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INTERVENTIONAL RADIOLOGY

ORIGINAL ARTICLE

CT-guided gastrostomy tube placement—a single center case series

Junaid T. Yasin
Philip A. Schuchardt
Naomi Atkins
Dave Koch
Ryan M. Davis
Sachin S. Saboo
Ambarish P. Bhat

PURPOSE
The role of computed tomography (CT)-guided gastrostomy tube placement is still evolving. It is a valuable alternative to guide gastrostomy tube placement in a few selected patients, who are not candidates for the established endoscopy- or fluoroscopy-guided gastrostomy tube placement. Our objective was to describe our institutional experience placing gastrostomy tubes using CT guidance and to conduct a review of literature for similar studies to provide the best current evidence on success rates and complications.

METHODS
We identified gastrostomy tubes placed under CT guidance at our institution using a comprehensive case log. We also identified studies in the literature, through a systematic search of PubMed. In both the local and literature analyses, we recorded success and complication rates.

RESULTS
A total of 31 patients underwent 33 attempted CT-guided gastrostomy tube placements at our institution, with 32 successful procedures yielding a success rate of 97%. The overall rate of successful gastrostomy tube placement using CT-guidance was 94.9% (634/668), as reported in the existing literature.

CONCLUSION
CT-guidance is an effective method for gastrostomy tube placement and may play an important role in patients for whom endoscopic or fluoroscopic gastrostomy tube placement is not feasible.

Gastrostomy tube (G-tube) placement is indicated for several reasons, most often for patients with conditions that preclude adequate oral nutrition. Most G-tube placements are currently performed by either interventional radiology (percutaneous radiological gastrostomy, PRG) or by gastroenterology (percutaneous endoscopic gastrostomy, PEG). However, certain conditions, such as post-surgical anatomical changes, and head/neck cancers may make G-tube placement via conventional methods difficult. Computed tomography (CT) is a useful tool with the potential to improve success rates by providing greater anatomic structural details.

Herein, we aim to review success rates and complications of CT-guided G-tube placement in patients treated at our institution and to compare our results to existing studies by performing a literature review of similar studies to provide stronger evidence.

Methods

Patient selection

All the cases were performed in our academic teaching hospital, which provides care for two-thirds of the state's population. Institutional Review Board (IRB) approval was obtained for our retrospective review of all interventional radiology procedures from January 2005 and January 2019 (IRB approval number 2004777). Patients were enrolled into the study if CT-guidance was used by an interventional radiologist to place a G-tube. The operators were interventional radiology fellowship trained and had at least 2 years' experience practicing interventional radiology, after fellowship training. All the patients provided informed

From the Department of Radiology (J.T.Y., P.A.S), University of Missouri Columbia School of Medicine, Columbia, Missouri, USA; Department of Radiology, Division of Interventional Radiology (N.A., D.K., R.M.D., A.P.B. ✉ *bhatap@health.missouri.edu*), University of Missouri- Columbia School of Medicine, Columbia, Missouri, USA; Department of Radiology (S.S.S.), University of Texas Health Science Center, San Antonio, Texas, USA.

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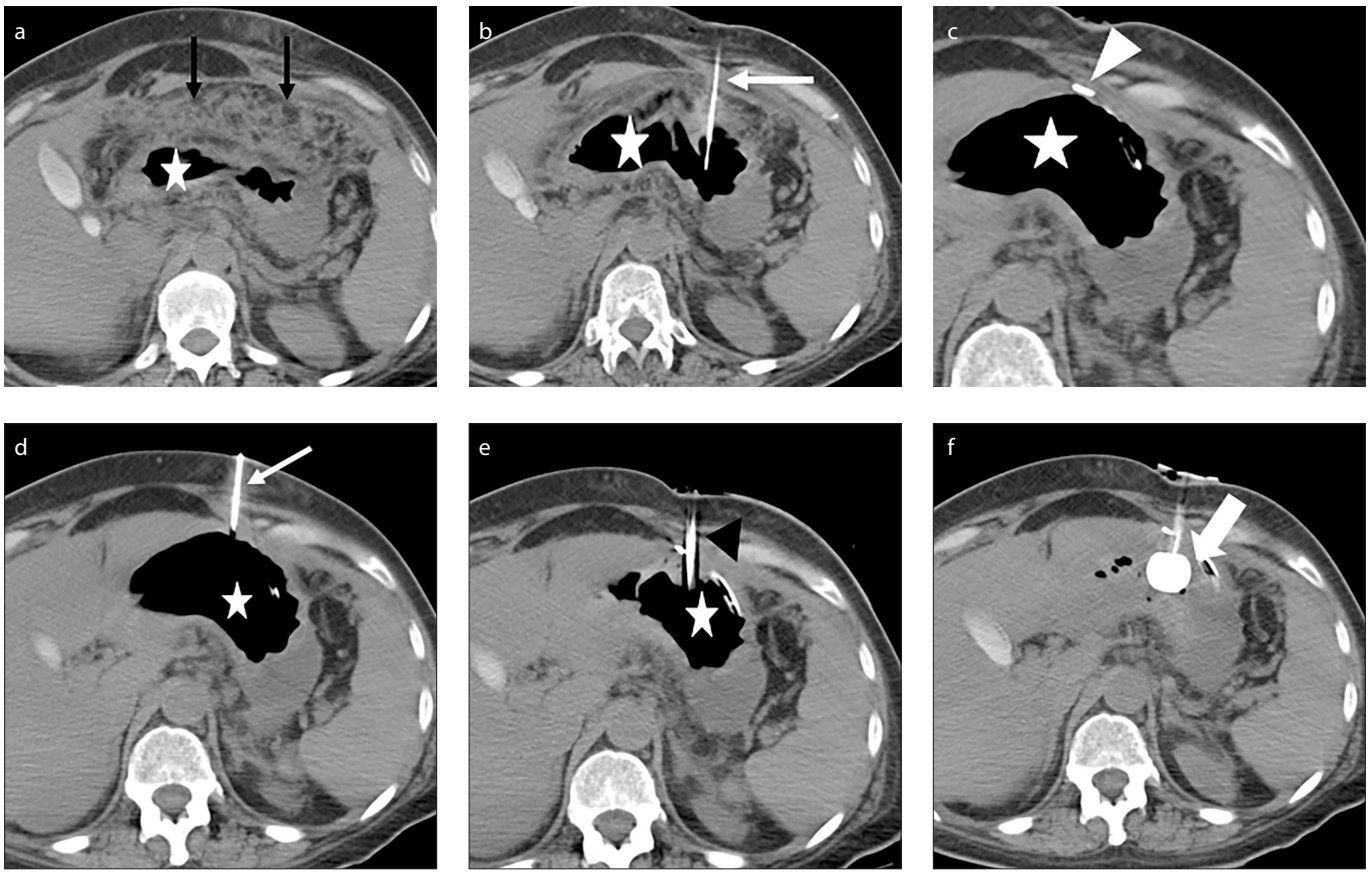

Figure 1. a–f. Multiple sequential axial unenhanced CT images: Panel **(a)** shows a case of peritoneal carcinomatosis *(black arrows)*. In order to avoid placing a G-tube through the infiltrated omentum, CT guidance was chosen for G-tube placement. Panel **(b)** shows needle *(white arrow)* to place the T-fastener entering the anterior stomach wall, with its tip in the lumen of the stomach *(white star)*. In panel **(c)**, after successful deployment of the T-fastner *(white arrowhead)*, the stomach *(white star)* is tacked to the anterior abdominal wall. Panel **(d)** shows 18 G access needle *(white arrow)* about to puncture the anterior wall of the air-filled stomach *(white star)*. Panel **(e)** shows 22 G peel-away sheath *(black arrowhead)* in the stomach *(white star)*, after serial dilatation over an Amplatz wire. Panel **(f)** shows a G-tube placed in the lumen of the stomach with the balloon inflated *(white block arrow)*.

consent for the procedure; however, informed consent for study participation was waived by the IRB, because of anonymized patient data and the retrospective nature of the study.

Fig. 1 illustrates the steps involved in CT-guided placement of a G-tube in a case of peritoneal carcinomatosis. All patients in our study were positioned supine on the CT table (Fig. 1a). In two cases, CT fluoroscopy was used for guidance. Intermittent limited sequential CT slices were used in the remainder. After preparing the upper abdomen, with the appropriate sterile precautions, two sites were marked about 3-4 cm apart, for introduction of the T-fasteners. Once the T-fasteners were deployed under CT guidance (Fig. 1b) and confirmation of the gastric wall tacked against the anterior abdominal wall (Fig. 1c), a 1 cm incision was made between the T-fasteners, for introduction of the G-tube. Access into the stomach was obtained with an 18 G needle (Fig. 1d) and sequential dilatation was performed over a stiff wire, followed by introduction of a 22 G peel away sheath (Fig. 1e). The G-tube was then introduced in through the peel away sheath and secured by inflating the balloon (Fig. 1f).

Main points

- Fluoroscopy or endoscopy guidance is most commonly used for G-tube placement.
- CT guidance can be used very effectively in placing G-tubes in patients with altered anatomy or pathology which precludes conventional methods for G-tube placement.
- Further study, preferably a prospective randomized controlled trial, is needed to compare each modality.

Data collection

For each patient, information about patient characteristics, procedural details, and complications were recorded. Patient characteristics included age, sex, clinical indication, and previous attempts at G-tube placement. Procedural details included technique description, procedure time, tube type and subsequent replacements. Intervention failure was based on the definition of Norton et al. (1) of any event resulting in failure to introduce the G-tube, recurrent displacement of the tube, or interruption of treatment (1).

Brief literature review

A systematic review of the literature was performed using PubMed for articles from inception to December 2018 using the search strategy (Computed tomography OR Image guided AND Gastrostomy). Bibliographies of selected studies were also screened for additional articles. Articles published after December 2018 were obtained through examination of recently published interventional radiology journals.

Studies that did not explicitly mention CT-guidance during G-tube placement where excluded. Further, studies with fewer

Table 1. CT-guided gastrostomy tube placement data at our institution

Patient number	Gender	Age	Indication	Consulted GI or surgery first? (Y/N)	Attempted by GI or surgery first? (Y/N)	Immediate complications	Long-term complications	Successful (Y/N)	Follow-up duration (months)
1	F	46	Post-RYGB malnourishment	Y	N	-	-	Y	67
2	M	50	Laryngeal cancer	Y	Y	-	Cellulitis, tube dislodgement	Y	68
3	M	68	Vocal cord paralysis	Y	N	Cellulitis	Tube dislodgement	Y	39
4	F	56	Post-RYGB decompression	Y	N	-	Drainage-replaced via CT	Y	50
		60	RYGB and short gut syndrome	-	N	-	-	Y	0.33
5	F	68	Post-RYGB anatomy	Y	N	-	Cellulitis	Y	6
6	F	55	Esophageal cancer	Y	N	-	Pain	Y	1
7	M	76	Head and neck SCC	Y	Y	-	-	Y	12
8	F	54	Post-RYGB malnutrition	Y	N	-	Pain	Y	54
9	F	53	Post-RYGB gastric remnant leak	Y	N	-	Cellulitis	Y	11.5
10	M	70	SCC with post-laryngectomy swelling	N	N	-	Cellulitis	Y	17
11	F	39	Post-RYGB malnutrition	Y	N	-	Cellulitis	Y	53
12	F	58	Post-RYGB decompression	Y	N	-	Tube dislodgement -Replaced via CT	Y	37
			Post-RYGB decompression	-	N	-	-	Y	35
13	F	46	Peritoneal carcinomatosis	Y	Y	Clogging of tube with oral feeds Replacement not necessary	-	Y	8
14	F	58	Post-RYGB decompression	Y	N	-	-	N	23
15	F	60	Post-RYGB decompression	Y	N	Leak from G-tube site in remnant, requiring surgical replacement	Soft tissue infection	Y	14.5
16	M	30	Ventral hernia	Y	N	-	-	Y	39
17	M	56	Laryngeal SCC	Y	N	Multiple episodes of clogged tube due to medications	-	Y	15
18	F	51	Post-RYGB malnutrition	Y	N	Bleeding at access site	-	Y	61
19	F	53	Post-RYGB and small bowel resection	Y	N	-	-	Y	3
20	F	56	Post- Whipple procedure	N	N	Pain	-	Y	111
21	M	70	Colonic obstruction of gastric window	Y	N	Hematoma along the gastroepiploic artery	Ileus, leak	Y	26
22	F	37	Post-RYGB decompression	Y	N	-	Leakage	Y	3
23	F	41	Post-RYGB decompression	Y	N	Incarcerated bowel caused obstruction and leakage requiring surgery	-	Y	3
24	M	49	Subglottic stenosis	N	N	-	-	Y	7
25	M	45	Pancreatic pseudocyst	Y	N	-	-	Y	14

Table 1. CT-guided gastrostomy tube placement data at our institution (cont'd)

Patient number	Gender	Age	Indication	Consulted GI or surgery first? (Y/N)	Attempted by GI or surgery first? (Y/N)	Immediate complications	Long-term complications	Successful (Y/N)	Follow-up duration (months)
26	F	64	Post-RYGB malnutrition	Y	N	Hemoperitoneum secondary to t-tack in greater omentum	-	Y	1
27	M	23	Failed EGD	Y	Y	Initial needle placement inferior to the stomach	Tube dislodgement	Y	108
28	M	59	Colonic obstruction of gastric window	N	N	-	-	Y	16
29	F	69	Anatomical variance	Y	N	-	Leakage	Y	6
30	M	33	Esophageal rupture	Y	N	-	Tube dislodgement	Y	3
31	M	75	Anatomical variance	Y	N	-	-	Y	1

CT, computed tomography; GI, gastrointestinal medicine (gastroenterology); Y, yes; N, no; F, female; M, male; RYGB, Roux en Y gastric bypass; SCC, squamous cell carcinoma; G-tube, gastrostomy tube; EGD, esophagogastroduodenoscopy.

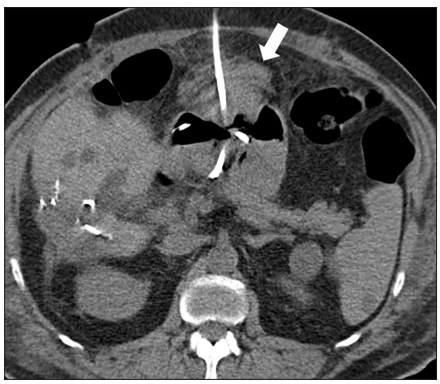

Figure 2. Axial CT image after placement of a G-tube showing hemorrhage in the anterior omentum *(white block arrow)*. Please note no gastropexy was performed for this case, which increases the risk for bleeding.

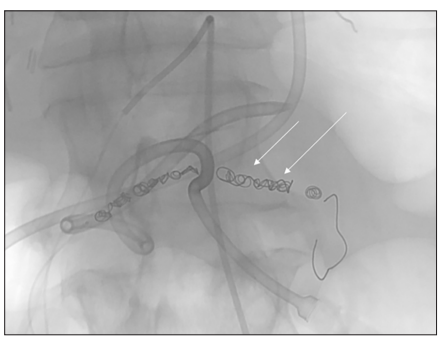

Figure 3. Single shot image during angiography, showing coils *(white arrows)* used to occlude the gastroepiploic artery, which was the source of the bleed.

than five patients were excluded to reduce publication bias that may be present in small studies. Studies arising from the same institution were evaluated equally and the larger sample size was included to prevent double-counting of patients. Only studies with outcome variables directly attributable to CT-guided G-tube placement were selected.

Data was extracted by two extractors (J.Y., P.S.) and discrepancies between records were addressed by repeat extraction and joint discussion. Recorded variables included success rates, complications, and reasons for procedure failure.

Statistical analysis

Descriptive statistics were used for analysis of patient demographic, success rate, and complications.

Results

We conducted a retrospective analysis of 31 patients who underwent 33 CT-guided gastrostomy procedures between 2006 and 2018 (Table 1). Gastroenterology or general surgery were either the primary team or consulted on 27 of 31 patients (87%) prior to interventional radiology involvement. Of the 33 attempted placements, 32 were successful, yielding a success rate of 97%. Common indications for CT-guided G-tube placement included decompression or nutritional supplementation post Roux-en-Y bypass (RYGB) in 45% (14/31) and head and neck cancer in 16% (5/31). Less common indications for G-tube placement are listed in Table 1. Major complications were observed in 12% (4/33) of CT-guided G-tube placements. These complications included bleeding requiring surgery or embolization in 6% (2/33) (Figs. 2, 3) and leakage of gastric contents requiring surgery in 6% (2/33). No mortalities or long-term morbidities were observed as a direct result of this procedure. Minor complications were much more common. Two patients suffered from immediate minor complications, which included severe pain that responded to medical management and bleeding at the access site that was well-controlled with Gelfoam injection.

Late minor complications included cellulitis in 18% (6/33), clogging/leaking/irritation/minor pain with the G-tube in 33% (11/33), and dislodged G-tube in 15% (5/33). Mean radiation dose and procedure time were 51.9±26.5 mSv and 36.5±17.2 minutes, respectively.

Systematic search of PubMed yielded 518 published studies. Two additional studies were obtained by examining bibliographies of selected studies. After application of eligibility criteria, 15 studies were selected, and data was subsequently extracted (2–16). Success rates and complications from these 15 studies are listed in Table 2.

Data was available on 668 patients (Table 2). The overall rate of successful G-tube placement using CT-guidance was 94.9% (634/668). Tube dysfunction, including tube dislocation, blockage, inadvertent removal, kinked catheter, fractured catheter, and Buried Bumper syndrome, occurred in 12.3% (78/634) of patients. Intervention-related complications, including bleeding, infection, skin irritation, balloon leakage, wound granulation, peristomal leakage, hemorrhage, and inflammation, intraper-

Table 2. Reported outcomes of CT-guided gastrostomy tube placement in the existing literature

Primary author, Year	Success rate % (n/N)	Tube dysfunction[a] % (n/N)	Procedural complications[b] % (n/N)
Current study	97 (32/33)	41 (13/32)	45 (15/33)
Jiang et al., 2018	100 (13/13)	0 (0/13)	46 (6/13)
Albrecht et al., 2017	87 (89/102)	7 (6/89)	9 (9/102)
Tamura et al., 2016	97.7 (173/177)	1 (2/173)	11 (20/177)
Kato et al., 2015	100 (48/48)	0 (0/48)	8 (4/48)
Spelsberg et al., 2013	88 (89/101)	57 (51/89)	16 (16/101)
De Bucourt et al., 2012	97 (30/31)	0 (0/30)	10 (3/31)
Teichgraber et al., 2011	100 (14/14)	0 (0/14)	21 (3/14)
Fujita et al., 2011	100 (35/35)	0 (0/35)	14 (5/35)
Petras et al., 2010	96 (24/25)	0 (0/24)	92 (23/25)
Mohlenbruch et al., 2010	100 (18/18)	17 (3/18)	6 (1/18)
Stein et al., 2007	100 (10/10)	0 (0/10)	20 (2/10)
Goiten et al., 2006	91 (10/11)	0 (0/10)	0 (0/11)
Tsukuda et al., 2005	100 (21/21)	0 (0/21)	19 (4/21)
Vogt et al., 1996	86 (6/7)	0 (0/6)	0 (0/7)
Sanchez et al., 1992	100 (22/22)	14 (3/22)	0 (0/22)
Total	94.9 (634/668)	12.3 (78/634)	16.6 (111/668)

[a]Tube dysfunction referred to clogging, leaking, and malfunction after placement.
[b]Procedural complications included bleeding, cellulitis, infection, pain, and need for image-guided tube replacement.

itoneal leakage, peritonitis, trans-colonic placement, aspiration, superficial or deep skin infection, gastric wall tear or dissection and pneumoperitoneum, was noted in 16.6% (111/668) of patients.

Discussion

CT-guided percutaneous gastrostomy has been used in patients with advanced stenosis of the pharynx or esophagus (14, 17) and in patients with head and neck cancers due to anatomical constraints of advancing an endoscope (14, 18). The role for percutaneous gastrostomy tube placement in patients with a RYGB is still undefined. Altered anatomy post RYGB prevents adequate distention of the stomach for fluoroscopy-guided G-tube placement, hence making CT an attractive alternative in this cohort of patients.

Our results suggest that G-tube placement using CT- guidance is an effective option, particularly in patients with pathology or altered anatomy restricting traditional methods of placement. Successful placement was noted in approximately 94.9% (634/668) of patients, a reasonably acceptable rate of success, especially when taking into consideration that many patients were only considered for CT after previous unsuccessful attempt by fluoroscopy or endoscopy or were considered poor surgical candidates.

Intervention failure, defined as failed tube placement or recurrent tube dysfunction, was noted in 16.6% (111/668) of patients. In contrast, a Cochrane review found an intervention failure rate in percutaneous endoscopic gastrostomy of 9.22% (19/206)(19). Thus, our results indicate that CT-guided gastrostomy has a higher rate of intervention failure, albeit, in patients often considered non-candidates for first-line treatment.

This study is primarily limited by its retrospective design. A randomized trial in patients with treatment equipoise between CT-, endoscopy-, and fluoroscopy-guided placement is needed to account for confounding factors, such as provider experience. Further, studies referenced in the review largely arise from academic institutions with dedicated interventional radiology faculty, thus the findings of this study are limited to similar institutions.

In conclusion, based on our retrospective review and systematic literature search, we feel CT-guided G-tube placement is a minimally invasive interventional radiological procedure, with a low risk of complications and is extremely valuable in specific clinical situations which preclude the use of fluoroscopy/endoscopy for placement of G-tubes.

Conflict of interest disclosure

The authors declared no conflicts of interest.

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