Nutritional support for the trauma and emergency general surgery patient: What you need to know

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ABSTRACT: Decades of research have provided insight into the benefits of nutritional optimization in the elective surgical patient. Patients who are nutritionally prepared for surgery enjoy reduced length of hospital and intensive care unit stays and suffer fewer complications. In the trauma and emergency general surgery patient populations, we are not afforded the preoperative period of optimization and patients often suffer longer lengths of hospital stay, discharge to nonhome destinations, and higher infectious and mortality rates. Nonetheless, ongoing research in this vulnerable and time critical diagnosis population has revealed significant outcomes benefits with the meticulous nutritional support of these patients. However, it is important to note that optimal nutritional support in this challenging patient population is not simply a matter of "feeding more and feeding earlier." In this review, we will address assessing nutritional needs, the provision of optimal nutrition, the timing and route of nutrition, and monitoring outcomes and discuss the management of nutrition in the complex trauma and emergency general surgery patient. (*J Trauma Acute Care Surg.* 2024;96: 855–864. Copyright © 2024 Wolters Kluwer Health, Inc. All rights reserved.)

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Decades of research have provided insight into the benefits of nutritional optimization in the elective surgical patient.[1] Patients who are nutritionally prepared for surgery enjoy reduced length of hospital and intensive care unit (ICU) stays and suffer fewer complications.[2] The preoperative preparation in this patient population often includes weight management, blood glucose control, and protein-calorie supplementation.[3] Conversely, in the trauma and emergency general surgery (EGS) patient populations, we are not afforded the preoperative period of optimization and patients often suffer longer lengths of hospital stay, discharge to nonhome destinations, and higher infectious and mortality rates.[4–6] Nonetheless, ongoing research in this vulnerable and time critical diagnosis population has revealed significant outcomes benefits with the meticulous nutritional support of these patients.[7,8] However, it is important to note that optimal nutritional support in this challenging patient population is not simply a matter of "feeding more and feeding earlier." In fact, there is likely as much risk and harm because of overfeeding calories and aggressive initiation of full caloric loads as there is in delayed or underfeeding.[9,10] Table 1 provides a "Top 10" list of nutritional practices to avoid or change in the acute care surgery setting.

In this review, we will address assessing nutritional needs, the provision of optimal nutrition, the timing and route of nutrition, and monitoring outcomes and discuss the management of nutrition in the complex trauma and EGS patient.

NUTRITIONAL ASSESSMENT

Assessment of a patient's nutritional status should begin immediately upon hospital admission by taking a thorough history, querying family members or caretakers as necessary, to obtain information about any recent unintentional weight loss and current dietary habits. Identification of the patient who will benefit from nutritional therapy is a decision process that must consider not only multiple individual variables but also the interactions between those variables. Ultimately, this will result in an estimate of the patient's likelihood of receiving some or all of the benefits from nutritional therapy (Table 2), which must then be weighed against the potential risks and adverse effects of the nutritional intervention. Definitive determination of malnutrition remains an area of ongoing international research and debate.[11] Patients who present with a BMI of <19 kg/m^2, history of poor oral intake, unintentional weight loss >10% to 15% of baseline, and history of cancer with cachexia should all be considered to be at high nutritional risk.[12] Several objective scoring systems, such as the Nutritional Risk Screening 2002 (NRS) and the more recently developed Nutrition Risk in Critically Ill (NUTRIC) scores are available and should be used to risk stratify ICU patients into high and low risk categories.[13,14] Table 3 lists the variables and scoring rubric to calculate the NUTRIC score, with a score of 6 to 10 indicating high nutritional risk. Of note, although the classically described NUTRIC scoring system includes measurement of a serum IL-6 level, this is not widely available and can be omitted without loss of accuracy or reliability in trauma and EGS patients.[15] Patients who score >5 by these tools should be considered "high risk," and early (24–48 hours after admission) attempts to provide protein and calories should be made.[13] An additional scoring system specific for geriatric patients, the Geriatric Nutritional Risk Index is available for this patient population, with a score of <82 indicating a high-risk patient.[16] Patients with low muscle mass diagnosed by impaired functional status or diminished muscle on imaging (eg. psoas muscle atrophy on CT) are also high risk.[17] Of note, serum albumin and prealbumin should not serve as proxy measures of total body protein or total muscle mass and should not be used as nutrition markers, as these markers are both acute phase reactants and are unreliable in the ill or injured patient.[18] However, there may be some utility to serial measurements of prealbumin as a marker of response to nutritional therapy and recovery from the acute hypercatabolic phase of illness/injury.

Nutritional Needs

Initial priorities in the critically ill or injured patient include adequate volume resuscitation, correction of metabolic abnormalities, hemorrhage control, and reversal of shock. The initial period of critical illness or injury is marked by hypermetabolism with resulting loss of lean body mass and impaired

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TABLE 1. Top 10 Nutritional Practices to Avoid or Change

1. Overfeeding based on erroneous assumptions about increased metabolism and increasing delivered calories based on "stress factors"
2. Delivering supplemental nutrition in patients with minimal illness and expected to resume regular oral intake within several days
3. Delaying nutritional support in critically ill patients with existing malnutrition or who are at high nutritional risk
4. Failing to consider the dynamic changes in physiology, metabolism, nutritional needs, and ability to properly process nutrient loads that occurs in ICU patients over the course of an acute illness and recovery
5. Routine use of glutamine supplementation in ICU patients or other "immune-enhancing" formulas in unselected critically ill patients
6. Withholding enteral feedings for prolonged periods based on presumed postoperative or medical "ileus," or using low-volume thresholds (100–200 mL) for gastric residual.
7. Failure to attempt postpyloric feeding and prokinetics before switching to TPN for "enteral intolerance" to gastric feeds
8. Aggressive attempts at initiating enteral feeding and increasing rapidly to a "goal" rate in the presence of hemodynamic instability, moderate- to high-dose pressor dependence, rapidly declining renal/hepatic function, or the open abdomen with major ileus/bowel distension
9. Inadequate glucose control with prolonged or persistent intermittent blood glucose >180 mg/dL
10. Performing nonurgent major surgical procedures in patients with preexisting moderate to severe malnutrition without attempts at preoperative nutritional optimization

immunity.[4,19–21] Provision of nutrition should be delayed until these first priorities are stabilized, as enteral nutrition (EN) and parenteral nutrition (PN) are not resuscitative fluids. However, once resuscitation goals have been met, attention should then be turned to the provision of adequate protein and calories to support patients through their critical illness.

TABLE 2. Key Patient, Disease, and Nutritional Therapy Considerations in Selecting the Timing, Route, and Dosage of Nutritional Therapy

Key Patient and Disease Factors	Potential Risks of EN or TPN
Baseline nutritional status	Volume overload syndromes
Weight loss, laboratory markers, anthropometric measurements	Hyperglycemia
Age	Glucose shunting to lactate production
Existing co-morbidities	Lipogenesis
Current diagnosis/cause of critical illness	Protein shunting to nitrogenous waste, urea
Severity of illness	Azotemia (rising BUN)
APACHE, SAPS, ISS, MELD	Increased CO_2 production, impaired ventilator weaning
Pressor dependence and dose required	Central line associated infections
Length of critical illness	Fungal infections
Gut integrity, function, surgical interventions	Emesis and aspiration
Estimated duration until able to resume oral intake	Proinflammatory (TPN/lipids)
Need for additional procedures or interventions	Bowel distension, edema, abdominal pain
Available routes for feeding access or delivery	Electrolyte abnormalities
	Bowel ischemia (rare)

BUN, blood urea nitrogen; APACHE, acute physiology and chronic health evaluation; SAPS, simplified acute physiology score; ISS, injury severity score; MELD, model for end-stage liver disease.

TABLE 3. Nutrition Risk in the Critically Ill Score[14]

Variables	Range	Points
Age	<50	0
	50–75	1
	>75	2
APACHE II	<15	0
	15–19	1
	20–28	2
	≥28	3
SOFA	<6	0
	6–9	1
	≥10	2
Comorbidity (n)	0–1	0
	≥2	1
Hospital to ICU admission, d	0–1	0
	≥1	1
IL-6 (optional)	<400	0
	≥400	1

Low score (0–5), patients with low risk of malnutrition; high score (6–10), patients with high risk of malnutrition.

APACHE, acute physiology and chronic health evaluation; SOFA, sequential organ failure assessment.

Patients who are at low or moderate nutritional risk (NRS or NUTRTIC ≤5) should have nutrition started with goals to provide approximately 70% of energy needs or 15 to 20 kcal/kg per day over the first 1 to 4 days. Low- to moderate-risk patients will require 1.2 g/kg per day to 1.3 g/kg per day of protein.[22,23] However, patients at high risk (NRS or NUTRIC >5) should have earlier and more aggressive protein and calorie goals. Using actual body weight for calculation in patients with BMI of ≤30 kg/m^2 or substituting BMI of 25 kg/m^2 for patients with BMI of >30 kg/m^2, it is recommended that these high-risk patients achieve a minimum of 1.5 g/kg per day of protein, increasing up to 2 g/kg per day as indicated by severity of illness or injury. Traditional energy goal recommendations are for 25 to 30 kcal/kg per day, although there is conflicting evidence on the impact and benefit of these caloric targets particularly early in the acute critical illness or injury phase.[13,24,25] Caution must be exercised in this high-risk population to avoid the life-threatening complication of refeeding syndrome or the adverse effects of overfeeding. Monitoring for electrolyte disturbances, particularly hypophosphatemia, is crucial in this population. In one large randomized controlled trial, a "ramp-up protocol" was shown to offer superior survival when protein delivery was kept low for the first 4 days of critical illness and then pushed above 1.5 g/kg/d after the ICU stay and above 2 g/kg/d after discharge from the hospital.[26]

Timing of Initiation of Nutritional Therapy

After initial resuscitation goals have been met, attempts to begin EN or PN should start within 24 to 48 hours after admission. Enteral nutrition is routinely preferred over PN because it is generally well tolerated, can be initiated without invasive central venous access, and has been shown to portend improved outcomes, in part because of the maintenance of intestinal microvilli.[4,13] Enteral nutrition can be initiated via nasogastric (NG) or nasojejunal access. This is discussed in depth in a

subsequent section. It is also interesting that most or all of these early benefits of early EN appear to be relatively independent of the dose (amount of calories delivered) and to be related more to the nonnutritional benefits outlined in Table 2. Therefore, it is more important to have some level of enteral feeding delivered early in the ICU course than it is to immediately achieve some total caloric target or goal range. For the patient who requires TPN because of some complication or contraindication to EN, there is no similar strong evidence of benefit of early administration.

The American Society for Parenteral and Enteral Nutrition (ASPEN) recommends that patients at low nutritional risk should not have PN started within the first 5 to 7 days of admission, as the risk of PN likely outweighs any benefits.[13] However, for the high-risk patient who has had poor nutritional intake prior to hospitalization, early PN may be indicated even in the first 1 to 2 days of hospitalization. For patients scheduled to undergo major surgery and with evidence of current malnutrition, nutritional supplementation with EN (or TPN if enteral contraindicated or not tolerated) should be administered preoperatively for at least 5 to 7 days if possible.

Use of EN in Special Situations: Vasopressors, Open Abdomen, and Preoperative

There are relatively fewer contraindications to EN than previously believed. It has been proven to be safe and effective for patients to begin EN even in those with an open abdomen after damage-control surgery,[27–29] those with newly created ostomy,[30] and patients who require prone positioning[31–33] and neuromuscular blockade.[33,34] Controversy remains about initiating EN in patients requiring vasopressors. While data are accumulating that

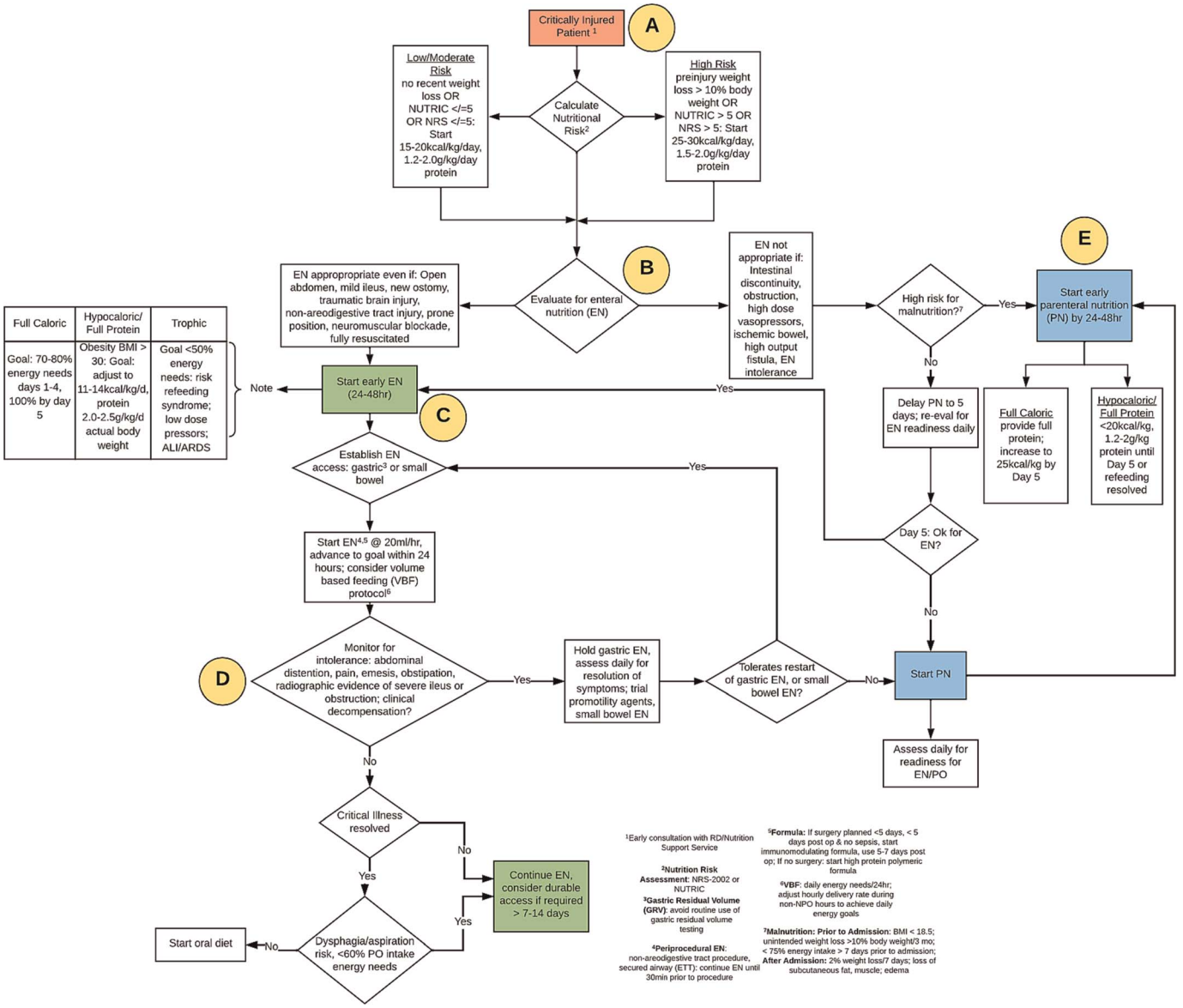

Figure 1. Western Trauma Association algorithm for nutritional support in the critically injured patient (reproduced with permission from Hartwell et al.[35]).

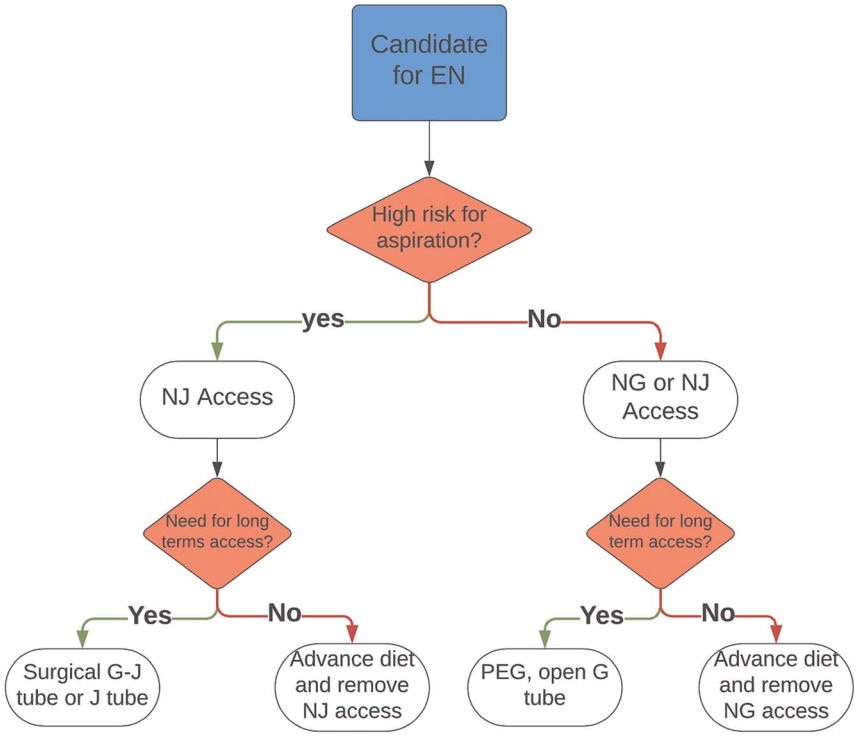

Figure 2. Algorithm outlining the approach to enteral feeding access in the critically ill trauma or surgical patient. NJ, nasojejunal; G-J, gastrojejunal; J, jejunal; PEG, percutaneous endoscopic gastrostomy.

this practice is safe and indeed preferred to withholding EN or using PN, providers remain hesitant to start EN while vasopressors are required. The recently published Western Trauma Association Critical Decisions Algorithm for Nutrition Delivery in the Critically Injured Adult (Fig. 1) recommended initiating trophic EN (10–20 mL/h) with slow advancement to goal rate over the next 24 to 48 hours even in patients on vasopressors with the equivalent of 12.5 μg/min of norepinephrine or less, or up to 0.3 μm/kg/min. The authors recommended close monitoring for EN tolerance including abdominal distention, emesis, or peritonitis and advised against EN in the setting of rising lactate levels and the need for escalating doses or additional vasopressors.[35] Another common source of decreased caloric delivery in the trauma and EGS populations is the widely used practice of holding enteral tube feeds for a prolonged period before any surgical intervention. Numerous studies and guidelines have now demonstrated the safety of continuing enteral feeding up until the time of surgery and even during surgery for select procedures and particularly with postpyloric feeding access.[3,12,28,29,32,35–38]

Route and Access of Nutritional Therapy

Enteral Access

Selection of enteral access depends on patient factors and institutional experiences and preferences (Fig. 2). While avoidance of NG tubes has become common in enhanced recovery or "fast track" programs in elective surgery, NG tubes are still quite routine in EGS where bowel edema, ileus, and intra-abdominal inflammation are common. Trauma and EGS patients often are endotracheally intubated and have NG or OG access in place for gastric decompression and enteral medication administration. OG tubes are removed at the time of extubation because they trigger the gag reflex, similar to NG tubes.

After gastric decompression is no longer needed, small bore enteral feedings tubes become the preferred access device. These are typically 8- to 12-Fr single lumen devices without a sump but are softer, more pliable, and better tolerated. These can be placed either in the stomach or postpyloric in the duodenum or jejunum. These tubes are typically used for periods of less than 4 weeks. Disadvantages include risk of airway placement (1%) and frequent clogging.[39]

Gastric feeding can be safely performed in most patients but has an increased association with aspiration and pneumonia in some series.[40] Patients with known aspiration, altered mental status or known dysphagia, delayed gastric emptying, high residuals (if checked), nausea, vomiting, or failed gastric feedings are candidates for consideration of postpyloric tube placement.[13] Intraoperative placement of nasoenteric access should also be considered in cases with foregut anastomosis or repair, particularly if there is preexisting malnutrition or anticipated slow return of bowel function. Intraoperative open gastrostomy, gastrojejunostomy, or jejunostomy tube placement can be considered in rare circumstances where gastrointestinal function is not anticipated within 4 weeks or with select high-risk pathology such as complex pancreaticoduodenal trauma or any surgery requiring a complex gastrointestinal reconstruction. In cases where the need for gastric access is required beyond 4 weeks and laparotomy is not planned, percutaneous endoscopic gastrostomy is the preferred access. Direct percutaneous jejunostomy and endoscopic or fluoroscopic gastrojejunostomy tubes are options for nonsurgical access but require specialized skill sets and may not be routinely available at many centers.[38]

Parenteral Access

For parenteral nutrition access, a clean lumen dedicated to PN use is preferred.[41] Critically ill patients may have a temporary central venous catheter in place. These catheters have lifespans of several weeks and cannot leave the hospital but are acceptable for PN administration. For patients who need PN access for less than 3 months, the peripherally inserted central catheter is the preferred access. This is typically a patient's first PN access and is often the best choice when first starting parenteral nutrition, particularly in the postsurgical period when infection risks are elevated.

The most feared complication of PN access is catheter-associated bloodstream infection (CLABSI). For this reason, for long-term venous access, the preferred PN access is a tunneled central venous catheter because of lower infection rates.[42] While implanted subcutaneous ports generally have even lower infection rates overall, they have been shown to have higher infection rates in PN populations because of the daily access required (as opposed to their limited access design/purpose for other infusion therapies such as chemotherapy).[43] Subclavian placed catheters have the lowest infection rate, followed by the internal jugular site with the femoral site lagging with nearly a four-fold higher infection rates.[44] However, the jugular catheter placement is typically safer, particularly with ultrasound guidance, and many practitioners prefer jugular access for this reason.[44] It is important to note that the overall trends in the incidence of CLABSIs in the ICU setting have decreased markedly over the past two decades, and the rates associated with TPN in older literature are not applicable to modern practice. This risk can be mitigated with hand hygiene, ethanol lock therapy (when cost-permitting),[45] chlorhexidine impregnated sponges at the catheter exit site,[46] and the use of antimicrobial catheter caps such as those impregnated with 70% isopropyl alcohol.[47]

EN Versus PN

Enteral nutrition is preferred over PN based on physiologic observations and clinical trial outcomes well described in the 1980s and 1990s. Parenteral nutrition is associated with increased inflammation and stress responses, immunosuppression, mucosal atrophy, perturbations in glycemic control, and disruptions in the microbiome when compared with EN.[13] Two classic randomized controlled trials of EN versus PN in trauma patients reported that patients receiving EN had lower rates of infection (abdominal abscess and pneumonia).[48,49] Several clinical trials in critical illness over the past decade have demonstrated equivalent clinical outcomes between PN and EN use during the early phase of intensive care. The 2022 ASPEN Critical Care Nutrition guidelines recommend either PN or EN as acceptable alternatives in the ICU.[37] Enteral nutrition, however, remains the preferred standard because of cost, ease of administration and monitoring, and the well-established physiologic evidence base supporting EN. In addition, a recent meta-analysis of studies of enteral versus TPN demonstrated that there was no difference in mortality between the two routes, but there was a decrease in infectious complications and length of stay associated with enteral feeding.[50] However, this difference appears to be attributable to studies where the TPN groups were given significantly more average caloric intake versus enteral feeding. When caloric delivery was equal between enteral and TPN, there was no difference in either mortality or morbidities. None of the recent trials address long-term differences in outcomes with EN versus PN or the impact on non-ICU patient populations. While the reasons behind the improved outcomes of PN have not been fully elucidated, it is theorized that reduced calorie targets, improved glycemic control, new lipid emulsions, increased use of image-guided line insertions, CLABSI reduction initiatives, and innovations in PN prescribing and compounding safety all have contributed to the improved safety profile of PN in published trials since 2010.[51]

The benefits of early initiation of EN both after surgery and ICU admission have been well established. Several factors have been found to improve the delivery of higher volumes/calories of EN and are recommended for all ICU patients. These include the initiation of EN at a slow rate (10–20 mL/h) and then slow advancement to the calculated "goal" rate, the use of prokinetic agents, the use of higher thresholds of gastric residual volumes, and postpyloric feeding if there is persistent high gastric residuals/emesis/distension or in patients who are high risk for aspiration. The optimal method to ensure maximized use of adequate nutritional support is having all of the above included in a local protocol or algorithm using best-practice and evidence-based guidelines. However, the consensus regarding the optimal timing of PN initiation has been evolving. The ASPEN/SCCM 2016 guidelines recommended waiting 7 to 10 days before initiating PN in most ICU patients and consideration of earlier PN in patients with diagnosed malnutrition. This recommendation is primarily based on the 1991 Veterans Affairs TPN Cooperative trial where complications were increased with the use of perioperative parenteral nutrition in all but the most malnourished patients.[52] The VA trial placed patients on PN even if there was no evidence of GI dysfunction and provided hyperalimentation with PN delivering 1,000 kcal over resting energy expenditure. Trials of PN versus EN in the ICU (discussed in the previous paragraph) typically initiated PN within 48 hours of ICU admission and found similar outcomes with early PN compared with early EN.[37] By 2019, the ESPEN critical care guidelines were recommending PN initiation within 3 to 7 days for all patients where EN was contraindicated (eg, GI dysfunction) and sooner (within 24–48 h) in those with documented malnutrition.[53]

There is increasing interest in the role of early supplemental PN, but early trials in critical care have not demonstrated benefit and supplemental PN is typically not recommended in patients receiving EN unless they fail to achieve nutrition goals after roughly 7 days in the ICU.[37,53] A Chinese trial of supplemental PN randomizing postoperative colorectal surgery patients to start at either day 3 or day 8 after surgery did demonstrate fewer nosocomial infections in the early supplemental PN group.[54] A Spanish trial randomized colorectal surgery patients to supplemental peripherally administered PN versus control intravenous fluids and found a 28% reduction in postoperative complications with the use of supplemental peripherally administered PN.[55] A small pilot randomized trial in trauma patients examined the addition of early supplemental peripheral amino acid supplementation to standard care and found beneficial effects on protein catabolism and decreased inflammatory profiles, but confirmation with a larger trial and using clinically relevant outcomes is needed.[56] Particularly in patients with preillness malnutrition, early and supplemental PN may increasingly be accepted as routine therapy as more evidence emerges.

Caloric Content: Hypocaloric Versus Full Feeding

Although determining the optimal dose of PN or EN to deliver to a critically ill patient may seem relatively straightforward, in practice this remains poorly understood, widely debated, and highly complex. The traditional teaching on this subject has almost exclusively focused on estimating the "caloric needs" of the ICU patient, and much less consideration has been given to estimating their physiologic and metabolic readiness, and ability to tolerate a caloric load. It is critical to understand that critical illness-induced catabolism is entirely different than simple protein/calorie nutrition (or "starvation") and leads to disruption and dysfunction of the host's intrinsic nutrition processing capacity and antioxidant defense systems. As a result, nutritional supplementation is not just a matter of supplying adequate calories and nutritional substrates. The critical illness response will mainly shuttle these nutrients into maladaptive and inefficient pathways that result in energy expenditure and the creation of useless or even harmful byproducts such as lactate, urea, nitrogenous waste products, oxidative agents, and fat mass. Thus, initiating early feeding in these patients, particularly high-calorie feeding during peak periods of illness, may have the paradoxical effect of inducing cellular, tissue, and organ injury without providing any substantive nutritional benefit. This is supported by numerous lines of evidence detailing the ultimate fate of supplied nutrients, the adverse effects of overfeeding in the ICU, and the consistently equivalent outcomes between patients receiving lower amounts of calories versus moderate and higher amounts. The best and most appropriate methods of nutritional support in the ICU patient must consider both sides of this equation, with equal attention paid to nutritional needs and to nutritional readiness or tolerance. An excellent paradigm for this tailored approach is depicted in Figure 3 as outlined by Dr. Paul Wischmeyer in his thoughtful review of this issue titled "Are we creating survivors…or victims in critical care? Delivering targeted nutrition to improve outcomes," which we would highly recommend as further reading on this topic.

There are many available options and widely varying practices between providers in estimating the caloric requirements and calculating the optimal caloric dose of enteral or parenteral nutrition to deliver to the critically ill patient. The three main methods that are used in the majority of ICUs are (1) indirect calorimetry, (2) predictive equations, and (3) simplified weight-based calculation. There is a paucity of level 1 evidence examining the optimal method for estimating caloric needs and for guiding the delivered doses of supplemental nutrition. A review of two randomized trials comparing indirect calorimetry to predictive equation or weight-based calculation demonstrated no effect on mortality but concerns that indirect calorimetry guided strategy results in increased infections and longer ICU lengths of stay.[57] Using indirect calorimetry-guided dosing did result in an increased average daily caloric delivery, but this is not necessarily a beneficial outcome and, in some cases, could contribute to a higher complication profile. There has been no demonstrated evidence that the more complex predictive equations have any benefit over simple weight-based approaches, and a general range of 20 to 35 kcal/kg/d of nonprotein calories is widely accepted and used. For initiation of feeding or for feeding in the severely ill or acutely worsening patient, a lower caloric target may be chosen, with subsequent adjustment based on the patients overall clinical status, trajectory of disease, and response to nutrition therapy. Of note, in the most recent guidelines update from ASPEN for nutrition in the critically ill population, the energy prescription recommendation was decreased to 12 to 25 kcal/kg/d.[37]

While the goal calorie and protein requirements are discussed previously, clinicians may choose to modify nutrition delivery in the

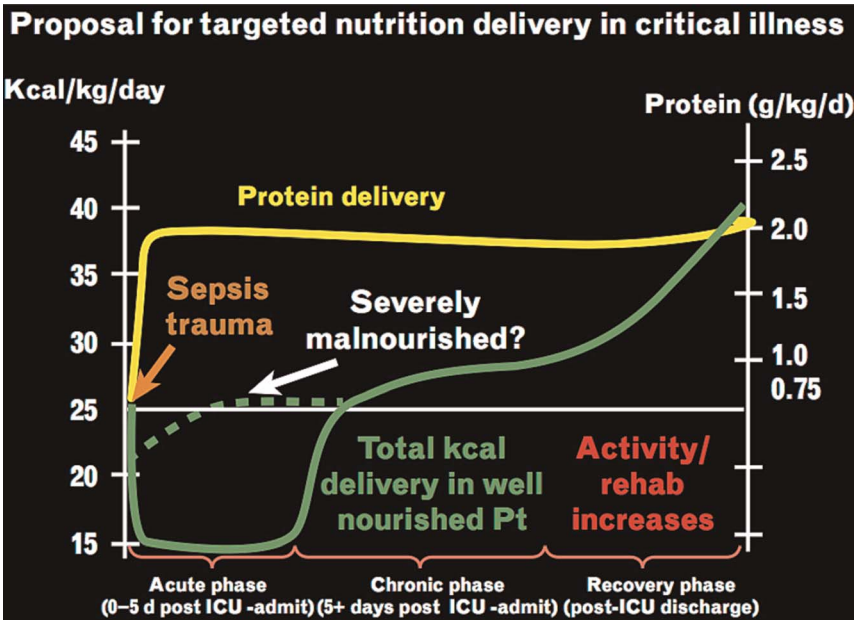

Figure 3. Graph demonstrating targeted or "personalized" nutrition delivery in a standard ICU patient as they progress through the standard phases of critical illness and that also considers the disease severity and the presence of preexisting severe malnutrition (reproduced with permission from Wischmeyer PE. Are we creating survivors…or victims in critical care? Delivering targeted nutrition to improve outcomes. *Curr Opin Crit Care.* 2016;22 (4):279–284).

TABLE 4. Summary of Recommendations

Recommendation	Rationale
Assess nutritional risk upon admission High-risk indicators: BMI of <19 kg/m^2, recent weight loss >10% body weight, recent/current cancer diagnosis, score >5 on validated screening tools	Precise definitions of malnutrition vary; a thorough history and screening are the optimal method to determine nutrition risk
Attempt early (24–48 h) nutrition therapy for high-risk patients	Early achievement of protein and calorie goals leads to fewer complications and improved outcomes
Use EN before PN if possible	Maintain intestinal integrity; fewer complications; lower cost
EN is safe in patients on vasopressors, prone position, open abdomen	Early achievement of protein and calorie goals leads to fewer complications and improved outcomes; lower cost than PN; maintenance of intestinal integrity
Delay initiation of PN for 5–7 d in non–high-risk patients	Risks outweigh benefits (infection, central access complications, electrolyte disturbances); high cost
Consider early (24–48 h) initiation of PN in high-risk patients	Early achievement of protein and calorie goals in patients at high-malnutrition risk portends improved outcomes over delays

first week of hospitalization, particularly in the ICU. An individualized assessment of the risks and benefits of full versus hypocaloric feeding appears to be the safest strategy. Although some data suggest that outcomes are improved when patients receive close to their goal calories and do not develop a significant caloric deficit, this benefit has failed to be demonstrated in most randomized trials examining hypocaloric feeding strategies.[58] Trauma patients without gastrointestinal injury typically tolerate full enteral feeding within the first 24 to 48 hours after injury and may be particularly hypercatabolic. Patients who undergo gastrointestinal surgery may not tolerate full enteral feeding as rapidly and require individualized physical examination and assessment of GI function.

Trophic, or "trickle" feeding (typically at infusion rates no more than 20–30% of goal), is a generally accepted strategy when enteral feeding tolerance is a concern. The EDEN trial evaluated the use of trophic feeding in ARDS patients for the first week of ICU admission and demonstrated equivalent outcomes when compared with aggressive full feeding.[59] It should be noted that similar intentional underfeeding trials have not been replicated in trauma or surgical populations. Trophic feeding is commonly used when patients are on vasopressors. While there is limited evidence in the surgical and trauma ICU settings, a large multicenter trial of enteral feeding in patients with high levels of vasopressor use reported bowel ischemia rates as high as 2% with aggressive enteral feeding.[60] In patients on vasopressors, trophic feeds should not be started until adequate resuscitation with resolution of lactic acidosis is achieved.[35] Advancement to full feeds should not occur until trophic feeds are clearly tolerated as monitored by abdominal distension, avoidance of emesis, or worsening acidosis or hemodynamics (see previous sections for additional discussion).

Early full protein-calorie feeding should also be avoided in patients with malnutrition. Patients with preexisting malnutrition are at risk for refeeding syndrome or refeeding phenomena such as hypophosphatemia and should undergo close electrolyte monitoring while feeds are initiated at 10 to 20 kcal/kg/d and advanced no more than 33% per day if electrolyte levels are normal.[61]

Finally, there has been great interest in evaluating the independent effects of the primary nutrient sources (fat, protein, carbohydrates) and various added supplements, as well as varying ratios and combinations of these components. Some of the current recommendations regarding the composition of TPN and EN, as well as the role of various additives and supplements, are listed in Table 2. A complete description of this topic is beyond the scope of this syllabus, but several key summary points are as follows:

1. Carbohydrate, protein, and fats/lipids are the backbone nutritional components, and there appears to be no evidence for very low or very high protein or carbohydrate/fat ratio strategies.
2. Intravenous lipids, particularly soybean oil based compounds, have a number of proinflammatory effects and have been associated with adverse outcomes in ICU patients. Interval and lower dosing of these lipids to avoid essential fatty acid deficiency is adequate in most patients.
3. "Immune enhancing" formulas have no proven benefit in unselected ICU patient populations and may be associated with worse outcomes in certain subpopulations (i.e., severe sepsis). There is some evidence that specific formulas containing fish oils, borage oils, and antioxidants are beneficial in patients with acute lung injury or ARDS.
4. Glutamine supplementation should not be routinely used in critically ill patients and particularly in patients with shock or multiple-organ failure. There may be some benefit in the burn patient population, but further study results are needed to clarify the safety vs. benefit.

CONCLUSION

Nutritional support in the critically ill or injured acute care surgery patient may be a key factor in determining both the short- and longer-term outcomes and risk of major morbidity or mortality. A summary of our key recommendations for nutrition in these challenging patient populations is provided in Table 4. The choice of the best route of feeding, dose, composition, supplementation, and adjustment strategy will vary highly, and the complex decision making requires integration of multiple patient and disease factors. Simplistic policies that take a universal approach and attempt to provide full caloric support regardless of the patient status and disease severity will often result in overfeeding and have no benefit (or even harm) to the patient. For additional information and more in-depth analyses and evidence-based recommendations, we recommend several key resources including the Canadian Critical Care Nutrition Guidelines (www.criticalcarenutrition.com), which include numerous toolkits and up-to-date focused systematic reviews; the ASPEN/SCCM Guidelines, which were published in 2009 and updated in 2016

and most recently in 2022; and the Western Trauma Association Algorithm as shown in Figure 1.[35,37,57,62–64] Based on available evidence, the early and adequate provision of nutrition therapy to patients who have sustained trauma or EGS portends improved outcomes and may mitigate some complications. This article should reassure the providers of ill or injured surgical patients that thoughtful and methodical attention to nutrition therapy is both safe and beneficial for patients.

AUTHORSHIP

M.M., J.H., and D.E. contributed in the conception and design. M.M., J.H., and D.E. contributed in the acquisition of data. M.M., J.H., and D.E. contributed in the analysis and interpretation of data. M.M., J.H., and D.E. contributed in the drafting of the manuscript. M.M., J.H., and D.E. contributed in the critical revision of the manuscript. M.M. contributed in the administrative, technical, or material support. J.H. and D.E. contributed in the supervision.
All authors meet authorship criteria for this article. All authors have seen and approved the final manuscript as submitted. The corresponding author (M.M.) had full access to all data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

DISCLOSURE

Conflicts of Interest: Author Disclosure forms have been supplied and are provided as Supplemental Digital Content (http://links.lww.com/TA/D634). Disclaimer: The results and opinions expressed in this article are those of the authors and do not reflect the opinions or official policy of any of the listed affiliated institutions.

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