

A guide to enteral access procedures and enteral nutrition

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Abstract | The advent of total parenteral nutrition in the late 1960s meant that no situation remained in which a patient could not be fed. Unfortunately, total parenteral nutrition was complicated by serious infective and metabolic side effects that undermined the beneficial effects of nutrient repletion. Consequently, creative ways of restoring upper gut function were designed, based on semielemental diets and novel feeding tube systems. The employment of specific protocols and acceptance of increased gastric residual volumes has allowed most patients in intensive care to be fed safely and early by nasogastric tube. However, nasogastric feeding is unsuitable for patients with severely compromised gastric emptying owing to partial obstruction or ileus. Such patients require postpyloric tube placement with simultaneous gastric decompression via double-lumen nasogastric decompression and jejunal feeding tubes. These tubes can be placed endoscopically 40–60 cm past the ligament of Treitz to enable feeding without pancreatic stimulation. In patients whose disorders last more than 4 weeks, tubes should be repositioned percutaneously, by endoscopic, open or laparoscopic surgery. Together, the advances in enteral access have improved patients' outcomes and led to a 70–90% reduction in the demand for total parenteral nutrition.

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Learning objectives

Upon completion of this activity, participants should be able to:

- 1 Describe the procedure of nasogastric tube feeding.
- 2 Identify the best practice for nasoenteric feeding.
- 3 List the conditions that are not appropriate for percutaneous endoscopic gastrostomy placement.
- 4 Describe the procedure of percutaneous endoscopic gastrostomy.

Competing interests

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Introduction

Although nasogastric tubes have been available for many years, their principal function in the past was to decompress the stomach in critically ill patients and thus prevent reflux and aspiration. In chronically ill and mentally retarded patients, however, bolus nasogastric tube feeding has been used for decades as a temporary measure until a surgical gastrostomy could be placed.

The advent of total parenteral nutrition (TPN) in the late 1960s meant that for the first time any sick patient who was unable to eat could be artificially fed intravenously. As a consequence, most patients in intensive care units (ICUs) were given TPN if they remained unable to eat after 3–5 days of critical illness.^{1,2} Unfortunately, experience soon showed that this feeding technique was associated with serious septic and metabolic complications, which often worsened patients' outcomes.³ A number of studies reported that outcomes were improved with standard care (intravenous fluids and dextrose) compared with those achieved with TPN.⁴ These findings raised considerable concern, particularly among intensive-care specialists, and led to a controversial claim of “death by TPN”⁵ in critically ill patients, which led to considerable debate.^{6,7} The current use of TPN is restricted to the nutritional support of malnourished patients with intestinal failure due to extreme short bowel or absolute obstruction, although it might also prove useful to ‘top up’ nutrition in patients who cannot tolerate sufficient intake by the enteral route.

Developments in feeding tube manufacture and enteral access procedures, particularly in techniques that enable intestinal placement of feeding tubes, have

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Key points

- Enteral feeding is more effective and is associated with fewer serious complications than total parenteral nutrition
- Patients who would previously have been dependent on total parenteral nutrition can be fed enterally, which improves their outcomes
- Patients with gastroesophageal reflux, subacute gastroduodenal obstruction, ileus, and diarrhea can be successfully fed by enteral access techniques
- Patients who require enteral feeding for longer than 4 weeks should be considered for percutaneous feeding tube placement by endoscopy, radiology, laparoscopy or open surgery



Figure 1 | Endoscopic view of a nasogastric tube incorrectly placed in the right main bronchus. In this patient, a Salem Sump® nasogastric tube (Covidien AG Corp. Switzerland, Rheinfahl, Switzerland) had been placed at the bedside. Tube misplacement was confirmed when the patient was sent for endoscopy the following morning, according to protocol. Remarkably, this patient had not complained of breathlessness or cough.

resulted in exponential growth of enteral nutrition over the past decade. This technique is now used to support and restore intestinal function in hospitalized patients who are unable to eat. Improved understanding of the physiology of the upper gastrointestinal tract and how it reacts to severe illness and to various diet formulations^{8,9} has led to development of modified diets and techniques of enteral access. The result of these advances has been a massive increase in demand for enteral feeding.

Enteral nutrition was initially thought to be absolutely contraindicated in patients considered to have 'intestinal failure' due to ileus, dysmotility, or subacute obstruction and, thus, they were fed by TPN.^{10,11} Many patients who cannot tolerate oral intake are now, however, recognized to be able to receive some form of enteral nutrition. Prospective, randomized, controlled, clinical trials have shown that patients' outcomes are better with enteral feeding than with TPN with regard to infection rates,^{12–14} multiorgan failure,^{13,15–19} and mortality.^{13,15} Enteral feeding has also been associated with reduced costs.²⁰

In this Review, I describe various techniques for enteral access with their attendant benefits and risks, and note the main conditions in which enteral nutrition may be employed to avoid the use of TPN.

Techniques of enteral access**Nasogastric feeding**

Nasogastric tube feeding is the most common and oldest form of interventional feeding. The benefits of this method are that little skill is required for tube placement and it enables early commencement of enteral feeding, which, in turn, maintains intestinal function. In patients with chronic disorders, bolus feeds can be administered, which are easier for nursing staff to administer than continuous feeds. Manual placement of a nasogastric tube at the bedside, without guidance, can result in potentially lethal complications, such as misplacement, mucosal injury with bleeding and/or esophageal, gastric, or intestinal perforation. These complications require immediate treatment. Enteral feeding can usually be continued after misplacement or bleeding, but TPN and bowel rest plus antibiotics will be needed if perforation occurs. Another common occurrence is for the tube not to be inserted far enough and to be left in the distal esophagus or, in the extreme situation, placed in the trachea or bronchial tree (Figure 1) rather than passed into the stomach, which increases the risk of aspiration. To ensure correct placement in the stomach, at least 50 cm of the tube should go in easily. Placement is initially assessed by insufflation of 50 ml air, which should be easily audible by auscultation (with bubbling) in the epigastrium. Confirmation of correct placement should be sought by radiography before feeding commences.

Nasogastric tube feeding is understandably associated with an increased risk of reflux and microaspiration. In 54 critically ill individuals, technetium-99m-labeled sulfur colloid was added to enteral feeds, and patients' pulmonary secretions or lungs were assessed daily to determine whether aspiration had occurred. A trend towards increased aspiration was observed in gastrically fed versus transpylorically fed patients (7% versus 13%).²¹ A similar trend towards increased microaspiration in gastrically fed patients was also observed in a study of 33 patients randomly allocated to gastric or postpyloric enteral feeding (7.5% versus 3.9%).²² Gastroesophageal regurgitation was significantly more common in the gastrically fed patients (39.8% versus 24.9%). However, nasogastric tubes are remarkably effective in providing enteral feeding even to patients in the ICU,^{23–26} as long as appropriate antireflux measures are imposed (Box 1). A gastric residual volume of 250 ml is generally accepted as the safe maximum during nasogastric feeding. A Spanish study published during 2008, however, showed that the risk of aspiration was not increased in patients in the ICU if a maximum gastric residual volume of 500 ml was used.²⁷ The findings from this study persuaded the American

Society for Parenteral and Enteral Nutrition and the American Society of Critical Care Medicine to revise their guidelines and raise the threshold for gastric residual volume to 500 ml.²⁸ McClave *et al.*²⁹ showed that aspiration was no more common in ventilated patients in the ICU managed with a gastric residual volume of 400 ml than in those managed with a 200 ml limit. They studied 40 ventilated patients who were fed via a nasogastric tube or a percutaneous endoscopic gastrostomy (PEG) tube and measured the incidence of aspiration by labeling feeds with yellow microscopic beads and blue dye. They found no association between gastric residual volume and aspiration; some patients with proven aspiration had gastric residual volumes of only 31 ml. This result implies that aspiration pneumonia in ventilated patients is more likely to result from inhalation of pharyngeal secretions than from aspiration of stomach contents.

Although gastric emptying is generally reduced during critical illness, it does continue. Provided that feeds are given at a rate equal to or below that of gastric emptying, nasogastric tube feeding can be remarkably well tolerated by most critically ill patients.⁹ A number of prospective, randomized studies have found little evidence of an increased incidence of aspiration pneumonia among nasogastrically fed patients.^{21,23–26} In 2007, a study reported that release of cholecystokinin during rest and food stimulation is increased in patients in the ICU, which provides a humoral explanation for their delayed gastric emptying.⁹ In such patients, commencement of duodenal feeding can be expected to slow gastric emptying even further as a result of an increased release of cholecystokinin. This study provides further support for the use of simultaneous gastric decompression during nasoenteric, postpyloric feeding.

Nasoenteric, postpyloric tube feeding

The principal benefit of postpyloric tube placement is its large feed capacity, which is useful for patients who have poor gastric emptying, such as critically ill individuals and those with chronic diabetes.^{24,26,30} If a nasoenteric tube is placed more than 40 cm into the jejunum, past the ligament of Treitz, enteral feeds can be given without stimulating pancreatic secretion—a useful approach in the management of patients with acute pancreatitis.^{31,32} The avoidance of pancreatic secretion can, however, lead to maldigestion and, therefore, an elemental formula feed should be used with nasoenteric feeding at this intestinal level.

Nasoenteric tube placement is more invasive than the corresponding nasogastric procedure and, therefore, carries a greater risk of mucosal injury if the tube is placed manually. As the control of delivery of fluid by the stomach is bypassed, nasoenteric feeds should be given as a constant infusion and not in bolus form. Furthermore, if the stomach is bypassed, bacterial suppression by gastric acid is lost and a sterile feed should be given via a 'closed' system.

Box 1 | Measures to reduce aspiration risk in patients fed via a nasogastric tube

The following simple measures should be used for all critically ill patients to minimize the likelihood of reflux and regurgitation, and thus aspiration risk:

- The head of the bed should always be elevated by 30–40°
- Feeds should be started slowly (e.g. at 25 ml/h); the feeding rate can be increased according to the patient's tolerance^a
- Feeds should be given continuously; bolus feeding should be avoided
- Gastric residual volumes should be checked every 4 h

^aIf the gastric residual volume is >400 ml, the feeding rate should be reduced to 20–25 ml/h until this value falls below 400 ml. The feeding rate can then be slowly increased according to the patient's tolerance over the next few days. If gastric residual volumes continue to be high, a prokinetic drug (e.g. intravenous metoclopramide 10 mg every 6 h) or acid-secretion inhibitor (e.g. an intravenous PPI) should be used. In patients with slow gastric emptying associated with narcotic therapy, naloxone 10 mg added to the feed may be effective. If these approaches fail to reduce gastric residual volumes to below 400 ml, nasogastric feeding should be converted to small-bowel enteral feeding with intermittent, low-pressure, gastric decompression.

Bedside postpyloric tube placement

Many large hospitals have enteral nutrition teams of nurses with specialized training and experience in feeding tube placement, which has undoubtedly increased the success rate for this method. A number of techniques that assist bedside nasoenteric tube placement have been published and recently reviewed in detail by Haslam and Fang.³³ In 1991, Zaloga described a simple technique, in which the patient was placed on their right side. A bent guide wire was used in conjunction with a standard feeding tube to enable manipulation of the tip within the stomach towards the pylorus; this approach achieved an overall success rate of 92% for postpyloric placement, but only 17% of these successful procedures involved jejunal placement.³⁴ Other researchers have added a prokinetic agent (metaclopramide or erythromycin) or inflated the stomach with 500 ml air³⁵ to stimulate gastric emptying. Use of specialized, spiral tubes³⁶ and novel tip-guidance devices (such as electromagnetic fields³⁷) has been reported to improve the success of transpyloric tube passage. These techniques are usually effective in the hands of experienced personnel when used for patients with normal gastrointestinal motility and anatomy, but are less successful in critically ill patients with disturbed upper gastrointestinal function, in whom they usually fail to pass beyond the ligament of Treitz.

Postpyloric tube placement with radiography

The techniques discussed above will fail to achieve transpyloric tube migration in patients with gastroparesis or distortion or compression of the upper gastrointestinal tract. In such patients, the next step would be to attempt postpyloric tube placement under radiographic guidance. The downside of this approach is that the patient must be moved to the radiography suite, which interferes with their care and could be a critical issue for patients who need to be managed in the ICU. A second problem is that delays (frequently 24–48 h in my institution) might be experienced before the procedure can be undertaken.

Postpyloric tube placement with endoscopy

Several methods of endoscopic tube placement are possible. Traditionally, a regular 12 mm upper-gastrointestinal endoscope is used for postpyloric tube placement via the oral route. The duodenum is cannulated as far as possible and a guide wire is placed through the endoscope and advanced blindly past the ligament of Treitz. The endoscope is then withdrawn, leaving the guide wire in position. This procedure, however, leaves the other end of the guide wire emerging from the patient's mouth and an additional, awkward procedure is required to reroute it through the nose before the feeding tube can be deployed. A slim (for example, 2 mm diameter) length of tubing is passed through the nostril into the retropharynx, where it is grasped with forceps and pulled out of the mouth. The proximal end of the guide wire is then threaded back through this tube and passed out through the nose. The tube is pulled out of the nose and the guide wire is straightened to enable passage of the feeding tube through the nose, stomach, pylorus, and into the duodenum.

Some practitioners use endoscopic forceps to grasp the free end of the feeding tube (or a thread attached to its end), and drag it through the pylorus. In my experience, this method rarely enables duodenal tube placement, as the feeding tube commonly recoils into the stomach with the endoscope when it is withdrawn. One solution to this problem is to use an Endo Clip® (US Surgical Corporation, Norwalk, CT) to tether the tip of the tube to the duodenal mucosa.²⁵

Our group has developed a fully transnasal endoscopic procedure for postpyloric feeding tube placement that avoids the need to reroute the feeding tube through the nose. Our technique¹⁰ uses an ultraslim 5.8 mm diameter endoscope that permits transnasal intubation of the gastrointestinal tract, and also facilitates cannulation of compressed or stenosed segments of bowel.³⁸ Postpyloric placement of the guide wire is the same as described above, but it emerges out of the patient's nose with the endoscope.

The most effective way of ensuring that feeding tubes are placed far down the jejunum is to use transnasal endoscopy with fluoroscopic guidance. This procedure is, however, only suitable for patients who can be transported to the endoscopy suite. In patients who must be treated in the ICU, deployment of the guide wire must be done without such guidance, but this technique is generally easy for endoscopists to learn and becomes easier with experience. Although many feeding-tube systems used for postpyloric enteral access have a dedicated guide-wire system, in my institution we prefer to use specialized guide wires of the type used for endoscopic retrograde cholangiopancreatography (for example, JAG-wire, Wilson-Cook, Winston Salem, NC) as we find they facilitate manipulation of the guide wire through the loops of small intestine distal to the ligament of Treitz.

When withdrawing the endoscope, a very important point is to make sure that no loops of redundant

guide wire are left within the stomach, to avoid recoil, as described above. Reintroducing the endoscope through the opposing nostril after the feeding tube has been advanced over the guide wire and through the stomach can be useful to make sure that the feeding tube and guide wire take the shortest route to the pylorus without any gastric loops.

Double-lumen tube systems that include a proximal port for gastric decompression and a distal port for jejunal feeding are particularly useful in patients with gastric outlet obstruction. Two examples are given of such double-lumen systems used in the USA: the COMPAT STAYPUT® (Nestlé Soci  t   des Produits Nestl  , Vevey, Switzerland) is a fixed system that has a 6 mm diameter gastric decompression tube and a 3 mm diameter jejunal tube that will reach the ligament of Treitz, which is most useful in general ICU patients; the Kangaroo-Dobhoff system (Covidien-Kendall-Tyco Products, Mansfield, MA), which has a 5.3 mm diameter, 97 cm long outer gastric decompression tube and an inner 3 mm diameter, 170 cm long, adjustable jejunal extension that permits midjejunal feeding. The latter system is particularly useful in patients with acute pancreatitis who require gastric decompression.

As mentioned above, decompression of the upper gastrointestinal tract is critically important in patients who have compression and/or obstruction of the duodenum. Accumulations of fluid in the stomach proximal to the obstruction will make the patient vomit and the whole system might be dislodged.

Percutaneous endoscopic gastrostomy

Nasogastric or nasoenteric feeding tubes should not be used for periods longer than 4 weeks because of discomfort and the risk of nasal injury and sinusitis. Placement of a PEG tube should be considered for patients who continue to require enteral feeding beyond 4 weeks. PEG is also indicated as first-line intervention in conditions where enteral feeding is expected to be required for longer than 2–4 weeks, for example in patients with acute stroke. PEG tube placement is easy for experienced endoscopists, but the procedure is associated with severe complications and should not be performed unless the potential benefits outweigh the risks. For example, this type of feeding should be avoided in patients with Alzheimer disease, dementia or in the terminal stages of life^{39,40} because of the substantial risk of interference with the PEG, which is particularly common in elderly individuals who have lost the will to eat.

Although complications of PEG tube feeding are rare in stable patients, they become increasingly common in critically ill and debilitated patients. PEG necessitates perforation of the stomach, which has attendant risks of infections and bleeding. Furthermore, the procedure requires deep sedation that might, in patients with poor respiratory reserve or cardiac failure, result in respiratory or cardiac arrest. Consequently, in my practice,

monitored anesthesia care is used for such patients during PEG so that maximum sedation can be used in safe, expert hands.

Infection at the abdominal incision site is universal but is usually mild and resolves with time. Controlled studies have shown that a single, intravenous, peri-procedural dose of a broad-spectrum antibiotic (for example, 1 g cefazolin) reduces the risk of serious infections. Complications of PEG tube placement, such as perforation or injury of the colon, liver, or spleen, can be minimized if CT is performed beforehand to make sure that an appropriate 'window' of entry to the stomach exists; nonetheless, PEG should be attempted only if good transmural illumination of the light from the endoscope is observed through the abdominal wall. The procedure must include a full esophagogastroduodenoscopy to exclude the possibility of mucosal disease, such as gastric ulceration, and to ensure the absence of gastric outlet obstruction or outflow impairment due to distal disease. Finally, the patient must undergo repeat endoscopy following PEG to check the position and tension of the internal bumper. If it is too loose it might migrate and create an obstruction, and if too tight the bumper may be pulled under the mucosal surface (a 'buried bumper'). The risks of PEG can be reduced if certain safeguards are maintained (Box 2).

A wide variety of commercial PEG systems are available. The tube diameters commonly used range from 6 mm to 8 mm. In general, small-diameter tubes should be avoided in patients with poor gastric emptying who require intragastric administration of medication. If a PEG with jejunal extension is required (PEG-J), such as for patients with gastroparesis, a wide (for example, 8 mm diameter) tube will be required that can be cannulated with a narrow (for example, 5.3 mm diameter) jejunal tube.

With practice, placement of a PEG-J is easy to perform but, again, a skilled assistant is essential. The initial step is placement of a suitable PEG as described above. The course of the duodenum must first be assessed for deformation before attempting to place the jejunal feeding tube extension, because the first part of the duodenum is often compressed or displaced due to disease. Next, a guide wire is passed through the PEG tube and grasped with endoscopic biopsy forceps. The forceps are then retracted into the end of the endoscope, and the tip of the endoscope is passed through the pylorus to drag the guide wire as far down the duodenum as possible (into the fourth part, before the ligament of Treitz). Once the final position of the guide wire in the duodenum is achieved, the secondary jejunal feeding tube is passed from outside the body through the PEG and slipped over the guide wire, which is held taut to prevent the formation of loops in the stomach. The biopsy forceps can be advanced slightly forward of the endoscope to check that the tip of the jejunal tube has indeed reached the junction between the guide wire and the forceps. Once the tip of the jejunal tube is seen,

Box 2 | Risk-reduction strategies for percutaneous endoscopic gastrostomy

- Use monitored anesthesia care
- Provide prophylactic antibiotics (e.g. 1 g cefazolin) given before endoscopy
- Always perform a complete esophagogastroduodenoscopy to rule out disease or deformed anatomy
- Active gastric ulceration should ideally be treated before PEG placement
- Before placing a PEG ensure that good transmural illumination of the endoscope through the anterior abdominal wall can be seen with the overhead lights darkened; simple palpation of the abdomen while looking for a bulge of the gastric wall is not good enough for PEG siting as the colon can be transfixed between the stomach and the anterior abdominal wall
- Avoid PEG placement in patients with moderate or severe ascites
- Avoid PEG placement in patients on peritoneal dialysis
- Avoid PEG placement in patients who have had a ventriculoperitoneal shunt placed within the past week
- Ensure that no coagulopathy is present and that the patient is not on anticoagulant therapy. Subcutaneous heparin should be withheld for at least 6 h before the procedure. If the platelet count is below $50 \times 10^9/l$, provide platelet cover at the time of placement
- Do not perform the procedure single-handed; an endoscopy assistant can help with PEG placement so that sterility is optimized
- After insertion of the PEG button, perform a repeat endoscopy to check its final placement and to detect complications
- Do not overtighten the internal-external bumper system; it should swivel easily

Abbreviation: PEG, percutaneous endoscopic gastrostomy.

the biopsy forceps are gradually advanced through the endoscope while allowing the endoscope to be withdrawn slowly back towards the stomach, leaving the biopsy forceps, guide wire, and jejunal tube well down the duodenum. Once the endoscope is outside the pylorus, the biopsy forceps are then opened to release the guide wire and the forceps are withdrawn through the endoscope. The endoscope is then brought back into the stomach to check that the jejunal tube goes directly from the internal PEG bumper to the pylorus, without any loops in the stomach. Once good placement has been confirmed, the endoscope may safely be withdrawn. An alternative method of PEG-J placement involves this exchange (that is, of jejunal tube for guide wire) when the endoscope is still well down the duodenum.

In some patients with gastroparesis and large stomachs, the position of the internal PEG bumper faces the esophagus rather than the pylorus, and in this case the jejunal tube will invariably form a loop within the stomach before entering the pylorus. Such placement is bad, as the whole jejunal tube will soon fall back into the stomach. In this situation, loosening the external bumper of the PEG tube and pushing the tube 5–10 cm further into the stomach can be helpful, so the bumper faces the pylorus.

Another strategy for PEG-J placement is to use a 9.3 mm diameter PEG tube. An ultraslim, 5.8 mm diameter endoscope may then be passed directly through the PEG and pylorus, and advanced through the

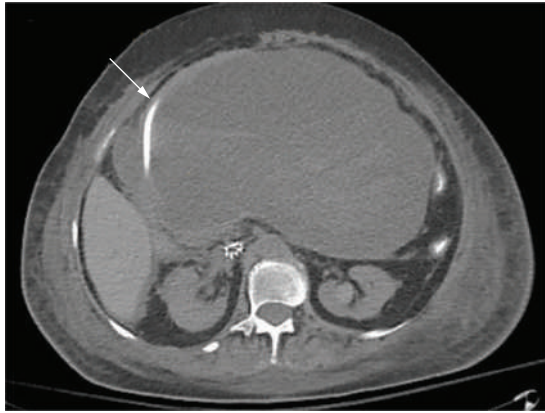


Figure 2 | A CT scan of a patient with a massive pseudocyst of the pancreas that compressed not only the stomach but also the duodenum. A feeding tube (arrow) can be seen passing through the compressed segment, which allowed access to the distal, still-functional bowel.

duodenum before placement of the guide wire. The endoscope is then withdrawn, leaving the guide wire in the intestine, and the feeding tube is placed in the way described above for transnasal endoscopy. With the rapid advancement of endoscopic technology, we predict that this form of endoscopy-assisted placement will become standard with time.

Percutaneous jejunostomy placement

The percutaneous endoscopic jejunostomy (PEJ) procedure is very similar to that used for PEG tube placement, but instead involves direct placement of the percutaneous tube into a loop of small intestine. A segment of intestine is selected that lies immediately below the abdominal wall and allows clear transmural illumination of the endoscope tip after the loop of intestine is distended with air. Direct PEJ placement is more risky than PEG placement as the small bowel is more mobile and smaller in size than the stomach, and satisfactory transmural illumination from the endoscope is not often seen. The same precautions used for standard PEG placement need to be imposed. Generally, a small-diameter (for example, 5.3–6.0 mm) PEG tube is used. Shike *et al.*⁴¹ at Memorial Sloan-Kettering Hospital have vast experience of PEJ feeding, which is particularly useful in patients with complicated gastrointestinal malignancy.

An increasingly popular option for patients who have chronic enteral access problems is to place a percutaneous jejunostomy laparoscopically. In a patient who requires abdominal surgery, however, an open surgical jejunostomy would be the best option.

Enteral access to avoid TPN

Gastrointestinal obstruction

Masses in the mediastinum or epigastrium can compress the upper gastrointestinal tract and cause obstruction. The bowel distal to the obstruction, however, remains functional and, therefore, these patients can

benefit from enteral nutrition. Tube placement involves the compressed segment being traversed by endoscopy or interventional radiology to gain access to the functional distal bowel.

Pancreatic disorders

Jejunal feeding is particularly useful in patients with acute pancreatitis.³² For patients who cannot be moved from the ICU, placement of a jejunal feeding tube can be done without fluoroscopic guidance at the bedside; however, in stable patients with acute pancreatitis and those with chronic pancreatic disorders and pseudocysts, transport to the endoscopy laboratory is easy and allows confirmation of deployment of the tip of the guide wire well past the obstruction and well down the jejunum.

Barium studies and CT scans performed in patients with acute pancreatitis or chronic pancreatitis who have large pseudocysts that compress the upper gastrointestinal tract often demonstrate complete obstruction of the outlet of the stomach (Figure 2,3) or the duodenum. Attempts at bedside or even radiological placement of feeding tubes usually fail in this situation. Transnasal endoscopy allows the compressed segment of bowel to be cannulated under direct vision. Once the endoscope passes the obstruction, the distal bowel is seen to be completely open and to have peristaltic function. Consequently, if a safe passageway is maintained through the compressed segment by deployment of a soft-tip, flexible guide wire passed through the endoscope, a feeding tube can subsequently be passed (after withdrawal of the endoscope) down over the guide wire and through the constricted segment (Figure 4). At the same time, the bowel segment proximal to the obstruction must be decompressed. In the absence of decompression, secretions will collect and induce nausea and vomiting, which increase the risk of aspiration.

Absent bowel sounds

Bowel sounds are an indication of intestinal activity, and their absence can indicate the presence of ileus or intestinal failure. However, these sounds are produced by a mixture of air and fluid within the intestinal lumen, and treating physicians should bear in mind that this mixture results from oral intake of food. In a patient who is not eating and has continuous gastric decompression owing to a nasogastric tube, fluid in the stomach is aspirated and thus no air or fluid enters the bowel; as a result, bowel sounds will not occur. Enteral feeding enables the passage of air and fluid into the bowel and can, therefore, be a treatment for absent bowel sounds.

Ileus

For many years the dogma was not to give patients any oral or enteral feeds unless bowel sounds were present. Many clinicians would consider a patient who was admitted to hospital with vomiting, abdominal pain, acute respiratory distress syndrome and ileus due to severe,

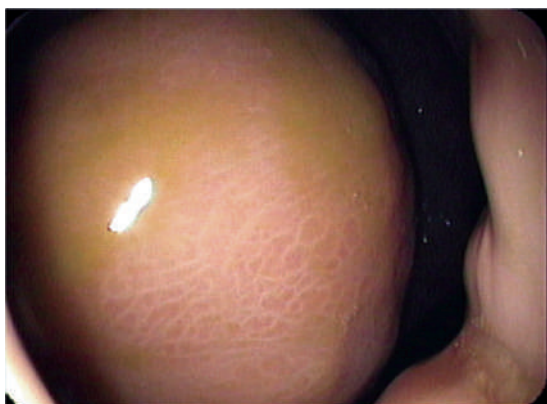


Figure 3 | An endoscopic view of a cystic mass in a patient with gastric compression caused by a large pancreatic pseudocyst. The mass obliterated the lumen of the patient's stomach, which made nasogastric feeding impossible.

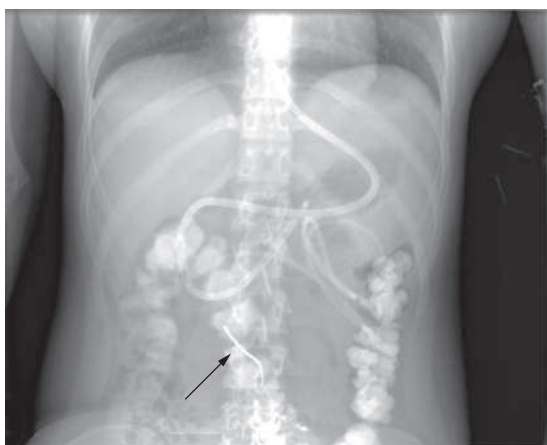


Figure 4 | Radiographic image of the patient in Figure 3 that shows the final placement of a double-lumen feeding tube, which allowed simultaneous decompression of the stomach and distal jejunal feeding.



Figure 5 | Radiographic view of a double-lumen tube (the tube tip is indicated by an arrow) that was successfully placed by transnasal endoscopy in a patient with vomiting, abdominal pain, acute respiratory distress syndrome and ileus due to severe acute pancreatitis, which had also caused duodenal compression. The tube enabled simultaneous gastric decompression and slow continuous (25 ml/h) jejunal feeding. Ileus resolved within 24 h and total parenteral nutrition was never needed.

acute pancreatitis to have intestinal failure; conventional management would include nasogastric decompression, no oral intake, and TPN. However, a number of studies have shown that ileus is not equated with intestinal failure and that bowel function and nutrient-absorbing capacity may be suppressed in patients with ileus, but are not absent.^{10,42,43} A double-lumen enteral feeding tube can be successfully placed in such a patient by transnasal endoscopy (Figure 5). This approach enables simultaneous gastric decompression and commencement of slow (25 ml/h), continuous, jejunal feeding. If ileus resolves with this approach, which it usually does, TPN will not be needed.

Intraoperative placement of a feeding tube via percutaneous jejunostomy can allow enteral feeding to be initiated within 24 h of major surgery, even in the presence of postoperative ileus, with good tolerance and absorption.⁴³

Diarrhea

Enteral feeding is often associated with diarrhea in patients in the ICU, but this type of feeding is rarely the cause. Diarrhea is most commonly associated with administration of sorbitol-containing drugs, disturbance in the gut microbiota related to antibiotic therapy and an inactive bowel. Although exacerbation of pre-existing diarrhea may occur on commencement of enteral feeding, this symptom usually abates after 72 h without antidiarrhetic therapy; consequently, feeding should not be interrupted or stopped. One very important point to note is that continued bowel rest exacerbates bacterial overgrowth and bowel dysmotility, which perpetuates the diarrhea. If diarrhea continues beyond 72 h, a stool sample should be tested for *Clostridium difficile* toxin, and measures such as the use of antimotility agents (for example, loperamide), a trial of probiotic therapy, or the avoidance of acid-suppressant drugs, should be instituted.

Gastric reflux

The chief concern about the use of nasogastric feeding in critically ill patients is the risk of reflux and aspiration of

gastric contents. Gastric reflux is often caused, however, by factors other than feeding, such as sepsis, trauma, drugs, body position, gastroparesis, esophageal dysmotility, and obesity, all of which can be treated or managed. Gastric reflux, therefore, need not be a contraindication to nasogastric feeding. If gastric reflux persists despite the employment of such strategies, postpyloric enteral feeding should be employed.

Conclusions

The field of interventional tube feeding is expanding rapidly, which has led to a profusion of enteral access techniques and specialized feeding tubes and liquid formula diets being developed. This variety will make it progressively more difficult for the primary-care physician to keep up with best practice, and will open up the

need for specialized nutritional teams that incorporate gastroenterologists, surgeons and radiologists.

Review criteria

This Review is based on personal experience and on literature searches performed via PubMed. I searched for original articles focusing on enteral access and enteral nutrition in MEDLINE and PubMed databases published during the past 5 years. The search terms used were "enteral access", "enteral nutrition", "nutrition", "critical care", "percutaneous endoscopic gastrostomy" and "percutaneous endoscopic jejunostomy". Identified papers were primarily English-language, full papers or English translations in abstract form. I also searched the reference lists of identified articles, or linked articles, for further papers.

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