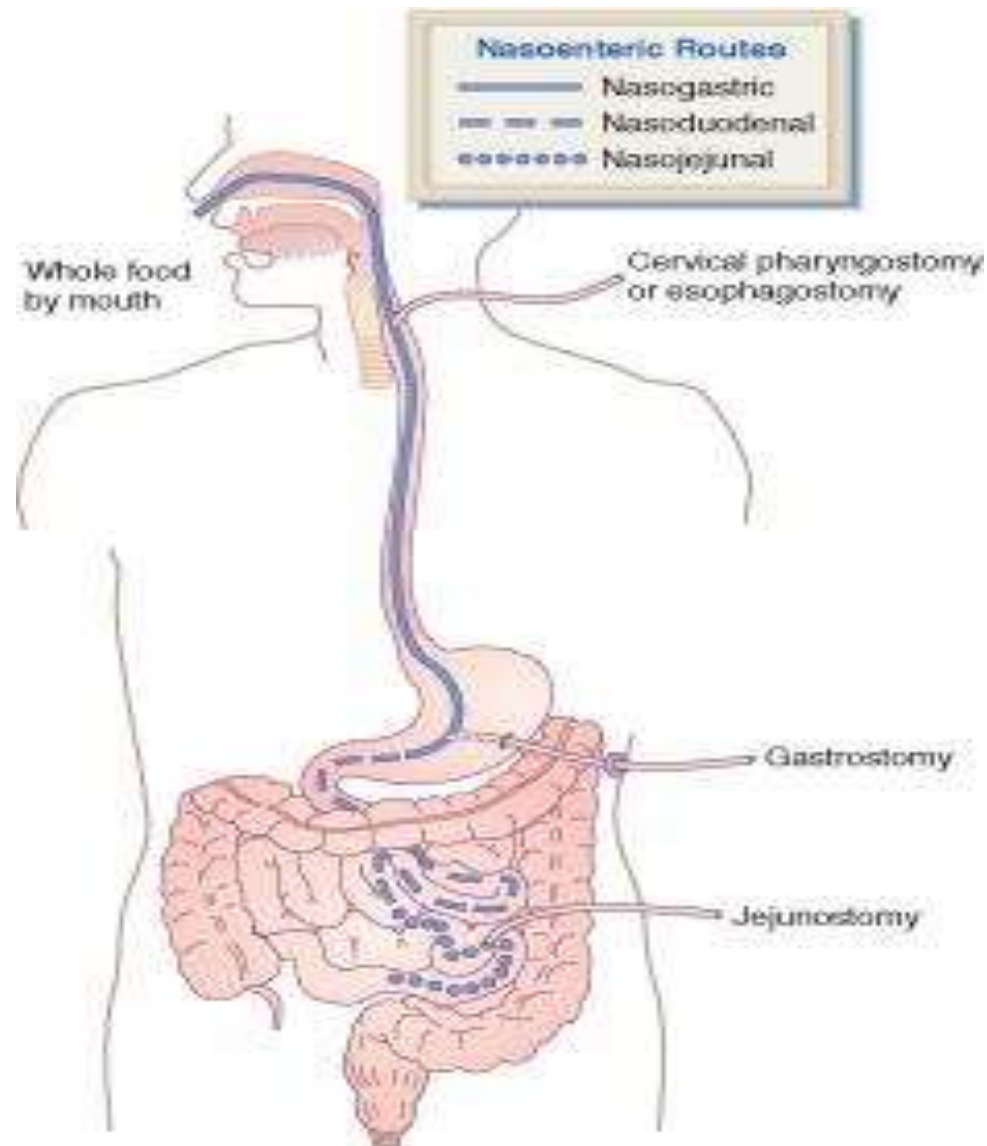
Enteral Access: Clinical Considerations

- **Duration of tube feeding**
 - Nasogastric or nasoenteric tube for short term
 - Gastrostomy and jejunostomy tubes for long term
- **Placement of tube**
 - Gastric
 - Small bowel

Placement Site

- Access (medical status)
- Location (radiographic confirmation)
- Duration
- Tube measurements and durability
- Adequacy of GI functioning

Enteral Tube Placement



Formula Selection

The suitability of a feeding formula should be evaluated based on

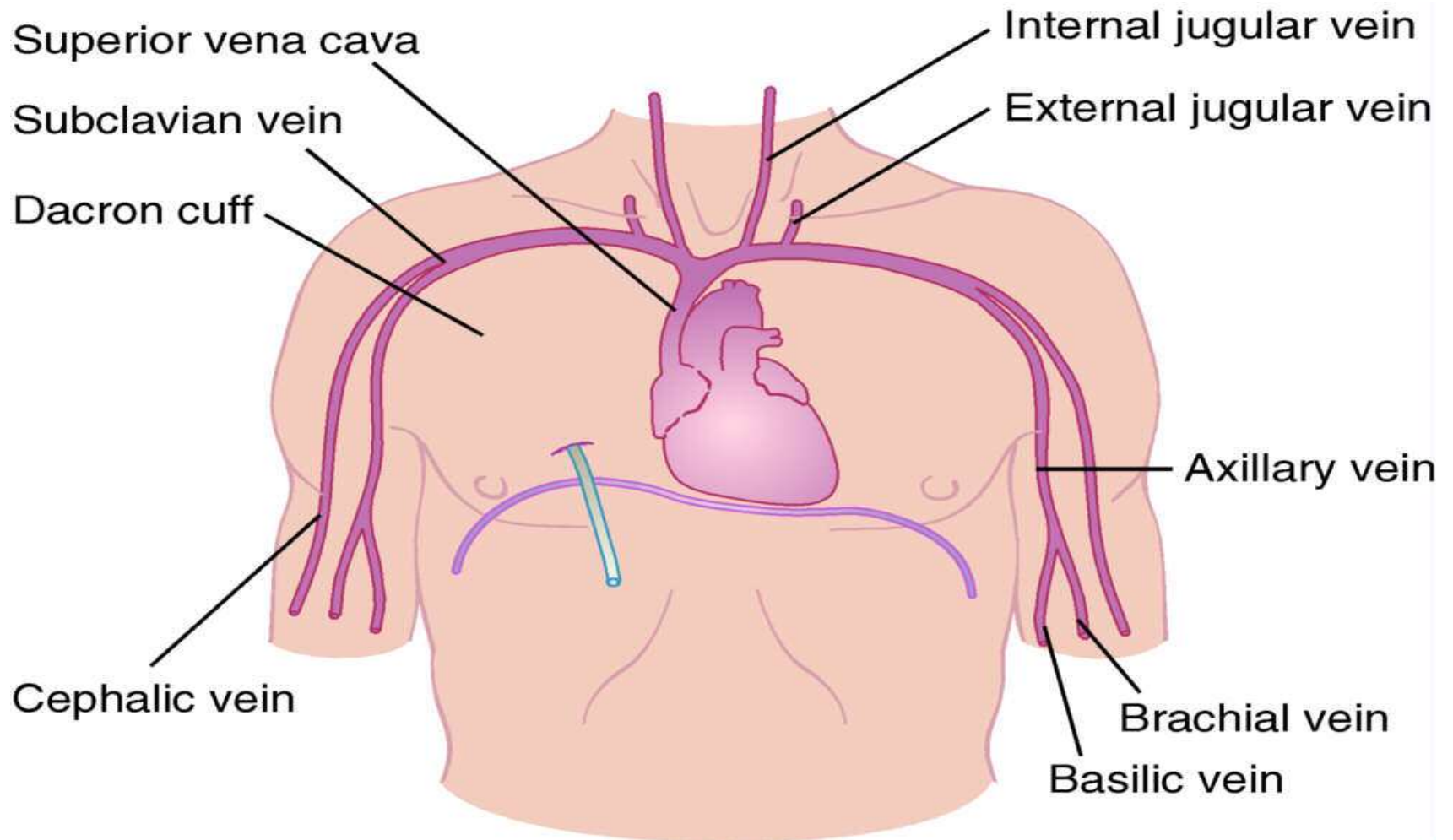
- Functional status of GI tract
- Physical characteristics of formula (osmolality, fiber content, caloric density, viscosity)
- Macronutrient ratios
- Digestion and absorption capability of patient
- Specific metabolic needs
- Contribution of the feeding to fluid and electrolyte needs or restriction
- Cost effectiveness

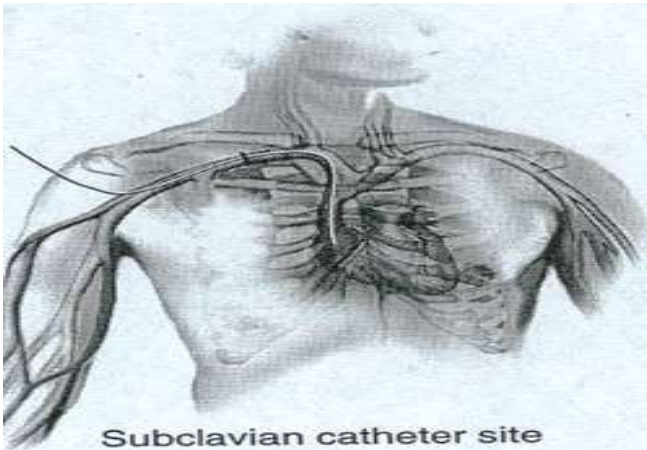
Parenteral nutrition

PN Central Access

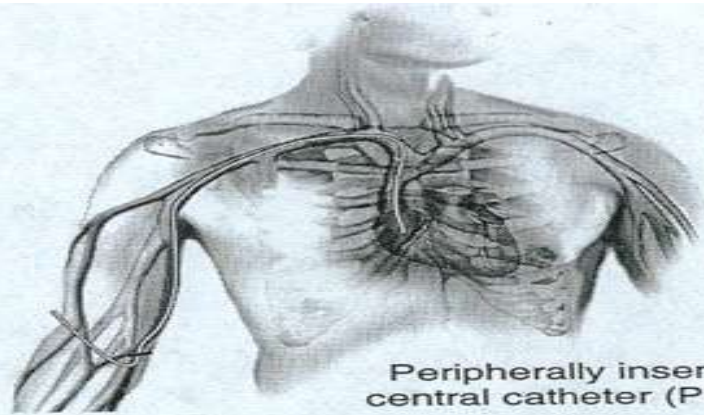
- May be delivered via femoral lines, internal jugular lines, and subclavian vein catheters in the hospital setting
- Peripherally inserted central catheters (PICC) are inserted via the cephalic and basilic veins
- Central access required for infusions that are toxic to small veins due to medication, pH, osmolarity, and volume

Venous Sites for Access to the Superior Vena Cava





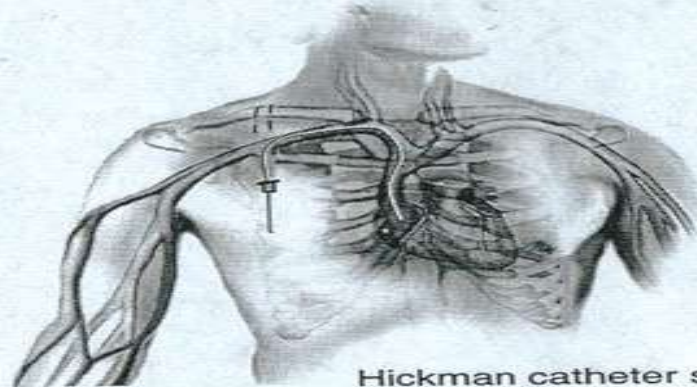
Subclavian catheter site



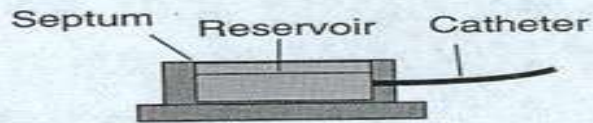
Peripherally inserted
central catheter (PICC)



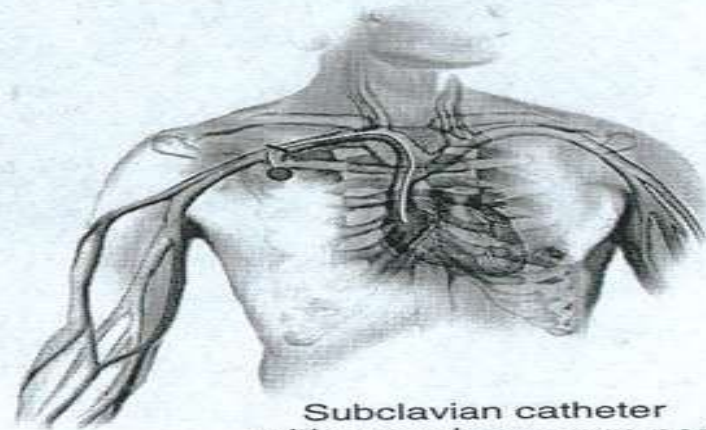
Femoral catheter site



Hickman catheter site



Vascular access port



Subclavian catheter
with vascular access port

PICC Lines (peripherally inserted central catheter)

- PICC lines may be used in ambulatory settings or for long term therapy
- Used for delivery of medication as well as PN
- Inserted in the cephalic, basilic, median basilic, or median cephalic veins and threaded into the superior vena cava
- Can remain in place for up to 1 year with proper maintenance and without complications

PN: Peripheral Access

PN may be administered via peripheral access when

- Therapy is expected to be short term (10-14 days)
- Energy and protein needs are moderate
- Formulation osmolarity is <600-900 mOsm/L
- Fluid restriction is not necessary

**A.S.P.E.N. Nutrition Support Practice Manual, 2005;
p. 94**

Parenteral Nutrition

Macronutrients &
Micronutrients

Macronutrients: Carbohydrate

- Source: Monohydrous dextrose
- Properties: Nitrogen sparing
Energy source
3.4 Kcal/g
Hyperosmolar
- Recommended intake:
2 – 5 mg/kg/min
50-65% of total calories

Macronutrients: Carbohydrate

Potential Adverse Effects:

- Increased minute ventilation
- Increased CO₂ production
- Increased RQ
- Increased O₂ consumption
- Lipogenesis and liver problems
- Hyperglycemia

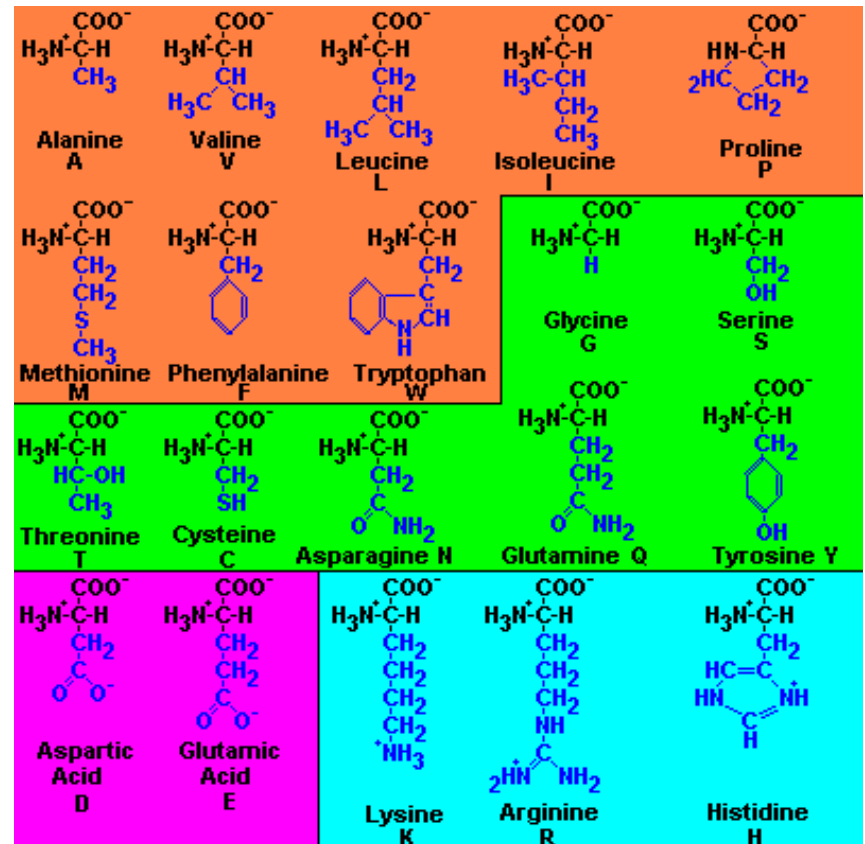
Macronutrients: Amino Acids

- Source: Crystalline amino acids—
standard or specialty
- Properties: 4.0 Kcal/g
EAA 40–50%, NEAA 50-
60%
Glutamine / Cysteine
- Recommended intake:
0.8-2.0 g/kg/day
15-20% of total calories

Macronutrients: Amino Acids

Potential Adverse Effects:

- Increased renal solute load
- Azotemia



Macronutrients: Amino Acids

- Specialized Amino Acid Solutions
 - Branched chain amino acids (BCAA)
 - Essential amino acids (EAA)
- Not shown to improve patient outcome
- More expensive than standard solutions

Macronutrients: Lipid

- Source: Safflower and/or soybean oil
- Properties: Long chain triglycerides
Isotonic or hypotonic
Stabilized emulsions
10 Kcals/g
Prevents essential fatty acid deficiency
- Recommended intake:
0.5 – 1.5 g/kg/day (not >2 g/kg)
12 – 24 hour infusion rate

Macronutrients: Lipids

Requirements

- 4% to 10% kcals given as lipid meets EFA requirements; or 2% to 4% kcals given as linoleic acid
- Generally 500 mL of 10% fat emulsion given two times weekly or 500 mL of 20% lipids given once weekly will prevent EFAD
- Usual range 25% to 35% of total kcals
- Max. 60% of kcal or 2 g fat/kg

Macronutrients: Lipids

Potential Adverse Effects:

- Egg allergy
- Hypertriglyceridemia
- Decreased cell-mediated immunity (limit to <1 g/kg/day in critically ill immunosuppressed patients)
- Abnormal LFTs

Parenteral Base Solutions

- Carbohydrate
 - Available in concentrations from 5% to 70%
 - D30, D50 and D70 used for manual mixing
- Amino acids
 - Available in 3, 3.5, 5, 7, 8.5, 10, 15, 20% solutions
 - 8.5% and 10% generally used for manual mixing
- Fat
 - 10% emulsions = 1.1 kcal/ml
 - 20% emulsions = 2 kcal/ml
 - 30% emulsions = 3 kcal/ml (used only in mixing TNA, not for direct venous delivery)

The A.S.P.E.N. Nutrition Support Practice Manual, 2nd edition, 2005, p. 97; Barber et al. In ASPEN, The Science and Practice of Nutrition Support: A Case-Based Core Curriculum. 2001.

Other Requirements

- Fluid—30 to 50 ml/kg (1.5 to 3 L/day)
 - Sterile water is added to PN admixture to meet fluid requirements
- Electrolytes
 - Use acetate or chloride forms to manage metabolic acidosis or alkalosis
- Vitamins: multivitamin formulations
- Trace elements

Daily Protein and Calorie Requirements for Adults*

Protein	
Maintenance	0.8-1.0 g/kg
Catabolic patients	1.2-2 g/kg
Energy	
Total calories	25-30 kcal/kg
Volume	20-40 mL/kg

*Assumes normal organ function

Reprinted with permission from ASPEN Safe Practices. *JPEN*. 1998; 22:49-88

Electrolytes/Vitamins/Trace Elements

- Because parenterally-administered vitamins and trace elements do not go through digestion/absorption, recommendations are lower than DRIs
- Salt forms of electrolytes can affect acid-base balance

Parenteral Nutrition Vitamin Guidelines

Vitamin	FDA Guidelines*
A IU	3300 IU
D IU	200 IU
E IU	10 IU
K _{mcg}	150 mcg
C _{mg}	200
Folate mcg	600
Niacin _{mg}	40

Vitamin	FDA Guidelines*
B ₂ mg	3.6
B ₁ mg	6
B ₆ mg	6
B ₁₂ mg	5.0
Biotin _{mcg}	60
B5 dexpanthenol mg	15

*Federal Register 66(77): April 20, 2000

Daily Electrolyte Requirements Adult PN

Electrolyte	PN Equiv RDA	Standard Intake
Calcium	10 mEq	10-15 mEq
Magnesium	10 mEq	8-20 mEq
Phosphate	30 mmol	20-40 mmol
Sodium	N/A	1-2 mEq/kg + replacement
Potassium	N/A	1-2 mEq/kg
Acetate	N/A	As needed for acid-base
Chloride	N/A	As needed for acid-base

ASPEN: Safe practices for parenteral nutrition formulations. JPEN 22(2) 49, 1998

PN Contaminants

- Components of PN formulations have been found to be contaminated with trace elements
- Most common contaminants are aluminum and manganese
- Aluminum toxicity a problem in pts with renal compromise on long-term PN and in infants and neonates
- Can cause osteopenia in long term adult PN patients

PN Contaminants

- FDA requires disclosure of aluminum content of PN components
- Safe intake of aluminum in PN is set at 5 mcg/kg/day

PN Contaminants

- Manganese toxicity has been reported in long term home PN patients
- May lead to neurological symptoms
- Manganese concentrations of 8 to 22 mcg/daily volume have been reported in formulations with no added manganese
- May need to switch to single-unit trace elements that don't include manganese

ASPEN Nutrition Support Practice Manual 2005; p. 98-99

Calculating Nutrient Needs

- Provide adequate calories so protein is not used as an energy source
- Avoid excess kcal (>35 kcal/kg)
- Determine energy and protein needs using usual methods (kcal/kg, Ireton-Jones 1992, Harris-Benedict)
- Use specific PN dosing guides for electrolytes, vitamins, and minerals

Peripheral Parenteral Nutrition

- New catheters allow longer support via this method
- In adults, requires large fluid volumes to deliver adequate nutrition support (2.5-3L)
- May be appropriate in mild to moderate malnutrition (<2000 kcal required or <14 days)
- More commonly used in infants and children
- Controversial

Contraindications to Peripheral Parenteral Nutrition

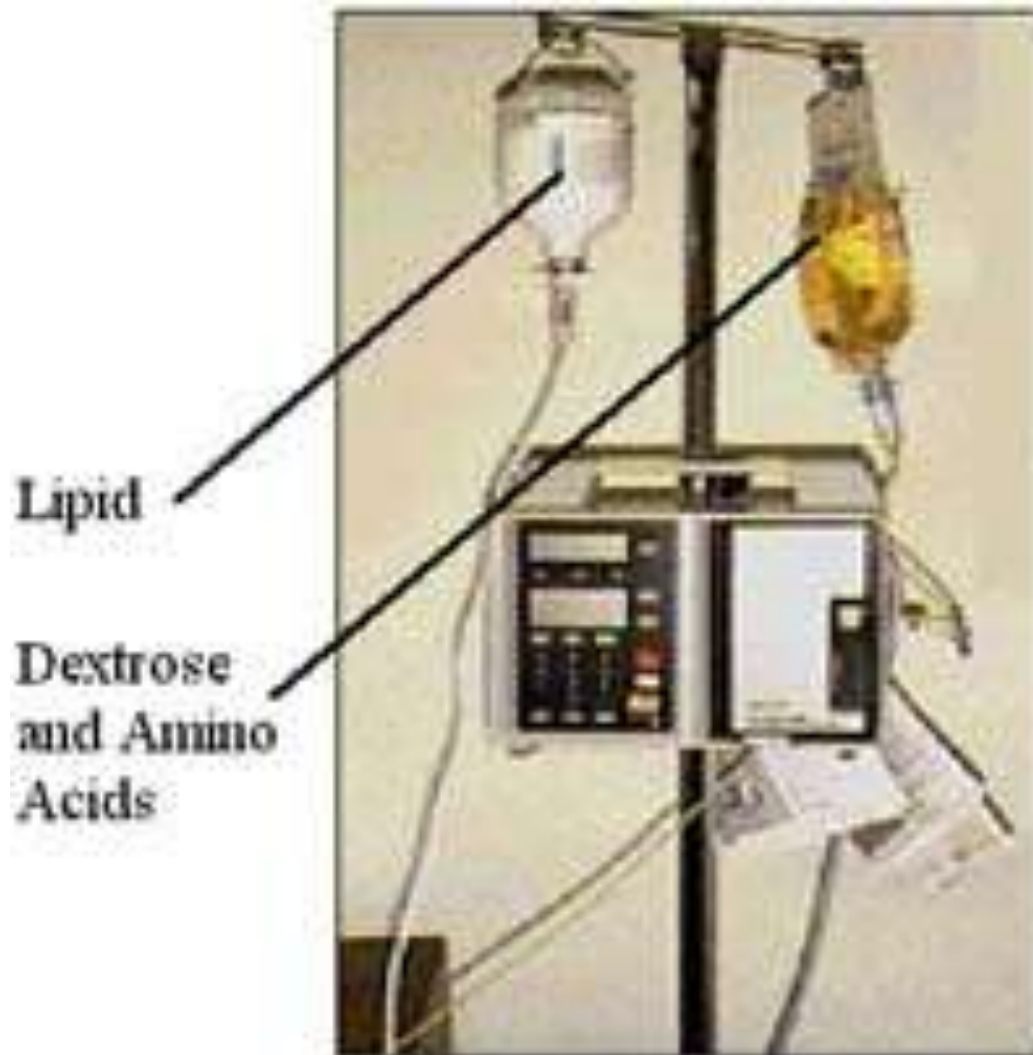
- Significant malnutrition
- Severe metabolic stress
- Large nutrition or electrolyte needs (potassium is a strong vascular irritant)
- Fluid restriction
- Need for prolonged PN (>2 weeks)
- Renal or liver compromise

From Mirtallo. In ASPEN, The Science and Practice of Nutrition Support: A Case-Based Core Curriculum. 2001, 222.

Compounding Methods

- **Total nutrient admixture (TNA) or 3-in-1**
 - Dextrose, amino acids, lipid, additives are mixed together in one container
 - Lipid is provided as part of the PN mixture on a daily basis and becomes an important energy substrate
- **2-in-1 solution of dextrose, amino acids, additives**
 - Typically compounded in 1-liter bags
 - Lipid is delivered as piggyback daily or intermittently as a source of EFA

Two-in-One PN



Advantages of TNA

- Decreased nursing time
- Decreased risk of touch contamination
- Decreased pharmacy prep time
- Cost savings
- Easier administration in home PN
- Better fat utilization in slow, continuous infusion of fat
- Physiological balance of macronutrients

Disadvantages of TNA

- Diminished stability and compatibility
- IVFE (IV fat emulsions) limits the amount of nutrients that can be compounded
- Limited visual inspection of TNA; reduced ability to detect precipitates

**ASPEN Nutrition Support Practice Manual 2005;
p. 98-99**

PN Compounding Machines: Automix



PN Compounding Machines: Micromix



PN Solution Components

	Central ---Solutions---		Peripheral Solutions
	Lipid- based	Dextrose- based	
Dextrose	14.5%	35.0%	<10.0%
Amino Acids	5.5%	5.0%	≤4.25%
Fat	5.0%	250 ml/ 20% fat	3.0 - 8.0%

Courtesy of Marian, MJ.

Initiation of PN

- Adults should be hemodynamically stable, able to tolerate the fluid volume necessary to deliver significant support, and have central venous access
- If central access is not available, PPN should be considered (more commonly used in neonatal and peds population)
- Start slowly
(1 L 1st day; 2 L 2nd day)

Initiation of PN: formulation

- As protein associated with few metabolic side effects, maximum amount of protein can be given on the first day, up to 60-70 grams/liter
- Maximum CHO given first day 150-200 g/day or a 15-20% final dextrose concentration
- In pts with glucose intolerance, 100-150 g dextrose or 10-15% glucose concentration may be given initially

Initiation of PN: Formulation

- Dextrose content of PN can be increased if capillary blood glucose levels are consistently ≤ 180 mg/dL
- IVFE in PN can be increased if triglycerides are ≤ 400 mg/dL

PN Administration: Transition to Enteral Feedings in Adults

- Controversial
- In adults receiving oral or enteral nutrition sufficient to maintain blood glucose, no need to taper PN
- Reduce rate by half every 1 to 2 hrs or switch to 10% dextrose IV) may prevent rebound hypoglycemia (not necessary in PPN)
- Monitor blood glucose levels 30-60 minutes after cessation

PN Administration: Transition to Enteral Feedings in Pediatrics

- Generally tapered more slowly than in adults as oral or enteral feedings are introduced and advanced
- Generally PN is continued until 75-80% of energy needs are met enterally

Medications That May Be Added to Total Nutrient Admixture (TNA)

- **Phytonadione**
- **Selenium**
- **Zinc chloride**
- **Levocarnitine**
- **Insulin**
- **Metoclopramide**
- **Ranitidine**
- **Sodium iodide**
- **Heparin**
- **Octreotide**

Parenteral Nutrition

Infusion Schedules

Infusion Schedules

- Continuous PN

Non-interrupted infusion of a PN solution over 24 hours via a central or peripheral venous access



Continuous PN

Advantages

- Well tolerated by most patients
- Requires less manipulation
 - decreased nursing time
 - decreased potential for “touch” contamination

Continuous PN

Disadvantages

- Persistent anabolic state
 - altered insulin : glucagon ratios
 - increased lipid storage by the liver
- Reduces mobility in ambulatory patients

Infusion Schedules

- Cyclic PN
 - The intermittent administration of PN via a central or peripheral venous access, usually over a period of 12 – 18 hours
 - Patients on continuous therapy may be converted to cyclic PN over 24-48 hours



Cyclic PN

- **Advantages**

- Approximates normal physiology of intermittent feeding

- Maintains:

- Nitrogen balance

- Visceral proteins

- Ideal for ambulatory patients

- Allows normal activity

- Improves quality of life

Cyclic PN

- **Disadvantages**

- Incorporation of N_2 into muscle stores may be suboptimal
 - Nutrients administered when patient is less active
- Not tolerated by critically ill patients
- Requires more nursing manipulation
 - Increased potential for touch contamination
 - Increased nursing time

Home TPN

- Patient selection
 - Reasonable life expectancy
 - Demonstrates motivation, competence, compliance
 - Home environment conducive to sterile technique

Home TPN

- **Safety and efficacy**
depends on:
 - Proper selection of patients
 - Adequate discharge planning/education
 - Home monitoring protocols

Home TPN: Discharge Planning

- Determination whether patient meets payer criteria for PN; completion of CMN forms
- Identification of home care provider and DME supplier
- Identification of monitoring team for home
- Conversion of 24-hour infusion schedule to cyclic infusion with monitoring of patient response

Home TPN

Cost effective

- Quicker discharge from hospital
- Improved rehabilitation in the home
- Reduced hospital readmissions

EN vs PN in Critical Care

- If the critically ill ICU patient is hemodynamically stable with a functional GI tract, then EN is recommended over PN.
- Patients who received EN experienced less septic morbidity and fewer infectious complications than patients who received PN.
Strong, Conditional

EN vs PN in Critical Care

- In the critically ill patient, EN is associated with significant cost savings when compared to PN. There is insufficient evidence to draw conclusions about the impact of EN or PN on LOS and mortality.
Strong, Conditional

