

Nutrition Support Handbook

2nd Edition

*Walter Reed Army Medical Center
Washington, DC*

Second Edition; Dec 2002

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Information in this booklet should be used as a guide only. It is designed to assist medical professionals in the nutritional care of **adult** patients. The evolving nature of nutrition science mandates that the care of each patient be individualized.

This booklet is intended for the use of the patient care staff at Walter Reed Army Medical Center, Washington, D.C. and not for general distribution or sale.

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Introduction

Prolonged, excessive starvation can be life threatening. It may also add to the morbidity and mortality of already-ill patients. There are strong associations of malnutrition with poor outcome; the cause-and-effect nature is less clear. Many studies using nutrition support have been done; unfortunately few show clear-cut benefits in clinical outcome. Serious adversities of nutrition support can result from mechanical, infectious, metabolic, and GI complications. **INAPPROPRIATE FEEDING or OVERFEEDING MAY BE AS HARMFUL AS NOT FEEDING.** Therefore, a major goal is to **PREVENT UNNECESSARY HARMFUL STARVATION and SUPPORT THE HOST'S METABOLIC and IMMUNE RESPONSE WHILE MINIMIZING MORBIDITY FROM NUTRITION SUPPORT.**

The timing of nutrition support in relation to the patient's illness is yet another poorly defined issue. Different nutrients may benefit the host at different times; these facts are not yet known. Therefore, this guide should be combined with solid clinical judgment in the delivery of nutritional therapies to individual patients.

MALNUTRITION may be defined as an absolute or relative deficiency of nutrients relative to body requirements, which contributes to an abnormality in body composition and/or function. This deficiency may arise from inadequate intake or absorption, abnormal losses or altered utilization secondary to disease, drugs or other interventions.

Unstressed starvation leads to **MARASMUS**, a wasting of body energy stores, to include body fat and somatic muscle protein with relative preservation of the functioning visceral protein compartment

(the circulating serum proteins) and the immune system. The physical hallmark is wasting and dramatic weight loss. In the absence of stress, adaptation occurs. The initial muscle protein loss used for energy via gluconeogenesis slows as fat and ketone utilization increases. Daily nitrogen losses drop from an initial 10 - 15 gm to 2 - 4 gm. (One gram of nitrogen represents about 6.25 gm of protein.) The body normally contains 10-15 kg of protein. As it takes a loss of 10-20% of the body's protein to cause functional deficits and a 25-40% loss to accelerate morbidity and mortality, the individual is able to withstand many weeks before succumbing to pure starvation.

Stressed metabolism on the other hand, overcomes many of the body's adaptive processes and leads to serious sequelae earlier. This form of malnutrition is HYPOALBUMINEMIC MALNUTRITION, similar to the KWASHIORKOR of undeveloped regions. An excessive duration and magnitude of hormonal and cytokine signals promotes a continuing acute phase liver response and amino acid redistribution to include accelerated gluconeogenesis, acute phase protein synthesis, and lipoprotein synthesis. There is muscle protein breakdown (CATABOLISM), and sometimes elevated energy expenditure (HYPERMETABOLISM). These processes make glucose fuel and acute phase proteins available to tissues involved in host defense. Anorexia further impairs nutrient intake and availability. This stressed state is characterized by altered/impaired immune responses, decreased circulating serum proteins, and variable body weight (losses may be masked by edema). There is a marked loss of intracellular body cell mass with an increase in extracellular space. The initial response of anorexia and amino acid redistribution is likely beneficial, but with prolongation results in excessive loss of lean mass and immune function. The continuing gluconeogenesis, protein turnover and 15 - 20 gm/day nitrogen loss driven by the injury response bring about a critical loss of lean mass in 2 - 3 wks, if not sooner.

Nutrition Assessment

History and Interview: weight changes, appetite, satiety, recent vs. usual food intake, alcohol, dietary/herbal supplements, food intolerances, GI complaints, and changes in functional status.

Unintentional weight loss of:

> 10% within 6 mo is associated with significant malnutrition and is a negative prognosticator of clinical outcome in surgery and oncology patients.

5-10% within 1 month may also indicate significant wt loss.

Conditions associated with Malnutrition Risk: trauma, burns, prolonged NPO or clear liquids, sepsis, organ failure, chronic infections/inflammation, >75 y/o, >65 y/o and admitted for surgery, neoplastic diseases, endocrine disorders (e.g., diabetes), digestive or absorptive disorders, tobacco or alcohol abuse, poverty, poor oral health, mental illness, impaired ADL, fatigue/weakness.

Physical Findings possibly associated with Malnutrition: hollowing of the temples, cachexia, signs of dehydration (poor skin turgor, sunken eyes, dry mucous membranes), edema, poor hair quality, skin ulcers or rashes, poorly healing surgical or traumatic wounds, pallor or redness of gums, cheilosis, stomatitis, or glossitis.

Obesity is also a risk factor for increased morbidity.

<80% of Desirable Body Weight (DBW) is associated with at least moderate malnutrition.

DBW estimated from 1983 Metropolitan Height Weight Tables:

Female: 119 lb for 5 ft; add 3 lb for each additional inch

Male: 135 lb for 5 ft, 3 in; add 3 lb for each additional inch

Small Frame: Subtract 10% Large Frame: Add 10%

Effect of Selected Drugs on Nutritional Status			
Drug	Nutritional Implication	Drug	Nutritional Implication
Alcohol	loss of thiamin, folate, vitamin B12, Mg, zinc	Corticosteroids	glucose intolerance; protein catabolism; increase need for vitamin D, and possibly Ca, K, vitamin A, and vitamin C
Amphotericin	loss of K, Mg	Diuretic	loss of K, Mg, thiamin, Ca anorexia, nausea
Antacids	decreased absorption of iron, thiamin, folate	Isoniazid	pyridoxine (B6) depletion, decreased folate
Anticonvulsants	decreased 25-OH vitamin D3, Ca, Mg	Proton Pump Inhibitors	decreased absorption of vitamin B12 from food; possibly decreased iron
Aspirin	decreased vitamin C, vitamin B12	Phenytoin	may need folate, vit D, Ca, thiamin, Ca and Mg decrease drug absorption

Serum Protein Assessment:

Albumin, and **prealbumin (transthyretin)** are synthesized in the liver. They are **negative acute-phase** proteins. Levels decline rapidly during stress/surgery/infection.

Albumin: not sensitive or specific to nutritional status; useful as a prognostic index for morbidity and mortality; may help to identify patients on DOA at high risk for becoming malnourished. **Preop alb <2.8 associated w/ major complications and risk for clinically significant malnutrition.** Long half-life (14-20 d) and dilutional effect of hydration contribute to its delayed response to nutrition.

Prealbumin: inverse association with C-reactive protein; increased by corticosteroids and renal failure. 2-3 d half-life. Can have a (+) association with acute nutritional adequacy (CHO and protein intake), although significant changes in levels may take 6-7 days. (See page 40.)

Prealbumin depression and associated risk of poor clinical outcome:

Mild: 11-15 mg/dl **Moderate:** 5-10 mg/dl **Severe:** <5 mg/dl

Critical Components of the Nutrition Assessment

- **Adequacy of recent (1-2 wk) nutritional intake**
- **Unintentional body weight loss**
- **Level of metabolic stress and physical functioning**

Nutritional Requirements

Energy Requirements

A patient's energy requirement can be met, at least in part, from endogenous fuel stores, especially fat. For this reason, it is not always necessary to meet 100% of patients' **total energy expenditure (TEE)** with food or nutrition support on a short-term basis. However, in a study by Mault, development of a cumulative negative energy balance of >10,000 Kcal while in the ICU was associated with prolonged mechanical ventilation and LOS.

In studies showing positive clinical outcomes, patients were fed **> 50% of their TEE**.

Hypocaloric feeding with adequate protein can be justified by obesity (see page 48), poorly controlled glucose, or when starting to feed malnourished or highly stressed patients.

Hypercaloric feeding can be justified in underweight preoperative patients and during unstressed convalescence. 500 to 600 additional Kcal/d promotes 1-lb to 0.5 kg/wk weight gain. However, excess Kcal can increase risk of complications. (See page 41 - 43.)

Basal energy expenditure (BEE) refers to that energy expended in 24 hr to maintain life processes at complete rest, after a 12 hr fast in a thermoneutral environment. For practical reasons, BEE is now rarely measured. **Resting energy expenditure (REE)** refers to energy expended over 24 hr at rest under conditions other than strictly basal. Since the REE is only 5-10% > than BEE, the same equations to estimate BEE can be used to estimate REE.

Methods to Estimate Energy Expenditure

1) **Harris-Benedict equation** estimates BEE (REE) in healthy, unstressed adults:

(wt = weight in kg, ht = height in cm)

men: $66.5 + (13.8 \times wt) + (5 \times ht) - (6.8 \times age)$

women: $655.1 + (9.6 \times wt) + (1.8 \times ht) - (4.7 \times age)$

Stress and Activity factors - Stress/injury and activity factors may be required along with the Harris Benedict equation to estimate TEE.

$$TEE = REE \times \text{stress factor} \times \text{activity factor}$$

Stress Factors Activity Factors

<1.0 hypotensive shock (anaerobic) **1.0 - 1.15** bedrest

0.85 simple starvation **1.2 - 1.3** mildly ambulatory

1.10 elective surgery

1.2 - 1.5 multiple trauma, closed head injury, sepsis, SIRS

1.07 (7% increase) for each degree above 98.6 F, or 1.13 (13% increase) for each degree above 37 C.

(To avoid extreme overestimation of EE, **do not exceed a total stress factor of 1.5.**)

2) **Harris-Benedict equation x 1.3** estimates average TEE in ICU patients.

3) **25 Kcal/kg/d**, ranging from 20 - 40 kcal/kg/d, estimates mean **TEE** in hospitalized adults, including those in the ICU.

4) **Indirect Calorimetry** - using a "metabolic cart" measures oxygen consumption and carbon dioxide production. It allows for **the most accurate clinical calculation of REE (including any stress)**, which is also called the **measured energy expenditure (MEE)**. It may be necessary to include an activity factor (page 7) to estimate TEE.

Protein Requirements

Protein needs are usually based on a patient's nonedematous body weight.

Factors used to estimate protein requirements:

g/kg/day

Non-stressed **0.8 - 1.0**

Stressed* **1.2 - 1.5 (up to 2.0)**

Repletion **1.3 - 1.5**

* In many **critically ill patients**, **1.2 - 1.3 g protein/kg** of non-edematous weight (or **1.0 g/kg** of current edematous weight) suffices to minimize net loss of body protein.

See handbook sections on obesity, liver failure, pancreatitis, renal failure, and trauma/sepsis for additional protein guidelines.

Macronutrients

Protein / Amino Acids (See Protein Requirements, page 8.)

- 4 kcal/g
- Usual recommended dietary range is 10-35% of total caloric intake.
- Excessive protein can cause azotemia and lead to dehydration through diuresis.

Carbohydrate (CHO)

- Dietary carbohydrate = 4 kcal/g; IV dextrose = 3.4 kcal/g
- Usual recommended dietary range is 45-65% of total caloric intake.
- CHO intake should not exceed 5-7 mg/kg/min (or 7-8 g/kg/d). Limit to 4 mg/kg/min in ICU.
- Complications from excessive CHO intake: hyperglycemia, hypercapnea, hypertriglyceridemia

Fat

- Dietary fat = 9 kcal/g
- 20% IV fat = 10 kcal/g; 10% IV fat = 11 kcal/g, which includes Diprivan (Propofol®).
- Usual recommended dietary range is 20-35% of total caloric intake, with 12-17 gm/d of linoleic acid, and 1.1-1.6 gm/d of alpha linolenic acid to provide essential fatty acids.
- Fat administration should not exceed 1.5-2.5 g/kg/day to minimize the risk of immune dysfunction, enhanced inflammatory response, and hypertriglyceridemia.

Electrolytes

Electrolytes are initially added to parenteral nutrition in amounts approximating the normal requirements in adults (see table 1, and see page 36 for acid-base considerations). Individual needs can vary greatly, therefore, need to monitor serum levels. Enteral formulas vary in electrolyte content. Additionally, absorption from the GI tract can be <100%, therefore, the oral dosage may be > the parenteral dosage. Review specific dosage/pharmacokinetics or contact a pharmacist or nutrition support dietitian for additional information.

Table 1. Estimated Daily Parenteral Electrolyte Requirements		
	<u>Normal</u>	<u>Renal failure</u>
Sodium (chloride or acetate)	60 - 150 mEq	30 - 100 mEq
Potassium (chloride, acetate, or phosphate)	60 - 120 mEq	30 - 60 mEq
Calcium* (gluconate)	10 - 15 mEq	10 - 15 mEq
Magnesium (sulfate)	10 - 20 mEq	4 - 10 mEq
Phosphorus* (sodium or potassium)	15 - 30 MMol	4 - 6 MMol
* Limited solubility in solution.		

Knowledge of the location and quantity of GI losses can better aid in replacing those electrolytes and preventing metabolic disturbances. (See table 2.)

Source	Sodium	Potassium	Chloride	Bicarbonate
Gastric	60	10	90	NA
Upper small bowel	100	15	100	20
Ileum	115	5	100	20
Bile	145	5	100	35
Pancreatic fistula	140	5	75	90
Diarrhea	60	45	45	45

Vitamins and Trace Minerals

Oral. Adults >50 y/o may require a synthetic source of vitamin B12 which can be obtained from an oral B12 supplement, multivitamin (MVI) supplement, tube feeding formula, or fortified foods. If you suspect that a patient may have suboptimal vitamin status, supplementing with an oral MVI may be indicated. Oral MVIs that are available at WRAMC include:

- **MVI:** 100% adult RDA levels of vitamins (except vitamin K); does not contain minerals
- **Centrum Kids Complete®:** chewable MVI with minerals; **1 tab** = 100% adult vitamin RDAs (13% for vitamin K), 100% RDA for Fe, Zn, Cu, Iodine; **1/2 tab** = RDA for 4-10 y/o
- **Prenatal vitamin ("PNV"):** MVI for pregnancy with iron and calcium
- **Nephrocap®:** water soluble MVI for renal failure patients, including dialysis

WRAMC also has numerous individual vitamin and mineral supplements.

- Therapeutic iron supplementation is not generally recommended without objective evidence of iron deficiency.
- It is recommended to give (enterally or parenterally) 50-100 mg/d of thiamin and a standard MVI qd (which includes folate) for 3 days to patients at risk for alcohol abuse.

Parenteral Multivitamins. 10 ml of standard parenteral MVI (see page 29) meets the normal daily IV requirements of most or all vitamins. Parenteral MVI may be indicated even prior to the start of TPN or PPN in malnourished patients unable to be fed enterally.

Parenteral Multiple Trace Minerals. "MTE-5" (see page 29) meets approximate normal daily parenteral requirements for trace minerals (except iron).

- Additional zinc (2-4 mg/day) may be added to parenteral nutrition solutions in patients with hypercatabolism. There may be a loss of 12 mg zinc/L of diarrhea or bowel fistula output.
- Iron is not added to our TPN/PPN because large amounts of iron are not compatible with IV fat emulsions. In those patients without iron intake for prolonged periods, supplementation with iron (enterally or parenterally) may become necessary if iron deficiency is diagnosed.

Normal Fluid Requirements

* Per kilogram method

older than 55 years 25-30 ml/kg/day

18-55 years 35 ml/kg/day

muscular young adults 40 ml/kg/day

* Kilogram Increment ml/kg/day

first 10 kg 100

next 10 kg 50

each additional kg (if < 50 yr) 20

each additional kg (if > 50 yr) 15

Oral Diets and Supplements

Prior to starting a patient on an oral diet, assess risk for dysphagia and aspiration, especially in individuals with mental status or neurological defects and those who were on a ventilator.

Clear liquid diet supplies fluid and sugar in a form that requires minimal digestion, stimulation, and elimination by the gastrointestinal tract. It is often ordered before or after surgery, or after prolonged fasting. This diet is inadequate in all nutrients: 600 Kcal, 150 g CHO, and negligible protein and fat. Clear liquids can be supplemented with Resource (page 15).

Full liquid diet may be used when progressing to solid foods, with chewing or swallowing problems, gastric stasis or partial ileus. Adequate in most nutrients (especially if a high protein liquid supplement is added...see page 15-16). Because milk-based foods constitute a large portion of this diet, patients with milk/lactose intolerance may need milk substitutions, such as Ensure HP.

Progression to solid food may include consistency modifications, such as **pureed**, for significant problems chewing or swallowing.

Mechanical soft diet is appropriate for many patients having difficulty eating because of mild difficulty chewing, mild dysphagia or weakness.

Soft postsurgical diet provides fairly easy to digest items, but requires normal ability to chew.

Patients recovering from recent gastrectomy may need a **postgastrectomy** diet that includes snacks, limits simple sugars and size of meals, and discourages liquid intake with solids.

NOTE: Diabetic, cardiac, and renal diets restrict the type and amount of food provided, therefore, may not be appropriate in patients who are eating poorly. If only a sodium restriction is desired, order a 2 gm Na diet, not a cardiac prudent diet (CPD).

Oral Liquid Supplements at WRAMC

- **Resource Fruit Beverage:** 8 oz., high protein, no fat, clear liquid, lactose-free Berry, Peach, and Orange flavors. 250 Kcal, 9 gm Protein, 53 g CHO, 0 gm Fat <80 mg Na, <20 mg K, 160 mg Phos, 10 mg Ca, 1 mg Mg
- **Ensure High Protein:** 8 oz., high protein, high Kcal, low residue, lactose-free Vanilla, Chocolate, and Berry flavors. 230 Kcal, 12 gm Protein, 31 gm CHO, 6 gm Fat 290 mg Na, 500 mg K, 250 mg Phos, 240 mg Ca, 100 mg Mg
- **Health Shake:** 6 oz., high Kcal, moderate protein, dairy shake, small-moderate lactose Vanilla, Chocolate, and Berry flavors. 300 Kcal, 9 gm Protein, 53 gm CHO, 6 gm Fat 175 mg Na, 250 mg K, 200 mg Phos, 220 mg Ca, 220 mg Mg
- **Nepro:** 8 oz., low in K, Phos, Mg, water; high in Kcal and fat; moderate protein, lactose-free Vanilla and Butter Pecan flavors. 475 Kcal, 16.6 gm Protein, 53 gm CHO, 23 gm Fat 200 mg Na, 250 mg K, 165 mg Phos, 325 mg Ca, 50 mg Mg
- **Instant Breakfast,** Regular or No Sugar Added: Mix powder packet with 8 oz. milk for high protein, high Kcal dairy shake, high in lactose. Vanilla or Chocolate flavors.
Regular instant breakfast w/whole milk = 280 Kcal, 12 gm protein, 40 gm CHO, 8-9 gm fat, 220-250 mg Na, 630-730 mg K, 310 mg Phos, 89 mg Ca, 89 mg Mg

- **Scandishake:** Mix powder packet with 8 oz milk (or substitute) for very high Kcal, moderate protein shake with **no added vitamins or minerals**. Vanilla or Chocolate flavors.
Mixed with whole milk: 600 Kcal, 13 gm Protein, 69 gm CHO, 29 gm Fat, 215 mg Na, 650 mg K, high in phos and Ca, no info. for Mg

Modular Enteral/Oral Additives at WRAMC

- **ProMod:** Whey protein powder. 1 scoop = 5 g protein. Mix 1 scoop with 50-100 ml of water (for bolus administration into enteral feeding tube) or mix with oral liquids or pureed foods.
- **GlutaSolve:** glutamine powder, 1 pkg = 15 g glutamine. Mix with liquid to drink or bolus.
- **Polydose Powder:** Glucose polymers, 1 tbsp powder = 23 Kcal
- **Microlipid:** 50% safflower oil/50% water emulsion. 1 ml = 4.5 Kcal.
- **Medium Chain Triglyceride (MCT) Oil:** 15 ml (1 tbsp) = 115 Kcal. Does not emulsify w/ water.
- **Instant Food Thickener** See instructions on can for a nectar, honey or pudding-like consistency. (Food thickener significantly reduces the palatability of beverages.)

Nutrition Support

Nutrition support (NS) generally refers to parenteral and/or enteral tube feeding.

If and **when** to begin NS is unclear in many patient populations. In postop patients, Sandstrom, et al, found morbidity and mortality increased significantly after 2 wk of glucose infusion when compared to full TPN and that initiating TPN after 2 wk did not improve outcome.

There have been some positive outcomes reported when > 50% of feeding goal was met, but no positive outcomes reported when intake was < 50% of protein and energy needs.

Situations That May Warrant NS

- * Inadequate oral intake (or strong anticipation of) for 7 - 14 days in a previously well-nourished patient without severe stress.
- * Critically ill and inadequate oral intake (or strong anticipation of) for 5 - 10 days. Attempt early feeding, preferably enteral feeding, in major trauma and burn patients.
- * Moderate to severe malnutrition and inadequate oral intake (or strong anticipation of) for > 4 days.
- * Moderate to severe malnutrition and critically ill. Consider early NS, as soon as safe feeding access can be provided and patient is hemodynamically stable.
- * Moderate to severe malnutrition and planned elective surgery. Consider 1 - 2 wk preoperative NS, followed by postoperative NS until patient resumes oral intake. For elective GI surgery, consider use of immune-enhancing oral/enteral feeding (see page 22).

Outcomes in Early (<48-72 hr after insult) vs Delayed NS

- ◇ **Major abdominal trauma surgery:** Early jejunal feeding was associated with a significantly lower sepsis rate compared to patients without any early NS. However, 26% of control patients received TPN after day 5, which complicates interpretation of results.
- ◇ **Moderate to severe traumatic brain injury:** Use of early NS (enteral and/or parenteral) may decrease: infections, disability, and LOS.
- ◇ **Elective GI surgery:** *Moderately to severely malnourished* patients should receive 1-2 wk preop (and postop) NS to decrease postop complications, preferably using an immune-enhancing formula, such as Impact, or if unable to feed enterally, with TPN or PPN. TPN should not be routinely given in the immediate postop (or preop) period secondary to overall increase in infectious complications in fairly well-nourished patients.
- ◇ **Malnourished elderly women s/p hip fracture requiring surgery:** Those given early postoperative oral or enteral tube supplementation had less morbidity and mortality than unsupplemented patients.
- ◇ **Liver transplant:** Decreased postop infections with early enteral feeding (vs. simple IVF). Decrease in ICU LOS with TPN (vs. simple IVF). A study failed to show any clinical differences between use of TPN and enteral feeding.
- ◇ **Major Burns:** Positive outcome benefits have also been suggested with early enteral feeding.

Enteral vs Parenteral Nutrition

In controlled animal trials, chow fed animals do better than those given parenteral or liquid enteral formulations. Enterally fed mice generally have a better outcome than parenterally fed mice. Therefore, the use of oral intake with a variety of "real food" may be preferable.

Overall, the literature does not clearly show a difference in clinical outcomes between enteral and parenteral tube feeding in hospitalized patients. The potential mechanical, metabolic, and infectious complications of both forms of delivery are significant and can be minimized with careful precautions. Overfeeding and hyperglycemia (which is easy with TPN) increases complications, including sepsis.

"IF THE GUT WORKS, USE IT." This expression is commonly heard on rounds. Why?

- Cost. Enteral formulas cost 1/2 to 1/20 the cost of parenteral solutions.
- Possible metabolic and immune function advantages that are absent when the parenteral route only is used. Gut lymphoid populations suffer, and immune functions such as IgA secretion are impaired in parenteral feeding.
- Hepatobiliary dysfunction, to include cholestasis, gallbladder sludge and acalculous cholecystitis may be more frequent when enteral stimulation is absent and/or parenteral feeding is long-term.
- Absence of "food-like" substances from parenteral solutions, such as choline, nucleotides, fiber, phytochemicals, and others yet unidentified, may compromise immune and hepatic health.
- Early enteral feeding has yielded fewer infectious complications than those randomized to parenteral nutrition in the trauma population.

In defense of parenteral feeding:

- There is little evidence that several processes described in animals and ascribed to TPN, such as severe intestinal atrophy and increased bacterial translocation, significantly occur in humans.
- We are not aware of any positive clinical outcomes in humans with so-called “trophic” enteral feeding, providing <50% of nutritional needs.
- TPN undertaken by experienced nutrition support teams does not cause more complications than does enteral tube feeding. In a recent 562 patient trial Woodcock, et al, compared enteral feeding to TPN. Sepsis rates were not different, but enteral feeding delivered less nutritional intake than TPN, and procedure-related complications were greater with enteral tube feeding compared to TPN.

Recommendation:

If the GI tract can **safely** be used for feeding it should be considered first. Strive to transition from parenteral to enteral or oral nutrition and to feed the gut with complex substances if possible.

Enteral Tube Feeding (TF)

Indications for enteral TF: Patients with adequate GI function, inadequate oral intake, at significant risk for clinical malnutrition, and who are likely to benefit from nutrition support. See pages 17-18.

Contraindications for enteral TF:

- Complete bowel obstruction or severe bowel ileus
- Intractable vomiting; major UGI hemorrhage
- Complete inability to absorb nutrients through the GI tract
- Severe hemodynamic instability, severe post prandial pain, GI ischemia, diffuse peritonitis
- Inability to obtain safe or proper enteral access or maintain elevation of upper body
- GI abscesses, fistulas, or lymphatic (chylous) injury that seriously impair feeding integrity
- No outcome benefit expected or risk is greater than expected benefit
- Patient refuses (This does not suggest that TPN should then be offered.)

Enteral Access (Tubes)

Nasoenteric: To feed the stomach, duodenum, or jejunum. Appropriate for short-term use. Can cause patient discomfort, bleeding and sinusitis. **Postpyloric TF**, especially **beyond the Ligament of Treitz**, reduces the risk of gastroesophageal reflux and possibly aspiration compared to gastric TF.

Orogastric: Desirable in mechanically ventilated patients to prevent sinusitis.

Gastrostomy: Long-term (>6 wk) access. Inserted by surgery, endoscopy or fluoroscopy.

Percutaneous endoscopic gastrostomy (PEG) is the most popular. Complications include tube dislodgment, bleeding, infection, leakage, and persistent gastric fistula. PEG tubes with a jejunal extension (PEG/J) may be beneficial in acute-care when a patient requiring long-term access cannot tolerate gastric feeding short-term.

Jejunostomy: (usually placed surgically) For short and long-term TF into the small bowel. Indicated when unable or unsafe to feed stomach, e.g., prolonged gastric ileus or obstruction, severe gastroparesis, gastric reflux, severe trauma, or expected multiple operative procedures. Complications include tube dislodgement (they are difficult to replace), clogging, and bowel obstruction.

Formula Selection (see table 3, page 25-26):

- * **Average patients** generally tolerate standard 1 Kcal/ml isotonic formulas, 16-17% of Kcal from protein, e.g., **Osmolite HN** (low residue) or **Jevity** (contains soy fiber)
- * **Volume intolerance** - use a 1.5 Kcal/ml formula, e.g. **Isosource 1.5**, which may help to reduce gastric residuals, as well as limit water volume
- * **Catabolic protein losing state** - use high protein formula, e.g. **Promote with Fiber**
- * **Renal failure** - use a renal formula with less fluid volume and electrolytes, e.g. **Nepro**
- * **Malabsorption** - consider need for a peptide/amino acid, low fat formula, e.g. **Pep tinex**
- * **Elective GI surgery and significantly malnourished** - consider use of an immune-modulating formula 1-2 wks preop. and early postop., e.g., **Impact** to decrease infectious complications
- * **Long-term** nutritional adequacy, cost, and availability may need to be considered

- * **Reassess choice of formula** if the selected one does not provide sufficient calories, protein, vitamins and minerals, and then consider need for additional nutrient (modular) additives (page 15), including need for vitamins or minerals
- * **Constipation** (but not impaction) or **diarrhea**, may be helped by gradually advancing to a **fiber-containing formula or psyllium** (in 8 oz water 1-3 x day)

Administration Guidelines:

WRAMC has an **Enteral Feeding Protocol** available for use in CIS "Standard Orders" in the ICU's.

- **Nasoenteric or orogastric tube placement** should be **verified radiographically** before feeding. (If the tube has moved >10 cm it should be reinserted and radiographic confirmation obtained.)
- **Hang no more than a 8-12 hr supply of formula** at one time to minimize risk of microbial contamination. **If rate of infusion is <20 ml/hr, change feeding bag q 12 hr.**
- **Label bag** with formula, **date and time hung** and **change feeding bag** and tube **q 24 hr** (or less if same formula is still in the bag after 8-12 hr).
- **Avoid handling.** Adding meds, water, etc. to the feeding bag, increases the potential for microbial contamination. Better to bolus water than add it to bag. Routine addition of dye to TF is not recommended for a number of reasons, including potential contamination.

- **Elevate head of bed 45 degrees** during, and at least 30-60 minutes after discontinuing TF.
- **Continuous pump-assisted feeding:** for most critically ill patients, jejunally-fed patients, and often for patients beginning TF to minimize risk of reflux, aspiration, distention and diarrhea.
- **Avoid bolus** feeding, esp. >250-350 ml, due to poor tolerance in some neurologically-impaired or critically-ill patients and those with gastroparesis.
- **Initiate** continuous TF at 20-30 ml/hr and **advance rate** by 10-25 ml q 4-6 hr, as tolerated, to goal. Calculate TF **goal rate** in the ICU based on a **"20-22 hr day"** to compensate for interruptions in feeding. Can alternatively give TF over 16 hr/d (TF goal rate based on 15 hr day).
- **Flush tube** with 20-30 ml of warmwater: **q 4 hr** during continuous TF, **immediately** after stopping infusion, and **before** and **after** each medication. (Metamucil and pills may clog small bore tube.)
- **Hold feeding** if there is significant hypotension, increased vasopressors, paralytic agents, emesis, increasing abdominal distention or pain, or repeated gastric residuals of >200 ml.
- The nurse should **assess all TF orders** before giving any feeding. **Any questionable or potentially harmful feeding order should be addressed directly with the physician.**

Table 3. WRAMC Enteral Formulary	Kcal/L	Protein g/L (% kcal)	CHO g/L (% kcal)	Fat g/L (% kcal)	% water	Osmolarity	Na mEq/L	K mEq/L	Phos mM/L	Mg mEq/L	Manufacturer
Osmolite HN (standard)	1000	44 (17)	144 (54)	35 (29)	84	300	40	40	24	13	Ross
Jevity (standard, w/ fiber)	1000	44 (17)	155 (54)	35 (29)	83	300	40	40	24	13	Ross
Promote (high protein w/ fiber)	1000	62 (25)	139 (50)	28 (25)	83	370	57	51	39	17	Ross
Isosource 1.5 (fluid restriction)	1500	68 (18)	170 (44)	65 (38)	78	650	56	58	34	18	Novartis

Table 3. (con) WRAMC Enteral Formulary	Kcal/L	Protein g/L (% kcal)	CHO g/L (% kcal)	Fat g/L (% kcal)	% water	Osmolarity	Na mEq/L	K mEq/L	Phos mEq/L	Mg mEq/L	Manufacturer
Nepro (renal)	2000	70 (14)	222 (43)	96 (43)	70	665	37	27	22	9	Ross
Pep tine x DT (low fat, peptide)	1000	50 (20)	160 (65)	17 (15)	83	460	74	21	21	11	Novartis
Impac t (immune- modulating)	1000	56 (22)	130 (53)	28 (25)	85	375	48	36	26	11	Novartis

Potential Complications with TF

- **Aspiration risk** greatest in ICU patients with: H/O previous aspiration, decreased consciousness, neuromuscular disease, endotracheal intubation, vomiting, failure to maintain elevated head of bed. **Recommendations:** 1) Verify tube placement if in doubt. 2) Avoid large-volume bolus feeding. 3) With multiple risk factors for aspiration (see above) or gastroparesis, use pro-motility agents (metoclopramide or erythromycin). 4) If gastric emptying remains poor or if multiple risk factors for aspiration (see above), feed into small bowel, preferably jejunum.
- Do not TF during extreme hypotensive shock due to case reports of **bowel ischemia, necrosis** and/or **perforation**.
- **Obstruction of feeding tube lumen.** Suction, then attempt flush with warm distilled water. If unsuccessful, suction; inject a mixture of 1/4 tsp Viokase (pancreatic enzyme powder), one crushed 324 mg Na bicarbonate tablet and 1.5 ml tap water. After 30 min, flush tube with warm water. (Acidic pH, such as cranberry juice, can precipitate protein and cause tube clogging.)
- **Diarrhea.** Stool assay for *C. difficile*. Avoid rapid feeding (bolus). Avoid enteral meds, esp. those containing sorbitol (elixirs), Phos and Mg. Dilute hypertonic meds and feeding formulas if diarrhea is osmotic. Consider low-fat, peptide or fiber-containing formulas; psyllium mixed with water; or antidiarrheal meds.
- **Microorganism contamination** can occur from excessive handling of the tube feeding (e.g. adding water or supplements to the TF bag), from prolonged formula hang time (> 8-12 hours), or use of our feeding tubing and bag for >24 hr. The tube can also be a source of infection, especially sinusitis.

Parenteral Nutrition

Indications for Parenteral Nutrition: When anticipated (or demonstrated) that the patient will be unable to obtain > 50% of nutritional needs from oral nutrition or TF for > 5-10 days. See page 17-18.

- * Massive Small Bowel Resection * GI Ischemia or Post-Prandial Pain
- * Intractable Vomiting * Bowel Obstruction/Ileus
- * Diffuse Peritonitis * Severe Radiation Enteritis
- * Severe Pancreatitis (see section on Pancreatitis) * Some GI Abscesses or Fistulas
- * Moderately to severely malnourished and preop for elective GI surgery, unable to feed enterally

The term 3-in-1, or total nutrient admixture (TNA) refers to a parenteral solution of amino acids, glucose, and fat emulsion in one bag. Electrolytes, vitamins, and trace minerals are also added.

Amino Acids = 4 Kcal/g

- Travasol 10% - designed to meet the needs of a typical patient
- Freamine HBC 6.9% - contains elevated levels of the branched chain amino acids which are preferentially catabolized during severe stress. Intended for patients with trauma or sepsis, however, only 1 clinical trial demonstrated superior clinical outcome (decreased mortality compared to standard amino acid TPN in septic ICU patients). This product is similar to amino acid solutions designed for patients with hepatic encephalopathy, and therefore, could reasonably be used in this population if Travasol 10% induces significant encephalopathy.

Dextrose 70% = 3.4 Kcal/g

Lipid Emulsion 20% = 10 Kcal/g; contains 20% soybean oil, glycerol, phospholipids

- IV fat infusion should not exceed 0.11 g/kg/hr to avoid variable changes in pulmonary blood flow, reticuloendothelial dysfunction, and increased risk for significant hypertriglyceridemia.
- Note: IV lipid can cause an **acute adverse clinical reaction** (see page 36) requiring immediate cessation of the infusion and omission of lipid from any future TPN.

Electrolytes - See table 1, page 10.

Vitamins: "MVI-12", "MVI-13" or "Infuvite" (10 ml) contains the following range of vitamins:

Ascorbic Acid	100-200 mg	Niacinamide	40 mg
Vitamin A	3300 IU	Pantothenic Acid	15 mg
Vitamin D	200 IU	Vitamin E	10 IU
Thiamine (B1)	3-6 mg	Biotin	60 mcg
Riboflavin (B2)	3.6 mg	Folic Acid	400-600 mcg
Pyridoxine (B6)	4-6 mg	Cyanocobalamin (B12)	5 mcg
vitamin K	0-150 mcg		

Multiple Trace Minerals (MTE)

MTE-5 (4 ml) contains the following trace minerals:

- Zinc 4 mg
- Copper 1.6 mg
- Manganese 0.4 mg
- Chromium 16 mcg
- Selenium 80 mcg

(See page 12-13 for more information on trace minerals.)

Sterile Water is added to peripheral parenteral nutrition and can be added to an individualized TPN formula by increasing the volume of solution ordered.

Peripheral Parenteral Nutrition (PPN)

The administration of amino acids, dextrose, fat emulsion, electrolytes, vitamins, and trace minerals via the peripheral venous system.

- It may be used for up to 2 weeks but often for only 3-5 days secondary to phlebitis.
- Our PPN usually meets 75-80% of TEE and 0.8-1.0 g/protein/kg/day. Additional IVF containing D5 can provide more Kcal.
- Our PPN provides 65% of the Kcal and 56% of the protein per liter as our standard TPN
- Fat and low dose hydrocortisone are prophylactic measures against thrombophlebitis
- Total osmolarity of our PPN = 750-800 mOsm/L
- Order in liters/day, usually dependent on how much fluid volume and fat the patient can tolerate, such as 1.6-3.0 L/day.

WRAMC Standard PPN contains the following:

Calories	650/L		
Protein	28 gm/L (17% of Kcal)	CaGlu	4 mEq/L
Dextrose	55 gm/L (29% of Kcal)	MgSO ₄	8 mEq/L
Fat	35 gm/L (54% of Kcal)	KPhos	6 mM/L
NaCl	30 mEq/L	MVI-12	10 ml/day
NaAc	30 mEq/L	MTE-5	4 ml/day
KCl	20 mEq/L	Hydrocortisone	5 mg/L

Individualized PPN: Contact a member of the nutrition support team for special ordering.

A **Peripherally Inserted Central Catheter (PICC)** is not necessary for the administration of PPN and obviates the primary advantage associated with PPN in comparison to TPN. (See table 4.)

Table 4. Advantages and Disadvantages of PPN
Advantages
Does not require a central line.
Associated with less hyperglycemia due to lower dextrose concentration.
Initiated at goal rate on day 1; no need to taper rate when terminating.
Disadvantages
High risk for peripheral vein thrombophlebitis. Requires good peripheral veins.
Contains significant amount of fluid and fat.
Requires inserting a new peripheral line every 48-72 hours.

Total Parenteral Nutrition (TPN)

Parenteral nutrition via a central vein is indicated in patients when: parenteral feeding is required for longer than one week, PPN is not possible (poor venous access, fluid or IV fat restriction), or nutrient needs are significantly greater than what PPN can provide.

1. **Standard TPN** - formula meets the needs of many patients requiring TPN. It contains a fixed macronutrient, electrolyte and micronutrient content. Ordered by volume but the amount ordered should be **based on the patient's energy and protein needs**. Supplemental fluid may be required to satisfy full fluid requirements. For patients without protein, mineral, acid or base restrictions. Standard TPN contains:

Protein 50 gm/L KCL 25mEq/L
Dextrose 153 gm/L CaGhuc 6 mEq/L
Fat 28 gm/L MgSO4 10 mEq/L
Kcal 1000 per L KPhos 10 mM/L
NaCl 30 mEq/L MVI-12 10 ml/day
NaAcetate 30 mEq/L MTE-5 4 ml/day

2. **Individualized TPN** - can be ordered if the standard TPN is not desirable. Amount of each ingredient can be individualized. A new TPN order form must be initiated in CIS (not copy and edit the standard TPN form) when changing from standard to individualized TPN. The nutrition support dietitian or nutrition support pharmacist (see inside cover) will be glad to assist you.

Ordering Guidelines for an Individualized TPN (TPN templates in CIS can do these calculations.)

a. Determine **total caloric requirements** (see page 6-8) = _____

b. Determine daily protein requirements (see page 8) and calculate **protein calories**

$$\text{Grams of protein} \times 4 \text{ Kcal/g} = \text{Protein calories} = \underline{\hspace{2cm}}$$

c. Determine **non-protein calories (NPC)**

$$\text{Total calories} - \text{protein calories} = \text{NPC} = \underline{\hspace{2cm}}$$

d. Calculate **grams of dextrose** and **fat** from NPC

$$\text{Grams of dextrose} = \frac{0.6-0.7}{3.4} \times \text{NPC} = \underline{\hspace{2cm}}$$

$$\text{Grams of fat} = \frac{0.3-0.4}{10} \times \text{NPC} = \underline{\hspace{2cm}}$$

e. Order **electrolytes** (see page 10), **vitamins** (page 12) and **trace minerals** (see pages 12 and 29)
Note that 1 mMol of KPhos = 1.5 mEq of K and that 1 mMol of Na Phos = 1.33 mMol of Na.

f. Determine **fluid requirements** (see page 13). If **additional volume** is desired in the TPN, modify the volume block of the Individualized TPN order form to reflect total volume desired. (Unfortunately, this template reverts back to the minimal volume whenever it is edited, therefore, modify the volume **after** all other changes are made in the TPN order.) The amount of Na may need to be adjusted as the default amounts of NaCl and Na acetate are based on an average TPN volume of approximately 1.5-2.5 L for patients with normal Na status.

* Don't forget to activate the "**TPN/PPN Standard Orders**" in the standard order section of CIS to ensure that initial baseline chemistries (see table 5), daily wt, I's and O's, etc., are ordered. This order set includes that the TPN or PPN should be administered at the rate printed on the label of the bag (unless overridden by physician order) to **minimize rate errors** and to enter the volume as "Intake".

Table 5. Standard Chemistry Monitoring with Parenteral Nutrition

Lab	Frequency
Na, K, Cl, HCO₃, Glucose, BUN, Cr	Days 1, 2, and 3 of TPN or PPN, then as needed
Ca, Phos, Magnesium, Albumin	Days 1, 2, and 3 of TPN or PPN, then as needed
Alk Phos, AST, ALT, Bilirubin, PT	Day 1 of TPN or PPN, then as needed
Glucose	BID if on TPN, adjusted frequency as needed
Triglyceride, Prealbumin	Day 1 of TPN or PPN, prealbumin q wk

Medication Additions to Parenteral Nutrition - The medications below are commonly added to parenteral nutrition solutions and have been determined to be compatible:

- **Insulin** - can be added to the TPN if glucose remains above 150-200 mg/dl and the use of an insulin drip is not feasible. See page 42 for specific guidelines on blood sugar control.
- **Histamine-2 antagonists (ranitidine, cimetidine)** - have been shown to be compatible with TNA solutions. The 24 hour dose can be ordered in the TNA. (Avoid duplicate med orders in CIS.)
- **Individual vitamins and minerals** - such as zinc, vitamin K, C, B12, folic acid, and thiamin are available as additives and are used when a deficiency exists or is anticipated. Vitamin C should probably not be added in large amounts to TPN since it degrades to oxalic acid and can form calcium oxalate precipitates. Iron is not compatible in fat containing TNA's.
- **Hydrocortisone** - at 5-10 mg/L can be added to PPN to possibly decrease risk of phlebitis.
- **Albumin** - has never been proven to be of nutritional benefit, but has been shown to be compatible at a concentration of 25 gm/L of TNA solution.

Acid-Base Considerations (Chloride and Acetate) - Chloride and/or acetate are also ordered when Na (and usually K) are ordered. Suggested amounts provide a chloride to acetate ratio of 2:1 - 1:1. Chloride causes H⁺ ion retention, which can induce a metabolic acidosis. Acetate is converted to bicarbonate, which can induce a metabolic alkalosis. Chloride is also supplied in many other IV solutions in the form of NaCl and KCl.

If primary metabolic acidosis or alkalosis is diagnosed, the chloride to acetate ratio can be modified in the parenteral nutrition solution.

Complications Possible with Parenteral Nutrition (Also see page 41-43, Management of Metabolic and Fluid Complications Associated with Nutrition Support)

Precipitation of Calcium and Phosphorus - The potential precipitation of calcium phosphate from TPN has been documented and was thought to be the cause of at least two deaths from pulmonary embolism. This problem is often difficult to predict because solubility in solution is dependent on other factors (e.g. pH, temp., amino acid concentration).

- If more than twice the usual amount of Ca and/or Phos is desired, order a separate infusion or call the pharmacy for solubility data.
- As an added precaution, a **1.2 micron filter** should be placed on each TPN or PPN line.

Visually inspect TNAs for precipitates, discoloration, or breaking of the fat-water emulsion.

Mildly elevated transaminase and alkaline phosphatase concentrations may occur days to weeks after initiation of TPN. Enzyme levels may return to normal while still on TPN but almost always normalize when TPN is stopped. (See "Home Nutrition Support" and "Liver Disease".)

Acute Adverse Reactions to Parenteral Nutrition:

Note that the IV lipids can cause an **acute adverse clinical reaction**, such as back or chest pain, dyspnea, cyanosis, flushing, dizziness, headache, nausea, etc., requiring immediate cessation of the infusion and omission of lipid from any future TPN. Submit an Acute Drug Reaction (ADR) report if this should occur. The IV sedative Diprivan (Propofol) contains the same type of IV lipid and may trigger the same clinical reactions.

Tips to Avoid Parenteral Nutrition Errors (or “How to Avoid Imitating the Authors!”)

1. The TPN/PPN order template is in the Note section of CIS. Use the standard TPN or PPN solution if possible and specify volume desired in L/d (not mL). Do not order the standard TPN formula to meet volume requirements if the calorie load will be excessive.
2. Ingredients in a standard TPN are expressed “per Liter”, but in an individualized TPN are “per Day”.
3. Unless otherwise ordered, the pharmacy only makes 1/2 of the TPN order on the first day of TPN to minimize risks of refeeding syndrome and hyperglycemia. The full TPN order is made by the 2nd bag and thereafter. (A full order of PPN is made on day 1 since PPN has a low dextrose concentration.)
4. Don't forget to activate the applicable “TPN/PPN Standard Orders” in the Standard Order section of CIS to ensure that proper baseline lab work, daily wt, “In's and Out's”, etc., are ordered. This order set includes that the TPN (or PPN) should be administered at the rate printed on the label of the bag unless overridden by a physician order (to minimize rate errors).
5. TPN/PPN must be ordered daily before 1300 hr. The first order must be printed and hand-delivered to 2nd floor pharmacy. To reorder, first “copy”, then “edit” if needed, and then store the “note”.
6. Do NOT attempt to use TPN to correct acute electrolyte deficits.
7. The Nutrition Support team members are usually available to assist you!

Discontinuing Parenteral Nutrition

- Decrease the **full TPN** volume/rate by 50% for 1 or 2 hrs before stopping it completely. This reduces the risk of rebound hypoglycemia. If abrupt discontinuation of full TPN cannot be avoided and the patient is not receiving oral/enteral nutrition, 10% dextrose may be administered at the same rate for 2 hours and then discontinued. (Prolonged administration of D10W can cause hyponatremia.)
- Full rate **PPN** may be stopped without decreasing the rate since it only contains 5.5% dextrose.
- TPN can have a negative effect on appetite, therefore, it is reasonable to decrease the rate of TPN when a PO diet (more than clear liquids) is ordered.
- In relatively well-nourished patients, TPN can be discontinued soon after oral or enteral nutrition is tolerated. In patients at higher risk for malnutrition, feeding should be gradually transitioned from parenteral to oral/enteral to ensure adequate intake. Once $\geq 60\%$ of goal energy and protein is met orally or enterally, TPN may be stopped.

Evaluating Nutrition Support Effectiveness

Weight. Although it is sometimes difficult to obtain a reliable weight it can be an important parameter to follow to help assess fluid balance and long-term appropriateness of caloric intake.

- A body fluid increase of **1 Liter = 1 Kg** wt gain
- Add or subtract 500 or 600 Kcal/d to promote 1-lb/wk or 0.5 kg/wk **wt gain or loss**, respectively
- Assuming normal fluid status, most patients should gain or lose no more than 1 kg/wk when receiving repletion (hypercaloric) or hypocaloric feeding, respectively.

Nitrogen Balance (NB) is the difference between the N intake and N excretion. A practical means to determine degree of catabolism and protein requirements. NB is estimated by the N intake along with collecting a "urine urea nitrogen, 24 hr". Stable N intake is required for accurate assessment. A factor of 3 to 4 gm is added to the N excretion to account for insensible N losses. The standard equation is:

$$\text{NB (+ or - 2 gm)} = \frac{\text{protein(gm) intake}}{6.25} - (24 \text{ hr UUN converted to gm} + 4 \text{ gm})$$

Consider increasing protein intake if in negative NB, however, negative NB may be unavoidable during high stress states, regardless of the amount of nutrients provided. Positive NB may be a reasonable goal during recovery, but may also require increased Calories. Limitations of the NB equation exist with renal impairment (Cr Cl <50) and large insensible losses (e.g., diarrhea). NB can be fraught with inaccurate urine collection, CHCS order entry error, lab error and miscalculation.

Prealbumin: monitor q wk as a marker for short-term gross adequacy of calorie and protein intake in patients with stable renal function, preferably not receiving corticosteroids. Prealbumin has an inverse correlation with C-reactive protein, therefore, it may not be a useful nutrition index in stressed states. Levels <1.1 mg/dl were associated with malnutrition. Levels >13.5 were associated with return to stable nutritional status in hospitalized patients.

Indirect calorimetry using a "metabolic cart" measures oxygen consumption ($\dot{V}O_2$) and carbon dioxide production ($\dot{V}CO_2$) by the patient and calculates respiratory quotient (RQ) and energy expenditure, extrapolated to 24 hr. Ideally, the measurement should be done in a resting state to = MREE. The RQ is the ratio of $\dot{V}CO_2$ to $\dot{V}O_2$ and reflects net substrate oxidation.

Indirect calorimetry may be indicated in the following situations:

- Difficulty weaning from mechanical ventilation and suspected underfeeding or overfeeding.
- Unexplained hyperglycemia or hypertriglyceridemia associated with feeding
- Failure to respond to current feeding as expected
- Patients with altered body composition (e.g., ascites) in whom standard energy equations are N/A
- Conditions, such as sepsis, in which the range of energy expenditure can be highly variable.

Interpretation of RQ:

- RQ < 0.81 suggests underfeeding
- RQ 0.8 - 0.95 suggests mixed substrate utilization; regimen roughly meeting TEE
- RQ > 1.0 suggests overfeeding (lipogenesis). Decrease total calories if overfeeding is not desired. (Or, the feeding solution may be modified by decreasing the CHO and increasing the fat).

Limitations of our metabolic cart:

- Unable to get accurate results if ventilator FIO₂ is >50%, while on hemodialysis, and if unable to obtain consistent measurements (steady state)
- Requires patient to be at rest, preferably with no interventions for 1 hr prior to study
- Patients with chest tubes and endotracheal cuffs must have no air leaks
- Cannot be used in patients getting supplemental oxygen unless they are on a mechanical ventilator
- Does not include miscellaneous energy expended in physical activities or stressful procedures

Management of Metabolic and Fluid Complications

- * **Refeeding Syndrome** - may result when refeeding malnourished patients, patients unfed for >1 wk, or highly stressed patients. Large amounts of calories, especially from carbohydrates, stimulate a surge in insulin release which can result in electrolyte abnormalities such as hypophosphatemia, hypokalemia, and hypomagnesemia. Refeeding syndrome may also be characterized by volume overload which may precipitate congestive heart failure. Begin nutrition support with less than the REE, such as our policy of making only a half order of TPN on day #1, and correct any serious electrolyte and fluid abnormalities before advancing calorie intake. The initial feeding goal should not exceed TEE.

- * **Hyperglycemia** is a common metabolic abnormality associated with TPN, but also seen in TF. It can lead to osmotic diuresis and immune dysfunction. Several studies have found that postoperative hyperglycemia was related to a significant increase in infections. In a study of postop, mostly cardiothoracic ICU patients, those in the intensive insulin therapy group (mean AM glucose of 103 mg/dL) had significantly less morbidity and mortality than the group with conventional treatment (mean AM glucose 153 mg/dL).

Recommendations to prevent or treat hyperglycemia:

- * **Avoid excessive total CHO and Kcal**, (DS, TPN, TF, and/or PO intake). Limit CHO to $\leq 4-5$ mg/kg/min. Sometimes useful to decrease CHO and increase fat.

- * **Order TPN at low end of estimated Kcal needs.** *

Hypocaloric feeding may be appropriate, especially in the obese (see page 48).

- * **PPN** can be used for short-term feeding and is less glycemic than TPN (see page 30).

- * **Do not increase Kcal intake if Glu >200.**

* **If Glu >150-200, monitor Glu, at least q 6h, order SSI insulin** (or if in an ICU, consider an IV insulin infusion). In insulin-requiring DM, can initially add 0.1 units of regular insulin to TPN for each gram of dextrose in TPN. Consider adding 50-75% of the previous 24 hr SSI to next TPN order. If longer-acting IM insulin is used BID, will need a ratio that is close to 1:1 for AM and PM insulin dosage when feeding is administered over 24 hr/d.

- * Use continuous rather than intermittent feeding (also decreases risk of hypoglycemia).

- * **Hypoglycemia** can be avoided by not adding insulin to TPN when hyperglycemia is likely transient. Patients at high risk for hypoglycemia, such as those on long-acting insulin and those with severe hepatic failure, may require supplemental CHO when feeding is stopped.

- * **Fluid Imbalances.** Water provided from all routes needs to be compared to the patient's estimated total losses to assess volume status. High-protein intake (≥ 1.5 g/kg/d) increase urinary fluid losses. Concentrated TF formulas (1.5-2.0 Kcal/mL) provide limited amounts of water. Minimal-volume TPN without additional fluids may not meet water requirements. Dehydration and overhydration can be assessed by monitoring fluid intake and output, wt change of $>$ or $<$ 0.2 kg/day, serum sodium, BUN:Cr, etc.
* Be aware of the electrolyte composition of fluid losses and patient's overall clinical status before making specific fluid replacement recommendations.
- * **Hypertiglyceridemia** has been associated with immune suppression, acute pancreatitis, and decreased alveolar oxygen transfer. More likely when fat infusion rates are high, esp. in poorly controlled diabetes, renal failure, and severe stress. Decrease infusion of fat, including Diprivan (Propofol), when TG is $>$ 400 mg/dl and D/C IV fat when TG is $>$ 500 mg/dl.
- * **Hypercapnia.** Common in patients with COPD. Worsened by the infusion of **excess calories**, esp. CHO, causing an increase in CO₂ production, esp. from synthesis of fat, and may exceed ability to rid the CO₂ through the lungs. May lead to hyperventilation, respiratory decompensation, and respiratory acidosis, resulting in need for mechanical ventilation or difficulty in weaning off. If you suspect overfeeding, reduce total calories or request a metabolic cart study (see pages 40-41). If patient is not being overfed in total calories, the feeding solution may be modified by decreasing the CHO concentration and increasing fat.

Diabetes Mellitus

- * See page 42 for guidelines to prevent and treat hyperglycemia and hypoglycemia associated with nutrition support in hospitalized patients.
- * The use of specialized diabetes enteral formulas in hospitalized patients has not been studied well and these formulas have not been shown to be superior to other, less expensive enteral formulas.
- * Avoid using extremely low-fat, high-carbohydrate feeding unless there is a compelling reason.
- * Fiber-containing commercial TF formulas have not been shown to result in lower blood glucose than formulas without added fiber.

Home Nutrition Support

When considering TF or TPN at home, the demonstrated or anticipated benefits versus burdens of the therapy must be weighed. Criteria for patient selection include:

- * Documented inability to meet nutrient requirements without forced feeding.
- * Clinical status appropriate for home discharge.
- * Demonstration of tolerance to the prescribed nutrient therapy.
- * Willingness and ability of the patient/caregiver to perform the necessary tasks and lifestyle changes for safe enteral (or parenteral) feeding.

WRAMC does not provide TPN or TF support outside the hospital, therefore, the inpatient's discharge planner may need to arrange for a home health care agency to provide equipment, feedings, and possibly the education and monitoring required for home nutrition support. There may be significant financial costs to the patient, especially with TPN. Home hospice almost never accepts patients on TPN.

Studies in long-term patients show that TPN contains insufficient or excessive amounts of some vitamins and trace minerals in some patients, therefore, additional lab monitoring and modifications of the TPN formula may be necessary. Iron deficiency is a concern with long-term TPN because iron is incompatible with the fat in TPN. Choline is not currently provided in TPN, however, choline deficiency causes reversible hepatic abnormalities in patients receiving long-term TPN.

TPN can be given over ≥ 12 hr qd, if tolerated. Some patients may require half rate TPN over first and last hr of infusion to prevent hyperglycemia or reactive hypoglycemia, respectively.

Liver Failure

It is common for patients with acute and chronic liver disease to have varying degrees of malnutrition. There is a decrement of intracellular mass and an expansion of the extracellular space. The actual body weight, with or without clinical edema, may overestimate the amount of functioning lean body cell mass. Energy expenditure (per kg actual body weight) may be relatively normal owing to a mild hypermetabolism of the remaining lean tissue. These patients are also hypercatabolic. Micronutrient deficiencies of vitamins, especially A, D, E and K and zinc are common, more so in alcohol-related disease. Recent research has strengthened the theory that ammonia is an important neurotoxic chemical that causes hepatic encephalopathy in susceptible patients. The ratio of brain to blood ammonia increases as liver failure progresses. The synthesis of glutamine removes ammonia.

It has been estimated that 40% of long-term TPN patients develop severe liver dysfunction.

Therapy Considerations to maintain/replace body composition and function and reduce morbidity

- * 30-35 Kcal/kg in 4-6 meals/d, including a late evening snack.
- * Provide 1.0-1.2 gm protein/kg/d. Only in acute or chronic encephalopathy, limit protein to 0.6-0.8 g/kg/d. Do not give supplemental glutamine.
- * Vegetable protein may be less likely to precipitate encephalopathy than animal protein.

- * Some trials demonstrate more rapid recovery from encephalopathy and/or better nitrogen balance using feeding formulas containing higher levels of branched chain amino acids and lower levels of aromatic amino acids and methionine, but many of these were not controlled against standard amino acid preparations. Consider a trial of these special formulas only in chronic encephalopathy unresponsive to other dietary modifications or pharmacotherapy.
- * Only restrict water and sodium intake if clinically necessary.
- * Screen for micronutrient deficiencies, including vitamins A, D, E, K, and zinc. In 1 study, 200 mg oral zinc sulfate TID for 3 months normalized serum zinc level, improved amino acid metabolism and reduced encephalopathy.
- * Perioperative nutrition (TPN or TF) for approximately 14 days is recommended to reduce postoperative morbidity in poorly nourished cirrhotics and/or those w/ hepatocellular carcinoma undergoing liver resection.
- * Choline is not currently added to TPN, however, choline deficiency causes reversible hepatic abnormalities in patients receiving long-term TPN. (IV choline may be commercially available soon.)

Obesity

The **definition of obesity** used for the following formulas ranges from >120 to >130% of desirable body weight (DEW) or body mass index (BMI) >27 to >30. As the degree of obesity and the severity of concomitant illness increase, estimating nutritional needs by any formula becomes progressively more difficult and potentially inaccurate, and the risk of adverse consequences from overfeeding increase. Indirect calorimetry, if technically feasible, can identify overfeeding.

Note: ABW = actual body weight; DEW = desirable body weight

Estimating energy expenditure in hospitalized obese patients*:

- 1) Use "**adjusted body weight**" (the average of the ABW and DEW) in **Harris Benedict equation** (see page 7) x 1.3. This equation was developed in patients receiving nutrition support.
- 2) **Ireton-Jones Equation = 629 - 11(age) + 25 (ABW in kg) - 609**
This equation was developed/validated in obese patients receiving nutrition support.
- 3) **Anato formula = 21 kg/kg ABW** This equation was validated in mechanically ventilated patients.

*Subtract 250-750 Kcal/d from TEE for **0.5 to 1.5 lb/wk wt loss**, if desired.

Hypocaloric Protein-Sparing Feeding in hospitalized obese patients:

1.2-2.0 g protein /kg/day of DBW and a total Kcal to nitrogen ratio of 75:1
(1 g nitrogen = 6.25 g protein)

This formula provides approximately 50-60% of energy expenditure (EE), yet was shown to achieve zero to positive nitrogen balance. The higher end of protein range is recommended for the more highly stressed patients.

In a retrospective ICU study, by Dickerson, obese patients on hypocaloric feeding including 2 g protein/kg DBW had no differences in prealbumin or nitrogen balance, but had a significant reduction in length of stay and time on antibiotics compared to patient receiving eucaloric feeding (also including 2 g protein/kg DBW). Multivitamin/mineral supplementation will be needed if feeding does not meet the RDA for vitamins and trace minerals.

Guidelines for calculating Protein requirements:

Hepatic encephalopathy or severe azotemia: 0.8-1.0 g protein/kg DBW
or adjusted wt (page 47)

Normal maintenance needs: 1.0-1.2 g protein/kg DBW

Hypocaloric feeding (see above): 1.2-2.0 g protein/kg DBW

Stressed: 1.5-2.0 g protein/kg DBW

Oncology

Indications for using nutrition support in many cancer patients is not clear from the existing literature.

Therapy Considerations

1. Routine use of TPN in patients undergoing cancer treatment has been associated with an increased rate of infection and is not recommended. Nutrition support is appropriate for those receiving active anticancer treatment who are malnourished and anticipate to be unable to ingest and/or absorb adequate nutrients for a prolonged period of time.
2. Nutrition support should not be used routinely in patients undergoing cancer surgery. In moderately to severely malnourished patients, 1-2 weeks of preoperative TPN or TF, continued postop until eating, was associated with decreased postoperative complications.
3. There have been reports of fewer infections and wound complications in significantly malnourished UGI cancer surgery patients who received early postop or periop TF with an immune-modulating formula, e.g., Impact (enriched with arginine, omega-3 fatty acids, and RNA) compared with a control group on a standard enteral formula.
4. Given risks and burdens of parenteral and enteral tube feeding, nutrition support may not improve length and quality of life in many terminally ill patients. However, long-term nutrition support may be beneficial in patients with a significant life expectancy and unable to eat for a prolonged period.

Pancreatitis and Pancreatic Insufficiency

- REE varies widely (77-139% REE) and is generally highest in those with sepsis.
- Protein needs also vary widely (0.8-1.5 g P/0/kg or sometimes higher in very severe stress).
- Mild pancreatitis can be supported with simple IV fluids with electrolytes and generally a rapid return to oral diet. Studies have not shown nutrition support to improve outcome.
- In severe pancreatitis, oral or gastric feeding is withheld. Jejunal feeding is safe, less costly, and may be associated with better clinical outcome compared to TPN. Intact protein, peptide and elemental TF formulas have been successfully used. If jejunal feeding is not feasible or tolerated, TPN may be necessary. A mixed fuel regimen should be used and labs monitored for Glu, Na, K, Phos, Ca, Mg, and triglycerides (reduce fat if TG >400 mg/dl).
- Chronic pancreatitis patients are at risk for chronic malnutrition. Pain, nausea, vomiting, and/or diarrhea may be associated with eating. Nonenteric coating pancreatic enzymes may decrease pain. Large, high-fat meals and alcohol should be avoided.
- When 90% of pancreatic function is lost, expect maldigestion/malabsorption of fat, protein, and possibly starch, fat-soluble vitamins, zinc, and vit B12 from food. Pancreatic enzyme replacement (nonenteric coated or enteric coated) becomes mandatory. Dietary fat should be the max tolerated without increased steatorrhea or pain. Modest amounts of MCT oil can supplement Kcal intake. Monitor for nutrient deficiencies. Endogenous insulin and glucagon secretion may be inadequate to maintain normal glucose levels, therefore, need to adjust meals and medication to avoid hyperglycemia and hypoglycemia.

Pulmonary Insufficiency

Respiratory failure and emphysema are risk factors for developing malnutrition. Malnutrition increases the risk of respiratory infections and death from pneumonia.

Therapy Considerations

- * Most patients require 20-35 Kcal/kg/day. Indirect calorimetry (page 40) may help to determine EE. Generally, the goal should be to meet, but not exceed, energy expenditure since overfeeding will:
 - increase CO₂ production and work of breathing
 - increase risk of respiratory acidosis and ventilator dependence
 - increase fluid retention and risk of hyperglycemia
 - increase risk of an acute drop in serum K, Phos and Mg
- * Special high-fat formulas marketed for patients with pulmonary insufficiency may not be necessary, although it is prudent to include a moderate amount of fat in the diet to decrease the risk of CHO overfeeding (since CHO overfeeding increases CO₂ production). One study in early ARDS demonstrated that patients on a TF formula high in omega-3 fatty acids and antioxidants spent less time on mechanical ventilation, less time in the ICU, and had a decrease in organ failure. Unfortunately the control formula was extremely high in omega-6 fatty acids and extremely low in omega-3 fatty acids and not comparable to any of our standard TF formulas.
- * The use of a 1.5 Kcal/ml TF formula may be useful in minimizing fluid, CHO and gastric volume.
- * If weight gain is desired in stable COPD patients, include liberal amounts of dietary fat, including some omega-3 fatty acids.
- * Time on mechanical ventilation and LOS are increased in patients who become hypophosphatemic.

Renal Failure

Therapy Considerations for Acute Renal Failure (ARF) and Chronic Renal Failure (CRF)

- * **Dosing weight** may be somewhere between the ideal body wt and usual or actual "dry" wt.
- * **Energy requirements** are not altered by renal failure, per se.
- * **Protein requirements:**
 - ARF: 0.6-1.0 g/kg/day without dialysis; 1.0-1.5 g /kg/day with dialysis or hemofiltration
 - CRF: 0.6-0.8 g/kg/day without dialysis; 1.2-1.3 g/kg /day with dialysis
 - Special methods can be used to assess catabolic rate and N-balance (consult renal specialist).
- * **Minerals:** Restriction of Na, K, Phos and Mg and supplemental oral Ca may be needed. See page 10 for estimated daily parenteral electrolyte requirements for renal failure.
- * **Water** restriction may be needed if oliguric or anuric.
- * **Vitamin considerations** include:
 - increased risk for vitamin A toxicity
 - water soluble B-vitamins is recommended for patients on dialysis (e.g., Nephrocaps®).
 - consider need for dihydroxy-vitamin-D
- * **Hypertriglyceridemia** (TG >400 mg/dl) and **glucose abnormalities** are common, therefore TG and glucose should be monitored. High-dose Propofol can cause severe hypertriglyceridemia.
- * **Nepro®** (pages 15 and 26) can be used for enteral tube feeding or an oral supplement.

Short Bowel Syndrome

The **normal** small intestine is 300-800 cm (10-25 ft) in length (1/3 jejunum and 2/3 ileum). The normal colon is approximately 150 cm. Most nutrients are absorbed in the jejunum. Nine L of fluid/day enters the small bowel, and normally, all but 1 L is absorbed proximal to the colon. The colon absorbs >80% of the remaining fluid, and can absorb up to 3-4 L daily. The colon also has the capability to salvage energy by converting complex carbohydrates to short chain fatty acids.

Loss of significant distal ileum, ileocecal valve, and/or colon results in faster overall transit and the potential for greater fluid and nutrient losses. Following a resection, the ileum has a greater ability to adapt than the jejunum. The tolerable amount of small bowel loss is always less when a sizable section of ileum or colon is removed or nonfunctional. The function of the remaining bowel may be hindered by mucosal disease, bacterial overgrowth, rapid gastric emptying, excessive gastric acid with inactivation of pancreatic lipase and deconjugation of bile salts, or pancreatic insufficiency. Oxalate nephrolithiasis develops in the setting of steatorrhea and an intact colon.

Loss of 100 cm or more of terminal ileum will significantly impair absorption of vitamin B12 and bile salts (and thus, fat and fat soluble vitamins). Less than 100 cm of remaining jejunum or ileum (without a colon or ileocecal valve) or < 50 cm of small bowel with a colon may require at least some TPN for an indefinite period. The process of intestinal adaptation begins soon after the injury and continues for up to two years, therefore, the need for parenteral or enteral tube feeding may not be permanent. Intestinal adaptation is promoted by luminal nutrients.

Therapy Considerations

- Initially post-op (or during later decompensation): NPO, IVF, electrolytes, and TPN, if needed, until enteral/oral sufficiency attained.
- Oral/Enteral attempts when stable, starting with small frequent feedings, <500 cc/d, isotonic liquids; avoid caffeine and alcohol.
- Sipping an oral rehydration solution containing approximately 90 mMol/L (or mEq/L) of Na can decrease or eliminate need for IV fluid. Intake of these solutions is limited by palatability. Commercial products with better taste, such as Ceralyte, are on the market.
- Separate solid and liquid intake to slow GI transit.
- Consider need for supplemental overnight enteral tube feeding.
- Without distal ileum, provide vitamin B12, via IV or IM.
- Require supplemental MVI (probably with trace minerals); often require supplemental Ca, Mg, and possibly zinc. Monitor electrolytes, Mg, volume, liver function, zinc, folate, vitamin B12, bone density, and urinary calcium and oxalate.
- In patients with an intact colon: Diet should be rich in complex CHO and low in fat and oxalate. (Calcium supplements may bind oxalate.) May need to limit intake of refined CHO if evidence of D-lactic acidosis and/or osmotic diarrhea. Supplemental MCT may increase total calories absorbed.

Trauma and Sepsis

- Once the trauma patient has been hemodynamically stabilized, early initiation of TF and/or TPN should be considered if the patient is likely to be unable to eat for ≥ 4 days since some studies showed decreased complications with early vs delayed feeding. (See page 18.)
- Preferably feed by the enteral route, since some studies have shown lower infectious complications with early enteral feeding vs. TPN in trauma patients.
- Positive clinical outcomes have been shown in some studies of trauma patients using early enteral feeding with immune-modulating formulas containing one or more of the following added nutrients: glutamine, arginine, omega-3 fatty acids, and nucleotides. Immune-modulating feeding should be continued for at least 5 days and discontinued when the acute stress is resolving.
- It is reasonable to give 25-30 Kcal/kg and 1.5-2.0 g Pro/kg. Chemical neuromuscular paralysis decreases energy expenditure by as much as 30%. Energy expenditure (EE) may be higher (35-40 Kcal/kg) in some forms of head injury and during the second week after onset of sepsis. Metabolic cart measurements of EE may be helpful given the significant range of EE possible in these patients. However, it has been reported that varying the non-protein Kcal intake of trauma patients during the first week following injury did not affect catabolic rate or N-balance, which was about -8 g/d.

Another way to estimate EE of ventilator-dependent patients is the Hetton-Jones equation:
 $EE = 1784 - 11(\text{age}) + 5(\text{Wt in Kg}) + 244(\text{if male}) + 239(\text{for trauma}) + 804(\text{for burns})$

- Delayed gastric emptying can be a problem, therefore, consider use of promotility medication and/or consider placement of jejunal feeding tube.
- TPN should be initiated if the enteral route has not or will not provide adequate nutrition. TPN and enteral TF may both be given until patient is tolerating at least 75% of needs from enteral TF. FreAmine HBC (high in branch-chain amino acids) was associated with significantly lower mortality than a standard amino acid solution in 1 study of septic patients needing TPN.
- As in all critically ill patients, overfeeding and significant hyperglycemia and hypertriglyceridemia should be avoided (see page 41-43). Monitor K, Phos, Mg, glucose and triglyceride levels. Fluid and electrolyte changes can occur rapidly, therefore, require frequent monitoring, especially during initial refeeding.
- Vitamin and trace mineral requirements for these patients are unknown although at this time it is recommended that least 100% of RDA for vitamins and trace minerals be provided, which most enteral TF formulas will supply if at least 75% of patient's energy and protein needs are met.

SELECTED REFERENCES

Nutrition Support (including, Nutrition Assessment, Enteral, Parenteral, and Outcomes)

Guidelines for the Use of Parenteral and Enteral Nutrition in Adult and Pediatric Patients. JPEN 2002; 26(1S):1S-138S.

American Society for Parenteral and Enteral Nutrition. The Science and Practice of Nutrition Support: A Case-Based Core Curriculum 2001.

American Society for Parenteral and Enteral Nutrition. The A.S.P.E.N. Nutrition Support Practice Manual 1998.

Jeejeebhoy KN. Total parenteral nutrition: potion or poison? Am J Clin Nutr 2001; 74:160-163.

Monitoring and Complications associated with Nutrition Support

Bistrian BR. **Hyperglycemia** and infections: Which is the chicken and which is the egg? JPEN 2001; 25:180-181.

Rosmarin DK, et al. **Hyperglycemia** associated with high, continuous infusion rates of total parenteral nutrition dextrose. Nutr Clin Practice 1996; 11(4):151-156.

Buckman AL, et al. **Choline deficiency** causes reversible hepatic abnormalities in patients receiving parenteral nutrition: Proof of a human choline requirement: A placebo-controlled trial. JPEN 2001; 25:260-268.

Klein S, Miles JM. Metabolic effects of long-chain and medium-chain **triglycerides** in humans. JPEN 1994; 18:396-397.

McClave SA, et al. Can we justify continued interest in **indirect calorimetry**? Nutr Clin Pract 2002; 133-136.

McClave SA, et al. North American summit on **aspiration** in the critically ill patient: Consensus statement. JPEN 2002; 26:S80-S85.
Solomon SM, Kirby DF. The **refeeding syndrome**: A review. JPEN 1990; 14(1):90-95.
Woodcock NP, et al. **Enteral versus parenteral** nutrition: a pragmatic study. Nutrition 2001; 17:1-12.

Selected Intensive Care Studies

Dickerson RN, et al. Hypocaloric enteral tube feeding in critically ill **obese patients**. Nutrition 2002; 18:241-246.
Moore EE, et al. Benefits of immediate jejunostomy feeding after **major abdominal trauma** -A prospective randomized study. J Trauma 1986; 26:874-880.
Kudsk KA, et al. A randomized trial of isonitrogenous enteral diets after **severe trauma**. Ann Surg 1996; 224:531-543.
Frankenfield DC, et al. Accelerated nitrogen loss after **traumatic injury** is not attenuated by achievement of energy balance. JPEN 1997; 21:324-329.
Garcia-de-Lorenzo A, et al. Parenteral administration of different amounts of **branch-chain amino acids in septic patients**: Clinical and metabolic aspects. Crit Care Med 1997; 25:418-424.
Heyland DK, et al. Should **immunonutrition** become routine in critically ill patients? JAMA 2001; 286:944-953.
Kalfarentos F, et al. Enteral nutrition is superior to parenteral nutrition in severe acute **pancreatitis**: results of a randomized prospective trial. Brit J Surg 1997; 84:1665-1669.
Malone AM. Methods of assessing **energy expenditure** in the intensive care unit. Nutr Clin Pract 2002; 17:21-28.
Mault J. **Energy balance and outcomes** in critically ill patients: Results of a multicenter, prospective randomized trial by the ICU Nutrition Study Group. JPEN 2000; 24:S4.

Van Den Berghe G, et al. **Intensive insulin therapy** in critically ill patients. *N Engl J Med* 2001; 345:1359-1367.

Other Specific Patient Populations

(See sections on specific patient populations) IN Guidelines for the Use of Parenteral and Enteral Nutrition in Adult and Pediatric Patients. *JPEN* 2002; 26(1S):1S-138S.

(See sections on specific patient populations) IN American Society for Parenteral and Enteral Nutrition. The Science and Practice of Nutrition Support: A Case-Based Core Curriculum. 2001.

Choban PS, et al. Nutrition Support of **Obese** Hospitalized Patients. *Nutr Clin Practice* 1997; 12:149-154.

Glynn CC, et al. Predictive versus measured energy expenditure using limits-of-agreement analysis in hospitalized **obese** patients. *JPEN* 1999; 23:147-154.

Marchesini G, et al. Zinc supplementation and amino acid-nitrogen metabolism in patients with advanced **cirrhosis**. *Hepatology* 1996; 23:1084-1092.

Proceedings from Summit on Immune-Enhancing Enteral Therapy. *JPEN* 2001 25:S1-63.

Scolapio JS. **Short bowel syndrome**. *JPEN* 2002; 26:S11-16.

The Veterans Affairs Total Parenteral Nutrition Cooperative Study Group: **Perioperative total parenteral nutrition** in surgical patients. *N Engl J Med* 1991; 325:525-532.

Sandstrom R, et al. The effect of **postoperative intravenous feeding (IPN)** on outcome following major surgery evaluated in a randomized study. *Am Surg* 1993; 217:185-195.

Windsor ACJ, et al. Compared with parenteral nutrition, enteral feeding attenuates the acute phase response and improves disease severity in **acute pancreatitis**. *Gut* 1998; 41:431-435.