

# Gastrostomy Tube Outcomes Among Surgical and Non-Surgical Services: A Retrospective Review

The American Surgeon  
2021, Vol. 0(0) 1–8  
© The Author(s) 2021



Article reuse guidelines:

[sagepub.com/journals-permissions](https://sagepub.com/journals-permissions)

DOI: 10.1177/00031348211047173

[journals.sagepub.com/home/asu](https://journals.sagepub.com/home/asu)



Joshua Herb, MD<sup>1,2</sup>, Nidia Rodriguez-Ormaza, MD, MPH<sup>1</sup>,  
Clark Cunningham, PhD<sup>1</sup>, Neal Bartl, MD<sup>3</sup>, Jihane Jadi, MD<sup>3</sup>,  
Anthony Charles, MD, MPH<sup>1</sup>, and Trista Reid, MD, MPH<sup>1</sup>

## Abstract

**Background:** Our objective was to evaluate differences in baseline characteristics, complications, and mortality among patients receiving a gastrostomy tube (GT) by surgical or non-surgical services.

**Methods:** We performed a retrospective analysis of adult patients who underwent GT placement from 2014 to 2017 at a single institution. Using bivariate and multivariable analyses, we compared baseline characteristics, complications, and overall 30-day mortality of patients undergoing GT placement with surgical or non-surgical services.

**Results:** Of the 1339 adults who underwent GT placement, surgical and non-surgical services performed 45% (n = 609) and 55% (n = 730) procedures, respectively. Gastrostomy tube-related complications were similar (29.6% surgical vs 28.8% non-surgical,  $P = .76$ ). Thirty-day mortality was higher among non-surgical services (23.7% vs 16.5%,  $P = .004$ ). On multivariable analysis, this was not significant (OR 1.21, 95% CI 0.83; 1.77).

**Conclusion:** Surgical and non-surgical service placement of GTs had equivalent GT-related mortality and complication rates.

## Keywords

gastrostomy tube, complications, outcomes, mortality

## Key Take-Aways

- Short-term complications after gastrostomy tube (GT) placement were common.
- Gastrostomy tube complications/mortality did not differ by placement service (surgical and non-surgical).
- Need for GT likely a proxy indicator for frailty/increased short-term mortality.

## Introduction

In patients who are unable to tolerate oral intake, at risk of malnutrition, and those requiring long-term nutrition support, gastrostomy tube (GT) placement is indicated.<sup>1</sup> The underlying etiology mandating the indication for GT placement includes traumatic brain injury, respiratory failure, head and neck cancer, and esophageal disease, among many others. Conventional modalities for GT placement include percutaneous endoscopic gastrostomy (PEG), surgical (laparoscopic and open techniques), and radiologic-guided placement. Percutaneous endoscopic

gastrostomies are often preferred as they are less expensive and can be efficiently placed by either a surgical team or medical proceduralists.<sup>2</sup> However, some patients may require an operative approach for GT placement due to special anatomic considerations such as prior abdominal surgery, esophageal obstruction, or colonic interposition.<sup>3</sup> Previous studies demonstrate no difference in morbidity or mortality between PEG and operative gastrostomy.<sup>2,4</sup>

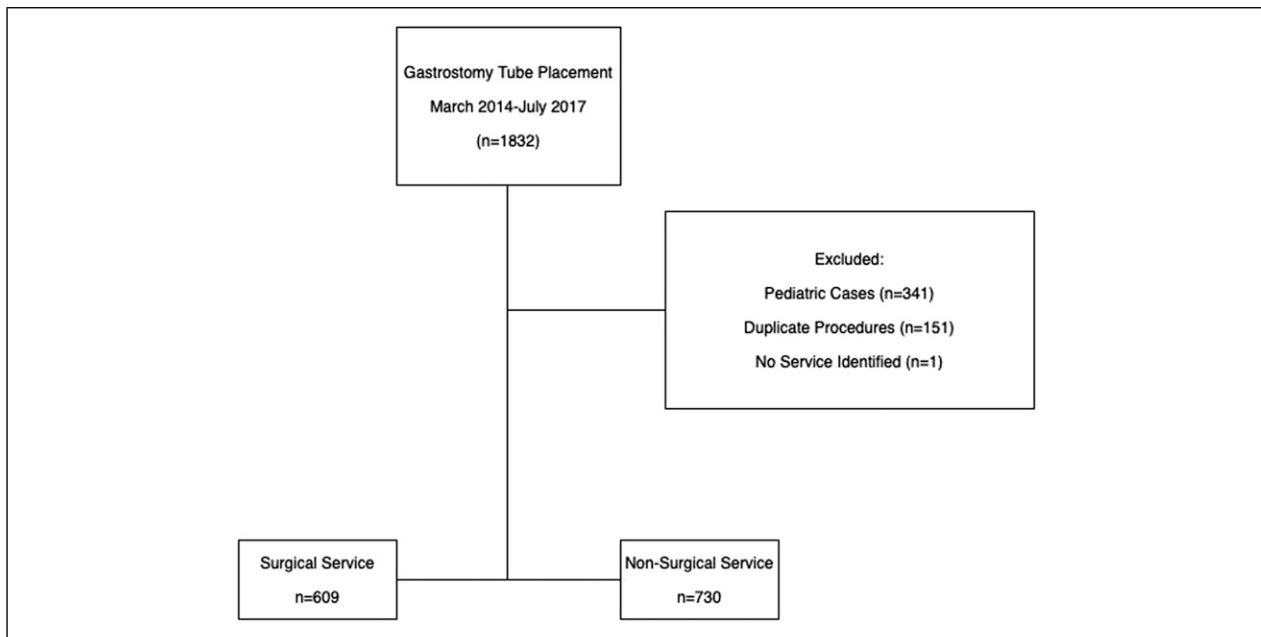
<sup>1</sup>Department of Surgery, University of North Carolina at Chapel Hill, Chapel Hill, NC, USA

<sup>2</sup>Cecil G. Sheps Center for Health Services Research, University of North Carolina at Chapel Hill, Chapel Hill, NC, USA

<sup>3</sup>School of Medicine, University of North Carolina at Chapel Hill, Chapel Hill, NC, USA

### Corresponding Author:

Trista Reid, MD, MPH, Department of Surgery, Division of General, Trauma and Acute Care Surgery, UNC, 101 Manning Drive, 4008 Burnett Womack Building, CB #7228, Chapel Hill, NC 27599, USA.  
Email: [Trista\\_reid@med.unc.edu](mailto:Trista_reid@med.unc.edu)



**Figure 1.** Cohort selection for gastrostomy procedures.

While previous studies have focused on GT outcomes by placement modality (PEG vs radiologic-guided and laparoscopic vs open), there is a paucity of data regarding differences in the prevalence of complications based on the characteristics of procedural *service*, specifically medical proceduralists such as gastroenterologists compared to surgical teams. Though experienced endoscopists and surgeons may not differ in technical ability to place a GT, they may draw from different patient populations with different underlying risk profiles, or they may have differences in post-procedural care that can lead to differences in post-procedure outcomes. Therefore, the primary aim of this study was to describe baseline patient characteristics, complications, and mortality among patients who have had GTs placed by either a surgical or non-surgical team. Our null hypothesis was that GT outcomes would be equivalent between surgical and non-surgical services.

## Methods

The University of North Carolina Institutional Review Board reviewed the study protocol and approved this study, and informed consent was waived given the retrospective nature of the study (IRB No. 17-3075).

We performed a retrospective descriptive cohort study of all patients who underwent GT placement between March 2014 and July 2017 at a single institution, an academic tertiary care level 1 trauma center with a comprehensive cancer hospital. We identified patients in the electronic medical record system based on ICD-9 and 10 codes. We excluded children (<18 years) and duplicate patients who had their GT replaced for dislodgement or

leaking, or those who had procedures aborted and never had a GT placed. We did include patients with aborted procedures that subsequently underwent GTs placed by another service line. We included 1339 patients in our analysis (Figure 1). We also collected the following demographic and health data for each patient: sex, age at placement, BMI, tobacco use (never, former, and current), and discharge disposition {home with self-care, home with home health, facility (transfer to another hospital including long-term acute care hospitals [LTACH] and skilled nursing facilities), inpatient rehab, inpatient death, or hospice}.

We dichotomized the performing service into surgical and non-surgical. Surgical services that place GTs in adults at our institution include trauma/critical care surgery, surgical oncology, gastrointestinal surgery, minimally invasive surgery, transplant surgery, burn surgery, cardiothoracic surgery, and gynecologic-oncologic surgery. Non-surgical services included pulmonary critical care, gastroenterology, and vascular interventional radiology. We classified the GT placement technique as percutaneous, laparoscopic, or open. Those placed by radiology were classified as percutaneous. Therefore, those classified as “percutaneous” and performed by a surgical service were all PEGs, and those classified as percutaneous on a non-surgical service could be either a PEG placed by a medical proceduralist team or a radiologic-guided placement.

We performed a manual chart review for each patient. Comorbidities were identified, including diagnosis of any congestive heart failure (CHF), chronic obstructive pulmonary disease (COPD), dementia, and acute or chronic

renal failure. We classified the primary indication for GT placement as malnutrition (including failure to thrive and short gut syndrome), neurologic (including traumatic brain injury, cerebrovascular disease, psychomotor, other neurologic), anatomic (including congenital anomalies, intraoperative/structural reasons [eg, as gastropexy with hiatal hernia repair]), and cancer or palliative (including non-palliative esophageal or head and neck cancers and any palliative decompression).

The primary outcome was all-cause 30-day mortality. We additionally examined 30-day mortality attributable to GT placement. Gastrostomy tube complications included mechanical (dislodgement without need for operation, leakage, pressure wound, and clogging), infectious (cellulitis and abscess), and minor bleeding, and we defined significant complications as any complication potentially requiring operative intervention (eg, necrotizing soft tissue infection [NSTI], peritonitis, organ injury, gastrocutaneous [GC] fistula requiring reoperation, and significant bleeding) or a GT-related death. We chose not to use the Clavien-Dindo scale<sup>5</sup> as we wanted to be more specific about the complication profile rather than use a summary measure of complication severity. To ensure consistency of the chart review process, we randomly selected 200 charts for reviewers by 2 independent reviewers, and we compared their results.

We calculated descriptive statistics using frequency and percentage for categorical variables, mean and standard deviation for normally distributed continuous variables, or median and interquartile range (IQR) for non-normally distributed variables. As determined by cell size, we used chi-square or Fisher's exact tests to evaluate statistical differences for categorical variables. Likewise, we used the t-test to compare means and the Wilcoxon test to compare medians. We utilized multivariable logistic regression to examine the odds of any complications and 30-day all-cause mortality by service, respectively. We adjusted for baseline demographic variables as well as those that may influence short-term mortality. These were chosen a priori and included age, sex, indication for placement, and comorbidities. We also performed a subgroup analysis where we limited the analyses to only PEG procedures in order to compare surgical and non-surgical teams to a single procedure. We used SAS statistical software v9.4 (Cary, NC) for all statistical analyses, and two-sided *P*-values <.05 were considered statistically significant.

## Results

Over the study period, 1339 adult patients underwent GT placement. Of these, 53% were male, with a mean age of 59 years (SD 12.2). Forty-eight percent of patients were obese, with other common comorbid conditions listed in Table 1. Surgical and non-surgical services performed GT placement in 45% and 55% of patients, respectively. In

general, baseline characteristics, including prior GTs or prior abdominal surgery, were similar between placement services. However, patients who had GTs placed by non-surgical services had a higher prevalence of CHF and COPD (Table 1). Non-surgical services placed all GTs percutaneously, as expected, while surgical services placed 52.6% percutaneously, 37.3% laparoscopically, and 10.1% open. Surgical services most commonly placed GTs for cancer or palliative decompression (32.8% total for cancer and palliative, with 7.9% palliative specifically), followed by anatomic or structural reasons (23.8%), while non-surgical services more commonly placed GTs for neurological diseases (39.7%) or malnutrition/failure to thrive (32.1%).

Disposition from the hospital was most commonly to another facility, such as a skilled nursing facility (32.0%) followed by home with self-care (23.1%), home with home health nursing (22.4%), and inpatient rehabilitation (12.0%). The most common disposition among surgical services was home with self-care (29.9%) and to another facility (36.6%) among non-surgical services (Table 1).

The overall complication rate was 29.6% (N = 396), the majority of which were mechanical at 23.5% (N = 314). The rate of serious complications was .8% (N = 11). This includes 5 NSTIs and 6 GT-related deaths. Four GT-related deaths were related to dislodgement with subsequent peritonitis and sepsis, and the remaining 2 were due to bleeding complications. There was no difference in complication rate among services (29.6% surgical vs 28.8% non-surgical, *P* = .76) (Table 1). The adjusted odds for complications by non-surgical vs surgical service placement was .96 (95% CI .76, 1.22) (Table 2).

Among all patients, all-cause 30-day mortality was 20.9% (N = 279). Thirty-day mortality related to GT placement was .5%, and 30-day mortality from other causes was 20.4%. Among patients dying within 30 days of GT placement, 26.5% died in the hospital, 22.9% died after discharge to hospice, and the rest (49.4%) died after discharge to home or another facility. Another 12 patients died as inpatients within 60 days after GT placement (Table 3). Compared to survivors, non-survivors were older (mean 62 years ±15.8 vs 59 ± 16.2, *P* < .001), had lower BMIs (mean 24.7 ± 7.55 vs 25.9 ± 6.95, *P* = .02), less likely to be active smokers (20.6% vs 28.8%, *P* = .03), were more likely to have prior abdominal surgery (44.8% vs 37.5%, *P* = .03), and were most commonly discharged home with home health or to another facility (22.9% and 21.2%). They were more likely to have comorbid conditions like COPD (16.9% vs 10.2%, *P* = .002), CHF (11.5% vs 4.5%, *P* < .001), and renal disease (12.9% vs 4.9%, *P* < .001). Non-survivors were more likely to have their GT placed for cancer/palliative reasons (38.7% vs 26.8%, *P* < .001) and were more likely to have had the GT placed percutaneously (82.1% vs 77.1%, *P* = .04) (Table 3).

When stratified by placement service, there was no difference in GT-related mortality frequency between

**Table I.** Baseline Characteristics and Complications by Performing Service.

Characteristic	Total (N = 1339)	Performing service		P-value
		Surgical (N = 609)	Non-surgical (N = 730)	
Gender, n (%)				
Male	713 (53.3)	337 (55.3)	376 (51.5)	.16
Female	626 (46.7)	272 (44.7)	354 (48.5)	
Age at visit, years, M (SD)	59.4 (16.2)	58.8 (16.0)	59.8 (16.5)	.31
BMI, kg/m <sup>2</sup> , median (IQR)	24.6 (20.7- 29.2)	24.8 (20.7-29.2)	24.4 (20.7-29.1)	.82
Comorbidities, n (%)				
Congestive heart failure	80 (6.0)	24 (3.9)	56 (7.7)	.004
COPD	155 (11.6)	59 (9.7)	96 (13.2)	.05
Dementia	24 (1.8)	9 (1.5)	15 (2.1)	.43
Renal failure	88 (6.6)	36 (5.9)	52 (7.1)	.37
Tobacco use, n (%) (missing n = 151)				
Never	439 (37.0)	180 (33.8)	259 (39.5)	.03
Current	323 (27.2)	163 (30.6)	160 (24.4)	
Former	426 (35.9)	190 (35.7)	236 (36.0)	
Indication for GT, n (%)				
Malnutrition/FTT	366 (27.5)	132 (21.7)	234 (32.1)	<.0001
Neurologic <sup>a</sup>	422 (31.6)	132 (21.7)	290 (39.7)	
Anatomic <sup>b</sup>	159 (11.8)	145 (23.8)	14 (1.9)	
Cancer/palliative <sup>c</sup>	392 (29.3)	200 (32.8)	192 (26.3)	
Type of GT, n (%)				
Percutaneous	1047 (78.4)	320 (52.6)	727 (100.0)	<.0001
Laparoscopic	227 (17.0)	227 (37.3)	0 (0)	
Open	62 (4.6)	62 (10.1)	0 (0)	
Prior abdominal surgery, n (%)	521 (38.9)	225 (37.0)	296 (40.6)	.19
Prior GT, n (%)	68 (5.1)	31 (5.1)	37 (5.1)	.99
Mortality, n (%)				
Mortality related to G tube	6 (.5)	3 (.5)	3 (.4)	.002
Deceased from other cause	273 (20.4)	100 (16.5)	173 (23.7)	
Complications, n (%)				
No complications	948 (70.9)	443 (72.7)	531 (72.8)	.76
Any complications	390 (29.2)	180 (29.6)	210 (28.8)	
Mechanical (dislodgement, leakage, pressure wound, and clogging)	314 (23.5)	141 (23.2)	173 (23.7)	
Infectious (cellulitis and abscess)	29 (2.2)	16 (2.6)	13 (1.8)	
Serious (NSTI, peritonitis, organ injury, reoperation, GC fistula, significant bleeding, or death)	11 (.8)	5 (.8)	6 (.8)	
Minor bleeding	14 (1.0)	6 (1.0)	8 (1.1)	
Other	26 (1.9)	14 (2.2)	12 (1.6)	
Discharge disposition, n (%)				
Home with self-care	308 (23.0)	181 (29.9)	125 (17.2)	<.0001
Home with home health	298 (22.2)	142 (23.5)	156 (21.5)	
Facility	426 (32.0)	162 (26.8)	264 (36.4)	
Inpatient rehab	160 (12.0)	65 (10.7)	95 (13.1)	
Inpatient death or hospice	139 (10.4)	54 (8.9)	85 (11.7)	

SD, standard deviation; BMI, body mass index; FTT, failure to thrive; TBI, traumatic brain injury; NSTI, necrotizing soft tissue infection.

<sup>a</sup>TBI, cerebrovascular disease, and other neurologic/psychomotor reason.

<sup>b</sup>Congenital anomaly such as TE fistula, structural reasons, and intraoperative reasons.

<sup>c</sup>Non-palliative esophageal or head and neck cancer and palliative decompression.

**Table 2.** Odds of Gastrostomy Tube Complications and Mortality by Placement Service.

	Complications		30-day mortality	
	Crude OR (95% CI)	Adjusted OR <sup>a</sup> (95% CI)	Crude OR (95% CI)	Adjusted OR <sup>a</sup> (95% CI)
All GTs	.96 (.76, 1.22)	.93 (.68, 1.27)	1.56 (1.19, 2.05)*	1.19 (.83, 1.72)
PEG only	1.09 (.81, 1.46)	.87 (.63, 1.21)	1.51 (1.08, 2.12)*	1.21 (.83, 1.77)

All odds ratios reported as non-surgical vs surgical.

GT, gastrostomy tube; OR, odds ratio; CI, confidence interval; PEG, percutaneous endoscopic gastrostomy.

\*P < .05.

<sup>a</sup>Adjusted for age, sex, indication, comorbidities, and complications (mortality model).

**Table 3.** Gastrostomy Tube Population Characteristics by 30-Day Overall Mortality and Cause of Mortality.

Characteristic	Overall 30-day mortality		P-value	Mortality cause		P-value
	Alive at 30 days (n = 1058)	Deceased at 30 days (n = 279)		GT related (n = 6)	Other causes (n = 273)	
Gender, n (%)						
Male	561 (53.0)	151 (54.1)	.74	1 (16.7)	150 (55.0)	.10
Female	497 (47.0)	128 (45.9)		5 (83.3)	123 (45.1)	
Age, years, M(SD)	58.7 (16.2)	62.3 (15.8)	<.001	57.2 (20.5)	62.4 (15.8)	.43
BMI (kg/m <sup>2</sup> ), median (IQR)	24.9 (21.1-29.4)	23.5 (19.5-28.8)	<.01	23.3 (16.7-31.0)	23.5 (19.5-28.8)	.79
Comorbidities, n (%)						
Congestive heart failure	48 (4.5)	32 (11.5)	<.001	2 (33.3)	30 (11.0)	.14
COPD	108 (10.2)	47 (16.9)	<.01	3 (50.0)	44 (16.1)	.06
Dementia	17 (1.6)	7 (2.5)	.31	1 (16.7)	6 (2.2)	.14
Renal failure	52 (4.9)	36 (12.9)	<.001	2 (33.3)	34 (12.5)	.17
Tobacco use, n (%) missing n = 151						
Never	339 (36.3)	100 (39.7)	.03	3 (60.0)	97 (39.3)	.84
Current	269 (28.8)	52 (20.6)		1 (20)	51 (20.7)	
Former	326 (34.9)	100 (39.7)		1 (20)	99 (40.1)	
Indication for GT, n (%)						
Malnutrition/FTT	285 (26.9)	81 (29)	<.0001	2 (33.3)	79 (28.9)	.50
Neurologic	351 (33.2)	69 (24.7)		3 (50.0)	66 (24.2)	
Anatomic	138 (13.0)	21 (7.5)		0 (0)	21 (7.7)	
Cancer/Palliative	284 (26.8)	108 (38.7)		1 (16.7)	107 (39.2)	
Type of GT, n (%)						
Percutaneous	816 (77.1)	229 (82.1)	<.0001	4 (66.7)	225 (82.4)	.29
Laparoscopic	194 (18.3)	34 (12.2)		2 (33.3)	32 (11.7)	
Open	48 (4.5)	16 (5.7)		0 (0)	16 (5.9)	
Prior abdominal surgery, n (%)	396 (37.5)	125 (44.9)	.03	3 (50)	122 (44.7)	1.0
Prior GT, n (%)	53 (5.0)	15 (5.4)	.79	1 (16.7)	14 (5.2)	.29
Any complications, n (%)	298 (28.2)	91 (32.6)	.15	6 (100)	85 (31.1)	.001
Discharge disposition, n (%)						
Home with self-care	261 (24.9)	47 (16.9)	<.0001	0 (0)	47 (17.2)	.68
Home with home health	234 (22.3)	64 (22.9)		1 (16.7)	63 (23.1)	
Facility <sup>a</sup>	366 (34.9)	59 (21.2)		1 (16.7)	58 (21.3)	
Inpatient rehab	143 (13.6)	17 (6.1)		0 (0)	17 (6.2)	
Inpatient death/hospice	46 (4.4) <sup>b</sup>	92 (33.0)		4 (66.7)	88 (32.4)	

SD, standard deviation; IQR, interquartile range; BMI, body mass index; COPD, chronic obstructive pulmonary disease; GT, gastrostomy tube; FTT, failure to thrive.

<sup>a</sup>Includes skilled nursing facility, hospital transfer, discharge to mental health facility, and long-term acute care hospital.

<sup>b</sup>Includes 12 inpatient deaths >30 days after the procedure.

**Table 4.** Patient Characteristics by Placement Service, PEG Placement Only.

Characteristic	Total (N = 1047) <sup>a</sup>	Performing service		P-value
		Surgical (N = 320)	Non-surgical (N = 727)	
Gender, n (%)				
Male	545 (52.1)	171 (53.4)	374 (51.4)	.55
Female	502 (47.9)	149 (46.6)	353 (48.6)	
Age, years, M (SD)	59.6 (16.6)	59.1 (17.0)	59.8 (16.5)	.54
BMI (kg/m <sup>2</sup> ), median (IQR)	25.1 (21.1-29.8)	26.5 (21.8; 30.7)	24.4 (20.7; 29.1)	<.001
Comorbidities, n (%)				
Congestive heart failure	72 (6.9)	16 (5.0)	56 (7.7)	.11
COPD	130 (12.4)	34 (10.6)	96 (13.2)	.24
Dementia	18 (1.7)	3 (.9)	15 (2.1)	.30
Renal failure	68 (6.5)	16 (5.0)	52 (7.2)	.19
Tobacco use, n (%) (missing n = 120)				
Never	357 (38.5)	100 (36.4)	257 (39.4)	.13
Current	245 (26.4)	85 (30.9)	160 (24.5)	
Former	325 (35.0)	90 (32.7)	235 (36.0)	
Indication for GT, n (%)				
Malnutrition/FTT	333 (31.8)	100 (31.3)	233 (32.1)	<.0001
Neurologic	406 (38.8)	116 (36.3)	290 (39.9)	
Anatomic	94 (9.0)	80 (25.0)	14 (1.9)	
Cancer/palliative	214 (20.4)	24 (7.5)	190 (26.1)	
Prior abdominal surgery, n (%)	402 (38.4)	107 (33.4)	295 (40.6)	.03
Prior GT, n (%) (missing n = 4)	44 (4.2)	8 (2.5)	36 (5.0)	.07
Mortality, n (%)				
Mortality related to G tube	4 (.4)	1 (.3)	3 (.4)	.04
Deceased from other cause	225 (21.5)	54 (16.9)	171 (23.6)	
Any complications, n (%)	293 (28.0)	86 (26.9)	207 (28.5)	.88
Discharge disposition, n (%)				
Home with self-care	197 (18.9)	72 (22.6)	125 (17.3)	.002
Home with home health	190 (18.3)	36 (11.3)	154 (21.3)	
Facility <sup>a</sup>	382 (36.7)	118 (37.1)	264 (36.5)	
Inpatient rehab	147 (14.1)	52 (16.4)	95 (13.1)	
Inpatient death/hospice	125 (12.0)	40 (12.6)	85 (11.8)	

SD, standard deviation; IQR, interquartile range; BMI, body mass index; COPD, chronic obstructive pulmonary disease; GT, gastrostomy tube; FTT, failure to thrive.

<sup>a</sup>Includes skilled nursing facility, hospital transfer, discharge to mental health facility, and long-term acute care hospital.

surgical and non-surgical services (surgical .6% vs non-surgical .5%,  $P = 1.0$ ). Overall, 30-day mortality was lower among surgical as compared to non-surgical services (16.5% vs 23.7%, respectively,  $P = .004$ ) (Table 1). While the crude odds of all-cause 30-day mortality were significantly higher among non-surgical services (OR 1.56, 95% CI 1.19, 2.05), there was no difference after adjustment (OR 1.19, 95% CI .83, 1.72) (Table 2).

On subgroup analysis of only patients who had PEG tubes placed ( $n = 1047$ ), these were most commonly placed for neurologic (38.8%) and malnutrition (31.8%). Those who had PEGs placed by a surgical service were less likely to have had prior abdominal surgery (33.4% vs 40.6%,  $P = .03$ ). However, there was otherwise no difference between groups in terms of baseline characteristics. The most common disposition among both placement services was to

another facility (37.1% and 36.5% in surgical and non-surgical services, respectively). Complication rates were similar for surgical and non-surgical services (26.9% vs 28.5%, respectively,  $P = .59$ ). The overall 30-day mortality rate was lower in surgical vs non-surgical services (17.2% vs 24.0%, respectively,  $P = .02$ ) (Table 4); however in multivariable logistic regression analysis, there was no difference in adjusted odds of complications (OR .87, 95% CI .63-1.21) or 30-day overall mortality (OR 1.21, 95% CI .83, 1.77) by service (Table 2).

## Discussion

In this study, we described outcomes in patients who had GTs placed by surgical vs non-surgical services and demonstrated that these teams had similar complication



rates and mortality. All-cause patient mortality was high at 20%, with .5% attributable to GT placement. Although complication rates were similar between services, roughly 1 in 4 patients experienced a complication in our analysis.

To our knowledge, this is the first study examining GT outcomes by surgical or non-surgical placement services. Prior studies of overall complications in GT placement have demonstrated widely variable complication rates between 10 and 88%.<sup>6-10</sup> This variation may be due to several factors, including differences in morbidity definitions and study populations. While the data are inconsistent, those with higher rates of complications were older or had more comorbid conditions, particularly cancer or cirrhosis.<sup>6,7,10,11</sup>

The overall complication rate in this study is within reported ranges. The vast majority of complications were minor mechanical complications such as blockage requiring replacement, pressure injuries, dislodgement, and leakage. Even though these procedures are generally well-tolerated, any complication can lead to infections and the need for further procedures (such as tube studies/exchanges), which can increase hospital length of stay and increase health care costs. These complications, however minor, highlight the need for optimal patient selection.<sup>8,12</sup> While close monitoring and education of bedside staff and patients in the initial postoperative phase by procedural team members may help prevent some common complications, this study demonstrates no evidence that the complications are affected by whether a surgical or non-surgical service is placing the GT.

Some data show no differences in complication rates by placement technique.<sup>13</sup> In contrast, an investigation of 91 patients assessing PEG vs laparoscopic vs open placement found significantly lower complications in the PEG and open group compared to the laparoscopic group.<sup>14</sup> While differences in complications between placement techniques may exist in other studies, our data indicate these differences are likely not due to placement service. Even with a more direct comparison of PEGs only, there were still no differences.

Overall mortality after GT placement ranges from 6% to 52%, while GT-specific mortality is lower and ranges from 0% to 2%.<sup>9,15-18</sup> Other studies have identified several patient characteristics related to increased 30-day mortality including acute illness, pulmonary cachexia, neurological debilitation, and head and neck cancers.<sup>16,19</sup>

Consistent with these data, procedural mortality was low, but overall mortality was relatively high in this study. Thirty-day mortality, but not GT-related mortality, was higher in non-surgical services; however, this difference resolved with adjustment, likely accounting for some of the comorbid conditions that were higher among patients receiving GTs by non-surgical services. These findings again highlight the importance of optimal patient selection for these procedures. Additionally, these findings hint at

the underlying need for a GT as a harbinger of either frailty or a significantly morbid medical issue that places the patient at risk for mortality.

Not surprisingly, discharge to a skilled nursing facility was common. The frequency of discharge to nursing homes has important implications for discussions with patients and their families in terms of future prognosis and the likelihood of going home. While the presence of a GT itself is unlikely to be the principal reason for these discharge outcomes, if a patient is ill to the point of needing a GT, it may be an indicator of higher short-term mortality and a non-home discharge disposition. Furthermore, patient selection for GT may be problematic as GT is often placed to facilitate discharge from the hospital. Proper patient selection for GT placement is essential, though it is often difficult to anticipate feeding needs in a complicated operative or medical patient.<sup>20</sup>

This study has several limitations. This is a single institution study which limits generalizability and statistical power. However, this study included a large sample of patients, the findings are generally consistent with other work, and the indications for GT placement are widely accepted. We did not delineate patients who had an operative GT placement as the primary procedure vs secondarily as part of a larger procedure, nor did we account for other feeding tubes placed simultaneously, such as feeding jejunostomy tubes. This could affect overall 30-day mortality rates, but we also examined GT-specific mortality. Given the retrospective methodology of this study, we cannot account for all possible confounders. Additionally, the degree of post-procedural surveillance, feeding regimens, and tube care was difficult to ascertain in both service types. We did not evaluate the subset of patients who had aborted procedures that subsequently underwent GT placement by another service line; these data may have been relevant given potential increased difficulty and risk of complication in these patients.

Gastrostomy tubes placed by surgical and non-surgical services have equivalent mortality and complication rates. The high overall mortality and complications associated with placement underscore the need for careful patient selection. Patients and families should be aware of the prognostic implications of the need for GT placement, including the potential for a non-home discharge and the fact that patients who require GT often have significant 30-day mortality related to their underlying conditions. Further studies evaluating long-term outcomes are needed to help direct full informed procedural consent and decision-making.

### Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

## Funding

The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: This work was supported by National Research Service Award Pre-Doctoral/Post-Doctoral Traineeship from the Agency for Healthcare Research and Quality sponsored by the Cecil G. Sheps Center for Health Services Research, University of North Carolina at Chapel Hill, Grant No. 5T32 HS000032 partially supported Josh Herb.

## References

- Kurien M, McAlindon ME, Westaby D, Sanders DS. Percutaneous endoscopic gastrostomy (PEG) feeding. *BMJ*. 2010;340:c2414. doi:10.1136/bmj.c2414.
- Stiegmann GV, Goff JS, Silas D, Pearlman N, Sun J, Norton L. Endoscopic versus operative gastrostomy: Final results of a prospective randomized trial. *Gastrointest Endosc*. 1990;36(1):1-5. doi:10.1016/s0016-5107(90)70911-x.
- Bankhead RR, Fisher CA, Rolandelli RH. Gastrostomy tube placement outcomes: Comparison of surgical, endoscopic, and laparoscopic methods. *Nutr Clin Pract*. 2005; 20(6):607-612. doi:10.1177/0115426505020006607.
- Jones M, Santanello SA, Falcone RE. Percutaneous endoscopic vs surgical gastrostomy. *J Parenter Enter Nutr*. 1990;14(5):533-534. doi:10.1177/0148607190014005533.
- Dindo D, Demartines N, Clavien PA. Classification of surgical complications: A new proposal with evaluation in a cohort of 6336 patients and results of a survey. *Ann Surg*. 2004;240(2): 205-213. doi:10.1097/01.sla.0000133083.54934.
- Taylor CA, Larson DE, Ballard DJ, et al. Predictors of outcome after percutaneous endoscopic gastrostomy: A community-based study. *Mayo Clin Proc*. 1992;67(11): 1042-1049. doi:10.1016/s0025-6196(12)61118-5.
- Blomberg J, Lagergren J, Martin L, Mattsson F, Lagergren P. Complications after percutaneous endoscopic gastrostomy in a prospective study. *Scand J Gastroenterol*. 2012; 47(6):737-742. doi:10.3109/00365521.2012.654404.
- Keung EZ, Liu X, Nuzhad A, Rabinowits G, Patel V. In-hospital and long-term outcomes after percutaneous endoscopic gastrostomy in patients with malignancy. *J Am Coll Surg*. 2012; 215(6):777-786. doi:10.1016/j.jamcollsurg.2012.08.013.
- Larson DE, Burton DD, Schroeder KW, DiMagno EP. Percutaneous endoscopic gastrostomy. Indications, success, complications, and mortality in 314 consecutive patients. *Gastroenterology*. 1987;93(1):48-52. doi:10.1016/0016-5085(87)90312-X.
- Raha SK, Woodhouse K. The use of percutaneous endoscopic gastrostomy (PEG) in 161 consecutive elderly patients. *Age Ageing*. 1994;23(2):162-163. doi:10.1093/ageing/23.2.162.
- Richter-Schrag HJ, Richter S, Ruthmann O, Olschewski M, Hopt UT, Fischer A. Risk factors and complications following percutaneous endoscopic gastrostomy: A case series of 1041 patients. *Can J Gastroenterol*. 2011;25(4):201-206. doi:10.1155/2011/609601.
- Singh Curry R, Evans E, Raftery AM, Hiscock J, Poolman M. Percutaneous venting gastrostomy/gastrojejunostomy for malignant bowel obstruction: A qualitative study. *BMJ Support Palliat Care*. 2019;9(4):381-388. doi:10.1136/bmjspcare-2019-001866.
- Thaker S, Misra MV. A comparison of laparoscopic gastrostomy tubes and percutaneous endoscopic gastrostomy in infants: Results from a single institution. *J Pediatr Surg*. 2019; 54(11):2453-2456. doi:10.1016/j.jpedsurg.2019.06.024.
- Zettervall SL, Holzmacher JL, Radomski M, et al. Comparison of complications following laparoscopic and endoscopic gastrostomy placements. *J Gastrointest Surg*. 2017;21(9):1396-1403. doi:10.1007/s11605-017-3475-1.
- Wasiljew BK, Ujiki GT, Beal JM. Feeding gastrostomy: Complications and mortality. *Am J Surg*. 1982;143(2): 194-195. doi:10.1016/0002-9610(82)90065-4.
- Stuart SP, Tiley EH, Boland JP. Feeding gastrostomy: A critical review of its indications and mortality rate. *South Med J*. 1993;86(2):169-172.
- Gençosmanoglu R, Koç D, Tözün N. Percutaneous endoscopic gastrostomy: Results of 115 cases. *Hepato-Gastroenterology*. 2003;50(51):886-888.
- Wirth R, Voss C, Smoliner C, Sieber CC, Bauer JM, Volkert D. Complications and mortality after percutaneous endoscopic gastrostomy in geriatrics: A prospective multicenter observational trial. *J Am Med Dir Assoc*. 2012;13(3): 228-233. doi:10.1016/j.jamda.2011.07.010.
- Abuksis G, Mor M, Segal N, Fraser GM, Niv Y. Percutaneous endoscopic gastrostomy: High mortality rates in hospitalized patients. *Am J Gastroenterol*. 2000;95(1): 128-32. doi:10.1016/S0002-9270(99)00731-5.
- Mathus-Vliegen LM, Koning H. Percutaneous endoscopic gastrostomy and gastrojejunostomy: A critical reappraisal of patient selection, tube function and the feasibility of nutritional support during extended follow-up. *Gastrointest Endosc*. 1999;50(6):746-754. doi:10.1016/s0016-5107(99) 70153-7.