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# *Gastrointestinal tract access for enteral nutrition in critically ill and trauma patients: indications, techniques, and complications*

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REVIEW ARTICLE

# Gastrointestinal tract access for enteral nutrition in critically ill and trauma patients: indications, techniques, and complications

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**Abstract**

*Background* Enteral nutrition (EN) is a widely used, standard-of-care technique for nutrition support in critically ill and trauma patients.

*Objective* To review the current techniques of gastrointestinal tract access for EN.

*Methods* For this traditional narrative review, we accessed English-language articles and abstracts published from January 1988 through October 2012, using three research engines (MEDLINE, Scopus, and EMBASE) and the following key terms: "enteral nutrition," "critically ill," and "gut access." We excluded outdated abstracts.

*Results* For our nearly 25-year search period, 44 articles matched all three terms. The most common gut access techniques included nasoenteric tube placement (nasogastric, nasoduodenal, or nasojejunal), as well as a percutaneous endoscopic gastrostomy (PEG). Other open or laparoscopic techniques, such as a jejunostomy or a gastrojejunostomy, were also used. Early EN continues to be preferred whenever feasible. In addition, evidence is mounting that EN during the early phase of critical illness or trauma trophic feeding has an outcome comparable to that of full-strength formulas. Most patients tolerate EN through the stomach, so postpyloric tube feeding is not needed initially.

*Conclusion* In critically ill and trauma patients, early EN through the stomach should be instituted whenever feasible. Other approaches can be used according to patient needs, available expertise, and institutional guidelines. More research is needed in order to ensure the safe use of surgical tubes in the open abdomen.

**Keywords** Enteral nutrition · Feeding tube · Percutaneous endoscopic gastrostomy · Gastrostomy · Gastrojejunostomy · Nasojejunostomy

## Introduction

The benefit of the early institution of adequate enteral or parenteral nutrition in the overall care of critically ill and trauma patients has been well established [1–4]. Early nutrition support has the potential to reduce disease severity, diminish complications, and decrease the intensive care unit (ICU) length of stay. In general, whenever possible, the gastrointestinal (GI) tract is the optimal route of gut access for nutrition support. But if patients cannot receive all the required nutrient substrates and calories enterally, nutrition should be provided parenterally. The enteral route should be used in patients with a normally functioning GI tract; this route is considered to be safe [5, 6], cost-effective, and practical, with clear metabolic and immune-related advantages [7, 8].

## Methods

For this traditional narrative review, we accessed English-language articles and abstracts published from January

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1988 through October 2012, using three research engines (MEDLINE, Scopus, and EMBASE) and the following key terms: gut, access, critical illness, nutrition, enteral nutrition. We used "mesh term" or "all fields". We found 44 articles relevant to "gut access" for the purposes of our review. Forty-two articles were not considered to be relevant to our review, mainly because they were review articles or did not offer any value to our study. We also excluded outdated abstracts.

## Results

The indications for enteral nutrition (EN) are fairly straightforward and well established. All critically ill and trauma patients who cannot, will not, or should not receive nutrition orally and who have a functional GI tract need, for nutrition support, GI access—as early as possible after they are fully resuscitated [9].

EN delivery can be via temporary nasoenteric tube placement (orogastric, nasogastric, nasoduodenal, or nasojejunal) or via more long-term techniques (gastrostomy or gastrojejunostomy, which can each be done either surgically or endoscopically). Factors to consider, in terms of the individual patient, include the anticipated duration of EN, aspiration risk, GI tract function, ability to tolerate the given EN technique, degree of critical illness or injury, and specific goal of EN [10–12]. Each major technique is discussed below.

### Tube feeding

Many critically ill and trauma patients, once they are resuscitated, can be started on orogastric or nasogastric tube feeding. If they show signs of gastric intolerance, they may be switched to postpyloric tube feeding.

Nasogastric tube placement must be confirmed by the presence of aspirating gastric fluid or by radiographic studies [13]. Other verification methods have also been described, such as assessment of the pH of aspirate, ultrasound, and capnography [14–16]. Furthermore, the position of the feeding tube should be confirmed at the time of insertion, before each intermittent feeding session is started, and during continuous feedings. The mark on the tube at the exit site indicates that the exposed tube length has not changed [17].

Many physicians depend on gastric peristalsis in order for the nasogastric tube feeding to migrate to a postpyloric position. One way to ensure tube placement within the duodenum is the Cortrak Enteral Access System$^{TM}$, which uses an electromagnetic sensing device to track and display the tube's path [18, 19]. Fluoroscopic or endoscopic guidance can also be used to ensure proper positioning of the tube [20–22].

The notion that postpyloric tube feeding offers advantages over gastric tube feeding has been widely studied [23–25, 27–29, 31]. However, most studies were limited by variability of the population and by small sample sizes [26]. In many randomized controlled trials, postpyloric tube feeding was associated with a higher caloric intake [23, 24, 25] and with a lower rate of pneumonia as compared with gastric feeding [23, 25].

Yet, the authors of a systemic review of a heterogeneous group of 522 critically ill patients found no differences in the rates of pneumonia, ICU length of stay, and mortality between a subgroup on postpyloric tube feeding and a subgroup on gastric tube feeding. Those authors concluded that patients on gastric tube feeding received their nutrition earlier than those on postpyloric tube feeding [27].

A meta-analysis of 11 randomized controlled studies showed that the mortality and risk of aspiration or of pneumonia were not significantly different between patients on gastric versus postpyloric tube feeding. In addition, the gastric tube feeding group had a lower risk of tube placement difficulties [28]. Similarly, White et al. [29] found that gastric tube feeding was quicker to initiate than postpyloric tube feeding, and that the time from ICU admission to reaching target feeding goals was faster in the gastric tube feeding group, with similar complication rates.

All of the above studies recruited patients when they became sicker and required feeding tubes for nutrition. But note that a special subset of more critically ill patients, namely, those who develop elevated gastric residual volumes (about 500 mL in 12 h), require postpyloric tube feeding after gastric tube feeding [30]. To address shifting from gastric to postpyloric tube feeding, Davies et al., in a well-designed controlled trial, showed that patients switched to postpyloric tube feeding who already had elevated gastric residual volumes did not have better outcomes. In such patients, Davies et al. [31] recommended continuing gastric tube feeding, even if they showed some signs of gastric intolerance.

Another important variable to consider is trophic feeding, which is a low-dose feeding of 10–30 mL/h used to maintain gut integrity [32]. In a study that examined the first 6 days of mechanical ventilation, trophic feeding was associated with better gastric tolerance and an outcome similar to that of full-energy EN [33].

Given the current evidence, we recommend starting and continuing patients on gastric tube feeding, provided that the volume of feeding is low and they are not gravely ill.

Many complications can be encountered during nasoenteric tube placement, which makes this technique less favorable for long-term EN. Complications include erosion of the nasal cartilage, sinusitis, and gastroesophageal reflux, which, in turn, can lead to aspiration, pneumonitis, or pneumonia. Smaller-diameter tubes often become blocked and require replacement. In addition, nasogastric tubes can be inadvertently removed [34].

## Percutaneous endoscopic gastrostomy (PEG)

Ever since Ponsky and Gauderer [35] first reported a technique for percutaneous endoscopic gastrostomy (PEG) in the early 1980s, countless patients have been provided with EN through PEG. This minimally invasive technique is relatively safe as compared with open surgical procedures.

Absolute contraindications to PEG include a limited life expectancy, esophageal obstruction due to malignancy or other pathology, and the inability to receive nutrition support via the gut (as in patients with a non-functional GI tract or with multiple enterocutaneous fistulas). Obviously, other absolute contraindications include the presence of peritonitis, major neck trauma involving the esophagus, trauma to the floor of the mouth and oropharynx, and the inability, on the part of the surgeon, to pass an endoscope.

Relative contraindications specifically related to the endoscopic approach include portal hypertension with esophageal and gastric varices, peritoneal dialysis, hepatomegaly, a large hiatal hernia, a previous subtotal gastrectomy, and morbid obesity [34].

The first step in PEG tube placement is to perform a full upper endoscopy. Under direct vision, the gastroscope is introduced into the patient's esophagus. If difficulty is encountered in the supine position, the patient may be rotated to the left lateral decubitus position, temporarily, in order to facilitate passage of the endoscope. Rotating the patient may not be possible if he or she has spine injuries; the surgeon should use a laryngoscope to visualize the cords clearly and, thus, avoid tracheal intubation. Air should be insufflated during the passage through the esophagus to ensure safe passage. To assess for any pathology and to rule out pyloric obstruction, the surgeon should evaluate the esophagus, stomach, and duodenum [36].

The endoscope is then withdrawn into the body of the stomach, and the stomach is insufflated, resulting in better opposition of the anterior gastric and abdominal walls. A point is chosen in the mid- to left epigastrium that ensures maximal transillumination of the endoscope; darkening the room may facilitate this task. The abdominal wall should be, simultaneously, directly palpated externally and visualized by the gastroscope [37]. Multiple sites may be palpated to achieve the best location for transillumination and gastric indentation, in order to decrease the risk of passing through the transfer colon or other tissues.

Once the best site for puncture is identified, a local anesthetic is administered into the skin and subcutaneous tissue at the chosen site; a 1-cm incision is made in the transverse direction. A small-caliber needle (attached to a syringe filled with fluid) is introduced through the anterior abdominal wall, while negative pressure is applied to the plunger [38]. The syringe is slowly advanced through the abdominal wall, and the needle is visualized by the gastroscope. Any air seen in the syringe before visualization of the needle in the gastric lumen implies that the needle is within an unintended loop of bowel. Aspiration of blood implies that the left segment of the liver is interposed between the gastric and abdominal wall. If either of those two possibilities occurs, the surgeon should remove the needle, choose an alternative site, and reintroduce the needle [34].

Next, under direct visualization via the endoscope, a needle angiocatheter is introduced into the gastric lumen. A polypectomy snare is passed through the working channel of the endoscope and used to grasp the angiocatheter. The needle component of the angiocatheter is then removed, and a guidewire is passed through the abdominal wall via the catheter. After several centimeters of guidewire have been passed, the snare is loosened and the guidewire is grasped. The endoscope is then withdrawn, while the proximal end of the guidewire is advanced through the esophagus and mouth.

Two methods are possible for advancing the guidewire. If the pull method is used, the tapered gastrostomy tube is attached to the guidewire outside the patient's mouth; gentle tension is applied to the guidewire from the abdominal side to introduce the gastrostomy tube and guidewire unit into the esophagus and then into the stomach [39].

If the push method is used, the gastrostomy tube is passed over the guidewire, and the endoscope is used to grasp and stabilize the end of the wire beyond the gastrostomy tube; the gastrostomy tube is then pushed, by the endoscope, through the abdominal wall into the stomach, while tension is applied to both ends of the guidewire.

With both methods, the endoscope may be reintroduced to confirm optimal placement (but without undue tension) of the internal bumper against the gastric mucosa. An external bumper is then used to secure the PEG tube, with care taken to avoid undue pressure on the skin. A distance of 1–2 mm between the external bumper and the skin is advisable, in order to decrease ischemic necrosis and subsequent infection.

If the surgeon is unable to see the light of the gastroscope on the abdominal wall, we suggest aborting the procedure and switching to a laparoscopically assisted technique for PEG tube placement. This technique is applicable when distorted anatomy is a concern, as in patients who are morbidly obese or who have undergone previous gastric or other abdominal surgery [40]. Some surgeons instead prefer the aid of interventional radiology, but its use depends on local expertise. Endoluminal ultrasound (EUS) has been used to successfully confirm luminal proximity to the abdominal wall and to subsequently identify a location suitable for PEG tube placement [41].

After PEG tube placement, wound problems are common. They are often associated with excessive tension on the tube, leading to tissue ischemia and necrosis. Excessive tension on the tube may also result in buried bumper syndrome (a condition in which the head of the tube extrudes from the gastric lumen into the subcutaneous tissue) or in progressive enlargement of the stoma. Minimizing tube mobility and reducing tension on the tube should allow healing to proceed normally around the GI tract [34]. The most common complication is peristomal wound infection, which occurs in about 11 % of patients within 1 week after PEG tube placement.

One recent study found that the rate of peristomal wound infection significantly increased in patients with malignancy, cirrhosis, and radiation exposure [42]. Evidence is accumulating, from randomized studies, that prophylactic intravenous (IV) antibiotics during PEG tube placement have a clear benefit in reducing peristomal wound infection [43]. In 0.03 % of patients during routine upper endoscopy, perforation occurs [44], most commonly at the pharynx and upper esophagus. Avoiding forceful insertion of the endoscope can decrease this risk. When performing PEG tube placement in patients who have had a tracheostomy or are intubated, as is common in patients with traumatic brain injury [45, 46], the surgeon should consider deflating the balloon in order to make the passage of the scope easier.

After PEG tube placement, early postoperative feeding is becoming a common practice, but the exact timing varies. A recent meta-analysis involving 355 patients from five randomized controlled trials found that tube feeding within 3 h after PEG tube placement (versus delayed feeding, i.e., on the next day) was associated with no significant differences in the rate of complications, in the rate of early death, or in residual volume [47]. Caring for PEG patients requires a multidisciplinary approach by a nutrition support team, in order to help identify and obtain the optimal route for gut access, to reduce complications, to ensure adherence to existing guidelines, and to optimize cost-effectiveness [48].

### Percutaneous gastrojejunostomy

Another technique for patients who cannot tolerate stomach feeding is a percutaneous gastrojejunostomy, often called a PEG gastrojejunostomy [34]. A standard 20-French PEG tube accommodates an up to 8.5-French J-tube. The J-tube is passed through the existing PEG tube; the suture on the distal end of the J-tube is grasped with an endoscopic clip applicator passed through the working channel of the endoscope. The gastroscope and jejunal tube are then passed, under direct visualization, through the pylorus and into the small bowel. By firing the endoscopic clip, the surgeon secures the suture loop to the small-bowel mucosa. This technique allows for easier removal of the endoscope from the small bowel and minimizes the risk of inadvertent dislodgement of the jejunal feeding tube back to the stomach.

### Surgical gastrostomy

If PEG tube placement is contraindicated (see above), a surgically placed gastrostomy is an option, via either an open technique or a laparoscopy [49]. The Stamm open technique begins with the surgeon placing inner and outer purse string sutures on the mid-anterior gastric wall, and then making an incision in the central portion of the purse string sutures. Next, a balloon-type or mushroom-type catheter is inserted through the anterior abdominal wall and through the stomach wall. The purse string sutures are sequentially tied, and the seromuscular gastric wall is inverted around the catheter; the anterior gastric wall is fixed to the posterior aspect of the abdominal wall with four nonabsorbable sutures; the catheter is secured externally to the skin at the exit site; and the laparotomy site is closed in the standard fashion. What tube is used (i.e., a flange or a balloon-type tube) mostly depends on the hospital and local practice; we do not have any preference for one type over the other.

As a modification of the Stamm procedure, a laparoscopic approach can be used instead. The construction of a simple gastrostomy, without a mucosa-lined tube, is appropriate for most patients [50]. With two ports (at the umbilicus for a 30° camera and in the right upper quadrant for use as a working port), the surgeon grasps the stomach and elevates it to the anterior abdominal wall, and then selects an appropriate location for gastrostomy tube placement. The use of T-fasteners (through the anterior abdominal wall and the gastric wall) ensures that the stomach is secured well and reduces the overall morbidity if dislodgement occurs [51]. Through a small incision, a 14-gauge needle is introduced into the stomach, and a guidewire is passed into the gastric lumen. The tract is serially dilated until the gastrostomy tube can be introduced. Then, the gastrostomy tube is secured to the skin, and the laparoscopic port sites are closed [34].

For the replacement of gastrostomy tubes, special attention should be paid when re-inserting balloon-type tubes, which can migrate distally into the duodenum and cause obstruction of the gastric outlet, biliary tree, or pancreatic duct [52–54].

### Laparoscopically assisted PEG

Laparoscopically assisted PEG is preferred in obese patients, in patients who have undergone a previous laparotomy, and during an open operation when the surgeon "does not see the light" (i.e., the light of the gastroscope on the abdominal wall). Laparoscopically assisted PEG ensures that tube placement is checked by both the endoscopist and the surgeon [55].

The peritoneal cavity is accessed in the usual fashion. We use an open technique to insert a 30° laparoscope. Then, also under direct vision, we insert one or two 5-mm ports. These ports are important to help "stabilize" the stomach and also to help guide the needle insertion into the stomach. Occasionally, as in patients with adhesions over the stomach, these ports can be used to insert laparoscopic scissors for adhesiolysis. The stomach is inflated with a gastroscope; the needle from the anterior abdominal wall is inserted into the stomach under direct vision. The rest of the procedure is similar to PEG as described above. Note that the surgeon must remember to lower the patient's intraperitoneal pressure to 8–10 cm of $H_2O$, in order to allow approximation of the stomach to the posterior abdominal wall.

### Surgical jejunostomy

Surgical jejunal (SJ) access for feeding is a well-recognized option that does not require a special tube, but, rather, simply needs a rubber catheter. Some surgeons use needle jejunostomy. Both the open and laparoscopic approaches are acceptable: which method is selected depends on the individual surgeon's experience, as well as the clinical situation. For example, if the patient is undergoing a laparotomy and long-term EN is needed, an open jejunostomy is the logical choice.

Many techniques have been described, such as the Stamm, Witzel, and permanent jejunostomy. For patients who need EN, we prefer the open Witzel jejunostomy. It is usually performed under general anesthesia, but if the patient is too sick for general anesthesia and if exploration of the abdomen is not required, then local anesthesia can be used [56].

Typically, we make a vertical left paramedian incision (5–6 cm), carried to the peritoneum through the external oblique, internal oblique, and transversalis muscles. We choose a loop of jejunum 20–25 cm distal from the duodenojejunal flexure. Using a Babcock forceps or finger, we gently grasp the bowel loop and withdraw it through the abdominal wound. Then, we make an enterotomy in the antimesenteric aspect of the bowel, passing the catheter distally at least 10–15 cm into the distal lumen. Using interrupted seromuscular stitches, we suture-fold the intestine over the rubber tube, until the tube is completely buried in the jejunal wall, but not to an excessive length (in order to avoid bowel narrowing).

Next, we bring out the outer end of the catheter through a separate stab wound in the abdominal wall. We fix about 10 cm of the small bowel, along with the tube, against the abdominal wall, in order to avoid volvulus of the jejunum. The usual tube for a jejunostomy is a 14- to 16-French red rubber catheter; however, a T-tube has been tried with good success [57].

In good hands, this procedure is safe and easy to perform; still, numerous complications have been described, both technical and mechanical [58, 59]. Holmes et al. [60] reported complications in 22 of 222 trauma patients who underwent a laparotomy. And *major* complications occurred in nine patients (4 %), including two small-bowel perforations, two small-bowel volvuli with infarction, two intraperitoneal leaks, and three small-bowel necrosis; three of those patients died. Moreover, more of those nine patients underwent a Witzel tube jejunostomy than a needle catheter jejunostomy. Holmes et al. cited an open abdomen as a risk factor for developing complications related to a surgical jejunostomy. However, that observation was not confirmed in a recent study on feeding in patients with an open abdomen [9] and deserves further research.

A surgical jejunostomy can be performed totally via a laparoscopy or partially via laparoscopically assisted placement [61]. A total laparoscopic jejunostomy starts with the establishment of a pneumoperitoneum and placement of three trocars; next, three or four transabdominal sutures are placed in a diamond shape, incorporating the anterior abdominal wall and the seromuscular layer of the jejunal wall [62]. The feeding tube or a needle catheter is inserted through the center of the sutures and fixed to the skin. The complication rate varies (range 17–50 %). Mild complications include wound infections and catheter dislodgement; major complications require a reoperation and can even lead to death [63]. A multidisciplinary approach, surgical experience, and appropriate selection of patients can help ensure the best results.

### Gut access in the open abdomen

Historically, surgeons have been reluctant to start EN in patients with an open abdomen. Such patients have been felt to be at high risk for bowel edema and ileus, with subsequent aspiration pneumonia. Additionally, there has been a fear of inducing small-bowel necrosis by stressing an underperfused bowel [64]. Still, another concern has been the danger of increasing bowel distention, which could reduce the surgeon's ability to obtain fascial closure [65]. In a series of 33 patients described by Byrnes et al., 52 % of them were safely fed enterally before fascial closure. Overall, 50 % of the patients were fed via a surgical jejunostomy, 25 % via the stomach, and 25 % via postpyloric tube feeding. About two-thirds of the patients tolerated their goal rates of tube feeding; the remaining third tolerated tube feeding at 20 mL/h. Byrnes et al. found no benefit to early fascial closure. However, we must point out that their fascial closure patients had no complications (such as bowel ischemia, enterocutaneous fistulas, or anastomotic leaks) and had a lower incidence of pneumonia [66].

A similar safety profile in patients with an open abdomen was reported by the Western Trauma Association [9]. Of 597 patients with an open abdomen after trauma, 230 received EN before abdominal closure. The stomach was most frequently used for gut access, in 139 patients (60 %), followed by the duodenum in 37 patients (16 %) and the jejunum in 49 patients (21 %). In all, 42 patients underwent surgical placement of gastrostomy tubes, 24 of which were jejunostomy tubes. The EN group had lower complication rates and a marked increase in successful fascial closure: those without (versus with) a bowel injury that required an open abdomen had a higher survival rate. Although no survival benefit was seen in EN patients with a bowel injury who required an open abdomen, they, nonetheless, had a lower rate of overall and abdominal complications than the non-EN patients.

In light of the above data and our own practice in patients with an open abdomen, we believe that EN is safe and should be considered as soon as possible, whether via short-term options (nasogastric, nasoduodenal, or nasojejunal tube placement) or via permanent options (surgical or endoscopic gastrostomy or gastrojejunostomy).

## Conclusion

Obtaining gut access in order to provide enteral nutrition (EN) to critically ill and trauma patients is obligatory, whenever feasible, and is, in fact, the standard of care. Nonsurgical techniques include simple orogastric, nasogastric, or nasojejunal feeding tube placement. Invasive surgical techniques include an open gastrostomy, gastrojejunostomy, or jejunostomy; less invasive techniques include percutaneous endoscopic gastrostomy (PEG) and laparoscopically assisted or totally laparoscopic gastric or jejunal feeding tube placement. Surgeons and other physicians caring for critically ill and trauma patients need to be familiar with the array of techniques for gut access, including their potential benefits and complications. Such familiarity will ensure proper nutritional care for vulnerable patients. We recommend early gastric trophic feeding in critically ill and trauma patients whenever feasible, reserving postpyloric tube feeding for gravely ill patients. Further research is warranted in order to ensure the safety of surgically placed tubes in patients with an open abdomen.

**Conflict of interest** The authors declare no conflict of interest.

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