

Chapter 36

NUTRITIONAL SUPPORT IN THE INTENSIVE CARE UNIT

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INTRODUCTION

Nutritional support in military critical care patients has a relatively limited evidence base from which to build recommendations. Most of the evidence for the caloric goals, timing, and route of feeding comes from the civilian setting.¹⁻³ The evidence informing these civilian guidelines is of variable quality and should be interpreted with caution. Some apparently sensible expert recommendations, such as early institution of parenteral nutrition (PN), have been shown to be harmful when formally tested.⁴ Key points from the literature have been extracted, tempered by clinical experience caring for both military and civilian patients in deployed military hospitals and civilian teaching hospitals during the recent conflicts.

The majority of military patients in the current conflicts have been admitted to the critical care unit with complex polytrauma resulting from blast or

ballistic injury. Figure 36-1 shows a complex ballistic trauma patient transferred to a Role 3 hospital following damage control surgery at a forward surgical Role 2 facility. Military patients tend to be young and active, with a greater proportion of their body mass made up of muscle than in the general population. They can therefore be expected to have a correspondingly higher basal metabolic rate. Additional complexity is introduced by the limited resources in the austere military environment, the absence of PN products in most deployed settings, the high frequency of damage control surgery, and the short time before evacuation to advanced medical facilities in the patient's home country. General recommendations are further complicated by the diversity of host nation casualties, including soldiers, civilians, and children.

NUTRITIONAL REQUIREMENTS

The nutritional requirements for intensive care patients include various components: carbohydrate, protein, fat, trace elements, and vitamins. Patients who are fed longer than a short period of time may also require fiber supplementation to prevent constipation. Exactly how much of each component a patient needs may be estimated using various formulae, none of which are proven to affect outcome in polytrauma patients. Alternatively, the energy expenditure of the patient may be measured by indirect

calorimetry, which requires specialized equipment, and feeding prescribed based on this measurement. There are also simple formulae based on estimated ideal body weight, which may prove more practical in austere settings. A pragmatic approach is to recommend 20 to 30 kcal of energy per kilogram of body weight and 1.2 to 2.0 g of protein per day,⁵ with an increase in the amount of protein and calories for patients with more severe trauma or burns, discussed further below.

INITIATION OF NUTRITIONAL SUPPORT

Military trauma patients rapidly lose muscle bulk and weight, almost as soon as they are admitted to the intensive care unit. Some of the muscle loss may be due to inactivity; data from aerospace research demonstrate that inactivity leads to marked reduction in muscle protein synthesis.⁶ However, most of the muscle and weight loss is due to the catabolic state experienced by critically ill patients, during which they cannot efficiently metabolize fat stores, and instead break down muscle proteins.⁷ Infantry soldiers and combat support troops make up the majority of casualties and are typically lean, with little body fat reserve. Feeding is believed to reduce the extent of muscle catabolism, but we do not know exactly how many calories should be delivered at various stages in the patient's journey from the battlefield to hospital discharge, and we do not yet have an effective strategy to prevent patients from losing muscle bulk during their stay on the critical

care unit. Delays in initiating feeding in the field hospital have been demonstrated by a prospective evaluation of American casualties evacuated from a combat support hospital in Iraq.⁸

Two groups have carried out extensive reviews of the literature relating to feeding in critically ill patients. Guidelines from the European Society for Parenteral and Enteral Nutrition (ESPEN) recommend enteral feeding for critically ill patients unless they are likely to be eating and drinking normally within 3 days.³ The Canadian clinical practice guidelines (CCPGs) for nutrition support in mechanically ventilated, critically ill adult patients recommend early enteral feeding within 24 to 48 hours of admission.² However, the majority of patients in the trials that informed these guidelines were medical or surgical rather than trauma patients.

An international multi-center study by Cahill of almost 3,000 patients showed that only 60% of criti-



Figure 36-1. Complex ballistic trauma patient on arrival in a Role 3 hospital following damage control surgery at a forward surgical Role 2 facility. The notes on his abdominal dressing list the numerous procedures he has had as an additional safeguard during a period of high patient throughput.

cally ill patients meet their caloric and protein targets, as defined by the CCPG, and that the average time to initiating nutrition was 46 hours.⁹ Heyland demonstrated, in 638 patients in 59 intensive care units across Canada, that using the CCPG as a guide makes it more likely that patients will meet their caloric requirements; however, a significant proportion of patients do not

meet their target, and the average time to feeding initiation was 1.6 days.¹⁰

Does meeting these nutritional targets affect outcome? We do not know for sure, but a study of 243 critically ill patients, which measured actual energy expenditure using indirect calorimetry, found a marked reduction in the likelihood of death in female patients in whom energy expenditure was matched with calorie and protein delivery.¹¹ It is not clear why male patients did not benefit, and fewer than 10% of the patients had suffered traumatic injuries, so these findings may not be directly applicable to military trauma populations. Other authors have also used indirect calorimetry to guide therapy, with similar outcomes: Scheinkestel, in a study of 50 critically ill patients, showed that the delivery of appropriate amounts of calories and protein resulted in mortality lower than predicted by the severity of illness.¹² Again, the findings may not be directly applicable to military trauma patients because the study patients were older adults with a mean age of 53.

In summary, there is reasonable evidence (albeit not relating to trauma patients in particular) and strong consensus that enteral feeding should be started as soon as the patient is stable in the critical care unit. Although some guidelines² recommend waiting up to 3 days to initiate enteral nutrition, the authors begin feeding as soon as possible and preferably within the first few hours after injury. Delivery of adequate calories and protein is important because it may improve outcome.

ENTERAL AND PARENTERAL ROUTES

Parenteral feeding is more difficult to achieve than enteral, requiring a dedicated central venous access port, and it is associated with more infective complications in most studies, although no increases in mortality have been seen. Historical studies of PN demonstrated high morbidity rates, predominantly due to infection, possibly from infection of the line used to deliver the nutrient-rich solutions, or due to immunosuppression associated with parenteral feeding. Both the CCPG and the ESPEN guidelines therefore recommend using the enteral route to feed all patients unless there are compelling reasons not to do so,^{2,3} such as discontinuity of the gastrointestinal tract. These guidelines also recommend considering a combination of both enteral and parenteral feeding if insufficient feed is delivered by the enteral route, as do other authors.^{2,3,13} These recommendations are based on limited evidence, however.

There is little published data to support very gradual upward titration of the rate of enteral nutrition. In the authors' institutions, the practice is to start feed

at half of the target rate, then increase feeding to the target rate within 4 hours if tolerated. Starting feed at the target rate is also a reasonable option.

Concerns about gut ischemia are cited as reasons not to feed patients who require significant doses of vasopressor drugs to maintain their blood pressure. There are anecdotal cases of such ischemia occurring; however, the authors have not seen any cases, and this rare occurrence seems unlikely in a previously fit military population. We would generally feed all patients unless they are on very large doses of vasopressors.

Researchers have suspected that the high morbidity attributed to PN in historical studies may prove to be lower in modern populations due to interventions that reduce line infection.¹⁴ Morbidity would be lower if the infection were due to mechanical factors associated with the line rather than hyperglycemia or poorly understood immunosuppression related to receiving intravenous glucose and lipids. The suggestion that harmful effects of PN are related to outdated practices (and of historical relevance only) is refuted by recent

strong evidence that exclusive PN causes increased morbidity when delivered within the first 48 hours of admission to intensive care. Delaying PN until day 8 after admission appears to be a safer strategy, leading to a shorter length of stay and less infection.⁴ In sum-

mary, parenteral feeding should be used only when the enteral route is not possible after a week of critical illness, or clearly impossible for anatomical reasons. Figure 36-2 provides a pragmatic and simplified approach to determining which feeding route to use.

SPECIFIC CONSIDERATIONS

Types of Enteral Feed Preparations

Enteral feed preparations available on the market include a large variety of proprietary formulations with a caloric content ranging from 1 to 2 kcal/mL. Higher calorie feeds are indicated for patients who have higher energy requirements or electrolyte abnormalities, or in the chronic setting when the patient may be unable to tolerate a large volume of feed. There

are also preparations containing varying amounts of insoluble and soluble fiber, ranging from low-residue feeds with almost no fiber, to high-fiber feeds aimed at preventing constipation. More specialized feeds are available for patients with chronic renal failure (high protein content), Crohn's disease (elemental feeds), and various inborn errors of metabolism (metabolically appropriate content), but these are outside the focus of this chapter. Feeds containing shorter peptides rather than the whole protein molecules found in standard feeds have no evidence of benefit.³

The authors aim to feed military polytrauma patients 35 kcal per kilogram of ideal body weight for the first 48 hours after injury. In practice, for a 70-kg patient this rate will approximate to 100 mL/h of feed containing 1 kcal/mL in the first 24 to 48 hours. Feed is increased in the following days if tolerated. Caloric targets are based on extrapolation from civilian patients. It should be noted that in civilian patients high calorie delivery has been associated with poor outcome, albeit with a low level of certainty that the high caloric load was responsible.³ We have not seen evidence of adverse outcomes in military patients. The ongoing United Kingdom Surgeon General's Casualty Nutrition Study may provide additional information on the caloric requirements of military casualties.⁵

Most deployed military critical care units stock only one type of feed, containing 1 kcal/mL. Logistic considerations argue against the provision of multiple preparations, and therefore this feed is used for all patients who require enteral feeding, including children. In summary, enteral feed should be delivered with the aim of supplying sufficient calories and protein based on ideal body weight and adjusted for severity of injury.

Immunonutrition

Immunonutrition refers to supplementing enteral or parenteral feed with various compounds that have theoretical or proven benefits in critical illness. Supplements that have been subjected to trial in critical care patients include glutamine, fish oils, and trace elements.

Glutamine is made in large amounts in healthy individuals, but in critical illness glutamine levels

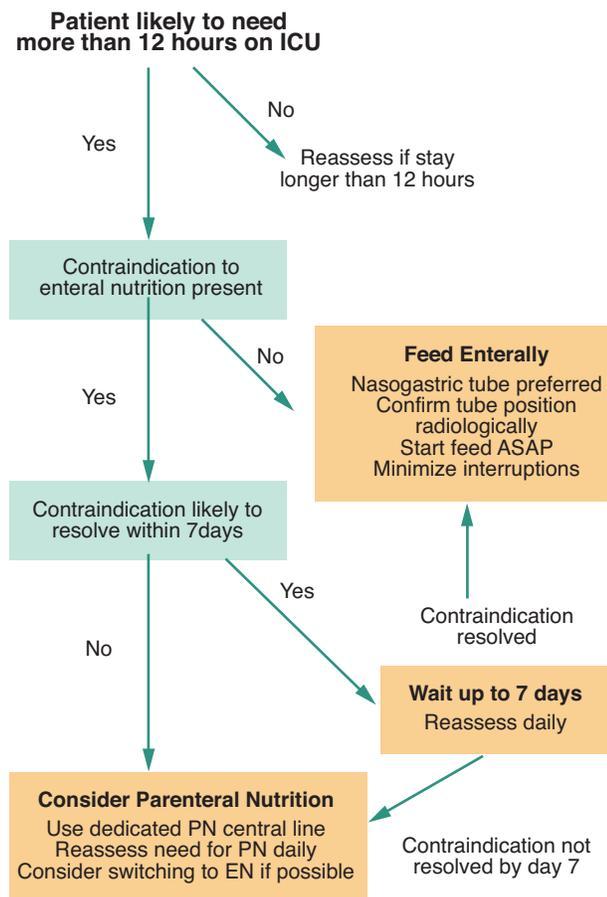


Figure 36-2. Flowchart for deciding between enteral and parenteral feeding.

ASAP: as soon as possible

EN: enteral nutrition

ICU: intensive care unit

PN: parenteral nutrition

drop, due either to reduced production or increased consumption.¹⁵ Trials comparing enteral glutamine supplementation with standard feed have been carried out in trauma patients by two groups. Houdijk studied 72 polytrauma patients and demonstrated a reduction in pneumonia and sepsis in the intervention group, with no effect on mortality.¹⁶ Brantley carried out a study (published in abstract form only) also in 72 trauma patients that demonstrated a reduction in length of hospital stay of just over 1 day for the intervention group and no reduction in mortality. Infection rates were not reported.¹⁷ Novak et al¹⁵ carried out an extensive review of trials of glutamine in critically ill patients, the majority of which did not allow firm conclusions, but some evidence of benefit for high-dose glutamine in surgical and critically ill patients was found, with the possibility that glutamine may reduce length of stay and infective complications in the former group and possibly reduce complications and mortality in the latter group. The ESPEN and CCPG guidelines recommend the use of feed containing glutamine in patients with burns and trauma.^{2,3}

The purported benefits of fish oils and various other polyunsaturated fatty acids include reduction of inflammation by altering the balance between proinflammatory and antiinflammatory parts of the eicosanoid pathway.¹⁸ A well-conducted trial of fish oil supplementation in 173 critically ill patients showed no effect on inflammatory mediators or outcome¹⁹; however, analysis of the literature for the ESPEN PN guideline suggests these supplements do have some effect on length of stay in the intensive care unit.²⁰ In subgroups of intensive care patients with acute respiratory distress syndrome (ARDS), enteral feed containing fish oils has been shown to reduce length of ventilation and length of intensive care stay.²¹ The ESPEN and CCPG guidelines differ on fish oils, with ESPEN recommending fish oil supplementation in patients who have had gastrointestinal surgery, mild sepsis, trauma, or ARDS, but not severe sepsis.³ The CCPG guideline reserves their use for patients with ARDS.²

Trace elements are thought to improve healing, especially in burn patients and those with gastrointestinal disease. Enteral and parenteral feeds typically contain a range of trace elements and vitamins. There is no strong evidence that additional trace elements are beneficial, except in burn patients.^{3,20} Recently some manufacturers have started adding fish oil or omega-3 vegetable oils to their standard feeds.

In summary, glutamine supplementation appears to be helpful in trauma patients. Immunonutrition with feeds containing fish oil, while showing some promise, should be reserved for subgroups of patients

with ARDS, and trace element supplementation may benefit burned patients.

Enteral Feeding After Abdominal Surgery

A period of fasting, followed by the gradual reintroduction of fluids and then solids, was for many years an integral and unchallenged part of postoperative care.²² This approach was felt to allow resolution of the "inevitable" postoperative ileus, reduce the risk of vomiting and aspiration, and prevent anastomotic complications. There is no evidence to support this practice. Several well conducted, civilian randomized trials of early enteral nutrition,²³⁻³² which have been eloquently summarized in two recent systematic reviews,^{30,33} do not show an increase in anastomotic leak rates. However, the evidence is stronger for lower gastrointestinal anastomoses³⁴ than for upper gastrointestinal anastomoses. Only four of the trials included patients who had undergone upper gastrointestinal or hepatobiliary surgery,^{23,25,31,32} and even the total number of such patients was too small to allow for a meaningful metaanalysis. A recent nonsystematic review on early oral nutrition after elective upper gastrointestinal surgery, however, concluded that, despite little direct evidence, early feeding will most likely prove to be equally safe after gastric, and possibly also esophageal surgery, as it is after other types of gastrointestinal surgery.³⁵

Only one study, also conducted in the civilian setting, specifically investigated the effect of early enteral nutrition in abdominal trauma patients. This study showed a reduction in septic complications, but was too heterogeneous and underpowered to detect differences in anastomotic complications.^{36,37}

In summary, although there is little direct evidence from the trauma or military setting, it seems reasonable to extrapolate the findings of civilian primary studies and systematic reviews to a recommendation that gastrointestinal anastomoses and repairs, including those in the upper gastrointestinal tract, are not a contraindication to early enteral feeding.¹

Postpyloric Feeding

Intragastric feeding using nasogastric tubes is associated with complications such as gastroesophageal reflux that may result in aspiration and delayed gastric emptying, which can result in failure to attain caloric goals. Postpyloric feeding is conceptually attractive, but no good evidence shows it to be advantageous. Further work is required to demonstrate the benefits and relative advantages of the nasoduodenal and nasojejunal routes, and new devices are needed to

ensure that catheters can be placed quickly, accurately, and consistently to prevent delays in the initiation of feeding.³⁸ Infrequently, intraoperative placement, at the time of the index laparotomy—although not always straightforward because of technical difficulties—may have a role. The route chosen is dependent on the clinical setting, but intragastric delivery is usually more physiological and convenient than postpyloric feeding, and thus the preferred route for the initiation of nutritional support.¹

Surgical Access to the Gastrointestinal Tract

Direct access to the gastrointestinal tract, through a gastrostomy or jejunostomy, is used in two distinct populations of trauma patients: (1) those who are expected to require nutritional support in the short term only, whose caloric requirements may not be met with nasogastric or postpyloric feeding, and (2) those who will require long-term nutritional support, such as patients with traumatic brain injuries.¹ Gastrostomy placement for long-term nutritional management is outside the scope of this book and will therefore not be discussed further.

The volume of evidence for the short-term use of feeding jejunostomies is small and the quality of studies poor. Furthermore, no reports are specifically from the military setting. Early studies by Dunn and Moore describe small series of civilian patients with a combination of blunt and penetrating abdominal injuries who underwent jejunostomy formation at the time of their initial operation.^{39,40} A subsequent randomized study by the same group compared early enteral nutrition using a jejunostomy with controls who received no supplemental nutrition for 5 days and revealed a decrease in septic complications in the jejunostomy group.⁴¹ However, given that most patients in the control group received no nutrition at all (some were given PN), the study actually identifies the benefits of enteral nutrition, rather than jejunostomy. Holmes et al⁴² retrospectively analyzed 222 trauma patients who underwent early feeding jejunostomy insertion, and reported a major complication rate of 4%. Eddy et al⁴³ also found a significant complication rate relating to the use of jejunostomies in trauma patients.

In summary, there is little evidence to recommend the formation of feeding jejunostomies for short-term nutritional support as part of the initial surgical management of patients with abdominal injuries. Nasogastric, or indeed nasoduodenal or nasojejunal access, is more convenient and probably associated with fewer complications. Many of the original reports of feeding jejunostomy use were published in the 1980s, and it is possible that feeding jejunostomy use has declined

with the increasing utilization of damage control surgery, since jejunostomies tend to interfere with temporary abdominal closure.

Enteral Nutrition After Temporary Abdominal Closure

The damage control approach is now widely accepted as the standard of care for trauma patients with abdominal injury and severe physiological derangement, and has been utilized extensively in the recent conflicts in Afghanistan and Iraq.^{44,45} Damage control laparotomy often entails temporary abdominal closure, to expedite transfer to the intensive care unit, facilitate repeat laparotomy, and prevent abdominal compartment syndrome. Although the “open abdomen” is a testament to the success of modern trauma surgery, it has also been accompanied by new challenges, including nutritional management. Patients who require damage control surgery often have multiple significant injuries, and therefore accentuated metabolic responses. Conventionally, however, these patients were often not fed enterally until after fascial closure, because exposure of the bowel was theorized to promote ileus and intestinal edema, which was thought to be exacerbated by enteral nutrition, thus delaying or preventing fascial closure, or leading to aspiration and pneumonia.

Few studies of enteral feeding in patients with temporary abdominal closure exist. Three civilian case series compare patients managed with early enteral nutrition to those for whom enteral nutrition was introduced late.⁴⁶⁻⁴⁸ All three studies are retrospective and nonrandomized, and although the groups appear well matched, there is a risk of bias from unmeasured factors. Allowing for these limitations, Collier et al, in a study of 78 trauma patients, reported earlier fascial closure in patients who were fed enterally within 4 days of admission.⁴⁷ A further study of 100 trauma patients with hemorrhagic shock, from several facilities, found no difference in mortality, incidence of multiorgan dysfunction syndrome, duration of ventilation, intensive care unit or hospital stay, or fascial closure rates between those given early and late enteral nutrition, but it did report a lower incidence of pneumonia in those managed with early enteral nutrition, and early enteral nutrition remained independently associated with a reduction in the incidence of pneumonia on stepwise regression analysis.⁴⁸ A third, more recent but smaller study of 23 trauma patients also showed no differences in fascial closure rates or mortality, but also no difference in the incidence of pneumonia, in patients with an open abdomen who were given early enteral nutrition.⁴⁶

In summary, there is no evidence that enteral feeding of patients with an open abdomen delays fascial closure or prolongs time spent in intensive care, and there is some evidence that it reduces the incidence of ventilator-associated pneumonia. Unless other contraindications are present, enteral nutrition should therefore be established early in patients with an open abdomen.¹

Continuation of Enteral Nutrition During Repeat Operations

The widespread use of damage control surgery, and the nature of military wounds in general, has resulted in increasing numbers of “relook” or “take-back” operations, involving both the abdomen and other body regions such as amputation stumps. Many Role 3 trauma patients who are not eligible for transfer to Role 4 are returned to the operating theater every 48 to 72 hours during the initial 7 to 10 days of their hospital course. If patients are al-

ready intubated and ventilated in the intensive care unit prior to returning to the operating theater, and there are no plans for extubation immediately after reoperation, the question arises as to whether enteral feeding should be discontinued preoperatively and intraoperatively. Adherence to standard fasting guidelines intended for elective surgery will result in lengthy interruptions to feeding and failure to attain caloric goals.

To the authors' knowledge, there is no evidence or guidance, from the military or civilian setting, to inform a recommendation on this subject. Preoperative fasting is intended to reduce the risk of aspiration. Unless dislodged during transfer, patients with a cuffed endotracheal tube are arguably not at increased risk of aspiration, regardless of whether in the operating room or intensive care unit. It would therefore appear reasonable to continue enteral nutrition, certainly for extraabdominal procedures not involving manipulation of the airway, and possibly also for intraabdominal surgery.¹

SUMMARY

Nutritional support is a broad and complex subject, and current practice is supported by a limited evidence base. Most of this evidence relates to critically ill patients in general, rather than surgical or trauma patients, and virtually all of it originates from the civilian setting. Military trauma patients, and the deployed environment, bring unique challenges and pose unique questions, which current guidelines cannot fully answer, necessitating a degree of extrapolation and pragmatism.

Despite these caveats, certain interventions can be recommended with confidence:

- Enteral feeding is superior to parenteral feeding,

and should be started as early as practicable.

- The nasogastric route offers the benefit of being simple to use and facilitates early feeding.
- Early feeding does not adversely affect outcomes following gastrointestinal anastomosis, and is safe when the patient has an open abdomen. It does not delay closure of the abdomen and may reduce the incidence of pneumonia.
- Enteral feeding should be continued when patients are returned to the operating theater for surgery (other than airway or hollow-viscus procedures) in the days after the initial injury.

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