How often should percutaneous gastrostomy feeding tubes be replaced? A single-institute retrospective study

Byung Hyo Cha ©,[1,2] Min Jung Park,[1] Joo Yeong Baeg,[1] Sunpyo Lee,[1] Eui Yong Jeon,[3] Wafaa Salem Obaid Alsalami,[4] Osama Mohamed Ibrahim Idris,[4] Young Joon Ahn[5]

[1]Gastroenterology, Sheikh Khalifa Specialty Hospital, Ras Al Khaimah, UAE
[2]Gastroenterology, Seoul National University Hospital, Jongno-gu, the Republic of Korea
[3]Radiology, Sheikh Khalifa Specialty Hospital, Ras Al Khaimah, UAE
[4]Division of Medicine, Sheikh Khalifa Specialty Hospital, Ras Al Khaimah, UAE
[5]Surgical Oncology, Sheikh Khalifa Specialty Hospital, Ras Al Khaimah, UAE

Correspondence to
Dr Byung Hyo Cha;
doctorhyo@gmail.com

ABSTRACT

Objective Percutaneous gastrostomy (PG) is a common procedure that enables long-term enteral nutrition. However, data on the durability of individual tube types are insufficient. We conducted this study to compare the longevities and features of different PG tube types.
Design We performed a 5-year retrospective analysis of patients who underwent endoscopic and radiologic PG-related feeding tube procedures. The primary and secondary outcomes were tube exchange intervals and revenue costs, respectively. Demographic factors, underlying diseases, operator expertise, materials used, and complication profiles were assessed.
Results A total of 599 PG-related procedures for inserting pull-type PG (PGP), balloon-type PG (PGB), PG jejunal MIC* (PGJM; gastrojejunostomy type), and PG jejunal Levin (PGJL) tubes were assessed. On univariate Kaplan-Meier analysis, PGP tubes showed longer median exchange intervals than PGB tubes (405 days (95% CI: 315 to 537) vs 210 days (95% CI: 188 to 238); p<0.001). Larger PGB tubes diameters were associated with longer durations than smaller counterparts (24 Fr: 262 days (95% CI: 201 to NA), 20 Fr: 216 days (95% CI: 189 to 239), and 18 Fr: 148 days (95% CI: 100 to 245)). The PGJL tubes lasted longer than PGJM counterparts (median durations: 168 days (95% CI: 72 to 372) vs 13 days (95% CI: 23 to 65); p<0.001). Multivariate Cox proportional regression analysis revealed that PGJL tubes had significantly lower failure rates than PGJM tubes (OR 2.97 (95% CI: 1.17 to 7.53); p=0.022). PGB tube insertion by general practitioners was the least costly, while PGP tube insertion by endoscopists was 2.9-fold more expensive; endoscopic PGJM tubes were the most expensive at two times the cost of PGJL tubes.
Conclusion PGP tubes require replacement less often than PGB tubes, but the latter are more cost-effective. Moreover, PGJL tubes last longer than PGJM counterparts and, owing to lower failure rates, may be more suitable for high-risk patients.

INTRODUCTION

Percutaneous gastrostomy (PG) is an effective method for delivering enteral nutrition to the gastric lumen while bypassing the oral cavity in patients who cannot tolerate oral or nasogastric tube feeding. The rate of

Summary box

What is already known about this subject?
► Practice guidelines recommend percutaneous gastrostomy (PG) tube feeding for patients who require enteral feeding treatment for more than 30 days.
► Endoscopic and radiologic PG tube insertion and replacement are minimally invasive and cost-effective procedures; however, the tube must be changed regularly to avoid various long-term complications.
► According to previous studies, jejunal tube feeding via the PG site is recommended to prevent aspiration pneumonia in patients who have high regurgitation tendencies.

What are the new findings?
► We determined optimal median exchange durations for different types of PG tubes; the pull-type PG (PGP) lasted longer than the balloon-type PG (PGB), but the latter was more cost-effective.
► PGB tubes with larger diameters showed longer durability than smaller sized tubes. Moreover, PG jejunal Levin tubes (PGJL) had lower complication rates than the PG jejunal MIC* tubes (PGJM) in patents requiring percutaneous gastrojejunostomy.

How might it impact on clinical practice in the foreseeable future?
► A PGP can be selected for initial insertion and replaced by a PGB after 1 year, which in turn can be changed 8 months later to a balloon type (except in patients who require replacement every 2 months).
► For patients at risk of recurrent aspiration, PGJL tubes can be considered to prevent aspiration pneumonia.

this procedure has greatly increased since the 1980s commensurate with the growth in home nursing care.[1] Currently published guidelines for this procedure and its postoperative care recommend PG tube insertion for candidates who are at risk of moderate-to-severe malnutrition within 2–3 weeks of nasogastric tube feeding.[2–4] Although this minimally invasive procedure is quite safe

and instructions for tube care are well-known, the risks of minor or major complications (such as wound infection, occlusion, peristomal leakage, tube dislodgement, stomal hypergranulation, and buried bumper syndrome) increase as long as tube feeding persists.[5] Because of such complications, the PG tube should be exchanged periodically; however, physicians and nurses have remained uncertain about the optimal time to perform these exchanges with respect to the different types of tubes as well as the patients' conditions. There have been a few studies comparing the durability of PG tubes constructed of different materials in small populations[6–9]; however, no clinical data have been published addressing how often PG tubes need to be replaced. Within this context, the aim of this study was to investigate longevity of PG tube patency according to type, and thus to determine the optimal replacement time.

METHODS
Study design and patients
We performed a retrospective observational study by reviewing medical records at a single institution.

The study population included all patients who underwent endoscopic or radiologic PG tube placement (initial or exchange) for long-term enteral feeding at Sheikh Khalifa Specialty Hospital in Ras Al Khaimah, United Arab Emirates, between 2016 and 2020. PG tube insertion was performed for patients deemed by physicians to require enteral tube feeding for more than 30 days in order to avoid any long-term complications from nasogastric tube feeding. In patients with recurrent vomiting and a high risk of aspiration, PG with a jejunal tube extension (PGJ) was performed via a previously created PG tract per the physician's instructions. Severe paralytic ileus, lower gastrointestinal obstruction, altered anatomy, inability to perform, colon interposition, uncontrolled coagulation disorders (prothrombin time-international normalised ratio>1.5 and/or a peripheral platelet count<50 000/mm^3), extensive ascites, and severe gastric erosions or ulcers on endoscopic examination were considered contraindications for PG.

Procedural techniques
All initial PG placement procedures were performed in an endoscopy unit or radiologic fluoroscopy room. Each percutaneous endoscopic gastrostomy was performed by two expert endoscopists from among four gastroenterology consultants employed at the Gastroenterology Department of Sheikh Khalifa Specialty Hospital.

After informed consent was obtained from the patients or their guardians, each candidate underwent preprocedural assessment by registered endoscopy nurses. After sterilising the surgical site (which was delineated using both percussion and transillumination by the scope) from the gastric lumen toward the anterior abdominal wall by another endoscopist, 2% lidocaine was injected by the operator as a local anaesthetic. A hollow introducer

16-gauge needle was passed through the incision into the gastric lumen under endoscopic guidance, after which a long, soft looped wire was passed through the needle and grabbed by the snare catheter that was inserted via the instrument channel of scope. The wire was pulled out of the mouth through the patient's stomach and oesophagus and was tightly attached to a tapered loop wire at the end of the PG tube. The operator pulled the wire gently and slowly, passing the tube through the mouth and oesophagus into the stomach lumen where it was anchored to the wall. The external fixator of the tube was attached at the proper position, and the location documented with photographs.

Percutaneous radiologic gastrostomy insertion procedures were performed by two radiologic interventionists with modified methods in the fluoroscopy room.[10 11] The stomach was transorally probed with a 5-Fr catheter and a guidewire. A second access was performed percutaneously through the anterior abdominal and gastric wall using an 8-Fr sheath and an 8-Fr guiding catheter, after securing the gastric wall to the anterior abdominal wall with anchor device. A snare catheter in the gastrostomy catheter set was introduced through the sheath and the transoral guidewire was captured and tightened with this loop. The snare catheter in the sheath is pulled by the transoral guidewire until the tip of the snare catheter exited the mouth. A thread was fed through the snare catheter for fixation of the pull-type gastrostomy tube. Finally, the fixed tube was pulled through the oesophagus into the stomach with avoiding too much tension (that can injure the oropharyngeal and oesophageal mucosa) and through the abdominal wall until the anterior gastric wall fixed the retention plate of the tube.

In most cases, fluoroscopy was not used during tube exchange. Replacement tubes were inserted through the stomal tract after the previous tubes were removed; their positions were then confirmed via water infusion by gravity and postexchange abdominal radiography. In cases in which the replacement tube would not insert despite a gentle push or in those in which the operator was unable to confirm that the tract was sufficiently intact to pass the proper-sized tubes, we used a guidewire, balloon dilation, endoscopy or fluoroscopy.

Materials
For the initial endoscopic and radiologic PG tube insertion, we used a 20 French (Fr) FLOW-20-PULL-I-S (Cook Medical Europe) PG set. MIC* gastrostomy feeding tubes (G-Tube, Halyard, Georgia, USA) with diameters between 8 and 24 Fr were inserted as replacements. For PG with a jejunal tube (PGJ), two different materials were used: the MIC* Percutaneous Gastric-Jejunal Feeding Tube (PGJM) kit (18 Fr, 45 cm) (AVANOS, Alpharetta, Georgia, USA), and Long Silicon 18/20 Fr nasogastric tubes (Levin tube (PGJL)) with a 120 cm radiopaque line (Sewoon Medical, Cheonan, Korea) guided by a hydrophilic coated angiographic catheter (5 Fr, 125 cm, 0.038 inch guidewire) (Radi-focus, Terumo, Tokyo, Japan). Two

patients used a 10 Fr nasal jejunal feeding tube (NJFT-10, 240 cm) (Cook Medical, Bloomington, Indiana, USA) (online supplemental file 1).

Primary and secondary outcomes

The primary outcome was the PG tube exchange interval, defined as the median in-dwelling time from the date of insertion or replacement to the date of exchange or removal of tubes (days). Subgroup analysis was performed to compare the median survival time between any two

groups. The secondary outcome was the estimated cost of the procedure as a function of the physician's specialty and tube materials used.

Statistical analysis

All continuous variables are presented as means±SD or medians and ranges, while categorical variables are depicted as numbers and proportions. We compared the differences between the mean values of each group using Student's t-test, and between proportions using the χ^2

Table 1	Clinical characteristics and outcomes with respect to the two percutaneous gastrostomy tube types (N=542)				
		PGP N=208	PGB N=334	PG total N=542	P value
Age in years	Mean+SD	72.18+19.76	69.05+22.85	70.25+21.75	0.092
	Median (min–max)	78 (14–106)	77 (3–107)	78 (3–107)	
Sex	Female: N (%)	70 (33.7)	117 (35.0)	150 (34.2)	0.081
	Male: N (%)	138 (66.3)	217 (64.9)	289 (65.8)	
Tube diameter (French)	Mean±SD	19.92±1.16	19.57±2.31	19.71±1.96	0.020
	Median (min–max)	20 (12–24)	20 (12–24)	20.0 (12.0–24)	
Fix level or tube length (cm)*	Mean±SD	4.11±1.35	3.92±3.54	3.93±3.39	0.643
	Median (min–max)	4.0 (2.0–8.0)	4.0 (0.5–8.0)	4.0 (0.5–8)	
Procedure time (min)	Mean±SD	22.38±11.26	10.75±8.22	15.21±11.05	<0.001
	Median (min–max)	20 (2–68)	9 (1–60)	11.0 (1.0–68)	
Follow-up (days)	Mean±SD	366.37±433.21	473.55±440.54	432.42±440.44	0.006
	Median (min–max)	199.5 (0–2125)	354.5 (0–1972)	296.5 (0.0–2125)	
Interval (days)	Mean±SD	193.45±195.14	166.55±161.13	176.87±175.28	0.097
	Median (min–max)	142 (0–1328)	150 (0–1486)	149.0 (0.0–1486)	
Procedure	Initial: N (%)	201 (96.63)	0 (0)	201 (37.1)	<0.001
	Replacement: N (%)	7 (3.37)	334 (100.00)	341 (62.9)	
Indication	Neurologic disease: N (%)	148 (71.1)	277 (82.9)	425 (78.4)	NA
	Non-neurologic loss of consciousness: N (%)	23 (11.1)	14 (4.2)	37 (6.8)	NA
	Oncologic disease: N (%)	29 (13.9)	42 (12.6)	71 (13.1)	NA
	Others: N (%)	8 (3.8)	1 (0.3)	9 (1.7)	NA
Events	Occlusion: N (%)	23 (11.06)	49 (14.67)	72 (13.8)	0.273
	Dislocation: N (%)	9 (4.33)	74 (21.86)	82 (15.1)	<0.001
	Leakage: N (%)	14 (6.73)	51 (15.27)	65 (12.0)	0.002
	Tube damage: N (%)	8 (3.85)	10 (2.99)	18 (3.3)	0.785
	Aspiration: N (%)	10 (4.81)	1 (0.30)	11 (0.2)	NA
	BBS: N (%)	2 (0.96)	6 (1.80)	8 (0.1)	0.676
	Infection: N (%)	1 (0.48)	5 (1.50)	6 (0.1)	0.4981
	Bleeding: N (%)	2 (0.96)	2 (0.60)	4(0.1)	NA
	No event: N (%)	131 (62.98)	116 (34.73)	247 (45.5)	<0.001
	Miscellaneous: N (%)	8 (3.85)	21 (6.29)	28 (3.58)	0.338

*Fixed level of external stopper in PGP & PGB group
BBS, buried bumper syndrome; PG, percutaneous gastrostomy; PGB, balloon-type percutaneous gastrostomy; PGP, pull-type percutaneous gastrostomy.
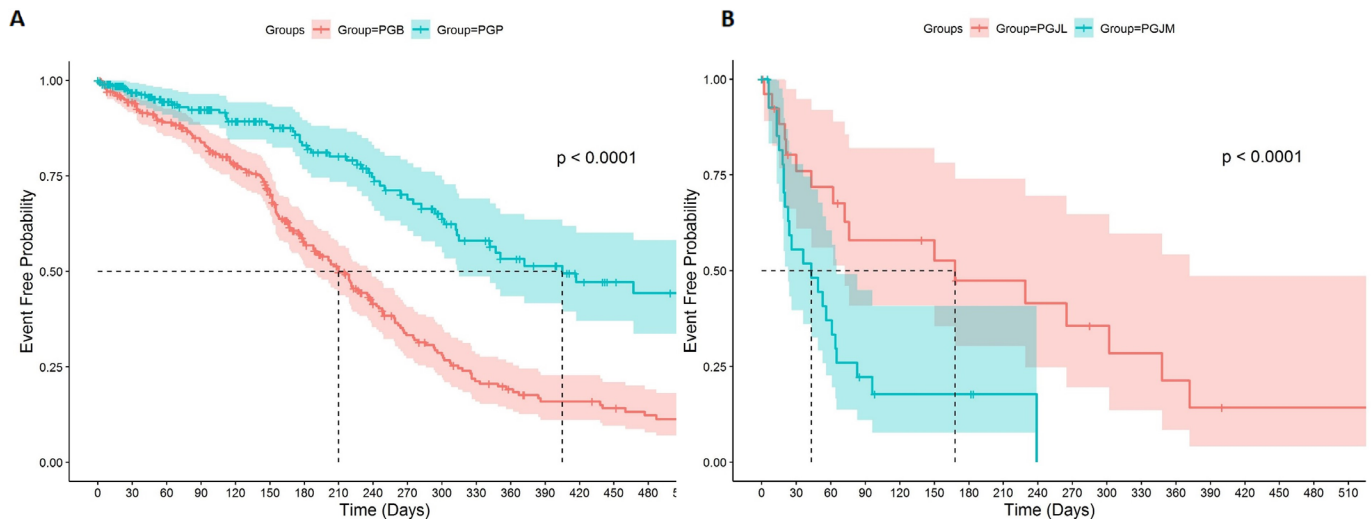
Figure 1 Kaplan-Meier curve of tube exchange intervals (days) in the PGP and PGB groups (A) and in the PGJM versus PGJL groups (B). The dashed lines indicate the medians. PGB, balloon-type percutaneous gastrostomy gastric tube; PGJL, percutaneous gastrostomy jejunal tube with the Levin tube; PGJM, percutaneous gastrostomy jejunal tube with the MIC* tube; PGP, pull-type percutaneous gastrostomy gastric tube.

test. For two-sided tests, a p value<0.05 was considered statistically significant. The cumulative frequencies of tube replacement were investigated using Kaplan-Meier analyses and compared using log-rank tests. Patients who died or were lost to follow-up were censored. Multivariate analyses using a Cox proportional regression model were performed to determine the association of factors including age, sex, tube size, tube length, and tube material type with the tube replacement interval. All statistical analyses were performed using R version V.4.0.2 (The R Foundation of Statistical Computing, UK).

RESULTS

All patients who underwent long-term enteral feeding tube placement and replacement procedures by gastrointestinal endoscopists and intervention radiologists at Sheikh Khalifa Specialty Hospital between 2015 and 2020 were extracted from the hospital's medical records system. Among 721 tube placements, 599 were PG-related and remnant procedures, 62 involved nasoenteric feeding tube insertion, 4 were for feeding tubes inserted via surgical gastrostomy or jejunostomy, and 56 were for tube check only. The 599 PG-related procedures were performed for 274 patients, among which 452 (75.5%) were percutaneous endoscopic gastrostomy feeding tube insertions and replacements as well as 147 (24.5%) percutaneous radiologic gastrostomy insertions and replacements. A pull-type PG (PGP) tube was the initially inserted device in 208 instances, while the balloon-type PG (PGB) tube was involved in 334 tube replacements. There were 29 episodes of PG tubes with jejunal extension (PGJM, GJ type, Halyard MIC*) and 28 of jejunal feeding tube via PG plus a Levin tube (PGJL). The most common underlying conditions for initial PG placement were neurologic diseases (including cerebrovascular occlusive and degenerative diseases), followed

by non-neurologic loss of consciousness, and oncologic diseases (online supplemental table S1).

There were no significant differences between the PGP and PGB groups in terms of mean age, sex distribution, tube diameter, fixed level of tube, follow-up duration, and tube exchange interval (table 1). Kaplan-Meier analysis revealed significant differences in the median exchange intervals between the PGP and PGB groups (405 days, 95% CI: 315 to 537 vs 210 days, 95% CI: 188 to 238; p<0.001) (figure 1A).

We compared the durabilities of different-sized tubes in the PGB group and found that the median exchange intervals lengthened as tubes diameters increased (18 Fr (N=54): 148 days (95% CI: 100 to 245); 20 Fr (n=203): 216 days (95% CI: 189 to 239); and 24 Fr (N=33): 262 days (95% CI: 201 to NA)).

As for PGJ tubes, there were significant differences between the PGJL and PGJM groups in mean tube length from the stoma (62.86±15.95 vs 48.41±2.86 cm, p<0.01) and in the mean exchange intervals (139.75 vs 55.21 days, p=0.009, table 2). Kaplan-Meier analysis revealed a large difference in the median tube exchange intervals (168 days (95% CI: 72 to 372) for PGJL vs 43 days (95% CI: 23 to 65) for PGJM; p<0.001) (figure 1B). On multivariate analysis using a Cox proportional regression model, being in the PGJM group was the only significant factor related to tube failure when compared with the PGJL group (OR=2.97, 95% CI: 1.17 to 7.53; p=0.022) (figure 2).

The revenue costs for each procedure, which were estimated based on the materials, procedure types (radiologic vs endoscopic), and operator expertise (general practitioners vs consultants), are summarised in table 3. PGB-type tube insertion by general practitioners was the least costly, while PGP insertion by endoscopists was 2.9-fold more expensive than PGB. Endoscopic insertion

Table 2 Clinical characteristics and outcomes with respect to the two percutaneous gastrostomy tube types with jejunal extensions (N=57)

		PGJL N=28	PGJM N=29	Total PGJ N=57	P value
Age in years	Mean+SD	69.71±24.79	73.41±25.69	71.6±25.1	0.582
	Median (min–max)	77.5 (28–94)	86 (18–96)	86 (18–96)	
Sex	Female: N (%)	9 (32.1)	14 (48.3)	23 (40.4)	0.332
	Male: N (%)	19 (67.9)	15 (51.7)	34 (59.6)	
Tube diameter (French)	Mean+SD	18.71, 2.68	17.86, 1.19	18.28, 2.09	0.131
	Median (min–max)	20 (10–20)	18 (12–20)	18 (10–20)	
Fix level or tube length (cm)*	Mean+SD	62.86±15.95	48.41±2.86	55.5±13.4	<0.001
	Median (min–max)	60 (45–120)	49 (35–53)	49 (35–120)	
Procedure time (min)	Mean+SD	27.14±13.85	21.62±14.86	24.3±14.5	0.152
	Median (min–max)	25 (5–60)	17 (5–76)	50 (5–76)	
Follow-up (days)	Mean+SD	364.32±367.70	254.90±184.24	308.7±291.9	0.166
	Median (min–max)	264.5 (0–1197)	232 (0–628)	232 (0–1197)	
Interval (days)	Mean+SD	139.75±151.31	55.21±58.47	96.7±120.7	0.009
	Median (min–max)	69 (0–569)	36 (0–239)	53 (0–569)	
Procedure	Initial: N (%)	0 (0)	0 (0)	0 (100)	0.895
	Replacement: N (%)	28 (100.00)	29 (100.00)	57 (100)	
Indication	Neurologic disease: N (%)	28 (100)	29 (100)	57 (100)	NA
	Non-neurologic loss of consciousness: N (%)	0 (0)	0 (0)	0 (0)	
	Oncologic disease: N (%)	0 (0)	0 (0)	0 (0)	
	Others: N (%)	0 (0)	0 (0)	0 (0)	
Events	Occlusion: N (%)	9 (32.14)	17 (58.62)	26 (45.6)	0.082
	Dislocation: N (%)	9 (32.14)	4 (13.79)	13 (22.8)	0.182
	Leakage: N (%)	0 (0)	1 (3.45)	1 (1.8)	NA
	Tube damage: N (%)	0 (0)	1 (3.45)	1 (1.8)	NA
	No events: N (%)	10 (35.71)	6 (20.69)	16 (28.1)	0.333
	Miscellaneous: N (%)	1 (3.58)	0 (0.00)	1 (1.80)	NA

*The length of tubes measured from the stoma of PG in PGJL group, and PGJM group has same fixed level of 45cm from the stoma
PGJ, percutaneous gastrostomy jejunal extension; PGJL, percutaneous gastrostomy jejunal extension with Levin tube; PGJM, Percutaneous gastrostomy jejunal extension with MIC*, GJ Type.

of PGJM by gastroenterology consultants was the most expensive procedure, bearing two times the cost of PGJL.

DISCUSSION

Since Gauderer *et al* introduced PG for the long-term nutritional support of paediatric patients in 1980,[12] the demand for PG placement has risen as the numbers of patients in nursing homes and geriatric long-term care facilities have broadly increased. According to National Hospital Discharge Survey analyses performed by Grant and Herman, there was a dramatic increase in the incidence rates of PG between 1988 and 1999 (from 61 000 to 138 000); moreover, PG accounted for 10.9 per 1000 discharges (1.09%) among hospitalised patients aged 65 years or older in the USA.[1]

Very limited data are available from few studies that compared the longevities of tubes made of different materials such as latex, silicone, and polyurethane.[6 7 13 14] Although certain studies were designed as randomised controlled trials, comparisons between the types (pull vs balloon) and sizes of PG tubes were not performed in detail, and the sample sizes in each study were small.

Our current study compared the longevities of four different types of silicone-based PG-related enteral feeding tubes, and included approximately 600 samples. The median tube exchange intervals were 13 months, 7 months, 5.5 months, and 55 days for PGP, PGB, PGJL, and PGJM, respectively. When we compared our results to those of previous studies, the median exchange interval of PGP was longer than those found in randomised
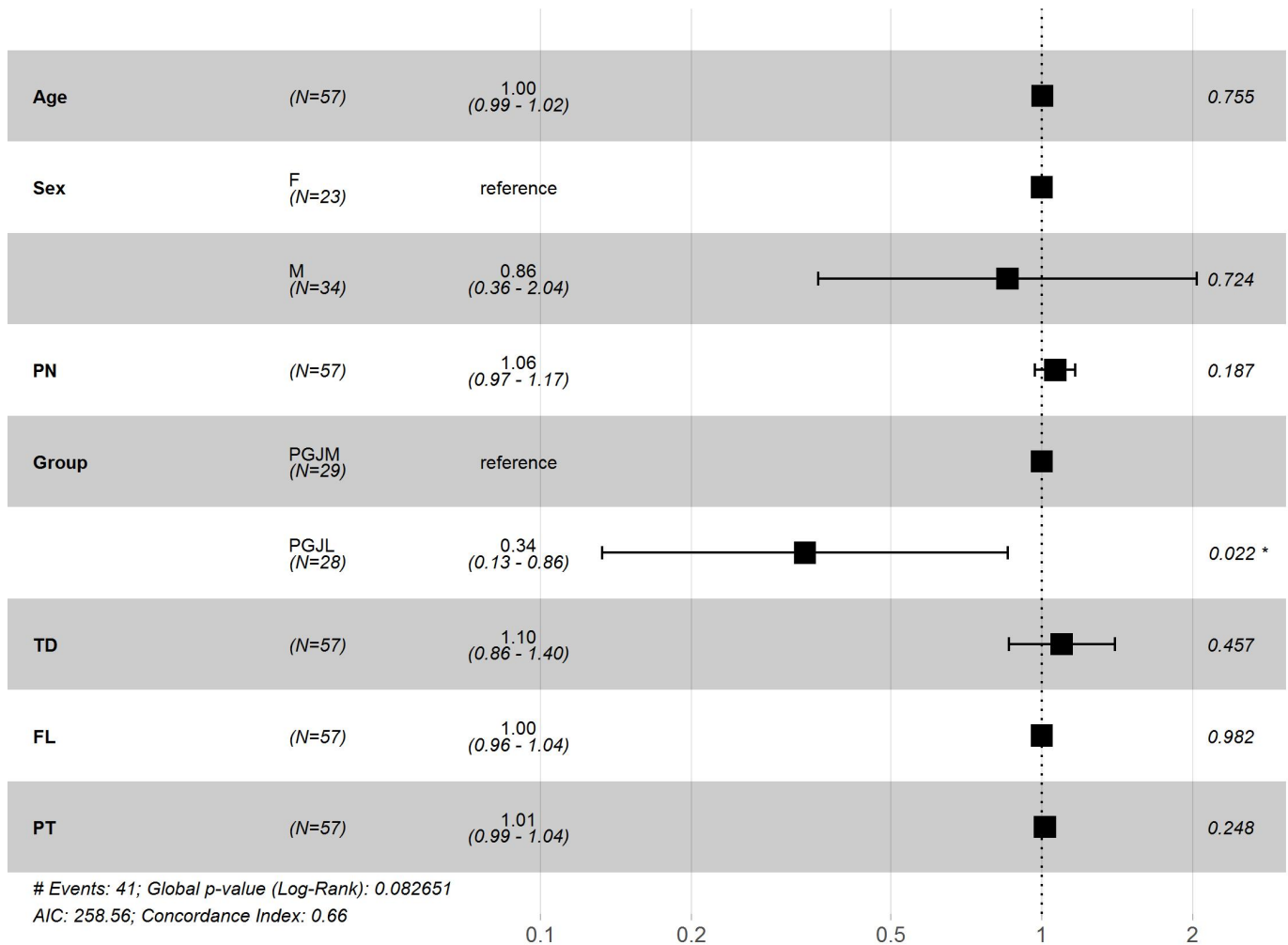
Figure 2 Multivariate analysis using a Cox proportional regression model of variables potentially predictive of tube exchange intervals in the PGJ group. FL, fixed level; PGJ, percutaneous gastrostomy jejunal tube; PGJL, percutaneous gastrostomy jejunal tube with the Levin tube; PGJM, percutaneous gastrostomy jejunal tube with the MIC* tube; PN, procedure number; TD, tube diameter; PT, procedure time.

Table 3 Cost estimations of long-term enteral feeding tube insertions according to procedure type, physician expertise, and tube material

Procedure name	Cost (US$*)	Detail
PGP	AED 3722.00 (1013.34)	Tube+endoscopy, initial+consultant
	AED 4632.00 (1261.09)	Tube+radiology, initial+consultant
PGB	AED 1528.00 (416.01)	Tube+replacement+consultant
	AED 1278.00 (347.94)	Tube+replacement +GP
PGJ	AED 5048.00 (1374.35)	Tube (PGJM)+radiology, replacement+consultant
	AED 4446.00 (1210.45)	Tube (PGJM)+endoscopy, replacement+consultant
	AED 2646.00 (720.36)	Tube (PGJL)+radiology, replacement+consultant
	AED 2044.00 (556.49)	Tube (PGJL)+endoscopy, replacement+consultant

*Estimated cost by using Google Current Exchange Convertor at February 2022.
AED, Arab Emirates dirham; PGB, balloon-type percutaneous gastrostomy; PGJ, percutaneous endoscopic gastrostomy jejunal extension; PGJL, percutaneous endoscopic gastrostomy jejunal extension with Levin tube; PGJM, percutaneous endoscopic gastrostomy jejunal extension with MIC*, GJ-Type; PGP, pull-type percutaneous gastrostomy.

controlled trials of silicone-based PG tubes.[6 7 9 13] Likewise, median PGB exchange intervals were longer than those previously determined for five silicone-based commercial PGB tubes[14] online supplemental table 1.

While the common sense notion is that a larger diameter tube ought to have a longer half-life and a lower risk of occlusion, there have been no trials to investigate this hypothesis. We found that a larger PGB tube diameter was indeed associated with a longer median exchange interval that increased stepwise going from 18 to 20 to 24 Fr.

In critically ill patients, postpyloric enteral feeding not only reduces the risk of pneumonia but also improves the patient's nutritional status per recently published meta-analyses.[15 16] However, studies of the durations of jejunal extension tube groups are sparse.[17] The median tube exchange interval of PGJL in our study was longer than that derived by Ridtitid et al[18] while that for PGJM was shorter than the durations calculated by Uflacker et al.[19] Commercially available gastrojejunal tubes that are inserted through the PG stoma reportedly have frequent incidences of migration and occlusion[20 21]; however, no previous studies have investigated the silicon Levin tube in the same manner that we did. The reason for the shorter durations of PGJM tubes in our study compared with others might be that we included patients who underwent radiologic PGJ insertion; these procedures are more complex and are performed after endoscopic trial failure. Another possible explanation may be that the lengths of tube tips from the stoma in the PGJL group were longer than those in the PGJM group. These observations suggest that further studies on the relationship between the length of the tube inserted in the jejunum, incidence of migration, and tube longevity are warranted (online supplemental table 1).

Another important question was whether an elective replacement schedule could prevent complications or minimise the frequency of hospital visits. North American practice guidelines recommend elective replacement every 3–5 months for balloon-type tubes,[22] while a British agency recommends replacement without specifying the interval.[23] However, these recommendations have not been supported with clear evidence; on the contrary, certain studies concluded that the elective replacement of PG tubes does not reduce adverse events or lower the frequency of hospital visits.[24 25]

In our study, the PGP tubes achieved longer durations than PGB tubes owing to their lower rates of dislocations. However, the insertion of pull-type tubes requires endoscopic or fluoroscopic guidance, which increases their cost three-fold over balloon-type tube replacement. Therefore, PGB tubes are recommended only as replacements for PGP tubes; the latter being more suitable for initial placement until tract maturation. However, in cases requiring more frequent tube exchange (ie, every 2 months), a pull-type tube is more prudent than a balloon-type replacement in terms of cost-effectiveness, per our data.

The limitations of this study included its retrospective design and its sole reliance on medical records; hence, we cannot rule out selection and encoding biases. We also cannot generalise our findings regarding the four different types of PG-related tube groups because the procedures were not assigned randomly. In particular, the PGP and PGB groups had different indications and roles; namely, initial insertion versus replacement. Moreover, we could not assess feeding patterns and caregiver management-related factors, which are important when predicting tube longevity. Additionally, accidental dislodgement, self-removal by patients or spontaneous balloon ruptures/collapses were included in the definition of dislocation, although those incidences can be reduced by using preventive measures such as cautious manoeuvring, patient restraint, and regular balloon check-up. If we excluded incidents of self-removal and family-requested removal, the exchange intervals we calculated would likely be even longer. Another limitation is that we could not compare the several available tube materials except for silicone and certain commercial products, as other types were not available. To validate our data, further randomised studies, which control for patient conditions, caregiver management, standard tube care protocols, and different tubes materials, would be warranted. Despite these limitations, our data were derived from a relatively larger number of cases compared with previous PG-tube patency-related studies published to date.

In conclusion, ours was a unique study that investigated specific parameters such as exchange intervals of silicone tubes, different diameter sizes, and challenges of using nasogastric tubes for gastrojejunal feeding via PG. We found that PGP tubes showed the longest median duration and the highest cost, whereas PGB tubes were cheaper but had shorter durations. Additionally, PGB tubes with larger diameters had longer durations than did those with smaller sizes. Furthermore, PGJL tubes had longer median dwelling times than PGJM tubes among subjects who had a high risk of aspiration; therefore, the Levin tube (which is a commonly used nasogastric tube) can be considered for use as a gastrojejunal feeding tube via PG. Our data ought to provide clinicians with information to support cost-benefit analysis when selecting the optimal type of tube in different clinical situations for purposes of long-term enteral tube feeding.

ORCID iD
Byung Hyo Cha http://orcid.org/0000-0002-1770-1722

REFERENCES

1 Grant MD, Herman S. Ethnic and geographic variation in gastrostomy placement among hospitalized older patients. *J Natl Med Assoc* 2004;96:1346–9.
2 Löser C, Aschl G, Hébuterne X, *et al*. ESPEN guidelines on artificial enteral nutrition--percutaneous endoscopic gastrostomy (PEG). *Clin Nutr* 2005;24:848–61.
3 Blomberg J, Lagergren J, Martin L, *et al*. Complications after percutaneous endoscopic gastrostomy in a prospective study. *Scand J Gastroenterol* 2012;47:737–42.
4 Jaafar MH, Mahadeva S, Tan KM, *et al*. Long-term nasogastric versus percutaneous endoscopic gastrostomy tube feeding in older Asians with dysphagia: a pragmatic study. *Nutr Clin Pract* 2019;34:280–9.
5 Pars H, Çavuşoğlu H. A literature review of percutaneous endoscopic gastrostomy: dealing with complications. *Gastroenterol Nurs* 2019;42:351–9.
6 Campoli P, Cardoso D, Turchi M, *et al*. Clinical trial: a randomized study comparing the durability of silicone and latex percutaneous endoscopic gastrostomy tubes. *Dig Endosc* 2011;23:135–9.
7 Blacka J, Donoghue J, Sutherland M, *et al*. Dwell time and functional failure in percutaneous endoscopic gastrostomy tubes: a prospective randomized-controlled comparison between silicon polymer and polyurethane percutaneous endoscopic gastrostomy tubes. *Aliment Pharmacol Ther* 2004;20:875–82.
8 Crosby J, Duerksen DR. A prospective study of tube- and feeding-related complications in patients receiving long-term home enteral nutrition. *JPEN J Parenter Enteral Nutr* 2007;31:274–7.
9 Sartori S, Trevisani L, Nielsen I, *et al*. Longevity of silicone and polyurethane catheters in long-term enteral feeding via percutaneous endoscopic gastrostomy. *Aliment Pharmacol Ther* 2003;17:853–6.
10 Pitton MB, Herber S, Düber C. Fluoroscopy-guided pull-through gastrostomy. *Cardiovasc Intervent Radiol* 2008;31:142–8.
11 Bakdık S, Keskin M, Öncü F, *et al*. Radiology guided antegrade gastrostomy deployment of mushroom (pull type) catheters with classical and modified methods in patients with oropharyngeal, laryngeal carcinoma, and anesthesia risk. *Br J Radiol* 2021;94:20201130.
12 Gauderer MW, Ponsky JL, Izant RJ. Gastrostomy without laparotomy: a percutaneous endoscopic technique. *J Pediatr Surg* 1980;15:872–5.
13 Van Den Hazel SJ, Mulder CJ, Den Hartog G, *et al*. A randomized trial of polyurethane and silicone percutaneous endoscopic gastrostomy catheters. *Aliment Pharmacol Ther* 2000;14:1273–7.
14 Villela EL, Sakai P, Almeida MR, *et al*. Endoscopic gastrostomy replacement tubes: long-term randomized trial with five silicone commercial models. *Clin Nutr* 2014;33:221–5.
15 Alkhawaja S, Martin C, Butler RJ, *et al*. Post-pyloric versus gastric tube feeding for preventing pneumonia and improving nutritional outcomes in critically ill adults. *Cochrane Database Syst Rev* 2015;2015:CD008875.
16 Jiyong J, Tiancha H, Huiqin W, *et al*. Effect of gastric versus post-pyloric feeding on the incidence of pneumonia in critically ill patients: observations from traditional and Bayesian random-effects meta-analysis. *Clin Nutr* 2013;32:8–15.
17 Toh Yoon EW, Yoneda K, Nakamura S, *et al*. Percutaneous endoscopic transgastric jejunostomy (PEG-J): a retrospective analysis on its utility in maintaining enteral nutrition after unsuccessful gastric feeding. *BMJ Open Gastroenterol* 2016;3:e000098.
18 Ridtitid W, Lehman GA, Watkins JL, *et al*. Short- and long-term outcomes from percutaneous endoscopic gastrostomy with jejunal extension. *Surg Endosc* 2017;31:2901–9.
19 Uflacker A, Qiao Y, Easley G, *et al*. Fluoroscopy-guided jejunal extension tube placement through existing gastrostomy tubes: analysis of 391 procedures. *Diagn Interv Radiol* 2015;21:488–93.
20 DeLong CG, Pauli EM. Enteral feeding: percutaneous endoscopic gastrostomies, tubes, and formulas. *Adv Surg* 2020;54:231–49.
21 Haskins IN, Strong AT, Baginsky M, *et al*. Comparison of laparoscopic jejunostomy tube to percutaneous endoscopic gastrostomy tube with jejunal extension: long-term durability and nutritional outcomes. *Surg Endosc* 2018;32:2496–504.
22 Itkin M, DeLegge MH, Fang JC, *et al*. Multidisciplinary practical guidelines for gastrointestinal access for enteral nutrition and decompression from the Society of interventional radiology and American gastroenterological association (AGA) Institute, with endorsement by Canadian interventional radiological association (CIRA) and cardiovascular and interventional radiological Society of Europe (CIRSE). *Gastroenterology* 2011;141:742–65.
23 Westaby D, Young A, O'Toole P, *et al*. The provision of a percutaneously placed enteral tube feeding service. *Gut* 2010;59:1592–605.
24 Sbeit W, Kadah A, Shahin A, *et al*. Scheduled percutaneous endoscopic gastrostomy tube replacement did not reduce PEG-related complications. *Scand J Gastroenterol* 2021;56:1386–90.
25 Cococcia S, Rovedatti L, Lenti MV, *et al*. Safety and durability of PEG-J: a single-centre experience. *Scand J Gastroenterol* 2020;55:1377–80.