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ORIGINAL ARTICLE

Factors predicting major complications, mortality, and recovery in percutaneous endoscopic gastrostomy

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Abstract

Background and Aim: Percutaneous endoscopic gastrostomy (PEG) has been used in patients with dysphagia and inadequate food intake via an oral route. Despite being a procedure with a high success rate, complications and death have been reported. The aim was to identify the factors related to major complications and mortality, as well as PEG removal prognostic factors due to improvement of their general condition.

Methods: Patient characteristics, comorbidities, laboratory data, concomitant medication, sedation, and indication for PEG placement were collected. Major complications, mortality, and PEG removal factors were assessed.

Results: A total of 388 patients were enrolled. There were 15 (3.9%) cases of major complications, with major bleeding being the most frequent in 6 (1.5%) patients. Corticosteroids were the independent variable associated with major complications (odds ratio [OR] 5.85; 95% confidence interval [CI] 1.71–20; P = <0.01). Advanced cancer (hazard ratio [HR] 0.5; 95% CI 0.3–1; P = 0.05), albumin (HR 0.6; 95% CI 0.4–0.9; P = <0.01), and C-reactive protein (CRP) (HR 1.1; CI 1–1.2; P = 0.01) were considered risk factors for mortality. Previous pneumonia (HR 0.4; CI 0.2–0.9; P = 0.02) was a factor for permanent use of a PEG; however, oncological indication (HR 8.2; CI 3.2–21; P = <0.01) was factors for PEG withdrawal.

Conclusions: Chronic corticosteroid users potentially present with major complications. Low albumin levels and elevated CRP were associated with death. Previous aspiration pneumonia was a factor associated with permanent use of PEG; however, patients with oncological indication were the most benefited.

Introduction

Percutaneous endoscopic gastrostomy (PEG) is commonly used as an enteral nutrition technique as developed by Gauderer et al.[1] and Ponsky et al.[2] in 1980. This method has been used to ensure enteral nutrition, maintain mucosal barrier function, intestinal immunity, and a normal intestinal flora. Specifically, this includes a time frame exceeding 1 month in patients with dysphagia and inadequate food intake via an oral route due to oncological, neurological, or other pathologies.

This method is considered a minimally invasive and safe technique, with a success rate of 95–100%[3] demonstrating improved patient survival, nutritional status, and quality of life.[4–7] However, adverse events and death have been reported.[8,9]

According to previous reports, the incidence of mortality for the PEG procedure is only 0–2%. The incidence of 30-day mortality is 2.4–9%,[10–13] and PEG related-complications between 12 and 38%.[14]

This data suggest that it is important to identify the risk factors associated with PEG complications and mortality, so that clinicians can better identify which patients will benefit from PEG placement, thus avoiding unnecessary morbidity and mortality.

The aim of this study is to identify the factors related to major complications and mortality, as well as PEG removal prognostic factors in those patients due to improvement of their general condition.

Methods

Study design and data collection. The study included the medical charts of 400 consecutive patients who underwent PEG placement between January 2012 and December 2019 at Keio university hospital in Tokyo, Japan. This study was approved by the ethics committee of the same institution (Approval No. 20200268).

Patients who underwent PEG placement for enteral nutrition purposes were included.

The following collected data were included: age, gender, body mass index (BMI), comorbidities (diabetes mellitus, cerebrovascular disease, coronary heart disease, chronic kidney disease, advanced cancer, and previous gastric surgery); previous history (pneumonia and ischemic heart disease); laboratory data: white blood cell (WBC)/μL; hemoglobin (Hb): g/dL; alanine aminotransferase (ALT); aspartate aminotransferase (AST); blood urea nitrogen (BUN): mg/dL; serum creatinine (Cr): mg/dL; serum albumin: g/dL; C-reactive protein (CRP): mg/dL; sodium (Na): mmol/L; Concomitant medications (antithrombotic agents and corticosteroids). PEG insertion reasons were divided into two categories, including oncological (head, neck, and esophageal cancer as well as preemptive PEG before chemoradiation therapy or radiotherapy of the head, neck, or esophagus and other oncological diseases), and non-oncological (stroke, dementia, neurodegenerative diseases, malnutrition, and long-time intensive care treatment); method of insertion (modified introducer and pull method) and procedure sedation.

Additionally, we divided patients into groups of major complications (major bleeding, sepsis, colocutaneous fistula, surgery intervention or permanent tube removal, aspiration pneumonia, blocked PEG tube with tube exchange, abdominal wall abscess, and buried bumper syndrome) and minor complications (PEG site infection, peristomal leakage, inadvertent PEG removal, minor bleeding, blocked PEG tube, dislocation of the PEG that could be reinserted without endoscopic assistance, and minor bleeding), and the time period of their occurrence (≤7 days, >7 to ≤30 days, and >30 days).

Data collection continued until patient death, removal of PEG or loss of contact with the patient, and for patients still undergoing follow-up, as well as the final contact with the patient taken as the end point.

Definitions. Patients with some type of cancer and lymph node invasion were categorized with advanced cancer.

Major bleeding was defined as an event related to a decrease in Hb levels from 2 g/dL or more, or an event requiring intervention (hemoclipping, embolization, epinephrine injection, or blood transfusion).

Aspiration pneumonia was defined as the presence of new associated symptoms (cough, fever, and purulent sputum) with indicative computed tomography (CT) image or chest X-ray image changes subsequent to the PEG procedure.

Outcome measure. The primary outcome measures were the occurrence of any type of complication event after PEG insertion. The secondary outcome measures were established as death, and the third endpoint was the removal of PEG due to improvement in the patient's condition.

PEG placement. All patients fasted for 12 h prior to PEG placement. Antithrombotic therapy and sedation were managed according to the guidelines.[15,16] Kangaroo Seldinger PEG kit (Nippon Sherwood medical industries Ltd., Tokyo, Japan) and IDEAL PEG kit (Olympus Co, Tokyo, Japan) were used for the modified introducer method, and One-Step Button kit (Boston Scientific Co, Tokyo, Japan) for the Pull method.

During the procedure, heart rate, electrocardiographic signs, and oxygen saturation were monitored.

Post-PEG placement. On the next day, patients with a soft abdomen and no abdominal discomfort were flushed clear with water via a PEG tube. Patients who tolerated the water flush with no evidence of leakage at the PEG site received tube feeding. All patients were followed up during their hospital stay by nurses specializing in wound healing. Patients or relatives of patients were offered PEG handling training and provided contact information to report adverse events when discharged to their homes.

Statistical analysis. Categorical data are expressed as a number and percentage (%).

Statistical analyses were performed using Student's *t*-test for normally distributed continuous variables, a chi-square test, and a Fisher's exact test for noncontinuous variables. To identify parameters influencing major complications, we examined potential factors using univariate analysis, and after determining relevant risk factors (P values <0.05), these factors were entered into a multivariate analysis using a binary logistic regression model. Odds ratios (ORs) and corresponding 95% confidence interval (CI) were generated for all variables. P values <0.05 were considered significant. To identify the parameters influencing mortality and PEG removal, Cox proportional hazard models were used for multivariate analysis using significant variables. A hazard ratio (HR) and 95% (CI) were determined. Kaplan–Meier curves were drawn and compared using the log-rank test and log-rank (mantel-cox) test. Data were analyzed with IBM SPSS Statistics software, version 26.

Results

Patient background. Figure 1 shows a flowchart of enrolled patients. Of 400 patients selected, 12 were excluded from the study. Eight patients were excluded as they had missing data, three patients did not have a safe location for PEG placement, and one patient was excluded due to an arterial bleeding during stomach puncture.

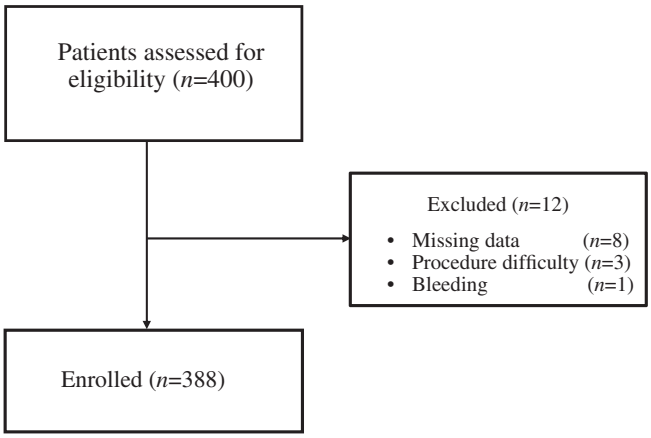

Figure 1 Flow chart of patients assessed.

Table 1 Patient background

Number of patients	388
Gender (male/female), *n* (%)	277(71.4)/111(28.6)
Age ± SD (range), years	72.04 ± 13.7 (4–101)
BMI (kg/m^2) ± SD (range)	19.5 ± 3.8 (8–31)
Laboratory values, ±SD (range)	
WBC/μL	7239 ± 4785.8 (1700–77 900)
Hemoglobin, g/dL	10.8 ± 1.8 (6.5–16.2)
Alanine aminotransferase, IU/L	27.2 ± 32.4 (3–302)
Aspartate aminotransferase, IU/L	29.2 ± 23.6 (8–269)
Blood urea nitrogen, mg/dL	18.2 ± 12.9 (2–102.4)
Serum creatinine, mg/dL	0.86 ± 0.87 (0.2–8.9)
Albumin, g/dL	2.94 ± 0.65 (1.1–4.5)
C-reactive protein, mg/dL	1.97 ± 3.93 (0.01–16.6)
Sodium	137.9 ± 3.93 (125.5–150.2)
Previous history, *n* (%)	
No previous history	181 (46.6)
Pneumonia	144 (37.1)
Pneumonia and ischemic heart disease	37 (9.5)
Ischemic heart disease	26 (6.7)
Comorbidities, *n* (%)	
Advanced cancer	139 (35.8)
Esophageal cancer	112 (28.9)
Hypopharyngeal cancer	8 (2.1)
Laryngeal cancer	7 (1.8)
Oropharyngeal cancer	5 (1.3)
Tongue cancer	5 (1.3)
Others	2 (0.4)
No comorbidities	122 (31.4)
Diabetes mellitus	85 (21.9)
Cerebrovascular disease	82 (21.1)
Coronary heart disease	74 (19.1)
Chronic kidney disease	40 (10.3)
Previous gastric surgery	6 (1.5)
2 comorbidities	70 (18)
3 comorbidities	26 (6.7)
Concomitant medications, *n*(%)	
Antiplatelet drug	
Antiplatelet single therapy	44 (11.4)
Antiplatelet dual therapy	9 (2.3)
No	335 (86.3)
Anticoagulant drug	
Warfarin	28 (7.2)
DOAC	27 (7)
No	330 (85.1)
Antiplatelet and anticoagulant drug	8 (2.1)
Corticosteroid	27(7)
PEG insertion reason, *n* (%)	
Non-oncological	212 (54.6)
Oncological	176 (45.4)

BMI, body mass index; DOAC, direct oral anticoagulant; WBC, white blood cell.

Table 2 Details of PEG procedure and complications

Method of insertion, *n* (%)	
Modified introducer	382 (98.5)
Pull	6 (1.5)
Use of sedation, *n* (%)	
Pethidine and flunitrazepam	267 (69.1)
No sedation	39 (10.1)
Pethidine	38 (9.8)
Flunitrazepam	34 (8.9)
Midazolam	5 (1.4)
Pethidine and midazolam	1 (0.3)
Others	4 (1.1)
Follow-up days, ±SD (range)	246 ± 384 (3–2332)
Complications, *n* (%)	86 (22.2)
Minor complications, *n* (%)	71 (18.3)
PEG site infection	36 (9.3)
Minor bleeding	16 (4.1)
Blocked PEG tube	8 (2.1)
Peristomal leakage	8 (2.1)
Others	3 (0.9)
Major complications, *n* (%)	15 (3.9)
Major bleeding	6 (1.5)
Sepsis	3 (0.8)
Aspiration pneumonia	3 (0.8)
Blocked PEG tube with tube exchange	1 (0.3)
Abdominal wall abscess	1 (0.3)
Buried Bumper Syndrome	1 (0.3)
No complications	301 (77.6)
Period of complications	
Major complications, *n* (%)	Overall (%)
≤7 days	11 (73.3)
>7 days to ≤30 days	3 (20)
>30 days	1 (6.7)
Minor complications, *n* (%)	
≤7 days	28 (39.4)
>7 days to ≤30 days	21 (29.6)
>30 days	22 (31)
Mortality	% of all PEG
Deaths, *n* (%)	125 (32.2)
PEG unrelated deaths, *n* (%)	122 (31.4)
PEG related deaths, *n* (%)	3 (0.7)
Mortality period, *n* (%)	
1 week	2 (0.5)
1 month	13 (3.9)
2 months	11 (6.7)
6 months	35 (15.7)
1 year	31 (23.7)
>1 year	33 (32)

PEG, percutaneous endoscopic gastrostomy.

Patient's background, laboratory values, previous history, comorbidities, concomitant medications, and reasons for PEG insertion are shown in Table 1. A total of 388 were included in the study. These patients included 277 (71.4%) men and 111 (28.6%) women. The mean age was 72 years old and the mean BMI was 19.5 kg/m^2. One hundred and forty-four (37.1%) patients had pneumonia as a previous history. Among the comorbidities, most of the patients presented with advanced cancer, of which 112 (29%) cases of esophageal cancer were the most prevalent cancer at our Hospital. Among patients using medications, only 44 (11.4%) used antiplatelet agents as a single therapy, followed by 28 (7.2%) patients consumed warfarin as an anticoagulant therapy, and 27 (7%) patients used steroids prior to

Table 3 Risk factors for major complications

	Univariate			Multivariate	
	Major complication (+) (n = 15)	Major complication (–) (n = 373)	P value	OR (95% CI)	P value
Age (mean ± SD)	76.6 ± 15.5	71.9 ± 13.6	0.18		
Gender (male:female)	10:5	267:106	0.77		
BMI (mean ± SD)	19.5 ± 4.0	19.5 ± 3.8	0.99		
Previous history, n (%)					
Pneumonia	8 (53.3)	136 (36.5)	0.27		
Ischemic heart disease	0 (0)	26 (7)	0.61		
Pneumonia and ischemic heart disease	2 (13.3)	35 (9.4)	0.64		
Comorbidities, n (%)					
Diabetes mellitus	2 (13.3)	83 (22.3)	0.54		
Chronic kidney disease	1 (6.7)	39 (10.5)	1.0		
Coronary heart disease	2 (13.3)	72 (19.3)	0.75		
Advanced cancer	2 (13.3)	137 (36.7)	0.97		
Cerebrovascular disease	4 (26.7)	78 (20.9)	0.53		
Previous gastric surgery	0 (0)	6 (1.6)	1		
Oncological indication, n (%)	3 (20)	173 (46.4)	0.062		
Laboratory data (mean ± SD)					
WBC (/dL)	6826.6 ± 3562.1	7256.5 ± 4831.5	0.73		
Hemoglobin (g/dL)	10.8 ± 1.9	10.8 ± 1.9	0.98		
Alanine aminotransferase (IU/L)	39.3 ± 43.0	26.8 ± 31.9	0.28		
Aspartate aminotransferase (IU/L)	29.4 ± 17.3	29.2 ± 23.9	0.97		
Blood urea nitrogen	26.7 ± 29.3	17.8 ± 11.8	0.25		
Serum creatinine	1.17 ± 1.7	0.84 ± 0.83	0.46		
Albumin	2.87 ± 0.5	2.95 ± 0.7	0.54		
C-reactive protein	1.37 ± 0.94	2.0 ± 2.7	0.03	0.87 (0.66–1.15)	0.32
Sodium	137.7 ± 3	138 ± 4	0.75		
Medications, n (%)					
Antiplatelet single therapy	0 (0)	44 (11.8)	0.39		
Antiplatelet dual therapy	1 (6.7)	8 (2.1)	0.3		
DOAC	0 (0)	27 (7.2)	0.61		
Antiplatelet and anticoagulants	0 (0)	8 (2.1)	1.0		
Warfarin	2 (13.3)	26 (7)	0.29		
Corticosteroids	4 (26.7)	23 (6.2)	0.01	5.85 (1.71–20.02)	<0.01

BMI, body mass index; DOAC, direct oral anticoagulant; WBC, white blood cell.

the placement of the PEG tube. PEG tubes were placed in 212 (54.6%) patients with non-oncological indication, and in 176 (45.4%) oncological patients.

PEG procedure and complications. A modified introducer, with 382 (98.5%) insertions, was the most common method (Table 2). In 69.1% of the insertions, flunitrazepam with pethidine hydrochloride was often used to achieve sedation and analgesia. Patient follow-up had a mean of 246 days with a ±SD of 384 days. A total of 86 (22.2%) complications occurred. Seventy-one (18.3%) cases included minor complications, of which the PEG site infection was the most frequent in 36 (9.3%) patients. There were 15 (3.9%) cases of major complications, with major bleeding being the most frequent in 6 (1.5%) patients, of which 11 (73.3%) cases occurred within the first week.

In total, there were 125 (32%) deaths, of which 2 (0.5%), 13 (3.9%), 11 (6.7%), 35 (15.7%), 31 (23.7%), and 33 (32%) died at 1 week, 1 month, 2 months, 6 months, 1 year, and >1 year, respectively. There were three (1%) PEG-related deaths, and the cause of deaths was sepsis, and pneumonia in two cases respectively. The first patient was 75 years old in a delicate general state presenting with Parkinson's disease, dementia, anemia, hypoalbuminemia, a previous history of aspiration pneumonia, and cerebral infarction. After the introduction of PEG, the patient suffered an increase in CRP levels and WBCs and died due to septic shock after 3 days of PEG placement. The second patient was 71 years old with advanced esophageal cancer and chronic kidney disease. After placement of the PEG tube without any complications, the patient presented with aspiration pneumonia. As a result, the tube was changed from PEG to percutaneous endoscopic transgastric jejunostomy (PEG-J), which did not improve the patient's general condition, and died 18 days after PEG placement. The third case was a 91-year-old patient who underwent PEG tube nutrition due to a swallowing disorder, hypoalbuminemia, aspiration pneumonia, dementia, and Alzheimer's disease. Days later, the patient presented with symptoms of reflux accompanied by vomiting causing aspiration pneumonia. Despite administration of antibiotic therapy, the patient's general condition deteriorated, and died.

Table 4 Mortality risk factors

	Univariate			Multivariate	
	Deceased (+) (*n* = 125)	Deceased (–) (*n* = 263)	*P* value	HR (95% CI)	*P* value
Age (mean ± SD)	70.8 ± 13.9	72.54 ± 13.6	0.27		
Gender (male:female)	92/33	185/78	0.63		
BMI (mean ± SD)	19.02 ± 3.5	19.8 ± 3.9	0.05	1.0 (0.95–1.06)	0.78
Previous history, *n* (%)					
Pneumonia	55 (44)	89 (33.8)	0.06		
Ischemic heart disease	2 (1.6)	24 (9.1)	<0.01	0.33 (0.08–1.40)	0.33
Pneumonia and ischemic heart disease	13 (10.4)	24 (9.1)	0.7		
Comorbidities, *n* (%)					
Diabetes mellitus	30 (24)	55 (20.9)	0.43		
Chronic kidney disease	15 (12)	25 (9.5)	0.48		
Coronary heart disease	18 (14.4)	56 (21.3)	0.13		
Advanced cancer	58 (46.4)	81 (30.8)	<0.01	0.55 (0.30–1.0)	0.05
Cerebrovascular disease	18 (14.4)	64 (24.3)	0.02	0.87 (0.48–1.57)	0.87
Previous gastric surgery	1 (0.8)	5 (1.9)	0.67		
Oncological indication, *n* (%)	67 (53.6)	109 (41.4)	0.03	1.86 (1.00–3.46)	1.86
Laboratory data (mean ± SD)					
WBC (/dL)	7704.8 ± 6913.7	6999.2 ± 3316	0.17		
Hemoglobin (g/dL)	10.37 ± 1.7	11.14 ± 1.9	<0.01	0.91 (0.80–1.03)	0.91
Alanine aminotransferase (IU/L)	28.46 ± 36.9	26.92 ± 30.3	0.67		
Aspartate aminotransferase (IU/L)	32.42 ± 31.2	27.8 ± 18.9	0.13		
Blood urea nitrogen	19.23 ± 15.1	17.75 ± 11.9	0.30		
Serum creatinine	0.88 ± 0.8	0.85 ± 0.9	0.81		
Albumin	2.82 ± 0.7	3 ± 0.6	0.01	0.59 (0.41–0.85)	<0.01
C-reactive protein	2.56 ± 2.9	1.69 ± 2.5	0.05	1.11 (1.05–1.19)	<0.01
Sodium	137.6 ± 3.8	138.2 ± 4.0	0.14		
Medications, *n* (%)					
Antiplatelet single therapy	9 (7.2)	35 (13.3)	0.09		
Antiplatelet dual therapy	6 (4.8)	3 (1.1)	0.02	2.03 (0.82–5.06)	0.13
DOAC	4 (3.2)	23 (8.7)	0.054		
Antiplatelet and anticoagulants	1 (0.8)	7 (2.7)	0.45		
Warfarin	3 (2.4)	25 (9.5)	0.01	0.81 (0.25–2.62)	0.73
Corticosteroids	13 (10.4)	14 (5.3)	0.09		

BMI, body mass index; DOAC, direct oral anticoagulant; WBC, white blood cell.

Major complications. A univariate analysis was performed with possible variables that triggered major complications (Table 3). CRP (P = 0.03) and corticosteroid users (P = 0.01) were identified as risk factors. The multivariate analysis identified corticosteroids (P = <0.01) as the only independent variable associated with major complications. (OR 5.85; 95% CI 1.71–20; P = <0.01).

Mortality. Variables associated with mortality were analyzed (Table 4). The univariate analysis identified BMI (P = 0.05), ischemic heart disease (P = <0.01), advanced cancer (P = <0.01), cerebrovascular disease (P = 0.02), oncological indication (P = 0.03), Hb (P = 0.01), albumin (P = 0.01), CRP (P = 0.05), antiplatelet dual therapy (P = 0.02), and warfarin users (P = 0.01). Multivariate analysis using Cox proportional hazard models identified advanced cancer (HR 0.5; 95% CI 0.3–1; P = 0.05), albumin (HR 0.6; 95% CI 0.4–0.9; P = <0.01), and CRP (HR 1.1; CI 1–1.2; P = 0.01) as independent risk factors for mortality.

PEG removed. Sixty-nine patients had their PEG removed due to recovery of their clinical condition (Table 5). In the univariate analysis, the significant variables were age (P = 0.02), pneumonia (P = <0.01), pneumonia with ischemic heart disease (P = 0.01), chronic kidney disease (0.02), coronary heart disease (P = 0.02), advanced cancer (P = <0.01), cerebrovascular disease (P = <0.01), oncological indication (P = <0.01), Hb (P = <0.01), AST (P = <0.01), albumin (P = <0.01), sodium (P = <0.01), and warfarin (P = 0.04). Multivariate analysis using Cox proportional hazard models identified previous history of pneumonia (HR 0.4; CI 0.2–0.9; P = 0.02) as a significant factor indicating permanent use of a PEG tube as well as oncological indication (HR 8.2; CI 3.2–21; P = <0.01) as independent factors for PEG withdrawal.

Kaplan–Meier for PEG removal curves were drawn and compared using the log-rank test and log-rank (mantel-cox) test. PEG placement for oncological indication had a better prognosis of removal than those who had a non-oncological indication (Fig. 2a). Those patients with no previous history of pneumonia had better outcomes for PEG removal as compared to those with a previous history of pneumonia (Fig. 2b). Interestingly, in

Table 5 PEG removal factors

	Univariate			Multivariate	
	PEG removed (+) (n = 69)	PEG removed (–) (n = 319)	P value	HR (95% CI)	P value
Age (mean ± SD)	68.2 ± 10.9	72.9 ± 14.1	0.02	1.0 (0.98–1.02)	1.0
Gender (male:female)	51/18	226/93	0.66		
BMI (mean ± SD)	19.69 ± 3.5	19.53 ± 3.9	0.75		
Previous history, n (%)					
Pneumonia	12 (17.4)	132 (41.4)	<0.01	0.44 (0.21–0.90)	0.02
Ischemic heart disease	6 (8.7)	20 (6.3)	0.43		
Pneumonia and ischemic heart disease	1 (1.4)	36 (11.3)	0.01	0.35 (0.04–3.0)	0.3
Comorbidities, n (%)					
Diabetes mellitus	11 (15.9)	74 (23.2)	0.20		
Chronic kidney disease	2 (2.9)	38 (11.9)	0.02	0.46 (0.11–2.0)	0.3
Coronary heart disease	6 (8.7)	68 (21.3)	0.02	1.02 (0.39–2.66)	0.9
Advanced cancer	45 (65.2)	94 (29.5)	<0.01	0.74 (0.39–1.37)	0.3
Cerebrovascular disease	6 (8.7)	76 (23.8)	<0.01	1.32 (0.53–3.30)	0.5
Previous gastric surgery	0 (0)	6 (1.9)	0.59		
More than 2 comorbidities	12 (17.4)	90 (28.2)	0.07		
Oncological indication, n (%)	59 (85.5)	117 (36.7)	<0.01	8.19 (3.19–20.97)	<0.01
Laboratory data (mean ± SD)					
WBC (/dL)	7608.7 ± 4194.9	7160.2 ± 4906.6	0.48		
Hemoglobin (g/dL)	11.7 ± 1.8	10.7 ± 1.8	<0.01	1.12 (0.94–1.34)	0.2
Alanine aminotransferase (IU/L)	22.22 ± 24.9	28.37 ± 33.8	0.15		
Aspartate aminotransferase (IU/L)	23.64 ± 14.2	30.42 ± 25.1	<0.01	1.0 (0.98–1.01)	0.7
Blood urea nitrogen	16.06 ± 9.5	18.66 ± 13.6	0.06		
Serum creatinine	0.89 ± 1.0	0.85 ± 0.8	0.71		
Albumin	3.34 ± 0.6	2.86 ± 0.6	<0.01	0.78 (0.46–1.32)	0.3
C-reactive protein	1.74 ± 2.7	2.03 ± 2.7	0.42		
Sodium	138.9 ± 3.1	137.8 ± 4.1	<0.01	1.01 (0.94–1.09)	0.7
Medications, n (%)					
Antiplatelet single therapy	3 (4.3)	41 (12.9)	0.06		
Antiplatelet dual therapy	1 (1.4)	8 (2.5)	1.0		
DOAC	4 (5.8)	23 (7.2)	0.80		
Antiplatelet and anticoagulants	0 (0)	8 (2.5)	0.36		
Warfarin	1 (1.4)	27 (8.5)	0.04	0.60 (0.08–4.67)	0.6
Corticosteroids	3 (4.3)	24 (7.5)	0.44		

BMI, body mass index; DOAC, direct oral anticoagulant; WBC, white blood cell.

non-oncological patients with a previous history of pneumonia (Fig. 2c), after 1000 days with PEG tube, there is an increase in probability of PEG removal.

Discussion

PEG insertion is the established method as a treatment to maintain mucosal barrier function, intestinal immunity, and normal intestinal flora for more than 1 month, leading to significant improvement in patient's nutritional status. Identification of risk factors for death and complications as well as good prognostic factors may lead to better management of unnecessary morbidity and mortality.

Several studies have been carried out that identified high levels of CRP, low levels of serum albumin, hypernatremia, advanced age, malnutrition, presence of comorbidities, advanced stages of cancer as risk factors associated with complications, and mortality.[10,11,13,17–30] This study reports a complication rate of 22.2%. According to previous reports, the complication rate ranges between 13.2 and 50.1%.[10,13,28,30,31] The large variance between these results may be attributed to the following: the short follow-up time of the patient in most of these studies, the difference in the number of patients in each study, or how major and minor complications were defined. By comparison, the rate of major complications was 3.9%, in which 11 (73.3%) of the major complications occurred during the first week, with major bleeding being the most frequent complication followed by sepsis and aspiration pneumonia, respectively.

Corticosteroid drugs are still commonly used and effective therapies for numerous inflammatory disorders. Interestingly, one of our most significant findings was the use of corticosteroids drugs as a significant risk factor for the development of major complications (OR 5.85; 95% CI 1.71–20; P = <0.01). In this study, four patients who presented major complications were chronic users of steroid drugs at doses of 5, 10, and 15 mg of prednisolone based on a long history of inflammatory disease (Rheumatoid arthritis, Sjogren's syndrome, and Wegener's granulomatosis). The major complications presented by these four patients varied, including pneumonia, sepsis as well as bleeding, and blockage of the PEG tube.

A review by Wang et al.[32] concluded that the use of steroids on a chronic basis increases the risk of wound complications by

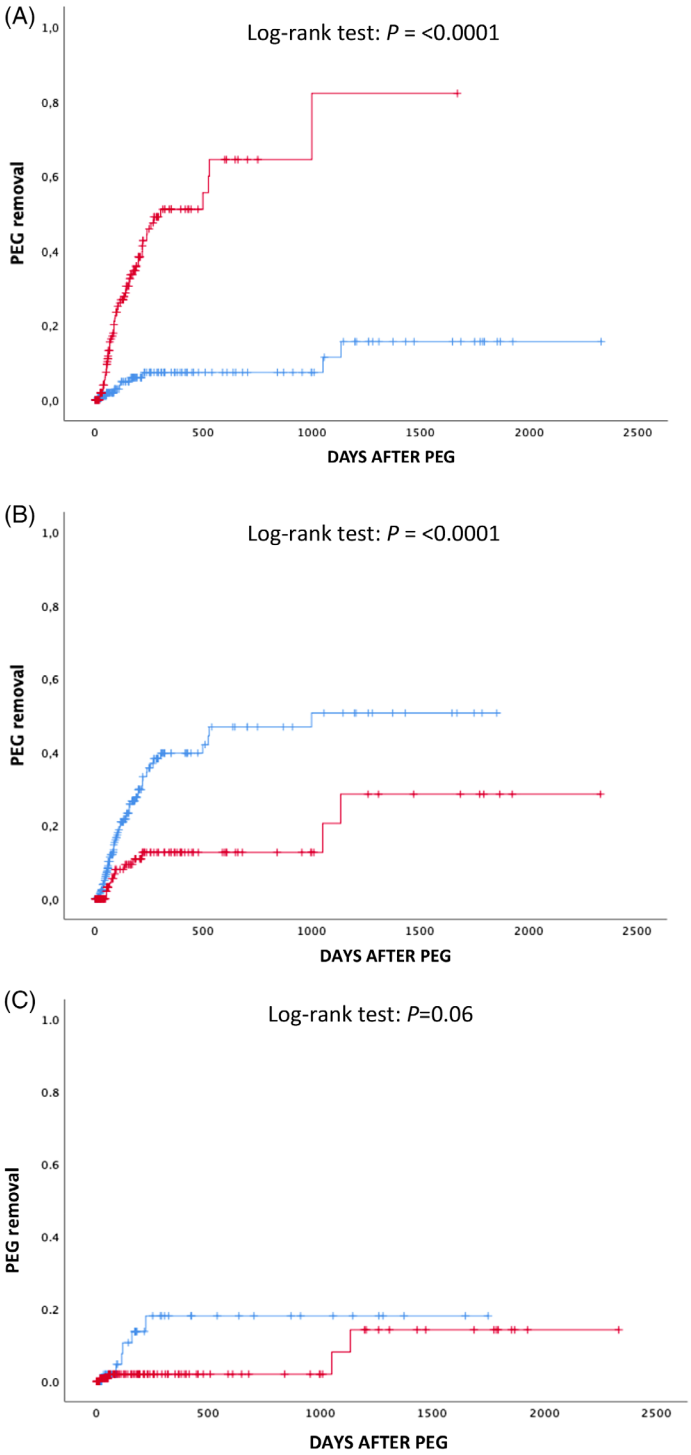

Figure 2 Kaplan-Meier percutaneous endoscopic gastrostomy removal curves comparison. (a) Oncological indication: ——, yes; ——, no; (b) Previous history of pneumonia: ——, yes; ——, no; (c) Previous history of Pneumonia in non-oncological patients: ——, yes; ——, no.

twofold to fivefold; however, many of the studies analyzed in his review were carried out retrospectively and not controlled, so for this reason it is difficult to determine whether complications were confounded by other factors. In another report using open surgical gastrostomy tube placement, the rate of infection in patients receiving steroids was considerably higher than those not receiving steroids (17 vs.0.9%).[33] As there was significant variance in the types of complications in this study, we cannot define if the cause of

complications were due to the use of corticosteroids or confounded by other factors. Robust studies are needed to help clarify this point.

In this study, 125 (32%) deaths were observed, with a mortality of 0.5, 3.9, 6.7, 15.7%, 23.7, and 32% of patients in 1 week, 1 month, 2 months, 6 months, 1 year, and >1 year, respectively. These data revealed that more than half of the patients survived more than 1 year. Significant factors for long-term mortality included advanced cancer, low albumin levels, and high CRP values. According to several reports, sicker patients with poor nutritional state and an advanced stage of cancer were most likely to die.[18,34,35] Interestingly, in our study, one of the factors for non-mortality included advanced stages of cancer. This may be due to the fact that most of these patients at our hospital had the PEG tube placed prophylactically before undergoing radiotherapy, chemotherapy, or surgery. In this way, patients maintained a better nutritional state while avoiding interruptions during treatment, leading to better results and a reduction in the risk of mortality.

On the other hand, low albumin levels and a high CRP have been reported as independent short-term mortality factors,[17,24,31,36,37] confirming in the present study that the same factors can also predict long-term mortality.

Chronic inflammatory states negatively affect the inflammatory system and metabolism, causing loss of appetite potentially associated with malnutrition, and a combination of low levels of albumin and high levels of CRP, markers of sicker and more vulnerable patient.[38,39] As the placement of PEG is not an emergency procedure, we suggest waiting with less invasive nutritional support such as parenteral nutrition or a nasogastric catheter until the underlying acute condition has been investigated.

A majority of studies analyze only the risk factors for mortality or complications for patients who undergo PEG tube placement, but very few studies have analyzed the factors that can predict the removal of the PEG due to the improvement in the general status of the patient. Of 69 (17.7%) patients with PEG removal in our study, a previous history of pneumonia was one of the statistically significant factors for the permanent use of PEG. In Figure 2b, our study shows that patients with a previous history of pneumonia in oncological and non-oncological patients are much more likely to permanently use the PEG tube. On the other hand, Figure 2c shows the same trend in non-oncological patients as Figure 2b, but it does not present a statistically significant result (P = 0.06). This difference may be because non-oncological patients with a previous history of pneumonia frequently have dysfunctional motor neuronal and motor diseases, such as cerebral palsy and bulbar paralysis with feeding and swallowing problems. Such dysfunction leads to aspiration and chronic lung infections necessitating the permanent use of the PEG tube to feed themselves. However, patients with oncological indication are more benefited from PEG. The most common type of cancer in this study was esophageal cancer, which plays an important role in the swallowing process since they interfere with good ingestion of food. The therapeutic strategies used are based on a combination of chemotherapy, radiotherapy, and surgery, frequently leading to adverse effects such as mucositis, xerostomia, dermatitis, and dysphagia leading to decreased oral ingestion and resulting in patient malnutrition. Langius et al. reported that weight loss before and during radiotherapy is an important prognostic factor for 5 years of survival in these types of patients.[40] For this reason, PEG nutrition is a good method to reduce treatment interruptions and rehospitalizations. Yanni et al., demonstrated that prophylactic PEG, applied in the majority of cases at our hospital, showed better nutritional outcomes and a higher quality of life as compared to non-prophylactic PEG.[41] This resulted in improved nutritional status with a probability of a better patient outcome during cancer treatment and subsequent removal of the PEG tube.

Limitations

The present study has some limitations. First, this is a retrospective study, and some of the data were missing from medical records.

Second, the study was conducted at a tertiary referral hospital where greater disease severity was observed as compared to general hospitals.

However, this study benefitted from a significant number of variables extracted in relation to the patient and procedure. Our study not only analyzes risk factors, but also analyzes good prognostic factors for PEG removal rarely seen in the literature.

Conclusions

Our study identified chronic corticosteroid users potentially presenting with major complications.

Prophylactic PEG tube placement in patients with advanced cancer was associated with improved survival, however, decreased albumin, and an elevated CRP were factors associated with death. We recommend placing greater emphasis on the criteria of patient selection in order to perform pre-procedure management of modifiable risk factors to avoid unnecessary interventions.

Previous history of aspiration pneumonia was a factor associated with permanent use of PEG; however, we recommend a prophylactic PEG tube feeding in patients with oncological indication since these patients were the most benefited in achieving recovery.

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