

Carol Rees Parrish, R.D., MS, Series Editor

# Prevention and Management of Complications of Percutaneous Endoscopic Gastrostomy (PEG) Tubes



Christopher R. Lynch



John C. Fang

The number of patients with PEG tubes continues to rise, and coincident with that rise, more gastroenterologists are being consulted with complications of PEG tubes. The majority of PEG tube complications are minor, but several have the potential to cause significant morbidity and even mortality if not recognized and managed correctly. Prevention and early identification of PEG complications will reduce morbidity and cost substantially. Expertise in the management of these complications is critical to the practicing gastroenterologist.

## INTRODUCTION

Since its introduction in 1980 (1), the use of percutaneous endoscopic gastrostomy (PEG) tubes has increased exponentially. While an estimated 61,000 PEG tubes were placed in 1988, an estimated 216,000 are performed annually today, making PEG placement the second most common indication for endoscopy of the upper gastrointestinal tract (2). Up to

10% of nursing home residents and as many as 1.7% of Medicare patients over the age of 85 years undergo gastrostomy (3). As data demonstrating the benefits of enteral over parenteral nutrition mounts, and our elderly population grows, we can expect the use of PEG tubes to continue to rise. However, the placement of a PEG tube is not without its risks. The overall complication rate has remained stable over the last 15-20 years, ranging from 4% to 23.8% of cases (4-7). Three to 4% of all cases are affected by major complications, i.e. those that are life threatening and/or require surgical intervention or hospitalization (Table 1) (4,6,8). The more common minor complications occur in between 7.4% and 20.0% of cases (Table 2) (4,6,9).

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Christopher R. Lynch, M.D., Department of Internal Medicine, University of Utah School of Medicine, Salt Lake City, Utah. John C. Fang, M.D., Associate Professor of Medicine, Division of Gastroenterology, Department of Internal Medicine, University of Utah School of Medicine, Salt Lake City, Utah.

## Prevention and Management of Complications of PEG Tubes

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**Table 1**  
**Major Complications**

Complication	Frequency	References
Aspiration	0.3%–1.0%	4, 27
Hemorrhage	0%–2.5%	5, 29, 30
Peritonitis	0.5%–1.3%	4, 5
Necrotizing fasciitis	rare	50–53
Death	0%–2.1%	6, 10–12
Tumor implantation	rare	67–70

While the overall mortality post-PEG placement is high due to underlying co-morbidity, the rate of procedure-related mortality and 30-day mortality attributable to PEG placement itself are extremely low (0% to 2% and 1.5% to 2.1% respectively) (6,10–12). It should be noted that mortality associated with PEG placement is significantly higher in hospitalized patients (13), patients with diabetes, poor nutritional status, and long-term corticosteroid administration (8). Complication rates of percutaneous gastrostomy tubes placed endoscopically versus radiologically using fluoroscopy are similar (14,15).

Enteral nutritional support is indicated for patients with poor volitional intake, permanent neurological impairment, oropharyngeal dysfunction, short gut syndrome, and major trauma and burns (16). Generally patients who meet one or more of these criteria for more than 30 days are candidates for PEG placement.

Absolute contraindications to PEG placement are the same as those of upper gastrointestinal endoscopy as well as an inability to transilluminate the abdominal wall and appose the anterior gastric wall. Relative con-

traindications include coagulopathy, gastric varices, morbid obesity, prior gastric surgery, ascites, chronic ambulatory peritoneal dialysis (CAPD), and neoplastic, infiltrative, or inflammatory disease of the gastric or abdominal wall (17).

### PROCEDURE-RELATED COMPLICATIONS

The overall success rates for PEG placement are consistently reported at 94% to 98% (4,18,19) and compare favorably with fluoroscopic placement by a radiologist (18,20). The pull and push techniques result in similar success rates (21). Factors that can lead to unsuccessful PEG placement can include obstruction of pharynx or esophagus, deterioration of the clinical status of the patient intraprocedurally, poor transillumination of the abdominal wall, incidental finding of gastric cancer, and development of hematoma at the gastrostomy site (4). Prior surgery that results in alteration of esophageal or gastric anatomy can also lead to a difficult PEG placement (22).

Patients undergoing PEG tube placement are subject to the complications associated with upper endoscopy and sedation. While the rate is low (0.1%), significant morbidity can result from these complications; the most common complications of endoscopy include perforation, hemorrhage, and aspiration (23), while sedation carries the risks of hypoxia, aspiration, and hypotension (24,25). It is not documented, but the risks of sedation are likely higher in the more severely debilitated PEG population.

### Aspiration

Upper gastrointestinal endoscopy is associated with a significant risk of aspiration. In a report in which 15% of 64 patients had aspiration related to PEG placement, only 2 of the patients had aspiration during the procedure while the other 11 did so over the next several weeks for reasons unrelated to PEG placement (26). In other reports, aspiration related to the procedure itself occurred in 0.3% to 1.0% of cases (4,27). Risk factors for intra-procedural aspiration include supine position, sedation, neurological impairment, and advanced age (17). The endoscopist can minimize the risk of this complication by avoiding over-sedation, minimizing air insufflation of the stomach, thoroughly aspirating

**Table 2**  
**Minor Complications**

Complication	Frequency	References
Ileus	1%–2%	4, 27
Peristomal infection	5.4%–30%	39–41
Stomal leakage	1%–2%	54
Buried bumper	0.3%–2.4%	4, 56, 57
Gastric ulcer	0.3%–1.2%	4, 29, 31, 60
Fistulous tracts	0.3%–6.7%	71
Inadvertent removal	1.6%–4.4%	4, 60, 61

the gastric contents before the procedure, and performing the procedure efficiently (17). Demortier, et al (28) have reported promising results using an unsedated transnasal approach to PEG placement, using a small-diameter endoscope, to lower the risks of aspiration.

### Bleeding

Acute bleeding during PEG placement is an uncommon complication, occurring in approximately 1% of cases (5,29,30). A review of 1338 patients reported that less than 0.5% of cases are complicated by hemorrhage requiring transfusion and/or laparotomy (31). Risk factors include anticoagulation and previous anatomic alteration (32). A case of fatal retroperitoneal hemorrhage believed to be associated with surgically altered anatomy has been reported (33). The development of a hematoma at the PEG site complicates roughly 1% of cases (5).

### Perforation of Viscera/Peritonitis

Complete laceration of the stomach, small bowel, or colon is a potentially catastrophic complication occurring in 0.5% to 1.3% of cases (4,5). It is recognized, however, that transient subclinical pneumoperitoneum occurs during PEG placement in as many as 56% of procedures and is generally not of any clinical significance (34). Peritonitis, manifested in the post-PEG patient as abdominal pain, leukocytosis, ileus, and fever, can result in significant morbidity if not identified and treated early (35). The prevalence of persistent subclinical pneumoperitoneum limits the utility of plain films for evaluation of suspected peritonitis. Therefore fluoroscopic imaging of the PEG tube with infusion of water-soluble contrast is most useful to evaluate visceral integrity in patients in whom peritonitis is a consideration (36). If active leakage of contrast is identified in a patient with clinical signs of peritonitis, broad-spectrum antibiotics and surgical exploration are usually indicated.

### Prolonged Ileus

It has been established that tube feedings may begin as soon as 3 hours after PEG placement (37). However, in 1%-2% of cases prolonged ileus may follow PEG placement, and should be managed conservatively (4).

Acute gastric distension post-PEG placement can be decompressed by simply uncapping the PEG tube (38).

### POST-PROCEDURE COMPLICATIONS

The PEG site should be cleaned with mild soap and water—hydrogen peroxide should not be used as it can irritate the skin and contribute to stomal leaks. Cut drain sponges should be placed over, rather than under, the external bumper so as not to apply excessive tension to the PEG site. Occlusive dressings should not be used as they can lead to peristomal skin maceration and breakdown. Should excessive granulation tissue develop at the PEG site, topical silver nitrate can be applied to reduce irritation and decrease drainage (Figure 1).

### PEG Site Infection

The most common complication of PEG placement is infection at the PEG site. As many as 30% of cases are complicated by peristomal wound infection (39–41), however more than 70% of these are minor with less than 1.6% of stomal infections requiring aggressive medical and/or surgical treatment (42). Patients with diabetes, obesity, poor nutritional status, and those on chronic corticosteroid therapy are at increased risk for infection (43). Excessive pressure between the PEG's external and internal bolsters is associated with a higher infection rate—thus setting and maintaining the proper tension can decrease the likelihood of infection. Loose contact of the outer bolster with the skin is all that is required to appose the gastric and abdominal wall. The introducer technique that does not pull the PEG tube through the oropharynx has been shown to result in fewer infections compared to the pull or push techniques (44,45).

The administration of prophylactic antibiotics prior to PEG placement reduces the risk of infection. Several trials have demonstrated the benefit of a single, broad-spectrum antibiotic immediately prior to PEG placement (42,46–48). The use of prophylactic antibiotics is cost-effective as well (49). It is general practice to administer a single dose of a first or third generation cephalosporin 30 minutes prior to the procedure. Prophylaxis is not necessary in those patients already receiving comparable antibiotics for other rea-



**Figure 1.** Granulation tissue around PEG. (Reprinted with permission from McClave and Chang, *Gastrointest Endosc* 2003;58:739-51.)



**Figure 2.** Local irritation and corrosion around PEG site. (Reprinted with permission from McClave and Chang, *Gastrointest Endosc* 2003;58:739-51.)

sons at the time of PEG placement. An adequate skin incision, 1–2 mm larger than the feeding tube, which can allow egress of bacteria and gastric secretions, may also reduce infection risk. If diagnosed early, oral broad-spectrum antibiotics for 5–7 days may be all that is required for a PEG site infection. If there are more systemic signs, intravenous broad-spectrum antibiotics coupled with local wound care are necessary. Should the patient with local site infection develop signs of peritonitis, surgical intervention may be required.

A rare but potentially life threatening complication is the development of necrotizing fasciitis. Patients with diabetes mellitus, chronic renal failure, pulmonary tuberculosis, and alcoholism appeared to be at enhanced risk (50–53). Management consists of broad-spectrum intravenous antibiotics and aggressive surgical debridement.

#### PEG Site Leakage/Irritation

Leakage of tube feeding formula and/or gastric contents around the PEG site can be a significant management problem, and small amounts likely occur more frequently than the 1%–2% reported in the literature (54). Risk factors include infection of the site, increased gastric acid secretion, excessive cleansing with hydrogen peroxide, buried bumper syndrome, side torsion on the PEG tube, and the absence of an external bolster to stabilize the tube (55). Evaluation of a leaking PEG site should include examination for evidence

of infection, ulceration, or a buried bumper. Should the patient not be on acid suppression, proton pump inhibitor therapy should be started. Side torsion resulting in ulceration and enlargement of the tract may be corrected with a clamping device to stabilize the tube (Vertical drain/tube

attachment device, Hollister, Inc., Libertyville, IL). The same result may also be accomplished by replacing the PEG with a low profile button device. Some practitioners replace the gastrostomy tube with a larger one, but this is usually ineffective and can result in continued leakage around an even larger stoma (36).

After the primary cause of the stomal leakage has been addressed, stoma adhesive powder or zinc oxide can be applied to the site to prevent local skin irritation (Figure 2). Foam dressing rather than gauze can help to reduce local skin irritation caused by gastric contents (foam lifts the drainage away from the skin while gauze tends to trap it). Local fungal skin infections may also be associated with leakage and can be treated with topical antifungals. Ostomy nurses are an invaluable resource in the management of leaking PEG sites and often are the primary caretakers in this setting. In refractory cases, the PEG tube must be removed for several days to allow the stoma to approximate the tube more closely, and occasionally the tube must be removed and a repeat PEG placed at a new site.

#### Buried Bumper Syndrome

Buried bumper syndrome refers to the clinical picture resulting from the partial or complete growth of gastric mucosa over the internal bolster, or bumper, and occurs in 0.3% to 2.4% of patients with PEG (4,56,57). The bumper may migrate through the gastric wall and may

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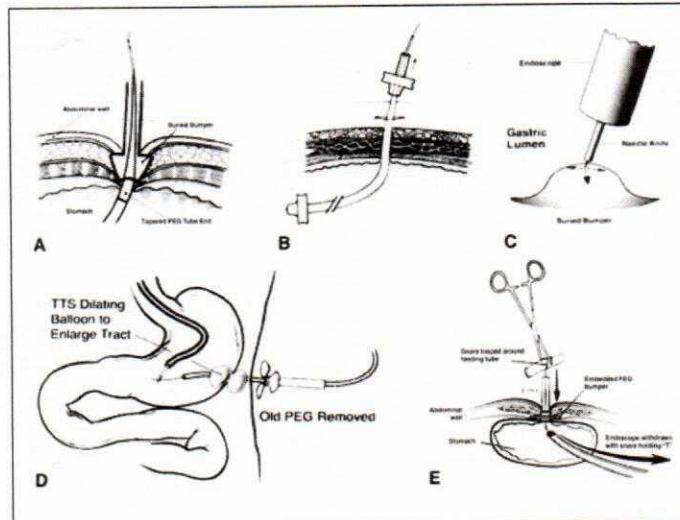
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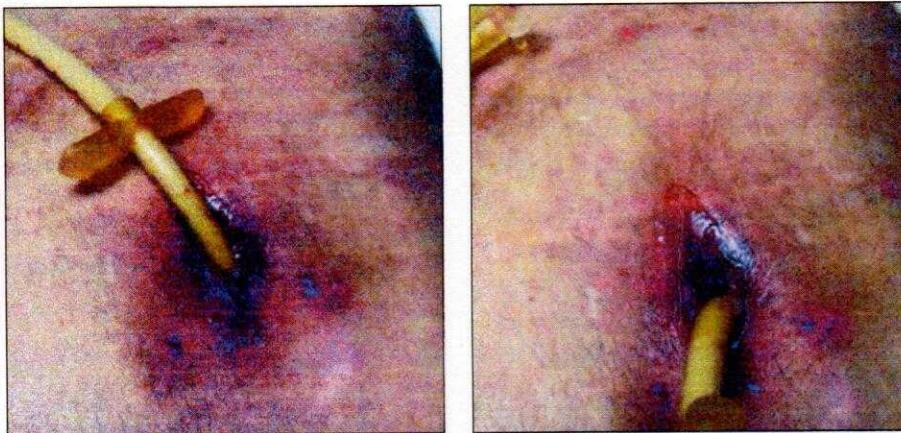
**Figure 3.** External and internal views of buried bumper syndrome. (Reprinted with permission from McClave and Chang, *Gastrointest Endosc* 2003;58:739-51.)

lodge anywhere along the PEG tract (Figure 3). Buried bumper syndrome typically presents with peritubal leakage or infection, an immobile catheter, or abdominal pain or resistance with formula infusion. A case of significant gastrointestinal bleeding secondary to buried bumper has been reported (58). Risk factors leading to buried bumper syndrome include excessive tension between the internal and external bolsters, malnutrition, poor wound healing, and significant weight gain secondary to successful enteral nutrition (55). The buried bumper may be confirmed endoscopi-



**Figure 4.** Techniques for managing buried bumper syndrome. A-The tapered tip of a push-type PEG engages the embedded PEG. B-The replacement PEG is pulled into position while removing the buried PEG out through the abdominal wall. C-Radial incisions are made in the gastric mucosa covering the dome of the PEG using a needle-knife. D-A balloon dilates the tract over a guidewire. E-A snare is used for the push-pull T technique. (Reprinted with permission from McClave and Chang, *Gastrointest Endosc* 2003;58:739-51.)

cally or radiographically. A gastrografin study should be performed with the patient prone, as radiocontrast appears to safely pass through the imbedded bumper into the gastric lumen by gravity when the patient is supine. Buried bumpers should be removed by any one of a number of methods (Figure 4). The key principle is to use a technique that minimizes trauma to the PEG tract. If the bumper is completely covered by gastric mucosa, electrosurgical incisions may be necessary to access and remove the bumper endoscopically (59).



**Figure 5.** Excessive side torsion on PEG causing ulceration. (Reprinted with permission from McClave and Chang, *Gastrointest Endosc* 2003;58:739-51.)

#### Gastric Ulcer/Hemorrhage

Bleeding that occurs after PEG placement is reported to complicate 0.3%–1.2% of cases (4,29, 31,60). It is typically caused by peptic ulcer disease, traumatic

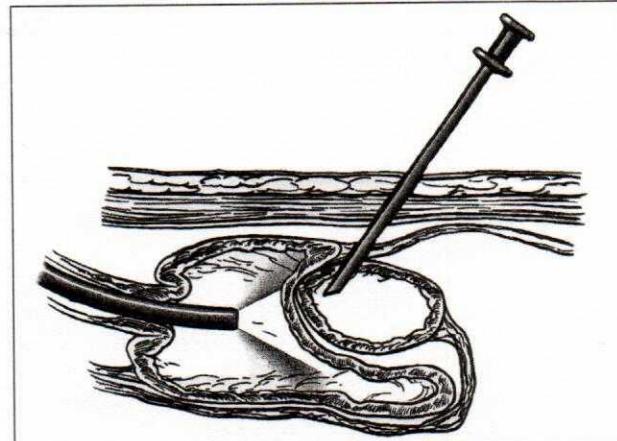
erosion of the gastric wall opposite the internal bolster, or ulceration beneath the internal bolster. To reduce risk of ulcerations at the gastrostomy site, excessive lateral traction on the tube should be avoided (Figure 5). In post-PEG patients with upper gastrointestinal bleeding, endoscopy is tolerated well. During endoscopy, the mucosa under the internal bolster should be visualized by externally manipulating the PEG (35).

### Fistulous Tracts

Fistulae connecting the stomach, colon, and skin are uncommon but potentially disastrous complications of PEG placement. Gastrocolocutaneous fistulae may occur when the colon is inadvertently punctured and traversed during PEG placement or less commonly with subsequent erosion of the tube into juxtaposed colon (Figure 6). Patients may present acutely with colonic perforation or obstruction. More commonly, patients present chronically with stool leaking around the PEG tube and diarrhea resembling formula. Another typical presentation is when a colocutaneous fistula results from a replacement PEG that is advanced through a previously created gastrocolocutaneous fistula and stops in the colon. A feeding tube misplaced into the colon may be identified radiographically (Figure 7). Management consists of removing the tube and allowing the fistula to close. Should the patient develop signs of peritonitis or the fistula fail to close, surgery is often required. Prevention is paramount—Foutch recommends elevation of the head of the bed during placement to displace the colon inferiorly. Additionally, the use of an aspirating syringe filled with saline can identify intervening bowel between the skin and the stomach if air bubbles appear in the syringe prior to endoscopic visualization of the needle in the gastric lumen (“the safe track technique”) (35).

### Inadvertent Removal

Accidental PEG tube removal occurs 1.6% to 4.4% of the time (4,60,61). PEG tract maturation usually occurs within the first 7–10 days but may be delayed up to 4 weeks in the presence of malnutrition, ascites, or corticosteroid treatment. A PEG tube that is accidentally removed during this period should be replaced endoscopically, as the tract may be immature and the stom-



**Figure 6.** Gastrocolocutaneous fistula creation by passage of trocar through loop of colon prior to entering the stomach. (Reprinted with permission from McClave, *Tech Gas-trointest Endosc* 2001;3:62-8.)

ach and anterior abdominal wall can separate from each other, resulting in free perforation. If recognized immediately, a new PEG tube may be placed through, or near, the original PEG site, sealing the stomach against the anterior abdominal wall. If recognition is delayed, management consists of nasogastric suction, broad-spectrum antibiotics, and repeat PEG placement in 7–10 days. Surgical exploration is reserved for patients with signs of decompensation or peritonitis. After stoma tract



**Figure 7.** Contrast study demonstrating gastrocolocutaneous fistula, as contrast infused through the PEG appears in the colon.

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**Table 3**  
**Summary Guidelines to Avoid Complications Associated with PEG Placement**

#### Procedure Related Complications

##### Aspiration

- Avoid over-sedation
- Minimize air insufflation
- Perform procedure efficiently

##### Bleeding

- Correct coagulopathy
- Consider any alteration of anatomy secondary to prior surgery

##### Perforation

- Early recognition
- Consider any alteration of anatomy secondary to prior surgery

##### Prolonged ileus

- Wait 3–4 hours before beginning feeding post-PEG placement
- If gastric distension occurs, uncap the PEG tube for easy decompression

#### Post Procedure Complications

##### Care of PEG site

- Use mild soap and water—NOT hydrogen peroxide
- Place drain sponges over, not under, external bumper
- Avoid the use of occlusive dressings

- For excessive granulation tissue, topical silver nitrate may be beneficial

##### PEG site infection

- Prophylactic antibiotics
- Adequate preoperative skin sterilization
- Consider introducer technique
- Set/maintain proper tension between internal and external bolsters

##### PEG site leakage/irritation

- Prevent infection
- Avoid local administration of hydrogen peroxide
- Prevent excessive side torsion on the PEG tube

##### Buried Bumper Syndrome

- Avoid excessive tension between internal and external bolsters
- Account for nutritional weight gain

##### Gastric ulceration

- Acid suppression
- Avoid lateral traction on the tube

##### Fistulous tracts

- Elevate the head of the bed during placement
- Utilize the “safe track technique”

##### Inadvertent removal

- Consider use of an abdominal binder
- Utilize low profile button at initial placement

maturation (generally >2–4 weeks) a replacement tube can be placed at the bedside without endoscopy. Balloon-type replacement PEGs have two ports—one for feeding and the other for inflating an internal balloon that acts as an internal bolster. A non-balloon-type replacement, which has a soft internal dome instead of a balloon, is an alternative. This type of replacement device tends to function longer, a fact attributable to breakage of the balloons in the balloon-types (62).

In patients prone to pulling at tubes, an abdominal binder can secure the PEG tube in place. Also consider cutting the tube down to 6–8 inches to decrease the likelihood that the tube is inadvertently caught on another object. Finally, an initial placement low profile device (button) may be beneficial.

Low profile PEG buttons, which lay flush with the skin, can reduce the risk of future inadvertent removal.

Like the replacement PEG tubes, the internal “bolster” can be either a balloon or a soft dome. Either can be placed at the bedside. PEG buttons are of fixed length, so prior to placement, a measuring device is carefully inserted into the tract so as not to risk damage to the tract. Also as a patient gains weight, the tension on the bolsters can increase. Replacement PEGs or PEG buttons should be confirmed radiographically or endoscopically if there is any concern for incorrect placement.

#### Fungal Tube Infection

Fungal colonization and/or infection of PEG tubes may lead to tube degradation and failure. This long-term complication of PEG tubes has been reported to cause up to 70% tube failure by 450 days. Histologic studies have demonstrated actual fungal growth into

the tube wall leading to brittleness, dilation and cracking with eventual puncture of the tube (63). No treatment has shown to be useful, but polyurethane initial placement and replacement devices may be more resistant to fungal infection (64,65).

### Tumor Implantation at PEG Site

Placement of prophylactic gastrostomy feeding tubes in patients with head and neck cancer has been shown to be beneficial (66). However, implantation of head and neck cancer at the stoma site has been reported in 25 cases between 1989 and 2002 (67), and should be suspected in patients with head and neck cancer who develop unexplained skin changes at the PEG site. The mechanism of implantation is most likely direct seeding of tumor at the PEG site after the tube shears tumor cells as it passes through the aerodigestive tract (68). It is reasonable in these patients to consider using the introducer technique, in which the PEG is placed directly through the abdominal wall. However, implantation has also been reported after open gastrostomy with no manipulation of the tumor by the PEG tube (69). Should a patient develop tumor at the gastrostomy site, no treatment is usually given, but palliative radiotherapy has been reported in one case (70). See Table 3 for a summary of suggested guidelines.

### SUMMARY

The PEG tube is an important tool in the armamentarium of the gastroenterologist. While very safe and well tolerated, it is not without its complications. It is vital that gastroenterologists minimize complications of PEG placement by utilizing optimal technique during placement and appropriate post-placement care. When complications do arise, early recognition and aggressive management are essential to optimize outcomes. ■

### References

- Gauderer MW, Ponsky JL, Iznat RJ. Gastrostomy without laparoscopy. A percutaneous endoscopic technique. *J Pediatr Surg*, 1980;15:872-875.
- Lewis BS. Perform PEJ, not PED. *Gastrointest Endosc*, 1990;36:311.
- Grant MD, Rudberg MA, Brody JA. Gastrostomy placement and mortality among hospitalized Medicare beneficiaries. *JAMA*, 1998;279:1973-1976.
- Larson DE, Burton DD, Schroeder KW, DiMango EP. Percutaneous endoscopic gastrostomy. Indications, success, complications, and mortality in 314 consecutive patients. *Gastroenterology*, 1987;93:48-52.
- Rabeneck L, Wray NP, Petersen NJ. Long-term outcomes of patients receiving percutaneous endoscopic gastrostomy tubes. *J Gen Intern Med*, 1996;11:287-293.
- Loser C, Wolters S, Folsch UR. Enteral long-term nutrition via percutaneous endoscopic gastrostomy in 210 patients: a four-year prospective study. *Dig Dis Sci*, 1998;43:2549-2557.
- Lockett MA, Templeton ML, Byrne TK, Norcross ED. Percutaneous endoscopic gastrostomy complications in a tertiary-care center. *Am Surg*, 2002;68:117-120.
- Calton WC, Martindale RG, Gooden SM. Complications of percutaneous endoscopic gastrostomy. *Mil Med*, 1992;157:358-360.
- Neef M, Crowder VL, McIvor NP, Chaplin JM, Morton RP. Comparison of the use of endoscopic and radiologic gastrostomy in a single head and neck cancer unit. *ANZ J Surg*, 2003;73:590-593.
- So JB, Ackroyd FW. Experience of percutaneous endoscopic gastrostomy at Massachusetts General Hospital—indications and complications. *Singapore Med J*, 1998;39:560-563.
- Kohli H, Bloch R. Percutaneous endoscopic gastrostomy: a community hospital experience. *Am Surg*, 1995;61:191-194.
- Davis JB Jr, Bowden TA Jr, Rives DA. Percutaneous endoscopic gastrostomy. Do surgeons and gastroenterologists get the same results? *Am Surg*, 1990;56:47-51.
- Abuksis G, Mor M, Segal N, Shemesh I, Plout S, Sulkes J, Fraser GM, Nir Y. Percutaneous endoscopic gastrostomy: high mortality rates in hospitalized patients. *Am J Gastroenterol*, 2000;95:128-132.
- Cosentini EP, Sautner T, Gnani M, Winkelbauer F, Teleky B, Jakesz R. Outcomes of surgical, percutaneous endoscopic, and percutaneous radiologic gastrostomies. *Arch Surg*, 1998;133:1076-1083.
- Moller P, Lindberg CG, Zilling T. Gastrostomy by various techniques: evaluation of indications, outcome, and complications. *Scand J Gastroenterol*, 1999;34:1050-1054.
- Souba WW. Nutritional support. *N Engl J Med*, 1997;336:41-48.
- Safadi BY, Marks JM, Ponsky JL. Percutaneous endoscopic gastrostomy. *Gastrointest Endosc Clin N Am*, 1998;8:551-568.
- Laasch HU, Wilbraham L, Bullen K, Marriott A, Lawrence JA, Johnson JA, Johnson RJ, Lee SH, England RE, Gamble GE, Martin DF. Gastrostomy insertion: comparing the options—PEG, RIG, or PIG? *Clin Radiol*, 2003;58:398-405.
- Taylor CA, Larson DE, Ballard DJ, Bergstrom LR, Silverstein MD, Zinsmeister AR, DiMango EP. Predictors of outcome after percutaneous endoscopic gastrostomy: a community-based study. *Mayo Clin Proc*, 1992;67:1042-1049.
- Wollman B, D'Agostino HB. Percutaneous radiologic and endoscopic gastrostomy: a 3-year institutional analysis of procedure performance. *Am J Roentgenol*, 1997;169:1551-1553.
- Kozarek RA, Ball TJ, Ryan JA Jr. When push comes to shove: a comparison between two methods of percutaneous endoscopic gastrostomy. *Am J Gastroenterol*, 1986;81:642-646.
- Stellato TA, Ganderer MWL, Ponsky JL. Percutaneous endoscopic gastrostomy following previous surgery. *Am Surg*, 1984;200:46.
- Kavic SM, Basson MD. Complications of endoscopy. *Am J Surg*, 2001;181:319-332.
- Hart R, Classen M. Complications of diagnostic gastrointestinal endoscopy. *Endoscopy*, 1990;22:22-33.
- Alexander JA, Smith BJ. Midazolam sedation for percutaneous liver biopsy. *Dig Dis Sci*, 1993;38:2209-2211.
- Jarnagin WR, Duh QY, Mulvihill SJ, et al. The efficacy and limitations of percutaneous endoscopic gastrostomy. *Arch Surg*, 1992;127:261-264.
- Grant JP. Percutaneous endoscopic gastrostomy. Initial placement by single endoscopic technique and long-term follow-up. *Ann Surg*, 1993;217:168-174.

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### NUTRITION ISSUES IN GASTROENTEROLOGY, SERIES #22

28. Dumortier J, Lapalus MG, Pereira A, Lagarrigue JP, Chavaillon A, Ponchon T. Unsedated transnasal PEG placement. *Gastrointest Endosc*, 2004;59:54-57.
29. Amann W, Mischinger HJ, Berger A, Rosanelli G, Schweiger W, Werkgartner G, Fruhwirth J, Hauser H. Percutaneous endoscopic gastrostomy (PEG). 8 years of clinical experience in 232 patients. *Surg Endosc*, 197;11:741-744.
30. Petersen TI, Kruse A. Complications of percutaneous endoscopic gastrostomy. *Eur J Surg*, 1997;163:351-356.
31. Mamel JJ. Percutaneous endoscopic gastrostomy. *Am J Gastroenterol*, 1989;84:703-710.
32. Hament JM, Bax NM, van der Zee DC, De Schryver JE, Nessaar C. Complications of percutaneous endoscopic gastrostomy with or without concomitant antireflux surgery in 96 children. *J Pediatr Surg*, 2001;36:1412-1415.
33. Lau G, Lai SH. Fatal retroperitoneal hemorrhage: an unusual complication of percutaneous endoscopic gastrostomy. *Forensic Sci Int*, 2001;116:69-75.
34. Wojtowycz MM, Arata JA Jr, Micklos TJ, Miller FJ Jr. CT findings after uncomplicated percutaneous gastrostomy. *Am J Roentgenol*, 1988;151:307-309.
35. Foutch PG. Complications of percutaneous endoscopic gastrostomy and jejunostomy. Recognition, prevention, and treatment. *Gastrointest Endosc Clin N Am*, 1992;2:231-248.
36. Schapiro GD, Edmundowicz SA. Complications of percutaneous endoscopic gastrostomy. *Gastrointest Endosc Clin N Am*, 1996;6:409-422.
37. Choudhry U, Barde CJ, Markert R, Gopalswamy N. Percutaneous endoscopic gastrostomy: a randomized prospective comparison of early and delayed feeding. *Gastrointest Endosc*, 1996;44:164-167.
38. Baskin WN. Enteral access techniques. *Gastroenterologist*, 1996;4:S40-S67.
39. Hull MA, Rawlings J, Morray FE, et al. Audit of outcome of long-term enteral nutrition by percutaneous endoscopic gastrostomy. *Lancet*, 1993;341:869-872.
40. Ponsky JL, Gauderer MW, Stellato TA. Percutaneous endoscopic gastrostomy: a review of 150 cases. *Arch Surg*, 1983;118:913-914.
41. Sangster W, Cuddington GD, Bachulis BL. Percutaneous endoscopic gastrostomy. *Am J Surg*, 1988;155:677-679.
42. Gossner L, Keymling J, Hahn EG, Ell C. Antibiotic prophylaxis in percutaneous endoscopic gastrostomy (PEG): a prospective randomized clinical trial. *Endoscopy*, 1999;31:119-124.
43. Lee JH, Kim JJ, Kim YH, Jang JK, Son HJ, Peck KR, Rhee PL, Paik SW, Rhee JC, Choi KW. Increased risk of peristomal wound infection after percutaneous endoscopic gastrostomy in patients with diabetes mellitus. *Dig Liver Dis*, 2002;34:857-861.
44. Maetani I, Tada T, Ukita T, Inoue H, Sakai Y, Yoshikawa M. PEG with introducer or pull method: a prospective randomized comparison. *Gastrointest Endosc*, 2003;57:837-841.
45. Deitel M, Bendago M, Spratt EH, Burul CJ, To TB. Percutaneous endoscopic gastrostomy by the "pull" and "introducer" methods. *Can J Surg*, 1988;31:102-104.
46. Preclik G, Grune S, Leser HG, Lebherz J, Heldwein W, Machka K, Hostege A, Kern WV. Prospective, randomised, double blind trial of prophylaxis with single dose of co-amoxiclav before percutaneous endoscopic gastrostomy. *Br Med J*, 1999;319:881-884.
47. Jain NK, Larson DE, Schroeder KW, Burton DD, Cannon KP, Thompson RL, DiMango EP. Antibiotic prophylaxis for percutaneous endoscopic gastrostomy. A prospective, randomized, double-blind clinical trial. *Ann Intern Med*, 1987;107:824-828.
48. Akkerskijl WL, van Bergeijk JD, van Egmond T, Mulder CJ, van Berge Henegouwen GP, van der Werken C, van Erpecum KJ. Percutaneous endoscopic gastrostomy: comparison of push and pull methods and evaluation of antibiotic prophylaxis. *Endoscopy*, 1995;27:313-316.
49. Kulling D, Sonnenberg A, Fried M, Bauerfeind P. Cost analysis of antibiotic prophylaxis for PEG. *Gastrointest Endosc*, 2000;51:152-156.
50. Greif JM, Ragland JJ, Ochsner MG, et al. Fatal necrotising fasciitis complicating percutaneous endoscopic gastrostomy. *Gastrointest Endosc*, 1986;32:292-294.
51. Cave DR, Robinson WR, Brotschi EA. Necrotising fasciitis complicating percutaneous endoscopic gastrostomy. *Gastrointest Endosc*, 1986;32:294-296.
52. Person JL, Brower RA. Necrotising fasciitis/myositis following percutaneous endoscopic gastrostomy. *Gastrointest Endosc*, 1986;32:309.
53. Korula J, Rice HE. Necrotising fasciitis complicating percutaneous endoscopic gastrostomy. *Gastrointest Endosc*, 1987;33:335-336.
54. Lin HS, Ibrahim HZ, Kheng JW, Fee WE, Terris DJ. Percutaneous endoscopic gastrostomy: strategies for prevention and management of complications. *Laryngoscope*, 2001;111:1847-1852.
55. McClave SA, Chang W-K. Complications of enteral access. *Gastrointest Endosc*, 2003;58:739-751.
56. Venu RP, Brown RD, Pastika BJ, Erickson LW Jr. The buried bumper syndrome: a simple management approach in two patients. *Gastrointest Endosc*, 2002;56:582-584.
57. Walton GM. Complications of percutaneous endoscopic gastrostomy in patients with head and neck cancer—an analysis of 42 consecutive patients. *Ann R Coll Surg Engl*, 1999;81:272-276.
58. Anagnostopoulos GK, Kostopoulos P, Arvanitidis DM. Buried bumper syndrome with a fatal outcome, presenting early as gastrointestinal bleeding after percutaneous endoscopic gastrostomy. *J Postgrad Med*, 2003;49:325-327.
59. Ma MM, Semlacher EA, Fedorak RN, et al. The buried gastrostomy bumper syndrome: prevention and endoscopic approaches to removal. *Gastrointest Endosc*, 1995;4:505-508.
60. Rimon E. The safety and feasibility of percutaneous endoscopic gastrostomy placement by a single physician. *Endoscopy*, 2001;33:241-244.
61. Dwyer KM, Watts DD, Thurber JS, Benoit RS, Fakhry SM. Percutaneous endoscopic gastrostomy: the preferred method of elective feeding tube placement in trauma patients. *J Trauma*, 2002;52:26-32.
62. Heiser M, Malaty H. Balloon-type versus non-balloon-type replacement percutaneous endoscopic gastrostomy: which is better? *Gastroenterol Nurs*, 2001;24:58-63.
63. Iber FL, Livak A, Patel M. Importance of fungus colonization in failure of silicone rubber percutaneous gastrostomy tubes. *Dig Dis Sci*, 1996;41:226-231.
64. Van Den Hazel SJ, Mulder CJ, Hartog GD, Thies JE, Westhof W. A randomized trial of polyurethane and silicone percutaneous endoscopic gastrostomy catheters. *Aliment Pharmacol Ther*, 2000;14:1273-1277.
65. Sartori S, Trevisani L, Nielsen I, Tassinari D, Ceccotti P, Abbasciano V. Longevity of silicone and polyurethane catheters in long-term enteral feeding via percutaneous endoscopic gastrostomy. *Aliment Pharmacol Ther*, 2003;17:853-856.
66. Romano MM, McLaughlin MP, Scolapio J. PEG tube placement in head and neck cancer patients prior to radiation therapy [abstract]. *JPNEN*, 2000;24:S25.
67. Thakore JN, Mustafa M, Suryaprasad S, Agrawal S. Percutaneous endoscopic gastrostomy associated gastric metastasis. *J Clin Gastroenterol*, 2003;37:307-311.
68. Hosseini M, Lee JG. Metastatic esophageal cancer leading to gastric perforation after repeat PEG placement. *Am J Gastroenterol*, 1999;94:2556-2558.
69. Alagaratnam TT, Ong GB. Wound implantation—a surgical hazard. *Br J Surg*, 1977; 64:872-875.
70. Laccourreye O, Chabardes E, Merite-Drancy A, Carnot F, Renard P, Donnadieu S, Brasnu D. Implantation metastasis following percutaneous endoscopic gastrostomy. *J Laryngol Otol*, 1993; 107:946-949.
71. Segal D, Michaud L, Guimber D, Ganga-Zandzou PS, Turck D, Gottrand F. Late-onset complications of percutaneous endoscopic gastrostomy in children. *J Pediatr Gastroenterol Nutr*, 2001; 33:495-500.