# Nutrition therapy in the critically injured adult patient: A Western Trauma Association critical decisions algorithm

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This is a recommended evaluation and management algorithm from the Western Trauma Association (WTA) Algorithms Committee addressing the nutrition management of critically injured adult patients.

Historically, trauma surgeons have been leaders in researching and advancing the science of nutritional support in critically injured patients by establishing the metabolic response to injury and studying the clinical impacts of nutritional practices and targeted interventions.[1–6] This seminal work helped to establish and provide evidentiary basis for many of the core nutritional principles for the injured patient, including early enteral feeding, establishing surgical feeding access when necessary, and criteria for the use of parenteral nutrition (PN). Although there are now numerous high-quality prospective randomized nutrition trials, many recent recommendations from these studies come from medical patients or mixed cohorts with only smaller subgroups of trauma patients included.

## Algorithm Development

Because there is a paucity of recent class I recommendations on nutrition in the critically injured patient population, the WTA Algorithms Committee set out to develop a practical guide to the approach of nutrition therapy for this cohort. After a literature search and group discussion, the authors established the key themes that should be addressed in the algorithm. These recommendations are based primarily on extrapolation of randomized trial data from nontrauma cohorts, review of published prospective and retrospective cohort studies in trauma populations, and expert opinion of the WTA Algorithms Committee and general members. The final algorithm is the result of an iterative process including an initial internal review and revision by the WTA Algorithm Committee members, and then final revisions based on input during and after presentation of the algorithm to the full WTA membership.

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The immediate management of the critically injured adult patient includes hemorrhage control, coagulation homeostasis, volume resuscitation, reversal of shock, and intervention for life and limb-threatening injuries. The provision of nutrition to these critically injured patients is appropriately not an initial priority; however, once resuscitation is complete, attention should be turned to a thoughtful evidence-based approach to adequate nutrition. The early period of critical injury is characterized by hypermetabolism from the acute phase response, which contributes to significant lean body mass loss and impaired immunity.[7–10] Coupled with inadequate energy and protein provision, which is not uncommon in the critically injured and ill, the acute phase response effects can lead to longer hospital length of stay, discharge to a nonhome destination (i.e., skilled nursing, long-term acute care facility), and higher infectious morbidity and mortality rates.[10–14] If more adequate energy and protein delivery can be achieved, the negative effect of injury on outcomes may be at least mitigated.[10,15,16] Despite this knowledge, a large proportion of critically ill patients still receive inadequate nutrition[10–14,17] or suffer the consequences of excessive delivery of nonprotein calories including increased length of hospital stay and ventilator days.[10]

Nutrition therapy in critically injured adult patients is complicated by the numerous individual characteristics of the patient including the presence of any preinjury comorbid conditions or malnutrition, the unique constellation and severity of injuries, and clinician experience and local practice patterns. Clinicians face multiple decision points in the provision of nutrition to critically injured adults including timing, route, rate, and monitoring of adequacy. This algorithm is intended to bring together the best available literature and expert consensus to aid in the decision-making process to optimally provide nutrition therapy in this complex patient group.

The algorithm (Fig. 1) and accompanying comments represent a safe and rational approach to the evaluation and management of nutrition therapy for the critically injured adult patient. We recognize that there will be multiple factors that may warrant or require deviation from any single recommended algorithm and that no algorithm can completely replace expert bedside clinical judgment. We encourage institutions to use this as a general framework in the approach to these patients and to customize and adapt the algorithm to better suit the specifics of that program or location.

# ALGORITHM

The following lettered sections correspond to the letters identifying specific sections of the algorithm shown in Figure 1. In each section, we have provided a brief summary of the important aspects and options that should be considered at that point in the evaluation and management process.

## A. Nutrition Risk and Needs Assessment

After initial resuscitation, consideration of early (within 24–48 hours of admission) nutrition therapy should begin. Provision of nutrition therapy may be particularly complex in patients with

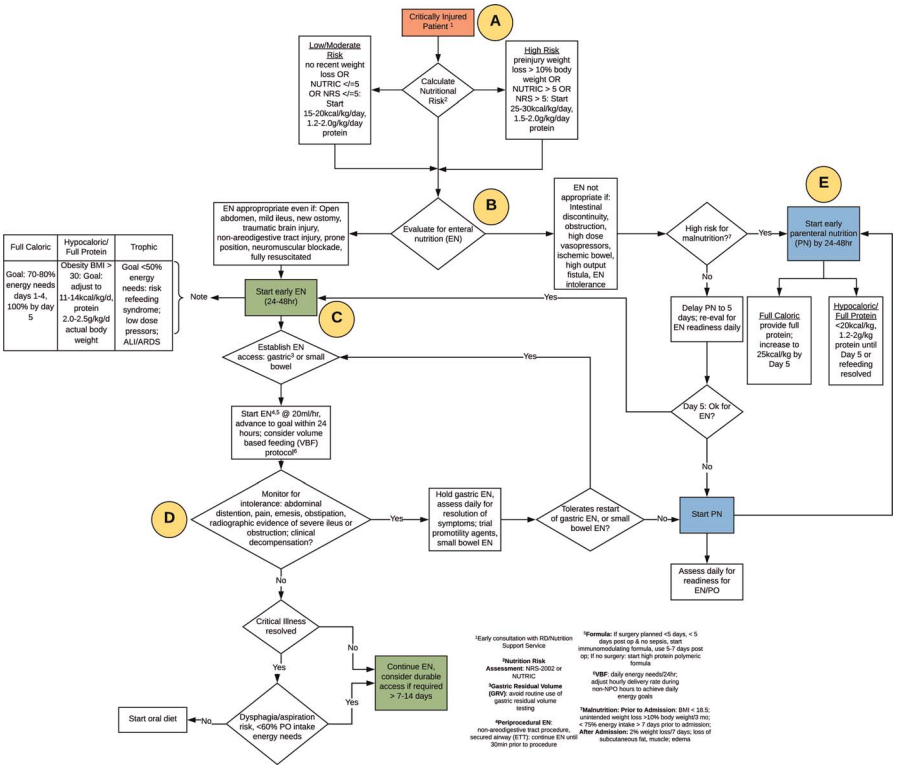


**Figure 1.** Western Trauma Association algorithm for the evaluation and management of nutrition therapy in critically injured patients. Circled letters correspond to sections in the associated article.

multiple injuries and/or preexisting comorbidities. Depending on the experience of the treating team, early consultation with a nutrition support team or registered dietitian should be considered, which has been shown to improve outcomes in some cohorts of patients.[18]

The determination of malnutrition remains an area of international discussion and research without definitive definitions or scoring systems.[19] Despite this, there is consensus that objective criteria such as body mass index (BMI) and a detailed history of recent volitional intake or weight loss are predictors of nutritional risk and postsurgical complications and should be used to help stratify patients as high or low risk.[20] An initial assessment of malnutrition should be completed using validated scoring systems such as the Nutrition Risk Assessment 2002 or Nutrition Risk in Critically Ill.[21] The determination of baseline nutritional risk guides the initial prescription for nutrition therapy including total energy and protein goals.

For patients determined to have low or moderate nutritional risk, nutrition support should begin at 70% of energy goals corresponding to 15 to 20 kcal/kg per day over the initial 1 to 4 days[22,23] following ICU admission. Limiting energy delivery to not greater than 70% of resting energy expenditure when initiating feeding early in critical illness or injury has demonstrated the lowest 60-day mortality compared with feeding at higher amounts of energy.[10,22] However, for patients determined to be at high risk of malnutrition, the progression to protein and energy goals should be more aggressive. For energy and protein estimations, we suggest using actual body weight if BMI is ≤30 kg/m$^2$ or a BMI of 25 kg/m$^2$ if actual body weight has a BMI of >30 kg/m$^2$.[24] Protein goals are calculated exclusive of total kcal needs; that is, total protein should be administered in addition to minimum kcal goals such that protein does not constitute all or most of the total kcal. Minimum protein needs should be estimated at least 1.2 g/kg per day to 1.3 g/kg per day and increased up to 2 g/kg per day of protein or higher in multiple injuries or burn patients. In addition, burn patients with 40% total body surface area or greater affected require at least 25 kcal/kg per day plus 40 kcal per percent total body surface area burn per day.[21,23,24]

With appropriate monitoring for refeeding syndrome (RS), no less than 80% of energy and protein goals should be achieved within 48 to 72 of ICU admission when possible.[21,25] A minimum of 1.5 g/kg per day of protein and 25 to 30 kcal/kg per day should be initiated.[21,26] Caution must be exercised, however, when initiating nutrition in patients at risk for malnutrition, and they must be monitored for the development of RS. Refeeding syndrome is defined as the constellation of metabolic and electrolyte disturbances resulting from rapid reintroduction of protein and energy to a patient after a prolonged period of decreased or absent intake. Hypophosphatemia is the traditional hallmark of RS, and frequent measurement of electrolyte panels is paramount in patients at risk for RS to prevent life-threatening complications from these derangements.[27] Those patients most likely to be at risk for RS includes those with a history of anorexia nervosa, bariatric or extensive bowel resection surgery, alcohol and substance use disorder, diseases associated with malabsorption (e.g., celiac), some mental health diagnoses, and malignancy and those whose social situation places them at risk for food insecurity.[27]

## B. Decision for Enteral Versus PN

Once a nutritional risk and needs assessment has been completed, the route of nutrition delivery must be decided.

Enteral nutrition (EN) is nearly always preferred to PN[10,21] and should be started after resuscitation goals have been met (e.g., normal or down trending lactate level, no longer needing large volume fluid or blood product resuscitation, adequate urine output) so long as there are no contraindications. If vasopressor support continues to be required despite adequate resuscitation, EN can be initiated when the vasopressor dose is deescalating or stable.[28] The need for ongoing vasopressor support is not an absolute contraindication to the initiation of EN or an indication for PN (discussed in Section C).

There are relatively fewer contraindications to EN than historically believed, and we advocate for a trial of EN in most patients including those with an open abdomen after damage-control laparotomy[17,29,30] and newly created ostomy,[31] those who require prone positioning[32–34] neuromuscular blockade infusions,[34,35] and those with traumatic brain injury (TBI).[36,37] Previous studies have shown EN to be not only safe but also advantageous for these patients. Specifically, patients with an open abdomen who receive EN derive benefits such as fewer overall complications, earlier fascial closure,[29] and decreased mortality.[30] In addition, early EN has been demonstrated to reduce length of hospital stay in TBI patient[37] and is associated with improved survival and Glasgow Coma Scale recovery.[38]

Contraindications to the use of EN include intestinal obstruction (e.g., extrinsic compression from hematoma, adhesions, anastomotic stricture), intestinal discontinuity after damage-control laparotomy, high-output enterocutaneous fistula,[39,40] high-dose vasopressor requirements,[41] intestinal ischemia,[42] or documented intolerance (discussed in Section D) to trials of EN.[43] If a patient has these contraindications, consideration should be given to the initiation of PN.

## C. Initiation of EN

Once the decision has been made to start EN, gastric access should be established and confirmed by radiograph. It is acceptable, and likely faster, to begin EN via the stomach.[21] It is recommended that EN begin in the first 24 to 48 hours after hospital admission and after resuscitation goals have been met.[10,21] There are numerous commercial EN products available that vary in caloric density, inclusive of protein and nonprotein calories (1.0–2.0 kcal/mL), fiber content, macronutrient source, and specialized products designed for patients with specific dietary restrictions or allergies, and finally disease specific formulas.[44] Enteral nutrition is available in polymeric formulas, in which the whole milk protein is intact, or hydrolyzed formula in which the milk proteins are partially broken down to aid in digestion. The various formulas vary in cost, but nearly all are less than US $10/1,000 kcal, which is substantially less expensive than 500 mL of PN, estimated to cost US $173.[45] Disease-specific formulas are available but are used infrequently and only in specialized situations beyond the scope of this review.[21] In the immediate perioperative period (within 5 days preoperative or postoperative), an immunomodulating formula should be started[21,26,46] but should be discontinued in the setting of sepsis, although it should be noted that the data for these formulas in the trauma patient population are less robust than in medical patients. If there is no surgery planned, a high protein polymeric formula should be used.[46] It is recommended that EN begin at a rate of 20 mL/h to assess tolerance (discussed hereinafter) and advanced to a goal rate over the following 12 to 24 hours unless there is some contraindication to advancement. Patients should receive 70% to 80% of their energy needs over the first 1 to 4 days and achieve 100% of protein and calorie goals by day 5.[21,23] Consideration should be given to implementing volume-based feeding protocols, which have been shown to safely increase the protein and energy delivered, although there has been little evidence of a positive impact on clinical outcomes.[47]

Trophic feeding has been advocated for its promotion in the maintenance of gut integrity, positive influence on the immune system, and the stimulation of insulin sensitivity, among other benefits.[10,48] Special consideration for obese patients (BMI, >30 kg/m$^2$) includes reduction of protein and energy goals to 11 to 14 kcal/kg per day and 2.0 to 2.5 g/kg per day of protein based on actual body weight.[21] Patients with a diagnosis of acute respiratory distress syndrome/acute lung injury may also benefit from trophic (<50% calculated protein and energy requirements) to promote feeding tolerance with equivalent ventilator-free and mortality outcomes by maintaining the provision of protein but limiting the excessive production of $CO_2$.[34,49]

Controversy remains regarding the administration of EN while patients require continuous administration of vasopressors, with some studies demonstrating concern about gastrointestinal complications without a mortality benefit or reduction in infections.[50] Two studies, however, have realized a mortality benefit when EN was administered with vasopressors.[51,52] Another study demonstrated the safety and efficacy of EN delivery to patients on vasopressors, with concomitant improvements in protein and energy delivery.[53] The Society of Critical Care Medicine/American Society of Parenteral and Enteral Nutrition guidelines recommend withholding EN in patients on "high-dose" vasopressors,[21] but the exact definition of high-dose remains elusive. Some studies reveal the safety and benefit to early trophic feeding to patients requiring vasopressors.[54] Additional randomized, controlled trials will be required to answer this question, but with the available evidence, we recommend that beginning trophic rate EN (10–20 mL/h) with slow advancement (to goal rate over the following 24–48 h)[21] is safe and tolerated in patients receiving the equivalent of 12.5 μg/min of norepinephrine or less, or up to 0.3 μg/kg per minute.[28,52,53] Patients should not have escalating vasopressor requirements, including the need for the addition of a second or third vasopressor agent even at "low dose" or rising lactate levels.[28] The gastric route of delivery is preferred, and vigilance is required to assess for signs of feeding intolerance or bowel ischemia such as abdominal distention, emesis, or peritonitis.[28]

## D. Monitoring and Maintenance of EN

After initiation of EN, daily assessments for tolerance and readiness for volitional intake should ensue, tempered by the risk of potential aspiration in the debilitated critically injured adult. Tolerance of EN is a clinical decision and should not be determined by gastric residual volume (GRV) assessment alone.[21] The routine use of GRV is discouraged because this practice has been demonstrated to yield unreliable and variable quantities of residual tube feeds[55] and leads to unnecessary and prolonged periods of nil per os (NPO).[21,56] Clinician discretion is recommended in using GRV as an adjunct for monitoring critically ill patients whose physical examination is unreliable (e.g., neuromuscular blockade, severe TBI) when concern about tolerance arises.[28]

When the decision is made to use GRV for monitoring, we recommend a threshold of >500 mL to hold EN.[21,28]

Although standard preprocedural practice is to make patients NPO for a period of 8 to 12 hours, we recommend against this historical practice, particularly for the critically ill patient with a protected airway (endotracheal tube or tracheostomy appliance). In a 2020 consensus statement, the authors conclude, "Current concerns about aspiration are out of proportion to the actual risk."[57] Frequent interruptions of EN for procedures contributes to failures to meet protein and energy delivery goals and has been shown to propagate an ileus.[21,58] For patients undergoing a nonaerodigestive tract procedure and who have a protected airway, we recommend continuing EN until the time of the procedure. Because most studies excluded patients who will be in the prone position for the procedure, we recommend caution in continuing EN until the time of these procedures.[21,56,58,59]

Monitoring for tolerance includes evaluation for abdominal distention, pain, emesis, obstipation, radiographic evidence of obstruction or severe ileus, or clinical decompensation.[21,28,60] As previously stated, ileus may be propagated, not mitigated, by NPO periods.[56,58] In the event a patient receiving EN via the gastric route demonstrates an ileus causing emesis or distention, and there is concern for gastroparesis and subsequent aspiration, an attempt should be made to place nasojejunal access prior to abandoning EN altogether. At this point, prokinetic medications such as metoclopramide or erythromycin may be added.[21]

If the patient appears to be tolerating full-dose EN, it should be maintained and consideration should be given to the expected duration of EN. If it is expected that even after resolution of the critical illness, oral intake will not be reasonable (e.g., severe TBI), then consideration should be given to placement of durable enteral access after 7 to 14 days.[60] Once it appears, a patient can be extubated and safely consume >60% predicted protein and energy of their own volition, and EN may be discontinued.[61]

### E. Parenteral Nutrition

As previously noted, PN is more costly than EN, requires central venous access, and does not confer the aforementioned benefits of using the GI tract.[10] Therefore, PN is reserved for the patient who cannot safely meet protein and energy goals via EN, as EN is the preferred route of nutrition delivery.[21] In fact, recent studies have demonstrated that PN administered to critically ill patients within 5 days has detrimental effects.[10,21] For patients with a high risk of malnutrition, such as those with a preadmission BMI of ≤18.5 kg/m$^2$, unintended weight loss of 10% of body weight over the previous 3 months, or <75% energy intake in 7 days before admission, they should be considered for PN within the first 24 to 48 hours if EN cannot safely be started.[62] Patients who do not meet these high-risk criteria should be reassessed for EN adequacy daily up to 7 days before the initiation of PN.[10,21] The initial PN prescription should provide full protein requirements, and energy delivery should be increased over a period of 5 days to reach the calculated goals.[21] Hypocaloric prescriptions should be used for patients at risk of RS while maintaining protein delivery.[21,27]

For patients who have had a period of EN but later are unable to tolerate EN because of severe ileus or a change in clinical status, PN should be considered. Evaluation and decision management can be made by returning to the beginning of the algorithm. Daily assessments should be performed to determine readiness for EN or volitional PO intake, as EN remains the preferred route of nutrition support for its evidence of gut mucosal integrity, ease of administration, reduced complications, and lower cost compared with PN.[21] However, the evidence to support the benefit of a course of PN less than 7 days is limited.[21]

## AREAS OF CONTROVERSY AND EXISTING KNOWLEDGE/RESEARCH GAPS

Discussion among the membership of WTA revealed lack of consensus regarding the use of EN while patients require vasopressors. While there is agreement that EN should not be completely withheld in patients on stable low-dose vasopressors, defining "low dose" remains elusive.

There was robust consensus that limiting NPO periods is of paramount importance, but clearly defining which patients can safely continue EN (gastric vs. small bowel access, prone vs. supine procedure positioning) was not achieved.

It is also important to note that there are many areas of this algorithm that lack high-quality evidentiary support and where further focused research is required. Table 1 provides a list of the most important specific topics or existing research "gaps" related to this topic that were identified by the authors during the development of this algorithm.

## CONCLUSION

In summary, based on the available evidence and the collective experience and expertise of the WTA membership, we provide these recommendations to promote the optimal delivery of nutrition therapy to this high-risk population: critically injured adults. Our algorithm aids the clinician in a step-wise approach to assessing patients for nutrition support therapy readiness and guides a management pathway that puts nutrition delivery on par in importance with all other interventions and therapeutics we offer our critically ill patients, not simply an adjunct, starting on day 1. This algorithm challenges historical practice patterns that withhold crucial protein and energy delivery required for healing, such as prolonged NPO periods for procedures, mild ileus, or the use of vasopressors. Early, adequate nutrition delivery has been demonstrated to improve patient outcomes, and

**TABLE 1.** Top Identified Knowledge and Research Gaps Related to Nutrition Therapy in the Critically Injured Adult Patient

| Topic or Research Gap | Algorithm Section |
|---|---|
| 1. Tailoring nutrition and changes in content and caloric delivery based on individual patient physiology and metabolism | A, C |
| 2. EN in the periprocedural period | C |
| 3. EN and the use of vasopressors | C |
| 4. Role and impact of immunonutrition in the trauma population and in select subgroups (TBI, burn, major abdominal surgery, etc.) | C |
| 5. Role and criteria for hypocaloric versus full caloric nutrition delivery in the critically injured patient | C |
| 6. Optimal timing for initiation of PN in high nutritional risk patients | E |

this algorithm will provide the clinician with a step-by-step decision tree to provide this crucial therapy.

## AUTHORSHIP

J.L.H., A.C., and M.J.M. contributed in the conception and design. All authors contributed in the acquisition of data. J.L.H. and A.C. contributed in the drafting of the article. All authors contributed in the critical revision of the article. M.J.M. provided administrative, technical, or material support and supervision.
All authors meet the authorship criteria for this article. All authors have seen and approved the final article as submitted. The first author (J.L.H.) 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

The authors declare no conflicts of interest.
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, the United States Army, or the Department of Defense (if military coauthors).

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