Chapter 35: Malnutrition and Enteral/Parenteral Alimentation

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This chapter addresses the following Geriatric Fellowship Curriculum Milestones: #29, #42, #49, #72, #73

LEARNING OBJECTIVES

Learning Objectives

- Describe common factors contributing to undernutrition in older adults.
- Identify the three most common causes of weight loss in older adults.
- Determine appropriate nutritional support interventions for persons with protein-energy malnutrition (PEM).

Key Clinical Points

1. **Weight loss of 5% or more of baseline body weight over 6 to 12 months is associated with increased morbidity and mortality and should prompt clinical investigation.**
2. **When malignancy is the cause of weight loss, the diagnosis is usually readily made with standard evaluations that include a careful history, physical examination, and basic laboratory tests.**
3. **High-protein, high-calorie oral nutritional supplements may reduce morbidity and mortality when provided to hospitalized, malnourished patients age 75 or older.**
4. **Enteral nutrition (EN) is preferred over parenteral nutrition (PN) for patients who are in need of nutritional support and have a functional gastrointestinal (GI) tract.**

MALNUTRITION

Definition

Protein-energy malnutrition (PEM) is present when insufficient energy and/or protein is available to meet metabolic demands. PEM may develop because of poor dietary protein or caloric intake, increased metabolic demands as a result of illness or trauma, or increased nutrient losses. Proposed clinical criteria from the Academy of Nutrition and Dietetics and the American Society for Parenteral and Enteral Nutrition to diagnose adult malnutrition are listed in **Table 35-1**.

TABLE 35-1

CLINICAL CHARACTERISTICS RECOMMENDED FOR THE DIAGNOSIS OF ADULT MALNUTRITION[a]

Insufficient energy intake
Weight loss
Loss of muscle mass (eg, temporal wasting, reduced pectoralis, deltoid, quadriceps, other muscle)
Loss of subcutaneous fat (eg, orbital, triceps, fat overlying ribs)
Localized or generalized fluid accumulation (eg, extremity or genital edema, ascites)
Decreased functional status as measured by reduced handgrip strength

[a]A minimum of two or more characteristics is recommended to diagnose malnutrition.

Epidemiology

Prevalence data, relying on a variety of measures of nutritional adequacy, suggest that deficiencies in macronutrients (protein-energy) and micronutrients (vitamins and minerals) are very common among older adults. National survey data indicate that 40% to 50% of noninstitutionalized older adults are at moderate to high risk for nutritional problems, and up to 40% have diets deficient in three or more nutrients. Prevalence estimates in selected populations over 65 years indicate that 9% to 15% of older persons seen in outpatient clinics, 12% to 50% of hospitalized older persons, and 25% to 60% of older persons residing in institutional settings have one or more nutritional inadequacies—with PEM being the most common. Physical and psychosocial factors that may lead to inadequate nutrition are listed in **Table 35-2**.

TABLE 35-2

FACTORS CONTRIBUTING TO INADEQUATE NUTRITION IN OLDER ADULTS

Socioeconomic	Physiologic
Fixed income	Impaired strength/aerobic capacity
Reduced access to food Social isolation Inadequate storage facilities Inadequate cooking facilities	Impaired mobility/dexterity (arthritis, stroke) Impaired sensory input (smell, taste, sight) Poor dentition/oral health Malabsorption
Poor knowledge of nutrition	Chronic illness (via anorexia, altered metabolism)
Dependence on others Caretakers Institutions	Alcohol Drugs (eg, SSRIs,[a] NSAIDs,[b] digoxin, opiates, levodopa, antibiotics, metformin, iron, others)
Psychological	**Acute Illness/Hospitalization**
Depression	Failure to monitor dietary intake and record weights
Bereavement	Failure to consider increased metabolic requirements
Anxiety, fear, paranoia	Iatrogenic starvation (eg, NPO[c] for diagnostic tests)
Dementia	Delay in instituting nutritional support

[a]Selective serotonin reuptake inhibitors.

[b]Nonsteroidal anti-inflammatory drugs.

[c]Nothing by mouth.

Energy intake declines significantly with age, attributable in part to decrements in lean body mass and physical activity that often accompany aging. A still greater reduction in caloric intake to levels that may be below daily requirements has been a consistent finding of nutritional surveys conducted among community-dwelling older adults. The National Health and Nutrition Examination Survey (NHANES III) found that the mean daily energy intake of persons aged 70 and older was approximately 1800 kcal/day for men and 1400 kcal/day for women, and more than 10% of older people reported consuming less than 1000 kcal/day. Even if this limited energy intake met the caloric needs of some less-active older adults, it is unlikely that all noncaloric nutrient needs (vitamins and minerals) would be met unless the diet was extremely diverse and rich in nutrients. Although micronutrient deficiencies are common when PEM is moderate to severe, it is the PEM that tends to have the greater clinical impact. Accordingly, this section focuses primarily on PEM, with particular attention to prevention and management of PEM in the acute-care setting.

Poor nutritional status and PEM are associated with altered immunity, impaired wound healing, reduced functional status, increased health care use, and increased mortality. Despite the confounding effect of coexisting nonnutritional factors, poor nutrition remains an independent source of increased morbidity and mortality after adjustment for nonnutritional factors. Although the efficacy of nutritional support to improve outcomes in many circumstances is unproven, there is growing evidence of measurable benefits from interventions to correct or prevent nutritional deficits.

Pathophysiology

PEM may occur as a consequence of inadequate intake alone (eg, starvation) or in association with disease-activated physiologic mechanisms that affect body metabolism, composition, and appetite (ie, cachexia). In the former (primary caloric deficiency state), the body adapts by using fat stores while conserving protein and muscle, and the resulting physiologic changes are often reversible with resumption of usual intake and activity. Cachexia is a complex metabolic syndrome that is associated with elevated inflammatory cytokines (eg, tumor necrosis factor-α [TNF-α] and interleukin-6 [IL-6]) and increased protein and muscle degradation that may not be readily reversed by refeeding. Although cachexia is usually associated with specific chronic disease conditions (eg, cancer, renal failure, chronic obstructive pulmonary disease [COPD]), this state may develop in older persons without obvious underlying disease. To some extent these physiologic changes may be adaptive. Thus, caution is necessary when devising strategies to halt the lean body mass loss and functional decline that often accompanies cachexia.

Presentation and Evaluation

Despite its apparent clinical importance, physician recognition of malnutrition is often lacking. Effective management of frail or ill older adults mandates an evaluation of nutritional status to better allow for early recognition of PEM and consideration of appropriate interventions. Assessment of nutritional status by standard anthropometric, biochemical, and immunologic measures can be complex, as both nutrient intake and nonnutrition-related factors can affect these parameters. The use of such measurements (eg, body mass index, skinfold thickness, muscle circumferences, serum concentrations of proteins, and lymphocyte counts) to detect the presence of poor nutrition is often advocated, but may not result in earlier or more effective intervention than can be achieved by a careful history and physical examination. The close monitoring of body weight, a readily obtainable measure that reflects imbalance between caloric intake and energy requirements, is a simple and reliable way to screen for malnutrition, particularly in the outpatient setting. Body weight should be recorded at all patient visits. Weight change should be expressed as a percentage of change from past to current weight, because proportional weight change helps account for variability in baseline weight and appears to be the most clinically relevant measure. Although weight gain caused by excessive energy intake is a common form of malnutrition, only undernutrition and weight loss caused by deficits in energy balance are considered here. Weight loss of 5% or more of usual body weight over 6 to 12 months is associated with increased morbidity and mortality in the outpatient setting, and so should prompt investigation. Illness-related weight loss exceeding 10% of preillness weight is associated with functional decline and poor clinical outcomes. Weight loss of 15% to 20% or more of usual body weight implies severe malnutrition.

In the hospital setting, where acute illness or injury often coexists with inadequate intake, alterations in nutritional parameters associated with PEM may develop rapidly. Elevated levels of inflammatory mediators appear to be responsible for the greater losses in lean body mass and the rapid declines in albumin that often accompany PEM in physiologically stressed patients. While serial weight measures remain clinically relevant, early detection and correction of PEM in acutely ill hospitalized patients is enhanced by determination of dietary intake relative to metabolic requirements. Although registered dietitians often provide this information, physicians should be aware of dietary intake and can readily estimate caloric and protein requirements using formulas presented in **Table 35-3**. Biochemical and immunologic measures (eg, albumin, prealbumin, transferrin, and lymphocyte counts) are useful adjuncts in the assessment of nutritional status and can provide prognostic information, but their lack of specificity limits their utility as markers of PEM. Anthropometric measures of fat stores (skinfolds) and muscle mass (midarm muscle area) may help in the assessment of PEM, but clinicians are generally not well versed in obtaining these measures and interrater variability can be high. Although less sensitive, clinical evaluation for loss of skin turgor and the presence of atrophy in hand interosseous or head temporalis muscles can help assess for losses in subcutaneous fat and muscle mass. Because all of these parameters may be affected by nonnutrition-related factors, an effective assessment of nutritional status requires synthesis of information provided from the dietary history, physical examination, and biochemical data. There are no definitive criteria for classifying degrees of PEM. However, when weight loss exceeds 20% of premorbid weight, serum albumin is less than 21 g/L, transferrin is less than 1 g/L, and total lymphocyte count is less than 800/μL, PEM is generally considered to be severe.

TABLE 35-3

ESTIMATION OF DAILY ENERGY AND PROTEIN NEEDS

I. Daily energy requirements (kcal/d)
   A. Quick estimate: maintenance 25–30 kcal/kg; stress 30–40 kcal/kg; sepsis 40–50 kcal/kg (tends to overestimate requirements for older and obese patients)
   B. Estimates based on resting metabolic rate (RMR, kcal/d):
      1. First estimate RMR (using either equation below)
         a. Harris-Benedict: RMRwomen = 655 + [9.5 × wt(kg)] +[1.8 × ht(cm)] - (4.7 × age)
            RMRmen = 66 + [13.7 × wt(kg)] +[5 × ht(cm)] - (6.8 × age)
         b. Schofield: RMRwomen = [wt (kg) × 9.1] + 659
            RMRmen = [wt (kg) × 11.7] + 588
      2. Then multiply RMR by adjustment factor to estimate total energy requirement:
         Total daily energy requirement = RMR × 1.3 for mild illness/injury
         = RMR × 1.5 moderate illness/injury
         = RMR × 1.7 - 1.8 severe illness/injury

II. Daily protein requirements (g/d) (may overestimate if patient obese)

RDA healthy nonpregnant adults	0.8 g/kg
Minimally stressed patients	1.0 g/kg
Injury/illness	1.2-1.4 g/kg
Severe stress/sepsis	1.4-1.8 g/kg

Assessment for Causes of Weight Loss

Initial management of patients with PEM and/or weight loss should include a thorough evaluation to identify underlying causes, and if found, to aggressively attempt to correct potentially remediable factors. In the acute-care setting the cause(s) of malnutrition are often readily evident, although depression may be a contributing factor that is frequently overlooked. In contrast, reasons for poor nutrition and weight loss among community-dwelling older persons may be multiple and not as readily discernible. Depression, GI maladies (eg, peptic ulcer, motility, or malabsorption disorders), and cancer are the three most common causes of weight loss in older adults (**Table 35-4**). When cancer is the cause of weight loss, the diagnosis is rarely obscure. Most diagnoses are readily made after standard evaluations that include a careful history and physical examination and basic screening tests (urinalysis, complete blood count, serum electrolyte, renal, liver, and thyroid function tests, stool hemoccults, and a chest radiograph), with additional tests only as directed by signs and symptoms. If the initial basic evaluation is unrevealing, as will occur in around 25% of cases, it is best to enter a period of “watchful waiting” rather than pursue more extensive undirected testing. A diagnostic algorithm (**Figure 35-1**) focusing first on verifying actual weight loss (patients may inaccurately report a history of weight loss) and then on whether caloric intake is adequate can help guide an appropriate work-up.

TABLE 35-4

DIAGNOSTIC SPECTRUM OF INVOLUNTARY WEIGHT LOSS

	STUDY (STUDY SIZE)								
	MARTON ET AL. (*N* = 91)	RABINOVITZ ET AL. (*N* = 154)	HUERTA ET AL. (*N* = 50)	LANKISCH ET AL. (*N* = 158)	LEVINE ET AL. (*N* = 107)	THOMPSON ET AL. (*N* = 45)	METALIDIS ET AL. (*N* = 101)	BILBAO-GARAY ET AL. (*N* = 78)	WU ET AL. (*N* = 136)
Study population	70% Inpatient 30% Outpatient	Inpatient	Inpatient	Inpatient	Outpatient	Outpatient	57% Inpatient 43% Outpatient	Outpatient	Inpatient
Weight loss definition[a]	≥ 5%/6 mo	≥ 5%/not stated	≥ 10%/6 mo	≥ 5%/6 mo	≥ 5%/6 mo	≥ 7.5%/6 mo	≥ 5%/6–12 mo	> 5%/3 mo or > 10%/6 mo	≥5%/6–12 mo
Mean age (range)	59 ± 17[b]	64 (27–88)	59 (18–83)	68 (27–92)	62 (17–91)	72 (63–83)	64 (51–71)	59 ± 19[b]	80 ± 6[b]
Gender (% male)	100%	45%	64%	44%	53%	33%	46%	49%	81%
Diagnosis %									
Neoplasm	19	36	10	24	6	16	22	23	17
Gastrointestinal	14	17	18	19	6	11	15	6	
Psychiatric	9	10	42	11	22	18	16	33	24
Endocrine	4	4	10	11	5	9	2	6	
Cardiopulmonary	14	—	2	10	9	—	5	3	
Other medical diagnoses[c]	18	9	8	8	16	22	13	17	34
Unknown	26	23	10	16	36	24	28	11	26

[a]Weight loss study definition: percent body weight lost per time interval in months.

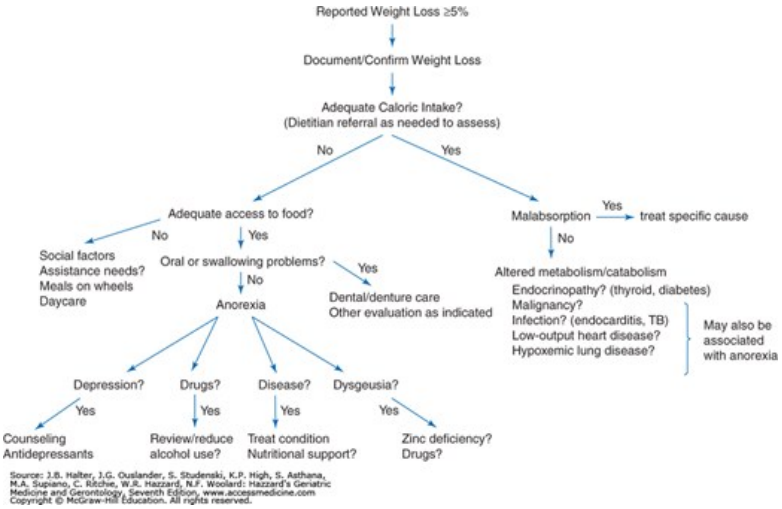
[b]Mean age in years ± standard deviation (age range not reported).

[c]Neurologic, infectious, alcohol, medication, renal, inflammatory disease, multifactorial. Wu study did not report specific medical diagnoses separately.

Data from Bilbao-Garay J, Barba R, Losa-García JE, et al. Assessing clinical probability of organic disease in patients with involuntary weight loss. Eur J Intern Med. 2002;13:24; Huerta G, Viniegra L. Involuntary weight loss as a clinical problem. Rev Invest Clin (Spanish). 1989;41(1):5; Lankisch PG, Gerzmann M, Gerzmann JF, Lehnick D.. Unintentional weight loss: diagnosis and prognosis. J Intern Med. 2001;249:41; Levine MA. Unintentional weight loss in the ambulatory setting: etiologies and outcomes. [Personal communication and abstract]. Clin Res 1991;39(2):580A; Marton KI, Sox HC Jr, Krupp JR.. Involuntary weight loss: diagnostic and prognostic significance. Ann Intern Med. 1981;95:568; Metalidis C, Knockaert DC, Bobbaers H, Vanderschueren S. Involuntary weight loss. Does a negative baseline evaluation provide adequate reassurance? Eur J Intern Med. 2008;19:345; Rabinowitz M, Pitlik SD, Leifer M, Garty M, Rosenfeld JB. Unintentional weight loss. Arch Int Med. 1986;146:186. Thompson MP, Morris LK. Unexplained weight loss in the ambulatory elderly. J Am Geriatr Soc. 1991;39:497; Wu JM, Lin MH, Peng LN, Chen LK, Hwang SJ. Evaluating diagnostic strategy of older patients with unexplained unintentional body weight loss. Arch Gerontol Geriatr. 2011;53:e51.

FIGURE 35-1.

Weight loss evaluation algorithm.



Management

General considerations

Older persons who are not meeting their protein and caloric requirements through oral intake should be considered for nutritional support. **Table 35-5** outlines approaches to nutritional support and factors to consider in deciding whether to pursue specific interventions. The urgency for nutritional interventions relates to the degree of protein-calorie depletion at the time of diagnosis coupled with the expected magnitude and duration of inadequate nutrition. In the hospital setting, clinicians must consider that patients may have been suffering from PEM for some time prior to admission. Therefore, delay in instituting appropriate nutritional support while waiting for improved intake should be avoided. One approach is to intervene after a period of 5 to 7 days of severely limited intake, or for weight loss more than 10% of preillness weight in hospitalized patients. However, attempts should be made to prevent PEM rather than wait for this degree of PEM to develop because weight loss and undernutrition are associated with worse clinical outcomes and recovery of lost lean body mass is often difficult. This is particularly important in severe stress states (eg, sepsis, major injury) where protein catabolism can lead to losses of lean body mass that approach 0.6 kg/day. In support of early intervention when the development of PEM is likely, a trial of enteral nutrition among patients with major injury found that early (within 24 hours) enteral feeding had clinical benefits over tube feeding started later in the course of hospitalization.

TABLE 35-5

APPROACHES TO IMPLEMENTING NUTRITIONAL SUPPORT

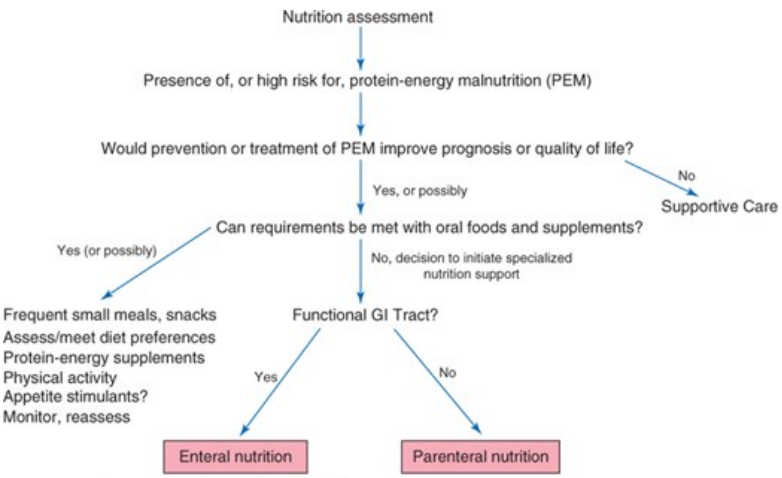
AVAILABLE INTERVENTIONS	FACTORS TO CONSIDER
Enhance oral intake Frequent meals, snacks Provide favorite foods, fortified foods, minimize/remove dietary restrictions Feeding assistance, company at meals Protein-calorie supplements Multivitamins Appetite stimulants?	Degree of baseline protein-calorie depletion Current intake relative to requirements Expected duration of inadequate nutrition Effect of intervention on clinical outcomes Potential benefits Potential adverse effects Burden of intervention
Anabolic agents	Potential for reversibility
Enteral nutrition	Quality of life
Parenteral nutrition	Patient care preferences

Patient preference

The effect of the planned intervention on the patient's quality and/or quantity of life should be addressed before proceeding with nutritional support. Although nutritional support interventions may improve weight and other nutritional parameters, their ability to improve clinical outcomes is still limited, particularly when PEM is associated with serious (eg, critically ill intensive care unit [ICU] patients) or irreversible underlying disease (eg, cancer). While efforts to improve nutrition, even in patients with serious underlying disease, are often warranted, late in the course of disease appropriate palliative care may include, if not mandate, discontinuing such efforts. Determination of the care preferences of the patient is a critical component of the decision-making process. Patient and family counseling prior to implementing nutritional support should include a review of the interventions being considered and their potential for adverse, as well as beneficial, effects. **Figure 35-2** shows an algorithm to help guide nutritional support decisions.

FIGURE 35-2.

An algorithmic approach to nutritional support.



Enhancing oral intake

Nonpharmacologic Approaches

Although it is uncommon for hospitalized older persons with PEM to be able to increase their food consumption sufficiently to correct their nutritional deficits, trials of strategies to improve voluntary intake are reasonable for stable patients with mild PEM (no definitive criteria exist, but parameters consistent with mild-moderate PEM include weight 85%–90% of premorbid weight, albumin 25–30 g/L, transferrin 1.5–2.0 g/L, total lymphocyte count 800–1200/μL). As previously outlined, underlying causative or contributing condition(s) to PEM should be sought, identified, and addressed. Strategies to help overcome anorexia and improve oral intake include assessing and meeting food preferences, providing frequent small meals and snacks, use of fortified and flavor-enhanced foods, providing company at meals and feeding assistance as needed, and minimizing dietary restrictions. Dietitians may aid greatly in these efforts.

The exact role for high-protein, high-calorie oral nutritional supplements is not clear. Some studies have demonstrated meaningful clinical benefits in malnourished older adults, but the effects are less clear in persons with dementia or other progressive illnesses, particularly in the outpatient setting. A Cochrane Library review concluded that oral nutritional supplements produce modest (2% on average) weight gain, may reduce mortality in undernourished individuals and may reduce hospital complications, but evidence for functional benefits or reduced length of hospital stay is lacking. As the greatest mortality impact was found in hospitalized malnourished patients age 75 or older who received high-calorie supplements, it seems reasonable to recommend such supplements in older hospitalized patients with, or at high risk for, PEM. Higher-calorie “plus” variety nutritional supplements (1.5–2.0 kcal/mL) are preferred over standard (1 kcal/mL) formulas. Costs are only slightly higher, and because they deliver higher–calorie content per milliliter ingested, patients do not need to drink as much volume to improve caloric intake. Supplements should be provided between, rather than with, meals as this appears to result in less compensatory decreases in food intake at mealtime, thereby more effectively increasing total daily caloric intake. However, even if total caloric intake is only marginally improved, the provision of energy from nutritionally dense supplement sources may be beneficial due to improved protein and micronutrient intake.

A standard multivitamin supplement should also be considered for all older adults with poor intake. Although study results are not consistent, improving micronutrition with multivitamins, particularly in malnourished or at-risk persons, may improve clinical outcomes (eg, infection rates). Increased physical activity is an important adjunct that can help maintain lean body mass, improve appetite and sense of well-being, thereby leading to improved caloric intake and functional status.

Drugs

Pharmacologic approaches to stimulate appetite and promote weight gain can be considered on an individual basis with the knowledge that the few agents (megestrol acetate [MA], dronabinol, cyproheptadine) that may improve intake in some patient populations (eg, cancer, human immunodeficiency virus [HIV], anorexia nervosa) have not been shown to be effective in older adults and have the potential to cause important side effects. Further, the weight gain that has been observed with these agents has usually been small, disproportionately fat mass, and not associated with improved function, quality of life, or decreased morbidity and mortality. MA increases risks of thrombotic events, fluid retention and mortality, and was added to the American Geriatrics Society’s Beers Criteria list of potentially inappropriate medications for older adults in 2012. Dronabinol has not been well-studied in older adults and at best has shown limited promise in small nonrandomized trials conducted in nursing home patients. A head-to-head comparison trial in cancer patients found MA to be more effective than dronabinol in improving appetite and promoting weight gain. MA’s mechanism of action may involve suppression of inflammatory cytokines (eg, IL-6 and TNF-α), consistent with the observation that this agent appears most effective in persons with elevated cytokine levels (eg, cancer or acquired immunodeficiency syndrome [AIDS] patients). If initiated, MA may not have a demonstrable effect on appetite for several weeks, but if no effect is seen by the eighth week, MA should be discontinued. If positive effects are demonstrated without significant side effects, MA may be continued for up to 12 weeks. Treatment for more than 8 to 12 weeks can suppress the adrenal-pituitary axis resulting in adrenal insufficiency and insufficient response to acute stressors. MA also appears to blunt the beneficial effects of progressive resistance exercise, consistent with an undesirable glucocorticoid-like catabolic effect.

If depression is felt to be a likely, or possible, contributing factor to poor intake, a trial of therapy is usually warranted. Selective serotonin reuptake inhibitors (SSRIs) are first-line antidepressant agents, and improve appetite by improving depression. Mirtazapine generally leads to more weight gain than SSRI antidepressants, but it is not clear that mirtazapine has a significant advantage over other antidepressants when weight loss is a predominant presenting sign in a depressed older adult. There is no high-quality evidence to support the use of mirtazapine for weight gain in the

absence of depression.

Maintaining lean body mass and functional status

Anabolic Agents

Anabolic hormones (eg, growth hormone [GH], testosterone, oxandrolone) have received considerable attention in the search to find strategies to help preserve or increase lean body mass in patients with malnutrition and weight loss. Although adequate nutrition is essential for patients with weight loss, a physiologically stressed catabolic patient may lose significant lean body mass despite aggressive nutritional support (and the weight gain that does occur with nutritional support and appetite stimulants may be primarily fat and water). GH has generally failed to demonstrate benefits on muscle mass or muscle strength in older adults, even in association with resistance training. The use of GH in intensive care and congestive heart failure patients has also yielded disappointing results with evidence of increased mortality. The cost, need for injection, and potential side effects of GH (eg, arthralgias, edema, insulin resistance, tumor growth) further limit its clinical utility. Testosterone increases muscle protein synthesis, mass and strength, and improvements in functional outcomes have been observed in small controlled trials in selected male populations (eg, older men after knee replacement surgery, deconditioned older men on a Geriatric Evaluation and Management unit). Although testosterone might be considered in men with documented clinical hypogonadism, its role in the setting of malnutrition and/or cachexia remains to be clarified, especially in light of known safety concerns (in particular cardiovascular). In terms of future possibilities, selective androgen receptor modulators (SARMs) have the potential to provide desirable anabolic effects on muscle and bone without undesirable effects on other organs but these agents are still under study and not available clinically. Oxandrolone, a synthetic testosterone derivative with an increased anabolic to androgenic effect ratio, has shown some utility for patients with weight loss in association with AIDS/HIV or burns, and preliminary data also suggest benefit in patients with COPD. This agent can cause hepatitis, hirsutism, and fluid retention, and is contraindicated in patients with breast or prostate cancer. Further research is needed to define the clinical role of oxandrolone as a pharmacologic intervention to be used in combination with nutrition therapy in older adults. Other anabolic agents that are under study include myostatin inhibitors. Myostatin is expressed in skeletal muscle and inhibits muscle protein synthesis and promotes fibrosis. Blocking these effects may provide a novel approach to prevent muscle loss and promote muscle growth.

Physical Activity

Efforts to increase physical activity are an important adjunct to any nutritional intervention, as positive effects of exercise include enhanced appetite and improved functional status. The benefits (and safety) of exercise in older populations are reviewed in Chapter 115.

NUTRITIONAL SUPPORT

Enteral Nutrition

Enteral nutrition is defined as the nonvolitional delivery of nutrients by tube into the GI tract. EN should be considered for patients with PEM, or at high risk for it, who cannot meet their nutritional requirements through oral intake. However, specific indications regarding if and when to provide EN are not clearly established, and patient prognosis and preference are critical factors that must be taken into account. EN requires a functional GI tract and is contraindicated in patients with bowel obstruction, inadequate bowel surface area, major upper GI bleeding, GI ischemia, paralytic ileus, or intractable vomiting or diarrhea. Purported benefits of enteral tube feedings relative to PN include the maintenance of GI structure and function, more physiologic delivery and use of nutrients, less risk of overfeeding and hyperglycemia, and lower costs. Although these advantages may be more theoretical than actual, EN is preferred when GI function is felt to be adequate. However, EN and PN should not be considered mutually exclusive. For patients unable to fully meet their nutritional requirements through EN, a mixture of PN and EN is preferable to moving to PN alone.

Efficacy

Enteral nutrition can improve prognostically important intermediate nutritional parameters, but the effects of EN on clinical outcomes (eg, functional status, medical complications, mortality) are unclear owing to limited and/or mixed data. EN is often not initiated until advanced undernutrition is present, which is a clear impediment to the potential positive effects of nutritional therapy. There is prospective clinical trial evidence among older undernourished hip fracture patients that EN can improve both nutritional parameters and clinical outcomes (eg, length of stay, infectious complications, and mortality). Further study is needed to determine which older hospitalized patients might benefit most from aggressive nutritional support. In the interim, sufficient rationale exists to consider EN for patients who are undernourished or at high risk for undernutrition, and cannot

meet their nutritional needs with oral intake.

Tube placement

The route selected for tube feeding depends on the anticipated duration of feeding, the potential for aspiration, and the condition of the gastrointestinal tract (eg, esophageal obstruction). Nasogastric (NG) or nasointestinal tubes provide the simplest approach for patients requiring relatively short-term EN (< 30 days). Patient comfort is often problematic and tolerance is best when a small-diameter, soft feeding tube is used rather than a standard large-bore NG tube. The use of longer specialized feeding tubes also allows the tube to reach beyond the pylorus into the distal duodenum or jejunum (ie, beyond the ligament of Treitz), which is the preferred site of placement for patients who are critically ill, have delayed gastric emptying, or are at high risk for aspiration. Methods to promote passage of the tube past the pylorus when postpyloric feeding is desired include ensuring adequate tube length, having the patient lie on their right side, and prescribing erythromycin or metoclopramide. If these methods fail and the risk of aspiration is felt to be very high, tube placement into the duodenum or jejunum can be performed endoscopically or under fluoroscopic guidance. After placement, the desired tube position should be verified radiologically before starting feedings and the tube should be marked at its exit point to help identify if subsequent movement occurs.

Percutaneous tube placement (gastrostomy, gastrojejunostomy, jejunostomy) is indicated when long-term tube feeding is anticipated (> 4 weeks). However, it may also be appropriately considered earlier, especially when EN is likely to exceed 2 weeks, because such a tube is better tolerated, allows more consistent nutrition delivery, and has less treatment failures than nasointestinal tubes. Percutaneous placement of gastrostomy tubes (G-tubes) can be performed either endoscopically or under radiographic guidance. The risks of major complications with either procedure are generally low, but infection, hemorrhage, and peritonitis have each been reported at rates of 1% to 3%.

Tube feeding is associated with an increased incidence of aspiration. However, most aspiration pneumonias are the result of difficulty handling endogenous (oropharyngeal or gastric) secretions rather than aspiration of material introduced through tube feeding. Thus it is not entirely surprising that although postpyloric feeding tube placement is generally advised in older and sicker patients, evidence is not definitive that such placement reduces rates of aspiration pneumonia. Postpyloric feeding may offer other advantages such as less gastric residual problems in persons with gastric dysmotility and reduced esophageal reflux symptoms. Placement of a feeding tube directly into the jejunum may be required for a patient with an abnormal or inaccessible stomach (eg, gastrectomy, duodenal obstruction). Although direct jejunostomy tube (J-tube) placement can be accomplished using percutaneous methods, a J-tube traditionally requires an open surgical procedure and is often placed at the time of laparotomy when the need for prolonged nutritional support is anticipated.

Formula selection

Adult enteral formulas fall into one of the following categories: standard, concentrated, predigested (previously called elemental or semielemental) and disease specific. All consist of varying mixtures of protein (often casein), carbohydrate (often cornstarch), and fat (usually vegetable oils), and most do not contain lactose. Formula variability includes nutrient composition, nutrient density, fiber content, digestibility, viscosity, osmolality, and cost (cost tends to be substantially higher for disease-specific specialty formulas, and up to 10-fold higher for critical care and predigested elemental specialty formulas). Isotonic standard formulas with caloric densities of 1 to 1.2 kcal/mL are usually the initial products of choice. Higher-caloric density formulas (1.5–2.0 kcal/mL) may be useful when volume restriction is paramount (eg, in patients with renal failure), but their higher viscosity increases the risk of tube clogging and their higher osmolality may be less well tolerated if delivered rapidly via tubes placed beyond the pylorus. There is no evidence that routine supplementation of EN with fiber prevents diarrhea, but formulas with higher fiber content may be tried if patients receiving EN are having problems with diarrhea or constipation. In predigested or elemental formulas, carbohydrates are supplied primarily as oligosaccharides and proteins have been partially or fully hydrolyzed to peptides and amino acids. Although they are promoted for patients with diminished ability to digest nutrients, it is uncommon for patients to be incapable of digesting and absorbing standard formulas unless they have significantly impaired gastrointestinal function (assuming appropriate adjustments are made in rates of feedings, osmolality, and fiber content). Elemental diets can also cause, rather than reduce, diarrhea because of their high osmolality.

Disease-specific/specialty formulas are available for patients with renal failure, liver failure, diabetes mellitus, pulmonary disease, gastrointestinal dysfunction, and critical illness. However, as costs are usually substantially higher and no clear clinical benefits have been consistently demonstrated, disease-specific formulations are not routinely recommended. Renal formulas do have a place in renal failure patients who have need for fluid and/or electrolyte restrictions. Renal disease formulas are low in protein, low in electrolytes, and dense in calories to assist in fluid restriction. These formulas may be useful before dialysis but are not necessary for most patients once on dialysis. Formulas have been developed for diabetic patients, but use of

cheaper standard formulas with adjustments in glucose control regimens as necessary is adequate for most diabetic patients. Formulas for pulmonary patients have higher fat content, because energy utilization from fat results in less carbon dioxide production relative to the metabolism of carbohydrate energy sources. Although possibly useful for patients being weaned from ventilators, these formulas are of questionable clinical importance for most patients with chronic lung disease. Hepatic formulas have specific amino acid mixtures (high in branched-chain, low in aromatic amino acids) that are less likely to cause or exacerbate hepatic encephalopathy. They are indicated when, in spite of appropriate medical therapy, hepatic encephalopathy limits the delivery of adequate protein to a patient with liver disease.

A number of specialty formulations have been designed for critically ill patients. Some of these products are enriched with glutamine (an amino acid associated with improved nitrogen balance and gut barrier function as well as immune-modulating effects when delivered parenterally), arginine (an amino acid associated with improved nitrogen balance and immune function), and/or other immune modulators (eg, antioxidants, selenium, omega-3 fatty acids). However, meta-analyses have not shown convincing clinical benefits and a large trial of such "immunonutrition" in an ICU population found that early provision of glutamine or antioxidants did not improve clinical outcomes, and glutamine was associated with increased mortality. Pending further study use of these amino acids in enteric formulas is not advocated.

Administration guidelines

After desired tube placement location is confirmed, tube feeds can be started at a rate of 10 to 30 mL/h. Isotonic formulas can be started at full strength, whereas hyperosmolar formulas are usually diluted to half strength to improve initial tolerance. Although standard clinical practice had been to monitor gastric residuals at regular intervals, this practice does not reduce aspiration pneumonia risk and is associated with decreased caloric delivery. Nonetheless, the most recent (2009) recommendations from the American Society of Parenteral and Enteral Nutrition advise gastric residual monitoring, and such monitoring is appropriate if there are concerns regarding GI motility or delayed gastric emptying. An evaluation for remediable factors (eg, medications, high-fat content formulas) should be conducted if gastric residual volume exceeds 250 mL, and feedings should be held if residuals exceed 500 mL. In non-ICU settings feeding rates can be advanced 25 mL/h every 8 to 12 hours based on individual tolerance, until target rate is reached. A large study in mechanically ventilated ICU patients indicated that EN was better tolerated (eg, less vomiting, lower mean plasma glucose levels, lower insulin requirement, reduced use of prokinetic agents) and clinical outcomes were similar when feeding rates were kept low (10–30 mL/h, roughly 30% of target rate) for 6 days before increasing by 25 mL/h every 6 hours as tolerated to target rate. Once daily requirements are reached, further adjustments to deliver nutrients primarily at night are often desirable to allow more freedom of movement during the day. Nocturnal feeds probably offer little benefit in terms of decreased satiety and improved intake during the day relative to continuous feeds. Larger-bore NG and gastrostomy tubes allow for intermittent gastric feedings without requirement of a pump. Although this offers convenience advantages and it is more physiologic for food to be placed into the stomach, intermittent bolus feedings are generally avoided in persons with delayed gastric emptying and those at high risk for aspiration.

Attention must also be paid to water and electrolyte requirements. Basal free-water requirements for hospitalized patients are roughly 30 mL/kg per day, or about 1 mL/kcal delivered. Free water will need to be increased if excess fluid loss is occurring as a consequence of diarrhea, urinary, or increased insensible losses. For patients with fever, an additional 300 to 400 mL of water is needed for each degree centigrade of temperature elevation. Monitoring of weight and electrolytes can help direct any necessary adjustments, with additional free-water needs given in divided boluses three or four times a day.

Risks and complications

Proper consideration of whether to proceed with EN entails an understanding of common adverse effects (**Table 35-6**). NG tubes are often not well tolerated, with patient agitation and self-extubation being particularly common among patients with cognitive impairment or delirium. The subsequent need for physical or chemical restraints can increase complications and appropriately dampen enthusiasm for NG tube feedings. Also, EN in actual practice often involves delayed and inadequate nutritional support because of frequent problems with tubes (eg, self-extubation, plugging) or GI intolerance (eg, high residuals, bloating, diarrhea). These factors may explain why attempts to provide EN to older persons are often abandoned after only a short course of therapy. Some have advocated for an early switch to PN, or even starting with PN, particularly if patients are confused or delirious and the expected duration of therapy is short (1–2 weeks). If longer-term support is likely, early use of a percutaneous gastrostomy tube, which tends to be better tolerated by uncooperative or confused patients, may be considered (along with a reevaluation of overall patient care preferences and intervention goals before proceeding with this more invasive approach).

TABLE 35-6

ADVERSE EFFECTS OF ENTERAL NUTRITION AND MANAGEMENT APPROACHES

ADVERSE EFFECTS	MANAGEMENT
Poor tolerance Frequent self-extubation Agitation	Consider Parenteral nutrition Percutaneous gastrostomy tubes
Pulmonary	Elevate head of bed ≥ 30° (ideally 45°)
Aspiration	Monitor gastric residuals, ↓ rate as needed Nasointestinal, G-J, J-tubes
Gastrointestinal Gastric retention Nausea/vomiting Diarrhea	Low-fat formula, metaclopramide Nasointestinal, G-J, J-tubes ↓ Delivery rate, ↑ fiber, antidiarrheals
Metabolic complications Hyperglycemia Fluid and electrolytes Refeeding syndrome[a]	Routine monitoring glucose, electrolytes Monitor weight, volume status, free water Monitor phosphate, magnesium, potassium
Mechanical problems Insertion site irritation/infection Tube plugging G-tube, J-tube extubation Nasopharyngitis, sinusitis, local pain, epistaxis	Local skin care Warm water or pancreatic enzyme flushes See text Use small-bore flexible tube and avoid prolonged nasal intubation (> 4–6 wk)
Drug interaction considerations Tube feeds ↓ bioavailability (eg, ciprofloxacin, azithromycin) Frequent medications interrupt nutrition	Hold feedings 15 min before and after medications Alternate medication routes (IV, IM, rectally, transdermal)

[a]Abrupt, often large drops in serum potassium, phosphorous, magnesium, which may accompany initiation of nutritional support in malnourished patients.

Pulmonary aspiration is a relatively common complication of EN, but unless aspiration causes an overt clinical event (eg, aspiration of a large volume), it is not clear that aspiration causes untoward clinical outcomes such as higher rates of pneumonia. Nonetheless, strategies to reduce aspiration are generally advised. Patients with gastric retention, decreased gag reflex, and altered levels of consciousness are at increased risk for aspiration, and mechanically ventilated patients should not be considered protected by the presence of an endotracheal cuff. The risk of aspiration can be reduced as outlined in **Table 35-6**.

EN-related GI issues include gastric retention and diarrhea. Gastric retention problems may respond to a change to a low-fat formula or to pharmacologic intervention with metoclopramide. When significant diarrhea occurs, infectious causes (particularly *Clostridium difficile*) must first be excluded. The possibility of intolerance to formulas with high osmolality or high fat content should also be considered. Interventions to reduce diarrhea include slowing the rate of infusions, diluting hypertonic formulas, increasing formula fiber content, and the use of antidiarrheal agents. In addition to the electrolyte abnormalities that can be caused by diarrhea, hyperglycemia and other metabolic abnormalities may develop related to tube feedings. Potassium and phosphorous requirements can be very high in the first few days after nutritional support is started because of extracellular to intracellular shifts that accompany nutrient utilization, particularly among very malnourished patients ("refeeding syndrome"). Fluid

retention problems are common in older adults with impaired renal or cardiac function. To minimize these problems, monitoring protocols should include frequent evaluations of GI tolerance, daily weights, and daily monitoring of glucose and electrolytes (including phosphorus, calcium, and magnesium) until stable.

Increased problems with tube clogging often occur when more viscous higher-calorie formulas and medications (especially fiber and calcium supplements) are passed via small-bore (smaller than no. 10 Fr) catheters. Tube maintenance with regular flushing every 4 to 8 hours for patients on continuous feeds, and before and after the delivery of intermittent tube feeds or medications (with 30 mL warm water), can reduce clogging problems. When possible, medications should be given by mouth rather than by feeding tube. If clogging occurs try flushing with 30 to 60 mL of warm water, or a solution containing pancreatic enzymes. Cola or cranberry juice flushes are not consistently effective for resolving occlusions, and when used, their dried residuals can narrow the lumen of the tube and contribute to clogging. Another common mechanical problem is the replacement of a gastrostomy or jejunostomy tube that has fallen out. Feeding tube fistula tracts are generally not well established for at least 1 to 2 weeks after placement (and often substantially longer given malnutrition's adverse effect on wound healing). Tubes that come out early (in the first 2–3 weeks after placement) require replacement by the original specialist. If the fistula tract is well established, patients or care providers should be able to gently replace tubes that have fallen out, and delay in doing so for more than 6 to 12 hours risks spontaneous closure of the tract. However, feeding should not be resumed until proper tube placement is radiologically confirmed.

Parenteral Nutrition

PN, the delivery of required nutrients by vein, is generally indicated to prevent the adverse effects of malnutrition in patients who are unable to obtain adequate nutrients by oral or enteric routes (ie, EN is not possible). However, specific indications regarding if and when to institute PN, as well as the utility of PN once instituted, have not been clearly delineated. In general, the decision to institute PN depends on the severity and expected course of the underlying disease(s) and the severity of preexisting and anticipated undernutrition. The duration of undernutrition that can be tolerated before adverse effects occur is not clear. For critically ill patients who are adequately nourished on admission and have contraindications to EN, guidelines recommend against PN during the first week as early PN may increase risk of infections and other complications. If a critically ill patient has evidence of PEM at admission and EN is not possible, PN initiation within the first few days should be considered. The European Society for Clinical Nutrition and Metabolism guidelines for PN in geriatric patients recommend initiating PN support in older persons facing a period of starvation of more than 3 days when oral nutrition or EN is not possible, or when oral nutrition or EN is likely to be insufficient for more than 7 to 10 days. Decisions to institute PN require careful consideration of the patient's clinical condition and prognosis, clinical judgment about the patient's ability to tolerate undernutrition, and insight regarding patient care needs and preferences.

Efficacy

The European Society for Clinical Nutrition and Metabolism concluded that PN can reduce morbidity and mortality in geriatric patients, but the evidence that PN improves clinical outcomes in older adults is not robust. The limited data that PN can have beneficial effects comes primarily from the following settings: perioperative PN in patients with GI cancers; severely malnourished patients (defined in the reference study by a low nutritional risk index score, which generally was reached if weight loss exceeded 10%–15% and serum albumin level was < 33 g/L, or, in the absence of weight loss, if albumin was < 28 g/L) undergoing major elective surgery; and bone marrow transplant recipients, malnourished critically ill patients, and patients with short bowel syndrome. Overall there is a paucity of studies and many unanswered questions about the efficacy and safety of PN in older adults. Furthermore, detrimental clinical outcomes observed with routine PN for cancer chemotherapy patients, along with the cost and invasiveness of PN, indicate that risks and benefits must be reviewed carefully for each patient. That PN may be of some benefit when used in cancer patients who are severely malnourished affirms the importance of patient selection and the identification of clear goals of therapy before instituting PN.

Administration guidelines

Intravenous Access

Total parenteral nutrition (TPN), the delivery of all required nutrients by vein, requires the use of hypertonic solutions that can only be tolerated when delivered into large venous vessels, preferably into the superior vena cava. Because peripheral veins are limited to solutions containing lower concentrations of amino acids and dextrose (< 10% dextrose), peripheral parenteral nutrition (PPN) usually cannot deliver nutrients in sufficient quantity to meet all requirements. Although the infusion of lipids can improve energy delivery and vessel tolerance to PPN, its role in PN is extremely limited given the uncertain clinical benefits of short-term PPN and the ease of obtaining central venous access to proceed to TPN. Short-term TPN in

the hospital setting is generally delivered through a subclavian or internal jugular venous catheter or via a peripherally inserted central catheter (PICC). PICC lines offer reduced risks of central placement complications (eg, pneumothorax, inadvertent arterial puncture, and hemorrhage) and may have a reduced risk of infectious complications. Tunneled central venous catheters (eg, Hickman or Groshong catheter) are generally preferred over PICCs for long-term TPN (eg, home TPN) owing to lower infection rates. Regardless of the placement method used, proper line position needs to be confirmed by x-ray before initiating TPN.

TPN Composition

Standard TPN solutions contain carbohydrate (dextrose) and protein (amino acid) concentrates, fat emulsions (soybean or safflower oil with egg phospholipids), micronutrients, and electrolytes. Although clinicians should have a basic knowledge of usual TPN formula composition (**Table 35-7**), PN should be initiated and monitored by a team (usually physicians, nutrition specialists, and pharmacists) with an advanced understanding of factors such as nutrient metabolism and solute compatibility. Clinicians should also be aware that electrolyte requirements are highly variable and often require adjustments, as they are influenced by the patient's underlying disease (eg, heart failure, renal dysfunction) and factors such as renal or GI fluid losses. Standard packages of vitamins and trace elements are added to TPN solutions daily to prevent the development of micronutrient deficiencies. Because patients on warfarin should not receive vitamin K, it is not included in standard vitamin packages and must be given separately in doses of 5 to 10 mg/week.

TABLE 35-7

"AVERAGE" TPN FORMULA COMPOSITION AND PARAMETERS FOR DAILY VITAMIN, MINERAL, AND ELECTROLYTE REQUIREMENTS

MACRONUTRIENTS[a]	
Protein	15%
Carbohydrate	55%–65%
Fat	20%–30%
MICRONUTRIENTS	
Vitamins	
Vitamin A	3300 IU
Vitamin D	200 IU
Vitamin E	10 IU
Thiamine (B_1)	6 mg
Riboflavin (B_2)	3.6 mg
Niacin (B_3)	40 mg
Pantothenic acid (B_5)	15 mg
Pyridoxine (B_6)	4 mg
Biotin (B_7)	60 µg
Folic acid (B_9)	600 µg
Cobalamin (B_{12})	5 µg
Vitamin C	200 mg
Trace Elements	
Zinc	5 mg
Copper	1 mg
Chromium	10 µg
Manganese	0.5 µg
Selenium	60 µg
Electrolytes	
Sodium	60–150 mEq
Potassium	40–100 mEq
Chloride	Equal to sodium
Magnesium	16 mEq
Phosphorus	10–30 mmol
Calcium	10 mEq

[a]Percentage of total calories.

The optimal proportions of fat and carbohydrate to meet energy needs are controversial. All standard formulas contain hypertonic glucose (10%–70% dextrose before mixing), but because glucose tolerance declines with age, slow upward titration in delivery rates is necessary in older adults. Aggressive glucose monitoring and treatment is important as hyperglycemia is associated with increased infection risk and worse clinical outcomes in critically ill patients. Glucose infusion rates should not exceed 5 mg/kg/min (about 500 g/day for a 70-kg person on continuous TPN) because the rate at which stressed patients can metabolize glucose as energy is limited. Overfeeding with glucose results in increased risks of hyperglycemia, increased carbon dioxide production, and the conversion of excess glucose calories into fat (which requires energy and contributes to fatty liver changes).

Lipids in the form of 10% to 20% fat emulsions are added to TPN as a source of concentrated energy and to supply essential fatty acids. Delivery of fat emulsions two to three times a week is usually adequate to prevent essential fatty acid deficiency. Fat emulsions are isotonic and are generally well tolerated, but patients occasionally develop hyperlipidemia and, less frequently, have allergic reactions (usually to the egg phospholipid component). Increasing the proportion of energy supplied by fat can reduce hyperglycemia and carbon dioxide production, but fat delivery should not exceed 2.5 g/kg/day (or 50%–60% of nonprotein calories) to avoid possible adverse consequences associated with fat overload. The fat overload syndrome is characterized by hyperlipidemia with diffuse fat deposition that can cause organ and reticuloendothelial system dysfunction and increased risk of sepsis. Lipid emulsions containing fish oil may have anti-inflammatory and antioxidant properties that could be beneficial during critical illness, but to date, evidence is inadequate to recommend their routine use.

Formula Delivery

Initial infusion rates should be at a rate of 25 to 50 mL/h and increased every 8 to 12 hours as metabolic status allows until fluid and nutrition goals are met. At some institutions carbohydrate, fat, and protein TPN components are mixed together into a single bag (total nutrient admixture or 3-in-1 formula), which may have cost and convenience benefits compared to traditional TPN administration of dextrose and amino acids (2-in-1) with separate IV fat emulsion infusions. In most circumstances, daily TPN volumes are infused continuously over the full 24 hours. This allows slower delivery of carbohydrate (which can help reduce hyperglycemia), and the continuous flow may decrease the risk of catheter occlusion while avoiding interruptions that might lead to hypoglycemia. Shorter infusion schedules with brief periods off TPN (cyclic TPN) are occasionally desirable, but this is more of an issue for long-term TPN in the home care setting. Because TPN formulas (especially the lipid component) can suppress appetite, it may be desirable to reduce or hold lipid emulsions for a few days to help improve intake prior to planned discontinuation of TPN.

Patient monitoring and complications

Older persons receiving TPN should be monitored closely (**Table 35-8**), with adjustments made in frequency of monitoring depending on the patient's acuity and stability. **Table 35-9** details common complications and their prevention and/or treatment. Correction of dehydration and volume depletion can most readily be accomplished with standard intravenous fluids, which can be infused separately or added to TPN bags for convenience. Fluid overload can be managed by using higher concentrations of macronutrients to limit total volumes infused, with diuretics added as needed. Although insulin can be added directly to TPN solutions to help control hyperglycemia, it is best to give intravenous insulin separately until caloric delivery and glucose control are stabilized. Intravenous insulin is preferred over subcutaneous insulin owing to the latter's potential for erratic absorption in malnourished patients. Infection and volume depletion need to be considered if hyperglycemia is a persistent problem. As with EN, potassium and phosphate must be monitored closely because they may drop precipitously after initiating TPN in malnourished patients. In most cases, electrolyte requirements stabilize within 1 week. The relative amounts of chloride (which can lead to metabolic acidosis) and acetate (which can be metabolized to bicarbonate and lead to metabolic alkalosis) can be adjusted as needed depending on the patient's acid-base balance. Patient monitoring should also include clinical (eg, weight, functional status) and laboratory (eg, albumin, prealbumin) assessment of the efficacy of nutritional support.

TABLE 35-8

GUIDELINES FOR MONITORING PATIENTS ON TPN

CLINICAL DATA	LABORATORY DATA
Vital signs three times per day until stable Daily weights Daily fluid input and output Daily line and skin inspection Efficacy of nutritional support	Glucose chemsticks QID until stable Daily: Electrolytes, glucose, creatinine, blood urea nitrogen, calcium, phosphorus, magnesium until stable, then twice weekly Weekly: LFTs, albumin, CBC, PT, triglyceride

CBC, complete blood count; LFTs, liver function tests (alanine and aspartate aminotransferase, alkaline phosphatase, bilirubin); PT, prothrombin time.

TABLE 35-9

TPN COMPLICATIONS AND POTENTIAL CORRECTIVE MEASURES

CONDITION	PREVENTION/MANAGEMENT
Metabolic	Restrict fluid by ↑ macronutrient concentrations
Fluid overload	↓ Carbohydrate delivery (rate, concentration), insulin IV; consider ↑ proportion energy from fat
Hyperglycemia	Avoid sudden cessation/interruption of TPN
Hypoglycemia	Start/titrate TPN slowly, avoid overfeeding
Refeeding syndrome	↓ Fat infusion rates and/or frequency of lipids
Hypertriglyceridemia	↑ Acetate/↓ chloride; consider renal/gastrointestinal causes
Hyperchloremic metabolic acidosis	Consider renal/gastrointestinal causes; replete K+;↓ acetate
Metabolic alkalosis	↓ Total calories, ↑ proportion energy from fat
Respiratory (hypercarbia)	
Nonmetabolic	Hand hygiene and maximal barrier precautions during insertion, single-lumen catheter; dedicated TPN line; aseptic line
Line infection	
Hepatic	
Steatosis/↑ LFTs	
Biliary (cholestasis)	Avoid carbohydrate overfeeding; rule out other causes
Catheter occlusion	Enteral feed if possible; rule out other causes
	Regular flushes; no line blood draws; urokinase

LFTs, liver function tests.

Infection of the access line is uncommon in the first 72 hours, so early fevers are usually a result of other causes. The risk of infection can be reduced by following optimal insertion techniques and providing aseptic vigilant catheter care. The line site should be monitored daily for erythema, tenderness, or discharge. Positive line cultures in the absence of other sources are usually an indication for line removal. The increased rates of sepsis that have been observed in some trials of TPN (and which possibly diminished the potential for TPN trials to demonstrate improved clinical outcomes) may have been related to overfeeding and hyperglycemia. Avoidance of hyperglycemia (in particular glucose levels > 200 mg/dL) may decrease the risk of TPN-associated infections. Liver abnormalities that can occur with TPN include fatty liver with elevated liver function tests (often occurs early, likely related to carbohydrate overfeeding, generally benign/reversible) and cholestasis (tends to occur later, after 3+ weeks). EN, even in small amounts, may reduce problems with cholestasis.

Special Issues

Comorbidity

Responses to nutritional support efforts may vary substantially owing to heterogeneity in underlying disease states associated with PEM (particularly the presence and severity of inflammatory/catabolic states). Limited data on the interaction between nutritional support and specific comorbid conditions and care settings include the following:

Hip Fracture

As many as half of all older patients who present with hip fractures are malnourished. Undernutrition may directly contribute to hip fracture events via increased presence of osteoporosis, increased risk of falls as a consequence of reduced lean body mass and strength, and reduced fat to “cushion” a fall. Oral nutritional supplements may improve energy balance and reduce complications and hospital length of stay following hip fracture. While a Cochrane review found the quality of the evidence to be weak, the risks and costs of oral protein energy supplementation are relatively low and as such

should be considered for all undernourished patients after hip fracture. Trials of EN after hip fracture indicate that NG feedings were not well tolerated and did not improve mortality, so consideration of EN should probably be reserved for patients with more severe levels of malnutrition with poor intakes not responsive to oral supplementation.

Chronic Obstructive Pulmonary Disease

Prevalence estimates of malnutrition in patients with COPD range from 20% to 70%. Causes are likely multifactorial and include increased inflammatory activity, higher metabolic rate due to work of breathing and diminished intake due to dyspnea, chronic sputum (can alter taste), flattened diaphragm (may contribute to early satiety), and medication side effects (eg, adverse GI effects). Although one meta-analysis concluded that energy supplementation does not have significant clinical effects in patients with *stable* COPD, another review indicated that 10 of 12 randomized controlled trials have noted positive effects of nutritional support (mostly oral supplements providing 400–1000 kcal/day) on anthropometric, immune, muscular strength, and respiratory function outcome measures. Given the relative low cost and potential for benefit, nutritional support should be considered for all patients with COPD and evidence of PEM.

Nursing Home Care Setting

Very high prevalence rates of PEM and weight loss have been documented in nursing home settings. Because conditions associated with reduced intake are common in nursing home residents (eg, dental, chewing, swallowing problems, depression, cognitive impairment, and dependence on others for feeding), it is likely that the proportion of patients with PEM caused by reduced intake (without inflammatory/cachexia states) is higher than among hospitalized patients. In this setting, simple interventions such as fortified foods, high-calorie snacks, nutritional supplements, and assisted feeding can improve nutritional parameters and help to stabilize weight. Although it is not clear that improvements in nutritional parameters translate to improved clinical outcomes, such interventions may enhance quality of life and are likely reasonable and appropriate for most nursing home residents.

Dementia

Use of tube feeds in patients with advanced dementia is not advised. Tube feeding patients with advanced dementia does not appear to improve nutritional status, decrease pressure sores or infections, reduce aspiration problems, or improve functional status or survival. Potential adverse effects of tube feeds in these patients include increased risk of aspiration, discomfort and complications from tube placement, agitation with increased use of physical and chemical restraints, worsening pressure ulcers from increased urine and fecal output, and diminished quality of life from decreased interaction at mealtime and loss of gustatory pleasure from food intake. The lack of demonstrable benefits, combined with considerable potential for harm, led the American Geriatrics Society to advise clinicians not to recommend percutaneous feeding tubes in patients with advanced dementia and instead to offer oral assisted feeding with food as the preferred nutrient.

Future directions

An increased understanding of the physiologic mechanisms underlying appetite, inflammatory and other systemic responses to acute stressors, illness and aging, is leading to new approaches that may help to attenuate the adverse outcomes associated with undernutrition and cachexia. Such approaches are needed. Despite aggressive nutritional support, it is often difficult to lessen the catabolic effects that occur in response to illness or injury. Also, anthropometric measures indicate that when body weight does increase with nutritional support, gains are mostly in the form of fat and water, whereas greater increases in lean body mass might lead to better functional and overall clinical outcomes. Strategies under investigation to better prevent protein catabolism and/or promote anabolism include enriched delivery of certain nutrients (eg, glutamine, arginine) that may have positive immunomodulating action independent of their role as nutritional substrates; agents with anti-inflammatory effects (eg, omega-3 fatty acids, thalidomide); agents with anticytokine activity (eg, inhibitors of TNF-α production, antibodies to TNF-α or to IL-6); and anabolic agents with more favorable benefit-to-risk profiles (eg, SARMs, myostatin inhibitors). Other approaches to prevent or ameliorate weight loss and cachexia may focus on overcoming anorexia by modulating effects of peptides and hormones involved in appetite and energy regulation such as ghrelin, neuropeptide Y, and leptin. Although promising, such strategies to increase appetite, anabolism, and/or decrease catabolism require further study to better define their efficacy and safety in various disease states before they can be considered for clinical use.

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