CORRELATIVE MEDICINE SERIES

NUTRITION: PARENTERAL NUTRITION

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Objectives:

After reviewing the **Parenteral Nutrition** handout, including use of all references, the student should be able to:

1. Recognize appropriate indications for total parenteral nutrition.
2. Describe the utility of a standard protocol for administrating total parenteral nutrition.
3. Describe two different insertion techniques for placement of central venous catheters for parenteral feeding use and their potential complications.
4. Understand the risks of septic complications, and the benefits of a rigid catheter protocol.
5. List the different types of parenteral protein, dextrose, and fat solutions for feeding.
6. Contrast the caloric density of intravenous fat and glucose solutions.
7. Calculate approximate calorie and protein requirements in the patient requiring parenteral feeding.
8. Recognize the proper way to write orders for the patient receiving parenteral feeding.
9. Describe the proper biochemical monitoring of the patient receiving parenteral feeding.
10. List the common metabolic and mechanical complications associated with parenteral feeding.

I. Parenteral Nutrition

A. **Indications** ***(see practice guidelines in appendix 1)***

- Malnourished Patient—Inadequate intake for > 7 days
  Unintentional weight loss > 10% or weight is > 20% below ideal body weight
- Inability to use GI tract—For greater than 7 days

B. **Conditions to use Parenteral Nutrition**

- Short gut syndrome
- Inflammatory bowel disease
- Fistula >1500 cc output per day
- Obstruction of GI tract
- Acute pancreatitis
- Major gastrointestinal surgery
- Ischemic bowel

C. **Contraindications**

- Ability to provide adequate energy and nutrients via the enteral or oral route
- Mild or moderate malnourished patient in preoperative period while consuming
- adequate enteral or oral intake
- PPN for > 2 weeks in patients 2nd limited access, osmolality, fluid restrictions, and large nutrient or
  electrolyte need
- Unlikely to benefit patients with advanced cancer who have been unresponsive to treatment

D. **Advantages**

- Provides nutrition when GI tract not functional
- Provides nutrition when access to GI tract not possible

E. **Disadvantages**

- Risk of infection associated with TPN
- Risk of central line placement
- Metabolic complications
- Sequelae of dormant gut—leads to increased risk for development of infectious complications

F. **Guidelines for Use (*see practice guidelines in appendix 1)***

- Preoperative TPN if patient cannot receive enteral feeds prior to surgery
- Preoperative TPN in severely malnourished surgical patients
- Postoperative TPN when NPO status after surgery for > 5 days with severely malnourished patients
- Postoperative TPN when NPO status after surgery for >7 days with mild to moderate malnourished patients

II. ACCESS—CENTRAL VENOUS CATHETERS

A. **Location**

- Subclavian Veins
- Internal Jugular Veins
- Femoral Veins
- Brachial Veins

B. **Terminology**

- Intravascular catheter—A device that consists of a slender tube and any necessary connecting fittings that that is inserted into the patient's vascular system for short-term use (<30 days) or long-term use (>30 days).
- Central Vena Cava (superior or inferior) CVC—A catheter placed within a vein and whose distal end in intended to be located within a central vein.
- Peripherally inserted central catheter (PICC)—A CVC with placement access via a peripheral vein.
- Distal end—Patient's end of a vacular catheter which is intended for location within a central vein.
- Proximal end—User's end of a vascular catheter with CVCs, the end farthest from the central vein.

C. **Catheter Types—Non-tunneled**

- Cordis
- Swan Ganz
- Double Lumen
- Triple Lumen
- PICC

D. **Catheter Types—Tunneled**

- Hickman
- Broviac
- Portacath

E. **Indications**

- Venous access
- Central pressures
- Drugs

F. **Insertion**

- Informed consent
- Preoperative preparation
- Patient preparation
- Patient positioning
- Skin preparation
- Equipment and procedure preparation
- Procedural preparation
- Catheter stabilization
- Documentation

G. **Insertion Complications**

- Pneumothorax
- Hemothorax
- Laceration of Vessel
- Injury to Brachial Plexus
- Injury to Thoracic Duct
- Air Embolism
- Catheter Embolism

- Catheter Misplacement
- Cardiac

H. **Mechanical Complications**

- Clotted catheter
- Venous thrombosis
- Air embolism
- Precipitation

I. **Septic Complications**

- Fever
- Hematogenous seeding
- Contaminated fluids
- Central line site—Erythema, tenderness, or purulent drainage
  Common organisms—Staph epidermidis & Staph aureus
  Diagnosis—Blood culture with a Maki tip culture

J. **Prevention of Sepsis**

- Handwashing
- Insertion Technique—aseptic technique
- Skin cleansing at site of insertion
- Using least number of hubs or lumens
- Keeping dressings dry, occlusive, and drainage-free
- Changing lines over wire using sterile technique
- Changing pulmonary artery catheters (including sheaths) every five days
- Use central venous catheters only when necessary
- Not accessing TPN frequently

K. **Questionable Prevention of Sepsis**

- Antibiotic-coated catheter
- Types of dressings
- Routine changing of catheters
- Silver-chelated catheters

II. TPN Components

The goal in parenteral nutrition is to provide all required nutrients in a fluid volume that is well tolerated.

A. Calories

1. Carbohydrate
   a. Dextrose = 3.4 Kcal/gm
   b. Dextrose 5% 1000 ml = 170 Kcal, not a significant calorie source
   c. Dextrose 25% 1000 ml = 850 Kcal, but mOsm/liter) must be administered through a <u>central vein</u>.
   d. To make a TPN solution the pharmacist will usually add 500 ml of a dextrose solution to 500 ml of an amino acid solution.
   Dextrose solutions are available as 10, 30, 50, and 70% solutions--when mixed with the amino acid solution the final concentration of the TPN would be 5, 15, 25, and 35% concentration of the TPN would be 5, 15, 25, and 35% respectively. They can be custom

mixed to other concentrations, but this is not usually necessary.

2. Fat
   a. Lipid = 9.0 Kcal/gm
   b. Brand names: Liposyn, Intralipid, Soyacal, and Travamulsion.
   c. Composition: an emulsion of soybean oil and water/or soybean oil and safflower oil and water.
   d. Available concentrations 10% (1.1 Kcal/ml), (2.0 Kcal/ml) and 30% (2.9 Kcal/ml).
   e. Can provide up to 60% of total calories.
   f. Supplies essential fatty acid: Linoleic acid.
   g. Isotonic - Primary calorie source in peripheral parenteral nutrition (P.P.N.)
   h. Can be infused into a peripheral vein or piggy-backed into central line.
   i. Cannot be run through IV filters. Infuse thru IV port below IV filter.
   j. Can be admixed with dextrose and amino acids to make a "Three-In-One" solution. This solution is stable with vitamins and the usual electrolytes.
   k. 1.2% egg yolk phospholipids as emulsifier (avoid persons wit egg allergies).

3. Protein (non-calorie source) = 4 Kcal/gm.

   a. Provided as free amino acids (crystalline amino acids); approximately 40% essential and 60% non-essential amino acids.
   b. Brand names include: Aminosyn, FreAmine, Travasol, Novamine. Available in various concentration.
   c. Commercially available amino acid concentrations:

Manufacturer:	Concentrations Available:(%)
Abbott Laboratories (Aminosyn)	3.5, 5, 7, 8.5, 10
Cutter Biological (Novamine)	8.5, 11.4
McGaw Laboratories (FreAmine)	3, 8.5, 10
Travenol Laboratories, Inc.	5.5, 8.5, 10, 15

   d. The optimal non-protein calorie: nitrogen ratio is close to 150:1. The usual range is 12-18 gm of nitrogen per day.
   e. The best determination of nitrogen requirement can be estimated from the calculation of nitrogen balance.

4. Electrolytes
   a. No single formula can meet the electrolyte requirements for all patients.

   b. Electrolytes usually required: sodium, potassium, calcium, magnesium, phosphorous. These can be provided by single or multiple electrolyte products.

   c. Electrolytes in TPN:

Daily Requirement:		Standard Concentration:
Na	60-150 meq	35-50 meq/L
K	40-140 meq	30-40 meq/L
Ca	3-30 meq	5 meq/L
Mg	10-30 meq	5-10 meq/L
Phos.	30-50 millimoles	12-15 millimoles/L

d. Electrolyte salt forms:

Sodium chloride	Potassium chloride
Sodium acetate	Potassium acetate
Sodium phosphate	Potassium phosphate
Sodium lactate	Calcium chloride
Sodium bicarbonate (should not be mixed with TPN solution)	Calcium gluconate
	Calcium gluceptate
Magnesium sulfate	

5. Trace elements
   a. Trace elements should be provided to prevent depletion of body stores. For most patients this can be accomplished with a multi-trace element solution.
   b. Adjustments should be made for patients with renal failure or biliary obstruction.

	Suggested daily intake	**Amt per 1 ml MTE-4**
Zinc	2.5-4 mg	1 mg
Copper	0.5-1.5 mg	0.4 mg
Chromium	10-15 mcg	4 mcg
Manganese	0.15-0.8 mg	0.1 mg

   c. Selenium, Molybdenum, and Iodide have also been supplemented.

6. Vitamins

The usual vitamin requirements can be met with 10 ml of MVI-12.

A,	IU	3,300	Riboflavin, mg	3.6
D,	IU	200	Thiamin, mg	3
E,	IU	10	B6, mcg	4
C,	mg	100	B12, mcg	5
Folacin, mcg		400	Pantothenic acid, mg	15
Niacin, mg		40	Biotin, mcg	60

III. Administering TPN Solutions

A. Standardization

1. A standard solution can meet the requirements of most patients.
2. Offers advantages
   a. lower risk of contamination
   b. less preparation time
   c. fewer preparation errors
   d. lower cost

B. Mechanics for solution administration

1. Rates of administration

   The solution is generally started at 25 ml/hr and the rate is gradually increased (see protocol). The purpose is to allow the body to adapt to the high concentration of sugar in the solution. In the presence of significant hyperglycemia, the rate should not be increased until control has been established.

   In a similar fashion, when the solution is discontinued, a tapering procedure much like the starting procedure, is used to prevent rebound hypoglycemia.

   If the solution must be discontinued abruptly for any reason, another solution of dextrose (5% or 10%) should be started to prevent hypoglycemia from occurring.

2. Control Device

   To assure the accuracy of the infusion rate, TPN should be administered via an IV control device, preferably a volumetric pump.

3. Filters

   In the process of solution preparation, it is possible for a particulate matter (glass, fibers, etc.) to enter the solution. For this reason, inline filters are used in the administration of TPN solutions. A 0.22 micron filter will remove most particulates and any organisms which might be present in the solution.

IV. Monitoring the patient

A. Anthropometrics

In monitoring patients, the aforementioned tests utilized to assess the presence of malnutrition can often be followed on a serial basis in an effort to detect improvement. The tricep skinfold may change in the period of 2-3 week subsequent to adequate nutrition. Other variables will increase at a somewhat slower rate. The visceral compartment may change also by seeing an increase in serum prealbumin within days after initiation of adequate nutrition. The serum albumin generally does not change substantially during parenteral nutrition. The total lymphocyte count may increase within days after beginning adequate nutrition. However, due to its high degree of variability, it is a less than useful test.

B. Nitrogen Balance

The test used to calculate nutritional repletion or depletion is known as nitrogen balance. Simply stated, nitrogen balance is the difference between nitrogen intake and nitrogen loss. If the loss of nitrogen from protein is greater then the intake of nitrogen from protein, the patient is said to be in negative nitrogen balance and is wasting his protein generally in an effort to make glucose from the carbon skeletons of the protein. If the patient retains the nitrogen which he has been given in the form of food or parenteral nutrition, then it is theorized that he is utilizing this to synthesize proteins and therefore, is deriving benefit. Thus, when the protein or nitrogen intake is greater than the nitrogen loss, the patient is said to be in positive nitrogen balance which is a desirable feature.

The nitrogen balance equation is:

$$N_2 \text{ Balance} = \frac{\text{Protein Intake (gm)}}{6.25} - (\text{Urine Urea Nitrogen gm} + 3 \text{ gm})$$

The nitrogen intake is estimated from protein intake by dividing by 6.25 (equivalent to multiplying by 0.16); and since the majority of nitrogen output occurs in the urine in the form of urea, the urine urea nitrogen is used as the nitrogen loss factor. As you will note in the nitrogen balance equation, a "fudge-factor" of 3 grams is utilized to correct for losses from fecal material, hair, skin or nails.

When determining the nitrogen balance keep the following in mind:

- TMC TPN is labelled as % *protein* and you must convert the total daily protein intake into nitrogen first.
- Recall the key conversion factors: 1 gram of protein = 160 mg of nitrogen. 1 gram of nitrogen = 6.25 grams of protein.
- Recall that **% implies grams per 100 ml.**
  - 5.5% 500 ml AA = 27.5 g/500 ml, 8.5% 500 ml AA = 42.5 g/500 ml.
  - 42 ml/hr = 1 L/day, 50 ml/hr=1.2 L/day, 75 ml/hr=1.8 L/day, 83 ml/hr= 2 L/day, 100 ml/hr=2.4 L/day, 125 ml/hr = 3L/day

Nitrogen Balance Example Calculations

Amino Acids % (grams per 500 ml)	Dextrose % (500 ml)	TPN Rate ml/hr [ml/day]	Protein (Nitrogen) Intake Per 24 hours	24 hr UUN (g)	Nitrogen Balanc
5.5 (27.5)	50	100 [2.4 L]	66 (10.5)	8	-0.5
5.5 (27.5)	70	125 [3.0 L]	82 (13.2)	8	+2.2
8.5 (42.5)	50	100 [2.4 L]	102 (16.3)	10	+3.3
10 (50.0)	50	100 [2.4 L]	120 (19.2)	12	+4.2

V. Complications of Total Parenteral Nutrition

Overview: complications associated with total parenteral nutrition (TPN) are customarily divided into metabolic, catheter, and septic events.

A. Metabolic Complications

Acute metabolic events most commonly involve glucose and electrolytes. Longer courses of therapy may involve complications with hepatic function, essential fatty acid deficiency, and metabolic bone disease.

<u>Glucose</u>: patients receiving TPN are commonly under high stress and receive other

interventions which influence glucose handling, eg., corticosteroids. Advancing TPN with hypertonic glucose in increments allows for progressive pancreatic adaptation to the exogenous load.

If blood glucose can't be maintained under 250-300 mg/dl, TPN should not be advanced. Not infrequently exogenous regular insulin (10-40 units per liter) is added to TPN to facilitate rate advancement. If higher amounts are needed, consideration should be given to reducing the glucose load and providing the needed calories as fat. Typically, glucose infusion isn’t advanced beyond 5-7 mg/kg/hr.

Sodium: patients receiving TPN may manifest hyponatremia. In most instances, the serum sodium reflects excess body water and infrequently a true body sodium deficit. Water restriction is usually indicated. You should evaluate changes in weight and sequential intakes and outputs, as well as looking for drainage and diarrhea. Standard TPN has 35 mEq/L (equivalent to ¼ NS)

Potassium: hypokalemia is more common with TPN than hyperkalemia. Potassium enters the cell with glucose administration and associated insulin release. Potassium disturbances are more common in patients with associated potassium wasting conditions: NG suction, intestinal drainage, diuretics, antibiotics, etc. In these patients, extra potassium can be added to the TPN.

Hyperkalemia is most commonly observed in patients with impaired excretion mechanisms, and potassium restriction in TPN fluid is generally advisable.

Phosphorus: phosphorus deficits occur most commonly due to cellular shifts which commonly result from glucose, insulin, and with respiratory alkalosis. In these settings true phosphorus depletion may not exist. Associated phosphate binder use wit antacids, calcium carbonate, and sucralfate may also contribute due to intestinal complexation. Severe hypophosphatemia is defined as < 1mg/dL and parenteral supplementation is appropriate. Avoid adding excessive phosphorus to the TPN (calcium phosphate complexation).

Hyperphosphatemia most commonly appears in patients receiving phosphorus who develop renal impairment.

Magnesium: magnesium deficits occur in patients with preexisting deficits or in patients on TPN who receive magnesium wasting drugs, eg., amphotericin, platinum most commonly.

Acetate: many amino acids are provided as acetate salts and generally the acetate load approximates the chloride load in TPN. Additional acetate may be added to TPN in patients with sever hyperchloremic metabolic acidosis (non anion gap) in place of some of the chloride.

Trace elements: because most institutions routinely supplement TPN with trace elements, there is seldom a problem with them. It may be necessary to increase zinc delivery in patients with unusually large intestinal fluid losses.

Zinc: clinical manifestations of deficiency include acrodermatitis, anorexia, with possible altered taste and smell, poor wound healing, diarrhea, impaired immune function (T cell). Trauma, burns, and sepsis including IBD, short bowel disease, and states with increased intestinal fluid loss may require supplemental zinc.

EFAD (essential fatty acid deficiency): a well-described complication resulting from inadequate fat intake is essential fatty acid deficiency. Typically, this is defined biochemically as a triene/tetraene ratio greater than 0.4. (The ratio refers to the concentration of 5, 8, 11 eicosatrienoic acid/arachidonic acid). Biochemical evidence does not correlate directly with clinical evidence which typically follows after the ratio change. Clinical evidence may consist of dry, thick desquamating skin, alopecia, thrombocytopenia, fatty liver with hepatomegaly, platelet dysfunction, and wound healing problems.

To prevent EFAD 8-10% of total calories per week should be administered as lipid emulsion. Typically this equals 500 ml of 10% lipid 2-3 times weekly.

Respiratory failure: **overfeeding** starved patients with glucose leads to glucose conversion to fat for storage with associated CO_2 production. Increased ventilatory work is required to eliminate the CO_2 produced. In patients with preexisting lung disease, this can be problematic. In general, don't overfeed. In particular, don't overfeed with glucose. Although data is limited, a useful rule is to avoid giving critically ill patients more than 5-7 mg/kg/min of glucose.

Hepatic function enzyme elevation occurs during long term TPN. In adults, hepatic dysfunction can be associated with mild to moderate increases in alkaline phosphatase, and amino transferase. Alterations in bilirubin are variable. Hepatic dysfunction during TPN has been postulated to occur due to:

(1) amino acid toxicity
(2) carbohydrate excess with overfeeding
(3) fat deposition
(4) deficiencies of EFAs, taurine, and choline
(5) sodium bisulfite toxicity

Metabolic Bone Disease: A controversial effect of long term (3 months) TPN is metabolic bone disease which is characterized by the appearance of excess demineralized bone characteristic of osteomalacia. This is commonly associated with bone pain and spontaneous fractures. Much attention has been centered on the role of vitamin D and enhanced sensitivity or excess dose has been suggested.

B. Septic Complications

Infection remains a major complication resulting in morbidity, mortality, and increased costs despite widespread use of TPN over the past 20 years. Two basic sources related to TPN represent avenues for infection: the nutrient solution and the catheter.

Solution contamination: reported rates of infusate related contamination range from 0.39 to 3.8% for standard IV fluids, 0-0.91% for crystalline amino acids, 2-4% for TNA. Sepsis from infusate contamination may be indistinguishable from sepsis from other causes. Suspect the solution when the same organism is isolated from the patients blood and patients infusate; when signs and symptoms of sepsis appear shortly after initiating the infusion; when they occur with no other apparent source

Crystalline amino acid and hypertonic dextrose solutions are generally hostile to the growth of bacteria. Peripheral TPN solutions create a more favorable setting for growth because of lower dextrose concentrations. Because of these possibilities, it is generally advised that once the infusion is begun, solutions should either be infused or discarded within 24 hours.

Lipid emulsions serve as a good growth media for gram positives, gram negatives, and fungi. Currently, the CDC recommends that infusion of lipid be completed within 12 hours. Note that lipid emulsions can't be filtered through 0.22 micron filters.