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Laparoscopic-Assisted Percutaneous Endoscopic Gastrostomy

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Abstract There are a variety of techniques for gastrostomy tube placement. Endoscopic and radiologic approaches have almost entirely superseded surgical placement. However, an aging population and significant advancements in modern healthcare have resulted in patients with increasingly complex medical issues or postsurgical anatomy. The rising prevalence of obesity has also created technical challenges for proceduralists of many specialties. When patients with these comorbidities develop the need for long-term enteral nutrition and feeding tube placement, standard approaches such as percutaneous endoscopic gastrostomy (PEG) by endoscopists and percutaneous image-guided gastrostomy (PIG) by interventional radiologists may be technically difficult or impossible. For these challenging situations, laparoscopic-assisted PEG (LAPEG) is an alternative option. LAPEG combines the advantages of PEG with direct intraperitoneal visualization, helping ensure a safe tube placement tract free of intervening organs or structures. In this review, we highlight some of the important factors of first-line gastrostomy techniques, with an emphasis on the utility and procedural technique of LAPEG when they are not feasible.

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Introduction

Since a sentinel report by Gauderer et al. in 1980, percutaneous endoscopic gastrostomy (PEG) has become the standard of care at many institutions when enteral feeding access is required for appropriate patients [1, 2]. As radiologic techniques improved, percutaneous image-guided gastrostomy (PIG) by interventional radiologists has also become popular and more widely available [3]. One approach is usually chosen over the other based on the clinical scenario or local procedure availability and expertise. As a result of their low morbidity, cost, and lesser sedation requirements, PEG and PIG have largely supplanted surgery for placement of enteral feeding tubes except when they are contraindicated or cannot be safely accomplished [4•]. These situations are usually related to anatomic considerations such as obesity, abdominal malignancy, or prior surgery. Open surgical or laparoscopic gastrostomy (LG) is therefore often reserved as a "back-up" option for patients who fail or who are not suitable for PEG or PIG. We herein describe another option, laparoscopic-assisted PEG (LAPEG), combining two previous techniques which may be suitable for select patients.

In past and recent literature, there is considerable variation regarding the terminology of various enteral feeding tube techniques. For the purpose of this article, we will adapt the terminology and abbreviations proposed by the practice guidelines from the Society of Interventional Radiology (SIR) and American Gastroenterological Association (AGA) [5•]. Referring to the most common procedural techniques employed by gastroenterologists, radiologists, and surgeons, transoral PEG

refers to the "Ponsky-pull technique" of a mushroom bumper-tipped catheter via endoscopy while transabdominal PIG refers to the direct placement of balloon type catheters inserted under image guidance by interventional radiologists and often accompanied by percutaneous gastropexy [2, 6].

Comparison of Percutaneous Endoscopic Gastrostomy, Percutaneous Image-Guided Gastrostomy, and Laparoscopic Gastrostomy

Since the primary alternative to PEG and LG (the components of LAPEG) is radiology inserted feeding tubes, these techniques and their advantages are briefly compared here (Table 1).

PIG is most commonly performed transabdominally under fluoroscopic guidance. First, a nasogastric tube is placed to insufflate the stomach, followed by gastropexy under fluoroscopic or ultrasound guidance using one to four T-tags (T-fasteners) arranged around the planned gastrostomy site to bring the stomach to the abdominal wall (gastropexy). Subsequently, using the Seldinger technique, a needle is passed into the stomach followed by a guidewire over which the tract can be dilated and eventually a gastrostomy tube can be passed [5•]. The colon is often opacified with contrast to ensure a radiologic window by administering oral contrast the night before the procedure or a contrast enema [4•].

PEG is performed with direct visualization often after a survey upper endoscopy to evaluate for lesions such as peptic ulcer disease or malignancy that can affect the choice of gastrostomy site. The stomach is then fully insufflated with air. External palpation with a finger to look for clear internal indentation and bright-light trans-illumination are used to identify the intended tract on either side as well as to help verify if there are no intervening structures. After sterile skin cleanser and local anesthesia are applied, a hollow introducer needle is inserted transabdominally into the stomach by a second operator. An endoscopic snare is used to grasp this needle and then to grasp a long, soft-looped wire inserted through the needle. The endoscope and this wire are then pulled through the esophagus and out of the mouth. The PEG tube is attached to the loop, and the second operator pulls the abdominal end of the wire until the tube reaches the stomach. Usually with the aid of a small skin incision, the tube is then further pulled under firm traction until the internal PEG tube bumper is against the stomach wall. The tapered end of the tube serves to dilate the gastrostomy tract. An external bumper is then attached to secure the tube in place [7].

Transabdominal PEG can also be performed, using endoscopy rather than image guidance to direct the needle and gastropexy needles. Conversely, transoral PIG is also possible by advancing the transabdominal guidewire under image-guidance up the esophagus and out of the mouth to attach a pull-type feeding tube, sometimes with the help of a transoral snare under fluoroscopic guidance [8]. Individual provider or institutional experience guides the use of these less common strategies.

A principle advantage of transoral PEG is its widespread availability compared to PIG, able to be performed by endoscopists in a standard procedure unit or even the bedside, if required, and obviating the need for an available surgical or interventional radiology unit. Another key advantage of transoral PEG compared to transabdominal PIG is the more robust and larger tube that is usually placed. In a transabdominal approach the catheter must be pushed through the gastric wall. Therefore, despite the use of dilators or peel-away sheaths that help facilitate catheter insertion into the stomach, the diameter of the catheters is generally smaller than transoral PEG tubes [4•]. The smaller size, combined with the use of a balloon as an internal bumper instead of the mushroom bumper of pull-type transoral tubes, contributes to the relatively higher occlusion rates, more frequent tube displacements, and less reliable internal fixation of the PIG tube [4•, 9, 10]. The reported balloon catheter dislodgement rates range from 3 to 36 % versus ~4 % rate of dislodgement of mushroom type catheters [9]. Transoral PEG overcomes some of these advantages by allowing for large diameter tubes to be pulled through a relatively small gastrotomy. For these reasons, while PIG holds some advantages over PEG, it is generally not yet employed as a routine first-line alternative to PEG [3, 4•].

Table 1 Summary of techniques for enteral feeding tube placement

Technique	Guidance technique[a]	Route of tube placement[a]
PIG	Fluoroscopy	Transabdominal
PEG	Endoscopy	Transoral
Laparoscopic gastrostomy	Surgery	Transabdominal
LAPEG	Combined surgery and endoscopy	Transoral

[a] Most commonly employed methods

PIG percutaneous image-guided gastrostomy, *PEG* percutaneous endoscopic gastrostomy, *LAPEG* laparoscopic-assisted percutaneous endoscopic gastrostomy

Utility of Diagnostic Upper Endoscopy During Gastrostomy

Another advantage of PEG is that diagnostic and therapeutic maneuvers can be performed during the endoscopy, although the importance of this has been questioned [11]. Advocates of

PIG over PEG dispute the yield of endoscopic exam prior to PEG placement, as evidenced by a recent study showing that the rate of undiagnosed malignancies and other significant pathology to be low [4•] However, in other recent reports, the rates of incidental abnormal findings have ranged from ~21 to 25 % or more of upper endoscopies [5•, 11–14]. Findings which would prevent PEG placement were rare, but in some populations 36 to 38 % warranted either biopsy or addition of acid blocker medication and less commonly immediate treatment (such as esophageal stricture dilation) or change in procedure method (conversion to a transabdominal push-technique with balloon catheter) [5•, 11, 13, 15, 16].

Endoscopic visualization can also confirm an appropriately snug internal bumper—tightened enough to keep the stomach against the internal abdominal wall and ensure gastrostomy tract maturation but loose enough to avoid pressure ischemia and buried bumper syndrome. This can be verified by external bumper position and by spinning the catheter and internal bumper under direct endoscopic visualization. While examination of the planned insertion site and endoscopic verification of the PEG tube after placement is not mandatory, it can provide reassurance of proper bumper position and tightness and is standard practice at our institution [17].

Contraindications

Absolute contraindications to enteric feeding tube placement by any method include severe coagulopathy, bowel ischemia, bowel obstruction (unless a venting tube is being placed), and active peritonitis [4•, 5•, 17].

Relative contraindications to PEG include ascites, as well as inflammatory, infiltrative, or neoplastic diseases of the stomach and abdominal wall, in addition to the standard contraindications of upper endoscopy. Additional relative contraindications include previous gastric surgery, organomegaly, obesity, and other situations which impede trans-illumination for safe PEG placement [17]. Similarly, situations in which intraabdominal structures interfere with a safe radiologic window for needle and tube insertion are considered relative contraindications to PIG [4•]. Certain neuromuscular disorders with diaphragm paralysis may also result in rostral displacement of the stomach, resulting in loss of safe window for PEG or PIG [4•]. While these relative contraindications have been overcome in case reports with modifications of equipment or techniques, in general they do not represent contraindications to LAPEG.

Safety and Efficacy

The rates of major complications of PEG and PIG are comparable, and include hemorrhage, reported to occur in 1–2 % of patients and requiring transfusion ~1 % of the time [4•, 5•, 10, 18–21]. Other complications include peritonitis attributed to tube displacement before a mature gastrostomy tract, leakage, or colonic puncture. The rate of unsuccessful procedures for each approach has been reported up to 5 % of attempted cases [4•, 20–22]. A recent large retrospective study on transabdominal PIG reported a 4 % rate of technical failure [9]. Early termination of the procedure was due to lack of a safe percutaneous window secondary to overlying liver, colon, or costal margin [9]. Intraluminal distention is also vital for the success of PIG and PEG, and inability to insufflate is another reason for procedure failure [4•].

However, these numbers are affected by selection bias, as they do not account for patients deemed unsuitable for these approaches. The proportion of all patients who require feeding tube placement who are deemed unsuitable for PEG or PIG is unknown, but in an aging population with increasing medical and surgical complexity, this may not be a trivial number. Careful patient selection is therefore the most important factor in considering LAPEG over standard PIG or PEG.

Laparoscopic Gastrostomy

Multiple LG techniques have been described. While some are more popular than others, chosen by operator experience or preference, the technique generally involves gastropexy using U-stitches, T-tags, or direct grasping via trochar [23, 24]. For example, three or four transparietal-transgastric U stiches are place laparoscopically around the chosen gastrostomy site, followed by gastrotomy. A balloon catheter (i.e., Foley) or balloon-gastrostomy tube is placed through the abdominal and gastric openings. Traction is applied to the balloon and stitches to bring the stomach to the abdominal wall where the stitches are tied to affix the gastrostomy in place (gastropexy) [25•, 26].

An alternative method is known as the laparoscopic Janeway permanent gastrostomy. A laparoscopic stapling device is first used to create and separate a tube or diverticulum out of the greater curvature. This tube is then directly grasped with a surgical trochar, externalized through an existing trochar incision site, sutured to the skin, then finally opened to create a gastrostomy [24].

LG has the obvious advantage of direct visualization and affixation of the stomach for gastrostomy insertion, allowing overlying adhesions and organs to be manipulated out of the desired tract. The downsides of LG without endoscopy are that LG is also usually performed with the push-technique, which is prone to a higher rate of dislocations and occlusions compared to transoral PEGs as previously mentioned, and the lack of endoluminal visualization [4•, 10]. LG usually employs gastropexy, which is not required with the use of

mushroom type transoral catheters and has some downsides, described below [5•]. Surgical gastrostomy also has the obvious disadvantages of requiring the placement of multiple ports, increased peritoneal insufflation, often general anesthesia, expertise in laparoscopy, and an increased procedure cost compared to standard PEG [27, 28].

Rationale/Indications for Laparoscopic-Assisted Percutaneous Endoscopic Gastrostomy

LAPEG was initially reported in 1993 in an effort to avoid inadvertent colon and small bowel perforation or injury to other structures [23, 29]. The principle advantage of LAPEG is the direct visualization of all cavities involved in gastrostomy tube placement, combining features of LG and PEG. This ensures with little doubt that the procedure tract and site of final gastrostomy is clear of undesired obstructions or vessels. The additional advantages are that organs can be pushed out of the way and any intraperitoneal adhesions can be safely lysed before proceeding with the PEG. LAPEG therefore minimizes the risk of inadvertent visceral injury, allows for early identification and control of hemorrhage, in straightforward cases typically requires only one port, and in certain circumstances can be performed with local and moderate intravenous sedation without general anesthesia [30]. LAPEG has also been described as easy to perform without advanced laparoscopic skills [27].

LAPEG should be considered when standard percutaneous access with PEG or PIG are contraindicated, unsuccessful, predicted to be technically unsafe or impossible, or affected by a complication [31]. Clinical situations that may preclude safe percutaneous access with PIG or PEG occur when trans-illumination and finger palpation are unsuccessful on endoscopy or when an adequate window for radiologic access is not visualized on fluoroscopy or ultrasound [27]. Examples of these situations (Table 2) often overlap with the contraindications of PEG and PIG and do not preclude LAPEG [27].

LAPEG can also be considered in patients who require enteral feeding and are already undergoing surgery for other indications. LAPEG has been described as an effective adjunct procedure to Nissen fundoplication for paraesophageal hernia repair or in the initial management of resectable esophageal and colon cancers [32–34]. It has also been described during placement of a peritoneal dialysis catheter [35].

The techniques and advantages of surgical gastrostomy approaches over PEG are particularly well described in the pediatric population. Procedure outcomes are similar, but LAPEG has also been advocated in children, for whom a low-profile gastric button is often favored over a long-feeding tube [36]. However, a PEG gastrostomy tract must be allowed to mature for several months before exchange to a skin-level device. Attempts to place a gastric button via single-session PEG is associated with a higher rate of complications, therefore requiring standard PEG followed by interval tube replacement after gastropexy site maturation [36]. Tube replacement in children often requires additional sedation since bedside exchange can be quite unpleasant [37]. The LAPEG approach with gastropexy can achieve placement of a gastric button in one setting [36, 37].

Finally, LAPEG can be used as an opportunity for surgical endoscopy training or multidisciplinary practice. At our institution, LAPEG has facilitated exchange of endoscopic techniques between gastroenterology and surgery providers. At the same time, the surgeons were able to demonstrate their techniques as well as to display in real time intraabdominal anatomy not often seen by endoscopists who are limited to endoluminal views.

Table 2 Clinical situations suitable for LAPEG which may preclude PEG and PIG [27]

Obesity
Inability to distend the stomach with air
Intraabdominal adhesions from prior surgery
Altered anatomy (i.e., gastric bypass)
Inability to visualize or isolate the transverse colon
Other overlying organs (colon, small bowel, omentum, enlarged liver, etc.)
Large hiatal hernia
Abnormal visceral rotation
Ileus
Intraabdominal masses
Ascites
Gastric varices
Gravid or recently post-partum uterus
Peritoneal dialysis

Procedure Techniques for LAPEG

Prior to LAPEG, the patient should receive standard preanesthesia evaluation and antibiotic prophylaxis as indicated for surgery and endoscopy based on society and institutional practice guidelines [17, 38].

The procedure itself essentially combines the methods of LG and PEG, with average operative duration reported to be ~32 min [25•]. In LAPEG, one laparoscopic port is placed. As in LG, an initial survey of the abdomen allows the surgeon to determine whether lysis of adhesions or manual movement of organs away from the desired tract will be required. Positioning the patient in a 30° reverse Trendelenburg may help displace the small bowel caudally [39]. When adhesions or other situations prevents removal of overlying organs to

visualize the stomach, additional ports may be required, but single port access LAPEG has also been described [27, 40] .

Simultaneous upper endoscopy is performed to choose an appropriate internal location for gastrostomy and to exclude any internal pathology (such as peptic ulcer disease and neoplastic lesion). Using bright-light trans-illumination and/or the tip of the endoscope pushed against the gastric mucosal wall, the endoscopist can identify a target for the surgeon to subsequently introduce the PEG needle under direct laparoscopic visualization. The remainder of the procedure employs the same technique as a standard "pull-type" transoral PEG. Once the PEG and stomach are pulled safely to the abdominal wall, the laparoscope and trocars are removed and the skin incisions are closed.

Gastropexy

The need to affix the stomach to the internal abdominal wall, known as gastropexy, is still under debate. Gastropexy was once considered mandatory to avoid intraperitoneal tube placement, but its role varies by procedure technique and individual patient considerations. While exceptions to standard practice are dependent on individual operator, equipment, or institutional practices, PIG generally employs the use of transabdominal-transgastric T-tag devices while LG employs U-stitch or purse-string sutures for gastropexy [4•, 5•]. However, for standard pull-type PEG, tension from the internal mushroom bumper and the external skin bumper is all that is required to hold the stomach to the abdominal wall and allow tract maturation in most cases. PIG, LG, and LAPEG can also be safely accomplished without gastropexy or with even one suture or T-tag with slight technique modifications [4•, 5•]. For example, sufficient insufflation of the stomach or directly grasping it (in the case of surgery) can avoid the need for gastropexy.

A randomized trial supported gastropexy in PIG [4•, 41], but more recent retrospective and prospective studies have observed similar outcomes with and without gastropexy, as well as an association with peristomal infection, leakage, or gastrocutaneous fistula secondary to gastropexy [5•, 42–45]. Tightened gastropexy sutures may also contribute significantly to post-procedure pain, and if not using absorbable sutures, may require a follow-up visit to remove the sutures, generally recommended between 2 and 21 days post-procedure) [4•, 45, 46]. While for many patients gastropexy may not be required, in patients with significant ascites or impaired wound healing due to severe malnutrition or immunosuppression (i.e., post-transplant patients), gastropexy should be strongly considered and can be accomplished during LAPEG [18].

Post-Procedure Considerations and Complications

LAPEG is considered a minimally invasive procedure, with postoperative management differing little from that of standard PEG. Routine surgical wound care is indicated for the laparoscope and (if present) trochar insertion sites as well as for the gastrostomy. Early initiation of tube feeds (≤4 h) has been shown to be safe when compared to next day feeding in PEG, but the timing should be coordinated with the operating surgeon [47]. To prevent pressure injury, buried bumper syndrome, and peristomal skin breakdown, the external bumper should be examined to ensure that it is not too tight. For this reason, dressings should be placed above the bumper, rather than in between the bumper and the skin. While a distance of 1 cm from the bumper to the skin has been suggested, common practice at our institution after PEG is to examine the site 1 day post-procedure for any swelling and to verify there is adequate spacing to the skin with a freely rotating tube and little tension on the gastric wall [5•].

Large studies on LAPEG outcomes in adults are not available, but smaller reports reveal similar complication rates as LG and PEG with a high rate of success [25•, 27]. Studies describing post-procedure morbidity and mortality should be assessed cautiously for selection bias. Patients requiring LAPEG may be unsuitable for the other techniques due to higher complexity, therefore at greater risk for poor outcomes at baseline. This phenomenon is seen in unadjusted comparisons of surgical gastrostomy to PEG and PIG. Studies of LAPEG also often describe patient populations who have failed or develop a complication from standard PEG [31, 48].

Contraindications

In additional to standard contraindications of surgery (i.e., inability to undergo general anesthesia), other contraindications include inability to insufflate the abdomen or perform upper endoscopy, such as when an obstructive lesion of the head and neck preclude passage of the endoscope [27, 31]. Metastatic "seeding" of a gastrostomy site from head and neck cancers has been reported, but may be avoided by using a transabdominal tube rather than a transorally pulled tube [49, 50]. Ethical considerations should also factor prominently prior to placement of any feeding tube.

Conclusions

An aging population and advances in medical care have resulted in clinically complex and often ill patients who, once ethical considerations are considered, may require long-term enteral feeding. In these situations, anatomic challenges, local resources, or the availability of experienced providers may

preclude safe or successful first-line approaches with PEG and PIG. LAPEG is a relatively routine procedure that can serve as a useful reserve alternative for these patients.

Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no conflicts of interest.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

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