REVIEW ARTICLE

NUTRITION IN MEDICINE

Enteral Nutrition in Hospitalized Adults

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CME

Enteral nutrition is defined as the provision of essential nutrients through an enteral tube to prevent or treat disease-related malnutrition in patients who are unable to consume adequate nutrients by mouth.[1] The interplay of inadequate dietary intake and inflammation that characterizes disease-related malnutrition affects a patient's response to medical nutrition therapy, including enteral nutrition. Randomized, controlled trials performed over the past 15 years, involving mainly critically ill patients, as well as recent studies involving medical and surgical patients who were not critically ill, have informed our current understanding of enteral nutrition. This review considers enteral nutrition in the context of disease-related malnutrition, provides evidence for the use of enteral nutrition in hospitalized patients, and discusses practice considerations.

NUTRITION CARE FOR HOSPITALIZED PATIENTS

Disease-related malnutrition is a complex syndrome involving inadequate nutrient intake, insufficient nutrient utilization, and disease-related systemic inflammation, factors that result in altered body composition and diminished bodily function.[2] This disorder is associated with a high risk of adverse health and economic outcomes, including death, prolonged hospitalization, hospital readmission, and high health care costs.[3,4] Globally, 30 to 45% of hospitalized adults are malnourished on admission.[2,3,5,6] Data published in the past 5 years indicate that enteral nutrition was used in 5.2% and 4.9% of malnourished hospitalized patients in the United States and Europe, respectively.[7,8] These findings highlight the need to identify patients with disease-related malnutrition in order to prevent continued nutritional decline, with the use of enteral nutrition when appropriate.[9] During hospitalization, most patients in the intensive care unit (ICU) and up to 1 in 20 non–critically ill medical or surgical patients receive enteral nutrition.[7,8]

The terms medical nutrition therapy and nutrition support are often used interchangeably. Whereas medical nutrition therapy includes patient counseling and the use of oral nutritional supplements in addition to enteral and parenteral nutrition, nutrition support refers only to enteral and parenteral nutrition.[10,11] The benefits of medical nutrition therapy in malnourished patients were shown in the landmark EFFORT (Effect of Early Nutritional Support on Frailty, Functional Outcomes, and Recovery of Malnourished Medical Inpatients Trial) investigation.[4] The EFFORT researchers randomly assigned more than 2000 patients at nutritional risk who were not receiving enteral nutrition to receive individualized medical nutrition therapy or standard care. Medical nutrition therapy led to higher mean daily caloric and protein intake than standard care (approximately 22 vs. 18 kcal per kilogram of body weight and 0.8 vs. 0.7 g of protein per kilogram per day, respectively); medical nutrition therapy also led to lower odds of an adverse outcome (adjusted odds ratio, 0.79; 95% confidence interval [CI], 0.64 to 0.97; P=0.02) and

KEY POINTS

ENTERAL NUTRITION IN HOSPITALIZED ADULTS

- Malnutrition is prevalent among hospitalized patients, many of whom may be able to meet nutritional needs through oral intake.
- Standardized nutrition care pathways aid in the detection of malnutrition and the identification of patients who may benefit from enteral nutrition.
- Patients with inadequate caloric intake may need enteral nutrition.
- Recent evidence suggests that underfeeding (providing 70% of energy and protein requirements) is not harmful during the acute phase of critical illness in patients in the intensive care unit.
- An area requiring further investigation in enteral nutrition is the dosing of nutrition during recovery and rehabilitation.

lower mortality (adjusted odds ratio, 0.65; 95% CI, 0.47 to 0.91; P=0.01).[4] According to the trial protocol, enteral or parenteral nutrition was used if at least 75% of the daily energy and protein requirements could not be met through oral feeding within 5 days; the need for such support was infrequent.[4]

Additional studies inform our understanding of the benefits of medical nutrition therapy. A 2019 meta-analysis of data from 6803 patients showed that medical nutrition therapy, as compared with usual care, significantly reduced the risk of death (by 27%) up to 6 months after hospital discharge, decreased nonelective hospital readmissions, improved protein and energy intake, and increased body weight.[12] However, no significant differences were noted in functional outcomes or hospital length of stay. A meta-analysis by Kaegi-Braun et al., who assessed in-hospital mortality among malnourished medical patients on the basis of claims data, showed a 21% lower risk of in-hospital death among 69,000 patients who received medical nutrition therapy than among matched patients who did not receive such therapy (incidence rate ratio, 0.79; 95% CI, 0.75 to 0.84; P<0.001).[8] This meta-analysis was later updated to include 16 randomized, controlled trials involving medical patients with two or more conditions and showed that medical nutrition therapy (mostly oral nutrition and enteral nutrition) was associated with significantly lower odds of death than no medical nutrition therapy (odds ratio, 0.68; 95% CI, 0.51 to 0.91; P=0.009), as well as with significantly lower odds of unplanned hospital readmission (odds ratio, 0.64; 95% CI, 0.45 to 0.90; P=0.01).[13]

Nutrition in hospitalized patients can be addressed through evidence-based pathways; an example is shown in Figure 1.[2,14] On admission, patients can be screened for malnutrition with validated tools such as the Malnutrition Screening Tool, the Malnutrition Universal Screening Tool, or Nutrition Risk Screening 2002.[15,16] Patients found to be at risk for malnutrition should then undergo a nutrition assessment by a skilled professional. Diagnostic criteria for disease-related malnutrition include the Global Leadership in Malnutrition (GLIM) criteria and the Academy of Nutrition and Dietetics–American Society for Parenteral and Enteral Nutrition Indicators of Malnutrition (AAIM) criteria.[17,18] The GLIM criteria, when applied in a secondary analysis of data from EFFORT, predicted adverse clinical outcomes and the response to nutrition treatment.[19] When medical nutrition therapy is needed, all available strategies to improve oral intake, including dietary modification and oral nutrition supplements, are recommended. If oral intake remains insufficient, with less than 75% of daily caloric and protein requirements met, enteral nutrition is indicated, in the absence of obvious contraindications.[1] The timing for initiation of enteral nutrition depends on the extent to which a patient is able to meet their needs through oral intake, the patient's clinical condition, and the degree of malnutrition. If enteral nutrition is associated with negative effects not acceptable to the patient or with other concerns, parenteral nutrition may be used (Fig. 1).

THE ROLE OF ENTERAL NUTRITION

Enteral nutrition should be considered in patients with conditions such as critical illness, dysphagia, neurologic disease, gastrointestinal or liver disease, cancer (particularly head and neck or esophageal cancer), cystic fibrosis, chronic

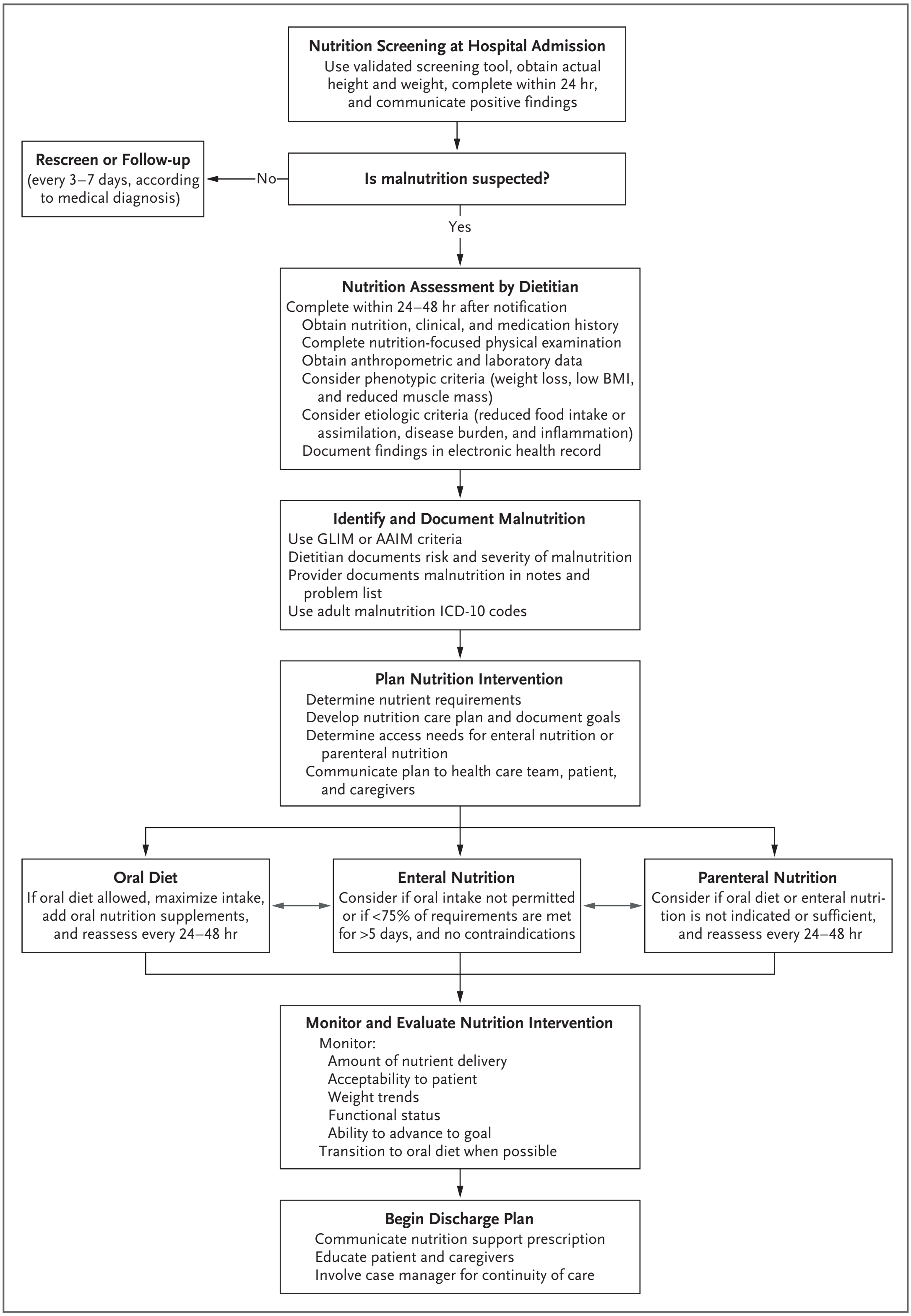

Nutrition Screening at Hospital Admission
Use validated screening tool, obtain actual height and weight, complete within 24 hr, and communicate positive findings
Is malnutrition suspected?
No
Rescreen or Follow-up
(every 3–7 days, according to medical diagnosis)
Yes
Nutrition Assessment by Dietitian
Complete within 24–48 hr after notification
Obtain nutrition, clinical, and medication history
Complete nutrition-focused physical examination
Obtain anthropometric and laboratory data
Consider phenotypic criteria (weight loss, low BMI, and reduced muscle mass)
Consider etiologic criteria (reduced food intake or assimilation, disease burden, and inflammation)
Document findings in electronic health record
Identify and Document Malnutrition
Use GLIM or AAIM criteria
Dietitian documents risk and severity of malnutrition
Provider documents malnutrition in notes and problem list
Use adult malnutrition ICD-10 codes
Plan Nutrition Intervention
Determine nutrient requirements
Develop nutrition care plan and document goals
Determine access needs for enteral nutrition or parenteral nutrition
Communicate plan to health care team, patient, and caregivers
Oral Diet
If oral diet allowed, maximize intake, add oral nutrition supplements, and reassess every 24–48 hr
Enteral Nutrition
Consider if oral intake not permitted or if <75% of requirements are met for >5 days, and no contraindications
Parenteral Nutrition
Consider if oral diet or enteral nutrition is not indicated or sufficient, and reassess every 24–48 hr
Monitor and Evaluate Nutrition Intervention
Monitor:
Amount of nutrient delivery
Acceptability to patient
Weight trends
Functional status
Ability to advance to goal
Transition to oral diet when possible
Begin Discharge Plan
Communicate nutrition support prescription
Educate patient and caregivers
Involve case manager for continuity of care

Figure 1 (facing page). Nutrition Care Pathway for Hospitalized Adults from Admission to Discharge.
AAIM denotes Academy of Nutrition and Dietetics–American Society for Parenteral and Enteral Nutrition Indicators of Malnutrition, BMI body-mass index, GLIM Global Leadership Initiative on Malnutrition, and ICD-10 *International Classification of Diseases, 10th Revision.*

obstructive pulmonary disease, and kidney disease.[1,20] Such patients may be unable to eat by mouth or may have chronic disease–related anorexia. Contraindications to enteral nutrition include intestinal obstruction or ileus, severe shock, intestinal ischemia, high-output fistulae, and severe intestinal hemorrhage.[1] Patients requiring enteral nutrition generally have polymorbidity, which itself is associated with poor outcomes.[21] Coordinated interdisciplinary care and patient-centered decision making are required for effective enteral nutrition.[2]

Enteral nutrition is used frequently in the ICU, which accounts for approximately 14% of beds in U.S. hospitals.[22] Enteral nutrition may be more effective in the ICU, with the high staff-to-patient ratios, multidisciplinary approaches to care, and focus on nutritional care, than in other hospital units.[23] Multiple high-quality trials have provided nuanced insights into the dose, route, timing, and composition of nutrition support in critically ill patients. Enteral nutrition is used less frequently in the treatment of general medical and surgical patients, and fewer high-quality studies have been undertaken to assess the role and effects of enteral nutrition in non–critical care settings.

PATHOPHYSIOLOGY OF MALNUTRITION AND THE ACUTE INFLAMMATORY RESPONSE

The development of disease-related malnutrition in hospitalized patients is multifactorial, involving reduced appetite and intake, endocrinopathies, muscle wasting associated with immobility, older age, adverse effects of disease treatments, polypharmacy, and disease-related inflammation.[2,24,25] Acute illness overrides the adaptive responses to starvation that normally help preserve muscle mass and reduce energy expenditure.[26-28] Inflammation affects metabolism through several mechanisms, including increased release of proinflammatory cytokines (e.g., tumor necrosis factor α, interleukin-6, and interleukin-1β) and C-reactive protein (CRP).[2] Driven by activation of the hypothalamic–pituitary–adrenal axis, altered metabolism is associated with the release of cortisol and catecholamines, increased glycogenolysis and hepatic gluconeogenesis, and peripheral insulin resistance.[2] In EFFORT, a subgroup analysis showed no beneficial effect of medical nutrition therapy in patients with CRP levels higher than 100 mg per liter (adjusted odds ratio for death within 30 days, 1.32; 95% CI, 0.70 to 2.50; P=0.39), a finding that suggests that the presence of inflammation affected the efficacy of medical nutrition therapy.[2,25] In addition, a recent GLIM consensus statement notes that inflammation is a driver of malnutrition and is one of the criteria used for diagnosis; both acute and chronic inflammation may be implicated, as indicated by clinical signs and markers such as elevated CRP levels.[29]

In ICU patients, metabolic responses are proportional to the severity of the injury or illness.[2,30] During the acute phase of critical illness, energy expenditure is reduced, and macronutrient metabolism is altered to provide glucose to vital organs such as the heart, brain, and red cells.[31] In addition, endogenous glucose production is elevated, with increases in glucose turnover in the liver, intestine, and kidneys.[27,32-34] Excessive protein breakdown occurs during the acute phase of critical illness as a result of overactivation of the ubiquitin–proteasome pathway. Muscle wasting occurs early and rapidly during the first week of critical illness and is more severe in people with multiorgan failure than in those with single-organ failure.[27,35,36] Amino acids derived from protein catabolism are the main substrates of hepatic gluconeogenesis but are diverted during critical illness to produce acute-phase proteins. In the late acute phase of critical illness, there is an increase in oxygen consumption and energy expenditure, with ongoing tissue breakdown providing substrates to preserve critical organ function. During the recovery phase, metabolic responses normalize, and protein and fat stores are gradually replenished.[27,37]

The duration of the acute phase of critical illness is a subject of debate but is generally thought to be on the order of days.[38] The acute phase results in anabolic resistance, suppression of cellular repair processes, and insulin resistance.[38] The lack of benefit of early full feeding (provision of 70 to 100% of estimated caloric requirements) may be explained by the inability of the body to counteract catabolism and the added metabolic burden of feeding, as indicated by increased ureagenesis, hyperglycemia, and hypertriglyceridemia.[39-41] Underfeeding (nutritional delivery of <70% of the calculated or measured energy requirements) is hypothesized to support an adaptive metabolic response by allowing for ketogenesis, avoiding hyperglycemia, and promoting autophagic clearance of cellular damage. By contrast, overfeeding in the acute phase can occur when energy and protein goals are fully met.[42] The concept of improving recovery in critical illness through early energy and protein restriction is further supported by additional clinical and translational evidence.[42] However, biomarkers and bedside monitors that can identify the resolution of the acute phase of critical illness and anabolic resistance, which would herald potential responsiveness to feeding, are currently lacking.[43]

ENTERAL NUTRITION IN SPECIFIC PATIENT POPULATIONS

Evidence-based guidelines for nutrition care are evolving. Several well-designed trials conducted over the past 15 years have informed guidelines and provided insight into the route, timing, and dose of nutrition in the ICU (Table S1 in the Supplementary Appendix, available with the full text of this article at NEJM.org). However, earlier ICU guidelines and guidelines for non–critically ill medical and surgical patients with multiple disorders lacked support from good-quality clinical evidence, did not include recent data from well-designed trials, and were subject to a high risk of bias from commercial influence and heterogeneity (Table 1).[21,37,44,46-49] Differences between European and U.S. critical care guidelines reflect uncertainty about the nutrition strategy indicated for different patient populations, particularly with regard to the recommended dose of energy and protein during the acute phase of critical illness.[38]

ENTERAL NUTRITION IN THE ICU

Patients in the ICU are commonly underfed, receiving approximately 50 to 60% of recommended energy and protein targets during the first week.[37,46,47,50] The 2014 CALORIES trial, in which 2400 critically ill adults were randomly assigned to receive isocaloric enteral or parenteral nutrition within 3 days after ICU admission, showed no significant difference in 30-day mortality between the two groups.[51] The researchers in the NUTRIREA-2 trial randomly assigned 2410 patients who were in shock and receiving mechanical ventilation to receive isocaloric enteral or parenteral nutrition within 24 hours after ICU admission, with a caloric target of 20 to 25 kcal per kilogram per day. Although there was no significant difference in 30-day mortality between the groups, early high-dose enteral nutrition was associated with more digestive complications than parenteral nutrition.[52] In three randomized, controlled trials involving critically ill patients assigned to receive a lower or higher dose of enteral nutrition, which was initiated in the acute phase of critical illness and continued for 6, 14, or 28 days, the higher dose was not associated with lower mortality than the lower dose, and results for secondary outcomes suggested that the higher dose was potentially harmful.[53-55]

In the recent NUTRIREA-3 trial, 3044 patients who were in shock and were receiving mechanical ventilation were randomly assigned to receive high-dose nutrition (25 kcal per kilogram per day and 1.0 to 1.3 g of protein per kilogram per day) or low-dose nutrition (6 kcal per kilogram per day and 0.2 to 0.4 g of protein per kilogram per day), provided by means of enteral or parenteral nutrition during the first week of ICU admission. The trial showed harm in the high-dose nutrition group, with a longer stay in the ICU and more complications.[56] To best meet caloric needs, easy-to-use indirect calorimeters that can measure energy requirements in patients have been developed.[57] However, the use of indirect calorimetry to guide energy delivery, as compared with a predictive equation, did not significantly affect the incidence of infection ($P=0.17$) in a randomized, controlled trial that involved 417 ICU patients.[58]

The EFFORT Protein trial evaluated the effects of providing a high dose of protein (≥2.2 g per kilogram per day) as compared with the

Table 1. **Considerations for the Use of Enteral Nutrition in Clinical Practice Guidelines for Specific Patient Populations.***

Patient Population and Applicable Organization	Timing	Dose		EN-Specific Recommendations
		Energy	Protein	
Critically ill adults				
ESPEN[37,44]	Initiate EN within 48 hr.	Days 1–3, ≤70% goal; days 3–7, 20–25 kcal/kg/day	1.3 g/kg/day	EN use should be delayed in patients with uncontrolled shock.[45]
ASPEN and SCCM[46,47]	Initiate EN within 24–48 hr.	12–25 kcal/kg/day	1.2–2.0 g/kg/day	EN is not preferred over PN. Implement enteral feeding protocols. When EN is not feasible or sufficient in high-risk or poorly nourished patients, start PN early.
Medical patients with multiple coexisting conditions[21]	In patients with inadequate oral intake, initiate EN early (<48 hr after admission).	27–30 kcal/kg/day	1.2–1.5 g/kg/day (0.8 g/kg/day in patients with impaired kidney function [eGFR <30 ml/min/1.73 m^2 of body-surface area])	
Surgical patients[48,49]	Use EN or PN if preoperative oral intake <50% of requirements. In perioperative period, use EN if patient unable to eat for >5 days. In postoperative period, use EN if intake <50% of requirements for >7 days.	25–30 kcal/kg/day	1.5 g/kg/day	

* For more detail on these guidelines, see Table S1 in the Supplementary Appendix. ASPEN denotes American Society for Parenteral and Enteral Nutrition, eGFR estimated glomerular filtration rate, EN enteral nutrition, ESPEN European Society for Clinical Nutrition and Metabolism, ICU intensive care unit, PN parenteral nutrition, and SCCM Society of Critical Care Medicine.

usual dose (≤1.2 g per kilogram per day), with nutrition support initiated within 96 hours after ICU admission and continued for up to 28 days, in 1301 critically ill patients receiving mechanical ventilation.[59] Higher protein dosing did not shorten the time to discharge from the hospital (hazard ratio, 0.91; 95% CI, 0.77 to 1.07; P=0.27) or reduce mortality (relative risk of death, 1.08; 95% CI, 0.92 to 1.26) and was harmful in patients with acute kidney injury and high organ failure scores. In contrast, a recent meta-analysis of 29 studies published between 2012 and 2022 showed little reduction in mortality and no harm associated with the provision of more than 1.2 g of protein per kilogram per day.[45,60,61]

Taken together, the currently available data reveal potential harms of early full-dose nutrition in patients with critical illness. Such data suggest that enteral nutrition, as compared with parenteral nutrition, may not affect mortality among patients in the ICU, but enteral nutrition is associated with more gastrointestinal complications. In addition, enteral nutrition and parenteral nutrition involving higher caloric intake are associated with harm, especially in patients with organ failure. Gaps remain in our knowledge of nutrition in patients with critical illness. Observational studies have shown associations between a cumulative protein and energy deficit and worse outcomes in critical illness, with findings that illuminate the potential benefits of ensuring an appropriate dose of nutrition throughout the ICU stay.[42,62-65] No guidelines are available to guide nutrition care during recovery from critical illness, which is considered to occur approximately between days 9 and 16. More research is needed to adapt enteral nutrition protocols used in the acute phase of critical illness for use during the recovery period, when patients are transitioned out of the ICU.[66]

ENTERAL NUTRITION IN MEDICINE AND SURGERY

Randomized, controlled trials of enteral nutrition in non–critically ill medical and surgical patients suggest the potential harm of underfeeding. In a study involving 1024 hospitalized patients with various conditions, 16% had food intake below 70% of estimated requirements. Low food intake was associated with an increased risk of infection (odds ratio, 2.26; 95% CI, 1.24 to 4.11).[67] In a study involving medical patients with multiple coexisting conditions who were at risk for malnutrition, patients who received enteral nutrition had a lower incidence of complications than those who did not receive enteral nutrition (20.3% vs. 28.1%; P=0.009), and nutrition support was a protective factor with regard to complications in at-risk patients when the analysis was adjusted for confounders (odds ratio, 0.54; P<0.001).[68] The OPENS (Optimizing Early Enteral Nutrition in Severe Stroke) trial included 321 patients with severe stroke who were randomly assigned to receive hypocaloric enteral nutrition (40 to 60% of estimated caloric requirements), full enteral nutrition (70 to 100% of estimated caloric requirements), or "modified" full enteral nutrition (full enteral nutrition with prokinetic agents). This trial was terminated early because of significantly higher 90-day mortality in the group receiving hypocaloric enteral nutrition than in the group receiving modified full enteral nutrition (34% vs. 17%; adjusted odds ratio, 2.89; 95% CI, 1.46 to 5.72; P=0.002).[69]

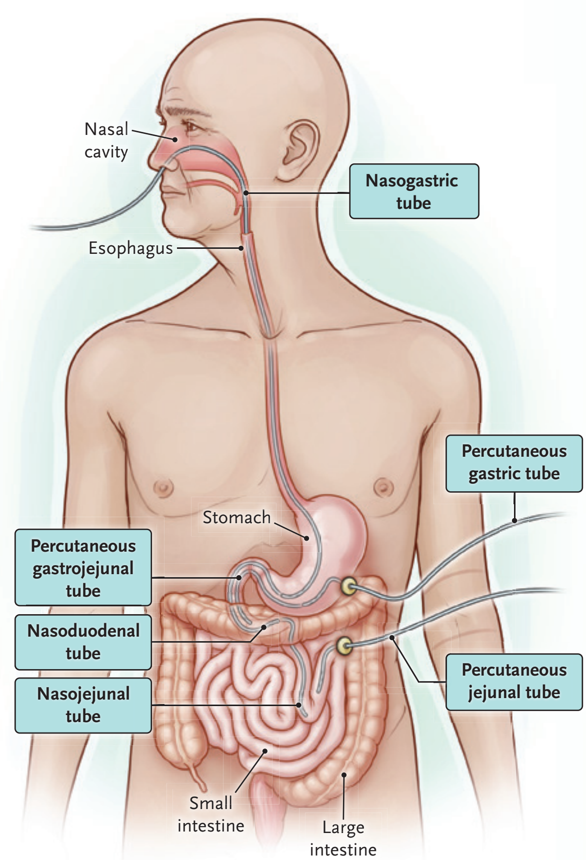
Studies of enteral nutrition in surgical patients suggest that the amount of energy provided in the postoperative period affects outcomes. The advantages of early as compared with late commencement of enteral nutrition in surgical patients have been shown in a Cochrane meta-analysis.[70] A trial involving ICU patients who had undergone major abdominal surgery and had inadequate nutrition with enteral nutrition alone compared early supplemental parenteral nutrition (started on postoperative day 3) with late supplemental parenteral nutrition (started on postoperative day 8).[71] Earlier provision of supplemental parenteral nutrition was associated with greater energy delivery (26 kcal per kilogram per day, vs. 15 kcal per kilogram per day with later provision of supplemental parenteral nutrition) and significantly fewer nosocomial infections (difference in risk, 9.7 percentage points; 95% CI, 0.9 to 18.5; P=0.04). In a trial involving patients with esophageal cancer who underwent esophagectomy, in which patients were randomly assigned to receive postoperative enteral nutrition initiated within 48 hours, at 48 to 72 hours, or more than 72 hours after the procedure, initiation of enteral nutrition within 48 hours was associated with greater energy delivery and significantly fewer pulmonary infections than initiation after 72 hours (P=0.008).[72]

PRACTICAL CONSIDERATIONS IN THE USE OF ENTERAL NUTRITION

To promote acceptance of enteral nutrition, it is important to incorporate a patient's values, beliefs, and goals in shared decision making to enhance adoption, comfort, and the overall experience. Patients may not believe that enteral nutrition is an acceptable treatment option, particularly if they are not critically ill. Enteral nutrition is an option in patients with mild or moderate dementia, but professional guidelines recommend against the use of enteral nutrition in patients with severe dementia or in the terminal phase of life.[73]

ENTERAL ACCESS

The choice of route for enteral access depends on the disease, gastrointestinal anatomy and function, and expected duration of therapy (Fig. 2).[14] Bedside placement of nasoenteric feeding tubes can either be unassisted or achieved with the use of a variety of advanced technologies, such as an electromagnetic or real-time visualization device.[74] Some hospitals have dedicated



Route	Anticipated duration	Tip location	Tube size and material	Method of insertion
Nasogastric, orogastric	Short term	Stomach	5-10 French, silicone or polyurethane	• Bedside placement by RN, RD, or MD with radiologic confirmation
Nasojejunal, nasoduodenal	Short term	Jejunum	5-10 French, silicone or polyurethane	• Bedside placement by RN, RD, or MD with radiologic confirmation • Electromagnetically guided bedside placement • Real-time imaging bedside placement system • Endoscopic • Radiologic
Percutaneous gastric	Long term	Stomach	18-24 French, silicone or polyurethane	• Endoscopic • Radiologic • Surgical
Percutaneous gastrojejunal	Long term	Jejunum	12-24 French, silicone or polyurethane	• Endoscopic • Radiologic • Surgical
Percutaneous jejunal	Long term	Jejunum	12-18 French, silicone or polyurethane	• Endoscopic • Radiologic • Surgical

Figure 2. Enteral Access.

Considerations for enteral access include route, duration, tip location, tube size and material, and method of insertion. MD denotes medical doctor, RD registered dietitian, and RN registered nurse.

trained clinicians who place short-term tubes.[75] Short-term enteral access (for durations of up to 6 weeks) is typically through the nostrils, with the tip of the tube terminating in the stomach or beyond the pylorus in the duodenum or jejunum.[76]

Postpyloric feeding may benefit patients who are unable to receive feedings at the goal rate by the gastric route. Gastric feeding was compared with postpyloric feeding in a meta-analysis that included 41 studies involving 3248 participants.[77] Postpyloric feeding was associated with a lower incidence of pulmonary aspiration, gastric reflux, and pneumonia ($P<0.001$ for each outcome); a lower incidence of gastrointestinal complications ($P<0.05$); and a shorter time to reach nutritional targets ($P<0.05$).

Small-bore (8- to 12-French) tubes made of silicone or polyurethane are softer and more comfortable than large-bore tubes but may be prone to clogging. Large-bore (≥14-French) tubes are stiffer, are less likely to clog, and facilitate aspiration of gastric contents but should be replaced with more pliable feeding tubes within 5 to 7 days.[78] The goal is often to transition hospitalized patients from short-term enteral nutrition to oral nutrition, but if enteral nutrition is needed for more than 4 to 6 weeks, placement of a long-term feeding tube should be considered.[79] The choice of a specialist to place a long-term feeding tube is often based on referral patterns within an institution, scheduling limitations, and the availability of resources.[80] In a study involving 184,068 patients in the Nationwide Readmissions Database, endoscopically placed tubes were associated with a significantly lower risk of inpatient adverse events, death, and readmission than tubes placed fluoroscopically or surgically.[81]

MEETING NUTRIENT REQUIREMENTS

Enteral feeding formulas generally meet micronutrient and protein requirements if there is macronutrient delivery of at least 1500 kcal per day. However, enteral nutrition is often prescribed at a dose below this target, with 1000 kcal per day the most frequently delivered dose.[82] In patients receiving less than 1500 kcal per day, supplemental protein and micronutrients may be required.[82] A variety of commercially prepared enteral nutrition products are available, which vary in concentration, macronutrient and micronutrient composition, fiber content, and inclusion of other nutrients.

ADMINISTRATION AND SAFETY

Pump-assisted continuous feeding is the most common method of delivering enteral nutrition, which is generally initiated slowly and advanced gradually while the patient is monitored for signs of electrolyte imbalance or other potential negative effects.[83] Strategies for reducing harm and maximizing the benefit of enteral nutrition are detailed in Table 2.[1,51,55,83-90] A recent advancement in safety is the use of enteral-specific connectors (ENFit) to prevent enteral misconnections.[91] Eliminating the measurement of gastric residual volumes has also improved the amount of enteral nutrition delivered. One trial showed that patients who did not undergo gastric residual volume measurement were more likely than those who did to receive 100% of caloric goals and did not have significantly higher risk of ventilator-associated pneumonia.[92] There were no significant between-group differences in other ICU-acquired infections, the duration of mechanical ventilation, the ICU length of stay, or mortality. In hospitals that continue to measure gastric residual volumes, guidelines suggest that feedings be withheld only when the volume is greater than 500 ml.[46]

Enteral nutrition is usually infused at a constant rate (rate-based feeding). By contrast, volume-based feeding focuses on giving the full amount prescribed over a 24-hour period, with rates adjusted to deliver the total prescribed volume. This method can help offset the effects of discontinuing enteral nutrition in order to perform procedures or administer therapies, may be used in both critically and non–critically ill patients, and is superior to rate-based feeding for meeting caloric goals.[93,94]

Intensification of glycemic control and treatment of refeeding syndrome may be required in patients who begin to receive enteral nutrition. Refeeding syndrome, defined by the presence of hypophosphatemia, hypokalemia, and hypomagnesemia, is managed by careful monitoring, supplementation of electrolytes and vitamins, and a slow increase in calories.[85,86]

Table 2. Reducing Harm and Maximizing Benefit in Patients Receiving EN.

Potential Harm	Strategies to Maximize Benefit
Metabolic	
Poor glycemic control[83,84]	Incorporate EN into insulin protocol. Reduce carbohydrate delivery. Consider using diabetes-specific formulas, fiber-containing formulas, or both.
Refeeding syndrome[85,86]	Monitor and replete potassium, phosphorus, and magnesium. Supplement thiamine, at least 100 mg daily, for 7–10 days. Restrict initial caloric intake to a maximum of 500 kcal/day and then gradually increase caloric intake.
Gastrointestinal	
Bowel ischemia[1,55]	Delay EN or introduce cautiously, watching for gastrointestinal intolerance. Consider trophic feeding only or withholding EN in patients with uncontrolled shock.
Dysmotility (including acute colonic pseudo-obstruction)[51]	Use prokinetic agents to increase motility. Reduce, replace, or discontinue medications that slow motility (e.g., opiates). Consider switching to a type of formula that is more easily digested and absorbed.
Nausea or vomiting[83]	Provide a scheduled antiemetic regimen. Use promotility strategies. Prioritize glucose control. Obtain postpyloric enteral access.
Diarrhea[83]	Discontinue or reduce dose of medications that may cause diarrhea. Identify and treat underlying medical or surgical issues and infections. Rule out other causes, such as exocrine pancreatic insufficiency.
Constipation[87]	Adjust medications that decrease gastrointestinal motility. Add or adjust bowel regimen.
Infectious	
Aspiration pneumonia[88]	Elevate head of bed 30–45 degrees. Use prokinetic medications. Consider postpyloric feeding.
Mechanical	
Clogged feeding tube[89,90]	Flush enteral tube after administration of medications and during tube feeding. Avoid frequent checking of gastric residual volumes.
Tube displacement[87]	Consider use of a device that secures nasal feeding tube (bridle). Consider need for use of patient restraints on the basis of hospital policy.

CONCLUSIONS

Enteral nutrition is used frequently in the ICU and can also be an important aspect of treatment in non–critically ill medical and surgical patients. The key function of enteral nutrition is to prevent and treat nutritional deficiency that contributes to disease-related malnutrition and its consequences. The administration of enteral nutrition requires multidisciplinary care and a patient-focused approach. Our understanding of nutrient metabolism during acute illness and the effects of enteral nutrition as a feeding strategy in hospitalized patients continues to evolve.

Disclosure forms provided by the authors are available with the full text of this article at NEJM.org.

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