Percutaneous radiologically guided gastrostomy tube placement: comparison of antegrade transoral and retrograde transabdominal approaches

Zachary M. Haber
Hearns W. Charles
Jonathan S. Gross
Daniel Pflager
Amy R. Deipolyi

PURPOSE
We aimed to compare the antegrade transoral and the retrograde transabdominal approaches for fluoroscopy-guided percutaneous gastrostomy tube (G-tube) placement.

METHODS
Following institutional review board approval, all G-tubes at two academic hospitals (January 2014 to May 2015) were reviewed retrospectively. Retrograde approach was used at Hospital 1 and both antegrade and retrograde approaches were used at Hospital 2. Chart review determined type of anesthesia used during placement, dose of radiation used, fluoroscopy time, procedure time, medical history, and complications.

RESULTS
A total of 149 patients (64 women, 85 men; mean age, 64.4±1.3 years) underwent G-tube placement, including 93 (62%) placed via the retrograde transabdominal approach and 56 (38%) placed via the antegrade transoral approach. Retrograde placement entailed fewer anesthesiology consultations ($P < 0.001$), less overall procedure time ($P = 0.023$), and less fluoroscopy time ($P < 0.001$). A comparison of approaches for placement within the same hospital demonstrated that the retrograde approach led to significantly reduced radiation dose ($P = 0.022$). There were no differences in minor complication rates (13%–19%; $P = 0.430$), or major complication rates (6%–7%; $P = 0.871$) between the two techniques.

CONCLUSION
G-tube placement using the retrograde transabdominal approach is associated with less fluoroscopy time, procedure time, radiation exposure, and need for anesthesiology consultation with similar safety profile compared with the antegrade transoral approach. Additionally, it is hypothesized that decreased procedure time and anesthesiology consultation using the transoral approach are likely associated with reduced cost.

Percutaneous radiologic gastrostomy tube (G-tube) placement is used for enteral nutrition in the setting of metastatic cancer, major trauma, and decline in neurologic status from dementia or stroke and, less commonly, for gastric decompression in patients with more distal chronic or uncorrectable bowel obstruction (1–4). Since it was first described in 1983 (3), two distinct approaches for G-tube placement have been developed: the antegrade transoral and retrograde transabdominal techniques (1–6), as described in the Society for Interventional Radiology practice guidelines (7). The antegrade and retrograde approaches have also been referred to as "pull" and "push" techniques (8), and "per oral image-guided gastrostomy" and "pigtail gastrostomy" (9), respectively.

Reports supporting the use of one approach over the other conflict, with proponents of the transoral technique citing a decrease in tube complications as a major advantage over the transabdominal approach, while other investigators find no such clinical advantage (10–13). However, comparison limited to complication rates is incomplete. With the known risks associated with exposure to increased doses of radiation (14, 15) and deeper levels of anesthesia (16), and the known costs associated with increased procedure time and anesthesiology consultation (17, 18), a true comparison should include these variables. The purpose of this retrospective study is to provide a comprehensive comparison of the two approaches to G-tube placement by evaluating these intra-procedure variables in addition to clinical outcomes.

From the Division of Vascular and Interventional Radiology Department of Radiology (Z.M.H., H.W.C., J.S.G., D.P.), NYU Langone Medical Center, New York, NY, USA; Interventional Radiology Service (A.R.D. ✉ *deipolya@mskcc.org*), Memorial Sloan Kettering Cancer Center, New York, NY, USA.

Methods

Patients

This retrospective study was performed at two academically affiliated tertiary care centers (Hospital 1 and 2) and received approval from both hospitals' institutional review boards.

Patients were identified by review of interventional radiology records of procedures performed between January 2014 and May 2015. This yielded a total of 152 G-tube placement performed in 152 patients. Three (2%) of these procedures required CT guidance and were excluded, leaving 149 patients (64 women [43%], 85 men [57%]) in the study population with a mean age of 64.4±1.3 years. Of these, 56 patients (38%) underwent G-tube placement via the antegrade technique, and 93 patients (62%) via the retrograde technique. A comparison of patients in the two groups showed that the primary indication for tube placement was head and neck cancer or stroke in a higher percentage of patients who underwent placement via the retrograde approach than in patients who underwent placement via the antegrade approach. Otherwise, patients in the two groups were similar with regard to demographics, with no significant difference in age, gender, or BMI (Table 1).

Gastrostomy tube placement procedure

Three types of anesthesia were used for G-tube placement: local anesthesia and/or mild or moderate sedation provided by radiology nurses, monitored anesthesia care, or general anesthesia with either endotracheal intubation or insertion of a laryngeal mask airway. The method of anesthesia used was based on patient presentation and preference of both the attending interventional radiology and anesthesiology physicians. At Hospital 1, anesthesiology was not consulted; at Hospital 2, by policy anesthesiology was always consulted. Both monitored anesthesia care and general anesthesia were performed by an anesthesiologist or a certified registered nurse anesthetist under supervision of an anesthesiologist. Nine fellowship-trained interventional radiologists placed the G-tubes with or without the assistance of a fellow, resident, or medical student. Use of an intravenous antibiotic for prophylaxis was based on the preference of the attending interventional radiology physician, with cefazolin 1 g or clindamycin 900 mg most commonly used. Two types of fluoroscopy machines were used for gastrostomy placement based on hospital site: an Allure Xper FD 20 (Philips Healthcare) at Hospital 1 and an AXIOM Artis (Siemens Healthcare) at Hospital 2. Both systems involve flat panel detectors and were set at the lowest reasonable fluoroscopy frame rate and lowest possible radiation settings. The Philips machine at Hospital 1 could be set at 15 pulses per second, whereas the Siemens machine at Hospital 2 could be set at 3 pulses per second. All procedures involved at least one lateral view and multiple frontal views of the stomach, regardless of placement technique. The transoral approach involved additional imaging of the chest and oropharynx.

All patients were positioned supine. G-tube placement was then performed by either the antegrade or retrograde approach based on the attending interventional radiologist's preference. Three interventional radiologists preferred the antegrade approach, with a mean post-fellowship experience of 14 years (8, 16, and 18 years); the remaining six interventional radiologists preferred the retrograde approach and had a mean post-fellowship experience of 14.3 years (1, 2, 3, 8, 27, and 45 years). In no case was a transoral approach planned and a transabdominal approach used instead; similarly, in no case was a transabdominal approach planned and a transoral approach used instead.

The retrograde transabdominal technique

A Kimberly-Clark MIC Introducer kit (Haylard Health) was used for placement of the tubes via the transabdominal approach, as previously described (19). Briefly, following inflation of the stomach with air or oxygen via a nasogastric tube, antero-posterior (AP) and lateral radiographic views of the stomach were acquired in order to confirm lack of interposition of the transverse colon. Two or more gastropexy T-fasteners were advanced into and deployed within the body of the stomach under fluoroscopic guidance to affix the anterior wall of the stomach to the anterior abdominal wall. A 19 G or 21 G needle was then advanced through the anterior abdominal wall into the stomach, and contrast was injected through the needle to confirm opacification of the gastric lumen. The transabdominal tract was serially dilated over a stiff 0.035-inch guide Amplatz wire (Boston-Scientific), and a 20 F peel-away sheath was advanced into the gastric lumen. An 18 F balloon-retention gastrostomy tube (Haylard Health) was advanced through the sheath, and the latter was removed. The retention balloon was inflated with a small volume of dilute contrast solution, retracted to the anterior gastric wall, and secured in place by a retention disc advanced to the overlying skin. Postprocedure position of the gastrostomy tube was confirmed by injection of contrast and opacification of the gastric lumen.

The transoral antegrade technique

G-tubes placed via the antegrade approach were performed using a Bard Deluxe Guidewire PEG system (Bard Access Systems, Inc.) as previously described (10, 19). Following inflation of the stomach with air or oxygen via a nasogastric tube, a 21 G or 19 G needle was advanced through the anterior abdominal wall into the stomach between the body and antrum, following AP and lateral radiographic views. The needle was exchanged over a wire for a 5 F angled catheter (Angiodynamics). This was directed over a 0.035-inch Glidewire (Terumo Corp.) from the gastric lumen through the esophagus and out of the mouth. A 300 cm 0.035-inch Amplatz (Boston Scientific) wire was passed through the catheter, and a 20 F Ponsky, mushroom-tip tube (Bard Access Systems, Inc.) was advanced over the wire from the mouth through the esophagus and into the stomach so that the retention mushroom at the end of the catheter was securely positioned against the anterior wall of the stomach. Postprocedure position of the G-tube was confirmed with injection of contrast and opacification of the gastric lumen.

Acquisition of clinical data

The primary indication for G-tube placement, intraprocedural variables, and clinical follow-up were obtained by review of patients' electronic medical records, including discharge summaries, operative and clinic notes, radiology reports, and notes from emergency room visits, from the date of

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Main points

- Gastrostomy tubes may be placed via the retrograde transabdominal or antegrade transoral approach.

- The transabdominal approach for gastrostomy placement is associated with significantly reduced procedure time, fluoroscopy time, radiation exposure, need for anesthesia consultation, and overall procedural cost.

- There were no significant differences in complications rates between transoral and transabdominal gastrostomy tube placement.

tube placement through May 2015. Major and minor complications were defined based on published SIR guidelines for G-tube (4). Major complications included aspiration, hemorrhage, peritonitis, necrotizing fasciitis, tumor implantation, and death directly related to G-tube placement. Minor complications included ileus, peristomal infection, stomal leakage, buried bumper, gastric ulcer, fistulous tract, inadvertent tube removal, and tube malfunction. Thirty-day mortality from all causes was recorded separately from major complications.

Estimation of cost savings

Cost savings to the hospital for retrograde placements compared with antegrade placements were estimated from data available in the cost allocation system, and assumed that anesthesiology services are used and antibiotics administered for antegrade but not retrograde placements. This system does not provide the cost of the anesthesiology attending. However, the cost of two hours of recovery time in the postanesthesia care unit compared with two hours in a routine nursing floor was available, and used to calculate recovery time savings. Supplies and implants were calculated based on the standard equipment used for each type of procedure, as detailed in the Methods section. While antegrade placement always entailed use of a Bard Deluxe Guidewire PEG system, in 17% of cases, an additional snare kit was used; also, additional Amplatz and Glidewires were frequently used. Cost savings to the hospital were calculated, rather than the amounts that were billed to insurance providers or patients.

Statistical analysis

Statistical analysis was performed using GraphPad Prism 6 (GraphPad Software, Inc.). After confirming normality of data with Shapiro-Wilk tests, the two groups were compared using t-tests for continuous variables and chi-square tests for categorical variables, with $P < 0.05$ considered statistically significant. Data are presented as mean ± standard error of the mean.

Results

The retrograde transabdominal approach required significantly less procedure and fluoroscopy time than the antegrade transoral approach (Table 2). Retrograde placement lasted 28±1.5 min vs. 36±3.4 min for the antegrade approach ($P = 0.023$).

Table 1. Patient characteristics

	Transoral	Transabdominal	P
Age (years), mean±SD	66±2.6	63±1.5	0.350
Number of men, n (%)	31 (55)	55 (59)	0.650
BMI (kg/m^2), mean±SD	24±0.7	26±0.7	0.210
Indication, n (%)			<0.001
Aspiration/dysphagia	22 (39)	11 (12)	
Brain surgery, dysphagia	6 (11)	1 (1)	
Intestinal obstruction	9 (16)	7 (8)	
Head and neck cancer	6 (11)	27 (29)	
Malnutrition	3 (5)	7 (7)	
Stroke, dysphagia	10 (18)	40 (43)	

SD, standard deviation; BMI, body mass index.

Table 2. Procedure technique

	Transoral	Transabdominal	P
Procedure length (min)	36±3.4	28±1.5	0.023
Fluoroscopy time (min)	8.7±1.1	2.1±0.2	<0.001
Radiation dose* (mGy)	28.1±4.8	4.9±1.1	<0.001
Type of anesthesia, %			<0.001
General anesthesia	15 (27%)	12 (13%)	
Monitored anesthesia care	40 (71%)	22 (24%)	
Nursing sedation/local anesthesia	1 (2%)	59 (63%)	

Data are presented as mean±standard error of the mean.
*Indicates comparison at Hospital 2 alone.

The mean retrograde placement required 2.1±0.2 min vs. 8.7±1.1 min of fluoroscopy for the antegrade approach ($P < 0.001$). Despite these differences, total radiation dose was similar between the two groups 27±3.5 mGy for retrograde placement vs. 28±4.8 mGy for antegrade placement ($P = 0.883$).

Due to operator preference, the antegrade approach was not used at one of the two institutions (Hospital 1). Of the 93 retrograde placements, 64 (69%) were performed at Hospital 1, and 29 (31%) were performed at Hospital 2. All antegrade placements were performed at Hospital 2. A subset analysis was used to compare retrograde placements between the two hospitals. Retrograde placement required 2.2±0.2 min of fluoroscopy time, 37.5±4.6 mGy of radiation to the patient, and 30.3±1.9 min of total procedure time at Hospital 1, compared with 1.8±0.2 min of fluoroscopy time, 4.9±0.7 mGy of radiation dose to the patient, and 24.6±1.6 min of total procedure time at Hospital 2. While fluoroscopy time ($P = 0.237$) and total procedure time ($P =$

0.058) did not significantly differ between hospitals, radiation dose was significantly different ($P < 0.001$), likely due to differences in fluoroscopy equipment and usage (e.g., higher fluoroscopy pulse rate).

A second subgroup analysis compared retrograde and antegrade approaches at a single institution, Hospital 2. The retrograde approach required decreased fluoroscopy time (1.8±0.2 min vs. 8.7±1.1 min; $P < 0.001$), reduced radiation dose to the patient (4.9±0.7 mGy vs. 28.1±4.7 mGy; $P < 0.001$), and shorter total procedure time (24±1.6 min vs. 36±3.4 min; $P = 0.022$), compared with antegrade placement. Among the operators at Hospital 2, those who used the retrograde technique had 1, 2, and 3 years of experience, whereas those who used the antegrade technique had 8, 16, and 18 years of experience.

There were also significant differences in the type of anesthesia and antibiotic prophylaxis used between groups. Of note, at Hospital 2, anesthesiology involvement is mandated for every G-tube placement by

Table 3. Complication rates

	Transoral	Transabdominal	P
Major complications	4 (7%)	6 (6%)	0.870
Minor complications	7 (13%)	18 (19%)	0.430
Death within 30 days*	7 (13%)	5 (5%)	0.122
*Deaths within 30 days were unrelated to the procedure.			

Table 4. Estimated cost savings for retrograde placement per procedure

	Estimated savings
Supplies and implants	$395.80
Procedure room time	$23.75
Recovery time	$209.78
Medications	$29.56
Total	$658.89

policy, whereas at Hospital 1, anesthesiology was never involved. This policy difference was due to the preference for retrograde placement at Hospital 1. For G-tubes placed via the retrograde approach, 63% were performed with local anesthesia alone or with mild or moderate sedation administered by interventional radiology nurses; 24% were performed with monitored anesthesia care; 13% were performed under general anesthesia. In contrast, tubes placed via the antegrade approach were most often placed with monitored anesthesia care (71%) or general anesthesia (27%), and rarely with radiology nursing sedation or topical anesthesia only (2%). These differences were statistically significant ($\chi^2=55.9$, $P < 0.001$). Whereas 52 of the 56 patients who underwent the transoral approach received antibiotics, only 49 of the 93 patients who underwent transabdominal approach received peri-procedural antibiotics (93% vs. 53%, $P < 0.001$).

Analysis of the tubes' performance immediately following placement demonstrated no significant difference in volumes of tube feeding between the two groups in the 48-hour period following tube placement. Volumes of feeds were 1546±309 mL for patients in the transabdominal group vs. 1322±202 mL for patients in the transoral group ($P = 0.528$).

Rates of major complications were similar between groups (Table 3). For the retrograde group, major complications included hemorrhage requiring transfusion (n=2), peritonitis requiring surgical intervention (n=1), aspiration (n=2), and respiratory distress requiring reintubation immediately following tube

placement (n=1). For the antegrade group, major complications included aspiration in four patients. Minor complication rates were 19% in the transabdominal group and 13% in the transoral group, a difference that was not statistically significant ($P = 0.430$) (Table 3). Transabdominal placement resulted in the following minor complications: inadvertent removal (n=5), clogged or broken tube (n=5), peristomal infection (n=5), and peristomal leakage (n=3). Of the five patients with peristomal infections, three did not receive periprocedural antibiotics. Transoral placements resulted in the following minor complications: peristomal leakage (n=2), gastric ulcer (n=1), inadvertent removal (n=2), and chest rash/drug reaction (n=1).

Cost estimates were calculated assuming the need for anesthesiology participation and antibiotic administration in antegrade but not retrograde tubes (Table 4). Patients who undergo anesthesia require recovery in a postanesthesia care unit, rather than a standard nursing floor. Per case, there is a $660 savings for retrograde placement; this estimate excludes the cost of an anesthesiologist, which was not available in the hospital cost allocation system. Supplies and implants alone account for the bulk of the increased costs, totaling nearly $400 per case, and primarily reflect the need for additional wires and the use of an additional snare kit in roughly 20% of cases.

Discussion

Fluoroscopy is an established method to guide placement of gastrostomy tubes (1, 3, 4, 20–22), although there is controversy

over whether an antegrade transoral or a retrograde transabdominal approach to placement is superior (4, 13, 22, 23). This study demonstrates that the transabdominal approach is associated with less radiation exposure, fluoroscopy and procedure time, reduced need for anesthesiology consultation, and decreased estimated costs, compared with the transoral approach. These findings likely reflect the need to traverse the esophagus and oropharynx when the transoral approach is used, which can be technically challenging for the operator and uncomfortable for the patient, thus increasing the length of the case and number of additional supplies needed and prolonging the procedure duration. This study confirms and expands findings from a prior study reporting that the retrograde approach entailed decreased fluoroscopy time, but did not quantify differences in radiation dose, cost, and procedure time (9).

Because patients who require G-tubes often have multiple comorbidities and undergo frequent radiologic imaging, an approach that limits radiation exposure may be particularly helpful in reducing risk of injury from cumulative radiation exposure. Furthermore, although the biologic effects of radiation may not occur in individual patients at the doses described in this study (5–40 mGy) (15), and would be expected to be minimal in the typical elderly patient population undergoing G-tube placement, repeated exposure to increased unnecessary radiation to operators and staff in the procedure room is also of concern. Multiple fluoroscopic machine characteristics and settings affect total radiation dosage to the patient, including the equipment, image field diameter, geometric magnification, and the pulse frequency (14, 15). This was also clearly demonstrated in the differences in radiation dose between the two different hospitals when comparing retrograde placements. Procedures at Hospital 2 entailed much less radiation for the same amount of fluoroscopy time compared with the equipment at Hospital 1, likely because the machine at Hospital 1 could not be set to pulse rates of any less than 15 pulses per second, whereas the machine at Hospital 2 was routinely set to 3 pulses per second.

The retrograde approach may reduce cost by decreasing room time and by reducing the need for anesthesiology involvement and furthermore postanesthesia recovery costs. Based on previous data analyzing mean cost of an interventional

radiology suite, the transabdominal approach is expected to reduce room cost by an mean of 28.6% compared with the transoral approach ($4.50 per min; $126 vs. $162, respectively) (18), which was similar to our estimate of roughly $24 savings. Because the transabdominal approach avoids crossing the oropharynx with a large bore tube, fewer patients require general anesthesia or monitored anesthesia care. A prior study similarly showed that deeper levels of sedation are needed for the antegrade approach (9). By avoiding anesthesiology consultation, overall cost may be reduced by 18% based on mean Medicare reimbursement data for other minimally invasive procedures (17). Here, we found that recovery and medication costs together were estimated to be over $200 per case. Our estimate excludes the cost of an anesthesiology attending, as the data was not available. Thus, the overall $660 per case cost savings is a conservative estimate.

As hospitals move to bundled payment systems and away from fee-for-services, administrative efforts will be made to reduce the cost to the hospital. Thus, the finding that costs are reduced with retrograde approaches may be useful for determining which approach is superior. One may argue that the increased initial cost of the antegrade approach is counterbalanced by the reduced cost of reinterventions due to complications. However, there were no significant differences in the rates of adverse event rates in our study, with a 13%–19% minor and 6%–7% major complication rates, similar to those reported per SIR guidelines (4). Prior studies are conflicting, with reports of increased risk with the transabdominal approach primarily related to tube failure (4, 10, 13, 23) and increased risk of infection with the transoral approach due to seeding of the stoma with oral flora (10, 23). Tubal complication rate may relate more to the luminal diameter of the tube placed, rather than the procedural approach (11). The nonsignificant trend for increased minor complications for retrograde placements (19%) compared with antegrade placements (13%) may reflect the small difference in lumen size (18 F compared with 20 F).

In this study, no infections occurred in the transoral group, whereas five infections occurred in the transabdominal group; three of these patients did not receive peri-procedural antibiotics. The absence of infection after antegrade placement may reflect the >90% rate of prophylactic antibiotic administration in that group. It is possible that the lack of prophylactic antibiotic administration may have played a role in the infections in the retrograde group. However, infections occurred in two patients who did receive antibiotics. Furthermore, literature review reveals very low rates of peristomal infection following transabdominal placement and at least one large randomized study showing no benefit of prophylactic antibiotics (24–26). Therefore, the observed infections may relate to postprocedure gastrostomy site care and, perhaps the presence of T-fasteners.

Previous studies have reported that G-tubes placed via transabdominal approach are associated with shorter length of time to reach target volume of tube feeds (11). However, in our study, patients in both groups tolerated early advancement of tube feeds. Patients in the transabdominal group received more tube feeds in the 48 hours following tube placement (1546 mL vs. 1322 mL), but the difference was not statistically significant. Interestingly, aspiration was more frequently observed in patients who underwent antegrade G-tube placement. Taken together with previous reports of antegrade tubes not reaching target feeds as quickly as retrograde tubes (11), and the trend reported here, findings may suggest that retrograde placement allows for more rapid early advancement of feeds following placement.

There are several limitations of this retrospective study. First, there were differences among the primary diagnoses between patients in each group, which may in theory have led to differences in postprocedure clinical outcomes. Another potential confounding factor may relate to differences in technical skills between operators, though there was no difference in the mean years of post-fellowship experience between operators who favored either approach. The preference of specific operators for each approach is a potential source of bias, as is the preference of the operators at Hospital 1 for using only the retrograde approach without anesthesiology consultation. A prospective randomized study could substantiate the findings here. Another limitation of this study is that different sized catheters were placed for each approach. An 18 F tube was placed when the transabdominal approach was used, while a 20 F tube was placed with the transoral approach. It is uncertain whether this minor difference in tube diameter may account for the nonsignificant trend toward more minor complications, including peristomal leakage and clogged tube, seen in the transabdominal group. Finally, the lack of access to anesthesiology attending costs is another limitation in accurately estimating cost savings; the numbers provided here are therefore conservative estimates.

In conclusion, G-tube placement by either transoral or transabdominal approach is associated with high rates of technical success and similar low rates of complications. Compared with the transoral approach, the transabdominal approach is associated with significantly reduced fluoroscopy time, procedure time, radiation exposure, need for anesthesiology consultation, and estimated costs to the hospital.

Conflict of interest disclosure

The authors declared no conflicts of interest.

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