Parenteral Nutrition

COURSE: CHAPTER 4

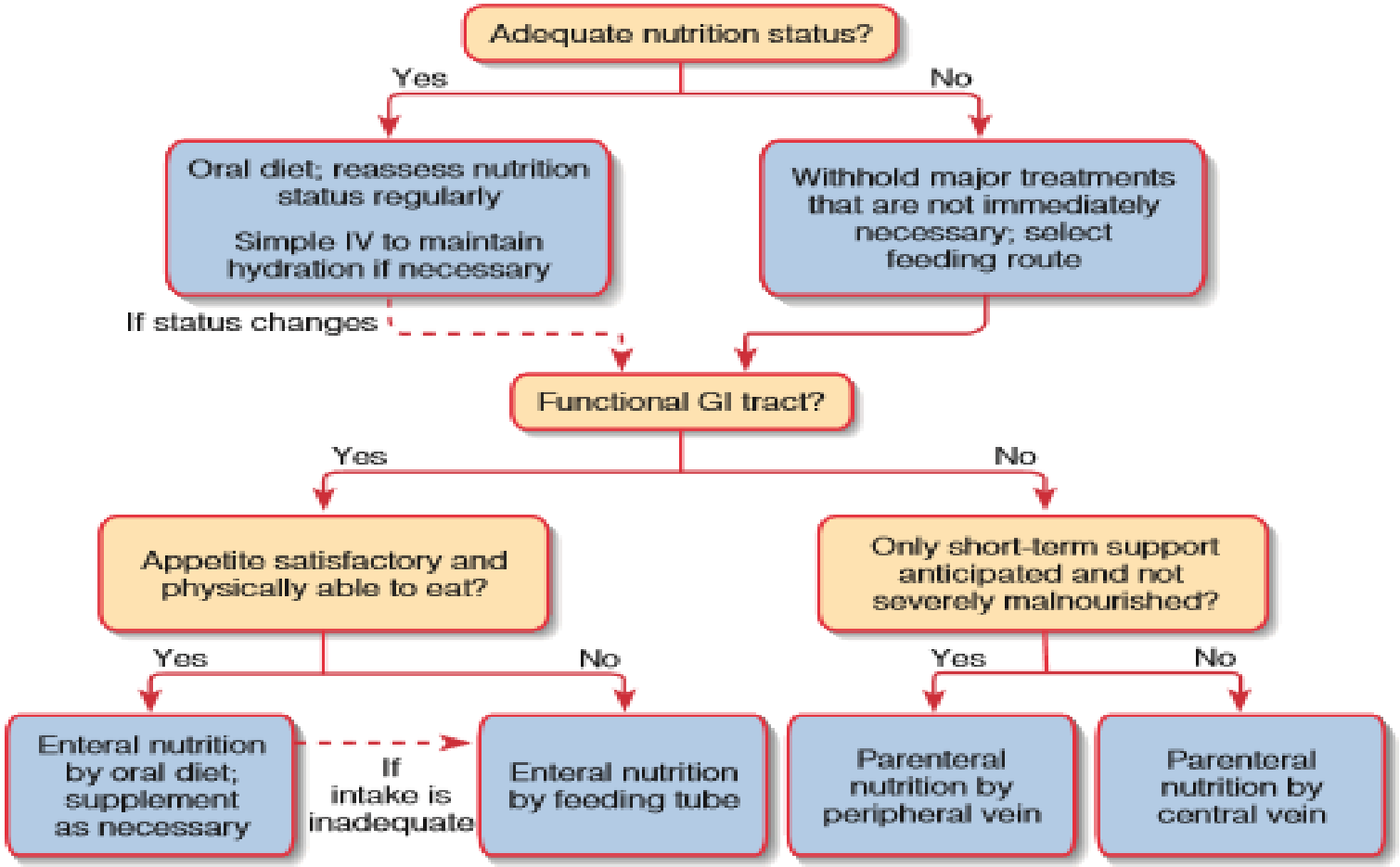
BOOK: CHAPTER 21

Introduction

- Enteral nutrition support is preferred over parenteral nutrition partly to avoid the expense and complications associated with intravenous therapy and partly to preserve healthy GI function.

- However, if intestinal function is inadequate, the ability to meet nutrient needs intravenously is a lifesaving option for critically ill persons.

Selecting a Feeding Route



Indications for Parenteral Nutrition

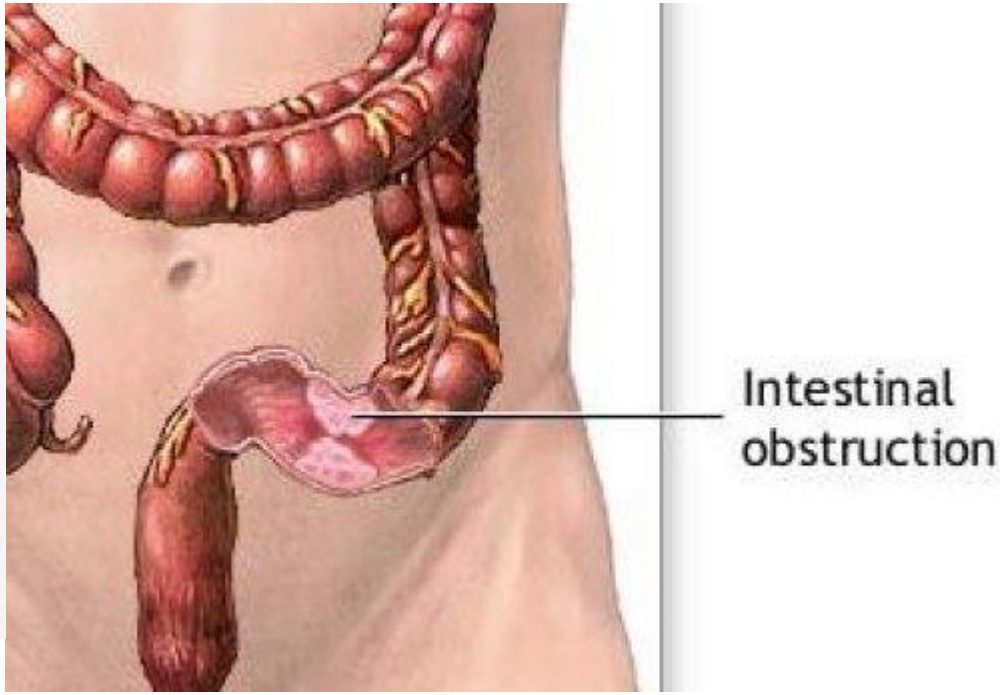
Generally, indicated for patients who are:

- Unable to use the GI tract
- AND malnourished or likely to become so

Indications for Parenteral Nutrition

1. Intestinal obstruction or fistulas

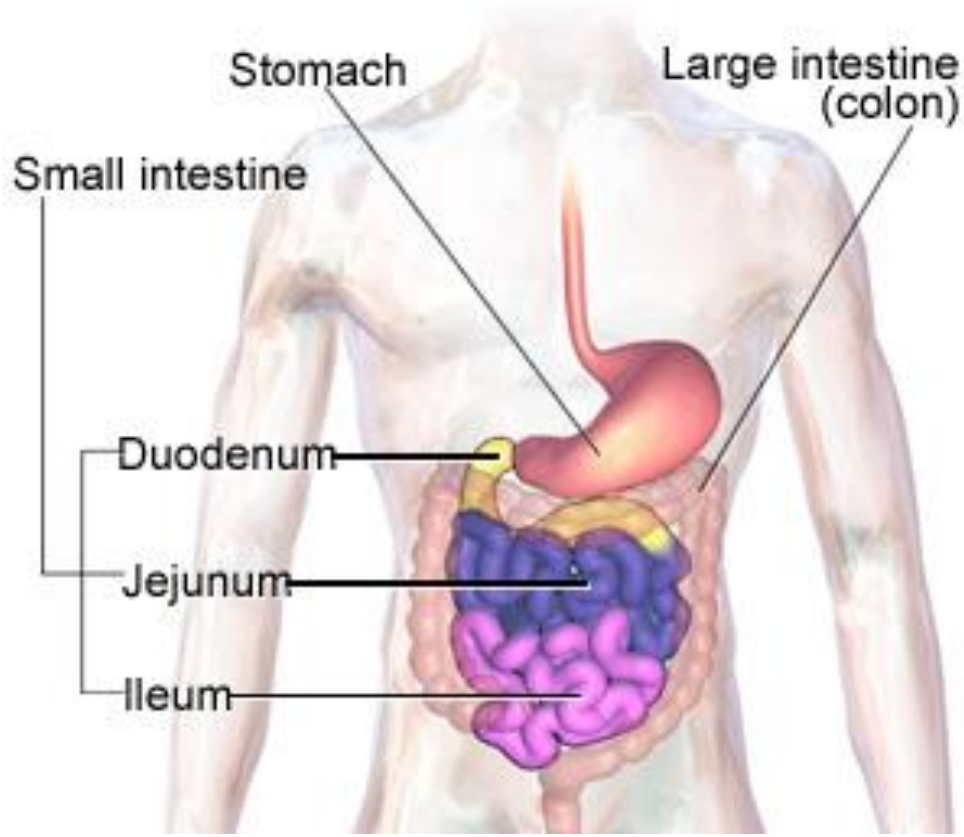
A fistula (Latin word for pipe): Abnormal connection between 2 epithelialized surfaces (usually involves the gut and another organ)



Indications for Parenteral Nutrition

2. Paralytic Ileus

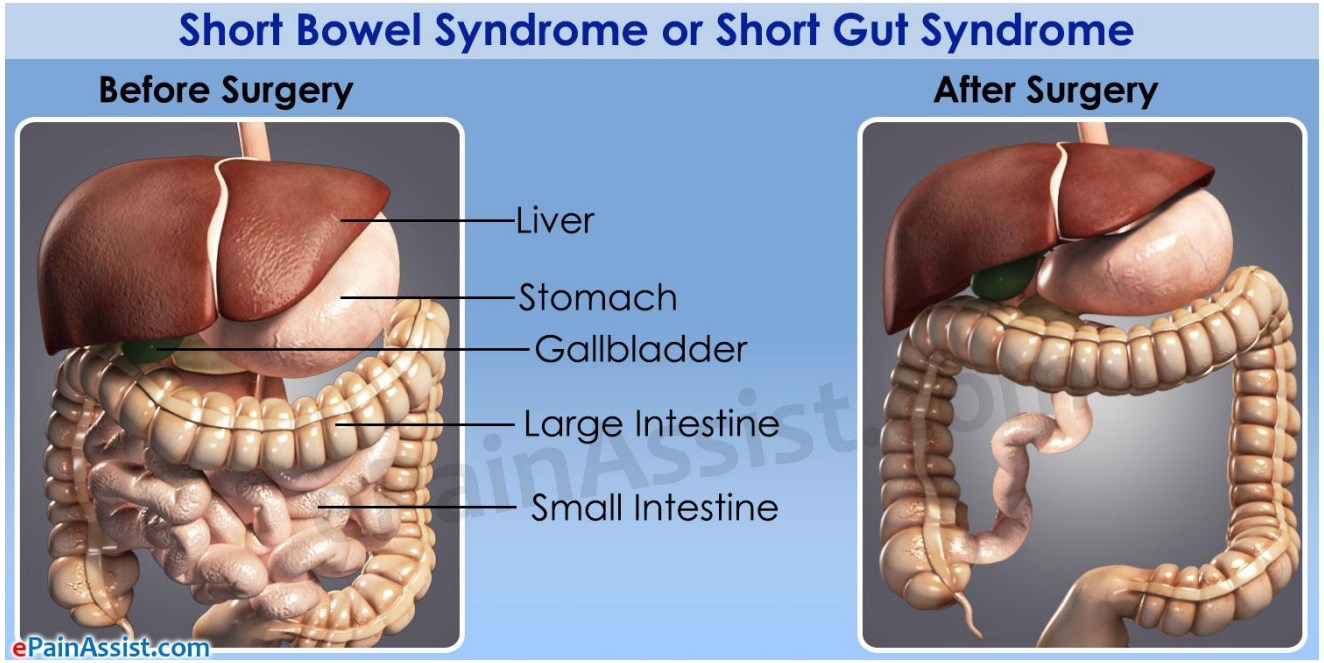
Obstruction of the intestines due to intestinal muscle paralysis (inability of the intestines to conduct peristalsis)



Indications for Parenteral Nutrition

3. Short bowel syndrome

A substantial portion of the small intestines has been removed



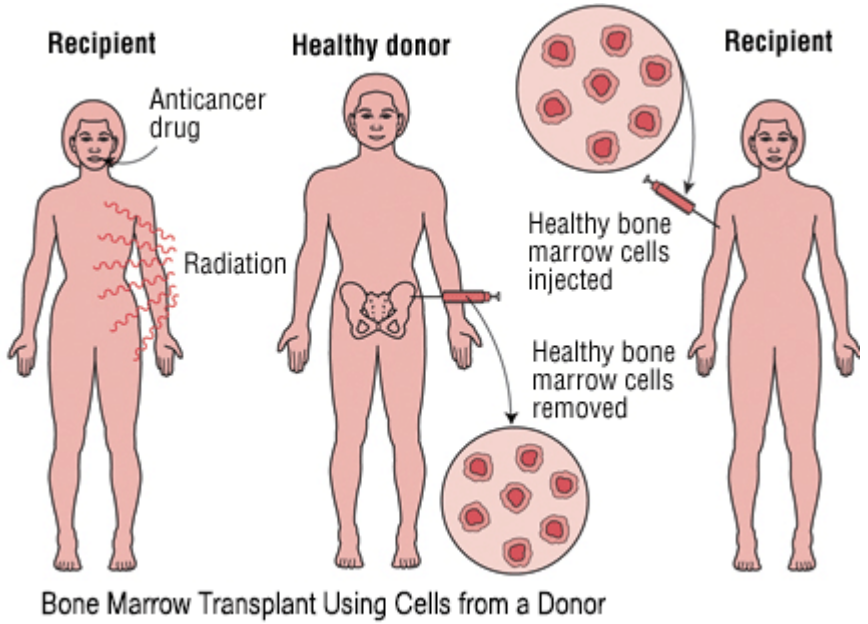
Indications for Parenteral Nutrition

4. Intractable vomiting or diarrhea

Unstoppable and/or difficult to control

Indications for Parenteral Nutrition

5. Bone marrow transplants



Bone Marrow Transplant Using Cells from a Donor

Indications for BMT

Malnutrition is a negative prognostic factor for outcome after BMT. Higher transplant-related mortality has also been observed in underweight patients (BMI < 20) who undergo BMT.

The presence of infection and the drugs used for treatment during the peri-transplant period can result in the development of mouth sores, nausea, vomiting and diarrhea. A common indication for PN use in BMT recipients is the occurrence of severe mucositis of the GI tract. It can affect up to 75% of BMT recipients and combined with other gastrointestinal toxicities such as GVHD, and severe nausea and vomiting, it can significantly affect food intake and absorption resulting in dehydration and malnutrition.

The routine use of PN in BMT recipients, either as a supportive care or adjunctive therapy, minimizes the nutritional consequences of transplantation. Despite overall favoring of enteral nutrition over PN, the presence of nausea, vomiting, and GI mucositis, make enteral nutrition support poorly tolerated by BMT patients. That coupled with the increased risk of bleeding associated with enteral tube placement in some patients.

Parenteral Nutrition Utilization in Bone Marrow Transplant Recipients Wilson S , Kohli-Seth R, Aldeguer Y, Pek M, Dharshan A, Oropello J, Manasia A, Bassily-Marcus A and Benjamin E*

Indications for Parenteral Nutrition

6. Severe malnutrition & intolerance to enteral nutrition

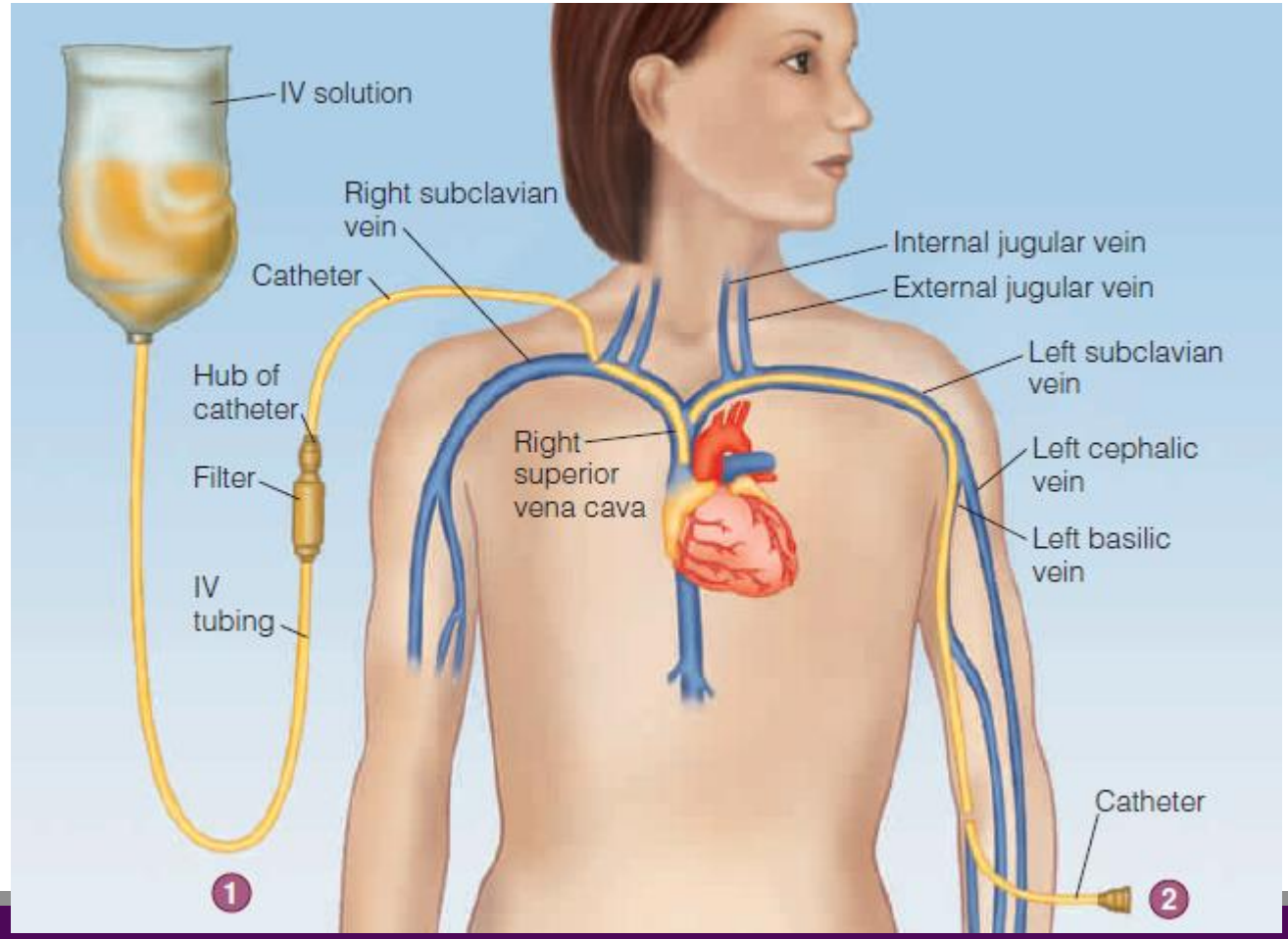
Note: PN is not advised to be used for fewer than 7 days in previously well-nourished patients

Choosing an access site

Peripheral Parenteral Nutrition (PPN)

Total Parenteral Nutrition (TPN)

Choosing an access site



Peripheral Parenteral Nutrition (PPN)

- Administering nutrition using the peripheral veins located in the arms and legs
- Peripheral veins can be damaged by overly concentrated solutions
- **Phlebitis** (inflammation of the vein) may result: redness, swelling, and tenderness at the infusion site.

Peripheral Parenteral Nutrition (PPN)

- The osmolarity of parenteral solutions used for PPN is generally kept below 900 milliosmoles per liter

- This limits the amounts of energy and protein the solution can provide.

- PPN is used most often in patients who require short-term nutrition support (about 7 to 10 days) and who do not have high nutrient needs or fluid restrictions.

- The use of PPN is not possible if the peripheral veins are too weak to tolerate the procedure. In many cases, clinicians must rotate venous access sites to avoid damaging veins

Total Parenteral Nutrition (TPN)

- Uses the larger, central veins. Also called Central Parenteral Nutrition
- Blood volume is greater → rapidly dilutes parenteral solutions → nutrient concentrations do not need to be limited
- Can reliably meet a person's complete nutrient requirements → TPN
- Patients with very high nutrient needs or fluid restrictions are able to receive the nutrient-dense solutions they require.
- Preferred for patients who require long-term parenteral nutrition.

Parenteral Solutions

- Parenteral solutions provide the combinations of amino acids, carbohydrate, lipids, vitamins, and minerals that are best suited to meet patients' requirements.

- Because the nutrients are provided intravenously, they must be given in forms that are safe to inject directly into the bloodstream.

Amino Acids

- Ranges from 3.5 – 20 %
- The more concentrated solutions (8.5 percent and higher) are most often used for preparing parenteral solutions
- Provides 4 kcal per gram
- Contains all essential AA and combinations of non-essential AA
- Disease-specific solutions are available

Carbohydrate

- Glucose is the main source of energy
- Provided as dextrose monohydrate (one glucose molecule + one water molecule)
- Provides 3.4 kcal per gram
- Available in concentrations from 2.5 – 70 %. Concentrations > 10% use only for TPN
- Expressed as D5, D5W, D5/NS

Lipids

- Supply energy and essential fatty acids (20-30% total daily calories)
- Contain: Triglycerides from soybean oil and safflower oil, Phospholipids as emulsifying agents, Glycerol
- Available in :

  10% solution → 1.1 kcal/ml

  20% solution → 2 kcal/ml

  30% solution → 2.9 or 3 kcal/ml

- Glucose-intolerant patients: this reduces energy needs from dextrose and reduces risk of hyperglycemia
- Hypertriglyceridemia: Lipid infusions may be restricted

Calculating Macronutrients & Energy

Suppose a patient is receiving 1.25 liters (1250 milliliters) of a parenteral solution that contains 5 percent amino acids and 30 percent dextrose, supplemented with 250 milliliters of a 20 percent lipid emulsion daily. How many grams of protein and carbohydrate is the person receiving, and what is the total energy intake for the day?

Amino acids: 250 kcal
Carbohydrate: 1275 kcal
Lipids: 500 kcal

Total: 2025 kcal

Nonprotein Kcalorie-to-Nitrogen Ratio

The nonprotein kcalorie-to-nitrogen ratio of the diet is sometimes used to determine whether a patient is receiving adequate nitrogen to maintain muscle tissue. A ratio between 150:1 and 200:1 is often adequate for stable patients, whereas ratios of 100:1 and below may be necessary for patients who are critically ill.

Nonprotein kcalories:

1275 kcal (dextrose) + 500 kcal (lipids) = 1775 kcal

Nitrogen content:

62.5 g amino acids x 16% nitrogen = 62.5 g x 0.16 = 10 g

Nonprotein kcalorie-to-nitrogen ratio:

1775 / 10 = 178:1

Practice Question

1. Calculate the energy content of 1 liter of a solution that provides 140 grams of dextrose monohydrate, 45 grams of amino acids, and 90 milliliters of 20 percent lipid emulsion.

2. Calculate the nonprotein kcalorie-to-nitrogen ratio in the solution.

3. If Jerry's energy requirement is 2100 kcalories per day, how many liters of solution will he need each day?

Fluids

- Calculate fluid needs for patient (use averages for different age groups), and adjust according to hydration assessment. Typical prescriptions provide 1.5-3 L/day.

- Subtract volume of TPN solution provided in a day from the fluid requirement. The difference is the volume of sterile water that should be added to the TPN solution.

Electrolytes

- Electrolytes added include: sodium, potassium, chloride, calcium, magnesium, and phosphate. (Differ from DRI values)

- Electrolyte imbalances may be lethal

- Content is expressed as mEq, which equals MW/Number of charge.

Example: 1 mEq Calcium = 40/2 = 20 mg

Na =

Parenteral solutions are neutral

1																	18
1 **H** 1.008	2											13	14	15	16	17	2 **He** 4.0026
3 **Li** 6.94	4 **Be** 9.0122											5 **B** 10.81	6 **C** 12.011	7 **N** 14.007	8 **O** 15.999	9 **F** 18.998	10 **Ne** 20.180
11 **Na** 22.990	12 **Mg** 24.305	3	4	5	6	7	8	9	10	11	12	13 **Al** 26.982	14 **Si** 28.085	15 **P** 30.974	16 **S** 32.06	17 **Cl** 35.45	18 **Ar** 39.948
19 **K** 39.098	20 **Ca** 40.078	21 **Sc** 44.956	22 **Ti** 47.867	23 **V** 50.942	24 **Cr** 51.996	25 **Mn** 54.938	26 **Fe** 55.845	27 **Co** 58.933	28 **Ni** 58.693	29 **Cu** 63.546	30 **Zn** 65.38	31 **Ga** 69.723	32 **Ge** 72.630	33 **As** 74.922	34 **Se** 78.97	35 **Br** 79.904	36 **Kr** 83.798
37 **Rb** 85.468	38 **Sr** 87.62	39 **Y** 88.906	40 **Zr** 91.224	41 **Nb** 92.906	42 **Mo** 95.95	43 **Tc** (98)	44 **Ru** 101.07	45 **Rh** 102.91	46 **Pd** 106.42	47 **Ag** 107.87	48 **Cd** 112.41	49 **In** 114.82	50 **Sn** 118.71	51 **Sb** 121.76	52 **Te** 127.60	53 **I** 126.90	54 **Xe** 131.29
55 **Cs** 132.91	56 **Ba** 137.33	57-71 *	72 **Hf** 178.49	73 **Ta** 180.95	74 **W** 183.84	75 **Re** 186.21	76 **Os** 190.23	77 **Ir** 192.22	78 **Pt** 195.08	79 **Au** 196.97	80 **Hg** 200.59	81 **Tl** 204.38	82 **Pb** 207.2	83 **Bi** 208.98	84 **Po** (209)	85 **At** (210)	86 **Rn** (222)
87 **Fr** (223)	88 **Ra** (226)	89-103 #	104 **Rf** (265)	105 **Db** (268)	106 **Sg** (271)	107 **Bh** (270)	108 **Hs** (277)	109 **Mt** (276)	110 **Ds** (281)	111 **Rg** (280)	112 **Cn** (285)	113 **Nh** (286)	114 **Fl** (289)	115 **Mc** (289)	116 **Lv** (293)	117 **Ts** (294)	118 **Og** (294)

* Lanthanide series	57 **La** 138.91	58 **Ce** 140.12	59 **Pr** 140.91	60 **Nd** 144.24	61 **Pm** (145)	62 **Sm** 150.36	63 **Eu** 151.96	64 **Gd** 157.25	65 **Tb** 158.93	66 **Dy** 162.50	67 **Ho** 164.93	68 **Er** 167.26	69 **Tm** 168.93	70 **Yb** 173.05	71 **Lu** 174.97
# Actinide series	89 **Ac** (227)	90 **Th** 232.04	91 **Pa** 231.04	92 **U** 238.03	93 **Np** (237)	94 **Pu** (244)	95 **Am** (243)	96 **Cm** (247)	97 **Bk** (247)	98 **Cf** (251)	99 **Es** (252)	100 **Fm** (257)	101 **Md** (258)	102 **No** (259)	103 **Lr** (262)

Daily Electrolyte Requirements During Total Parenteral Nutrition - Adults

Electrolyte	Standard Intake / Day
Calcium	10-15 mEq
Magnesium	8-20 mEq
Phosphate	20-40 mmol
Sodium	1-2 mEq/kg + replacement
Potassium	1-2 mEq/kg

Vitamins and Minerals

- Commercial multivitamin and trace mineral preparations are added to parenteral solutions to meet micronutrient needs.
- A preparation without vitamin K is available for patients using warfarin therapy
- The trace minerals typically added include zinc, copper, chromium, selenium, and manganese.
- Iron is excluded because it alters the stability of other ingredients and is injected separately

Adult Parenteral Multivitamins

Vitamins	FDA Requirements
A	1 mg
D	5 mcg
E	10 mg
B1	6 mg
B2	3.6 mg
B3	40 mg
B5	15 mg
B6	6 mg
B12	5 mcg
C	200 mg
Biotin	60 mcg
Folic Acid	600 mcg
K	150 mcg

Daily Trace Element Supplementation for Adult Parenteral Formulation

Trace Element	Intake
Chromium	10-15 mcg
Copper	0.3-0.5 mg
Manganese	60-100 mcg
Zinc	2.5-5 mg
Selenium	20-60 mcg

Osmolarity

PPN limited to 900 mOsm/L

TPN can be as dense as necessary

- The components of a solution that contribute most to its osmolarity are amino acids, dextrose, and electrolytes.

- Because lipids contribute little to osmolarity, lipid emulsions are used to increase the energy provided in PPN solutions.

Osmolarity Calculations

For a quick estimate of the Osmolarity (mOsm/L) of a 1-liter parenteral solution, follow these steps:

1. Multiply the grams of amino acids in the solution by 10.
2. Multiply the grams of dextrose in the solution by 5.
3. Multiply the grams of lipid by 0.71. For a 30% fat emulsion, multiply the grams of lipid by 0.67.
4. Multiply the sum of electrolyte milliequivalents (mEq) by 1.

Add the four values to determine the approximate osmolarity.

Osmolarity Calculations

Example:
A liter of a TPN solution has the composition shown. Determine the approximate osmolarity of the solution.

Amino acids: 40 g	Sodium: 40 mEq	Calcium: 5 mEq
Dextrose: 250 g	Potassium: 35 mEq	Magnesium: 8 mEq
Lipids:[a] 40 g	Chloride: 77 mEq	Phosphate: 21 mEq

Nutrient Needs

- Protein needs are calculated based on nutrition assessment data related to disease, injury, or clinical nutrition status, ranging between 15-20% of total energy intake

- Lipids provide 20-30% of daily energy needs. This should result in approx. 1 g fat/ 1 kg BW/day. Administration should not exceed 2 g fat/ kg BW/ day. Serum fatty acid levels may be similar to the pattern of FA in the emulsion.

- The rest of the balance comes from carbohydrates. Maximum administration rates should not exceed 5-6 mg/kg/min.

Safety Concerns

Similar to tube feedings in that careful attention to solution preparation and handling can minimize complications.

To prevent bacterial contamination and maintain stability:

1. Compounded in the pharmacy under aseptic conditions
2. Shielded from light
3. Refrigerated
4. Prior to infusion, the solutions are removed from the refrigerator and allowed to reach room temperature.
5. During feedings, the solution and catheter need to be checked frequently for signs of contamination.
6. Safety at home: https://www.youtube.com/watch?v=EIdUL_uRe04

Parenteral Formulations

Total Nutrient Admixture (TNA)

2-in-1 Solution

Parenteral Nutrition Administration

Continuous Parenteral Nutrition

Cyclic Parenteral Nutrition

Parenteral Nutrition Administration Approaches

Slow rate (ex: 40 ml/hr) → increase gradually

Full volume → advance nutrient conc.

Full volume & full strength

Parenteral Nutrition Order

Physician Orders
PARENTERAL NUTRITION (PN) – ADULT

Primary Diagnosis: _____ **Ht:** _____ cm **Dosing Wt:** _____ kg

PN Indication: _____ **Allergies** _____

Instructions: This form must be completed for a new order or continuation of PN and faxed to the Pharmacy by [Insert Time] to receive same day preparation. PN administration begins at [Insert Time]. Contact the Nutrition Support Service at (XXX) XXX-XXXX for additional information.

Administration Route: CVC or PICC *Note: Proper tip placement of the CVC or PICC must be confirmed prior to PN infusion*

Peripheral IV (PIV) *(Final PN Osmolarity ≤ _____ mOsm/L)*

Monitoring: Daily weights, Strict input & output, Bedside glucose monitoring every _____ hours

Na, K, Cl, CO_2, Glucose, BUN, Scr, Mg, PO_4 every _____

T, Bili, Alk Phos, AST, ALT, Albumin, Triglycerides, Calcium every _____

Base Solution: *Select one*

Parenteral nutrition MUST be administered through a dedicated infusion port and filtered with a 1.2-micron in-line filter at all times. Discard any unused volume after 24 hours.

PERIPHERAL 2-in-1
Dextrose _____ g
Amino Acids (*Brand* _____) _____ g
For patients with PIV and established glucose tolerance: Provides _____ kcal; Maximum Rate not to exceed _____ mL/hour

CENTRAL 2-in-1
Dextrose _____ g
Amino Acids (*Brand* _____) _____ g
For patients with CVC or PICC and established glucose tolerance: Provides _____ kcal; Maximum Rate not to exceed _____ mL/hour

CENTRAL 3-in-1
Dextrose _____ g
Amino Acids (*Brand* _____) _____ g
Fat Emulsion (*Brand* _____) _____ g
For patients with CVC or PICC and established glucose/fat emulsion tolerance: Provides _____ kcal; Maximum Rate not to exceed _____ mL/hour
Use of additional fat emulsion not required with 3-in-1 base solution

RATE & VOLUME: _____ mL/hour for _____ hours = _____ mL/day
Must specify

or **CYCLIC INFUSION:** _____ mL/hour for _____ hours, then _____ mL/hour for _____ hours = _____ mL/day

Fat Emulsion (*Brand* _____) **– via PIV or CVC with 2-in-1 base solutions** *(Select caloric density & volume)*

10% 250 mL
20% 500 mL

Infuse at _____ mL/hour over _____ hours
(Note: infusions < 4 or > 12 hours not recommended)

Frequency _____
Discard any unused volume after 12 hours.

Additives: *(per day)*

Sodium Chloride	_____ mEq	*1-2 mEq Sodium/kg/day*
as Acetate	_____ mEq	*pH or CO_2 dependent*
as Phosphate	_____ mmol of PO_4	*Consider if hyperkalemic*
Potassium Chloride	_____ mEq	*1-2 mEq Potassium/kg/day*
as Acetate	_____ mEq	*pH or CO_2 dependent*
as Phosphate	_____ mmol of PO_4	*20-40 mmol/day (1 mmol Phos = 1.5 mEq K)*
Calcium **Gluconate**	_____ mEq	*5-15 mEq/day*
Magnesium **Sulfate**	_____ mEq	*8-24 mEq/day*
Adult **Multivitamins**	_____ mL/day	*Contains Vitamin K 150 mcg*
Adult **Trace Elements**	_____ mL/day	*Zn ___ mg, Cu ___ mg, Mn ___ mg, Cr ___ mcg, Se ___ mcg (with normal hepatic function)*
H_2 Antagonist _____	_____ mg	_____ *mg/day with normal renal function*
Other:		

Normal Dosages

Additives: *(per day)*
Regular Insulin _____ units
Recommend if hyperglycemic, start with 1 unit for every 10 g of dextrose

***Pharmacy Use Only:* Ca/PO_4 Limit Checked** _____
(Note: Some brands of amino acids contain phosphate)

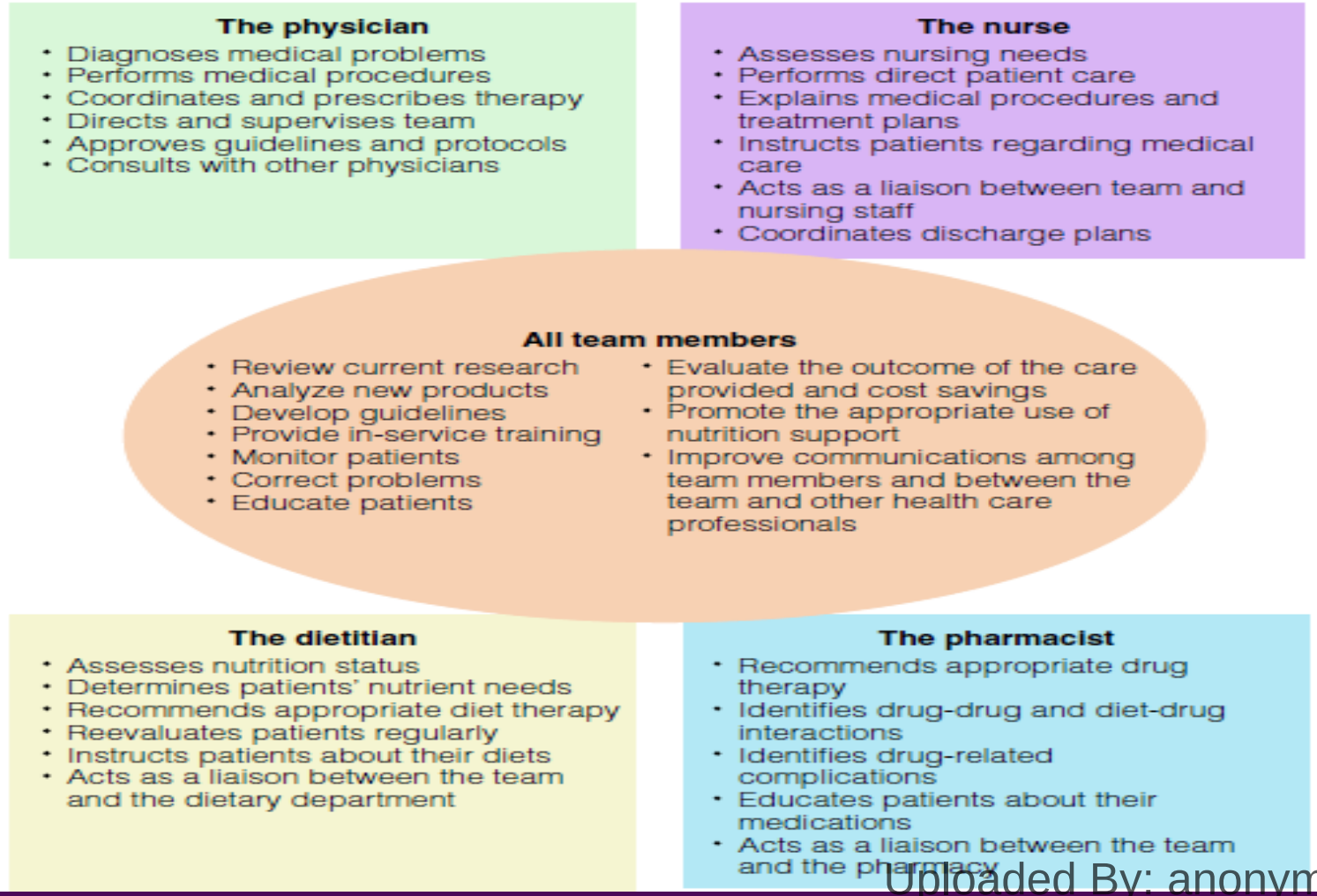
Physician's Signature: _____ **Pager Number:** _____ **Date/time:** _____

Orders transcribed by: _____ **Date/time:** _____ **Orders verified by:** _____ **Date/time:** _____

SEND COMPLETED ORDERS TO PHARMACY

Multidisciplinary team

https://www.youtube.com/watch?v=oEBlTe-nfuo



Metabolic Complications

- Hyperglycemia

- Most common in glucose intolerant patients, receiving excessive energy or dextrose, undergoing severe metabolic stress, or receiving corticosteroid medications.
- Management: Provide insulin along parenteral solutions, Avoid overfeeding, Avoid overly rapid infusion rates, or Restrict the amount of dextrose in the solution
- Limit to 5 mg/ kg BW/ min. (Blood glucose levels should not exceed 200 mg/dl)

Metabolic Complications

- Hypoglycemia

  - Occurs when: feeding is interrupted/discontinued OR excessive insulin is given
  - Feedings may be tapered off over several hours before discontinuation
  - Infuse 10% dextrose solution when feeding is interrupted/stopped

Metabolic Complications

- Hypertriglyceridemia

  - May result from dextrose overfeeding or overly rapid infusions of lipid emulsion.
  - If blood triglycerides levels exceed 400 mg/dl, feedings should be stopped

Metabolic Complications

- Refeeding Syndrome (RFS)

  - A condition that sometimes develops when a severely malnourished person is aggressively fed; characterized by electrolyte and fluid imbalances and hyperglycemia. Usually develops within 2 weeks

  - Symptoms: edema, cardiac arrhythmias, muscle weakness, confusion.

  - Dextrose infusion → raise circulating insulin levels → promote anabolic processes → Quickly removes potassium, phosphate, and magnesium from blood → electrolyte imbalances → fluid retention and life-threatening changes in organ systems → Possibly heart failure and respiratory failure

  - Start parenteral nutrition slowly and monitor electrolyte & glucose levels.

Refeeding Syndrome

❖ Normal physiology:

Food in abundance → carbohydrates provide most of energy requirements

Glucose enters the circulation → blood sugar levels rise → Stimulates insulin release → Promotes glucose uptake and storage (When exceeded, lipogensis occurs), inhibits the breakdown of fats, increases cellular uptake of potassium → Blood glucose levels fall & insulin secretion reduced.

❖ Starvation:

Glucose levels begin to fall within 24 to 72 hours → Glucagon release & reduction in insulin secretion → Glycogenolysis (glycogen stores rarely last more than 72 hours), gluconeogenesis, & fatty acid oxidation which generates ketone bodies → Loss of body fat and protein and an accompanying depletion of potassium, phosphate, and magnesium.

Homeostatic mechanisms maintain serum concentrations of the ions at the expense of intracellular stores.

Refeeding Syndrome

- Refeeding:

Reintroduction of nutrition → Rapid increase in insulin & decline in both gluconeogeneis and anaerobic metabolisms → Insulin stimulates the movement of extracellular potassium, phosphate, and magnesium to the intracellular compartment. Also, the reactivation of carbohydrate-dependent metabolic pathways increases demand for thiamine (a cofactor for cellular enzymatic reactions) → Deficiencies of phosphate, magnesium, potassium, and thiamine occur to varying degrees and have different effects in different patients.

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2945646/pdf/GRP2011-410971.pdf

Electrolyte imbalance

1. Hypophosphataemia (normal range 0.8–1.45 mmol/l)

   Heart failure, arrhythmia, hypotension, delirium, coma, seizures, insulin resistance, death.

2. Hypokalemia (normal range 3.5–5.1 mmol/l)

   Hypotension, ventricular arrhythmias, cardiac arrest, bradycardia or tachycardia, hypoventilation, respiratory failure, fatigue, muscle twitching, diarrhea, nausea, vomiting, anorexia, paralytic ileus, constipation.

3. Hypomagnesaemia (normal range 0.77–1.33 mmol/l)

   Atrial or ventricular arrhythmias, hypoventilation, respiratory failure, weakness, muscle cramps, hallucinations, depression, abdominal pain, diarrhea, vomiting, constipation.

4. Hyponatremia (normal range 136–145 mmol/l)

   Heart failure, arrhythmia, respiratory failure, renal failure, muscle cramps, fatigue.

Who's at risk for RFS?

1. Anorexia nervosa
2. Radiation therapy
3. Major stressors without food for >7 days
4. Oncology patients
5. Postoperative patients
6. Severe malnutrition
7. Pathological weight loss
8. Hunger strikes
9. Stroke (Neurological problems)
10. Malabsorption diseases
11. Inflammatory bowel diseases
12. Post bariatric surgery
13. Chronic pancreatitis
14. Elderly, poor social circumstance
15. Acquired Immunodeficiency Syndrome
16. Diabetes Mellitus

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2945646/pdf/GRP2011-410971.pdf

Refeeding Regime

Table 4: Refeeding regime for patients at risk of RFS [5, 29].

Day	Calorie intake (All feeding routes)	Supplements
Day 1	10 kcal/kg/day For extreme cases (BMI < 14 kg/m^2 or no food >15 days) 5 kcal/kg/day Carbohydrate: 50–60% Fat: 30–40% Protein: 15–20%	Prophylactic supplement PO_4^{2-}: 0.5–0.8 mmol/kg/day K^+: 1–3 mmol/kg/day Mg^{2+}: 0.3-0.4 mmmol/kg/day Na^+: <1 mmol/kg/day (restricted) IV fluids-Restricted, maintain "zero" balance IV Thiamine + vitamin B complex 30 minutes prior to feeding
Day 2–4	Increase by 5 kcal/kg/day If low or no tolerance stop or keep minimal feeding regime	Check all biochemistry and correct any abnormality Thiamine + vitamin B complex orally or IV till day 3 Monitoring as required (Table 3)
Day 5–7	20–30 kcal/kg/day	Check electrolytes, renal and liver functions and minerals Fluid: maintain zero balance Consider iron supplement from day 7
Day 8–10	30 kcal/kg/day or increase to full requirement	Monitor as required (Table 3)

If RFS is suspected based on clinical and biochemical assessment or the patient develops intolerance to artificial nutritional support, the energetic intake should be reduced or stopped.
Feeding rate should be increased to meet full requirements for fluid, electrolytes, vitamins, and minerals if the patient is clinically and biochemically stable.

Metabolic Complications

- Abnormal liver function

  - Fatty liver may occur, the cause is unclear. This is usually corrected after infusions are discontinued.
  - Monitor liver enzymes weekly. Abnormal values are seen within weeks.
  - Patients at risk: preexisting GI/liver disorders, malnutrition, severe infection
  - Avoid giving excess energy, dextrose, or lipids.
  - Various critical illnesses and disease treatments can also cause liver complications, so parenteral nutrition cannot be assumed to be the underlying cause

Metabolic Complications

- Gallbladder disease

  - Usually develops when GI is not used for long periods (> 4 weeks)
  - Thickened bile may build up in gallbladder → formation of gallbladder stones
  - Management: Initiate enteral feedings, patients may be given medications to stimulate gallbladder contraction, or gallbladder may be removed surgically

Metabolic Complications

- Metabolic Bone Disease

  - Prolonger parenteral nutrition is associated with reduced bone mineralization and lower bone density
  - Cause: related to altered intakes or metabolism of calcium, phosphorus, magnesium, and vitamin D.
  - Management: dietary adjustment, nutrient supplementation, medications, and physical activity.

Monitoring Parenteral Nutrition

Before starting:

1. Perform a nutrition assessment.
2. Record height and weight.
3. Check laboratory values, including the complete blood count, blood glucose levels, blood triglycerides, plasma proteins, serum bilirubin, liver enzyme levels, blood urea nitrogen, serum creatinine, and serum electrolytes (sodium, potassium, chloride, calcium, magnesium, phosphate, bicarbonate).
4. Check the parenteral solution label to ensure that solution components are correct and the expiration date is appropriate.
5. Visually inspect the solution to detect possible defects or visible changes in quality.
6. Confirm catheter placement by X-ray.

Monitoring Parenteral Nutrition

every 4 to 8 hr:

1. Check vital signs, including body temperature.
2. Inspect the catheter site for signs of inflammation or infection (frequency depends on patient condition).
3. Check the pump infusion rate and appearance of parenteral solution and tubing.
4. Check blood glucose levels (once stabilized, check daily).

Monitoring Parenteral Nutrition

Daily:

1. Replace the parenteral solution and tubing.
2. Monitor weight changes.
3. Record fluid intake and output.
4. Check blood glucose levels, blood urea nitrogen, serum creatinine, and serum electrolytes until stabilized.

Several times weekly (or as needed):

1. Reassess nutrition status.
2. Check laboratory values to monitor blood chemistry.

Discontinuing parenteral nutrition

- The patient must have adequate GI function before parenteral infusions can be tapered off and enteral feedings begun.
- Challenges: patient's appetite
- Possibly switch to nocturnal cyclic feedings before beginning oral intakes.
- During the transition to oral feedings, a combination of feeding methods is often necessary.
- A more gradual transition may be necessary for pediatric patients, patients who are older or debilitated, and patients who were without oral intakes for more than 2 weeks

Discontinuing parenteral nutrition

- Clear liquids are generally the first foods offered
- Later feedings include beverages and solid foods that are unlikely to cause discomfort (low-fat lactose-free diet)
- Notice GI symptoms. If present limit size or frequency until intestines adapt.
- When 60-75% of needs are met, parenteral infusions may be stopped.

Nutrition Support at Home

PN at Home

What to consider?

- Long-term therapy requires access to the larger, central veins that are appropriate for TPN.
- Most people prefer cyclic infusions over continuous infusions and transition to cyclic infusions before discharge from the hospital.
- Sufficient battery backup is necessary in case electric service is interrupted.
- Portable pumps are useful for individuals who prefer to infuse during the day or have active lifestyles.
- Parenteral solutions need to be sterile, aseptically prepared, and properly stored

Quality-of-Life Issues

Challenges: Users and their families may struggle with the lifestyle adjustments required, High costs, time consuming and inconvenience, explaining one's medical needs may be embarrassing, possible disturbed sleep in nocturnal feedings, inability to consume meals with family and friends

Support groups or counseling resources can help patients cope with the demands of treatment. The Oley Foundation (oley.org) is an excellent source.

Case study (page 675)

Jerry Huang, a 27-year-old man with an inflammatory intestinal disease, underwent a surgical procedure in which a substantial portion of his small intestine was removed. He had received TPN prior to surgery and continued to receive it afterwards. After 10 days, tube feeding was begun and initially delivered very small feedings.

Case study (page 675)

1. List some reasons why the nutrition support team initially chose TPN as a means of nutrition support for this patient. How would you explain the need for parenteral nutrition to Jerry?

2. Describe the components of a typical TPN solution. Calculate the energy content of 1 liter of a solution that provides 140 grams of dextrose monohydrate, 45 grams of amino acids, and 90 milliliters of 20 percent lipid emulsion. Then calculate the nonprotein kcalorie-to-nitrogen ratio in the solution. If Jerry's energy requirement is 2100 kcalories per day, how many liters of solution will he need each day?

3. Why is it important that Jerry begin enteral feedings as soon as possible? Assuming that Jerry eventually tolerates a tube feeding, in what ways can the health care team help Jerry make the transition from parenteral nutrition to tube feedings? Consider some of the physiological problems that Jerry might face when he begins eating an oral diet.

4. If Jerry is unable to meet his nutrient needs orally, he may need to continue tube feeding or TPN at home. As you read through the section on nutrition support at home, consider the factors that would make Jerry a good candidate for a home nutrition support program. Consider both the benefits of a proposed program and the problems he could encounter.