

WJG 20th Anniversary Special Issues (13): Gastrointestinal endoscopy**Percutaneous endoscopic gastrostomy: Indications, technique, complications and management**

Ata A Rahnama-Azar, Amir A Rahnamaiazar, Rozhin Naghshizadian, Amparo Kurtz, Daniel T Farkas

Ata A Rahnama-Azar, Amir A Rahnamaiazar, Rozhin Naghshizadian, Amparo Kurtz, Daniel T Farkas, Department of Surgery, Bronx-Lebanon Hospital Center, Albert Einstein College of Medicine, Bronx, NY 10457, United States

Author contributions: Rahnama-Azar AA substantially contributed to conception and design, reviewing and drafting of the article; Rahnamaiazar AA substantially contributed to conception and design, reviewing and drafting of the article, revising the article for important intellectual content; Naghshizadian R contributed to reviewing and drafting the article; Kurtz A contributed to reviewing and drafting the article; Farkas DT substantially contributed to conception and design, drafting the article, revising the article for important intellectual content, final approval of the version to be published.

Correspondence to: Daniel T Farkas, MD, FACS, Department of Surgery, Bronx-Lebanon Hospital Center, Albert Einstein College of Medicine, 1650 Selwyn Ave, Suite 4E, Bronx, NY 10457, United States. dfarkas@bronxleb.org

Telephone: +1-718-9601243 Fax: +1-718-9601370

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Abstract

Percutaneous endoscopic gastrostomy (PEG) is the preferred route of feeding and nutritional support in patients with a functional gastrointestinal system who require long-term enteral nutrition. Besides its well-known advantages over parenteral nutrition, PEG offers superior access to the gastrointestinal system over surgical methods. Considering that nowadays PEG tube placement is one of the most common endoscopic procedures performed worldwide, knowing its indications and contraindications is of paramount importance in current medicine. PEG tubes are sometimes placed inappropriately in patients unable to tolerate adequate oral intake because of incorrect and unrealistic understanding of their indications and what they can accomplish. Broadly, the two main indications of PEG tube

placement are enteral feeding and stomach decompression. On the other hand, distal enteral obstruction, severe uncorrectable coagulopathy and hemodynamic instability constitute the main absolute contraindications for PEG tube placement in hospitalized patients. Although generally considered to be a safe procedure, there is the potential for both minor and major complications. Awareness of these potential complications, as well as understanding routine aftercare of the catheter, can improve the quality of care for patients with a PEG tube. These complications can generally be classified into three major categories: endoscopic technical difficulties, PEG procedure-related complications and late complications associated with PEG tube use and wound care. In this review we describe a variety of minor and major tube-related complications as well as strategies for their management and avoidance. Different methods of percutaneous PEG tube placement into the stomach have been described in the literature with the "pull" technique being the most common method. In the last section of this review, the reader is presented with a brief discussion of these procedures, techniques and related issues. Despite the mentioned PEG tube placement complications, this procedure has gained worldwide popularity as a safe enteral access for nutrition in patients with a functional gastrointestinal system.

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Key words: Gastrostomy tube; Percutaneous; Enteral feeding; Indication; Contraindication; Complication; Management

Core tip: Following its introduction in 1980, the percutaneous endoscopic gastrostomy (PEG) tube has become the modality of choice for nutritional support in patients who require long-term enteral feeding. In this review we describe the indications and contraindications of PEG tube placement. Potential complications of a PEG

tube as well as their management and preventive measures are discussed in detail. A comprehensive review of all aspects of the PEG tube, in addition to providing practical tips in aftercare and management of potential complications make this review unique amongst similar articles.

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INTRODUCTION

The primary indication for enteral and parenteral feeding is the provision of nutritional support to meet metabolic requirements for patients with inadequate oral intake. Enteral feeding is usually the preferred method over parenteral feeding in patients with a functional gastrointestinal (GI) system due to the associated risks of the intravenous route, higher cost and inability of parenteral nutrition to provide enteral stimulation and subsequent compromise of the gut defense barrier^[1,2]. Moreover, it has been shown that enteric feeding can decrease the risk of bacterial translocation and corresponding bacteremia^[3]. Tube feeding through the GI tract is mainly considered in patients with insufficient oral intake who have a functional GI system and tube insertion into their alimentary tract can be safely maintained.

Gastric feeding is the most common type of enteral feeding. Access to insert the gastrostomy tube can be achieved by the use of endoscopy, radiological imaging, or surgical techniques (open or laparoscopic). Percutaneous endoscopic gastrostomy (PEG) was first introduced in 1980 by the application of endoscopy to insert a feeding tube into the stomach^[4]. Due to low cost, less invasive and no need for general anesthesia in most cases (which is a challenging factor in debilitated patients in whom gastrostomy tubes are most commonly placed), PEG is considered to be a better choice for the introduction of a feeding tube than surgical methods^[5,6]. PEG is currently the method of choice for medium- and long-term enteral feeding.

This article reviews the current knowledge on PEG in the medical literature.

INDICATIONS AND EFFICACY

Patients with adequate baseline nutritional status can tolerate up to 10 d of partial fasting (with maintenance fluids) before severe protein catabolism occurs. However, longer fasting periods, depending on the patient's baseline health status, can be unfavorable. To maintain or establish adequate nutrition, enteral feeding is necessary for patients with insufficient oral intake. Nasoenteric tubes

Table 1 Conditions for which patients are commonly referred for insertion of a percutaneous endoscopic gastrostomy tube

| |
|--|
| Neurological diseases and psychomotor retardation |
| Cerebrovascular disease |
| Motor neuron disease (amyotrophic lateral sclerosis) |
| Multiple sclerosis |
| Parkinson's disease |
| Cerebral palsy |
| Dementia |
| Cerebral tumor |
| Psychomotor retardation |
| Reduced level of consciousness |
| Head injury |
| Intensive care patients |
| Prolonged coma |
| Cancer |
| Head and neck cancer |
| Esophageal cancer |
| Miscellaneous |
| Burns |
| Congenital anomaly (<i>e.g.</i> , trachea esophageal fistula) |
| Fistulae |
| Cystic fibrosis |
| Short bowel syndromes (such as Crohn's disease) |
| Facial surgery |
| Poly-trauma |
| Chronic renal failure |
| HIV/AIDS |
| Gastric decompression |
| Abdominal malignancy |

HIV/AIDS: Human immunodeficiency virus infection/acquired immunodeficiency syndrome.

(nasogastric, nasoduodenal and nasojejunal) are usually reserved for short-term (< 30 d) enteral feeding in patients with intact protective airway reflexes.

Compared to PEG tubes, nasoenteric tubes result in more complications (irritation, ulceration, bleeding, esophageal reflux and aspiration pneumonia), lower subjective comfort and even lower feeding efficacy^[7-9]. Hence, PEG tube insertion is usually considered in patients at risk for moderate to severe malnourishment within 2-3 wk of nasoenteric tube feeding. However, there are unclear benefits of PEG feeding in certain patient populations, such as those with diabetes or advanced dementia and in elderly patients aged more than 80 years^[10,11]. The decision for tube placement should be individualized according to the patient's needs, preferences, diagnosis and life expectancy. The goal is not only to improve the patient's survival and nutritional status, but also to improve their quality of life which is not necessarily correlated with nutritional improvement^[12]. Also the long-term survival rate of some patients is low due to their underlying disease and this needs to be considered when deciding on PEG placement^[11].

There are a significant number of patients who can benefit medically from PEG placement (Table 1). In a 4-year prospective study of 210 patients with both malignant and benign underlying diseases, the mean weight loss in the three-month period before starting PEG tube nutrition was 11.35 ± 1.5 kg, while the mean weight gain at the end of 12-mo feeding *via* PEG tube was 3.5

$\pm 1.7 \text{ kg}^{[13]}$. This suggests that initiation of PEG tube nutrition, as soon as the medical necessity is established, can prevent further weight loss. However, another study published recently showed that better nutritional and metabolic parameters in PEG-fed patients are not always accompanied by improvements in body composition parameters^[14].

NEUROLOGICAL DISEASES AND PSYCHOMOTOR RETARDATION

Cerebrovascular disease/stroke

Neurological dysphagia (along with cancer-related reasons) is one of the most common reasons for referral for PEG tube insertion. Dysphagia is a common finding after a stroke and its incidence is reported to be as high as 45% among those admitted to hospital^[15]. Some experts recommend that patients who are not able to meet their nutritional needs by oral intake, should be started on nasogastric (NG) tube feeding in the first 24 h after their stroke^[16]. Nasogastric tube feeding alone may be enough in patients who need nutritional support for less than 4 wk, but PEG tube placement needs to be considered for longer periods^[17]. PEG feeding provides a safe and reliable means of nutrition in stroke patients and its superior long-term results over NG tube feeding have been demonstrated^[18,19]. Early PEG nutrition is also desirable in stroke patients, but the decision must be weighed up in patients with temporary dysphagia or those with short life expectancy due to underlying diseases. At least a two-week wait time for PEG insertion is clinically appropriate to evaluate its medical necessity. After insertion of the PEG tube, routine follow-up of patients should be carried out to evaluate regaining their swallowing ability. PEG tubes can be removed at any time if patients regain spontaneous swallowing.

Motor neuron diseases/amyotrophic lateral sclerosis

PEG is a standard method of feeding in patients with amyotrophic lateral sclerosis (ALS). In some patients the PEG tube placement technique should be modified in view of associated anatomic deformity. Also gastric insufflation during and after the procedure should be minimized due to the inability of these patients to spontaneously lower their raised diaphragm^[20]. Although there are some concerns about the safety of PEG tube placement in patients with restricted pulmonary function, Czell *et al.*^[21] showed that PEG can be performed in these patients under procedural non-invasive ventilation with minimal peri- and post-procedural complications. In addition their data showed no significant difference in long-term survival rate among patients with high ($> 50\%$) and low ($< 50\%$) forced vital capacity (FVC). This finding was in contrast to the results of other studies showing a lower survival rate after PEG tube placement in patients with ALS who had low FVC ($< 50\%$)^[22].

The role of the PEG tube has also been described in the nutritional support of other motor neuron and dysfunctional motor diseases such as cerebral palsy and

bulbar palsy^[23-25]. These patients frequently have feeding and swallowing problems that may lead to poor nutritional status, growth failure, chronic pulmonary aspiration and infection. The Epidemiologic Oxford Feeding Study reported a significant correlation between the severity of motor impairments and the need for gastrostomy feeding^[26].

Dementia

Most patients with advanced dementia are dependent on others in their daily living activities including eating. In a prospective study of nursing home residents, 86% of patients with advanced dementia had eating problems^[27]. There are several mechanisms that are responsible for impaired self-feeding in this population: altered smell and anorexia resulting in a lack of interest in food; apraxia interfering with the task of eating, and dysphagia and loss of airway protective mechanisms leading to choking episodes and eating avoidance^[28-30]. Feeding problems are usually considered one of the ominous symptoms of advanced dementia with a 6 mo mortality rate of 25%^[27], a similar life expectancy to some generally considered poor prognosis diseases such as stage 4 congestive heart failure^[31]. This is consistent with the finding that independent of age, patients with dementia undergoing PEG have a worse prognosis than other patient subgroups with a mortality rate of 54% after 1 mo and 90% after 1 year of tube insertion^[32]. In another study cited elsewhere, PEG has a higher mortality rate in demented patients who are at least 80 years old^[11]. The need for more aggressive palliative measures to prevent malnutrition in patients with advanced dementia is an important issue, however to date, there is no published evidence showing that PEG feeding can prolong survival or provide palliation in this patient population^[33-36]. In a recent study designed to assess the effect of PEG feeding on pressure ulcer healing in patients with advanced dementia, patients with PEG were less likely to heal and more likely to develop new ulcers^[37]. Given all these findings, PEG may not provide any clinical benefit to this patient population and simple efforts like hand feeding can be a viable alternative^[38]. In one study, PEG tube insertion in nursing home residents with advanced dementia was associated with a significant increase in annual inpatient health care costs as well as in hospital and intensive care unit stay^[39].

Psychomotor retardation

Patients with psychomotor retardation are prone to malnourishment and gastroesophageal reflux due to pathophysiologic causes inherent in this condition. The long-term efficacy of PEG tube feeding in improving nutritional status of severely disabled and mentally retarded adults and children has been shown. However, the use of PEG in those with aspiration and gastroesophageal reflux is not recommended^[40].

Reduced level of consciousness

The decision to start enteral nutrition in some patients with severe cerebral injury is challenging, as their recovery

Table 2 Contraindications

| |
|---|
| Serious coagulation disorders (INR > 1.5, PTT > 50 s, platelets < 50000/mm ³) |
| Hemodynamic instability |
| Sepsis |
| Severe ascites |
| Peritonitis |
| Abdominal wall infection at the selected site of placement |
| Marked peritoneal carcinomatosis |
| Interposed organs (e.g., liver, colon) |
| History of total gastrectomy |
| Gastric outlet obstruction (if being used for feeding) |
| Severe gastroparesis (if being used for feeding) |
| Lack of informed consent for the procedure |

time and the final outcome is not clear. Generally, in order to prevent nutrition depletion, enteral feeding should be started as early as possible to restore physiological function of the GI system. Some authors advocate that PEG tube nutrition should be started in severe cerebral injury patients if they do not recover in 14 d^[41].

MISCELLANEOUS

Cancer

More than 40% of patients with head and neck malignancy have some degree of malnutrition^[42]. The underlying mechanisms of this malnutrition include the obstructive effect of the tumor, oropharyngeal mucositis due to aggressive treatment with high dose radiotherapy and/or chemotherapy and reduced appetite. The PEG tube can be inserted either prophylactically or therapeutically in this setting^[43-45]. In a recent study, PEG tubes inserted prophylactically resulted in a lower complication rate compared to tubes inserted therapeutically^[46]. Recently a modified transnasal technique was introduced in patients with oropharyngeal cancer, when the routine method was unsuccessful^[47].

Gastric decompression

In chronic unresolved gastrointestinal stenosis or ileus, PEG can be used to drain gastric secretions and resolve persistent nausea and vomiting^[48,49].

Human immunodeficiency virus infection/acquired immunodeficiency syndrome

PEG tube nutrition in human immunodeficiency virus (HIV)/acquired immunodeficiency syndrome (AIDS) patients with wasting syndrome results in significant improvement in body weight and nutritional serum markers such as albumin and transferrin^[50]. In another study, children with AIDS who were fed chronically by gastrostomy tube gained more weight and had a shorter length of hospital stay when enteral feeding was started early^[51].

Cystic fibrosis

In patients with cystic fibrosis, better nutritional status is associated with superior survival^[52]. The role of PEG

tube feeding in improving nutritional status and baseline pulmonary functional status in these patients has already been described^[53-55]. Therefore, some experts recommend PEG tube insertion as an early intervention rather than as a last resort in malnourished patients with cystic fibrosis^[55].

Crohn's disease

Enteral nutrition is an important part of the treatment in patients with Crohn's disease, especially in children who require elemental diet. This type of nutrition not only reversed malnutrition and improved weight gain and linear growth, but also reduced steroid requirements^[56]. The concern of fistula formation has resulted in many physicians refraining from considering PEG tube insertion in this population, however, over time its safety during usage and after removal has been reliably demonstrated^[57,58]. However, considering the large number of oral nutritional supplements and other nutritional alternatives available, it is currently uncommon to insert a PEG tube for enteral feeding in patients with Crohn's disease.

CONTRAINDICATIONS

Medical necessity, like any other surgical intervention, must be clearly established prior to PEG tube insertion. Some of the absolute contraindications of PEG tube placement are summarized in Table 2. Besides the absolute contraindications conditions such as the presence of non-obstructing oropharyngeal or esophageal malignancy, hepatomegaly, splenomegaly, peritoneal dialysis, portal hypertension with gastric varices and history of previous partial gastrectomy are also considered relative contraindications.

Special considerations

In patients with prior abdominal surgery, a PEG tube can be inserted after confirming a "safe tract" with no interposed bowel^[59]. In obese patients, PEG can be safely performed with minor modifications, even in patients with an extreme body mass index (> 60 kg/m²)^[60,61].

During pregnancy, PEG tube insertion may be complicated by potential risks of uterine and fetal injury. However, tube insertion has been reported in pregnant women up to 29-wk gestation with no major complication after applying special precautions^[62-65].

Generally, ascites is considered a relative contraindication for PEG tube placement due to concerns regarding ascitic fluid leakage. There are some case reports of successful tube insertion, after paracentesis or modifications of the placement technique, even in patients with massive ascites^[66-68]. However, in a case series of patients with cirrhosis, the patient group with ascites had a higher mortality rate. Therefore, experts have concluded that the risks of PEG tube insertion in cirrhotic patients with ascites outweigh its overall benefits^[69].

When medically indicated, there is no age or weight limit in PEG tube placement. The safety of PEG inser-

Table 3 Complications reported

| |
|--|
| Minor: |
| Wound infection |
| Tube leakage to abdominal cavity (peritonitis) |
| Stoma leakage |
| Inadvertent PEG removal |
| Tube blockage |
| Pneumoperitoneum |
| Gastric outlet obstruction |
| Peritonitis |
| Major: |
| Aspiration pneumonia |
| Hemorrhage |
| Buried bumper syndrome |
| Perforation of bowel |
| Necrotizing fasciitis |
| Metastatic seeding |

PEG: Percutaneous endoscopic gastrostomy.

tion even in very small (3 kg) and medically complex infants has been determined^[70].

COMPLICATIONS

PEG tube insertion is usually considered a safe procedure, however, complications can occur with a variable rate based on the study population. These complications can be classified as minor or major (Table 3). Although there is low procedure-related mortality in most studies, the mortality rate may increase in patients with underlying comorbidities^[71].

MAJOR COMPLICATIONS

Major complications are not common but can occur after PEG tube insertion. As mentioned, mortality after PEG is very rare and is usually due to underlying co-morbidities.

Bleeding

Bleeding from the PEG tract, gastric artery, splenic or mesenteric vein injuries (massive retroperitoneal bleeding) and rectus sheath hematoma have been reported^[72-74]. In hemodynamically unstable cases, fluid support should be started immediately with close monitoring of vital signs. Bleeding can usually be controlled with simple pressure over the abdominal wound, however, endoscopic or surgical exploration of the bleeding source may be needed in some cases. Using a standard technique with consideration of anatomical structures and correcting coagulation disorders before PEG tube insertion can be helpful in the prevention of bleeding.

Aspiration pneumonia

Aspiration pneumonia is a serious and potentially fatal complication of PEG tube feeding. Although a PEG tube is usually preferred over a NG tube in high-risk patients, there is little data available on the comparable risk of aspiration between these two routes of feeding^[75]. In fact, despite its widespread usage, insertion of a PEG

tube in patients with neurologic dysphagia failed to reduce the risk of aspiration pneumonia^[76]. In a study of stroke patients, 18% suffered from aspiration pneumonia which was higher than the rate of PEG site infection in the same study^[77]. Aspiration pneumonia is quite common in this patient population and its risk increases with high-volume feeds and the prone position^[78]. A jejunal extension can be considered in patients with significant risk of aspiration, but its usage has been associated with more tube dysfunction and dislocation rates^[79].

Internal organ injury

Any intra-abdominal organ, more likely colon^[80] and small bowel^[81] and rarely liver^[82] and spleen^[73], is at risk of injury during PEG tube placement. Also few cases of complete laceration of the stomach following tube insertion have been reported in the literature^[83]. Iatrogenic perforation of the bowels during PEG tube insertion is more common among elderly patients due to laxity of the colonic mesentery^[84]. Patients with bowel injury may develop the classic signs of peritoneal irritation. However, in some instances, the diagnosis is challenging since candidates for PEG tube nutrition do not always communicate easily due to their underlying altered mental status. In addition, the persistence of transient subclinical pneumoperitoneum occurring during PEG^[85] limits the utility of plain films in the diagnosis of suspected visceral perforation. A watchful follow-up is important after any PEG tube insertion and there should be a low threshold for further investigation. Performing a computed tomography (CT) scan with water-soluble contrast, or fluoroscopy in the case of hemodynamic instability, is a useful alternative to confirm gastrointestinal integrity in this setting. Any evidence of active leakage of contrast into the peritoneal cavity in the presence of the signs of peritonitis warrants emergent surgical intervention.

Necrotizing fasciitis

Necrotizing fasciitis is a very rare, but potentially fatal complication of PEG^[86-88]. This complication is an acute surgical emergency and is characterized by rapidly spreading infection along the fascial planes resulting in abdominal fascia necrosis. Traction and pressure on the PEG tube are two main factors which have been shown to increase the risk of abdominal wall necrotizing fasciitis following PEG tube placement^[89]. Keeping the external bumper 1-2 cm away from the abdominal wall can take the pressure off the PEG wound and potentially prevent this complication. Treatment requires immediate wide surgical debridement, broad-spectrum empiric antibiotics and intensive care support.

Buried bumper syndrome

Buried bumper syndrome can occur in tubes with an internal bumper as early as 3 wk after PEG tube insertion^[90-93]. Excessive tension between the internal and external bumpers causes ischemic necrosis of the gastric wall and subsequently migration of the tube toward the

abdominal wall. The tube becomes dislodged anywhere between the gastric wall and the skin along the PEG tract. This complication can present as feeding problems, peristomal leakage, or pain and swelling at the tube insertion site^[94]. The tube should be removed as soon as the diagnosis is made, as grave complications such as perforation of the stomach, peritonitis and death may follow without appropriate management^[95]. Depending on the tube type, a PEG tube can be removed by endoscopy^[94,96], surgical incision^[97] or simply by external traction of the tube^[98,99]. This complication can be easily avoided by regular checking of the PEG tube position, leaving a small distance between the external bumper and the resident's skin and daily 180-360 degree rotation of the tube.

Tumour seeding of the stoma

This is a rare complication of PEG in patients with head and neck cancer. Generally, it is believed that seeding occurs during the "pull" or "push" method when the tube is in contact with oropharyngeal cancer during insertion^[100-103]. However, some authors consider hematogenous or lymphatic spread of the tumor cells as the main mechanism of metastasis in some instances^[104,105]. The diagnosis is usually delayed until the metastasis is large enough to be visible or local disorders such as bleeding or infection are seen. In the case of suspicion, diagnosis can be confirmed by biopsy and CT scan^[106].

MINOR COMPLICATIONS

Granuloma formation

The development of hyper-granulation tissue around the gastrostomy tube is a common complication in patients with a PEG tube^[107,108]. Although the exact mechanism of granuloma formation has not been described, factors such as friction from a poorly secured tube and excess moisture due to fluid leakage causing skin breakdown at the exit site seem to be responsible^[107,109]. The presence of a granuloma is not a life-threatening complication, but its moist and highly vascularized surface results in patients being prone to wound infection, biofilm formation and bleeding. While a wide variety of treatment options from the application of topical antimicrobial agents and low dose steroids to cauterization by silver nitrate and surgical removal have been described in the literature, none have proved to be more effective than others^[107,110].

Local wound infection

Tube site infection is the most common minor complication following PEG placement. The prevalence varies between 5%-25% in different studies, and in some series it was reported to be as high as 65%^[111,112]. Although mild redness around the stoma site is common due to tube movement, extension of the redness and addition of purulent discharge or other signs of systemic inflammation should raise suspicion regarding wound infection. Minor infections usually resolve with the application of local antiseptics and daily dressing changes, but in cases

of persistent infection further investigation is warranted. Peristomal swabs, although considered to have restricted results, can be cultured to tailor the systemic or local antibiotic treatments. The effectiveness of prophylactic antibiotic administration in preventing systemic and local infection has been studied in several articles^[112-119]. A systematic review of ten eligible randomized controlled trials (RCTs), which evaluated prophylactic antimicrobials in 1100 patients, showed a statistically significant reduction in the incidence of peristomal infection with prophylactic antibiotics (pooled OR = 0.31, 95%CI: 0.22-0.44)^[120].

The current gold standard for antibiotic prophylaxis is the intravenous administration of a single dose of cephalosporins in the first hour before PEG tube insertion. Recent efforts in exploring other prophylactic alternatives, found co-trimoxazole administered immediately *via* a newly inserted PEG catheter just as effective in preventing peristomal infection^[121,122].

The recent emergence of Methicillin-Resistant *Staphylococcus aureus* (MRSA) as a PEG-site infection pathogen, generally resistant to cephalosporins, has raised concerns over the use of prophylactic antimicrobials. Some studies showed benefits of pre-PEG MRSA screening and nasopharyngeal decolonization of MRSA in reducing peristomal wound infection rate^[123,124].

Peristomal leakage

This complication is more common among debilitated patients, those with previous gastric surgery and in patients with underlying medical conditions that predispose them to delayed wound healing. Peristomal leakage usually occurs within the first few days after PEG tube placement, although it can occur even in patients with a mature PEG tract. Evaluation of the leakage should include examination of the patient for any evidence of infection, ulceration, buried bumper^[83] or any other potential causes such as tube displacement, slowed gastric emptying, excessive gavage or residual, and enlarged gastric fistula. Intervention generally starts with meticulous prevention and continues with treatment of specific causes including underlying disease^[125]. Inserting a larger tube through the same PEG tube tract will create more problems such as further tissue breakdown resulting in an even larger stoma. In patients with a mature PEG tract, the PEG tube can be completely removed, allowing the tract to close completely. When medically indicated, another PEG tube can then be placed in another location on the abdominal wall.

Tube dislodgment

Tube dislodgment can occur when the gastrostomy tube either slides in or out of the gastrointestinal tract. If the tube slides too far into the gastrointestinal tract it can obstruct the gastric outlet. If the internal balloon deflates or the external bumper or disc is inadvertently removed, the gastrostomy tube can slide out. This is one of the common causes of emergency department presentation in patients with PEG tube and in some studies was reported

to occur in up to 12.8% of patients^[126,127]. In patients with a mature abdominal wall tract, *e.g.*, dislodgment of the tube more than a month after placement, the PEG tube can be replaced safely through the same tract without endoscopy. In the case of doubt, a water-soluble contrast study can be performed to confirm the location of the replaced tube prior to feeding. The remaining cases should be managed by endoscopic placement of a new PEG tube either near or even through the dislodged tube site^[110,128].

Gastric outlet obstruction

Although rare, PEG tube migration to the pyloric area can cause gastric outlet obstruction. Symptoms may include abdominal cramps and nausea and vomiting. This complication usually occurs when the external bolster migrates away from the abdominal wall, allowing the PEG tube to slide forward through the PEG tract into the duodenum^[129,130]. Maintaining the position of the external bumper 1-2 cm from the skin is the key factor in preventing the tube from being pulled into the stomach.

Pneumoperitoneum

Pneumoperitoneum is a common finding after PEG tube insertion and its prevalence is reported to be as high as 50% in some studies^[110,131]. In fact, post-PEG pneumoperitoneum is not generally considered a complication, because it does not cause any unfavorable consequences. This condition is usually related to air insufflation associated with the endoscopic procedure and needle puncture of the abdominal wall. In the absence of peritoneal signs, the presence of pneumoperitoneum should not prevent initiation or continuation of PEG feeding. However, the potential for bowel injury should be considered when free air (no matter how small) persists after 72 h of PEG insertion^[84,132-134].

PREPARATION

Informed consent should be obtained from patients or their legal surrogate decision makers. A considerable number of patients undergoing PEG tube placement do not have the required mental capacity to give informed consent, due to advanced dementia or other underlying medical conditions impairing their cognitive function (stroke, advanced cancer, failure of other internal organs). Obtaining consent from this population can be complicated. Several studies suggest that the quality of informed consent in patients undergoing PEG is inadequate^[135,136]. The intention of informed consent is to enhance the patient's care by giving the patient complete information on the benefits and burdens of tube feeding before PEG insertion.

Patients should fast overnight (8 h) and receive prophylactic antibiotics one hour before PEG tube placement. The current gold standard is intravenous administration of 1-2 g cephalosporin in the first one hour before tube insertion^[137].

Insertion technique

Since its introduction by Gauderer *et al.*^[4], several different techniques have been developed to insert the PEG tube. Generally, all of these methods share a common concept of insertion of the gastrostomy tube through the abdominal wall at a point where the stomach and abdominal wall are in closest contact. Herein, we briefly describe the 3 most commonly used techniques in clinical practice: "pull" technique, "push" (guide wire) technique and introducer (Russell) method. Finding the tube insertion site on the abdominal wall by endoscopic trans-illumination and one to one indentation is the first critical step in all these techniques.

The "pull" technique is the method initially introduced by Gauderer *et al.*^[4] and is currently considered to be the most common technique utilized to insert the PEG tube. In this method a string is inserted through a needle in the abdominal wall into the stomach, grasped with endoscopic biopsy forceps and then taken out through the esophagus and mouth. Subsequently the string is fixed to the external end of the feeding tube and the tube is pulled from the mouth to the esophagus, stomach and then out through the abdominal wall.

The first section of the "push" technique is similar to the "pull" technique. A guide wire is inserted into the stomach and pulled out through the mouth with the endoscope. The feeding tube is pushed over the guide wire into the stomach and out the puncture site^[138]. No significant differences in complication and efficacy rates between the pull and push methods have been reported^[138,139].

The introducer (Russell) technique^[140] uses the Seldinger method to place a guide wire into the stomach under endoscopic view. Afterwards, a dilating catheter and sheath are passed over the guide wire and after removal of the guide wire the feeding tube is advanced through the peel-away sheath.

Long-term protruding gastrostomy tubes may not be favorable in some patients due to the risk of peristomal leakage, inadvertent catheter dislodgment and cosmetic issues. These regular tubes can be replaced by a skin level low profile button gastrostomy tube after maturation of the stoma canal upon request by selected patients^[141-143]. Their higher cost and replacement, which is needed every 6 mo, limits their routine use and they are often reserved for adolescent patients for cosmetic reasons. Although one-step button gastrostomy tube insertion can be performed similar to the routine "pull technique" PEG tube placement, it is generally recommended that it is carried out following complete maturation of the stoma^[144].

POST-INSERTION CARE

After PEG tube insertion adequate pain relief should be administered. Many patients report abdominal discomfort after PEG insertion due to inflation of the stomach during the procedure. Traditionally, feeding was delayed until the next day due to the fear of peritoneal leakage risk after feeding. Many studies investigated the safety of

early feeding from 1 h to 6 h after PEG insertion, including a meta-analysis which found that feeding initiated as early as 4 h after PEG placement is safe^[145-150].

The stoma should be examined (for signs such as pain, discoloration, swelling, exudation, pus and leakage around the stoma) and cleaned daily. The tube should be rotated about 180 degrees and moved up and down about 1-2 cm in the stoma site on a daily basis after the stoma has completely healed.

The tube should be flushed before and after each feed and administration of medicine to prevent clogging of the tube and subsequent blockage. This blockage occurs particularly in small-bore feeding tubes secondary to feeding with thick formulas, inadequately crushed medications or incompatibility between medications and enteral feeds. In addition to regular flushing of the tube, dissolving medications in water before administration and preferential utilization of liquid forms of medications over solid-based forms are other preventive measures that should be taken to prevent clogging of the tube. If the tube is blocked, attempts can be made to clear it by attaching a 50 mL syringe filled with warm water to the tube and carrying out a pull and push technique. Gentle squeezing of the tube can help in some cases. Using pancreatic enzymes mixed with bicarbonate solution, prior to flushing with warm water, has been shown to be an effective method for unclogging the tube in some studies^[110,151].

REMOVAL OF PEG

Removal of the PEG tube is recommended when the tube is no longer needed or when complications such as persistent leakage or buried bumper syndrome require its removal. Experts have suggested using a “cut and push” technique for removal of PEGs in adults^[152-154]. However, reports of serious and sometimes fatal complications such as small bowel perforation and obstruction favor the use of endoscopic removal of PEG tubes^[155]. In children, tubes should always be removed by an endoscopic procedure due to the high risk of complications^[156-158].

In general, the PEG tract closes in the first few days after PEG removal, however, occasionally a gastrocutaneous fistula persists. Several factors such as prolonged duration of tube placement, local infection and underlying poor tissue healing contribute to delayed maturation of the PEG tract. Methods used to close the fistula include hemoclip placement and endoscopic band closure^[159,160].

CONCLUSION

Since its introduction in 1980, PEG has gained worldwide acceptance as a safe technique for providing enteral feeding in patients with poor oral intake who have a functional GI system. PEG tube placement has many indications, and is the recommended tube type if not contraindicated. PEG tubes can result in minor or even major complications, but most patients do well with them. The pull technique is the most commonly used method, but

other techniques are possible or even necessary in certain situations. Knowing when and how to place PEG tubes, as well as how to manage and even remove them, is an important part of the management of many patients. Quality and safe care of PEG tubes begin at pre-insertion screening and throughout post-insertion aftercare. Prevention of and proper management of complications are critical to ensuring successful outcome.

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