



# Multidisciplinary Practical Guidelines for Gastrointestinal Access for Enteral Nutrition and Decompression From the Society of Interventional Radiology and American Gastroenterological Association (AGA) Institute, With Endorsement by Canadian Interventional Radiological Association (CIRA) and Cardiovascular and Interventional Radiological Society of Europe (CIRSE)

Maxim Itkin, MD, Mark H. DeLegge, MD, John C. Fang, MD, Stephen A. McClave, MD, Sanjoy Kundu, MD, Bertrand Janne d'Othee, MD, MPH, Gloria M. Martinez-Salazar, MD, David Sacks, MD, Timothy L. Swan, MD, Richard B. Towbin, MD, T. Gregory Walker, MD, Joan C. Wojak, MD, Darryl A. Zuckerman, MD, and John F. Cardella, MD

## ABBREVIATIONS

GI = gastrointestinal, INR = International Normalized Ratio, NG = nasogastric, NJ = nasojejunal, OG = oral gastric, OJ = oral jejunal

## INTRODUCTION

Tube feeding has been practiced for more than 400 years (1). In addition to feeding, gastrointestinal (GI) access can be used for decompression in cases of enteral obstruction.

Temporary access can be achieved with a nasogastric (NG), oral gastric (OG), nasojejunal (NJ), or oral jejunal (OJ) feeding tube. These tubes can be placed “blindly” at the bedside, with the use of image guidance (eg, fluoroscopy, ultrasound), or with the use of endoscopic guidance. Unfortunately, natural orifice tubes often fail because of clogging as a result of their relatively small diameter or inadvertent dislodgement (2). More permanent enteral access can be obtained

surgically (open or laparoscopic) or percutaneously with endoscopic or image guidance, resulting in a gastrostomy, a jejunostomy, or a combination gastrojejunostomy. Although the indications for these enteral access devices are often similar, there are specific situations in which a particular enteral access tube may be more appropriate. More recently, the placement of a tube into the cecum (ie, cecostomy) has been described for GI decompression and as a treatment of fecal incontinence and constipation (3).

This document was written to be used as a practical guideline for the health care providers involved in creating and maintaining percutaneous gastroenteric access in adult patients, and covers the following

From the Department of Radiology, Division of Interventional Radiology (M.I.), University of Pennsylvania Medical Center, Pennsylvania Veterans Affairs Medical Center, Philadelphia; Department of Interventional Radiology (D.S.), Reading Hospital and Medical Center, Reading; Department of Radiology (J.F.C.), Geisinger Health System, Danville, Pennsylvania; Digestive Disease Center (M.H.D.), Medical University of South Carolina, Charleston, South Carolina; Division of Gastroenterology, Hepatology and Nutrition (J.C.F.), University of Utah Health Sciences Center, Salt Lake City, Utah; Division of Gastroenterology/Hepatology (S.A.M.), University of Louisville School of Medicine, Louisville, Kentucky; Department of Medical Imaging (S.K.), Scarborough General Hospital, Toronto, Ontario, Canada; Department of Radiology, Division of Interventional Radiology (B.J.d.), University of Maryland School of Medicine, Baltimore, Maryland; Division of Vascular Imaging and Intervention (G.M.M.-S., T.G.W.), Massachusetts General Hospital, Boston, Massachusetts; Department of Radiology (T.L.S.), Marshfield Clinic, Marshfield, Wisconsin; Department of Radiology (R.B.T.), Phoenix Children's Hospital, Phoenix, Arizona; Department of Radiology (J.C.W.), Our Lady of Lourdes Medical Center, Lafayette, Louisiana; and Mallinckrodt Institute of Radiology (D.A.Z.), Washington University School of Medicine, St. Louis, Missouri. Received April 7, 2011; final revision received and accepted April

8, 2011. Address correspondence to M.I., c/o Debbie Katsarelis, 3975 Fair Ridge Dr., Suite 400 N., Fairfax, VA 22033; E-mail: [maxim.itkin@uphs.upenn.edu](mailto:maxim.itkin@uphs.upenn.edu)

M.H.D. is a paid consultant for Cook Medical (Bloomington, Indiana). S.A.M. is a consultant for Kimberly Clark, Covidien, Nestle, and Abbott and is a recipient of research funds from Nestle and ACM Technologies. None of the other authors have identified a conflict of interest.

This article is being published concurrently in *Gastroenterology* 141(2), 2011. The articles are identical except for minor stylistic differences in keeping with each journal's style. Either citation can be used when citing this article. Permission to reproduce this article can only be granted by the copyright holder, the Society of Interventional Radiology. To request permission to print this article in a journal, Web site, or other publication, please contact the SIR at [dkatsarelis@SIR.org](mailto:dkatsarelis@SIR.org).

© SIR, 2011

*J Vasc Interv Radiol* 2011; 22:1089–1106

DOI: 10.1016/j.jvir.2011.04.006

topics: (i) patient selection, (ii) preprocedure evaluation, (iii) technical aspects of the procedures, and (iv) maintenance of the access. Quality assurance outcome measures for these processes, such as indications, success rates, and complication rates, are reported in this document.

## DEFINITIONS

*Gastroenteric access* is the establishment of an artificial access into the GI tract to provide feeding and decompression. This communication to the GI tract can be percutaneous or through natural orifices.

An *NG/NJ tube* is a flexible synthetic tube that is inserted into the stomach/jejunum through the nostril to provide feeding and/or decompression.

*Orogastric/Orojejunal tube* is a flexible synthetic tube that is inserted into the stomach/jejunum through the mouth to provide feeding and/or decompression.

*Percutaneous gastrostomy* is an artificial access into the stomach that is created through a small incision in the abdominal wall to provide food.

*Transabdominal access* is created when the gastrostomy tube is inserted through the abdominal wall into the stomach.

*Transoral access* is created when the gastrostomy tube is inserted through the mouth and then pulled or pushed through the stomach and abdominal wall.

A *gastropexy* is created by insertion of a gastropexy device (eg, T-fastener, suture) through the abdominal and stomach walls to secure the stomach while placing an enteric tube.

A *venting gastrostomy* is a gastrostomy created to decompress the upper GI tract for symptomatic relief in patients with distal obstruction or severe dysmotility.

*Percutaneous jejunostomy* is the creation of an artificial access into the small intestine through a small incision in the abdomen to provide feeding and/or decompression. Similar to gastrostomy, jejunostomy tubes can be inserted transorally or transabdominally.

*Primary jejunostomy* is the creation of a jejunostomy de novo.

*Secondary jejunostomy* is the percutaneous reestablishment of a previously created jejunostomy via a prior access site.

Similar to gastrostomy, jejunostomy tubes can be inserted transorally or transabdominally.

*Gastrojejunostomy* is the creation of access to the jejunum through the stomach.

*Cecostomy* is the creation of an opening in the cecum to facilitate an antegrade enema or to provide cecal decompression.

*Blind placement* is the placement of feeding tubes through the natural orifices without visualization of the access route.

*Endoscopic guidance* is the use of endoscopic equipment to visualize the intestinal tract to assist in the creation of enteric access.

*Image guidance* is the use of image guidance equipment, such as fluoroscopy, US, or computed tomography (CT), to visualize the intestinal tract to assist in creation of the enteric access.

## INDICATIONS

### Oral or Nasal Enteric Tubes

NG, OG, NJ, or OJ tubes are generally recommended for short-term use (ie, from a few days to 6 weeks). This can be for gastric or small bowel feeding or gastric decompression.

In general, patients who have facial trauma, nasal injury, or abnormal nasal anatomy that precludes nasal access are candidates for oroenteric tubes (4). There have been published data that indicate that patients with nasal airway intubation have more episodes of sinusitis than patients with oral airway intubation (5). From this study and other similar studies, the belief that there is a decreased incidence of sinusitis with an oroenteric feeding tube versus a nasoenteric feeding tube has been extrapolated. A prospective epidemiologic study (6) performed in patients in an intensive care unit noted that feeding through a nasoenteric tube, in addition to other factors, was associated with an increased risk of nosocomial sinusitis (odds ratio, 14.1) In patients with preexisting sinusitis, an oroenteric tube is preferred.

### Gastric Feeding

The gastric route is the most common artificial nutrition route used for feeding (7). Candidates for gastrostomy generally must have normal or near-normal gastric and small bowel motility. Their gastric anatomy has to be adequate to receive a gastric access tube. If a bolus feeding regimen is required for a patient, gastric feeding is most commonly prescribed, although there are no published, prospective, randomized trials demonstrating a superiority of bolus versus continuous gastric feeding (8).

### Small Bowel Feeding

Patients who are unable to tolerate gastric feedings, cannot receive a gastric enteral access tube as a result of altered anatomy, have gastric outlet or duodenal obstruction, have a gastric or duodenal fistula, or have severe gastroesophageal reflux disease should receive a jejunal feeding tube.

There has also been a great deal of discussion and clinical investigation regarding the use of small bowel feeding for the prevention of aspiration pneumonia. A metaanalysis by Heyland et al (9,10) reported a reduction in ventilator-associated pneumonia with small bowel feeding compared with gastric feeding. A separate metaanalysis by Marik et al (11) noted an odds ratio of 1.44 (95% CI, 0.84–2.46;  $P = .19$ ) for the risk of gastric feeding and the development of aspiration pneumonia compared with small bowel feeding. One prospective randomized trial (12) compared duodenal and gastric feeding showed that the nasoduodenal feeding group had a higher average daily calorie and protein intake compared with the nasogastric feeding group and achieved nutritional goals earlier. In terms of clinical outcomes, patients in the nasoduodenal feeding group had a lower rate of vomiting and ventilator-associated pneumonia (12).

The use of small bowel enteral feeding during episodes of pancreatitis has been a relative recent change in clinical practice. Multiple prospective, randomized trials have demonstrated improved outcomes, including decrease length of hospital stay, decreased infectious complications, and reduced overall health care cost with the use of jejunal feedings compared with parenteral nutrition (13,14). More recently, the use of gastric feedings in patients with acute pancreatitis has been evaluated, although a definitive conclusion regarding its appropriateness has not been determined (15).

### GI Decompression

For patients with GI obstruction or a GI fistula, decompression can be used to remove GI secretions and oral intake. A gastric decompression tube can be placed through the nose or mouth or percutaneously. Gastric decompression using a gastrostomy tube has been used with good clinical success (16). Some gastrojejunostomy tube systems have two ports (openings)—one into the stomach and one into the small intestine—and can be used for concurrent jejunal feeding and gastric decompression. There are some reports regarding the placement of small bowel feeding tubes for decompression of a small bowel obstruction. Direct small bowel decompression in these cases has resulted in improved clinical results compared with gastric decompression tubes (17).

### Intestinal Access for Biliary Procedures

Retrograde intestinal access can be the preferred access to the biliary system, especially in patients with previous surgically altered anatomy, such as Roux-en-Y anastomosis (18–20). The advantage of this approach is the ability to get access to the entire biliary tree from one access site. This route was found especially useful in patients who required repeat interventions in cases of large stone burden and biliary strictures (21).

### Cecostomy Tubes

Decompressive or lavage cecostomy tubes can be placed surgically or percutaneously with endoscopic or image guidance (22,23). Percutaneous cecostomy is indicated in patients with neurologic disease that results in fecal incontinence (eg, spina bifida, meningomyelocele, spinal cord injury, cerebral palsy) to facilitate cleansing enemas (24). Percutaneous cecostomy may also be indicated for chronic refractory constipation, chronic colonic pseudoobstruction, and colonic obstruction (25).

## CONTRAINDICATIONS TO ENTERAL ACCESS

### Absolute Contraindications

Absolute contraindications to tube placement include mechanical obstruction of the GI tract (unless the procedure is indicated for decompression), active peritonitis, uncorrectable coagulopathy, or bowel ischemia.

### Relative Contraindications

A number of other conditions represent relative contraindications to enteral access, such as recent GI bleeding, hemodynamic instability, ascites, respiratory compromise, and certain anatomic alterations. Recent GI bleeding from peptic ulcer disease with a visible vessel or from esophageal varices is associated with a high rate of recurrent bleeding, and therefore the decision to achieve access and initiate enteral nutrition should be delayed for 72 hours. Patients bleeding from angiodysplasia, gastritis, or stress gastropathy are at less risk for recurrent bleeding and therefore do not require a delay in seeking enteral access.

In case of interposition of the colon between the abdominal wall and stomach, percutaneous placement of a gastrostomy is contraindicated. In these cases, gastrostomy can be placed surgically.

Gastrostomy placement in the presence of ascites is difficult, increases the risk for bacterial peritonitis, and may impair maturation of the stoma tract. Gastrostomy tubes may be placed successfully after paracentesis if reaccumulation can be prevented for a period of 7–10 days after placement to allow the tract to mature. Gastropepy devices could be used to secure the stomach to the anterior abdominal wall.

Placement of the gastrostomy in the presence of the ventriculoperitoneal shunts may increase the risk of ascending meningitis (26,27).

Morbidly obese patients with a panniculus are at increased risk, as shifting of the panniculus in the postoperative period may dislodge the gastrostomy tube out of the stomach and into the peritoneal space.

Although fever and ongoing infection are a concern, they do not represent an absolute contraindication to tube placement.

Anatomic alterations such as an open abdomen, presence of ostomy sites or drain tubes, and surgical scars may alter the location for gastrostomy tube placement. Staying more than 2 cm away from a surgical scar reduces risk, as intervening loops of bowel tend to get trapped in the scar tissue immediately below the skin.

Specific problems that may preclude endoscopy guided placement include facial fractures, selective skull fractures with leakage of cerebral spinal fluid, high cervical fractures, and upper GI obstruction. In these cases, image-guided gastrostomy placement can be used successfully.

Problems that may impede image-guided placement include those conditions that prohibit transport to the radiology suite, such as hemodynamic instability, head injury with increased intracranial pressure, or cardiac dysrhythmias.

## PREPROCEDURE ASSESSMENT

### Management of Anticoagulant and Antiplatelet Therapy

Recently, the American Society for Gastrointestinal Endoscopy (ASGE) and Society of Interventional Radiology (SIR) issued recommendations regarding the management of patients receiving anticoagulant or antiplatelet therapy and patients with coagulopathy (28,29). Similar in essence, these recommendations are different in their approach. For that reason, both sets of recommendations are included here.

### ASGE Recommendations

According to the ASGE recommendations (30), the risk from bleeding related to the procedure itself must be evaluated with respect to the risk of a thromboembolic event if the anticoagulant or antiplatelet therapy is stopped. Preoperative assessment should focus on differentiating high-risk from low-risk procedures, and then determining whether the patient has a high-risk or low-risk condition (28,31). Procedural risk refers to the propensity for a given procedure to produce significant or uncontrolled bleeding should anticoagulant or antiplatelet therapy be continued

**Table 1.** Determination of Risk for Patients Receiving Anticoagulant or Antiplatelet Therapy Based on Procedure (28,31)

Low-risk procedure
Nasogastric/nasojejunal tube placement
Orogastric/orojejunal tube placement
Placement of jejunal tube through existing gastrostomy (mature stoma)
Secondary percutaneous jejunostomy (through mature stoma)
High-risk procedure
Percutaneous gastrostomy (image-guided, endoscopic)
Venting gastrostomy
Primary percutaneous jejunostomy (image-guided, endoscopic)
Percutaneous gastrostomy with immediate conversion to gastrojejunostomy
Cecostomy

throughout the intervention. A low-risk procedure would include routine use of endoscopy or fluoroscopy for tube placement, where no percutaneous incision is made. A high-risk procedure would include any enteral access technique that involves an incision or establishment of a fresh stoma (Table 1) (28,31). Risk based on patient condition relates to the probability of a thromboembolic complication occurring should anticoagulation or antiplatelet therapy be stopped before the procedure (Table 2) (28,31).

Recommendations for low-risk procedures regardless of patient condition are as follows (28,31). Anticoagulant therapy should be continued. If the patient is receiving warfarin, the International Normalized Ratio (INR) should not exceed therapeutic range and antiplatelet therapy should be continued. Recommendations for a high-risk procedure in patients with a low-risk condition are different. Warfarin should be stopped 5 days before the procedure. The INR should be checked on the day of the procedure and should be confirmed to be lower than 1.5. Warfarin may be started later on the night of the procedure, with the INR checked 1 week later. Clopidogrel therapy should be discontinued 7 days before the procedure, with aspirin therapy continued. Alternatively, if the patient is not receiving aspirin, aspirin therapy should be started as the patient discontinues receiving clopidogrel. Clopidogrel therapy may be restarted the day after the procedure (28,31).

Recommendations for a high-risk procedure in a patient with a high-risk condition are as follows. Warfarin should be stopped 5 days before the procedure. A therapeutic dose of low molecular weight heparin should be substituted, with the dose withheld on the morning of the procedure. That night, following the procedure, warfarin should be restarted at the full therapeutic dose. For clopidogrel therapy, the clinician should discuss the necessity of the procedure first with the primary care physician, as risk is significant. If the procedure is deemed to be essential, clopidogrel should be stopped 7 days before surgery and the patient given aspirin therapy in the interim. Clopidogrel therapy may be restarted on the morning after the procedure (28,31).

### SIR Recommendations

According to SIR recommendations (29), GI interventions involving percutaneous incision (eg, gastrostomy, jejunostomy, and cecostomy) are designated as category 2 procedures (ie, those with a moderate risk of bleeding). For this group of procedures, the following recommendations were issued:

1. INR: If greater than 1.5, correct until it is less than 1.5.
2. Platelets: If platelet count is lower than 50,000/ $\mu$ L administer transfusion until the count is greater than 50,000/ $\mu$ L.

**Table 2.** Determination of Risk for Patients Receiving Anticoagulant or Antiplatelet Therapy Based on Clinical Condition (28,31)

Patients receiving anticoagulant therapy	
Low risk	
Aortic metal valve	
Atrial fibrillation without valvular disease	
Xenograft valve	
Deep vein thrombosis > 3 mo after event	
High risk	
Mitral metal valve	
Atrial fibrillation with prosthetic valve	
Atrial fibrillation with mitral valve stenosis	
Deep venous thrombosis < 3 mo after event	
Thrombophilia syndromes	
Patients receiving antiplatelet therapy	
Low risk	
Coronary artery disease without stents	
Coronary artery disease with drug-eluting stents > 12 mo out	
Coronary artery disease with bare stents > 1 mo out	
Cerebrovascular accident	
Arteriosclerotic peripheral vascular disease	
High risk	
Coronary artery disease with drug-eluting stents < 12 mo out	
Coronary artery disease with bare stents < 1 mo out	

3. Clopidogrel: Withhold for 5 days before the procedure.
4. Aspirin: Do not withhold.
5. Low molecular weight heparin (therapeutic dose): Withhold one dose before the procedure.

### Antibiotic Prophylaxis

Patients undergoing gastrostomy placement are often at increased risk for infection secondary to poor nutritional status, advanced age, comorbidities, and immune compromise. Factors that increase risk for infection are patient-related (eg, diabetes, obesity, malnutrition, chronic steroid administration), technique-related (eg, transoral technique vs transabdominal technique or failure to provide antibiotic prophylaxis), and external bolster traction-related. The incidence of peristomal infection following percutaneous transoral tube placement ranges from 5.4% to 30.0% (32). The majority of infections (> 70%) are minor (32,33). Major infections requiring specific medical or surgical therapy are rare, involving fewer than 1.6% of cases (33). A metaanalysis of 11 prospective randomized trials (34) involving more than 1,100 patients has shown that there is a statistically significant decrease in the incidence of peristomal infection with the use of prophylactic antibiotics. A first-generation cephalosporin or some other similar agent that covers typical cutaneous organisms should be selected (34–36). Specific antibiotic prophylaxis is not required for these techniques in a patient who is already receiving antibiotics.

One of the advantages of the transabdominal route is the ability to avoid passage of a gastrostomy tube through the oropharynx, thus avoiding the exposure of the tube and subsequently the gastrostomy tract to oral flora. This potentially reduces the infection rate. A recent randomized controlled study (37) confirmed this assumption and demonstrated no statistically significant difference in rate of peristomal infection during transabdominal gastrostomy with or without administration of preprocedural antibiotics.

### Dietary Preparation

By general consensus, patients should be kept nil per os past midnight for a procedure the following day. However, it may be appropriate to provide clear liquids up to 2 hours before the procedure to reduce the risk of volume depletion.

### Laboratory Tests

Before the procedure, a complete blood count should be considered to confirm the platelet count, to evaluate for presence of anemia, or to identify an increased white blood cell count suggesting infection. If a percutaneous procedure is involved, prothrombin, partial thromboplastin, and INR should be checked. An arterial blood gas analysis is not required, as oxygen saturation is monitored continuously throughout most radiologic and endoscopic procedures. Obtaining an arterial blood gas analysis should be considered if there is concern for respiratory compromise or that the patient might not tolerate conscious sedation. For patients at high risk, the procedures may need to be scheduled with anesthesia to provide better airway control and monitoring of hemodynamic stability.

SIR recently issued the following recommendations regarding laboratory testing before the procedure (29):

INR: Recommended for all patients.

Activated PTT: Recommended for the patients receiving intravenous unfractionated heparin.

Platelet count: Not routinely recommended.

Hematocrit: Not routinely recommended.

### TECHNICAL ASPECTS

Since its original description in 1980, multiple variations of the percutaneous enteric access technique using different guidance modalities (eg, endoscopic, fluoroscopic and US) have been published. However, regardless of the guidance method, the main difference between the percutaneous techniques is the route by which the feeding/decompression tube is introduced into the intestinal tract: through the abdominal wall or through the natural orifices. At the beginning, the guidance modality was associated with the insertion route; for example, endoscopy guidance was used to insert the gastrostomy through the mouth and image guidance was used to insert the gastrostomy through the abdominal wall. Recognizing that both techniques have their advantages and disadvantages (eg, better anchoring with peroral route and lesser infection rate with transabdominal route) in different clinical situations, gastroenterologists and radiologists have adopted both insertion routes. For that reason, we decided to refrain from addressing the insertion technique as “endoscopic” or “radiologic,” but instead propose modified enteric access terminology (Table 3). In general, it is based on the route of access introduction (natural orifices vs transcutaneous) and the method of guidance (endoscopic vs image-guided).

### Nasoenteric and Oroenteric tubes

**Bedside enteric tube placement.** Bedside enteric tube placements are the most common enteral access technique used in the hospital and long-term care environments. A NG, NJ, OG, or OJ tube may be placed blindly.

There are many techniques available for passing bedside NG or OG tubes. Typically, an 8–12-F tube is passed into the stomach after the tube has been lubricated, the head is flexed, and the patient ingests sips of water to assist in passing the tube into the stomach (38). Many centers promote bedside auscultation for confirmation of an adequate position of the tube before use. However, this can be misleading, as inappropriate tube locations, such as in the lung, in the pleural cavity after perforation, or coiled in the esophagus may be misinterpreted as in proper position by bedside auscultatory techniques. For this reason, every patient should undergo radiography to confirm proper position of an NG or OG tube before feeding is initiated (39). Because blind, bedside gastric tube placement is often successful and reproducible from person to person, rarely is endoscopic or fluoroscopic placement necessary.

Blind NJ or OJ tube placement is more difficult than NG or OG

**Table 3.** Proposed Modified Enteric Access Terminology Based on Route of Access Introduction and Method of Guidance

Stoma/Target Organ		Placement Route	Guidance System	Examples of Previously Used Terminology	Suggested Term (Abbreviation)
Natural orifice					
Gastric	Nasal		Blind, endoscopic, image guided	NG tube (Dobhoff)	NG tube
	Oral		Blind, endoscopic, image guided	OG tube	OG tube
Jejunal	Nasal		Blind	NJ tube (corkscrew)	BNET
			Endoscopic	NJ tube (magnet, GPS, EKG)	
			Image guided	ENET (drag-and-pull, over guide wire), NJ tube (fluoroscopy guided)	ENET, INET
Colonic	Rectal		Endoscopic, image guided	Colonic decompression tube	Endoscopic guided colonic decompression tube, image-guided colonic decompression tube
Percutaneous					
Gastric	Transoral		Endoscopic, image guided	PEG (Ponsky pull, Sacks–Vine push), PIG	Transoral PEG, transoral PIG,
	Transabdominal		Endoscopic, image guided	(mushroom-retained, pull-through), PEG (Russell introducer), PRG (small-bore, large-bore, balloon-tip, retrograde, sonographic)	transabdominal PEG, transabdominal PIG
Jejunal	Direct transoral		Endoscopic	PEGJ (Johlin, Kirby), DPEJ	Transoral PEJ, transabdominal
	Direct transabdominal		Endoscopic, image guided	(one-step, two-step), PEGJ, DPEJ	PEJ, transabdominal PIJ, PEGJ, PIGJ
	Transgastric		Endoscopic, image guided		
Colonic	Transrectal		Endoscopic	Cecostomy	Transrectal PEC,
	Transabdominal		Image guided	Cecostomy (percutaneous, Chait Trapdoor)	transabdominal PIC

Note.—BNET = blind nasoenteric tube; DPEJ = direct percutaneous endoscopic jejunostomy; EKG = electrocardiography; ENET = endoscopy-guided nasoenteric tube; GPS = global positioning system; INET = image-guided nasoenteric tube; NG = nasogastric; NJ = nasojejunal; OG = orogastric; PEC = percutaneous endoscopy-guided cecostomy; PEG = percutaneous endoscopy-guided gastrostomy; PIC = percutaneous image-guided cecostomy; PIG = percutaneous image-guided gastrostomy; PEGJ = percutaneous endoscopic gastrojejunostomy; PEJ = percutaneous endoscopy-guided jejunostomy; PIGJ = percutaneous image-guided gastrojejunostomy; PIJ = percutaneous image-guided jejunostomy; PRG = percutaneous radiologic gastrostomy.

tube placement. A number of techniques have been promoted for blind bedside placement of an NJ or OJ tube. One common technique uses a stylet-filled tube (stiffened) and a corkscrew motion on the tube (40, 41). In a separate technique described by Ugo et al (42), the patient is placed into the right lateral decubitus position and the nasoenteric tube is tracked into proper position in the small bowel by auscultation. This technique resulted in an 83% rate of successful bedside NJ tube placement. In general, with blind bedside small bowel tube placement, unweighted (as opposed to weighted) feeding tubes should be used, as their success rate for spontaneous small bowel passage is far greater (92% vs 56%) (43). Good success with NJ/OJ tube placement requires practice and familiarity with a standard technique (44).

There have been many attempts to position a tube beyond the pylorus with the use of pharmacologic agents. A Cochrane review (45) of the use of metoclopramide for nasoenteric tube passage noted that there was drug-enhanced migration of nasoenteric tubes through the pylorus, although the success rate did not reach statistical significance

compared with placebo. To date, there cannot be a definitive statement for or against the use of pharmacologic agents to promote NJ or OJ tube passage.

More recently, devices have been developed to aid in passage of enteric tubes through the pylorus into the jejunum. A bedside magnet has been developed to assist in blind passage of bedside tubes into the jejunum by attracting a metal tip on the end of the tube and guiding the tube into proper position. In a report of 20 patients (46), there was a 95% rate of successful tube passage in an average of 9.6 minutes. An alternative device uses an NJ/OJ tube with an electromagnetic transmitter to create an image on a bedside monitor to track tube passage into the small bowel (47,48). Similar success rates have been reported with this technique as with the bedside magnet technique. Another technique requires the use of continuous gastric electromyography (49). Right and left arm leads from an electrocardiography machine are attached to left and right upper abdominal locations. Lead V5 is attached to the jejunal feeding tube. The NJ or OJ tube is advanced into the stomach after gastric insufflation. When the QRS com-

plex in lead V5 has changed polarity, it documents that the tube has crossed the midline of the body by passing through the pylorus. pH paper is used to check the tube aspirate for an alkaline pH consistent with small bowel placement. The limitations of definitively recommending any of these bedside devices to aid in NJ or OJ tube placement is the small number of studies currently available that document adequate success without complications.

Failure to blindly pass an NJ or OJ tube at the bedside requires the use of fluoroscopic or endoscopic methods of passage. The preference of either technique is center-dependent and relies on local expertise.

### Placement of NJ or OJ Tubes Under Endoscopic Guidance

Endoscopy-guided placement of NJ or OJ feeding tubes can be done at the bedside with or without moderate sedation. The drag-and-pull method is the method with the longest history (50). In this technique, a suture or other material is attached to the end of an NJ/OJ tube. This suture is used to drag the tube into position in the small intestine by the use of a grasping forceps. Difficulty usually occurs in releasing the suture from the grasping forceps, resulting in inadvertent displacement of the tube back into the stomach. A second common technique for tube placement, the over-the-wire technique, requires the initial placement of a guide wire into the small intestine. An endoscope is advanced into the distal duodenum or proximal jejunum, and a guide wire is passed through the biopsy channel of the endoscope, well into the proximal jejunum. The endoscope is removed and the guide wire is left in place. A feeding tube is subsequently passed blindly or with fluoroscopic assistance into position in the small intestine. Patrick et al (2) reported a 94% success rate with the use of this technique. Because the guide wire is passed orally, if an NJ tube is required, an oral/nasal transfer of the guide wire must be performed. A third endoscopy-guided technique uses a small-caliber endoscope for nasoenteric endoscopy (51). The small-caliber endoscope is passed into the small intestine through the nose. No sedation is required. A guide wire is advanced further into the jejunum, the endoscope is removed, and the guide wire is left in place. An NJ tube is passed over the guide wire into the small intestine, and the guide wire is then removed. No oral/nasal transfer of the guide wire is required. Success rates greater than 90% have been reported with this technique. A fourth technique uses the instrument channel of an endoscope to pass feeding tubes into position in the small intestine (52). A therapeutic gastroscope should be used with a 3.7-mm instrument channel. The endoscope is advanced into the small intestine. An 8- or 10-F feeding tube can be advanced through the endoscope into position in the small bowel. The endoscope is removed while the feeding tube tip is maintained in position. A feeding bolus adapter is then attached to the end of the feeding tube so it can engage a syringe or feeding set. An oral/nasal transfer is required if an NJ tube is desired. A fifth technique uses a 12-F small-bowel feeding tube. Two guide wires, a 0.035 inches and 0.052 inches in size, are placed into the feeding tube to the tip, but not out the end of the feeding tube (53). The patient receives upper endoscopy with a standard gastroscope. When the endoscope has reached the stomach, the stiffened feeding tube is passed into the stomach blindly through the nose or mouth. The endoscopist watches as the feeding tube is simply pushed into position into the small intestine. If the tube tip is having difficulty getting to or through the pylorus, the endoscope or a closed forceps, advanced through the instrument channel, can be used to nudge the tip of the tip into proper position. The final position of the tube in the small bowel is confirmed endoscopically. The endoscope is then removed. Because the feeding tube is stiffened, it does not get pulled back into the stomach by the endoscope upon its removal. The guide wires are removed, and the tube is ready for use.

### Placement of NJ or OJ Tubes Under Image Guidance

Placement of NJ tubes under fluoroscopy guidance can be performed at bedside by using a portable fluoroscopy unit and in the radiology department by using a stationary fluoroscopy machine. The techniques

are different and depend on local expertise and availability of the disposable interventional equipment. In the simplest scenario, the NJ tube is manipulated inside the stomach toward the pylorus by using a malleable internal stylet while opacifying the stomach with contrast medium. The patient is positioned in the right decubitus position to facilitate the passage of the tube. The success rate of this method is approximately 90% (54,55). A more sophisticated approach is to use an angled angiographic catheter to advance the guide wire through the pylorus and beyond the ligament of Treitz and then advance the feeding tube over the wire. This modification increases the success rates to 97% (56). This method is especially popular in the pediatric patient population (56,57). A similar technique that uses standard angiographic equipment was used successfully to place NJ tubes in patients with postoperative gastric and jejunal leaks (58).

### Outcomes of Nasoenteric and Oroenteric Tube Placement

The success rates of blind NJ and OJ placement vary from institution to institution but are low in general and range between 56% and 92% (42,43). Good success with NJ/OJ tube placement requires practice and familiarity with a standard technique (44). The success rate is higher for unweighted NJ/OJ tubes (43).

Several recent prospective randomized clinical trials that compared endoscopy-guided and image-guided placement of postpyloric tubes demonstrated no difference in success rate (51,54,55). The success rate for endoscopy-guided or image-guided placement of NJ/OJ tubes is greater than 90% (2,52,56–58).

Between 40% and 80% of NG tubes become dislodged (59). Approaches to fixing the nasoenteric tube to the nose or head have generally involved adhesive devices such as tape or clamps. Unfortunately, these fixing methods generally do not prevent a patient from removing the tubes, especially patients who are in a state of confusion.

The use of nasal bridles has been shown to have few complications and minimal discomfort (60). A bridle loop is a piece of thin tubing or suture that is passed in one naris, around the posterior bony portion of the nose, and out the other naris. It is then secured to the tube by tying it around the tube or using some other attachment technique. Reports on nasal bridle success have been mixed. Some studies have noted intolerance to a bridle by some patients and also the ability of the patient to still remove the NG tube with the bridle remaining in place (59). Another prospective study (61) evaluated a bridle to hold a nasoenteric tube in place versus taping the tube to the patient's nose or face. There was a significant reduction in accidental tube removal in the bridle group versus the tape group (10% vs 36%;  $P < .05$ ). Tube survival rates, as determined by a Kaplan–Meier analysis, also were increased in the bridle group (61).

### Percutaneous Gastrostomy

Generally, percutaneous gastrostomy can be divided in two groups by the way the tube enters the stomach: transoral or transabdominal. Each method uses different tube design and possesses advantages and disadvantages. One of the main disadvantages of the transoral technique is the increase rate of the peritubal infection rate and gastrostomy tract seeding with tumor in patients with upper GI tract or ear/nose/throat cancers (62). On the contrary, transabdominal insertion is less secure and smaller diameter, resulting in more frequent dislodgment and occlusion (63). Endoscopic or image guidance can be used for placement of the tubes. Both guidance techniques have certain advantages and disadvantages. Endoscopy-guided gastrostomy can be performed at the bedside, thus eliminating the need to transport the patient to the radiology suite (64). In addition, there is no radiation exposure. Another advantage of endoscopy-guided gastrostomy is that other diagnostic and therapeutic endoscopic maneuvers can be performed at the same time. Abnormal endoscopic findings have been identified during 10%–71% of gastrostomy procedures and altered management in as many as 36% (65). The advantage of the image guidance is the ability to perform procedure in patients with severe narrowing of the

upper GI tract and in morbidly obese patients in whom endoscopic transillumination is difficult (66).

### Transoral Gastrostomy Placement

**Endoscopic guidance.** Transoral endoscopy-guided gastrostomy tubes (also known as percutaneous endoscopic gastrostomy tubes) are most commonly placed using the Ponsky (ie, “pull”) technique (67). The stomach is insufflated with air and an optimal site for gastrostomy placement is determined by simultaneously transilluminating the gastric/abdominal wall and indenting the abdominal wall with a finger while visualizing that indentation endoscopically. Sterile technique should be followed for the percutaneous component of the procedure. The abdominal wall and peritoneum are anesthetized by injection of lidocaine. To help confirm that no interposed loops of bowel are present between the stomach and abdominal wall, the safe-track maneuver should be performed (68). The anesthetic needle is advanced into the stomach while aspirating with the plunger. Simultaneously, the endoscopist confirms gastric puncture by visual inspection and with air aspiration into the syringe. A small skin incision is made and a trocar is inserted through the abdominal wall into the stomach. A guide wire is passed through this trocar and grasped endoscopically. The guide wire is then withdrawn through the mouth and a gastrostomy tube is affixed to it. Finally, the guide wire is pulled back through the esophagus, stomach, and abdominal wall and held into place by a solid mushroom-type internal retention device and an external bumper. The external bumper should be placed approximately 1 cm or more from the abdominal wall (69).

A second method of endoscopy-guided gastrostomy placement uses the push introducer method. It is similar to the pull method except an introducer tube with a hollow central lumen is used. After the guide wire is placed, the introducer tube is threaded over the guide wire. It is then advanced over the guide wire from the mouth and pushed until it emerges from the abdominal wall. It is then grasped manually and pulled into position as described earlier. The push and pull gastrostomy placement methods are equally effective (70,71).

**Image guidance.** Similar transoral gastrostomy tube placement was described with fluoroscopic guidance (63,72–74). To identify a “safe window,” an abdominal CT or US examination can be performed and/or reviewed before the procedure (73). Optionally, oral barium can be administered the day before procedure to opacify the colon. In difficult cases, especially in the pediatric population, an abdominal US and water-soluble enema are performed during the procedure (75). In complicated cases in which it is difficult to identify the safe window by using fluoroscopy, the procedures can be performed under CT guidance (76). First, an NG tube is inserted and the stomach is insufflated with air. To reduce stomach motility and retention of the air, 1 mg of glucagon (73) or hyoscyamine (74) can be administered before insufflation, based on operator preference. Under fluoroscopy, the skin entry point in the middle body of the stomach and away from the rib margin is identified. The skin is anesthetized with lidocaine, and a 1–1.5 cm incision is made. A slightly curved 18-gauge needle or vascular sheath (74) is advanced into the stomach and pointed toward the gastroesophageal junction. The guide wire is then advanced with or without help of angiographic catheter, into the esophagus, then into the oropharynx, and out of the mouth. The gastrostomy tube is then threaded over the wire, advanced until it emerges from the abdominal wall, and then pulled into the desired position (63,74). If the advancement of the guide wire through gastroesophageal junction is unsuccessful, a snare loop can be placed through the mouth into the stomach to capture the guide wire (74). Some authors reported routine use of a snare (77). The external bumper is then positioned as described earlier (“Endoscopy guidance”).

### Transabdominal Gastrostomy

**Image guidance.** The transabdominal gastrostomy technique was initially described with the use of fluoroscopic guidance (78–80). The identification of the safe window and skin entry site is performed as described earlier. First, the stomach is insufflated with air through an NG tube. To secure the stomach wall to the abdominal wall, one to four gastropexy devices are deployed (79,81). The stomach is then accessed with the needle toward the pylorus; this is to facilitate future conversion of

the gastrostomy tube to a gastrojejunostomy. A guide wire is then advanced and the tract is dilated. A 10–20-F gastrostomy tube is placed through the dilated tract.

If an NG tube cannot be passed through the nasopharynx and esophagus, the stomach can be inflated through a small needle inserted through the abdominal wall into the stomach (82). During the early days of transabdominal placement of gastrostomy tubes, gastric wall fixation was argued to be imperative (79,81). However, some authors related peristomal infection (63), persistent leakage, and gastrocutaneous fistulas (83) to the use of the gastropexy and raised questions about their necessity and safety (84). Deutsch et al (85) described 64 cases of transabdominal gastrostomy that were performed without gastropexy, with no related complications. Dewald (86) reported on a series of 701 patients in whom gastrostomy and gastroenterostomy were performed with gastropexy and also did not observe gastropexy-related complication. A more recent randomized study (87) demonstrated a 10% major complication rate in the no-gastropexy group and a 26% minor complication rate related to gastropexy. In some groups of patients in whom there is a high chance of intestinal leakage (patient with ascites, malnourishment, and/or steroid treatment), placement of the gastropexy sutures is imperative (88,89).

Recommendations regarding timing of gastropexy removal vary between 1 and 3 weeks. In a recent retrospective study (90), the gastropexy was cut 2 days after the procedure in 109 patients, and no complications were demonstrated.

**Endoscopic guidance.** Endoscopy guidance for transabdominal placement of the gastrostomy tubes was introduced by Russell in 1984 (91). Recently, several authors (62,92–94) revived this approach in patients with head and neck cancer because of the incidence as high as 1% of gastrostomy tract seeding after using the transoral approach. Even though the details of the procedure varied depending on availability of the equipment, in general, the steps are as follows: following access to the stomach with an endoscope, the gastropexy is performed using T-fasteners (94) or gastropexy suture (92). The stomach is then accessed transabdominally with a needle, a guide wire is passed through the needle, the tract is dilated over the wire, and a balloon-tip gastrostomy catheter is placed into the stomach through the peel-away sheath (62,92,94).

### Outcome of Percutaneous Gastrostomy Methods

Overall success rates and complications (major and minor) are very similar for transabdominal and transoral gastrostomy. Reported success rates for percutaneous gastrostomy are 95%–100%. One metaanalysis (95) found a higher success rate (99.2% vs 95.7%) and lower complication rate (13.3% vs 29%) for transabdominal versus transoral gastrostomy. However, more recent studies have reported similar outcomes for both methods (96–98).

### Percutaneous Gastrojejunostomy

**Endoscopic guidance.** Percutaneous endoscopic gastrojejunostomy places a jejunal feeding tube through a gastrostomy into the small bowel using a variety of over-the-wire methods. If a patient already has a gastrostomy tube in place, conversion to a percutaneous endoscopic gastrojejunostomy does not require an additional skin puncture. Jejunal extension tubes (8–12 F) are available to match corresponding 20–28-F gastrostomy tubes. Previous non-guide wire methods required dragging the jejunal tube itself into the small bowel by grasping a suture attached to the tube. Removal of the endoscope from the jejunum and/or forceps from the attached string usually led to displacement of the jejunal tube back into the stomach. Most commonly, a guide wire is placed through an existing gastrostomy tube and is grasped endoscopically with a forceps or snare. An air plug device placed in the external gastrostomy tube allows for gastric insufflation for maximal endoscopic visualization. With a pediatric colonoscope or dedicated enteroscope, the guide wire is carried into the jejunum. The forceps and wire may then be passed an additional approximately 10 cm past the tip of the endoscope for deeper placement. The jejunal extension tube is then threaded over the guide wire into the small bowel under direct endoscopic visualization (99). Advancing the forceps or snare to maintain the guide wire in the jejunum as the endoscope

is withdrawn into the stomach helps to prevent dislodgment of the jejunal extension tube. When the endoscope has reached the stomach, the guide wire is released from the grasping forceps and the guide wire is removed while endoscopic confirmation of proper passage of the jejunal tube through the pylorus and absence of gastric looping is performed.

If there is a mature gastrostomy stoma site, the existing percutaneous gastrostomy can be removed and a wire or single-piece gastrojejunal feeding tube can be grasped endoscopically and carried into the jejunum as described earlier.

Another technique uses an ultrathin endoscope (5–6 mm in diameter) or pediatric bronchoscope (3–4 mm) passed through a large-diameter gastrostomy tube or mature gastrostomy tract into the small intestine. A guide wire is fed through the endoscope deep into the small bowel, and the endoscope is removed. The jejunal extension tube or single-piece gastrojejunoscopy tube (a jejunal tube manufactured permanently molded within a gastrostomy tube) is then passed over the wire into position and the wire is removed (100). With either method, the jejunal tube is advanced into place blindly or, more commonly, with fluoroscopic guidance. With any of the jejunal extension tube techniques, cutting the external gastrostomy tube length to shorter than 10 cm and using an extension tube of longer length will allow for deeper and more stable position in the jejunum. Placement of the gastrostomy position to the right of midline and lower in the antrum allows for a shorter, more direct route for the jejunal tube through the pylorus. This will minimize gastric looping and help prevent proximal migration.

**Image guidance.** Fluoroscopy guidance can be used to place a gastrojejunoscopy (101). The initial steps of the procedure are similar to those in transabdominal or transoral gastrostomy placement. To facilitate placement of the gastrojejunoscopy, puncture of the stomach is performed in the direction of the pylorus. If a transabdominal approach is used, gastropexy is performed and the vascular sheath is advanced into the stomach. Through this sheath, with the use of a stiff angiographic catheter or metal cannula (102), the wire is advanced into the small intestine beyond the ligament of Treitz. Donnelly et al (103) compared the use of different directional devices and their effect on radiation exposure in a pediatric population and found no difference in performance. The wire is then exchanged for the gastrojejunoscopy tube. In the transoral approach, the gastrostomy is initially performed and then the jejunal feeding tube is placed through the gastrostomy using a similar technique. If the tract is matured, the gastrostomy tube is removed, and catheterization of the proximal jejunum is performed using the technique described earlier. When using a surgical or endoscopy-guided gastrostomy tube, the subsequent placement of a jejunal catheter through the gastrostomy tube into the pylorus can be challenging. The gastrostomy tube is often facing away from the pylorus. This angle results in an additional challenge for fluoroscopy-guided jejunal tube placement, as the jejunal tube coils in the stomach fundus while the tube is advanced over the wire. A stiff wire, or sometimes two wires, may be used to overcome this obstacle.

## Outcome of Percutaneous Gastrojejunoscopy Methods

Success rates for percutaneous gastrojejunoscopy range from 90% to 100% (98,104–106). Studies have not shown significant or unique differences in success or complication rates between endoscopy-guided and fluoroscopy-guided gastrojejunal feeding tubes.

## Percutaneous Jejunostomy

**Endoscopic guidance.** Direct percutaneous endoscopic jejunostomy allows for direct percutaneous jejunal access and is performed in a manner similar to that of the pull endoscopy-guided gastrostomy technique (107). Any commercially available pull-type gastrostomy kit can be used, most commonly with 16–20-F tubes. A pediatric colonoscope or dedicated enteroscope is advanced to the small bowel until a site is identified by transillumination and finger indentation. Confirmation of discrete finger indentation at the site of transillumination is critical to the success and safety of the procedure. If no site is identified after advancement of the endo-

scope to its greatest insertion depth, controlled purposeful withdrawal is begun. When a potential site has been identified, a 19–21-gauge sounding/anesthetic needle is advanced into the small bowel. Use of a small-bore sounding needle allows for unsuccessful passes without significant adverse effects. When the sounding needle has been successfully passed into the jejunum under endoscopic visualization, stabilization of the site is obtained by snaring the sounding/anesthetic needle and anchoring the small bowel against the anterior abdominal wall (108). A 1-cm longitudinal skin incision is made by making stab wounds on both sides of the sounding needle. The larger hollow trocar is passed next to the sounding needle, the sounding needle is released, and the trocar is grasped with the snare. The insertion wire is passed through the trocar and grasped endoscopically. The safe-track technique is used when passing the sounding needle and trocar to ensure no bowel loops or stomach is interposed. The remainder of the procedure is as described for the endoscopy-guided gastrostomy pull technique. Although not absolutely necessary, repeat enteroscopy to confirm appropriate placement and approximation of the internal bumper to the anterior gastric wall may be performed.

Thin (as opposed to obese) body habitus and previous upper digestive tract surgery increase the likelihood of success (109). Care must be taken in patients with previous Billroth II anastomosis to identify and place the jejunostomy in the efferent limb. The afferent limb may be identified by recognition of the ampulla of Vater or blind end of the afferent loop. Glucagon may be used to decrease small bowel peristalsis, and repeating the procedure under general anesthesia may also increase the success rate. Periodic light amplification by using the transillumination function on the light source may also aid in localizing an appropriate site. Fluoroscopy and US have been reported to aid in localization, but they are not required in most cases (110,111). Procedure times are much longer than for gastrojejunoscopy as a result of the additional time required to find an appropriate site for stoma placement.

**Image guidance.** Image-guided jejunostomy is favored in patients with upper GI stenosis that prevents passage of an endoscope. Compared with gastrostomy, primary fluoroscopy-guided jejunostomy represents considerable challenge. The main obstacle is the mobility of the intestine, which result in difficulty advancing of the access equipment (21). Different jejunostomy techniques have been described, but, in general, they include the following steps. Identification of the target bowel loop is performed by advancing an angiographic catheter into the proximal jejunum and insufflating it with air and contrast agent (112) or placing an angioplasty balloon (21,113) or snare loop (114) in the desired location to serve as a target. Several authors describe the use of US guidance following injection of the saline solution and contrast agent into the proximal jejunal loop (115,116). The jejunal loop is accessed with a needle, and a T-fastener device is then delivered to secure the loop against the abdominal wall. A guide wire is then advanced through the needle, the tract is dilated, and the jejunostomy tube is placed. The jejunostomy is then injected with contrast agent to confirm the position. Most authors described the use of a tapered Cope loop catheter as their choice for primary jejunostomy (116). Secondary jejunostomy is performed to reestablish a previously created surgical jejunostomy. Reestablishment of jejunal access has reported to be necessary in 4.9% of patients after esophagectomy (117). Because the jejunal loop is already surgically tacked to the abdominal wall, the success rate of the procedure appears to be higher, and the complication rate lower (115,117). The technique of secondary jejunostomy is similar to that of primary jejunostomy with two exceptions: the surgical scar serves as a skin entry site, and, in some cases, there is no need to use T-fasteners because of surgical adhesions that secure the loop to the abdominal wall.

Retrograde jejunostomy through the afferent loop of the Billroth II anastomosis has been described as a means to access the Roux-en-Y biliary-jejunal anastomosis to treat anastomotic stricture, extraction of biliary stents and stones, decompression of the afferent loop, feeding, and diagnostic purposes (18,20,21). Some biliary surgeons mark the location of the loop with metal markers to facilitate future interventions (18).



## Outcome of Direct Percutaneous Jejunostomy Methods

Percutaneous endoscopic jejunostomy placement is successful in 68%–100% of attempts (104,118–120). The patient populations in these series contained a combination of patients with intact GI tracts and patients who had undergone previous GI surgery. The most common cause of failure was inadequate transillumination (50%) and gastric outlet or proximal small bowel obstruction (30%) (121).

Success rates after percutaneous image-guided jejunostomy were reported to be 87%–100% (112,115–117). The main reason for failure was difficulty in accessing the mobile intestinal loop. The success rate for secondary jejunostomy appears to be higher (115,117), but one group (21) reported a lower success rate for secondary jejunostomy (81%) than for primary jejunostomy (95%). Reported complications have been reported in 0%–15% of cases (21,114,116,117). The most severe complications were peritonitis as a result of puncture of the intestinal loop and subsequent loss of access (21) and GI bleeding (114).

There have been no comparison studies of endoscopic- and image-guided jejunal feeding tubes. Endoscopy-guided jejunostomy is less likely to be associated with inadvertent tube dislodgement as a result of the more secure mushroom-type internal bolsters (compared with pigtail catheters in image-guided jejunostomy); tube dysfunction is less common given the larger-bore tubes typically used (18–20 F with endoscopy guidance vs 10–14 F with image guidance).

In comparison studies, direct jejunostomy tubes have demonstrated greater longevity and decreased need for repeat intervention compared with gastrojejunostomy (104,122,123). This is likely a result of the greater stability in the jejunum and larger diameter of jejunostomy tubes compared with gastrojejunal feeding tubes. Therefore, in some cases, it may be advantageous to place separate direct gastrostomy and jejunostomy tubes rather than a single combined gastrojejunal tube.

## Percutaneous Cecostomy

**Endoscopic guidance.** The percutaneous endoscopy-guided cecostomy procedure is similar to that described for endoscopy-guided gastrostomy (124). Standard colonoscopy preparation with a polyethylene glycol solution is administered orally the night before the procedure. In patients with refractory constipation, a prolonged (2 d) preparation can be performed. In patients with refractory constipation whose colon is still inadequately prepared or those with pseudoobstruction, endoscopic lavage can be performed by infusing 1–2 L of polyethylene glycol solution as far proximally in the colon as possible, with the procedure attempted the next day (125). For the cecostomy procedure, a colonoscope is advanced to the cecum and the appropriate site is identified in the right lower quadrant by finger indentation and transillumination, similar to the endoscopy-guided gastrostomy procedure. The remainder of the procedure is as described for the endoscopy-guided gastrostomy pull technique. The cecum may be secured to the abdominal wall to help prevent leakage of fecal contents using fixation devices (similar to gastropexy) arranged in a triangular configuration around the cecostomy site to create a cecopexy immediately before or after cecostomy tube placement (23,126).

**Image guidance.** Fluoroscopically guided percutaneous cecostomy can be used as a treatment of fecal incontinence in children. It is performed according to the technique described by Chait et al (24,127). Several days before the procedure, a barium enema is performed to identify the location of the cecum. Initially, the cecum is distended with air, and, under fluoroscopy guidance, access to the cecum is obtained using an 18-gauge needle. After confirming the position of the needle in the cecum by injecting contrast material, cecum wall fixation devices (similar to gastropexy devices) are deployed to secure the position of the cecum against the abdominal wall. A guide wire is then advanced in the cecum; the tract is dilated and an 8–10-F Cope loop catheter is advanced. The catheter is then attached to gravity drainage for several days. The patient is then discharged home with instruction to flush the catheter twice a day. Six weeks later, the Cope loop catheter is exchanged for a low-profile Chait Trapdoor cecostomy catheter designed to accommodate different lengths of subcutaneous tissue.

In the adult population, cecostomy is indicated in cases of toxic megacolon and colonic obstruction (128–130). The technique is similar to the technique described earlier for initial access in the pediatric population and is somewhat easier as a result of the marked distention of cecum. CT guidance can be used instead of fluoroscopy to gain access to the distended cecum (129,130).

## Outcome of Percutaneous Cecostomy

The technical success rate for percutaneous cecostomy placement approaches 100% (24), although the number described with endoscopic or radiologic methods is small. Outcome in terms of treatment success has also been reported to be uniformly good, but includes only retrospective case series. In the largest study (22), satisfaction with cecostomy as a treatment for fecal incontinence was 94%, and 89% reported a decrease in the number of soiling accidents.

## SPECIAL CONSIDERATIONS

### Gastric Bypass

Excessive weight loss postoperatively in patients with gastric bypass and Roux-en-Y anastomosis may necessitate enteral feeding. However, the stomach may not be accessible by routine endoscopy. Several options for tube placement in this situation are possible. First, percutaneous gastrostomy may be performed at the time of the original bypass surgery (131). Although this is certainly not required in the vast majority of patients, placement of a gastrostomy tube at the time of surgery in patients deemed at high risk for complications (eg, obstruction or anastomotic leak, estimated to involve < 2% of the total bariatric population) obviates later repeat operation (131). Gastropexy helps to secure the excluded stomach to the anterior abdominal wall and Cope loop catheters may be used for the feeding device. This procedure tends to be a temporizing procedure, and repeat surgical intervention is often required at a later time (132). A third option is percutaneous gastrostomy with balloon enteroscopy (133). The double-balloon technique allows endoscopic evaluation deep into the small bowel, reducing loops of small bowel as the enteroscope is passed along the GI tract. The endoscopy does need to be done in conjunction with fluoroscopy, because it can be difficult to identify the pancreatic or biliary limb of the Roux-en-Y. When this limb has been identified, the entrance may be marked with an injection of India ink. The technique does still require adequate transillumination after the scope has been advanced into the excluded stomach, and failure to transilluminate may preclude successful placement. Although the pull technique for endoscopy-guided gastrostomy placement has been used successfully (133), tension on the guide wire and trauma to the mucosa can be excessive and increase the risk for perforation. For these reasons, the Russell introducer technique should be considered in patients with this postoperative anatomy (133).

### Enterocutaneous Fistula

Fistuloclysis in patients with enterocutaneous fistula involves placement of a tube through the fistula and delivery of enteral nutrition downstream into the small bowel. Such feeding in these difficult cases reverses malnutrition, ameliorates parenteral nutrition-induced hepatopathy, and improves function of the small bowel before repeat operation (134). In patients with multiple fistulas, fluoroscopy is used to probe each fistula to find the one most distal in the GI tract. Feeding in more proximal fistulas simply increases output from the fistulas below. A small-bore 8–12-F tube may be placed through the fistula, and secured by a stitch to the fibrous ring at the mouth of the fistula. The tube is further secured by running stitches from the tube to the adjacent skin, and then clipping the tube into a clamping device positioned on the surface of the abdomen next to the open wound. As a fistula may have both an afferent and an efferent limb, it is important to place the tube distal to, or downstream from, the fistula. Inadvertent placement of the tube in the afferent limb will result in poor tolerance, as peristalsis will drive the infused formula back out the mouth of the fistula (134).

## Billroth II Anastomosis

Direct percutaneous jejunostomy is actually facilitated or made easier by surgery resulting in an antecolic Billroth II anastomosis, as proximal jejunum is brought out of the retroperitoneal space and the chances for transillumination are increased. For patients with a long afferent limb, it is important to correctly identify and place the percutaneous jejunostomy in the efferent limb. Failure to do so results in a clinical situation similar to afferent limb syndrome, wherein poor peristalsis and retention of formula in the afferent limb causes pain, nausea, vomiting, and poor feeding tolerance (109,135).

## CONTINUOUS CARE/MAINTENANCE OF GI ACCESS

### Tube Dressing and Positioning

The gastrostomy site should be cleaned with mild soap and water; hydrogen peroxide should not be used after the first week after placement 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 gastrostomy site. Occlusive dressings should not be used, as they can lead to peristomal skin maceration and breakdown. Should excessive granulation tissue develop at the gastrostomy site, topical silver nitrate or a high-potency topical steroid can be applied or the tissue can be trimmed with surgical scissors to reduce irritation and decrease drainage (136). Daily cleaning of the tube with water and regular or antibacterial soap is adequate to keep the tube clean. Some institutions do not apply a dressing to the site.

To prevent buried bumper syndrome in transoral tubes, the external bolster of the transoral placed gastrostomy tube should be positioned in a manner such that the tube can be pushed in and out at least 1 cm. One retrospective study (137) demonstrated a significant reduction in tube-related complications in a group of patients with a loose external bolster.

### Initiation of Feeding

Traditionally, after endoscopic-guided transoral enteric access placement, feeding was initiated after period of time between 12 and 24 hours. It was expected that, during that time, the GI system returns to normal function and better seal of the enteral opening is achieved (138–140). Later, several prospective randomized studies (141–145) clearly demonstrated that earlier initiation of feeding at 3 hours (141,142), 4 hours (143), and even immediately (144) is safe. These data were further analyzed and confirmed in metaanalysis by Bechtold et al (145) that summarized six randomized trials.

Similar randomized studies comparing delayed and early feeding following transabdominal gastrostomy placement have not been performed. Generally, in older literature, the initiation of feeding was reported to be between 12 and 24 hours (89,146,147). In later studies describing experience with transabdominal access with endoscopic guidance, the initiation of feeding was shorter, at 4–6 hours (37,92), and appeared to be safe. Future randomized studies are needed to confirm this latest experience.

### Choice of Tube Configuration and Material

Gastrostomy tubes can be classified according to the diameter, material, and retention mechanism. Generally, the choice of diameter of a tube is dictated by the location of the tube (jejunostomy vs gastrostomy). Smaller-diameter tubes are prone to more frequent dysfunction (148–151), so it is recommended to place the largest diameter tube practically reasonable.

Silicone was the material of choice for enteric tubes for a number of years. Well known to be highly biocompatible, it is structurally weak, resulting in smaller internal diameter because of the thicker wall. In one laboratory study (152), polyurethane tubes clogged less than silicone tubes. In a retrospective study, Sartori et al (153) demonstrated that silicone tubes deteriorate significantly sooner than polyurethane tubes. That was supported by a well designed prospective randomized study (154) that also demonstrated greater patency and structural integrity of polyurethane gastrostomy tubes. However, in another prospective study,

Van Den Hazel et al (155) showed no difference in long-term patency and complications between polyurethane and silicone tubes. In addition, silicone tubes were found to be prone to fungal colonization, resulting in material degradation and tube occlusion (156).

### Routine Tube Flushing to Prevent Clogging

GI tubes have a tendency to clog, especially tubes of smaller diameter. This occurs between 20% and 45% of the time, depending on the definition of tube occlusion (149). This number could be increased 10-fold if gastric residuals are checked through the feeding tube (148). Tube occlusion is often caused by the interaction of protein-based formulas with an acidic environment and medications (157). If not flushed properly, the smaller-diameter tubes—such as jejunostomy tubes—often clog. Several flushing agents including water, carbonated beverages, and cranberry juice have been studied (152,158,159). Cranberry juice and carbonated beverages were shown to be inferior to water (159,160), most probably because their high sugar content was associated with stickiness.

Several published cases of infections were traced to tap water flushing (161–163). It is generally recommended to flush the tubes with the sterile water; however, it is recognized that the practices vary in different institutions. Several reports demonstrated superiority of prophylactic use of pancreatic enzymes to prevent tube occlusion (164,165).

### Unclogging the Enteral Tube

Even in the best clinical practice, feeding tubes occasionally clog. Simple flushing with water can relieve the obstruction in one third of patients (160). If simple water flushing fails to unclog a feeding tube, the installation of pancreatic enzymes can reopen an additional 50% of occluded tubes (166). If these efforts fail, attempt to clean the tube with mechanical devices such as a Fogarty balloon, biopsy brush, or commercially available tube decloggers can be performed. Replacement of the tube is performed as a last resort.

### Gastrostomy Tube Change

With optimal care, most transoral bumper-type gastrostomy tubes can remain in place for 1–2 years (167). However, eventually, all tubes will require replacement as a result of breakage, occlusion, or dislodgment. In contrast, the Cope loop type of transabdominal gastrostomy is usually replaced 1–3 months after initial placement.

There are two major types of replacement gastrostomy tubes on the market that differ in their retention mechanism: a double-lumen balloon-type tube and a single-lumen distensible bumper-type tube. The only study that compared the performance between these two types of tubes (168) demonstrated that there is no statistically significant difference in terms of skin infection and tube malfunction. The main cause of tube failure in balloon-type tubes was occlusion; that in the distensible bumper-type tubes was tube degradation.

Low-profile tubes that provide more aesthetic skin-level access to the stomach are especially popular in the pediatric population (169). The retention mechanism can be a balloon or distensible bumper, and each device is tailored to the length of the stoma tract of each patient.

Preventive maintenance of gastrostomy tubes that includes elective change at a fixed period of time (usually 3–6 months) is the standard practice in some places (169). This is more common for the balloon-tip gastrostomy tubes because of the potential for balloon failure.

In circumstances in which a gastrostomy is replaced blindly at the bedside, confirmation of the correct placement by using auscultation and gastric content aspiration is imperative. If correct position is in question, a postreplacement radiograph with contrast medium should be performed. Gastrojejunostomy tubes are usually changed over a guidewire under fluoroscopy or endoscopy guidance.

As a result of the small diameter and complicated configurations of gastrojejunostomy tubes, they often require more frequent maintenance and replacement. Replacement rates of 2.2 times in 39 days have been reported in a pediatric population (170).

**Table 4.** Major and Minor Complications of Gastrostomy Tube Placement (172)

Complication	Frequency (%)
<b>Major</b>	
Aspiration	0.3–1.0
Hemorrhage	0–2.5
Peritonitis	0.5–1.3
Necrotizing fasciitis	Rare
Death	0–2.1
Tumor implantation	Rare
<b>Minor</b>	
Ileus	1–2
Peristomal infection	5.4–30
Stomal leakage	1–2
Buried bumper	0.3–2.4
Gastric ulcer	0.3–1.2
Fistulous tracts	0.3–6.7
Inadvertent removal	1.6–4.4

## COMPLICATIONS

### Gastrostomy

Overall complication rates (major and minor) are similar for endoscopy-guided and image-guided gastrostomies, and range from 0.4% to 22.5% and from 13% to 43%, respectively (Table 4) (106,136,171,172). Procedure-related mortality rates are very low, ranging from 0% to 2% (173). Thirty-day mortality rates vary from 6.7% to 26%, and mortality is related to the underlying comorbidities of this debilitated population (174–177). It should be noted that the incidence of mortality associated with gastrostomy placement is significantly higher in hospitalized patients (178) and patients with diabetes, poor nutritional status, or long-term corticosteroid administration (179).

### Acute Complications

Patients undergoing gastrostomy tube placement are subject to the complications associated with sedation, and, in case of endoscopy-guided procedures, endoscopy-related complications. Although the rate is low (0.1%), significant morbidity can result from these complications. The most common complications of endoscopy include aspiration, hemorrhage, and perforation (180), and sedation carries the risks of hypoxia, hypotension, and aspiration (181,182).

### Aspiration

In a report in which 15% of 64 patients had aspiration related to endoscopy-guided gastrostomy placement, only two of the patients had aspiration during the procedure whereas the other 11 had aspiration during the next several weeks (183). In other reports (138,184), aspiration related to the procedure itself occurred in 0.3%–1.0% of cases. Risk factors for intraprocedural aspiration include supine position, sedation, neurologic impairment, and advanced age (185). The endoscopist can minimize the risk of this complication by avoiding excessive sedation, thoroughly aspirating the gastric contents before the procedure, suctioning previously insufflated gastric air after the procedure, and performing the procedure efficiently in terms of time.

### Bleeding

Acute bleeding during endoscopy-guided gastrostomy placement is an uncommon complication, occurring in approximately 1% of cases (186–188). A review of 1,338 patients (189) reported that fewer than 0.5% of cases are complicated by hemorrhage requiring transfusion and/or lapa-

rotomy. Risk factors include anticoagulation and previous anatomic alteration (190). The development of a hematoma at the gastrostomy site complicates approximately 1% of cases (188). Gastrostomy placement is categorized as a high risk procedure by the ASGE because of the risk for bleeding, and anticoagulation should be held and/or reversed before the procedure (30).

### Perforation of Viscera/Peritonitis

Complete laceration of the stomach, small bowel, or colon is a potentially catastrophic complication that occurs in 0.5%–1.3% of cases (138,188). Inadvertent perforation can be minimized with meticulous attention to obtaining excellent endoscopic transillumination and discrete (rather than diffuse) indention from finger palpation on the anterior abdominal wall to identify a safe gastric access site. In addition, full insufflations of the stomach to allow it to displace the colon caudally can assist in preventing inadvertent colon perforation. The safe-track maneuver described previously can also be performed to ensure there are no intervening loops of bowel between the stomach and anterior abdominal wall (68). In cases of very abnormal GI anatomy, a CT scan can be used to mark the stomach for safe insertion of a gastrostomy tube.

It is recognized that transient subclinical pneumoperitoneum occurs during gastrostomy placement in as many as 56% of procedures and is generally not of any clinical significance (191). Peritonitis manifests in the postgastrostomy patient as abdominal pain, leukocytosis, ileus, and fever. It can result in significant morbidity if not identified and treated early (192). The prevalence of persistent subclinical pneumoperitoneum limits the utility of plain radiographs for evaluation of suspected peritonitis. Therefore, fluoroscopic imaging of the gastrostomy tube with infusion of water-soluble contrast medium is most useful to evaluate visceral integrity in patients in whom peritonitis is a consideration (193). If active leakage of contrast medium 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 3–4 hours after gastrostomy placement (142). However, in 1%–2% of cases, prolonged ileus may follow gastrostomy placement, and should be managed conservatively (138). Acute gastric distension after gastrostomy placement can be decompressed by simply uncapping the gastrostomy tube.

### Delayed Complications

**Site infection.** The most common complication of transoral gastrostomy placement is peristomal infection of the gastrostomy site. As many as 30% of cases are complicated by peristomal wound infection (140,194,195), but more than 70% of these are minor, with fewer than 1.6% of stomal infections requiring aggressive medical and/or surgical treatment (33). Patients with diabetes, obesity, or poor nutritional status, and those on chronic corticosteroid therapy or other immunosuppressive therapy, are at increased risk for infection (196). In case of transoral gastrostomy, excessive pressure between the gastrostomy external and internal bolsters is associated with a higher infection rate and can also lead to mucosal ulceration, increased leakage, and buried bumper. Loose contact of the outer bolster with the skin is all that is required to oppose the gastric and abdominal wall (197). Allowing for approximately 1 cm of play between the skin and external bolster setting maintains the proper tension and decreases the likelihood of these complications. The transabdominal approach technique that does not pull the gastrostomy tube through the oropharynx has been shown to result in fewer infections compared with transoral techniques (198,199). If it is diagnosed early, oral broad-spectrum antibiotics for 5–7 days may be all that is required for a gastrostomy site infection. If there are more systemic signs, intravenous broad-spectrum antibiotics coupled with local wound care are necessary. Should a 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, or alcoholism appear to be at increased risk (200–202). Management consists of broad-spectrum intravenous antibiotics and aggressive surgical debridement.

**Peristomal leakage/irritation.** Leakage of tube feeding formula and/or gastric contents around the gastrostomy site can be a significant management problem and is reported in the literature to occur in 1%–2% of placements (203). Risk factors include infection of the site, increased gastric acid secretion, excessive cleansing with hydrogen peroxide, buried bumper syndrome, side torsion on the gastrostomy tube, and excessive tension between the internal and external bolsters (204). Evaluation of a leaking gastrostomy site should include examination for evidence of infection, ulceration, or a buried bumper. If the patient is not receiving 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. The same result may also be accomplished by replacing the gastrostomy with a low-profile device. Some practitioners replace the gastrostomy tube with a larger-diameter one, but this is usually ineffective and can result in continued leakage around an even larger stoma (193). Another potential treatment option is conversion of the gastrostomy tube to a gastrojejunostomy. 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. Foam dressing rather than gauze can help to reduce local skin irritation caused by gastric contents (foam lifts the drainage away from the skin, whereas gauze tends to trap it). Local fungal skin infections may also be associated with leakage and can be treated with topical antifungal agents. Wound and ostomy nurses are an invaluable resource in the management of leaking gastrostomy sites and often are the primary managers in these settings. In refractory cases, the gastrostomy 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 gastrostomy 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%–2.4% of patients with gastrostomy (138,205,206). The bumper may migrate through the gastric wall and may lodge anywhere along the gastrostomy tract. Buried bumper syndrome typically presents with peritubal leakage or infection, an immobile gastrostomy tube, abdominal pain, and/or resistance with formula infusion. 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 (204).

The buried bumper may be confirmed endoscopically or radiographically. Contrast study should be performed with the patient in prone position, as contrast agent may falsely appear to safely pass through the imbedded bumper into the gastric lumen by gravity when the patient is in supine position. Management of buried bumpers has been described by a number of methods involving endoscopic removal and replacement. The key principle is to use a technique that minimizes trauma to the gastrostomy tract. In many cases, the buried gastrostomy tube can be removed with external traction and a new gastrostomy tube placed through existing tract or nearby site. If the bumper is completely covered by gastric mucosa, electrosurgical incisions may be necessary to access and remove the bumper endoscopically (207,208).

**Gastric ulcer/hemorrhage.** Bleeding that occurs after gastrostomy placement is usually caused by peptic ulcer disease, traumatic erosion of the gastric wall opposite the internal bolster, or ulceration beneath the internal bolster, and is reported to complicate 0.3%–1.2% of cases (138,186,187,209). To reduce risk of ulcerations at the gastrostomy site, excessive lateral traction on the tube and tension between the internal and external bolsters should be avoided. During endoscopic evaluation, the mucosa under the internal bolster should be visualized by externally manipulating the gastrostomy (192).

**Fistulous tracts.** Fistulas connecting the stomach, colon, and skin are uncommon but potentially significant complications of gastrostomy placement. These fistulas may occur when the colon is inadvertently punctured

and traversed during gastrostomy placement or less commonly with subsequent erosion of the tube into juxtaposed colon. Patients may present acutely with colonic perforation or obstruction. More commonly, patients present chronically with stool leaking around the gastrostomy tube and diarrhea resembling formula during feeding. Another typical presentation is when a colocolic fistula results from a replacement gastrostomy that is advanced through a previously created gastrocolocutaneous fistula into the colon rather than through the colon into the stomach. A feeding tube misplaced into the colon may be identified radiographically. Usually, management consists of simply removing the tube and allowing the fistula to close. Surgery may be required on rare occasions, such as when signs of peritonitis develop or the fistula fails to heal. Use of the safe-track technique as described previously and elevation of the head of the bed with adequate gastric insufflations to displace the colon during placement to displace the colon inferiorly may help lessen this complication (68).

**Inadvertent tube removal.** Accidental gastrostomy tube removal occurs in 1.6%–4.4% of cases (138,209,210). Gastrostomy tract maturation usually occurs within the first 7–10 days, but may be delayed as long as 4 weeks in the presence of malnutrition, ascites, or corticosteroid treatment. A gastrostomy tube that is accidentally removed during this period should be replaced by using endoscopy or image guidance, as the tract may be immature and the stomach and anterior abdominal wall can separate from each other, resulting in free perforation. If recognized immediately a new gastrostomy tube may be placed through or near the original gastrostomy site, sealing the stomach against the anterior abdominal wall. If recognition is delayed, management consists of NG suction, broad-spectrum antibiotics, and repeat gastrostomy placement in 7–10 days. Surgical exploration is reserved for patients with signs of decompensation or peritonitis.

Delirium, dementia, and other causes of altered mental status increase the risk for inadvertent tube removal. Multiple maneuvers may prevent or decrease the risk of tube removal in these situations. Placing mittens on the patient's hands reduces the ability to grasp and pull the gastrostomy tubing. Abdominal binders are not recommended because they increase side torsion at the gastrostomy site, increasing risk of stoma enlargement. Placing gastropepy devices at time of tube placement will prevent the stomach from falling away from the skin in the event of premature removal and facilitate safer replacement. Finally, initial placement of, or replacement with, a low-profile device (ie, button gastrostomy) can be performed. In this case, if the connector tubing is accidentally pulled, it simply disengages, leaving the button in place (211).

**Fungal tube infection.** Fungal colonization and/or infection of gastrostomy tubes may lead to tube degradation and failure. This is a long-term complication of gastrostomy tubes has been reported to cause as many as 70% of cases of tube failure by 450 days. Histologic studies (212) have demonstrated actual fungal growth into the tube wall leading to brittleness, dilation, and cracking, with eventual puncture of the tube. No treatment has shown to be useful, but polyurethane initial placement and replacement devices may be more resistant to fungal infection than silicone ones (153,213).

**Tumor tract seeding.** Placement of prophylactic gastrostomy feeding tubes in patients with head and neck cancer has been shown to be beneficial (214,215). However, implantation of head and neck cancer at the stoma site has been reported in 28 cases between 1989 and 2005 (216,217), and should be suspected in patients with head and neck cancer who develop unexplained skin changes at the gastrostomy site. The mechanism of implantation is controversial, but is most likely direct seeding of tumor at the gastrostomy site after the tube shears tumor cells as it passes through the aerodigestive tract (218). However, implantation has also been reported after open gastrostomy with no manipulation of the tumor by the gastrostomy tube (219). It was advocated in these patients to consider the use of a transabdominal approach, in which the gastrostomy is placed directly through the abdominal wall (93). In patients who develop tumor at the gastrostomy site, metastases are commonly present elsewhere as well. No treatment is usually given, but palliative radiation therapy has been reported in one case (220).

## Gastrojejunostomy

Complications of percutaneous gastrojejunal tubes include those noted with percutaneous gastrostomy tubes, as described earlier. Despite the high technical success rate of initial endoscopic- or image-guided placement, functional success is often disappointing. Gastrojejunal feeding tubes are also complicated by frequent (53%–84%) malfunction caused by retrograde tube migration into the stomach or tube dysfunction caused by kinking, clogging, and/or occlusion of the smaller (8–12 F) jejunal extension tubes (105,221). Migration of the jejunal tube back into the duodenum or stomach is a unique complication of percutaneous gastrojejunal tubes and occurs in 27%–42% of cases (104,221,222). Tube occlusion is a significant problem, with reported rates of 3.5%–35% (223). To help prevent tube clogging, medications should be administered through the much larger diameter gastrostomy port of the gastrojejunostomy when possible. The average longevity for a jejunostomy tube in a gastrojejunostomy is 3–6 months (99,224). When the jejunostomy arm has become dislodged, it generally must be replaced to achieve correct positioning. Fortunato et al (170) conducted a retrospective review of 102 pediatric patients. The mean number of jejunal tube replacements was 2.2 (range, 1–14) tubes per patient over a median tube functional duration of 39 days (range, 2–274 d) per patient. The most common reasons for tube replacement included displacement (31%), clogged tube (22%), and mechanical failure (19%). However, some authors (99) have described gastrojejunostomy tube longevity as long as 120 days when they were placed with an over-the-wire method as described earlier. Finally, the data do not demonstrate that feeding with percutaneous gastrojejunal tubes decreases aspiration risk compared with gastric feeding. Aspiration has been reported in 17%–60% of patients with gastrojejunostomy, which is not significantly different than outcomes with gastrostomy feeding (1).

## Jejunostomy

Complications of jejunal tube placement are similar in nature and frequency to those observed with gastrostomy tubes. In addition, direct jejunostomy tubes may cause jejunal volvulus, small bowel perforation, and persistent enterocutaneous fistulas after tube removal. In a reported series of endoscopy-guided jejunostomy (121), the major complication rate was approximately 2%, and complications included colonic perforation, severe gastric bleeding, and an abdominal wall abscess. Minor complication rates were approximately 6%–11%, and minor complications included skin site infection, persistent pain at the jejunal access site, pressure-induced jejunal mucosal ulcerations, and persistent enterocutaneous fistulas (121). However, these rates are likely equal to or lower than reported complication rates of endoscopic or radiologic percutaneous gastrojejunostomy or surgical jejunostomy. Maple et al (120) performed the largest analysis of outcomes of jejunostomy placement. A total of 307 jejunostomy attempts were made, with a success rate of 68%. Adverse events were noted in 22.5%, with severe adverse events occurring in 4.2% of cases, including seven bowel perforations, three cases of serious bleeding, and three cases of jejunal volvulus. Jejunal volvulus appears to be a unique complication of endoscopy-guided jejunostomy. Use of multiple jejunostomy devices during radiologic or endoscopic direct jejunostomy placement may decrease this occurrence (225).

## Cecostomy

Complications of percutaneous cecostomy are similar to those seen with percutaneous gastrostomy, and include bleeding, excessive granulation tissue, leakage, and infection with sepsis or peritonitis (130,226–228). Peristomal infection rates range between 25% and 40% and are not clearly increased compared with percutaneous feeding tubes (126,225,229). As described earlier, creation of a cecostomy with T-fasteners may help decrease peristomal leakage of fecal contents. Inadvertent placement into the terminal ileum has been reported with fluoroscopic placement, although function was intact (24). No differences in rates of complications have been noted between endoscopic and radiologic placement, but the total number reported with each method is small (22,24,124,228–233).

## ETHICAL ISSUES

Medical ethics as applied to achievement of enteral access and provision of artificial specialized nutritional therapy follows five basic principles (234). Autonomy refers to self-autonomy, justice, beneficence, nonmaleficence, and futility. The direct application of these principles means that a competent adult has the right to decide for him- or herself whether a feeding tube is placed and feedings are started. No tubes should be placed without informed and educated consent. Patient autonomy takes precedence over beneficence. The ultimate decision to place the tube is based upon the following presumptions: that it would provide net benefit to the patient and not harm, that the benefits will outweigh the risk of the procedure itself, and that the procedure would be offered to the patient regardless of their socioeconomic status (234).

Following decades of legal cases and decisions formed by state courts and the US Supreme Court, the ethical principles that guide the provision of nutrition therapy in end-of-life situations have been redefined (234,235). Patient autonomy is paramount. The patient decides whether to receive therapy, as the right to consent is meaningless without the right to refuse medical intervention. Providing unwanted medical care actually diminishes patient dignity. Nutrition support is no more essential or basic than any other form of medical therapy. Providing nutrition and hydration is indistinguishable in the eyes of ethicists from the provision of antibiotics, oxygen therapy, or pressor support, all of which represent bodily functions that a patient cannot provide on their own. The distinctions between ordinary and extraordinary are meaningless, as are the distinctions of invasive versus noninvasive. Withdrawing or withholding nutritional therapy is no different than the definitive act of initiating provision; one is not “stuck” continuing feedings when they have been started. Clinicians must assume that a patient wants nutrition therapy until proven otherwise or until evidence is found to the contrary (234,235).

Considerable controversy surrounds the ethics of placing gastrostomy tubes in patient populations expected to have reduced clinical benefit (236). In certain patient populations, the decision to place a gastrostomy tube is clear. For neurologic disease, such as a cerebrovascular accident, gastrostomy tube feedings provide a valuable bridge in the interim following the initial event, as more than half of patients with dysphagia will recover neurologic function during the subsequent 4 months (237). Gastrostomy placement is more controversial in patient populations such as those with terminal cancer and widespread metastases or those with advanced dementia. Gastrostomy tubes should not be placed routinely in patients with end-stage, incurable cancer. Achievement of enteral access and provision of enteral nutrition may actually increase complications. If no therapy is provided, the majority of patients (as many as 63%) never experience hunger or thirst (238). Any symptoms of hunger or thirst that are expressed are transient and relieved easily with minimal intake. There appears to be no consistent benefit from gastrostomy placement in these patients (238).

Gastrostomy tube placement in patients with advanced dementia is commonly done for reasons of preventing aspiration, maintaining skin integrity, preventing pressure sores, improving function, and prolonging life expectancy (236). Unfortunately, the point at which there is loss of speech and smile and difficulty eating marks the terminal phase of dementia; the lifespan remaining is estimated to be less than 12–18 months (234,236). Although diverting the level of feeding lower in the GI tract from mouth to stomach to small bowel has been shown to reduce gastroesophageal reflux and pulmonary aspiration (10,239), it is not clear that actual pneumonia is reduced (240). Placement of a gastrostomy tube and provision of enteral nutrition should improve nutritional status and promote the healing of pressure sores. However, patients with dementia are usually chemically or physically restrained following the procedure, and the consequent immobility negates the nutritional benefits from gastrostomy placement (234,236,237). Although patients with stroke, head trauma, or an abnormality of the GI tract are more likely to improve in function or quality of life following gastrostomy placement, those with chronic dementia are more likely to see their function or quality of life worsen (241). Converting from hand feeding to gastrostomy feeding deprives these patients of touch, taste, nurturing, and social interaction, and the physical restraints may lead to distress, agitation, and the need for

sedation (236). Ironically, the quality of life for family, relatives, and caregivers usually improves with gastrostomy placement, as the difficulty and frustration with providing nutrition support to the patient with dementia are vastly improved (242). There is no evidence that the morbidity directly related to the gastrostomy procedure itself is any worse for patients with dementia (243). Gastrostomy placement in patients with dementia probably does not change mortality, as the death rate is more related to the underlying disease process and comorbidities (234,244). We have not been able to access the quality of life changes in dementia as affected by the use of a gastrostomy tube.

## CONCLUSIONS

Gastroenteric access is an integral part of the patient care provided by a variety of health care professionals. Transabdominal and natural-orifice approaches have been proven to be successful and safe under endoscopic or image guidance.

## REFERENCES

- DiSario J, Baskin W, Brown R, et al. Endoscopic approaches to enteral nutritional support. *Gastrointest Endosc* 2002; 55:901–908.
- Patrick PG, Marulendra S, Kirby DF, DeLegge MH. Endoscopic nasogastric-jejunal feeding tube placement in critically ill patients. *Gastrointest Endosc* 1997; 45:72–76.
- Chait P, Shandling B, Richards M, Connolly B. A fecal incontinence in children: treatment with percutaneous cecostomy tube placement—a prospective study. *Radiology* 1997; 203:631–624.
- Muzumdar D, Ventureyra EC. Inadvertent intracranial insertion of a soft rubber tube in a patient with Treacher-Collins syndrome: case report and review of literature. *Childs Nerv Syst* 2008; 24:609–613.
- Salord F, Gaussoy P, Marti-Flich J, et al. Nosocomial maxillary sinusitis during mechanical ventilation: a prospective comparison of orotracheal versus the nasotracheal route for intubation. *Intensive Care Med* 1990; 16:390–393.
- George DL, Falk PS, Umberto Meduri G, et al. Nosocomial sinusitis in patients in the medical intensive care unit: a prospective epidemiological study. *Clin Infect Dis*. 1998; 27:463–470.
- Silver HJ, Wellman NS, Arnold DJ, Livingstone AS, Byers PM. Older adults receiving home enteral nutrition: enteral regimen, provider involvement, and health care outcomes. *JPEN J Parenter Enteral Nutr* 2004; 28:92–98.
- Bowling TE, Cliff B, Wright JW, Blackshaw PE, Perkins AC, Lobo DN. The effects of bolus and continuous nasogastric feeding on gastroesophageal reflux and gastric emptying in healthy volunteers: a randomized three-way crossover pilot study. *Clin Nutr* 2008; 27:608–613.
- Heyland DK, Montalvo M, MacDonald S, Keefe L, Su XY, Drover JW. Total parenteral nutrition in the surgical patient: a meta-analysis. *Can J Surg* 2001; 44:102–111.
- Heyland DK, Drover JW, MacDonald S, Novak F, Lam M. Effect of postpyloric feeding on gastroesophageal regurgitation and pulmonary microaspiration: results of a randomized controlled trial. *Crit Care Med* 2001; 29:1495–1501.
- Marik PE, Zaloga GP. Gastric versus post-pyloric feeding: a systematic review. *Crit Care* 2003; 7:R46–R51.
- Hsu CW, Sun SF, Lin SL, et al. Duodenal versus gastric feeding in medical intensive care unit patients: a prospective, randomized, clinical study. *Crit Care Med* 2009; 37:1866–1872.
- Abou-Assi S, Craig K, O'Keefe SJ. Hypocaloric jejunal feeding is better than total parenteral nutrition in acute pancreatitis: results of a randomized comparative study. *Am J Gastroenterol* 2002; 97:2255–2262.
- McClave SA. Nutrition support in acute pancreatitis. *Gastroenterol Clin North Am* 2007; 36:65–74.
- Eatock FC, Chong P, Menezes N, et al. A randomized study of early nasogastric versus nasojejunal feeding in severe acute pancreatitis. *Am J Gastroenterol* 2005; 100:432–439.
- Felsher J, Chand B, Ponsky J. Decompressive percutaneous endoscopic gastrostomy in nonmalignant disease. *Am J Surg* 2004; 187:254–256.
- Gowen GF. Long tube decompression is successful in 90% of patients with adhesive small bowel obstruction. *Am J Surg* 2003; 185:512–515.
- Maroney TP, Ring EJ. Percutaneous transjejunal catheterization of Roux-en-Y biliary-jejunal anastomoses. *Radiology* 1987; 164:151–153.
- Martin EC, Laffey KJ, Bixon R. Percutaneous transjejunal approaches to the biliary system. *Radiology* 1989; 172:1031–1034.
- Perry LJ, Stokes KR, Lewis WD, Jenkins RL, Clouse ME. Biliary intervention by means of percutaneous puncture of the antecolic jejunal loop. *Radiology* 1995; 195:163–167.
- Cope C, Davis AG, Baum RA, Haskal ZJ, Soulen MC, Shlansky-Goldberg RD. Direct percutaneous jejunostomy: techniques and applications—ten years experience. *Radiology* 1998; 209:747–754.
- Chait P, Sciomovitz E, Connolly B, et al. Percutaneous cecostomy: updates in technique and patient care. *Radiology* 2003; 227:246–250.
- Lynch C, Jones R, Hilden K, Wills J, Fang J. Percutaneous endoscopic cecostomy in adults: a case series. *Gastrointest Endosc* 2006; 64:279–282.
- Chait PG, Shandling B, Richards HM, Connolly BL. Fecal incontinence in children: treatment with percutaneous cecostomy tube placement—a prospective study. *Radiology* 1997; 203:621–624.
- Chevallier P, Marcy PY, Francois E, et al. Controlled transperitoneal percutaneous cecostomy as a therapeutic alternative to the endoscopic decompression for Ogilvie's syndrome. *Am J Gastroenterol* 2002; 97:471–474.
- Gassas A, Kennedy J, Green G, et al. Risk of ventriculoperitoneal shunt infections due to gastrostomy feeding tube insertion in pediatric patients with brain tumors. *Pediatr Neurosurg* 2006; 42:95–99.
- Sane SS, Towbin A, Bergey EA, et al. Percutaneous gastrostomy tube placement in patients with ventriculoperitoneal shunts. *Pediatr Radiol* 1998; 28:521–523.
- Eisen GM, Baron TH, Dominitz JA, et al. Guideline on the management of anticoagulation and antiplatelet therapy for endoscopic procedures. *Gastrointest Endosc* 2002; 55:775–779.
- Malloy PC, Grassi CJ, Kundu S, et al. Consensus guidelines for peri-procedural management of coagulation status and hemostasis risk in percutaneous image-guided interventions. *J Vasc Interv Radiol* 2009; 20(7 Suppl):S240–S249.
- Eisen G, Baron T, Dominitz J, et al. Guideline on the management of anticoagulation and antiplatelet therapy for endoscopic procedures. *Gastrointest Endosc* 2002; 55:775–779.
- Barclay L. Anticoagulant and antiplatelet therapy for endoscopic procedures. *Medscape Medical News* 2008. Available at: <http://www.medscape.org/viewarticle/574397>. Accessed May 9, 2008.
- McClave SA, Chang WK. Complications of enteral access. *Gastrointest Endosc* 2003; 58:739–751.
- Gossner L, Keymling J, Hahn E, Ell C. Antibiotic prophylaxis in percutaneous endoscopic gastrostomy (PEG): a prospective randomized clinical trial. *Endoscopy* 1999; 31:119–124.
- Lipp A, Lusardi G. Systemic antimicrobial prophylaxis for percutaneous endoscopic gastrostomy. *Cochrane Database Syst Rev* 2009; 4:10.1002/14651858.CD005571.pub2.
- Banerjee S, Shen B, Baron TH, et al. Antibiotic prophylaxis for GI endoscopy. *Gastrointest Endosc* 2008; 67:791–798.
- Jain NK, Larson DE, Schroeder KW, et al. Antibiotic prophylaxis for percutaneous endoscopic gastrostomy. A prospective, randomized, double-blind clinical trial. *Ann Intern Med* 1987; 107:824–828.
- Shastri YM, Hoepffner N, Tessmer A, Ackermann H, Schroeder O, Stein J. New introducer PEG gastrostomy does not require prophylactic antibiotics: multicenter prospective randomized double-blind placebo-controlled study. *Gastrointest Endosc* 2008; 67:620–628.
- Caulfield KA, Page CP, Pestana C. Technique for intraduodenal placement of transnasal enteral feeding catheters. *Nutr Clin Pract* 1991; 6:23–26.
- McWey RE, Curry NS, Schabel SI, Reines HD. Complications of nasoenteric feeding tubes. *Am J Surg* 1988; 155:253–257.
- Thurlow PM. Bedside enteral feeding tube placement into duodenum and jejunum. *JPEN J Parenter Enteral Nutr* 1986; 10:104–105.
- Zaloga GP. Bedside method for placing small bowel feeding tubes in critically ill patients. A prospective study. *Chest* 1991; 100:1643–1646.
- Ugo PJ, Mohler PA, Wilson GL. Bedside postpyloric placement of weighted feeding tubes. *Nutr Clin Pract* 1992; 7:284–287.
- Lord LM, Weiser-Maimone A, Pulham M, Sax HC. Comparison of weighted vs unweighted enteral feeding tubes for efficacy of transpyloric intubation. *JPEN J Parenter Enteral Nutr* 1993; 17:271–273.

44. Haslam D, Fang J. Enteral access for nutrition in the intensive care unit. *Curr Opin Clin Nutr Metab Care* 2006; 9:155–159.
45. Silva Cd, Saconato H, Atallah IN. Metoclopramide for migration of naso-enteral tube. *Cochrane Database Syst Rev* 2002; 4:10.1002/14651858.CD003353.
46. Gabriel SA, McDaniel B, Ashley DW, Dalton ML, Gamblin TC. Magnetically guided nasoenteral feeding tubes: a new technique. *Am Surg* 2001; 67:544–548.
47. Rivera R, Campana J, Seidner D, Hamilton C. Small bowel feeding tube placement using an electromagnetic tube placement device: accuracy of tip placement. *JPEN J Parenter Enteral Nutr* 2009; 33:202.
48. Gray R, Tynan C, Reed L, et al. Bedside electromagnetic-guided feeding tube placement: an improvement over traditional placement technique? *Nutr Clin Pract* 2007; 22:436–444.
49. Slagt C, Innes R, Bihari D, Lawrence J, Shehabi Y. A novel method for insertion of post-pyloric feeding tubes at the bedside without endoscopic or fluoroscopic assistance: a prospective study. *Intensive Care Med* 2004; 30:103–107.
50. Stark SP, Sharpe JN, Larson GM. Endoscopically placed nasoenteral feeding tubes. Indications and techniques. *Am Surg* 1991; 57:203–205.
51. Fang JC, Hilden K, Holubkov R, DiSario JA. Transnasal endoscopy vs. fluoroscopy for the placement of nasoenteric feeding tubes in critically ill patients. *Gastrointest Endosc* 2005; 62:661–666.
52. Bosco JJ, Gordon F, Zelig MP, Heiss F, Horst DA, Howell DA. A reliable method for the endoscopic placement of a nasoenteric feeding tube. *Gastrointest Endosc* 1994; 40:740–743.
53. Wiggins TF, DeLegge MH. Evaluation of a new technique for endoscopic nasojejunal feeding-tube placement. *Gastrointest Endosc* 2006; 63:590–595.
54. Foote JA, Kemmeter PR, Prichard PA, et al. A randomized trial of endoscopic and fluoroscopic placement of postpyloric feeding tubes in critically ill patients. *JPEN J Parenter Enteral Nutr* 2004; 28:154–157.
55. Ott DJ, Mattox HE, Gelfand DW, Chen MY, Wu WC. Enteral feeding tubes: placement by using fluoroscopy and endoscopy. *AJR Am J Roentgenol* 1991; 157:769–771.
56. Pobel RS, Bisset GS III, Pobel MS. Nasojejunal feeding tube placement in children: four-year cumulative experience. *Radiology* 1994; 190:127–129.
57. Hoffer F, Sandler RH, Kaplan LC, Mandell VS, Haynie M, Leichner A. Fluoroscopic placement of jejunal feeding tubes. *Pediatr Radiol* 1992; 22:287–289.
58. Han YM, Kim CY, Yang DH, Kwak HS, Jin GY. Fluoroscopically guided feeding tube insertion for relief of postoperative gastrointestinal anastomotic obstruction and leakage. *Cardiovasc Intervent Radiol* 2006; 29:395–400.
59. Johnston RD, O'Dell L, Patrick M, Cole AT, Cunliffe RN. Outcome of patients fed via nasogastric tube retained with bridle loop. Do bridle loops reduce the requirement for percutaneous Endoscopic gastrostomy insertion and 30-day mortality. *Proc Nutr Soc* 2008; 67:E116.
60. Popovich MJ, Lockrem JD, Zivot JB. Nasal bridle revisited: an improvement in the technique to prevent unintentional removal of small-bore nasoenteric feeding tubes. *Crit Care Med* 1996; 24:429–431.
61. Gunn SR, Early BJ, Zenati MS, Ochoa JB. Use of a nasal bridle prevents accidental nasoenteral feeding tube removal. *JPEN J Parenter Enteral Nutr* 2009; 33:50–54.
62. Tucker AT, Gourin CG, Ghegan MD, Porubsky ES, Martindale RG, Terris DJ. 'Push' versus 'pull' percutaneous endoscopic gastrostomy tube placement in patients with advanced head and neck cancer. *Laryngoscope* 2003; 113:1898–1902.
63. Funaki B, Zaleski GX, Lorenz J, et al. Radiologic gastrostomy placement: pigtail- versus mushroom-retained catheters. *AJR Am J Roentgenol* 2000; 175:375–379.
64. Duszak R, Mabry M. National trends in gastrointestinal access procedures: an analysis of Medicare services provided by radiologists and other specialists. *J Vasc Interv Radiol* 2003; 14:1031–1036.
65. Wolfsen HC, Kozarek RA, Ball TJ, Patterson DJ, Botoman VA, Ryan JA. Value of diagnostic upper endoscopy preceding percutaneous gastrostomy. *Am J Gastroenterol* 1990; 85:249–251.
66. Thornton FJ, Varghese JC, Haslam PJ, McGrath FP, Keeling F, Lee MJ. Percutaneous gastrostomy in patients who fail or are unsuitable for endoscopic gastrostomy. *Cardiovasc Intervent Radiol* 2000; 23:279–284.
67. Ponsky J, Gauderer M. Percutaneous endoscopic gastrostomy: a non-operative technique for feeding gastrostomy. *Gastrointest Endosc* 1981; 27:9–11.
68. Foutch P, Talbert G, Waring J, Sanowski R. Percutaneous endoscopic gastrostomy in patients with prior abdominal surgery: virtues of the safe tract. *Am J Gastroenterol* 1988; 83:147–150.
69. DeLegge M, DeLegge R, Brady C. External bolster placement after percutaneous endoscopic gastrostomy tube insertion: is looser better? *JPEN J Parenter Enteral Nutr* 2006; 30:16–20.
70. American Society for Gastrointestinal Endoscopy. Endoscopic enteral nutritional access devices. *Gastrointest Endosc* 2002; 56:796–802.
71. Kozarek RA, Ball TJ, Ryan JA. When push comes to shove: a comparison between two methods of percutaneous endoscopic gastrostomy. *Am J Gastroenterol* 1986; 81:642.
72. Funaki B, Peirce R, Lorenz J, et al. Comparison of balloon- and mushroom-retained large-bore gastrostomy catheters. *AJR Am J Roentgenol* 2001; 177:359–362.
73. Szymiski GX, Albazzaz AN, Funaki B, et al. Radiologically guided placement of pull-type gastrostomy tubes. *Radiology* 1997; 205:669–673.
74. Laasch HU, Wilbraham L, Bullen K, et al. Gastrostomy insertion: comparing the options—PEG, RIG or PIG? *Clin Radiol* 2003; 58:398–405.
75. Towbin RB, Ball WS Jr, Bisset GS III. Percutaneous gastrostomy and percutaneous gastrojejunostomy in children: antegrade approach. *Radiology* 1988; 168:473–476.
76. Sanchez RB, vanSonnenberg E, D'Agostino HB, Goodacre BW, Moyers P, Casola G. CT guidance for percutaneous gastrostomy and gastroenterostomy. *Radiology* 1992; 184:201–205.
77. Pitton MB, Herber S, Düber C. Fluoroscopy-guided pull-through gastrostomy. *Cardiovasc Intervent Radiol* 2008; 31:142–148.
78. Preshaw RM. A percutaneous method for inserting a feeding gastrostomy tube. *Surg Gynecol Obstet* 1981; 152:658–660.
79. Brown AS, Mueller PR, Ferrucci JT Jr. Controlled percutaneous gastrostomy: nylon T-fastener for fixation of the anterior gastric wall. *Radiology* 1986; 158:543–545.
80. Coleman CC, Coons HG, Cope C, et al. Percutaneous enterostomy with the Cope suture anchor. *Radiology* 1990; 174:889–891.
81. Cope C. Suture anchor for visceral drainage. *AJR Am J Roentgenol* 1986; 146:160–162.
82. de Baere T, Chapot R, Kuoch V, et al. Percutaneous gastrostomy with fluoroscopic guidance: single-center experience in 500 consecutive cancer patients. *Radiology* 1999; 210:651–654.
83. Kavin H, Messersmith R. Radiologic percutaneous gastrostomy and gastrojejunostomy with T-fastener gastropexy: aspects of importance to the endoscopist. *Am J Gastroenterol* 2006; 101:2155–2159.
84. Moote DJ, Ho CS, Felice V. Fluoroscopically guided percutaneous gastrostomy: is gastric fixation necessary? *Can Assoc Radiol J* 1991; 42:113–118.
85. Deutsch LS, Kannegieter L, Vanson DT, Miller DP, Brandon JC. Simplified percutaneous gastrostomy. *Radiology* 1992; 184:181–183.
86. Dewald CL, Hiette PO, Sewall LE, Fredenberg PG, Palestrant AM. Percutaneous gastrostomy and gastrojejunostomy with gastropexy: experience in 701 Procedures 1. *Radiology* 1999; 211:651–656.
87. Thornton F, Fotheringham T, Haslam P, McGrath F, Keeling F, Lee M. Percutaneous radiologic gastrostomy with and without T-fastener gastropexy: a randomized comparison study. *Cardiovasc Intervent Radiol* 2002; 25:467–471.
88. Ryan JM, Hahn PF, Mueller PR. Performing radiologic gastrostomy or gastrojejunostomy in patients with malignant ascites. *AJR Am J Roentgenol* 1998; 171:1003–1006.
89. Hicks ME, Surratt RS, Picus D, Marx MV, Lang EV. Fluoroscopically guided percutaneous gastrostomy and gastroenterostomy: analysis of 158 consecutive cases. *AJR Am J Roentgenol* 1990; 154:725–728.
90. Foster A, Given M, Thornton E, et al. Removal of T-fasteners 2 days after gastrostomy is feasible. *Cardiovasc Intervent Radiol* 2009; 32:317–319.
91. Russell TR, Brotman M, Norris F. Percutaneous gastrostomy. A new simplified and cost-effective technique. *Am J Surg* 1984; 148:132–137.
92. Dormann A, Wejda B, Kahl S, Huchzermeyer H, Ebert M, Malferteiner P. Long-term results with a new introducer method with gastropexy for percutaneous endoscopic gastrostomy. *Am J Gastroenterol* 2006; 101:1229–1234.
93. Foster JM, Filocamo P, Nava H, et al. The introducer technique is the optimal method for placing percutaneous endoscopic gastrostomy tubes in head and neck cancer patients. *Surg Endosc* 2007; 21:897–901.
94. Terry NE, Boswell WC, Carney DE, Beck A, Lowe L, Rittmeyer C. Percutaneous endoscopic gastrostomy with T-bar fixation in children and infants. *Surg Endosc* 2008; 22:167–170.

95. Wollman B, D'Agostino H, Walus-Wigle J, Easter D, Beale A. Radiologic, endoscopic and surgical gastrostomy: an institutional evaluation and meta-analysis of the literature. *Radiology* 1995;699–704.
96. Bankhead R, Fisher C, Rolandelli R. Gastrostomy tube placement outcomes: comparison of surgical, endoscopic, and laparoscopic methods. *Nutr Clin Pract* 2005; 20:607–612.
97. Rustom I, Jebreel A, Ttayyab M, England R, Stafford N. Percutaneous endoscopic, radiological, and surgical gastrostomy tubes: a comparison study in head and neck cancer patients. *J Laryngol Otol* 2006; 120:463–466.
98. Silas A, Pearce L, Lestina L, et al. Percutaneous radiologic gastrostomy versus percutaneous endoscopic gastrostomy: a comparison of indications, complications and outcomes in 370 patients. *Eur J Radiol* 2005; 56:84–90.
99. DeLegge M, Patrick P, Gibbs R. Percutaneous endoscopic gastrojejunostomy with a tapered tip, nonweighted jejunal feeding tube: improved placement success. *Am J Gastroenterol* 1996; 91:1130–1134.
100. Adler D, Goustout C, Baron T. Percutaneous transgastric placement of jejunal feeding tubes with an ultrathin endoscope. *Gastrointest Endosc* 2002; 55:106–110.
101. Alzate GD, Coons HG, Elliott J, Carey PH. Percutaneous gastrostomy for jejunal feeding: a new technique. *AJR Am J Roentgenol* 1986; 147:822–825.
102. Ho CS. Percutaneous gastrostomy for jejunal feeding. *Radiology* 1983; 149:595–596.
103. Donnelly LF, Klosterman LA, Ball WS Jr, Bisset GS III. Comparison of duodenal intubation techniques during conversion of gastrostomy to gastrojejunostomy tubes in children. *AJR Am J Roentgenol* 1997; 169:1633–1634.
104. Fan A, Baron T, Rumalla A, Harewood G. Comparison of direct percutaneous endoscopic jejunostomy and PEG with jejunal extension. *Gastrointest Endosc* 2002; 56:890–894.
105. DeLegge M, Duckworth P, McHenry L, Foxx-Orenstein A, Craig R, Kirby D. Percutaneous endoscopic gastrojejunostomy: a dual center safety and efficacy trial. *JPEN J Parenter Enteral Nutr* 1995; 19:239–243.
106. Hoffer E, Cosgrove J, Levin D, Herskowitz M, Sclafani S. Radiologic gastrojejunostomy and percutaneous endoscopic gastrostomy: a prospective, randomized comparison. *J Vasc Interv Radiol* 1999; 10:413–420.
107. Shike M, Latkany L, Gerdes H, Bloch A. Direct percutaneous endoscopic jejunostomies for enteral feeding. *Gastrointest Endosc* 1996; 44:536–540.
108. Varadarajulu S, DeLegge M. Use of a 19-gauge needle as a direct guide for direct percutaneous endoscopic jejunostomy (DPEJ) tube placement. *Gastrointest Endosc* 2003; 57:942–945.
109. Mackenzie SH, Haslem D, Hilden K, Thomas KL, Fang JC. Success rate of direct percutaneous endoscopic jejunostomy in patients who are obese. *Gastrointest Endosc* 2008; 67:265–269.
110. Sharma V, Close T, Bynoe R, Vasudeva R. Ultrasound-assisted direct percutaneous endoscopic jejunostomy (DPEJ) tube placement. *Surg Endosc* 2000; 14:203.
111. Shetzline M, Suhocki P, Workman M. Direct percutaneous endoscopic jejunostomy with small bowel enteroscopy and fluoroscopy. *Gastrointest Endosc* 2001; 53:633.
112. Yang ZQ, Shin JH, Song HY, et al. Fluoroscopically guided percutaneous jejunostomy: outcomes in 25 consecutive patients. *Clin Radiol* 2007; 62:1061–1065.
113. Rosenblum J, Taylor FC, Lu CT, Martich V. A new technique for direct percutaneous jejunostomy tube placement. *Am J Gastroenterol* 1990; 85:1165–1167.
114. Richard HM, Widlus DM, Malloy PC. Percutaneous fluoroscopically guided jejunostomy placement. *J Trauma* 2008; 65:1072–1077.
115. van Overhagen H, Ludviksson MA, Lameris JS, et al. US and fluoroscopic-guided percutaneous jejunostomy: experience in 49 patients. *J Vasc Interv Radiol* 2000; 11:101–106.
116. Sparrow P, David E, Pugash R. Direct percutaneous jejunostomy—an underutilized interventional technique? *Cardiovasc Intervent Radiol* 2008; 31:336–341.
117. Brock MV, Venbrux AC, Heitmiller RF. Percutaneous replacement jejunostomy after esophagogastrectomy. *J Gastrointest Surg* 2000; 4:407–410.
118. Shike M, Wallach C, Likier H. Direct percutaneous endoscopic jejunostomies. *Gastrointest Endosc* 1991; 37:62–65.
119. Shike M, Latkany L, Gerdes H, Bloch A. Direct percutaneous endoscopic jejunostomies for enteral feeding. *Nutr Clin Pract* 1997; 12(Suppl):S38–S42.
120. Maple J, Petersen B, Baron T, Gostout C, Wong Kee Song LM, Buttar N. Direct percutaneous endoscopic jejunostomy: outcomes in 307 consecutive attempts. *Am J Gastroenterol* 2005; 100:2681–2688.
121. DeLegge M. Small bowel endoscopic enteral access. *Gastrointest Endosc Clin N Am* 2007; 17:663–686.
122. Krivian K, Peterson K, DiSario J, Fang J. Comparison of percutaneous endoscopic gastrostomy with jejunal extension to combined direct percutaneous endoscopic gastrostomy/direct percutaneous endoscopic jejunostomy. *Gastrointest Endosc* 2003; 57:AB159.
123. DeLegge M, Ginsberg G, McClave S, DiSario J, Lehman G, Fang J. Randomized prospective comparison of direct percutaneous endoscopic jejunostomy vs. percutaneous endoscopic gastrostomy with jejunal extension feeding tube placement for enteral feeding. *Gastrointest Endosc* 2004; 59:AB158.
124. Ponsky J, Aszodi A, Perse D. Percutaneous endoscopic cecostomy: a new approach to nonobstructive colonic dilation. *Gastrointest Endosc* 1986; 32:108–111.
125. Holm AN, Baron TH. Palliative use of percutaneous endoscopic gastrostomy and percutaneous endoscopic cecostomy tubes. *Gastrointest Endosc Clin N Am* 2007; 17:795–803.
126. Uno Y. Introducer method of percutaneous endoscopic cecostomy and antegrade continence enema by use of the Chait Trapdoor cecostomy catheter in patients with adult neurogenic bowel. *Gastrointest Endosc* 2006; 63:666–682.
127. Chait PG, Shandling B, Richards HF. The cecostomy button. *J Pediatr Surg* 1997; 32:849–851.
128. Casola G, Withers C, vanSonnenberg E, Herba MJ, Saba RM, Brown RA. Percutaneous cecostomy for decompression of the massively distended cecum. *Radiology* 1986; 158:793–794.
129. Haaga JR, Bick RJ, Zollinger RM. CT-guided percutaneous catheter cecostomy. *Gastrointest Radiol* 1987; 12:166–168.
130. van Sonnenberg E, Varney R, Casola G, et al. Percutaneous cecostomy for Ogilvie syndrome: laboratory observations and clinical experience. *Radiology* 1990; 175:679–682.
131. Wood MF, Sapala JA, Sapala MA, Schuhknecht MP, Flake TM. Micropouch gastric bypass: indications for gastrostomy tube placement in the bypassed stomach. *Obes Surg* 2000; 10:413–419.
132. Noshier JL, Bodner LJ, Girgis WS, Brolin R, Siegel RL, Gribbin C. Percutaneous gastrostomy for treating dilatation of the bypassed stomach after bariatric surgery for morbid obesity. *AJR Am J Roentgenol* 2004; 183:1431–1435.
133. Ross AS, Semrad C, Alverdy J, Waxman I, Dye C. Use of double-balloon enteroscopy to perform PEG in the excluded stomach after Roux-en-Y gastric bypass. *Gastrointest Endosc* 2006; 64:797–800.
134. Teubner A, Morrison K, Ravishankar HR, Anderson ID, Scott NA, Carlson GL. Fistuloclysis can successfully replace parenteral feeding in the nutritional support of patients with enterocutaneous fistula. *Br J Surg* 2004; 91:625–631.
135. Baron TH. Direct percutaneous endoscopic jejunostomy. *Am J Gastroenterol* 2006; 101:1407–1409.
136. Lynch C, Fang J. Prevention and management of complications of percutaneous endoscopic gastrostomy tubes. *Pract Gastroenterol* 2004; 28:66–76.
137. Chung RS, Schertzer M. Pathogenesis of complications of percutaneous endoscopic gastrostomy. A lesson in surgical principles. *Am Surg* 1990; 56:134–137.
138. Larson D, Burton D, Schroeder K, DiMaggio E. Percutaneous endoscopic gastrostomy. Indications, success, complications, and mortality in 314 consecutive patients. *Gastroenterology* 1987; 93:48–52.
139. George J, Crawford D, Lewis T, Shepherd R, Ward M. Percutaneous endoscopic gastrostomy: a two-year experience. *Med J Aust* 1990; 152:17–19.
140. Ponsky J, Gauderer M, Stellato T. Percutaneous endoscopic gastrostomy. Review of 150 cases. *Arch Surg* 1983; 118:913–914.
141. Brown DN, Miedema BW, King PD, Marshall JB. Safety of early feeding after percutaneous endoscopic gastrostomy. *J Clin Gastroenterol* 1995; 21:330–331.
142. Choudhry U, Barde C, Markert R, Gopalswamy N. Percutaneous endoscopic gastrostomy: a randomized prospective comparison of early and delayed feeding. *Gastrointest Endosc* 1996; 44:164–167.
143. McCarter TL, Condon SC, Aguilar RC, Gibson DJ, Chen YK. Randomized prospective trial of early versus delayed feeding after percutaneous endoscopic gastrostomy placement. *Am J Gastroenterol* 1998; 93:419–421.
144. Stein J, Schulte-Bockholt A, Sabin M, Keymling M. A randomized prospective trial of immediate vs. next-day feeding after percutaneous



- endoscopic gastrostomy in intensive care patients. *Intens Care Med* 2002; 28:1656–1660.
145. Bechtold ML, Matteson ML, Choudhary A, Puli SR, Jiang PP, Roy PK. Early versus delayed feeding after placement of a percutaneous endoscopic gastrostomy: a meta-analysis. *Am J Gastroenterol* 2008; 103:2919–2924.
  146. Given MF, Hanson JJ, Lee MJ. Interventional radiology techniques for provision of enteral feeding. *Cardiovasc Intervent Radiol* 2005; 28:692–703.
  147. Dinkel HP, Beer KT, Zbaren P, Triller J. Establishing radiological percutaneous gastrostomy with balloon-retained tubes as an alternative to endoscopic and surgical gastrostomy in patients with tumours of the head and neck or oesophagus. *Br J Radiol* 2002; 75:371–377.
  148. Powell KS, Marcuard SP, Farrior ES, Gallagher ML. Aspirating gastric residuals causes occlusion of small-bore feeding tubes. *JPEN J Parenter Enteral Nutr* 1993; 17:243–246.
  149. Simon T, Fink AS. Current management of endoscopic feeding tube dysfunction. *Surg Endosc* 1999; 13:403–405.
  150. Kuo YC, Shlansky-Goldberg RD, Mondschein JI, et al. Large or small bore, push or pull: a comparison of three classes of percutaneous fluoroscopic gastrostomy catheters. *J Vasc Interv Radiol* 2008; 19:557–563.
  151. Hofstetter J, Allen LV. Causes of non-medication-induced nasogastric tube occlusion. *Am J Hosp Pharm* 1992; 49:603–607.
  152. Metheny N, Eisenberg P, McSweeney M. Effect of feeding tube properties and three irrigants on clogging rates. *Nurs Res* 1988; 37:165–169.
  153. Sartori S, Trevisani L, Nielsen I, Tassarini 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.
  154. Blacka J, Donoghue J, Sutherland M, et al. Dwell time and functional failure in percutaneous endoscopic gastrostomy tubes: a prospective randomized-controlled comparison between silicon polymer and polyurethane percutaneous endoscopic gastrostomy tubes. *Aliment Pharmacol Ther* 2004; 20:875–882.
  155. Van Den Hazel SJ, Mulder CJ, Den Hartog G, Thies JE, Westhof W. A randomized trial of polyurethane and silicone percutaneous endoscopic gastrostomy catheters. *Aliment Pharmacol Ther* 2000; 14:1273–1277.
  156. Marcuard SP, Finley JL, MacDonald KG. Large-bore feeding tube occlusion by yeast colonies. *JPEN J Parenter Enteral Nutr* 1993; 17:187–190.
  157. Marcuard SP, Perkins AM. Clogging of feeding tubes. *JPEN J Parenter Enteral Nutr* 1988; 12:403–405.
  158. Nicolau DP, Davis SK. Carbonated beverages as irrigants for feeding tubes. *Ann Pharmacother* 1990; 24:840.
  159. Wilson MF, Haynes-Johnson V. Cranberry juice or water? A comparison of feeding-tube irrigants. *Nutr Supp Serv* 1987; 7:23–24.
  160. Marcuard SP, Stegall KS. Unclogging feeding tubes with pancreatic enzyme. *JPEN J Parenter Enteral Nutr* 1990; 14:198–200.
  161. Bert F, Maubec E, Bruneau B, Berry P, Lambert-Zechovsky N. Multi-resistant *Pseudomonas aeruginosa* outbreak associated with contaminated tap water in a neurosurgery intensive care unit. *J Hosp Infect* 1998; 39:53–62.
  162. Marrie TJ, Haldane D, MacDonald S, et al. Control of endemic nosocomial legionnaires' disease by using sterile potable water for high risk patients. *Epidemiol Infect* 1991; 107:591–605.
  163. Venezia RA, Agresta MD, Hanley EM, Urquhart K, Schoonmaker D. Nosocomial legionellosis associated with aspiration of nasogastric feedings diluted in tap water. *Infect Control Hosp Epidemiol* 1994; 15:529–533.
  164. Sriram K, Jayanthi V, Lakshmi RG, George VS. Prophylactic locking of enteral feeding tubes with pancreatic enzymes. *JPEN J Parenter Enteral Nutr* 1997; 21:353–356.
  165. Bourgault AM, Heyland DK, Drover JW, Keefe L, Newman P, Day AG. Prophylactic pancreatic enzymes to reduce feeding tube occlusions. *Nutr Clin Pract* 2003; 18:398–401.
  166. Marcuard SP, Stegall KL, Trogdon S. Clearing obstructed feeding tubes. *JPEN J Parenter Enteral Nutr* 1989; 13:81–83.
  167. Mathus-Vliegen LM, Binnekade JM, de Haan RJ. Bacterial contamination of ready-to-use 1-L feeding bottles and administration sets in severely compromised intensive care patients. *Crit Care Med* 2000; 28:67–73.
  168. Heiser M, Malaty H. Balloon-type versus non-balloon-type replacement percutaneous endoscopic gastrostomy: which is better? *Gastroenterol Nurs* 2001; 24:58–63.
  169. Buderus S, Adenauer M, Dueker G, Bindl L, Lentze MJ. Balloon gastrostomy buttons in pediatric patients: evaluation with respect to size, lifetime in patients, and parent acceptance. *Klinische Pädiatrie*. 2009; 221:65–68.
  170. Fortunado J, Darbari A, Mitchell S, Thompson R, Cuffari C. The limitations of gastro-jejunal (G-J) feeding tubes in children: a 9-year pediatric hospital database analysis. *Am J Gastroenterol* 2005; 100:186–189.
  171. Ozmen M, Akhan O. Percutaneous radiologic gastrostomy. *Eur J Radiol* 2002; 43:186–195.
  172. Lynch CR, Jones RG, Hilden K, Wills JC, Fang JC. Percutaneous endoscopic cecostomy in adults: a case series. *Gastrointest Endosc* 2006; 64:279–282.
  173. Eisen GM, Baron TH, Dominitz JA, et al. Role of endoscopy in enteral feeding. *Gastrointest Endosc* 2002; 55:794–797.
  174. Davis JB Jr, Bowden TA Jr, Rives DA. Percutaneous endoscopic gastrostomy. Do surgeons and gastroenterologists get the same results? *Am Surg* 1990; 56:47.
  175. Kohli H, Bloch R. Percutaneous endoscopic gastrostomy: a community hospital experience. *Am Surg* 1995; 61:191–194.
  176. Loser C, Wolters S, Folsch U. Enteral long-term nutrition via percutaneous endoscopic gastrostomy (PEG) in 210 patients: a four-year prospective study. *Dig Dis Sci*. 1998; 43:2549–2557.
  177. So J, Ackroyd F. Experience of percutaneous endoscopic gastrostomy at Massachusetts General Hospital—indications and complications. *Singapore Med J* 1998; 39:560–563.
  178. Abuksis G, Mor M, Segal N, et al. Percutaneous endoscopic gastrostomy: high mortality rates in hospitalized patients. *Am J Gastroenterol* 2000; 95:128–132.
  179. Calton W, Martindale R, Gooden S. Complications of percutaneous endoscopic gastrostomy. *Mil Med* 1992; 157:358–360.
  180. Kavic S, Basson M. Complications of endoscopy. *Am J Surg* 2001; 181:319–332.
  181. Alexander J, Smith B. Midazolam sedation for percutaneous liver biopsy. *Dig Dis Sci* 1993; 38:2209–2211.
  182. Hart R, Classen M. Complications of diagnostic gastrointestinal endoscopy. *Endoscopy* 1990; 22:229–233.
  183. Jarnagin W, Duh Q, Mulvihill S, Ridge J, Schrock T, Way L. The efficacy and limitations of percutaneous endoscopic gastrostomy. *Arch Surg* 1992; 127:261.
  184. Grant JP. Percutaneous endoscopic gastrostomy. Initial placement by single endoscopic technique and long-term follow-up. *Ann Surg* 1993; 217:168–174.
  185. Safadi B, Marks J, Ponsky J. Percutaneous endoscopic gastrostomy. *Gastrointest Endosc Clin N Am* 1998; 8:551–568.
  186. Amann W, Mischinger H, Berger A, et al. Percutaneous endoscopic gastrostomy (PEG). 8 years of clinical experience in 232 patients. *Surg Endosc* 1997; 11:741–744.
  187. Petersen T, Kruse A. Complications of percutaneous endoscopic gastrostomy. *Eur J Surg* 1997; 163:351–356.
  188. Rabeneck L, Wray N, Petersen N. Long-term outcomes of patients receiving percutaneous endoscopic gastrostomy tubes. *J Gen Intern Med* 1996; 11:287–293.
  189. Mamel J. Percutaneous endoscopic gastrostomy. *Am J Gastroenterol* 1989; 84:703–710.
  190. Hament J, Bax N, van der Zee DC, DeShryver J, Nesselaar C. Complications of percutaneous endoscopic gastrostomy with or without concomitant antireflux surgery in 96 children. *J Pediatr Surg* 2001; 36:1412–1415.
  191. Wojtowycz M, Arata JA Jr, Micklos T, Miller FJ Jr. CT findings after uncomplicated percutaneous gastrostomy. *Am J Roentgenol* 1988; 151:307–309.
  192. Fouch P. Complications of percutaneous endoscopic gastrostomy and jejunostomy. Recognition, prevention, and treatment. *Gastrointest Endosc Clin North Am* 1992; 2:231–248.
  193. Schapiro G, Edmundowicz S. Complications of percutaneous endoscopic gastrostomy. *Gastrointest Endosc* 1996; 6:409–422.
  194. Hull M, Rawlings J, Murray F, et al. Audit of outcome of long-term enteral nutrition by percutaneous endoscopic gastrostomy. *Lancet* 1993; 341:869–872.
  195. Sangster W, Cuddington G, Bachulis B. Percutaneous endoscopic gastrostomy. *Am J Surg* 1988; 155:677–679.
  196. Lee J, Kim J, Kim Y, et al. Increased risk of peristomal wound infection after percutaneous endoscopic gastrostomy in patients with diabetes mellitus. *Dig Liver Dis* 2002; 34:857–861.
  197. Mack L, Kaklamanos I, Livingstone A, et al. Gastric decompression and enteral feeding through a double-lumen gastrojejunostomy tube

- improves outcomes after pancreaticoduodenectomy. *Ann Surg* 2004; 240:845–851.
198. Deitel M, Bendago M, Spratt E, Burul C, To T. Percutaneous endoscopic gastrostomy by the “pull” and “introducer” methods. *Can J Surg* 1988; 31:102–104.
  199. 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.
  200. Cave D, Robinson W, Brotschi E. Necrotizing fasciitis following percutaneous endoscopic gastrostomy. *Gastrointest Endosc* 1986; 32: 294–296.
  201. Korula J, Rice H. Necrotizing fasciitis and percutaneous endoscopic gastrostomy. *Gastrointest Endosc* 1987; 33:335–336.
  202. Person J, Brower R. Necrotizing fasciitis/myositis following percutaneous endoscopic gastrostomy. *Gastrointest Endosc* 1986; 32:309.
  203. Lin H, Ibrahim H, Kheng J, Fee W, Terris D. Percutaneous endoscopic gastrostomy: strategies for prevention and management of complications. *Laryngoscope* 2001; 111:1847–1852.
  204. McClave S, Chang W. Complications of enteral access. *Gastrointest Endosc* 2003; 58:739–751.
  205. Venu RP, Brown RD, Pastika BJ, Erikson LW Jr. The buried bumper syndrome: a simple management approach in two patients. *Gastrointest Endosc* 2002; 56:582–584.
  206. Walton G. Complications of percutaneous gastrostomy in patients with head and neck cancer—an analysis of 42 consecutive patients. *Ann R Coll Surg Engl* 1999; 81:272–276.
  207. Ma M, Semlacher E, Fedorak R, et al. The buried gastrostomy bumper syndrome: prevention and endoscopic approaches to removal. *Gastrointest Endosc* 1995; 41:505–508.
  208. McClave SA, Jafri NS. Spectrum of morbidity related to bolster placement at time of percutaneous endoscopic gastrostomy: buried bumper syndrome to leakage and peritonitis. *Gastrointest Endosc Clin N Am* 2007; 17:731–746.
  209. Rimon E. The safety and feasibility of percutaneous endoscopic gastrostomy placement by a single physician. *Endoscopy* 2001; 33:241–244.
  210. Dwyer K, Watts D, Thurber J, Benoit R, Fakhry S. Percutaneous endoscopic gastrostomy: the preferred method of elective feeding tube placement in trauma patients. *J Trauma* 2002; 52:26–32.
  211. McClave S, Neff R. Care and long-term maintenance of percutaneous endoscopic gastrostomy tubes. *JPEN J Parenter Enteral Nutr* 2006; 30(1 Suppl):S27–S38.
  212. Iber F, Livak A, Patel M. Importance of fungus colonization in failure of silicone rubber percutaneous gastrostomy tubes (PEGs). *Dig Dis Sci* 1996; 41:226–231.
  213. Van Den Hazel SJ, Mulder CJ, Den Hartog G, Thies JE, Westhof W. A randomized trial of polyurethane and silicone percutaneous endoscopic gastrostomy catheters. *Aliment Pharmacol Ther* 2000; 14:1273–1277.
  214. Gibson S, Wenig B. Percutaneous endoscopic gastrostomy in the management of head and neck carcinoma. *Laryngoscope* 1992; 102: 977.
  215. Gibson S, Wenig B, Watkins J. Complications of percutaneous endoscopic gastrostomy in head and neck cancer patients. *Ann Otol Rhinol Laryngol* 1992; 101:46–50.
  216. Adelson R, Ducic Y. Metastatic head and neck carcinoma to a percutaneous endoscopic gastrostomy site. *Head Neck*. 2005; 27:339–343.
  217. Thakore J, Mustafa M, Suryaprasad S, Agrawal S. Percutaneous endoscopic gastrostomy associated gastric metastasis. *J Clin Gastroenterol* 2003; 37:307–311.
  218. Hosseini M, Lee J. Metastatic esophageal cancer leading to gastric perforation after repeat PEG placement. *Am J Gastroenterol* 1999; 94:2556–2558.
  219. Alagaratnam T, Smith B. Wound implantation—a surgical hazard. *Br J Surg* 1993; 64:872–875.
  220. Laccourreye O, Chabardes E, Merite-Drancy A, et al. Implantation metastasis following percutaneous endoscopic gastrostomy. *J Laryngol Otol* 1993; 107:946–949.
  221. DiSario J, Foutch P, Sanowski R. Poor results with percutaneous endoscopic jejunostomy. *Gastrointest Endosc* 1990; 36:257–260.
  222. Doede T, Faiss S, Schier F. Jejunal feeding tubes via gastrostomy in children. *Endoscopy* 2002; 34:539–542.
  223. DeLegge M. Enteral access in home care. *JPEN J Parenter Enteral Nutr* 2006; 30(1 Suppl):S13–S20.
  224. Gore D, DeLegge M, Gervin A, DeMaria E. Surgically placed gastrojejunostomy tubes have fewer complications compared to feeding jejunostomy tubes. *J Am Coll Nutr* 1996; 15:144–146.
  225. Fang J. Percutaneous access for enteral nutrition. *Tech Gastrointest Endosc* 2007; 9:176–182.
  226. Benacci J, Wolff B. Cecostomy. Therapeutic indications and results. *Dis Colon Rectum* 1995; 38:530–534.
  227. Maginot T, Cascade P. Abdominal wall cellulitis and sepsis secondary to percutaneous cecostomy. *Cardiovasc Intervent Radiol* 1993; 16:328–331.
  228. Rivera M, Kugathasan S, Berger W, Werlin S. Percutaneous colonoscopic cecostomy for management of chronic constipation in children. *Gastrointest Endosc* 2001; 53:225–228.
  229. Ramage Jr JI, Baron T. Percutaneous endoscopic cecostomy: a case series. *Gastrointest Endosc* 2003; 57:752–755.
  230. Malone PS, Ransley PG, Kiely EM. Preliminary report: the antegrade continence enema. *Lancet* 1990; 336:1217–1218.
  231. Salm R, Ruckauer K, Waldmann D, Farthmann E. Endoscopic percutaneous cecostomy (EPC). *Surg Endosc* 1988; 2:92–95.
  232. Ganc A, Netto A, Morrell A, Plapler H, Ardengh J. Transcolonoscopic extraperitoneal cecostomy. A new therapeutic and technical proposal. *Endoscopy* 1988; 20:309–312.
  233. De Peppo F, Iacobelli B, M De Gennaro, Colajacomo M, Rivoecchi M. Percutaneous endoscopic cecostomy for antegrade colonic irrigation in fecally incontinent children. *Endoscopy* 1999; 31:501–503.
  234. DeLegge MH, McClave SA, DiSario JA, et al. Ethical and medicolegal aspects of PEG-tube placement and provision of artificial nutritional therapy. *Gastrointest Endosc* 2005; 62:952–959.
  235. Mayo TW. Forgoing artificial nutrition and hydration: legal and ethical considerations. *Nutr Clin Pract* 1996; 11:254–264.
  236. Finucane TE, Christmas C, Travis K. Tube feeding in patients with advanced dementia: a review of the evidence. *JAMA* 1999; 282:1365–1370.
  237. Gillick MR. Rethinking the role of tube feeding in patients with advanced dementia. *N Engl J Med* 2000; 342:206–210.
  238. McCann RM, Hall WJ, Groth-Juncker A. Comfort care for terminally ill patients. The appropriate use of nutrition and hydration. *JAMA* 1994; 272:1263–1236.
  239. Lien HC, Chang CS, Chen GH. Can percutaneous endoscopic jejunostomy prevent gastroesophageal reflux in patients with preexisting esophagitis? *Am J Gastroenterol* 2000; 95:3439–3443.
  240. Heyland DK, Drover JW, Dhaliwal R, Greenwood J. Optimizing the benefits and minimizing the risks of enteral nutrition in the critically ill: role of small bowel feeding. *JPEN J Parenter Enteral Nutr* 2002; 26(6 Suppl):S51–S55.
  241. Weaver JP, Odell P, Nelson C. Evaluation of the benefits of gastric tube feeding in an elderly population. *Arch Fam Med* 1993; 2:953–956.
  242. Bannerman E, Pendlebury J, Phillips F, Ghosh S. A cross-sectional and longitudinal study of health-related quality of life after percutaneous gastrostomy. *Eur J Gastroenterol Hepato* 2000; 12:1101–1109.
  243. Bourdel-Marchasson I, Dumas F, Pinganaud G, Emeriau JP, Decamps A. Audit of percutaneous endoscopic gastrostomy in long-term enteral feeding in a nursing home. *Int J Qual Health Care* 1997; 9:297–302.
  244. Mitchell SL, Kiely DK, Lipsitz LA. The risk factors and impact on survival of feeding tube placement in nursing home residents with severe cognitive impairment. *Arch Intern Med* 1997; 157:327–332.