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Percutaneous endoscopic versus radiologic gastrostomy for enteral feeding: a retrospective analysis on outcomes and complications

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ABSTRACT

Background and study aims Percutaneous endoscopic gastrostomy (PEG) and percutaneous radiologic gastrostomy (PRG) are techniques used for long-term enteral feeding. Our primary aim was to analyze procedure-related and 30-day mortality and complications between PEG and PRG in relation to indications.

Patients and methods A single-center retrospective analysis was performed thath included all adult patients receiving initial PEG (January 2008 until April 2016) and PRG (January 2010 until April 2016). Outcomes were mortality (procedure-related, 30-day), complications (early (≤30 days) and late) and success rates.

Results A total of 760 procedures (469 PRG and 291 PEG) were analyzed. Most common indications were head and neck cancer (HNC), cerebrovascular accident (CVA) and amyotrophic lateral sclerosis (ALS). Success rates for placement were 91.2% for PEG and 97.1% for PRG ($P=0.001$). Procedure-related mortality was 1.7% in PEG and 0.4% in PRG ($P=0.113$). The 30-day mortality was 10.7% in PEG and 5.1% in PRG ($P=0.481$ after multivariate logistic regression) CVA was associated with higher 30-day mortality, whereas ALS, higher body weight, and prophylactic placements in HNC were associated with lower rates.

Tube-related complications were less frequent in PEG, both early (2.7% vs. 26.4%, $P\leq0.001$) and late (8.6% vs. 31.5%, $P\leq0.001$). The percentage of major complications and infections did not differ.

Conclusions With respect to procedure-related and 30-day mortality, PEG and PRG compare equally. PRG had a higher procedural success rate. Tube-related complications and pain are less frequent after PEG compared to PRG. The choice for either PEG or PRG therefore should primarily be based on local facilities and expertise.

Introduction

Gastrostomy is the method of choice for enteral feeding that is expected to last longer than 4 weeks (medium- and long-term enteral feeding) [1, 2]. Available gastrostomy techniques include percutaneous endoscopic gastrostomy (PEG) and percutaneous radiologic gastrostomy (PRG). PEG was developed in 1980 by Gauderer et al. Shortly afterwards, Preshaw et al. developed a radiologic alternative [3]; PRG, also called fluoroscopy-guided gastrostomy (FPG) or radiologically inserted gastros-

tomy (RIG). Both techniques are preferred over surgical gastrostomy due to lower morbidity rates [1, 4, 5].

Main indications for gastrostomy placement include dysphagia or swallowing dysfunction, caused by neurological disorders (cerebral vascular accidents [CVA], amyotrophic lateral sclerosis [ALS]), malignancies (esophageal, head and neck cancer [HNC]), malnutrition and motility disturbances of the upper gastrointestinal tract [1, 2]. Patients receiving a PRG or PEG are characterized by poor condition due to malnutrition and underlying disease. Therefore, complications of PEG or PRG placement are likely to have a major impact on prognosis and outcome.

Consensus on which technique/route should be preferred as access for enteral feeding, with respect to safety, success rates, complications, and availability, has not yet been reached.

Previous reports on this topic are of limited value due to small sample sizes and high risk of confounding and selection bias [6 – 13]. These studies suggest that both techniques are comparable in terms of morbidity and mortality [6, 14, 15]. Dislocation, obstruction, and other tube-related complications appear to occur more often in PRG. Peristomal infections more frequently occur in PEG. For this reason, antibiotic prophylaxis is now recommended to lower this risk, resulting in a risk reduction from 24.2 % to 8.4 % [16]. Because the tube is not pulled through the oropharynx cavity in PRG, transfer of oropharyngeal microbiota more distally is avoided. Risk of infection is therefore assumed to be lower (around 0.3 % to 7 % without antibiotics [17]) and routine administration of antibiotics in PRG procedures is not recommended.

An advantage of PRG is that the procedure is generally performed without sedation (in contrast to PEG) and that PRG can also be placed in cases of esophageal stenosis or (malignant) esophageal/oropharyngeal obstruction [18]. Tumor seeding to the stoma site is a feared complication of PEG, with 49 reported cases currently in the literature, whereas one case of tumor seeding has been described after PRG [19 – 21].

In our center, both PEG and PRG are available and used on a regular basis. Choice of one of the two techniques is empirical and primarily based on the referring physician's past experience and preferences. In general, patients with ALS and HNC are referred exclusively for PRG due to fear of sedation-related complications and tumor seeding, respectively (for more detail, see **Supplementary File 1**).

Our primary aim was to retrospectively analyze data from our center with respect to procedure-related and 30-day mortality and complications of PEG and PRG procedures in relation to indications and to compare PEG and PRG results. These data may help to better predict which technique may serve as best option for an individual patient.

Patients and methods

Data from all adult patients receiving initial PRG (January 2010 until April 2016) and PEG or PEG-J (January 2008 until April 2016) placement at the Maastricht University Medical Center, a tertiary referral center, were retrospectively analyzed. Patients with PEG placements with additional duodenal/jejunal extension were included in the PEG group. Data from PRGs prior to 2010 were not available. PEGs from 2008 and 2009 were included to create a sample size comparable to PRG. In case of incomplete follow-up data, patients were excluded from the analysis.

Procedure

Prior to gastrostomy placement, oral anticoagulants were temporarily stopped (preferable international normalized ratio [INR] < 1.5 in case of vitamin K antagonists) for 2 to 5 days, as well as thienopyridines (for 5 to 7 days). Use of acetylsalicylic acid was allowed.

PEG

Conscious sedation using midazolam (low-dose, mean 2.5 mg) and a fast-acting opioid was administered. Oral amoxicillin/clavulanic acid 1200 mg was given 30 minutes before the procedure (in case of allergy, a substitute was given). PEG (Freka PEG, 15Fr, Fresenius Kabi AG, Bad Homburg, Germany) placement was performed according to the standard Pull-method as first performed by Gauderer et al [22]. In several cases (n = 26), a jejunal extension tube was placed through the PEG tube, and pulled distally from the papilla of Vater with a grasping forceps. Afterwards, patients were observed for at least 1 hour at the day care unit. Immediately after placement, water was administered through the tube. Feeding was started the next day.

PRG

PRG placement was performed according to standard placement described by Preshaw [3] using a Wills-Oglesby Percutaneous Gastrostomy Set (12Fr, Cook, Bloomington, Indiana, United States).

Neither standard prophylactic antibiotics nor sedatives were given. Only local anesthetics were administered at the puncture site. Before the procedure, using ultrasound, the location of the stomach as well as any possible interposing organs (left liver lobe, (transverse) colon, small bowel) was checked. After intravenous injection of 20 mg of buscopan, the stomach was inflated using a nasogastric tube placed inside the stomach before the procedure. After local anesthesia with 20 mL to 30 mL of 1 % lidocaine, the stomach was punctured under fluoroscopic (and sometimes ultrasound) guidance to place the anchors. In total three anchors were placed in a triangular orientation. Intragastric position of the needle was confirmed using a small amount of contrast material. After fixation of the three anchors, the stomach was punctured centrally between the anchors, and a guidewire inserted. After dilatation of the tract, the gastric tube was placed over the wire. The day after placement, saline fluids were administered through the tube for 3 to 6 hours. Feeding was started thereafter and the patient was discharged. Ten to 14 days after the procedure, patients returned to the radiology department to remove the anchors.

Data collection

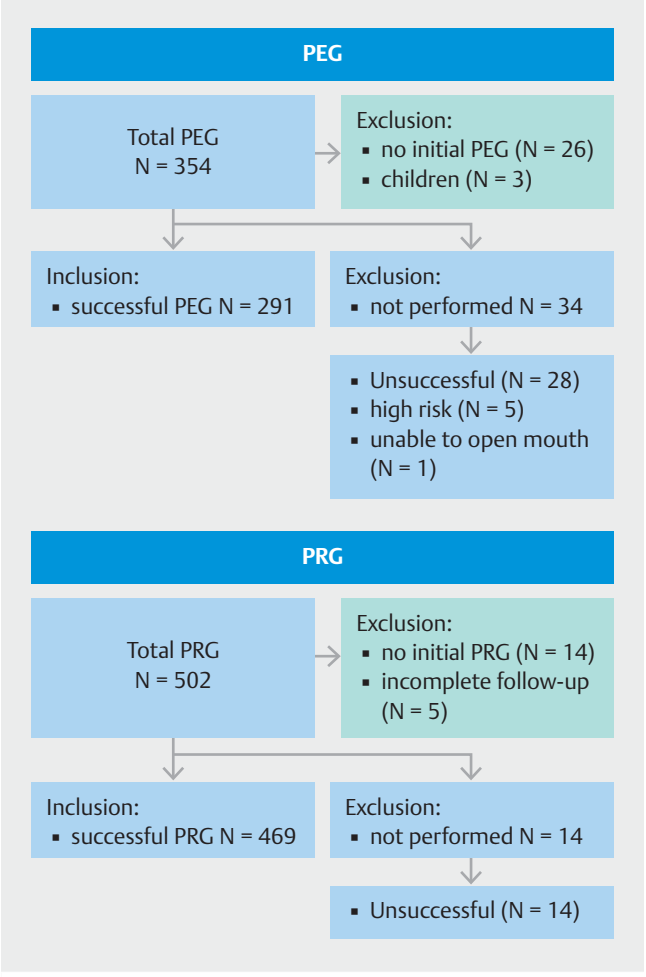
Baseline data collected from medical records were gender, age, body mass index (BMI) before tube placement, weight loss before gastrostomy placement, indication for tube placement,

significant comorbidities (chronic cardiac, pulmonary, kidney, gastrointestinal and liver diseases, malignancies and diabetes mellitus [DM]).

Retrospectively, all patient files, including endoscopic and radiologic reports, were reviewed to ascertain whether any complications had occurred during follow-up (maximum 6 years), including death. Inclusion and exclusion criteria for PEG and PRG are shown in ▶ **Fig. 1**.

Outcome measures

The primary outcome measure was mortality (30-day and procedure-related [defined as mortality occurring due to a complication of the procedure]). Secondary outcomes were occurrence of complications, early (< 30 days) and late, scored as minor or major [1, 2], and procedure success rates. Complications were analyzed according to the international CIRSE, AGA and ESPEN classification 1,2,23], and divided into early and late complications (≤ 30 days, and > 30 days), as well as severity: minor (requiring conservative treatment) or major. Infection was classified as erythema, pain, and/or purulent discharge, requiring antibiotic treatment (as diagnosed by expert clinical opinion). Dislocation, obstruction, leakage and tube/balloon defects were reported combined, as "tube-related complications". PRG tubes were preventively replaced after 3 to 6 months, through the existing fistula channel. These scheduled replacements were not scored as complications. PEG tubes or PEG tubes with a jejunal extension (PEG-j) tubes were not routinely replaced.



▶ **Fig. 1** Flowchart of all PEG and PRG patients showing criteria for inclusion and exclusion.
*Not first PEG/PRG: Multiple gastrostomy procedures
Unsuccessful procedure: due to absence of transillumination, intrathoracic position of stomach, colon interposition
High risk: presence of ascites or estimated high risk for tumor seeding

Statistical analysis

Data analysis was performed using SPSS for Windows, version 23 (IBM Corporation). Statistical methods are described in **Supplementary File 1**.

Ethical considerations

This study was approved by the Medical Research Ethics Committee of the Maastricht University Medical Center. The study was conducted according to the Dutch Codes of Conduct.

Results

In total, 856 patient files (502 PRG, 354 PEG) matching our search criteria were found.

The patient inclusion flowchart is presented in ▶ **Fig. 1**. The difference in procedural success rates—91.2 % for PEG (291/319) and 97.1 % for PRG (n = 469/483)—was statistically significant ($P = 0.001$). Various reasons account for failure of placement. In PEG, these included the inability to obtain transillumination (41 % of failed cases, n = 14), stenosis (26 %, n = 9), an intrathoracic position of the stomach (15 %, n = 5). In addition, PEG placement was not performed due to presence of high-risk factors such as ascites (15 %, n = 5) or inability of a patient to adequately open his mouth (3 %, n = 1).

Inability to puncture the stomach was the most frequent factor for failure of PRG placement (n = 8, 57 % of failed cases). This was either related to previous surgery (Billroth II stomach, n = 3, 21 %), or was due to a too painful procedure (21 %, n = 3). In case of PEG failure, PRG placement was successfully performed in eight cases. PEG after PRG failure was successfully performed in three patients.

Certain conditions such as ascites or previous partial gastrectomy are in fact contraindications for PEG or PRG placement. When these cases were excluded, the success rate for PEG placement was 92.9 %, which is still significantly lower than in case of PRG (97.7 %, $P = 0.001$).

A total of 760 successful procedures (469 PRG and 291 PEG) were included in the analysis (62.9 % male, mean age 62.8yrs [SD 12.64]). Baseline characteristics are shown in ▶ **Table 1** (an extended list of comorbidities can be found in **Supplementary Table 1**).

30-day mortality

The 30-day mortality was significantly different between the procedures, with a mortality rate of 10.7 % in the PEG group vs. 5.1 % in the PRG group ($P = 0.005$, OR 2.214 [1.263–

▶ **Table 1** Baseline characteristics of patients who underwent PEG or PRG at Maastricht UMC between 2008 and 2016.

Parameters	PEG N (%*) (total n = 291)	PRG N (%*) (total n = 469)	*P* value
Male	173 (59,5 %)	305 (65 %)	0.208
Age (yrs)			
▪ Range	20 – 90	22 – 72	0.306
▪ Mean [SD]	63,38 [10,97]	62,41 [14,94]	
Weight loss before (kg)			
▪ Range	0 – 42 kg	0 – 34 kg	0.023
▪ Mean [SD]	4,17 [6,281]	4,99 [6,364]	
BMI before (kg/m2)			
▪ Mean [SD]	23,61 [13,09]	22,19 [4,60]	0.120
Diagnosis			
Amyotrophic lateral sclerosis	8 (2.7)	46 (9.8)	< 0.001
Cerebrovascular accident	40 (13.7)	10 (2.1)	< 0.001
Cystic fibrosis	4 (1.4)	2 (0.4)	0.210
Gastrointestinal motility disorder	19 (6.5)	0 (0)	< 0.001
Head/neck malignancy (total, including prophylactic)	113 (38.8)	328 (69.9)	< 0.001
Head/neck malignancy (prophylactic placements only)	66 (22.6)	294(62.6)	< 0.001
Long-term enteral feeding, disorder not specified	21 (6.7)	9 (1.9)	0.001
Malignancy not in head/neck region	21 (7.2)	18 (3.8)	0.398
Muscular disease	11 (3.8)	15 (3.2)	0.668
Neurological disease, (including multiple sclerosis, Parkinson's disease)	41 (14)	13 (2.7)	< 0.001
Postsurgical/traumatic swallowing dysfunction	13 (4.5)	4 (0.9)	0.001
Comorbidities			
≥ 2 primary malignancies	10 (3.4)	41 (8.7)	0.004

PEG, Percutaneous Endoscopic Gastrostomy; PRG, Percutaneous Radiologic Gastrostomy; SD, standard deviation; BMI, body mss index
* (N = number, % = percentage)

3.879]). After correction for age, gender, weight, diagnosis, and comorbidities in a multivariate logistic regression model, the difference between PEG and PRG was no longer significant (*P* = 0.481, OR 0.771 [0.374 – 1.590]). Presence of CVA (OR 5.190 [2.139 – 12.597]) was associated with higher 30-day mortality. ALS (OR 0.231 [0.104 – 0.518]), a higher weight before placement (OR 1.002 [1.001 – 1.003]) and prophylactic placements in HNC were associated with lower 30-day mortality (OR 0.307 [0.212 – 0.444]).

Procedure-related mortality

Procedure-related mortality was 1.7 % (n = 5) for PEG and 0.4 % (n = 2) for PRG (*P* = 0.113). Four PEG patients died due to aspiration pneumonia and one patient died from a massive gastric bleeding. Indications for PEG in these patients were HNC (n = 3), and CVA (n = 2). Two patients with aspiration pneumonia had experienced recurrent aspiration before PEG placement (one probably due to a tracheoesophageal fistula) and two were in poor condition after a major CVA.

Both deceased patients in the PRG group died from aspiration pneumonia and had severe comorbidities (liver cirrhosis resp. vascular dementia). One of them had been treated for aspiration pneumonia prior to gastrostomy.

Complications

Tube patency and tube-related complications

Overall complication rates are shown in ▶ **Table 2**. Tube-related complications (including dislocation, obstruction, and leak and tube defects) were less frequent with PEG than with PRG, both within 30 days (2.7 % vs. 26.4 % of patients, *P* ≤ 0.001 and after 30 days (8.6 % vs. 31.5 %, *P* ≤ 0.001). Adjusted ORs after multivariate correction for baseline differences for PEG vs. PRG can be found in **Supplementary Table 2**. The overall adjusted ORs were 0.061 (0.026 – 0.139) for early tube-related complications, and 0.252 (0.155 – 0.411) for late tube-related complications. No multicollinearity or interactions were found.

In some patients, tube-related complications occurred more than once. The total number of tube-related complications are shown in **Supplementary Table 3**. In the PRG group, more than one tube-related complication occurred in 46 patients (9.8 %), in the PEG group in 17 patients (5.8 %, all PEG-j patients).

Other complications

Early major complications (including peritonitis, abscess, buried bumper, pneumonia) occurred in 3.4 % of patients with PEG vs. 1.8 % in PRG (*P* = 0.193). Late major complication rates were 5.4 % with PEG vs. 7.1 % (*P* = 0.121) for PRG.

We observed one case of tumor seeding (HNC) occurring after a PRG procedure. A significantly higher rate of post-procedural pain was found in PRG (9.2 % vs. 3.8 % in PEG). This was adequately treated with oral analgesics after the procedure.

Late skin deterioration (e. g. redness, mild granuloma formation) occurred more frequently in PEG patients (3.8 % vs. 0 % in PRG, *P* = 0.005). Removal of the PEG was required in three patients due to skin deterioration.

▶ **Table 2** Complications (total no. of pts).

Early Complications (≤30 days)				
	PEG n = 291 (%)	**PRG n = 469 (%)**	***P* value**	**Significant OR [95 %CI]**
Peristomal irritation (erythema)	4 (1.3)[1]	34 (7.2)[1]	**<0.001**	0.133 [0.041 – 0.438]
Peristomal infection	5 (1.7)[1]	7 (1.5)[1]	0.808	
Pain				
▪ Requiring conservative treatment	11 (3.8)	43 (9.2)	**0.005**	0.389 [0.197 – 0.768]
▪ Requiring removal	1 (0.3)	1 (0.2)	1	
Tube-related complications	8 (2.7)	124 (26.4)	**<0.001**	0.079 [0.038 – 0.164]
▪ Replacement through existing channel	7 (2.4)	115(24.5)	**<0.001**	0.083 [0.038 – 0.180]
▪ Requiring new tube procedure	1 (0.3)	9 (1.9)	0.064	
Bleeding	6 (2.0)	6 (1.3)	0.400	
Peritonitis	0 (0)	2 (0.4)	0.527	
Abscess	0 (0)	2 (0.4)	0.527	
Aspiration pneumonia	6 (2.1)	4 (0.9)	0.155	
Late complications (> 30 days)				
Skin deterioration /granuloma				
▪ Requiring conservative treatment	11 (3.8)	0[1]	**0.005**	18.905 [2.486 – 143.737]
▪ Requiring removal	3 (1)	0[1]	0.056	
Pain				
▪ Requiring conservative treatment	1 (0.3)	5 (1.1)	0.415	
▪ Requiring removal	2 (0.7)	1 (0.2)	0.562	
Tube-related complications[2] (no. pts)	23 (7.9)	139 (29.6)	**<0.001**	0.236 [0.151 – 0.368]
▪ Replacement through existing channel	19 (6.5)	122 (26)	**<0.001**	0.199 [0.119 – 0.330]
▪ Requiring new tube procedure	6 (2.0)	26 (5.5)	**0.026**	0.359 [0.146 – 0.882]
Abscess	1 (0.3)	2 (0.4)	1	
▪ Infection	4 (1.4)	5 (1.1)	0.702	
Bleeding (requiring laparotomy)	0 (0.0)	1 (0.2)	1	
Perforation (requiring laparotomy)	0 (0)	1 (0.2)	1	
Tumor seeding	0 (0)	1 (0.2)	1	
Buried bumper	4 (1.4)	2 (0.4)	0.21	

[1] Probably underreporting
[2] Including dislocation, leak, blockage

Discussion

Our study, involving 760 patients receiving either PEG or PRG for nutritional support, showed a higher procedural success rate for PRG compared to PEG. The overall 30-day mortality rate was significantly higher in the PEG group when compared to the PRG group. However, when corrected for age, gender, weight, diagnosis, and comorbidities, this difference was no longer significant. No differences in procedure-related mortality and complications were noted between both methods used.

30-day mortality

In literature, the reported 30-day mortality rates in PEG and PRG are comparable [6, 14, 15]. In our current analysis, multivariate logistic regression revealed no significant difference between PEG- and PRG-related 30-day mortality. It appears that a patient's underlying diseases and condition and not the procedure are predictive factors. Of particular note is that a significantly higher number of patients with CVA received PEG whereas a PRG was placed in a relatively high number of patients with HNC and ALS, which also might explain the differ-

ence seen in the uncorrected analysis. Patients with prophylactic placement for HNC, ALS, and a higher BMI before placement had a lower risk of 30-day mortality. Patients with prophylactic placement had often been treated with curative intentions for their malignancies. Prognosis across the different patient groups undergoing gastrostomy also impacts 30-day mortality rates following gastrostomy placement. In ALS, rates of 3% to 15% are reported for both procedures [24–27], whereas median survival for motor neuron disease in general is 32 months following diagnosis [18]. In HNC, rates of 0% to 1% in PEG and 0% to 4% in PRG are reported [18, 29, 30], with a 5-year survival for all forms and stages of HNC being 50% [31]. In CVA, which was predictive for higher 30-day mortality in our study, rates of 11% to 14% 30-day mortality have been reported [32]. Abuksis et al. reported a 30-day mortality of 72% after PEG placement in hospitalized patients in general [33]. Whereas higher BMI was protective for 30-day mortality, age and comorbidities (such as DM, cirrhosis, cancer, chronic obstructive pulmonary disease) were not risk factors for 30-day mortality in our analysis. Previous literature, however, reported all these factors as predictive factors for 30-day mortality [34–38].

Procedure-related mortality

Procedure-related mortality was not significantly different between PRG and PEG. Our findings are in contrast to some previous studies, in which a higher procedure-related mortality after PRG vs. PEG has been reported with rates of 1% in PEG vs. 2% to 7% for PRG [18, 30, 39]. On the other hand, our data are in line with several others reports with mortality rates of 0% to 2% for both PEG and PRG [6, 24, 40, 41].

The question remains whether aspiration pneumonia within 7 days after gastrostomy placement is attributable to the procedure itself or also results from other precipitating factors associated with a higher risk of aspiration in general. In other words, aspiration pneumonia was already present at the time of gastrostomy. Many patients experienced recurrent aspirations prior to placement of a gastrostomy tube. In our group, this was the case with 33 patients (4.3%) in total. In patients with procedure-related mortality with aspiration, incidence of recurrence was 50%.

Risk of periprocedural aspiration is considered to be higher after use of sedatives. As a consequence, risk of aspiration is supposed to be lower for PRG as no sedatives are used [42, 43]. However, our analysis did not show significant differences. Higher pneumonia rates have also been reported after PRG [41]. Special concern exists for patients with ALS, in whom respiratory function often is impaired. Moreover, masseter muscle spasms might occur as well, in which the small insufflation tube in PRG can mostly be introduced, contrary to the endoscope in PEG [24]. In our hospital, PRG is first choice of treatment for patients with ALS for the above-stated reasons. A recent study by our group analyzing an ALS subgroup showed that conscious sedation in ALS is safe, even in patients with moderate pulmonary dysfunction [44].

Tube-related complications

Early tube-related complications (dislocation, leak, blockage) were more likely to occur with PRG than with PEG. This is probably due to the smaller diameter of the PRG tubes, 12 Fr versus 15 Fr in PEG, and the less solid fixation (with a locked pigtail) versus a more solid flange in PEG. The higher rate found in PRG (26.4% early, 29.6% late) is comparable to previous literature, with rates reportedly between 21% and 40% [14, 30, 45, 46]. Tube dislocation appeared to be a risk factor for peritonitis due to leakage of gastric contents to the peritoneal cavity [14, 29, 39] However, that could not be demonstrated in our study. The jejunal extension in PEG-J is known to dislocate more often than regular PEG, in up to 27% to 36% of cases, but other complication rates are comparable with PEG [47–49].

Infectious complications

In line with previous reports, low rates of minor and major infections were observed. Rates of early minor infection were 1.7% for PEG and 1.5% for PRG) [28]. However, higher rates of (minor) infection of 8% to 15% have been reported for PEG 1, [40] and of 2% to 22% for PRG [15, 8, 25]. We cannot exclude that minor infections have been underreported, as our center is a tertiary referral center. Minor problems may have been treated at local hospitals or by general practitioners. This assumption is based on the exceptionally low numbers of these complications. At the start of data collection, we generally assumed patients always contacted us directly with complications, as this was specifically discussed with patients before placement of the gastrostomy. Therefore, due to the presumed underreporting, no solid conclusion regarding infectious complications can be drawn.

Other complications

Major complications did not differ between the two groups. Complication rates found in our study are largely comparable to data in the literature [18, 29, 43, 46]. Post-procedural pain at the gastrostomy site is common, probably due to gastropexy 6]. Previous studies showed pain in 9.5% after PRG, which is in line with our current findings, showing minor pain in 9.2% shortly after PRG placement (compared to 3.8% in PEG). Of note is that pain post-PRG is generally easily treated with a short course of oral analgesics. Skin deterioration might also be prone to underreporting. According to our findings, this complication occurs more often with PEG than with PRG. Not all patients consider this a problem and it may not even be recognized. We therefore cannot provide definite conclusions with respect to skin deterioration. Literature rates therefore vary from 0% to 12% for PEG and 2.3% to 20% for PRG [14, 25, 40].

Tumor seeding

At our institution, a PRG procedure is preferred over a PEG procedure for patients with oropharyngeal tumors. It may well be that the low incidence of tumor seeding in our study is related to avoidance of PEG placement as only eight patients who underwent PEG with an oropharyngeal tumor received the PEG

before surgery. Remarkably, tumor seeding occurred in one patient after PRG, which has been reported only once in the literature [21]. Tumor seeding is considered to occur by transposition of tumor cells to the stomal site after pulling the gastrostomy tube alongside the tumor. Hematogenous spread of tumor cells might be another explanation. Adhesion of tumor cells at a gastrointestinal wound site after desquamation of tumor cells with subsequent swallowing [19, 20, 50] has also been proposed.

Despite our remarkable finding, risk of tumor seeding in oropharyngeal tumors has been shown to be higher with PEG than with PRG, which is supported by numerous case reports [19, 21, 51]. For other HNC tumors, risk is comparable based on literature [18, 29, 30] and data presented here.

Limitations

The current study has several limitations. First, due to the retrospective nature of the analysis, assignment to groups was empirical, based on clinical judgment and practical considerations, instead of randomization, thereby rendering the patient groups for PEG vs. PRG quite heterogeneous. We have included all patients in the specified periods and corrected all baseline confounders by multivariate logistic regression to minimize risk of bias. Missing data with regard to weight loss prior to placement and BMI were mostly encountered in patients with PEG from 2008 and 2009. Second, the inclusion period was longer for PEG, to reach comparable numbers. Baseline characteristics of 2008 and 2009 did not significantly differ from those for 2010 to 2016. Therefore, we do not expect that the longer inclusion period will have influenced the results.

Third, some patients received a PRG after PEG failure and vice versa. We do not expect this deviation from the intended intervention to influence outcomes, because we only assessed outcomes of successful procedures. Approximately 20 % of "placement failures" were preventable if prior consultation with a gastroenterologist or radiologist had taken place (e. g. contraindications such as ascites, or inability to open their mouth). Fourth, mortality and complication rates are dependent on expertise of the radiologists/endoscopists and their supporting team. Local preference for PRG or PEG is dependent on availability, expertise, and teamwork. In an ideal setting, both techniques are available and can be used based on patient and team preference.

Finally, costs of both procedures may influence decision-making. However, precise estimation of costs is difficult. Not only procedural costs, but also follow-up, reinterventions, and complications should all be taken into account. The difficulty is emphasized by previous estimations, ranging from $591 to $2400 for PEG and $406 to $4500 for PRG [40, 43, 52].

Advice for daily practice

Considering the significant 30-day mortality, neither PEG nor PRG placement should be considered in patients with a very short life expectancy who are in very poor condition (e. g. after a major CVA) [53]. Nasogastric or nasoduodenal feeding is an acceptable and relatively safe alternative [54] with no higher aspiration rates than in case of gastrostomy.

In patients who require prolonged enteral feeding, both PEG and PRG should be considered, taking into account local practice and existing expertise. The process of clinical decision-making should take into account aspects of the underlying disease and preferences of a team of experienced gastroenterologists and interventional radiologists. We advocate for a thorough selection for each individual patient, taking into account the risks and burdens of a gastrostomy and the type of gastrostomy. A multidisciplinary approach combined with a dedicated outpatient clinic (for assessment of the patient and provision of information) is highly recommended.

Conclusion

With respect to procedure-related and 30-day mortality, PEG and PRG compare equally. Underlying disease appears to be the most important predictive factor for mortality. PRG has a higher procedural success rate and placement is possible even in case of a stenotic or narrow esophagus. Tube-related complications and pain are less frequent after PEG compared to PRG. These complications are generally easily managed. The choice for PEG or PRG, therefore, should primarily be based on local facilities and expertise.

Competing interests

None

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