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Bronchoscope-Guided Percutaneous Endoscopic Gastrostomy Tube Placement by Interventional Pulmonologists: A Feasibility and Safety Study

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Abstract

Background: Percutaneous endoscopic gastrostomy (PEG) tube placement is a procedure frequently done in the intensive care unit. The use of a traditional endoscope can be difficult in cases of esophageal stenosis and theoretically confers an increased risk of infection due to its complex architecture. We describe a technique using the bronchoscope, which allows navigation through stenotic esophageal lesions and also minimizes the risk of endoscopy-associated infections. **Methods:** Prospective series of patients who had PEG tube placement guided by a bronchoscope. Procedural outcomes including successful placement, duration of the entire procedure, time needed for passage of the bronchoscope from the oropharynx to the major curvature, PEG tube removal rate, and mortality were collected. Procedural adverse events, including infections and long-term PEG-related complications, were recorded. **Results:** A total of 84 patients underwent bronchoscope-guided PEG tube placement. Percutaneous endoscopic gastrostomy tube insertion was completed successfully in 82 (97.6%) patients. Percutaneous endoscopic gastrostomy tube placement was performed immediately following percutaneous tracheostomy in 82.1%. Thirty-day mortality and 1-year mortality were 11.9% and 31%, respectively. Overall, minor complications occurred in 2.4% of patients, while there were no major complications. No serious infectious complications were identified and no endoscope-associated hospital acquired infections were documented. **Conclusions:** The use of the bronchoscope can be safely and effectively used for PEG tube placement. The use of bronchoscope rather than a gastroscope has several advantages, which include the ease of navigating through complex aerodigestive disorders such as strictures and fistulas as well as decreased health-care utilization. In addition, it may have a theoretical advantage of minimizing infections related to complex endoscopes.

Keywords

percutaneous endoscopic gastrostomy, bronchoscopy, interventional pulmonology, complications, infection

Background

In patients who require prolonged mechanical ventilation, a reliable enteral access such as percutaneous endoscopic gastrostomy (PEG) tube might be needed. Although PEG tubes have been traditionally placed by surgeons, gastroenterologists, and interventional radiologists, a recent prospective study has evaluated the feasibility and safety of PEG tube placement by interventional pulmonologists (IPs).[1] This study showed that PEG tube placement guided by a gastroscope in critically ill patients was successful in 97.2% with a 1.4% complication rate.[1] A second study, described a 10-year experience placing PEG via transnasal route in patients with head and neck cancer.[2]

Although IPs are well suited to perform PEG tube placements due to advanced endoscopic training during their subspecialty fellowship,[3] training and ability to easily navigate

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using a gastroscope and easy accessibility are necessary before performing such a procedure. The use of a therapeutic flexible bronchoscope in place of a gastroscope is appealing. The therapeutic bronchoscope is readily accessible and its simplified internal architecture may confer a lesser risk of infectious complications. Previous studies have shown infection rates of 5% to 25% using the gastroscope[4] and 7.1% with radiographic guidance.[5] Mota et al described in a small cohort of patients an infection rate of 10% using the flexible bronchoscopy.[2] The aim of this study was to assess the feasibility and safety of PEG tube placement guided by a flexible bronchoscope in critically ill patients.

Material and Methods

Study Design

We conducted a review of prospectively collected data from October 2012 until July 2016 of all patients who had flexible bronchoscope-guided PEG tube placement. This study protocol was approved by the institutional review board of Beth Israel Deaconess Medical Center, Boston, Massachusetts (IRB #2012P-000291). All patients had written informed consent to the procedure provided by their health-care proxy.

Participant Population and Enrollment

Each participant underwent procedural consent for PEG tube placement per standard institution practices and guidelines. All requests were reviewed by the IP team for (1) clinical indication, (2) suitability of performing the procedure, and (3) appropriateness performing combination of percutaneous tracheostomy (PCT) and PEG tube consecutively and under the same anesthetic episode.

We included all the consecutive adult patients who were critically ill, patients in the medical intensive care units (ICUs) who required a PEG tube placement as determined by the attending intensivists, and patients who were deemed hemodynamically stable to undergo the procedure. Exclusion criteria included uncorrectable coagulopathy, significant ascites (directly visible), active peritonitis, esophageal varices, gastric outlet obstruction, and inability to adequately visualize gastrocutaneous transillumination and finger indentation. Unless contraindicated, medication administration was allowed immediately after procedure[6] and enteral feeding 24 hours later.

Operative Technique

All patients received preoperative antibiotic prophylaxis as per current guidelines[7] unless they were already receiving antibiotic therapy with an acceptable coverage. All PEG tube placements were performed under general intravenous anesthesia (propofol or midazolam and fentanyl). If PEG tube placement was scheduled in combination with PCT, it was placed immediately following tracheostomy using the same bronchoscope. The order of the procedures was intentional and intended to secure the airway and minimize any bacterial translocation into the trachea. All patients were monitored throughout the procedure as per American Society of Anesthesiologists guidelines.

All PEG procedures were performed with the "pull" technique as described by Gauderer et al.[8] A flexible Olympus 5.9-mm bronchoscope with a 2.8-mm working channel (Olympus America, Center Valley, Pennsylvania) was used for PEG tube placement. Insufflation of the esophagus and stomach was done by flow oxygen (4-6 L/min) via the suction port of the bronchoscope. Endoscopic examination of the gastrointestinal tract from the esophagus through the stomach was done in a systematic and deliberate fashion by rotating the bronchoscope both clockwise and counterclockwise in a 360° in order to minimize the amount of unexamined surface area. In order not to cause overdistention of the stomach, we stop insufflation of oxygen once the stomach rugae had disappeared. Complete endoscopic inspection of the esophagus and stomach was performed. Gastrocutaneous transillumination and finger indentation were performed to confirm proximity of the stomach to the abdominal wall and accurate entry site of the needle prior to abdominal puncture. The abdomen was prepped in a sterile fashion using 10.5-mL chlorhexidine gluconate for each procedure. All PEG tubes were done using 20F Ponsky Pull PEG Kit (Bard Access Systems, Inc, Salt Lake City, Utah and Boston Scientific, Natick, Massachusetts). After identification of an appropriate insertion site (left upper quadrant or epigastrium, 2-3 fingers below the costal margin), 5 mL of 1% lidocaine was infiltrated subcutaneously. A skin incision of 1 cm was then made and a needle–catheter combination was inserted across the stomach wall under direct visualization with the bronchoscope. The needle was then removed and a wire loop was inserted through the catheter into the stomach. A snare system was passed through the working channel of the bronchoscope to hold the wire loop. The loop is then pulled up through the esophagus along with the bronchoscope and out of the mouth where it is attached to the gastrostomy tube and pulled back down the esophagus to the stomach, and then through the skin. The PEG tube with stabilizing dome was then secured against the stomach wall. Direct visualization with the bronchoscope was used to confirm the absence of excessive tension or blanching of the gastric wall at the contact site of the PEG tube dome. The external bolster was attached over the external portion of the PEG tube, and the tube was cut to a desired length. All procedures were performed by A.M. and E.F. in collaboration with trainees. They were assisted by an ICU nurse or anesthesiologist during the procedure (Figure 1).

Data Collection and Outcomes Measures

Prospective data were collected, including patient demographics, comorbidities, body mass index (BMI), laboratory data (platelet count, blood urea nitrogen, creatinine, and coagulation profile), medications (anticoagulation therapy), and indication of the procedure.

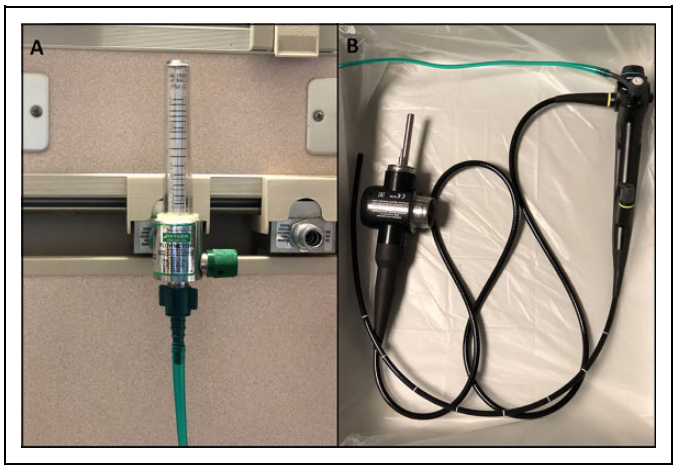

Figure 1. A, Insufflation of the esophagus and stomach was done by flow oxygen (4-6 L/min) via the suction port of the bronchoscope. B, Flexible Olympus 5.9 mm bronchoscope with a 2.8-mm working channel (Olympus America, Center Valley, Pennsylvania) was used for percutaneous endoscopic gastrostomy (PEG) tube placement.

Clinical outcome data collected included the following:

A. Procedure Outcomes
- ☐ Successful PEG tube placement.
- ☐ Duration of the entire procedure.
- ☐ Time needed for passage of the bronchoscope from the oropharynx to the gastric cardia.
- ☐ PEG tube removal rate.
- ☐ Infectious complications resulting from the procedure.

B. Other Outcomes
- ☐ Adverse events of the procedure including major complications (Common Terminology Criteria for Adverse Events [CTCAE] grade 3-4) such as bleeding (defined as drop in serum hematocrit or causing hemodynamic instability requiring blood transfusion, suturing, packing, or surgical intervention), peritonitis, and inadvertent abdominal organ puncture as well as minor complications (CTCAE grade 1-2) related to PEG tube including cellulitis, abdominal wall hematoma, and tube malfunction.
- ☐ Development of sepsis or soft tissue infection at the site of the PEG.
- ☐ Mortality.

Data Analysis and Statistical Methods

Statistical analysis was performed using SPSS version 21, with a P value of <.05 defined as significant. Descriptive statistics including mean, median, range, and percentage were utilized to describe patient demographics and outcomes. Survival rate was calculated by the Kaplan-Meier method.

Table 1. Demographics, Clinical Characteristics, and Patient Comorbidities.

Demographics (N = 84)	Value
Age, median (IQR)	69 (54-77)
Men, n (%)	54 (64.3)
BMI, median (IQR)	27.6 (22.5-34.1)
Anticoagulation therapy, n (%)	
Aspirin	29 (34.5)
Heparin prophylactic	39 (46.4)
Warfarin (INR >2)	1 (1.2)
Clopidogrel	1 (1.2)
Laboratory profile, median (IQR)	
Hemoglobin (g/dL)	8.5 (7.9-10.1)
INR	1.2 (1.1-1.3)
PTT (seconds)	32 (29-41)
Platelets $\times$ 10^9/L	238 (159-345)
Blood urea nitrogen (mmol/L)	28 (17-50)
Creatinine (mg/dL)	1 (0.7-2.0)
Comorbidities, n (%)	
Heart failure	36 (42.85)
Diabetes mellitus	35 (41.6)
COPD/asthma	30 (35.7)
Chronic kidney disease	17 (20.2)
Obstructive sleep apnea	11 (13.1)
Malignancy	11 (13.1)
Hepatic disease	9 (10.7)
Hypothyroidism	3 (3.6)
Other	30 (35.7)

Abbreviations: BMI, body mass index; COPD, chronic obstructive pulmonary disease; INR, International Normalized Ratio; IQR, interquartile range; PTT, partial thromboplastin time.

Results

Eighty-four consecutive patients who underwent bronchoscope-guided PEG tube placement were included in the study. Patients had a median age of 69 years (interquartile range [IQR]: 54-77), with 64.3% (n = 54) being men. The baseline demographic, clinical characteristics, and medical comorbidities of the patients are shown in Table 1. All patients were hospitalized in the medical ICU with an expected prolonged recovery as determined by their primary medical team. Sepsis at the time of requested procedure (35%), prolonged respiratory failure (25%), stroke (16%), neuromuscular disease (7%), Acute Respiratory Distress Syndrome (ARDS) (7%), cardiac arrest (5%), and malignancy (5%) were the underlying diagnosis at the time of PEG tube placement. Twenty-nine (34.5%) patients were on aspirin, 31 (46.4%) on prophylactic heparin, 1 (1.2%) on warfarin with (International Normalized Ratio [INR] >2) due to a prior history of mechanical heart valve, and 1 (1.2%) on clopidogrel because of a recent ST-segment elevation myocardial infarction at the time of the procedure.

Percutaneous endoscopic gastrostomy tube insertion was successfully completed in 82 (97.6%) of the 84 patients. Percutaneous endoscopic gastrostomy tube insertion was not completed in 2 patients. In the first patient, adequate gastric-cutaneous transillumination and finger indentation could not

Table 2. PEG Tube Data.

Variable	Value
Bronchoscopy mouth to stomach time (min:sec)	1:11 (0:40-02:0)
PEG tube procedure time (min:sec)	15:42 (12:36-23:36)
Minor complications, n (%)	2 (2.4): 1 cellulitis, 1 tube malfunction
Major complications, n (%)	0
Mortality at 30 days, n (%)	10 (11.9)
Mortality at 1 year, n (%)	26 (31)
Intensive care unit stay, days (IQR)	20 (14-29)
Total hospital stay, days (IQR)	24 (17-34)
Percutaneous tracheostomy performed simultaneously, n (%)	69 (82.1)

Abbreviations: IQR, interquartile range; PEG, percutaneous endoscopic gastrostomy.

Table 3. Rate of Complications Compared to Previous Studies.

Complication	Endoscopic Placement	Radiologic Placement	Our Series
Failed placement	4.3%-11%[12,13]	0%-2%[12-14]	2.4%
Bleeding	0[15]	5.56%[13]	0
Injury to internal organs	Case reports[4]	Case reports[4]	0
Necrotizing fascitis	Case reports[4]	NA	0
Aspiration pneumonia	0.3%-1%[16]	4%[12]	0
Buried bumper syndrome	1%[17]	NA	0
Tumor seeding[a]	9%[18]	Not tested	Not tested
Ileus	1%-2%[16]	5.56%[13]	0
Volvulus	Case reports[16]	NA	0
Granulation tissue	Case reports[4]	Case reports[4]	0
Gastric outlet obstruction	Case reports[16]	NA	0
Wound infection	5%-25%[4]	7.3%[5]	1.1%
Inadvertent tube dislodgement	1.6%-4.4%[16]	6.2%[5]	0
Peritonitis	1.3%[15]	5.56%[13]	0

[a]The clinical significance of tumor cell seeding is unknown.

successfully locate a safe puncture site; therefore, the procedure was aborted as this raised the concern of colonic transposition or lack of proximity of the stomach wall to the abdominal wall. In the second case, the needle was introduced but was not visualized by the bronchoscope and thus case was aborted. The thoracic surgery team later performed both PEG tube placements successfully by laparoscopic abdominal technique. No specific underlying pathology was identified to explain our failure to perform both procedures.

The median bronchoscope time from oropharynx to the major curvature was 1.11 minutes (IQR: 0.40-2 minutes). The median procedural time for PEG tube insertion was 15.42 minutes (IQR: 12.36-23.36 minutes; Table 2). The median follow-up time was 87 days (IQR: 19-459 days). The median ICU stay was 20 days (IQR: 14-29 days) and median hospital stay was 24 days (IQR: 13-74 days). Thirty-day and 1-year survival rates for the entire cohort were 83.1% and 60.3%, respectively.

Overall, minor complications such as soft tissue infections and PEG tube malfunction occurred in only 2.4% of patients, while there were no major complications such as perforation, sepsis, bleeding, peritonitis, or death. One patient had PEG tube malfunction, while another patient developed mild cellulitis around PEG tube insertion site. There was no major change in medical management, and PEG tubes were not removed for those patients until completion of the treatment. Percutaneous endoscopic gastrostomy tube removal occurred in 16 patients, with a median time to removal of 152 days (IQR: 96-240; Table 2).

From this cohort, 14.8% were obese (BMI > 30-35), while 13.6% were severely obese patients (BMI > 35-40) and 6.2% morbidly obese (BMI > 40). Percutaneous endoscopic gastrostomy tube placement was performed immediately following PCT in 69 (82.1%) patients. Percutaneous endoscopic gastrostomy tube placement was performed at bedside in 49 (58.3%) patients and in the Operating Room (OR) in 35 (41.7%) patients. The decision to perform PEG tube placement in the OR was driven by the complexity of the tracheostomy placement at bedside and not by PEG tube procedure itself. In our institution, we perform rigid bronchoscopy-guided PCT in patients with morbid obesity with a thick neck circumference, prior neck surgery, distorted airway anatomy, and uncorrected coagulopathy.[9]

Discussion

Avoiding unnecessary invasive procedures is the best way to prevent adverse events. However, the critically ill patient frequently requires a myriad of procedures in order to regain their homeostatic state.

Percutaneous endoscopic gastrostomy tube feeding is the preferred method to provide adequate and long-term tube feeding and its use is widespread in critically ill patients.[9] Enteral feeding is indicated in patients who cannot meet their metabolic requirements due to inadequate oral intake. Its low cost, absence of intravenous complications, and the possibility of maintaining gut functions, including inhibition of bacterial translocation, have made PEG placement a common procedure in the modern ICU.[10] Gastrostomy tubes may be placed endoscopically, radiologically, or by surgery. In the critically ill patient, the endoscopic approach is preferred as a less invasive alternative to the surgical approach, unless the patient is awaiting surgery for other reasons.[4] The endoscopic and radiologic techniques have been compared in retrospective studies and systematic reviews with conflicting results, but many favoring the endoscopic approach.[10,11]

This study demonstrated that flexible bronchoscope-guided PEG tube placement is feasible, safe, and without major procedural-related complications when performed by trained IP physicians. In Table 3, we show the rate of complications reported by previously published studies and the rate of complications in our study. Although a side-to-side

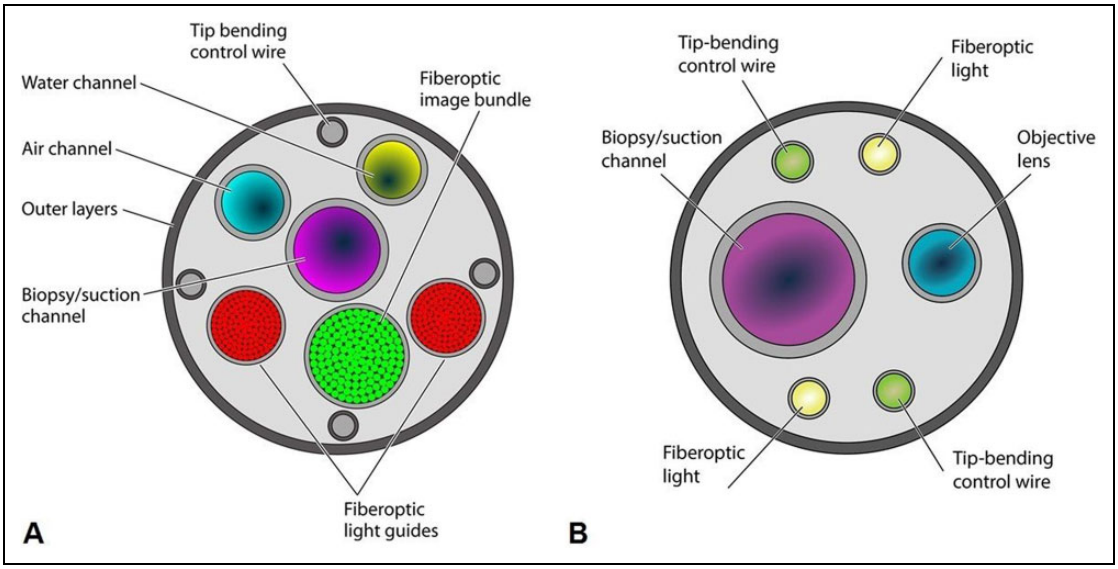

Figure 2. A, Schematic drawing of a cross section of a flexible endoscope showing the complex design and multiple internal channels (inner diameter, 2.8-3.8 mm). Reproduced with permission from American Society for Microbiology.[27] B, Schematic drawing of a cross section of a flexible bronchoscope showing the simplified design and single internal channel (inner diameter, 2.8 mm).

comparison is not possible, at the very least, the reduced rate of complications in our study suggests that future comparative studies should be done.

The average procedural time for flexible bronchoscope-guided PEG tube insertion was 15.42 minutes, slightly lower than the time (15.8 minutes) required to do gastroscope-guided PEG tube placement by IPs.[1] However, it is important to note that Yarmus et al[1] did not record the initial 20 cases, contrary to our study.

The American Society for Gastrointestinal Endoscopy guidelines suggest that proficiency is usually attained after performing of 15 PEG procedures and 130 upper endoscopies.[11] However, it is essential to recognize that trainees vary in the rate they acquire skills and the above recommendations were based on novice learners. Even though IPs have advanced endoscopic skills, they still need to learn how to navigate effectively using a gastroscope. Although this study was not intended to assess the number of PEG tube needed to define basic competency, the use of a familiar tool such as a flexible bronchoscope can potentially lead to steeper learning curve for PEG tube placement by IPs. The IPs who did the cases in the study were experienced at placing PEG tubes with the gastroscope and the traditional pull-through technique. Their initial credentialing required 20 supervised cases by thoracic surgeons with experience in esophageal disease. Moreover, the use of a bronchoscope for PEG placement resulted from our initial experience with difficult cases of esophageal high-grade stricture, where a gastroscope could not be passed and nutritional palliation was necessary. In those cases, we noticed the ease of navigation with a bronchoscope and placement of the percutaneous gastrostomy tube. In addition, this was driven by our previous experience with the use of endobronchial ultrasound through the esophagus, in cases where complete mediastinal staging was required.[19]

Once the proficiency to perform a minimally invasive procedure, such as PEG placement, has been reached, it is imperative to identify any factors that may improve patient outcomes and minimize complications. During PEG placement, infectious complications can occur during placement or after initiating enteral feeding. These infections are caused by either endogenous flora (the patient's own microorganisms) or exogenous microbes introduced into the patient via the endoscope in up to 14% of the patients.[20,21]

The most common PEG-related infectious complication is wound site infection. Incidence has been estimated between 5% and 25%.[4,22] A systematic review of 10 randomized controlled trials evaluating the role of prophylactic antimicrobials in 1100 patients showed a reduction in peristomal infection in the antibiotic group (pooled odds ratio = 0.31, 95% confidence interval: 0.22-0.44).[23] Following this rationale, all patients in our study received a single dose of prophylactic antibiotic before the procedure.

Another cause of infection resulting from percutaneous enteral feeding is aspiration pneumonia. This can occur either during the procedure or after feedings has been started. Aspiration associated with the procedure can occur during the supine position, sedation, neurological impairment, or advanced age.[4,16] An attempt to reduce the risk of aspiration is the use of postpyloric or jejunal feeding tubes, but unfortunately has not been able to significantly reduce this risk.[24,25] Minimizing the number of anesthesia events and times when the patient is in supine position has not been reported previously.

Recent reports of infectious complications linked to the complex architecture of the gastroscope have generated significant attention by the media. Although rare, the transmission of microorganisms through the endoscope from one patient to

another or through translocation of bacteria from the digestive flora through a perforation of the mucosa may occur.[26] Most modern flexible endoscopes cannot be heat sterilized and have a complex design, narrow lumens, and multiple channels, which are difficult to clean and disinfect (Figure 2).[27]

We believe that the simplified architecture of the bronchoscope confers a decreased risk of endoscopy-related infection. In Figures 1 and 2, we show a schematic representation of the internal structure of the endoscope and the bronchoscope. Regardless of the type of endoscope used, they should undergo a strict protocol of multistep cleaning, high-level disinfection, rinsing, and drying before storage.[27]

As the field of interventional pulmonology continues to expand, IPs role in minimizing health-care utilization costs and complications while providing efficient patient care is crucial. Around 82.1% of patients requiring mechanical ventilation had PEG tubes placed immediately following PCT.

Although this study did not directly address health-care cost utility, the ability of one team to perform both procedures may potentially lead to (1) decrease hospital and ICU stay, (2) less anesthetic exposure, (3) reduce wait time needed to perform both procedures (often by 2 separate services), (4) expedite patient discharge, and (5) minimize the amount of equipment and cost.

Furthermore, around one-third of patients in ICUs are obese and up to 7% are morbidly obese.[28] We demonstrated that flexible bronchoscope-guided PEG tube insertion is feasible and safe in such population since 34.6% of PEG tubes were placed in patients with BMI > 35 in this study.

In addition, another potential advantage of using the bronchoscope is to assist placement of PEGs during the "introducer" technique[29] as done by interventional radiologists or surgeons in patients with esophageal strictures and tracheoesophageal fistulas where the use of a gastroscope and the "pull-back" technique could be difficult, dangerous, or contraindicated. Also, our technique can be easily adopted by other services that are familiar with bronchoscopy and PEG tube placement such as trauma surgeons.

This study has limitations. It was a review of a prospective data collected from a single institution without a control arm (PEG tube performed by other services such as gastroenterologists or surgeons) leading to potential selection bias. Furthermore, the lack of a control arm does not allow us to compare directly patient-related outcome measures such as ICU stay, hospital stay, cost, and so forth.

In conclusion, flexible bronchoscope-guided PEG tube placement in critically ill patients performed by trained IP physicians is feasible and safe. Percutaneous endoscopic gastrostomy tubes placed with the use of a bronchoscope did not result in an increased rate of infection. More studies are needed to address health-care cost-effectiveness and utility. Future comparative studies are necessary to compare the risk of infection with complex endoscopes versus simpler bronchoscopes.

Authors' Note

Erik Folch, Amit Mahajan, Fayez Kheir, and Adnan Majid participated in data analysis, manuscript writing, and manuscript review. Daniel Alape participated in data collection, data analysis, and manuscript writing. Omar Ibrahim and Eugene Shostak participated in data collection and manuscript review. Erik Folch and Fayez Kheir contributed equally to the project. Drs Adnan Majid and Erik Folch are scientific consultants for Boston Scientific Corporation. Dr Adnan Majid is the guarantor of the content of the manuscript, including the data and analysis.

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Declaration of Conflicting Interests

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