

Complications Related to Percutaneous Endoscopic Gastrostomy (PEG) Tubes. A Comprehensive Clinical Review

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Abstract

Percutaneous endoscopic gastrostomy (PEG) has become the modality of choice for providing enteral access to patients who require long-term enteral nutrition. Although generally considered safe, PEG tube placement can be associated with many potential complications. This review describes a variety of PEG tube related complications as well as strategies for complication avoidance. In addition, the reader is presented with a brief discussion of procedures, techniques, alternatives to PEG tubes, and related issues. Special topics covered in this review include PEG tube placement following previous surgery and PEG tube use in pregnancy.

Key words

Percutaneous endoscopic gastrostomy – PEG – complications - endoscopy - management

Introduction

Percutaneous endoscopic gastrostomy (PEG), the modality of choice for long-term enteral access, was first described in 1980 by Ponsky and Gauderer (1,2). Several modifications of the original procedure have been described (3-6). Although generally safe, PEG tube placement is associated with many potential complications. To date, there have been no comprehensive reviews of PEG tube related complications. In an attempt to fill this void, we present a review that describes the most commonly encountered PEG complications as well as strategies for their avoidance.

Methods

A literature review was performed via the PubMed™ search engine from 1976 to 2007, using the search terms “PEG tube”, “PEG”, “complications”, “technique”, and “morbidity”. Relevant cross-referenced non-PubMed™ listed articles were also included. Three hundred thirty-two articles were found including randomized controlled trials, retrospective studies, case series, case reports, editorials, letters and abstracts. These sources were evaluated for relevance to current medical practices and goals of this review.

PEG: indications and contraindications

Indications

PEG tubes have two main indications – feeding access and gut decompression (7). In patients who are unable to maintain sufficient oral intake, PEG tubes provide long-term enteral access. This commonly includes patients with temporary/chronic neurological dysfunction, including those with brain injuries, strokes, cerebral palsy, neuromuscular and metabolic disorders, and impaired swallowing. Significant head/neck trauma and upper aerodigestive surgery that preclude oral nutrition also constitute important indications. In patients with advanced abdominal malignancies causing chronic obstruction/ileus, a PEG tube can be used to decompress the intestinal tract. PEG tubes may also be useful in the setting of severe bowel motility disorders (8).

Contraindications

Absolute contraindications to PEG placement include pharyngeal or esophageal obstruction, active coagulopathy and any other general contraindication to endoscopy. Of the three principal safety tenets of PEG placement, endoscopic gastric distension, endoscopically visible focal finger invagination, and transillumination, only the latter has been successfully challenged. Stewart et al. placed 62

PEG tubes without transillumination and had a 97% success rate, with no immediate complications, and two failures unrelated to the technique used (9).

The presence of oropharyngeal or esophageal cancer is a relative contraindication, due to the potential seeding of the PEG tract with cancer cells (10). Here, either a radiographically placed percutaneous gastrostomy or surgical gastrostomy tube may be more appropriate. In the face of esophageal cancer, PEG tubes are usually avoided to preserve the gastric conduit for reconstruction after esophagectomy.

Historically, gastroesophageal reflux was considered a contraindication. It is now known that gastroesophageal reflux may actually improve after PEG placement, as the PEG itself creates an anterior pseudo-gastropexy (11).

Other relative contraindications include abdominal wall abnormalities such as the presence of prior abdominal surgery, especially procedures involving the stomach, spleen or splenic flexure of the colon. While it is acceptable to attempt PEG placement in the face of prior surgery, one should have a low threshold to abort if the three safety tenets are absent. The presence of abdominal wall metastases, open abdominal wounds, or ventral hernia defects all constitute relative contraindications. Intra-abdominal contraindications include hepatomegaly, splenomegaly, and moderate or severe ascites. Portal hypertension with gastric varices also constitutes a contraindication to PEG placement. Systemic contraindications include recent myocardial infarction, hemodynamic instability, coagulopathy, and sepsis.

Technique

The knowledge and adherence to the proper techniques of PEG placement is crucial to complication avoidance. The most widely used PEG technique is the “pull” method (1-2). There are several modifications of the original technique. The gastrostomy tube can be pushed rather than pulled into place by a “push” (Sacks-Vine) method (12). In the “introducer” (Russell) method, the stomach is directly punctured and a Foley catheter placed over a guidewire. Percutaneous gastrostomy has also been described without endoscopy, using a nasogastric tube for gastric insufflation, fluoroscopy, and a direct percutaneous catheter insertion (6).

The most commonly used method of placement is the pull technique. After preparation of the abdomen, administration of prophylactic antibiotic and sedation/analgesia, a complete upper endoscopy is performed. The stomach is insufflated, resulting in close apposition of the stomach to the abdominal wall. A point is chosen in the mid-epigastrium, where there is maximal transillumination and indentation of the gastric lumen, with direct pressure of a blunt pointer. A local anesthetic is then infiltrated into the area around the puncture site and a small incision is made. A large-bore needle is inserted into the gastric lumen under endoscopic observation. A guidewire is threaded through

the needle, grasped with endoscopic snare, and the needle withdrawn. The endoscope-snare-guidewire is withdrawn from the mouth as a single unit. The tapered end of the gastrostomy tube is then secured to the guidewire and pulled back down into the stomach, followed by endoscopic confirmation of the internal bumper placement, which should be snug against the gastric wall. An external bumper is used to secure the PEG tube in place and prevent distal propagation of the internal bumper.

The “push” (Sacks-Vine) method and the “introducer” (Russell) method are the alternative techniques of PEG tube placement. Procedural details of these methods are beyond the scope of this review (5, 12). The basic elements common to all PEG techniques are: (a) gastric insufflation to bring the stomach into apposition with the abdominal wall; (b) percutaneous placement of a cannula into the stomach; (c) passage of a suture or guidewire into the stomach; (d) placement of the gastrostomy tube; and (e) verification of the proper position (1,2, 5,6, 12,13).

PEG in patients with previous abdominal surgery

Prior abdominal surgery was once considered a contraindication to PEG placement. However, clinical studies show that PEG tubes can be safely placed after abdominal surgery (14). In one series, PEG placement was successful in 36/37 patients with previous abdominal surgery (15). A unique challenge to the endoscopist is the patient with prior gastric surgery. In one report, PEG placement failed in 28% of patients who had previous gastric resections, while it was successful in 95% of the remaining patients with prior abdominal surgery (14).

To increase the chance of successful PEG placement in this patient group, adherence to well-established safety steps as described above is essential. A safe tract should be identified by aspirating air from the puncturing syringe and by endoscopically visualizing the intragastric needle (14). Abdominal wall transillumination may not be possible in morbidly obese patients. Here, a larger abdominal incision can be made and the subcutaneous fat dissected down to the fascia. The procedure should then proceed as usual, closing the skin incision at the end (16).

Overview of PEG tube related complications

In order to systematize this review, we categorized PEG complications into specific groups, which can be divided as follows: (a) complications of upper endoscopy; (b) direct complications of the PEG procedure; and (c) post-procedural complications associated with PEG tube use and wound care. The subsequent sections of this review will discuss complications grouped by the above criteria, describing complication identification, treatment, and prevention.

Complications associated with endoscopy

The most common complications associated with upper endoscopy include cardiopulmonary compromise, aspi-

ration, hemorrhage, and perforation. Mortality attributable to upper endoscopy is exceedingly low (0.005-0.01%) (17,18). However, most of the mortality data involve healthy ambulatory patients in experienced centers, not the debilitated patient population in need of feeding access.

Cardiopulmonary complications related to sedation/analgesia are the most frequent complications of diagnostic endoscopy (18). These include myocardial infarction, respiratory depression, and hypotension. Hypoxia is relatively common, occurring in 7-40% of endoscopies (18). The risks of intubation and anesthesia are beyond the scope of this review. Proper resuscitative and reversal agents and airway equipment should be present for all PEG procedures.

Upper endoscopy carries a significant risk of aspiration (0.3% to 1.0%) (19). Risk factors for aspiration include elderly age, chronic illness, depressed mental status, supine positioning, and sedation. The endoscopist can minimize this risk by avoiding over-sedation, optimizing gastric air insufflation, thoroughly aspirating gastric contents before and after the procedure, and performing the procedure efficiently. Some report a significantly lower aspiration rates utilizing an unsedated transnasal approach with a small caliber endoscope during PEG placement (20).

Severe hemorrhage is a rare complication of upper endoscopy (0.02% to 0.06% cases) (17-18). Risk factors include anticoagulation, antiplatelet therapy, and the presence of an anatomic anomaly. In a large prospective study of ambulatory upper endoscopies, strict adherence to the cessation of all antiplatelet agents 10-14 days before endoscopy likely led to an absence of procedural bleeding (21). Elective PEG tube placement should be avoided in coagulopathic or thrombocytopenic patients.

The most feared complication of upper endoscopy is esophageal perforation (incidence of 0.008-0.04%) (17-18). Anatomic anomalies contribute to perforation in up to 50% of cases. In patients with normal anatomy, the common sites of iatrogenic perforation include the cricopharyngeous, aortic knob, and the diaphragmatic hiatus where natural anatomic narrowing of the esophagus occurs. Predisposing factors include anterior cervical osteophytes, Zenker's or epiphrenic esophageal diverticuli, benign or malignant esophageal strictures, and mass lesions. Patients typically present with tachycardia, fever, dysphagia, odynophagia, respiratory distress, or sepsis. Early (<24 hours) recognition provides a substantial mortality benefit (mortality <10%) when compared to late (>24 hours) recognition (mortality up to 50%). Diagnosis of a perforation is based on radiographic contrast study. Treatment consists of broad-spectrum antibiotics, tube thoracostomy and wide surgical drainage, debridement, and operative repair. In selected patients without evidence of sepsis, with small, contained perforations and prohibitive comorbidities, non-operative management may be appropriate.

Complications related to endoscopy are rare but serious and should be discussed with patients or patient representatives prior to PEG placement.

PEG alternatives

Several surgical procedures have been described for the placement of enteral access. Direct pharyngostomy or esophagostomy is rarely utilized today, especially after the advent of interventional radiologic techniques (22,23). Other commonly performed procedures include open surgical gastrostomy, jejunostomy, and needle jejunostomy. Endoscopic jejunal access is possible but more difficult than PEG placement.

Percutaneous radiologic gastrostomy is indicated when other methods of enteral access prove risky (23). The percutaneous radiologic gastrostomy is associated with procedural success rates of 99.2%, major and minor complication rate of 5.9% and 7.8%, respectively (24). Interventionalists can also perform percutaneous jejunostomy catheter placement. In summary, various surgical, endoscopic, and radiologic procedures now make enteral feeding possible in nearly all patients.

PEG procedure - related complications

Pneumoperitoneum, portal, and mesenteric venous gas

Benign pneumoperitoneum is common after PEG tube insertion, with reported incidence of over 50% (25-27). It is thought that air escapes through the small opening in the stomach during the interval between the initial needle puncture and the PEG tube passage through the abdominal wall (26). Conservative management of patients with pneumoperitoneum, who have undergone a recent PEG in the absence of additional symptoms is suggested. Pneumoperitoneum is usually self-limiting, and should be clinically concerning only when intra-abdominal air is worsening or when it is found in the presence of signs of peritonitis, portal and/or mesenteric venous gas, systemic inflammatory response and/or sepsis (27).

Colon injury

The displacement of the transverse colon over the anterior gastric wall can predispose the patient to colonic injury during PEG placement (28,29). To avoid this complication, the introducing needle should not be inserted into the stomach without adequate gastric insufflation, appropriate transillumination, and endoscopically visible focal invagination of gastric wall upon external palpation. At times, the needle used to infiltrate local anesthetic into the PEG site can be used as a 'pilot' needle to visually confirm the closeness of the abdominal wall to the gastric lumen. The stomach and small bowel should not be overdistended, as overfilling the stomach and small bowel with air may 'lift' the transverse colon and increase the probability of colon injury (29).

Colonic injuries usually present with peritonitis and surgery is often required. Nonoperative management of controlled colonic fistulae can be entertained if the patient is hemodynamically stable, with no signs/symptoms of abdominal sepsis (30). To avoid this complication and facilitate PEG insertion, pre- and peri-procedural imaging

(ultrasound or CT), laparoscopy, and/or magnetic positional imaging can be used (31-33).

Gastro-colo-cutaneous fistula

Gastro-colo-cutaneous fistulae occur rarely after PEG placement, and result from interposition of bowel, usually the splenic flexure, between the anterior abdominal wall and the gastric wall (1, 34,35). The PEG tube is placed directly through the bowel into the stomach. Patients are often asymptomatic, except for transient fever or ileus. The problem is usually discovered months after the PEG placement when the original PEG tube is removed or manipulated, or when the replacement tube is placed into the colon. Once feeds are restarted, diarrhea usually develops.

The diagnosis is made using contrast radiography via the PEG tube. In most cases, there is no evidence of intraperitoneal leakage or gastro-colic fistula. The management of a symptomatic colo-cutaneous fistula involves the removal of the PEG and allowing spontaneous closure of the fistula (34). While the tube tract usually closes upon tube removal, surgery may be needed if there is evidence of peritonitis or abscess.

The prevention of this complication involves using both good transillumination and finger pressure as a guide to placement of the puncture site. Using a pilot needle, a sudden gushing of stool or gas with the needle tip not visualized endoscopically within the stomach suggests interposition of another structure. Ultrasound or CT guidance can be used selectively, but may have limited utility in patients with abdominal wall thickness greater than 3 cm. Some suggest using colonoscopy as an aid to PEG placement to prevent this complication (36).

Small bowel injury

Injuries to the small bowel after PEG placement are rare and can be difficult to diagnose. The small bowel is protected from injury by the greater omentum that restricts the small bowel from the upper abdomen. Unfortunately, this is not always the case, especially if the patient has had prior abdominal surgery. Postoperative adhesions can transfix the small bowel in the upper abdomen, particularly if the omentum has been resected. During PEG tube placement, the small bowel can be injured causing intraabdominal spillage acutely or presenting in a delayed fashion as an entero-cutaneous fistula. These fistulae tend to become clinically significant when the PEG tube is manipulated or replaced and the new tube finds its way into the small bowel (37). Radiographic confirmation of tube placement is recommended after replacing the PEG tube.

Small bowel volvulus about the PEG tube has been described, and usually presents with a small bowel obstruction (38). It is caused by slack on the PEG tube with a gap forming between the gastric wall and the abdominal wall. The loosening of the external flange can also allow the internal bumper to migrate through the pylorus and into the small bowel, which can present as a proximal small bowel obstruction.

Intussusception of the jejunum back into the duodenum around a migrated internal bumper has been described (39). Intentional or unintentional separation of the bumper from the external component of the PEG tube can lead to small bowel obstruction and can cause necrosis and bowel perforation at the site of the obstruction (40).

Liver injury

Liver injury related to PEG placement is rare (41,42). Close clinical observation is usually all that is needed, and failure of such observation has been described with major liver injury such as inflation of a feeding tube's balloon within the liver parenchyma (41).

Hepatic injury during PEG placement can be avoided by using careful technique and the usual precautionary steps described throughout this review. An additional method of verification is the "safe tract" technique, where a syringe attached to a needle is advanced slowly through the abdominal wall with retraction of the barrel (14). A "safe tract" is established by endoscopic visualization of the needle in the gastric lumen and simultaneous return of air into the syringe. Return of fluid or gas into the syringe without intragastric needle visualization suggests entry into bowel or a solid organ interposed between the abdominal wall and stomach.

Splenic injury

While there are no reported cases of actual injury to the spleen during PEG tube placement, one case report describes a fatal retroperitoneal hemorrhage associated with this procedure (43). Upon post-mortem analysis, a iatrogenic perforation and laceration of the splenic vein close to the confluence of the portal vein were found. Dense adhesions between the stomach and liver as a consequence of the patient's previous surgery may have predisposed to this complication (43).

Splenic injury following upper endoscopy is rare, but has been reported after procedures like ERCP. While only a handful of reports exist, splenic hematoma, splenic laceration, and splenic rupture following ERCP have been described (44,45). A possible mechanism for this injury is the avulsion of the splenic vessels secondary to bowing of the endoscope in the stomach during attempts to pass through the duodenum (45). In addition, one case report describes splenic injury following transesophageal echocardiography (46).

Splenic injury should be suspected after any upper endoscopic procedure if the patient develops sudden abdominal pain and hypotension. Intravenous access should be immediately obtained and resuscitation with crystalloid solution started. In a hemodynamically stable patient, a CT scan can be obtained to confirm the diagnosis. The patient should be transferred to an intensive care unit and monitored with serial hematocrit determinations. Surgical consultation should be obtained in the event the patient becomes hemodynamically unstable and requires emergent exploration and splenectomy.

Intraperitoneal and retroperitoneal bleeding

Intraperitoneal bleeding has been reported secondary to a liver laceration during PEG placement (42). Presentation included abdominal pain, hypotension, decreasing hemoglobin, rigid abdomen and no evidence of intraluminal blood. Computed tomography of the abdomen revealed intraperitoneal fluid and a liver laceration with an associated hematoma. The patient underwent operative repair of the liver laceration, evacuation of the hemoperitoneum and revision of the gastrostomy (42). In another case, introducer needle-related trauma led to a fatal outcome (43). Post-PEG intraperitoneal hemorrhage is a rare complication, presents with unexplained post-procedure hypotension, and should be promptly recognized and treated.

Abdominal wall bleeding

Abdominal wall bleeding following PEG placement usually occurs soon after placement, is most often caused by puncture of an abdominal wall vessel, and is frequently manifested by hemorrhage around the PEG insertion site (47). Bleeding from the PEG tract itself can be treated by tightening the external bolster against the skin, thereby tightening the internal bumper against the abdominal wall. Such compression should be released within 48 hours to prevent mucosal necrosis and development of a pressure ulcer (48). Standard resuscitative and operative indications should be followed when approaching cases of hemodynamic instability due to significant abdominal wall bleeding (i.e. rectus sheath hematoma) following PEG placement.

Complications associated with PEG use and wound care

Peristomal pain

Prevention of peristomal pain after PEG placement starts with ensuring that proper technique is followed. The procedure field should be sterile and free of contamination. A single dose of prophylactic antibiotics has been shown to reduce the risk of peristomal infection (49,50). Additionally, a stab incision 1-2 mm larger than the feeding tube may lower the infectious risk (51). If pain persists and an infection is suspected, a CT scan of the abdomen can be obtained to rule out an abscess. Plain abdominal roentgenography may show large amount of subcutaneous air and point to a significant infection. A CT scan may also show signs of the rare but life-threatening complication of necrotizing fasciitis.

The PEG tube site should be kept clean and dry by washing it with soap and water. Excessive tension of the external bolster against the skin should be avoided to prevent the complication of buried bumper syndrome. This leads to the erosion of the internal bolster into the gastric wall, which ultimately causes pain and the inability to infuse feeds (Fig.1). Loosening the external bolster also facilitates healing of any gastric mucosal ulceration that might have developed around the internal bumper.

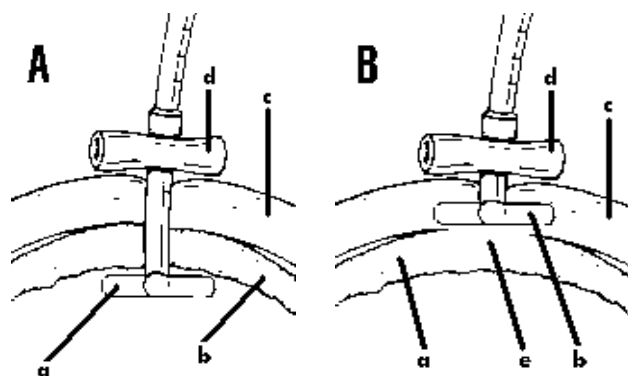


Fig.1 Schematic representation of the buried bumper. (A) Tissue configuration immediately after PEG placement; (B) Tissue configuration following the application of excessive tension on the internal bumper. Such undue tension causes local gastric necrosis around the bumper, followed by gradual migration of the bumper from the gastric lumen into the gastric mucosa and wall, and then into the abdominal wall. Finally, the gastric mucosa regrows and 'seals over' the original PEG opening, resulting in loss of the connection between the PEG tube and the gastric lumen. Legend: (a) internal bumper; (b) gastric mucosa/wall; (c) abdominal wall; (d) external bolster; (e) potential space between the 'sealed off' stomach and the 'buried' internal bumper.

Abscess and wound infection

PEG insertion is associated with a wound infection in up to 18% of patients who did not receive periprocedural antibiotics (52). Antibiotic prophylaxis reduces the infection rate to about 3% (49,50,53). Meta-analyses of randomized trials clearly show the benefits of systemic antibiotic use to reduce the incidence of parastomal infection (54,55).

Methicillin resistant *Staphylococcus aureus* (MRSA) has emerged as an important cause of PEG-site infection, and a strategy of nasopharyngeal decontamination of patients with MRSA (in addition to standard prophylactic antibiotics) has been reported to significantly reduce the incidence of wound infections (56).

Necrotizing fasciitis

Necrotizing fasciitis is a rare complication of PEG placement (57,58). Patients with pre-existing diabetes, wound infections, malnutrition, and impaired immunity are at increased risk. Traction and pressure on the PEG tube can also predispose to necrotizing fasciitis development.

One study demonstrated that patients who had their PEG tube external bolster set directly against the abdominal wall were more likely to develop wound infection, peristomal drainage, and necrotizing fasciitis compared to patients whose external PEG bolster was left 3 cm from the abdominal wall (59). The microbiology of necrotizing fasciitis is complex. Multiple aerobic and anaerobic microorganisms display synergy and are responsible for the lethality of this disease (60). Treatment requires wide surgical debridement, planned operative reassessment, antibiotics, and extensive patient support.

Buried bumper syndrome

Buried bumper syndrome (BBS) is an uncommon but serious complication of PEG, occurring in 1.5% to 1.9% of

patients (61,62). The bumper becomes lodged anywhere between the gastric wall and the skin along the PEG tract. BBS occurs as a result of excessive tension between the internal and external bumpers leading to gastric ulceration at the bumper site (Fig.1). The syndrome usually becomes apparent after 4 months of use, but time intervals as short as two months or as long as 7 years have been reported (63,64). Epithelialization with coverage of the internal gastrostomy stoma with gastric mucosa can result in complete closure of the orifice. Fatal cases of BBS have been reported, underscoring the potential seriousness of this complication (65).

The inability to infuse feeding solution through the tube, leakage around the tube and abdominal pain are the most common manifestations of BBS. Endoscopic evaluation may reveal a small irregular crevice, but findings can be limited to a raised mound and a central small round concave area of gastric mucosa without ulceration or edema (62,66). Changes in the physical characteristics of the bumper due to gastric acid may facilitate gastric wall necrosis and bumper migration (67).

A buried bumper should be removed even if the patient is asymptomatic, because of the risks of tube impaction in the abdominal wall and/or gastric perforation. Computed tomography, ultrasonography, and endoscopic ultrasound can facilitate the localization of the bumper, and can be helpful when deciding whether a surgical or endoscopic approach should be used to remove the PEG. A combination of surgical and endoscopic approaches has been used, with surgical PEG removal followed by endoscopic placement of a new PEG tube (62). The buried bumper can be removed through a local abdominal wall incision, but a more extensive abdominal procedure may be required. The "needle-knife" technique has been described in the management of BBS, where the mucosa covering the internal bumper is incised by an endoscopic needle-knife, and, after mobilization, the tube is extended into the gastric lumen and then cut near the tip before being endoscopically removed. The remaining portion of the tube is removed externally (66).

Peristomal leakage

Although the reported incidence of peristomal leakage is 1-2% (68), this complication is probably much more common, especially early after PEG placement. Persistent drainage beyond the early feeding period can pose a significant problem, and can be associated with patient factors that hinder wound healing (diabetes, malnutrition, immunodeficiency). Additional risk factors that may contribute to peristomal leakage include infection, gastric hypersecretion, excessive cleansing with hydrogen peroxide, BBS, side torsion on the PEG tube, and lack of external bolster to stabilize the tube (69).

Treatment should begin with optimizing nutritional and medical status (including glycemic control). Barrier creams and skin protectants containing zinc oxide can be applied. The external bolster should be examined and any excessive torsion relieved. Replacing the original PEG tube with a larger

one should be avoided as this may cause the tract to enlarge and exacerbate the leakage (70). In addition, some authors recommend instituting antisecretory therapy to reduce gastric acid secretion (51).

If leakage persists, the PEG tube can be removed for several days and the tract allowed to partially close. A new PEG can then be placed through the same site (71). This maneuver should only be attempted when sufficient time has passed to ensure scarring of the stomach to the abdominal wall (71). If all else fails, the PEG tube should be removed and a new PEG tube placed at a different site.

PEG site herniation

The literature reports only one case of gastric herniation through the PEG site (72). After several months of copious gastric drainage around the PEG site and the development of a deep ulcer, a CT scan demonstrated partial herniation of the stomach through the PEG tract. Herniation at the PEG site should be suspected whenever a reproducible mass is evidenced on a Valsalva maneuver. There is also one reported case of a ventral Richter's hernia that occurred at an old PEG site (73). When a hernia is suspected, a CT scan will confirm the diagnosis. Treatment should follow standard surgical indications.

Gastrointestinal bleeding and ulceration

Gastrointestinal bleeding is an uncommon complication of PEG placement with a reported incidence of about 2.5% (70,74). Causes include esophagitis, gastric pressure ulcers, concomitant peptic ulcer disease and rarely puncture of a gastric wall vessel.

Esophagitis is the most common endoscopic finding in patients with PEG associated gastrointestinal bleeding (75). It is more common in older patients and most commonly observed in the lower esophagus. It has been postulated that patients who receive enteral feeding may experience a 'bypass effect' and subsequent lack of adequate esophageal protection (75). H₂-receptor blockers offer little to no protection, but proton pump inhibitors may potentially prevent and treat this complication (75).

Gastric pressure ulcers following PEG placement can be located either anteriorly or posteriorly. Anterior ulcers are usually caused by pressure necrosis of the gastric mucosa by the internal bolster (70,74). Avoidance of excessive traction on the PEG tube may reduce the risk of this complication. Posterior ulcers are caused by mechanical mucosal injury, by long protruding tips of balloon PEG tubes, and by tall internal bolsters. Use of ballooned PEG with short (<5 mm) protruding tips and low profile (<3 mm) internal bolsters may reduce the incidence of this complication. Antisecretory therapy with H₂-receptor antagonists may not completely prevent the development of these ulcers. Removal and placement of the PEG in a different location, or replacing the PEG with a low-profile internal bumper can effectively treat this complication.

Peptic ulcer disease is seen in approximately 15% of patients with PEG tubes (70). Duodenal ulcers, gastric

erosions and gastritis are the usual manifestations. Peptic ulcer disease responds to standard treatment modalities.

Bleeding after PEG placement is usually caused by puncture of the gastroepiploic artery or its perforating branches. In these cases, tightening the external bolster against the abdominal wall, thereby tightening the internal bumper against the bleeding vessel may be tried to stop the bleeding. Compression should be released within 48 hours to prevent mucosal necrosis and pressure ulcer (48). Care must be taken to endoscopically visualize the gastric mucosa under the internal bumper.

Gastric outlet obstruction

Gastric outlet obstruction is a rare complication of PEG tubes, seen when part of the PEG tube gets lodged in the pylorus or duodenum causing partial or complete obstruction. In the pediatric population, the internal bolster of the PEG tube has been reported to cause obstruction of the gastric outlet when dislocated or retained (76). In adults, gastric outlet obstruction is usually a complication of the replacement Foley-type PEG tubes. The migration of the Foley balloon into the pylorus, duodenum or proximal jejunum can cause luminal obstruction (Fig.2) (70,77). The patient usually presents with abdominal cramping and intermittent vomiting.

Upper gastrointestinal study will confirm the diagnosis. In the case of Foley PEG tubes, deflating the balloon and pulling the tube back should provide symptomatic relief.

Treatment includes retrieval of the internal bolster via endoscopic techniques in the former. Gastric outlet obstruction can be avoided by properly using external bolster to anchor the PEG tube.

Ileus and gastroparesis

While tube feeds may be safely started as soon as three hours after PEG placement (78), post-procedural gastroparesis occasionally occurs. If a patient has history of diabetes, a trial of metoclopramide may be indicated. Alternatively, administration of erythromycin may be useful in stimulating gastrointestinal motility. If nausea and vomiting ensues, then the PEG tube should be unclamped for decompression and feeds withheld for 24-48 hours.

If the patient develops persistent abdominal distension and an absence of bowel sounds, a post-procedural ileus should be suspected. This may be more likely to occur in situations where significant pneumoperitoneum was present (79). If accompanied by pain, a gastrograffin study utilizing plain films or CT should be performed to rule out perforated viscus.

Prolonged ileus develops in 1-2% of cases after PEG placement (80). Here, supportive therapy is indicated, with gastric decompression and intravenous fluids. Electrolytes should be corrected and any medications that may contribute to an ileus should be minimized. Tube feeds should be held until the ileus resolves.

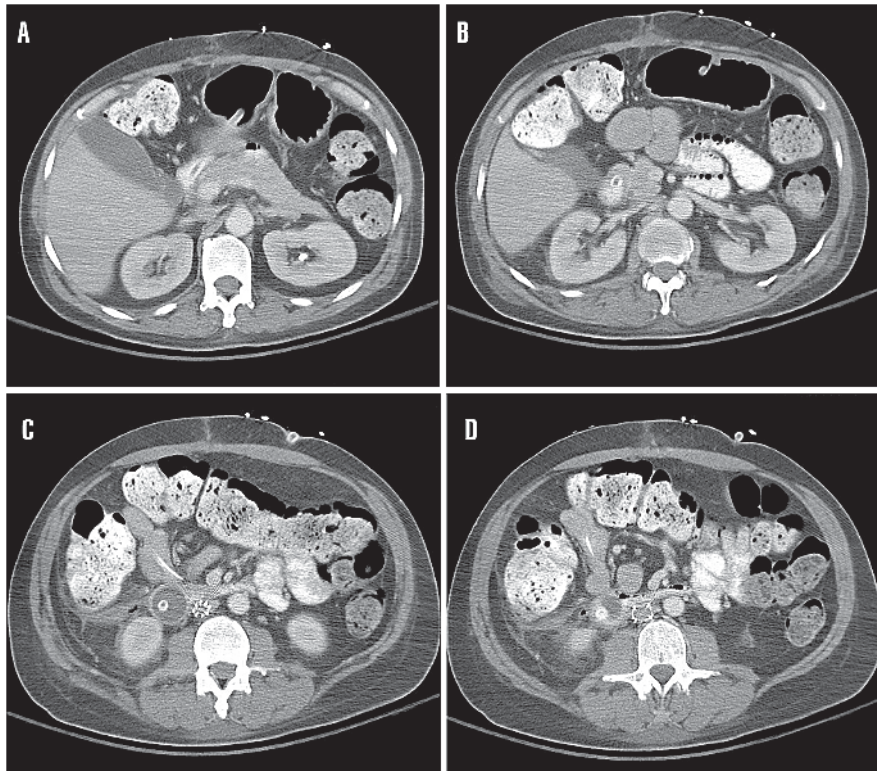


Fig.2 CT images of a Foley-type PEG tube that migrated into the mid-duodenum causing gastric outlet obstruction and duodenal perforation. (A, B) The tube passing from stomach into the proximal duodenum; (C, D) The balloon of the tube is inflated in the distal portion of the second part of the duodenum, with associated small pockets of free air.

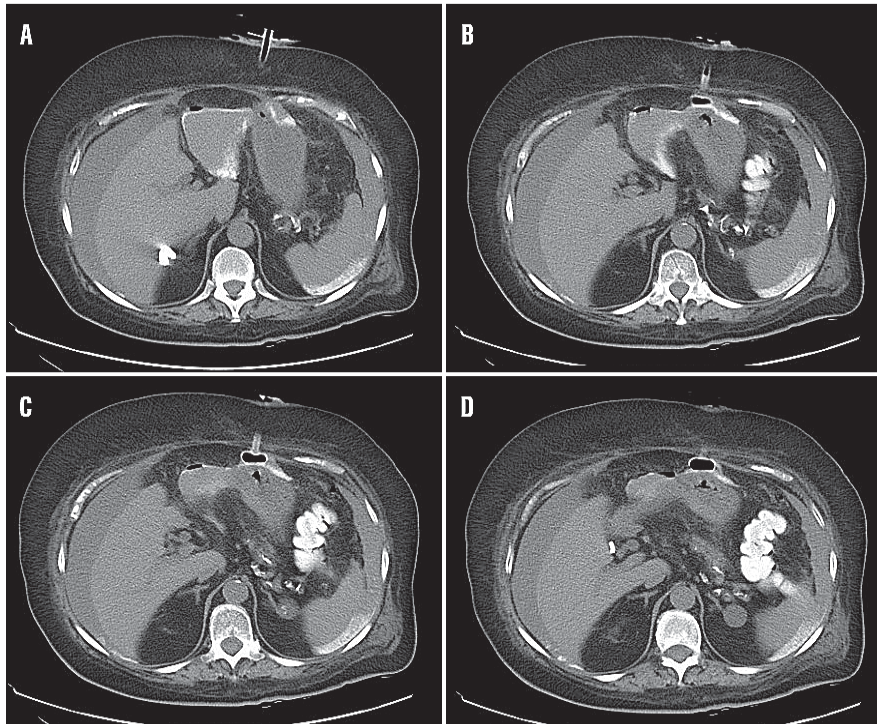


Fig.3 An example of partial PEG tube dislodgement with free contrast extravasation as seen on CT. (A) PEG tube is seen traversing the skin and subcutaneous tissues, with free fluid in the peritoneal cavity; (B) PEG tube bumper is seen adjacent to the gastric wall, with some contrast seen intraluminally; (C, D) Extraluminal contrast extravasation is present.

Bowel and gastric volvulus associated with PEG

Bowel volvulus around PEG tubes is rare. It is seen mainly in the pediatric population. Gastric, transverse colon, and small bowel volvulus around gastrostomy tubes have been described (81-84). The PEG-related gastric volvulus is usually of the organo-axial type, with gastrostomy as the fixed point (81). In one case, the PEG was introduced through the posterior wall of the stomach, leading to rotation of the stomach and volvulus (84). Treatment is surgical, including detorsion, repositioning of the gastrostomy with or without gastropexy. Careful placement of the PEG tube on the anterior wall of the stomach may prevent this complication (81,84).

PEG tube dislodgement

Inadvertent PEG tube removal occurs in 1.6% to 4.4% of patients (80,85). Combative or confused patients are more prone to this complication. While the PEG tract begins to mature approximately 7-10 days after PEG placement, in malnourished or immunosuppressed patients, this process can take up to one month. Partial PEG dislodgement presents a unique clinical challenge (Fig.3).

In the event that a PEG tube is dislodged less than one month after placement, repeat endoscopy should be performed to replace the tube. The stomach may have separated from the anterior abdominal wall, resulting in free perforation. Blindly reinserting a new PEG tube in this scenario may lead to its placement inside the peritoneal cavity. When recognized early, the replacement PEG tube can be placed

either near or even through the same PEG tube site (86). If recognition is delayed, the patient should be made NPO (nothing per oral), a nasogastric tube should be placed, and broad-spectrum antibiotics started. Surgical exploration is indicated if signs of peritonitis/sepsis are present. Otherwise, a new PEG should be placed in 7-10 days (Fig.4) (51). If a clinician feels that a tube has been dislodged through a mature tract during this period, then a water-soluble contrast

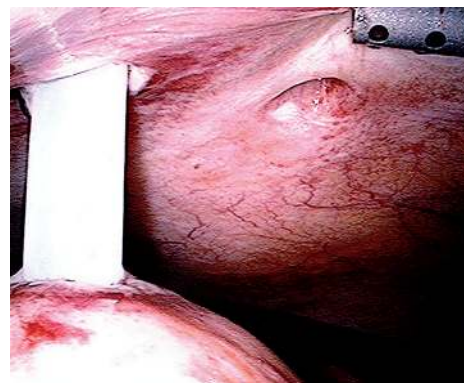


Fig.4 Laparoscopic appearance of an old PEG tube site (right) adjacent to a newly placed PEG tube (left). In this case, PEG tube dislodgement occurred within 7 days of tube placement, necessitating complete removal of the old tube and placement of a new PEG tube 8 days later. Note the lack of PEG tube tract formation between the stomach and the peritoneal surface, which is typical of a newly placed PEG tube.

study should be obtained after replacing the PEG to confirm its location. This should occur before feeding is restarted.

When a PEG tube becomes dislodged more than one month after placement, one can assume that a mature PEG tract is present. A replacement tube can be placed without endoscopy. To prevent repeat dislodgements, the use of an abdominal binder, ensuring the tube is not longer than 18 cm, or using a low-profile "button" may be beneficial. If any doubt exists as to the location of the new PEG tube, a water-soluble contrast study should be done prior to refeeding.

Clogged PEG tube

A clogged PEG tube occurs in up to 45% of patients (87). With thick enteral feeds and medications being delivered through a relatively narrow caliber tube, prevention is the key to avoiding this problem. Administration of bulking agents such as psyllium and resins such as cholestyramine through the tube should be avoided. Tubes should optimally be flushed with 30-60 mL of water using a large syringe every 4 hours. Saline should be avoided since it can crystallize within the tubing and promote gradual clogging. Flushing should occur after checking residuals and administering medication. All medications should be completely dissolved in water prior to being flushed. Liquid forms of medications should be preferentially utilized over solid-based formulation. Consultation with both nutritionists and pharmacists can be useful.

The best initial irrigant to unclog PEG tubes is water. In one study, warm water was shown to be superior to other unclogging liquids (88). Others found that carbonated beverages were effective in dissolving clogs (89). Another effective method involves the use of pancreatic enzymes, which can be mixed with bicarbonate solution and allowed to sit within the tubing for up to several hours before an attempt to flush with water (90). Finally, the PEG tube can be manually cleared with special 'declogging' plastic brush devices. The use of wires should be avoided due to a small risk of perforation.

Post PEG placement diarrhea

Diarrhea is a common complication of enteral nutrition, occurring in 10-20% of patients (91). Causes include infection, dietary factors, protein malnutrition, and drug therapy (91). The physician should review potential sources of contamination and treat infection as identified by microbiological techniques.

Dietary factors include hyperosmolar solutions, lactase deficiency, and fat malabsorption. Dilute solutions, lactose-free and low-fat formulas may be tried to reduce diarrhea. Protein malnutrition can be treated by administering isotonic solutions and supplemental nutrition. Medication-related causes of diarrhea include use of antibiotics, hyperosmolar drug solutions, magnesium antacids and other medications with direct effect on gastrointestinal function. Management includes evaluating the need for antibiotics, dilute hyperosmolar solutions, mixing medications with feeds, using magnesium-free antacids and/or using the parenteral

route for some medications (91). Correcting dietary factors will resolve diarrhea in nearly 50% of patients and anti-diarrheals may be effective for medication-related diarrhea (91). When all of the above causes are excluded, unusual causes such as colo-cutaneous and jejuno-cutaneous fistulae may be entertained (92,93). Diagnosis is made either by a contrast tube study or contrast CT.

Tumor implantation at PEG site

This complication of PEG placement is seen mainly with oropharyngeal tumors, with an incidence of <1% in this group (94). Direct inoculation of tumor cells secondary to instrumentation is the most likely mechanism of tumor spread (94). Metastasis can also occur due to selective implantation of circulating tumor cells in the PEG wound. Skin metastasis is associated with extremely poor prognosis (average survival of 7 months, and 0% 1 yr survival) (94). In order to reduce this complication, it is reasonable to either perform PEG after surgical removal of primary cancer or to place the PEG using the Russell technique (70,94).

Aspiration

The risk of aspiration related to PEG placement is low (0.3%-1.0%) (80,95). Risk factors for aspiration include supine position, sedation, neurological impairment, and advanced age (96). Since many patients undergo PEG placement because of the neurologic sequelae of a stroke or traumatic brain injury, this population is at an inherently high risk of aspiration (97). While a few patients aspirate during PEG placement, the great majority of aspiration events occur at a later time, unrelated to the PEG procedure (98). To prevent aspiration, the clinician should avoid excessive sedation, optimize gastric air insufflation, thoroughly aspirate gastric contents before/after the procedure, and perform the procedure efficiently (96).

PEG tubes and pregnancy

PEG tubes have been successfully used in the setting of pregnancy (99). A major difficulty encountered in this population is pregnancy-associated emesis (99,100). If severe emesis persists and interferes with nutritional maintenance, conversion of a PEG tube to a PEG-jejunostomy catheter may be needed (99,100).

Conclusions

Percutaneous endoscopic gastrostomy has become the modality of choice for providing enteral access to patients who need long-term enteral nutrition. Despite its good safety record, PEG can be associated with significant complications. Awareness of these complications and the use of preventive strategies can allow the endoscopist to maximize outcomes and to identify complications early. As with any invasive procedure, a thorough knowledge of indications, contraindications, and fundamental procedural steps constitutes the most important safety factor.

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