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Review Article

Clinical Practice Guideline for Percutaneous Endoscopic Gastrostomy

Chung Hyun Tae[1], Ju Yup Lee[2], Moon Kyung Joo[3], Chan Hyuk Park[4], Eun Jeong Gong[5], Cheol Min Shin[6], Hyun Lim[7], Hyuk Soon Choi[8], Miyoung Choi[9], Sang Hoon Kim[10,11], Chul-Hyun Lim[12,13], Jeong-Sik Byeon[14], Ki-Nam Shim[1], Geun Am Song[15], Moon Sung Lee[16], Jong-Jae Park[3], Oh Young Lee[17], The Korean Society of Gastrointestinal Endoscopy Task Force on Clinical Practice Guidelines

[1]Department of Internal Medicine, Ewha Womans University College of Medicine, Seoul, Korea; [2]Department of Internal Medicine, Keimyung University School of Medicine, Daegu, Korea; [3]Division of Gastroenterology, Department of Internal Medicine, Korea University Guro Hospital, Korea University College of Medicine, Seoul, Korea; [4]Department of Internal Medicine, Hanyang University Guri Hospital, Hanyang University College of Medicine, Guri, Korea; [5]Department of Internal Medicine, Hallym University College of Medicine, Chuncheon, Korea; [6]Department of Internal Medicine, Seoul National University Bundang Hospital, Seongnam, Korea; [7]Department of Internal Medicine, Hallym University Sacred Heart Hospital, Hallym University College of Medicine, Anyang, Korea; [8]Division of Gastroenterology and Hepatology, Department of Internal Medicine, Korea University Anam Hospital, Korea University College of Medicine, Seoul, Korea; [9]National Evidence-based Healthcare Collaborating Agency, Seoul, Korea; [10]Department of Gastroenterology, Dongguk University Ilsan Hospital, Goyang, Korea; [11]Korean College of Helicobacter and Upper Gastrointestinal Research–Metabolism, Obesity & Nutrition Research Group; [12]Division of Gastroenterology, Department of Internal Medicine, Eunpyeong St. Mary's Hospital, College of Medicine, The Catholic University of Korea, Seoul, Korea; [13]Korean Society of Gastrointestinal Endoscopy–The Research Group for Endoscopes and Devices; [14]Department of Gastroenterology, Asan Medical Center, University of Ulsan College of Medicine, Seoul, Korea; [15]Department of Internal Medicine, Pusan National University College of Medicine and Biomedical Research Institute, Pusan National University Hospital, Busan, Korea; [16]Division of Gastroenterology, Department of Internal Medicine, Soonchunhyang University Bucheon Hospital, Bucheon, Korea; [17]Department of Internal Medicine, Hanyang University School of Medicine, Seoul, Korea

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Corresponding Author

Moon Kyung Joo
ORCID https://orcid.org/0000-0001-6050-3695
E-mail latyrx@korea.ac.kr

Ki-Nam Shim
ORCID https://orcid.org/0000-0003-4004-6292
E-mail shimkn@ewha.ac.kr

Chung Hyun Tae and Ju Yup Lee contributed equally to this work as first authors.

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With an aging population, the number of patients with difficulty swallowing due to medical conditions is gradually increasing. In such cases, enteral nutrition is administered through a temporary nasogastric tube. Long-term use of a nasogastric tube leads to various complications and a decreased quality of life. Percutaneous endoscopic gastrostomy (PEG) is the percutaneous placement of a tube into the stomach, aided endoscopically, which may be an alternative to a nasogastric tube when enteral nutritional is required for 4 weeks or more. This paper is the first Korean clinical guideline for PEG. It was developed jointly by the Korean College of *Helicobacter* and Upper Gastrointestinal Research and led by the Korean Society of Gastrointestinal Endoscopy. These guidelines aimed to provide physicians, including endoscopists, with the indications, use of prophylactic antibiotics, timing of enteric nutrition, tube placement methods, complications, replacement, and tubes removal for PEG based on the currently available clinical evidence. **(Gut Liver 2024;18:10-26)**

Key Words: Endoscopy; Gastrostomy; Guideline; Gastrostomy

INTRODUCTION

With an aging population, the number of patients with difficulty in swallowing due to medical conditions is gradually increasing. Enteral feeding can be provided temporarily through a nasogastric tube; however, nasogastric tubes are typically replaced every 4 to 6 weeks. In addition, complications such as aspiration pneumonia due to regurgitation of the stomach contents, ulcers, and bleeding because of nasogastric tube may occur.[1] Percutaneous endoscopic gastrostomy (PEG) is the percutaneous placement of a tube into the stomach and may be an alternative to a nasogastric tube. PEG should be considered when enteral nutrition is required for 4 weeks or more.

PEG was first reported by Gauderer and colleagues in 1981.[2,3] Two methods are now used for PEG: the pull and push (or introducer) methods. In the pull method, a hollow needle is inserted percutaneously, and a guidewire is inserted after endoscopic confirmation of needle insertion into the stomach. The guidewire is then removed from the stomach using forceps or a snare. A PEG tube is then fixed to the guidewire and inserted through the esophagus into the stomach by pulling the guidewire. Finally, the PEG tube is secured using both internal and external fixation devices. The pull method is the most commonly used technique for PEG tubes placement in Korea. PEG tubes with large diameters can be inserted using this technique. However, two rounds of endoscopy are required to remove the guidewire and insert the PEG tube. Moreover, there is a risk of infection around the tube site during placement. In the push method, a PEG tube is directly inserted using a trocar that has already been inserted into the abdominal wall. The push method requires inserting the endoscope only once and carries a low risk of infection. However, because of the small diameter of PEG tubes, they can easily become clogged by debris. Additionally, if the fixation balloon is damaged, PEG tube dislodgement may occur.

PEG is widely performed in Korea as the procedure does not require general anesthesia and carries no risks or complications related to open surgery.[4,5] Moreover, it is relatively easy to perform by experienced endoscopists.[6] The success rate of tube placement is as high as 99.5%, whereas the mortality rate is 0.5% to 2%.[7,8] PEG tube can remain in place for a minimum of 6 months. However, most patients who require a PEG tube during poor health conditions may experience negative consequences in the clinical course before and after the PEG tube placement.[9]

Therefore, developing clinical practice guidelines for proper indications, effective timing of initial feeding, tube placement safety, and effective strategies to prevent complications for PEG is necessary. We aimed to comprehensively review studies related to PEG and develop guidelines that reflect the healthcare environment in Korea.

METHODS

1. Purposes of the clinical practice guideline development

The present clinical practice guidelines provide a reference for physicians caring for patients with normal gastrointestinal (GI) function but with swallowing problems that require nutrition administration through a PEG tube. In addition, the guidelines have been developed to provide practical and standard medical information for non-healthcare professionals caring for patients with PEG tubes.

2. Composition of the clinical practice guidelines committee and the development process

The clinical practice guidelines were developed by the Committee under the Practice Guideline Task Force of the Korean Society of Gastrointestinal Endoscopy. The Korean College of *Helicobacter* and Upper Gastrointestinal Research Metabolism–Obesity & Nutrition Research Group, Korean Society of Gastroenterology Endoscopy Research Group, and an expert methodologist participated in the development of the guidelines (Supplementary Table 1).

These guidelines were developed to provide a new set of clinical practice guidelines appropriate for Korea's healthcare environment. To incorporate guideline users' preferences, a survey regarding the timing of enteric nutrition initiation, tube placement methods, timing of PEG replacement, and PEG tube removal was conducted in nine gastroenterologists. Most gastroenterologists (66.7%) responded that the optimal timing for initiating enteral nutrition was 4 to 24 hours after tube placement, whereas 33.3% responded that enteral nutrition should be initiated more than 24 hours after tube placement. The preferred method for PEG in patients without esophageal or head and neck cancer was the pull method (88.8%). Most gastroenterologists (55.6%) reported that the optimal PEG tube replacement timing was within 6 months of placement, followed by between 7 and 12 months (22.2%) after tube placement, and upon breakage, dislodgement, occlusion, or leakage (22.2%). None of the gastroenterologists reported that the tube should be changed after ≥13 months.

3. Selection of key questions

We reviewed and discussed the guidelines created by the American Society for Gastrointestinal Endoscopy[10] and

the European Society of Gastrointestinal Endoscopy[11,12] to select key questions for the clinical practice guidelines. Key questions were selected while considering the following areas: the indications for PEG, use of prophylactic antibiotics, timing of enteric nutrition, PEG tube placement methods, complications, PEG tube replacement, and PEG tube removal (Table 1).

4. Literature search and article selection

The keywords were selected, and the search formulae were determined based on discussions among the members of the Committee responsible for each key question and the expert methodologist. Based on the keywords and search formulae, a literature search was performed to identify articles published between January 1987 (when PEG became more commonly used) and March 2021 in the MEDLINE, EMBASE, Cochrane, and KMBASE databases. Original articles, reviews, and abstracts studying adults (aged ≥18 years) were included, whereas editorials, letters, lecture notes, case reports, and case series were excluded. In the first phase of the literature search, articles were selected based on the title and abstract screening. The full texts were then reviewed to select the articles for inclusion. Two working group members were assigned for each key question and independently selected articles according to the inclusion criteria. Disagreements between the review-

Table 1. Key Questions for Domains of Percutaneous Endoscopic Gastrostomy

Area	Key question
Indications	KQ 1. What is the indication for PEG?
Periprocedural use of prophylactic antibiotics	KQ 2. Should prophylactic antibiotics be administered to patients undergoing PEG using the pull or the push method?
Timing of initiating enteral nutrition	KQ 3. Should enteral feeding be started early after the PEG tube placement?
PEG technique	KQ 4. Should the push or pull method be used in patients undergoing PEG for the first time?
	KQ 4-1. Should the push or pull method be used in patients without esophageal cancer or head and neck cancer who are undergoing PEG for the first time?
	KQ 4-2. Should the push or pull method be used in patients with esophageal cancer or head and neck cancer who are undergoing PEG for the first time?
Complications	KQ 5. Should the PEG tube be removed in patients with persistent peristomal leakage?
	KQ 6. Should the PEG tube be replaced in cases of tube breakage, occlusion, dislodgement, or degradation?
	KQ 7. Does loosening the external fixation device and adjusting the PEG tube help prevent BBS?
	KQ 8. Is endoscopic PEG tube removal effective in patients with BBS?
Feeding tube change and removal	KQ 9. When should the PEG tube be replaced in patients requiring chronic enteral nutrition?
	KQ 10. Is the cut-and-push technique appropriate for the removal of internal bolster-type PEG tubes?

KQ, key question; PEG, percutaneous endoscopic gastrostomy; BBS, buried bumper syndrome.

Table 2. Strength of Recommendations and Levels of Evidence

	Definition
Strength of recommendation	
Strong	The intervention is strongly recommended in most clinical situations as it has greater benefits than risks and the level of evidence is high.
Weak	It is suggested that the intervention be selectively used or used under certain conditions as its benefits may vary depending on the clinical situation or according to the society/patient value system.
Expert consensus	Though clinical evidence is insufficient, the intervention is recommended based on the benefits and risks, level of evidence, values and preferences, and available resources. The decision to use this intervention should be made based on the physician's clinical experience and expert consensus.
Level of evidence	
High	The likelihood for additional research to affect the level of certainty regarding the estimated effect is very low.
Moderate	Additional research may significantly affect the level of certainty regarding the estimated effect, and the estimate is likely to be modified.
Low	The likelihood for additional research to significantly affect the level of certainty regarding the estimated effect is high, and the estimate is very likely to be modified.
Very low	It is not feasible to make any prediction regarding the effect.

NA, not applicable; *C. difficile*, *Clostridium difficile*.

ers were resolved through discussion.

5. Meta-analysis, derivation of recommendations, and determination of recommendation strength and level of evidence

Research quality was evaluated using the Cochrane Collaboration's Tool for Assessing the Risk of Bias (RoB 2.0)[13] for articles reporting randomized studies and the Risk of Bias Assessment Tool for Non-Randomized Studies (ROBANS)[14] for articles reporting nonrandomized studies. A meta-analysis of the selected articles was performed using RevMan (version 5.3.3; the Nordic Cochrane Centre, Copenhagen), and the strength of recommendations and level of evidence were determined using the Grading of Recommendations Assessment, Development, and Evaluation (GRADE)[15] (Table 2).

Articles that reported findings relevant to the key questions were targeted during the literature search. However, if evidence regarding the key question was lacking because of either high heterogeneity within the selected articles or no articles regarding the key question, other clinical practice guidelines and review articles pertaining to the questions were used to draft the recommendations. In this case, the strength of the recommendation was described as an expert consensus on the systematic literature review of the relevant literature.

6. Review and approval

Review and approval of the recommendation grading process occurred if >80% of all members in the working group participated and >70% voted in favor of the recommendation. Nine members of the Korean Society of Gastroenterology, Korean Society of Gastrointestinal Endoscopy, Korean College of *Helicobacter* and Upper Gastrointestinal Research, Korean Society of Neurogastroenterology and Motility, Korean Pancreatobiliary Association, and Korean Society of Pediatric Gastroenterology as well as the members of the working group had to agree for the consensus and adoption of a recommendation. The first round of voting was conducted via e-mail using a

Table 3. Summary of Recommendations for Percutaneous Endoscopic Gastrostomy

Recommendation	Strength of recommendation	Level of evidence
We suggest considering PEG for patients with swallowing difficulty that require a nasogastric feeding tube for at least 4 weeks.	Expert consensus	Not applicable
We recommend the administration of prophylactic antibiotics at least once before tube placement in patients undergoing PEG using the pull method.	Strong	High
We suggest early enteral feeding within 24 hours after the PEG tube placement.	Weak	Low
We recommend using either the pull or push method for patients undergoing PEG for the first time, according to the endoscopist's preference.	Weak	Low
We recommend using the push method for patients with esophageal or head and neck cancer who are undergoing PEG.	Weak	Low
If peristomal leakage persists despite the correction of its causes and conservative treatment, we suggest removing the existing PEG tube and placing a new PEG at a different site.	Expert consensus	Not applicable
We suggest replacing damaged, occluded, dislodged, or degraded PEG tubes.	Expert consensus	Not applicable
We suggest loosely positioning the external fixation device 1 to 2 cm from the abdominal wall and pushing the tube inward 2 weeks after PEG tube insertion, when the tract has matured, to prevent BBS.	Expert consensus	Not applicable
We suggest removing PEG tube in the presence of BBS. Clinical considerations: In patients with incomplete BBS (when the internal bumper is visible and the PEG tube is intact), the PEG tube should be removed either by pushing the internal bumper inward or by pulling it from the inside using forceps. In patients with complete BBS, an endoscopic incision aids PEG tube removal.	Weak	Very low
We do not suggest routine replacement of internal bolster-type PEG tubes in the absence of infection, tube breakage, dislodgment, occlusion, or leakage.	Weak	Low
We suggest regularly replacing balloon-type PEG tubes once every 3 to 6 months or according to the manufacturer's recommendation.	Weak	Low
We suggest using the cut-and-push technique for the removal of internal bolster-type PEG in patients without GI stenosis, a history of abdominopelvic surgery, or decreased GI motility. Clinical considerations: We do not suggest this technique in pediatric patients; and, it may be considered if endoscopic removal of PEG tubes is difficult. If PEG tubes are not naturally excreted within 2 weeks after performing cut-and-push technique, endoscopic or surgical removal should be considered.	Weak	Very low

PEG, percutaneous endoscopic gastrostomy; BBS, buried bumper syndrome; GI, gastrointestinal.

5-point Likert scale (completely agree, generally agree, partially agree, generally disagree, and completely disagree). A recommendation was adopted if at least 70% of the total votes were "completely agree" or "generally agree." Seven recommendations were adopted, whereas five were not favored. Based on the experts' opinion, a recommendation draft regarding PEG tube replacement was divided into two parts. In the second round of voting, five revised recommendations reached consensus, whereas one was not favored. Finally, 12 recommendations were agreed upon and adopted (Table 3).

7. Dissemination of clinical guidelines and update plan

To widely distribute the guidelines, the Clinical Practice Guidelines for Percutaneous Endoscopic Gastrostomy will be published in the *Clinical Endoscopy, Gut and Liver*, and *Korean Journal of Gastroenterology*. These guidelines would also be available on the Korean Society of Gastrointestinal Endoscopy website and distributed through various channels. If a revision is deemed necessary, the Korean Society of Gastrointestinal Endoscopy will revise this guideline approximately every 5 years.

GUIDELINES

1. Indications

Key question 1. What is the indication for PEG?

Recommendation 1. We suggest considering PEG for patients with swallowing difficulty that require a nasogastric feeding tube for at least 4 weeks (strength of recommendation: expert consensus; level of evidence: not applicable).

Patients with normal GI function but swallowing difficulty should be provided with enteral nutrition via a nasogastric or PEG tube. No randomized controlled or observational studies have investigated the indications for PEG. Thus, the indications for PEG could only be inferred based on studies in patients who have undergone PEG. The indications for PEG are normal GI function but swallowing difficulty due to (1) neurologic injury, such as cerebrovascular accident;[16] (2) moderate to severe dementia;[17,18] or (3) head and neck cancer[19,20] requiring a nasogastric tube for 4 weeks or longer.

According to the Cochrane meta-analyses, the PEG tube placement failure rate was low, and the post-tube placement mortality rate was comparable to that of nasogastric tube feeding.[21] The mid-upper arm circumference and serum albumin levels, which are closely associated with patients' nutritional status, were higher in patients with PEG tubes than those with nasogastric tubes without a statistically significant difference.[21] In addition, no difference in the prevalence of pneumonia was observed. The prevalence of gastroesophageal reflux disease was higher in patients with nasogastric tubes.[21] The patient's satisfaction, ease of management, and tube placement–induced pain were comparable between the two groups. However, patients tend to prefer PEG owing to its low inconvenience and limitations in social activities.[21-23]

PEG is conventionally performed in patients who require nasogastric tube feeding for at least 4 weeks.[24] According to a study of 34,623 inpatients with ischemic stroke, 56.4% of the patients underwent PEG at days 3 to 23 of admission, and 53% underwent PEG within 7 days of admission. The length of hospital stay was short, and the rate of discharge to home or a rehabilitation hospital was high among patients who underwent PEG during the first 7 days of hospitalization.[25] The 1-year survival rate was 33% among patients aged ≥80 years who underwent PEG and 73% among patients aged <80 years who underwent PEG, suggesting that age should be considered when planning PEG for enteral nutrition.[26]

Because of blind placement of the PEG tube, a GI fistula might occur if the colon is caught between the stomach and the anterior abdominal wall. In addition, PEG tube placement failure may occur in cases of severe obesity or ascites. Peritoneal seeding may occur during PEG tube placement in patients with abdominal malignancies. In patients taking antiplatelet or anticoagulant agents, the bleeding tendency could be increased.[27-33] Therefore, the decision to perform PEG should be carefully considered.

To perform PEG tube placement, the pharynx and the esophagus should not be completely obstructed. It may be technically challenging to perform PEG in patients who have difficulty swallowing with a history of head and neck cancer, pharyngeal cancer, esophageal cancer, gastric cancer, extrinsic esophageal compression, esophageal stenosis, craniofacial anomalies, severe head and neck burns, severe hiatal hernia, or a history of gastric surgery. In such cases, percutaneous radiological gastrostomy (PRG), surgical gastrostomy or surgical jejunostomy may be performed instead of PEG.[34] PRG is as effective as PEG, with a success rate of >95% and a low risk of complications. In addition, it does not require sedatives or analgesics, and the use of prophylactic antibiotics is low. The success rate of PRG is higher than that of PEG.[35] However, gastrostomy tube occlusion and dislodgement occur more frequently because of smaller caliber and lower durability of the gastrostomy tubes.[36] Although surgical gastrostomy is relatively simple

and effective, it requires general anesthesia, which carries the risks of wound dehiscence, gastric perforation, bleeding, peritonitis, and complications due to the general anesthesia.[37]

2. Periprocedural use of prophylactic antibiotics

Key question 2. Should prophylactic antibiotics be administered to patients undergoing PEG using the pull or the push method?

Recommendation 2. We recommend the administration of prophylactic antibiotics at least once before tube placement in patients undergoing PEG using the pull method (strength of recommendation: strong; level of evidence: high).

Fourteen randomized controlled studies regarding the effectiveness of prophylactic antibiotics during PEG were identified, including 12 in which the pull method was used, and two in which the push method was used (Supplementary Table 2, Supplementary Fig. 1).[38-51] Various types of prophylactic antibiotics were used in the studies, including first-, second-, and third-generation cephalosporins, amoxicillin/clavulanic acid, and ampicillin/sulbactam. The meta-analysis revealed that the risk of infection at the tube insertion site during the pull method was lower when prophylactic antibiotics were administered compared to when they were not administered (relative risk [RR], 0.43; 95% confidence interval [CI], 0.30 to 0.62; I^2=30%) (Fig. 1). The duration of prophylactic antibiotic administration varied among the studies. In nine of the 12 studies regarding the pull method, antibiotics were administered only once before the PEG; in the other three studies, antibiotics were administered for only 1 day after the PEG. In the absence of any signs of infection following the tube placement, continued administration of prophylactic antibiotics was unnecessary. Adverse effects of prophylactic antibiotics were reported in three of the 14 studies included in the meta-analysis. A study reported that none of the 20 patients who were administered with prophylactic antibiotics experienced adverse effects,[49] whereas another study reported three occurrences of *Clostridium difficile*–associated diarrhea in a total of 33 patients who were administered with prophylactic antibiotics.[46] Nausea and epileptic seizures were reported in one of 41 patients administered prophylactic antibiotics in another study.[43] Overall, the incidence of adverse effects due to the prophylactic administration of antibiotics was not high, and the relationship between the

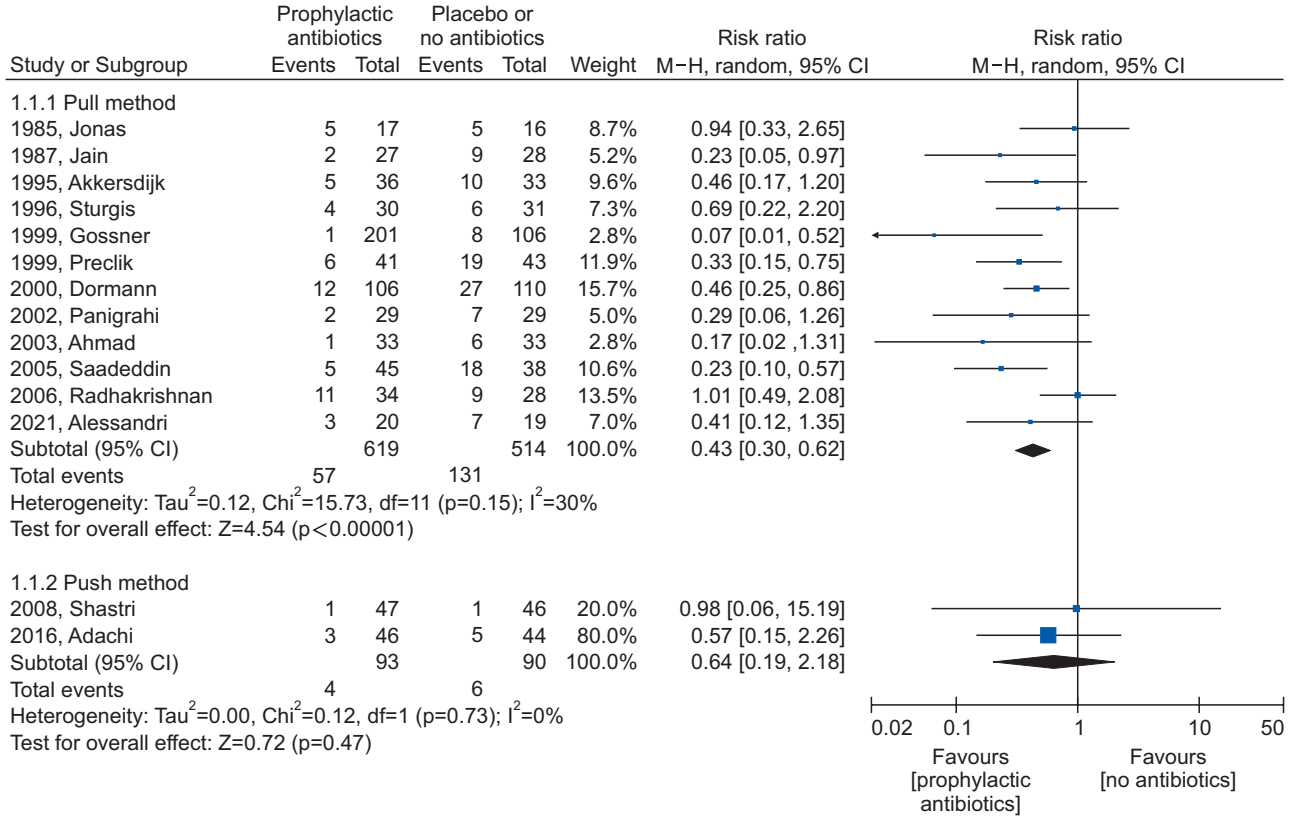

Fig. 1. Risk of percutaneous endoscopic gastrostomy tube insertion site infection based on the administration of prophylactic antibiotics.
M-H, Mantel-Haenszel; CI, confidence interval.

prophylactic use of antibiotics and the occurrence of epileptic seizure is unclear. In summary, the prophylactic use of antibiotics during PEG has several advantages; however, the risks are unclear. Accordingly, prophylactic antibiotic administration is recommended at least once before the tube placement in patients undergoing PEG using the pull method.

Unlike the pull method, the beneficial effects of prophylactic antibiotics in preventing tube insertion site infection during the push method were not confirmed through the meta-analysis (RR, 0.64; 95% CI, 0.19 to 2.18; I^2=0) (Fig. 1). This may be due to the lower risk for tube insertion site infection in the push method than that in the pull method. Tube insertion site infections occurred in 25.5% of patients who underwent the pull method and 6.7% of patients who underwent the push method. No evidence supporting the recommendation of routine prophylactic antibiotic administration during PEG using the push method was observed in this meta-analysis. However, it is difficult to conclude whether prophylactic antibiotics are ineffective during the push method because only two randomized controlled studies have examined this method. In clinical practice, some clinicians administer prophylactic antibiotics during PEG using the push method, whereas others do not. Additional research is necessary to clearly examine the effects of prophylactic antibiotics during the push method.

3. Timing of initiating enteral nutrition

Key question 3. Should enteral feeding be started early after the PEG tube placement?

Recommendation 3. We suggest early enteral feeding within 24 hours after the PEG tube placement (strength of recommendation: weak; level of evidence: low).

Five randomized controlled studies regarding the timing of enteral nutrition initiation following PEG were included in the meta-analysis (Supplementary Table 3, Supplementary Fig. 2).[52-56] Early feeding was defined as the initiation of enteral nutrition within 1 to 4 hours after PEG, whereas late feeding was defined as the initiation of enteral nutrition 24 hours after PEG or on post-tube placement day 1. No studies reported major PEG-related complications, such as bleeding or perforation. The rate of mild complications, including wound infection, surgical site infection, fever, vomiting, and diarrhea, was similar in the early and late feeding groups (RR, 0.96; 95% CI, 0.42 to 2.17; I^2=19%) (Fig. 2A). An increase in the residual gastric volume was more frequently observed in the early feeding group, although the difference was not significant (RR, 1.58; 95% CI, 0.92 to 2.70; I^2=1%) (Fig. 2B). Although an increased residual gastric volume may induce aspiration pneumonia, this complication was not reported in any study included in the meta-analysis.

The mortality rate within 72 hours after PEG was 1.4% (2/145) in the early feeding group and 3.4% (5/145) in the late feeding group (RR, 0.51; 95% CI, 0.13 to 1.99; I^2=0%) (Fig. 2C). In summary, compared to the initiation of enteral nutrition at 24 hours after PEG, earlier feeding did not increase the risks of complications or mortality. Therefore, initiation of enteral nutrition within 24 hours of PEG is recommended. If the patient's status and vital signs are stable following the PEG and no tube placement-related complications are present, early initiation of enteral nutrition will support the patient's nutritional and health status recovery. However, the total number of patients in the included studies was low, tube placement was not blinded owing to the nature of the intervention, and no information regarding the random assignment of patients or concealment of group allocation was provided in the studies. Therefore, the strength of this recommendation is weak.

4. PEG technique

Key question 4. Should the push or pull method be used for patients undergoing PEG for the first time?

Recommendation 4-1. We recommend using either the pull or push method for patients undergoing PEG for the first time, according to the endoscopist's preference (strength of recommendation: weak; level of evidence: low).

Recommendation 4-2. We recommend using the push method for patients with esophageal or head and neck cancer who are undergoing PEG (strength of recommendation: weak; level of evidence: low).

To date, several studies have investigated whether the pull or push method is more beneficial for patients undergoing PEG for the first time.[12] In Korea, the pull method is more commonly used for such patients. However, the push method is also safe, effective, and widely used.[28,57]

Among 12 articles included in the meta-analysis (Supplementary Tables 4, 5, Supplementary Fig. 3), two studies of patients with esophageal or head and neck cancer with PEG tract metastasis were analyzed separately; thus, two separate recommendations were developed.

According to studies on patients without esophageal or head and neck cancer who were undergoing PEG for the first time, the success rates did not differ between the two PEG methods (success rates of 98.7%–100% and 96.6%–100% for the pull and push methods, respectively).[28,57-65] Retes *et al.*,[62] Lee *et al.*,[57] Ohno *et al.*,[61] and Pih *et al.*[28] re-

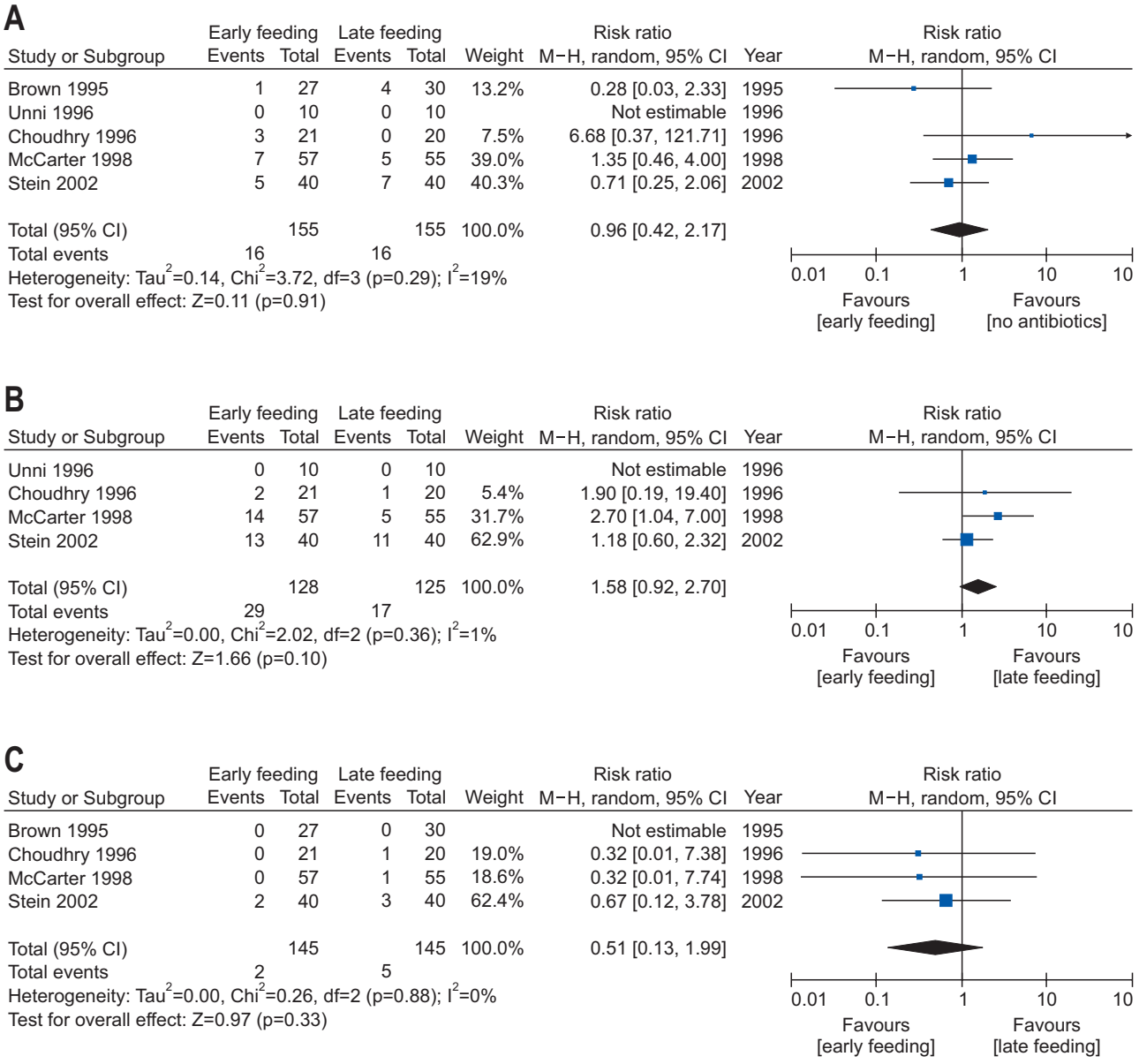

Fig. 2. Meta-analysis of early versus late feeding after percutaneous endoscopic gastrostomy. (A) Incidence of minor adverse events. (B) Significant increase in gastric residual volume. (C) All-cause mortality within 72 hours. M-H, Mantel-Haenszel; CI, confidence interval.

ported that the complication rates did not differ between the two methods, whereas Van Dyck *et al.*[65] and Köhler *et al.*[59] reported an increased risk of complications in patients who underwent the push method (Supplementary Table 4). The gastrostomy site infection rate was higher in patients who underwent PEG using the pull method than that in those who underwent PEG using the push method (odds ratio, 13.0; 95% CI, 4.6 to 36.8).[58] Therefore, there is insufficient evidence regarding the superior method for patients undergoing PEG. The endoscopist's preference and individual patient status should be used to determine which method to use.[59]

Two articles regarding the use of the two methods for patients with esophageal or head and neck cancer were reviewed.[66,67] As reported in a previous meta-analysis, gastrostomy tract metastasis was more likely to occur when the pull method was used even though lack of statistical significance (0.56% [95% CI, 0.40% to 0.79%] and 0.29% [95% CI, 0.15% to 0.55%] in the pull and push methods, respectively).[67] However, the level of evidence was low because almost all studies included in the previous meta-analysis were observational studies or case reports. As the pull method is widely used in clinical practice, some endoscopists may be unfamiliar with the push method. Moreover, evidence regarding the superior method in terms of overall mortality is lacking, and the level of evi-

dence is low.

The push method for PEG is currently less preferred in Korea because most endoscopists are familiar with and use the pull method for patients undergoing PEG for the first time. However, the pull method may not be feasible in patients with esophageal or head and neck cancer because of esophageal stenosis. The pull method also has an increased risk of complications owing to the risk of gastrostomy site metastasis. Therefore, the push method is preferred for these patients.

5. Complications

PEG is a relatively quick and easy tube placement method. However, periprocedural and early and late procedural complications may occur. Periprocedural complications include sedation-related complications, bleeding, perforation, pneumoperitoneum, and puncture of other organs.[68] Early complications before PEG tract maturation include PEG tube dislodgement, intraperitoneal leakage, infection around the fistula, skin ulcers, and necrotizing fasciitis. Late complications after PEG tract maturation include PEG tube dislodgement, occlusion, buried bumper syndrome (BBS), granuloma, and gastrocolocutaneous fistula.

Key question 5. Should the PEG tube be removed in patients with persistent peristomal leakage?

Recommendation 5. If peristomal leakage persists despite the correction of its causes and conservative treatment, we suggest removing the existing PEG tube and placing a new PEG at a different site (strength of recommendation: expert consensus; level of evidence: not applicable).

Peristomal leakage occurs in 1% to 2% of patients with long-term PEG placement.[69] Peristomal leakage should be prevented and treated appropriately, as it increases patient discomfort and the risks of hygienic complications and tube insertion site infections due to gastric content leakage.[70] However, no randomized controlled studies regarding peristomal leakage have been reported, and most articles available are case reports or expert opinions. Therefore, the evidence regarding peristomal leakage in patients with PEG tubes is lacking (Supplementary Fig. 4).[71,72]

Tube insertion site infection, increased gastric acid secretion, gastroparesis, excessive cleansing with hydrogen peroxide, BBS, granulation tissue formation around PEG tubes, and side torsion of the tubes are the primary causes of peristomal leakage.[73] Most clinical practice guidelines recommend identifying and treating the causes of peristomal leakage.[12,74,75] Prokinetics and antisecretory agents can help reduce gastric stasis and acid secretion. The risk of peristomal leakage can be lowered by appropriately fixing the PEG tube to prevent twisting and locally applying silver nitrate or argon plasma coagulation in patients with granulation tissues around the tube.[76] Local infections around the tube insertion site respond to regular wound cleansing and the use of topical antibiotics or antifungal agents. However, more severe peristomal infections require systemic antibiotics guided by sample culture and sensitivity test results. If peristomal leakage continues after the causes are identified and treated, the PEG can be converted to percutaneous endoscopic jejunostomy or partial closure by temporary tube removal (24 to 48 hours), and re-insertion through the same site can be attempted.[12,73] Tube replacement with tubes with greater diameter for peritoneal leakage is not recommended because the stoma eventually becomes even larger.[74] If peristomal leakage persists despite the correction of its causes and conservative treatment, the PEG tube should be removed, and a new PEG tube should be placed at a different site after confirming that the previous PEG site has been completely improved. The clinical practice guidelines for PEG developed by the American Gastroenterological Association, European Society of Gastrointestinal Endoscopy, and British Society of Gastroenterology recommend removing the existing PEG tube and inserting a new PEG tube at a different site if peristomal leakage is unresponsive to treatment.[12,74,75]

Key question 6. Should the PEG tube be replaced in cases of tube breakage, occlusion, dislodgement, or degradation?

Recommendation 6. We suggest replacing damaged, occluded, dislodged, or degraded PEG tubes (strength of recommendation: expert consensus; level of evidence: not applicable).

Internal bolster-type tubes can be maintained for up to 1–2 years if appropriately managed.[74,77] However, all PEG tubes are at risk of breakage, occlusion, dislodgement, and degradation, which can impede proper nutrition supply. Inadvertent PEG tube dislodgement occurs in 1.6% to 4.4% of patients,[74] but no randomized controlled studies regarding PEG tube replacement for these complications have been reported (Supplementary Fig. 5). The clinical practice guidelines developed by the American Gastroenterological Association, European Society of Gastrointestinal Endoscopy, and British Society of Gastroenterology recommend replacing PEG tubes that are broken, occluded, dislodged, or degraded to continue proper nutrition supply.[12,74,75] In patients undergoing PEG tube replacement due to tube breakage, occlusion, dislodgement, or degradation,

the timing of PEG tube insertion should be considered. Although the PEG tube tract generally matures within 1 to 2 weeks, it can take 3 to 4 weeks in patients receiving corticosteroids, who are malnourished, or who have ascites or other conditions.[78] Within 4 weeks after PEG tube insertion, replacement should be avoided if possible, as the PEG tube tract is unlikely to be mature, increasing the risks of tube malposition and peritonitis due to gastric content leakage into the peritoneum. If the PEG tube must be replaced within 4 weeks of its insertion, a new tube should be inserted using endoscopic or radiologic guidance rather than blindly.[12] Four weeks after PEG tube insertion, the tract is already mature, reducing the risk for peritonitis. At this point, balloon-type tubes can be placed blindly without endoscopic guidance using the formed tract. If a PEG tube becomes dislodged more than 4 weeks after its insertion, a replacement tube should be inserted within 24 hours before the tract closes. If tube replacement is delayed, a Foley catheter can be inserted to prevent tract closure.[79,80]

Key question 7. Does loosening the external fixation device and adjusting the PEG tube help prevent BBS?

Recommendation 7. We suggest loosely positioning the external fixation device 1 to 2 cm from the abdominal wall and pushing the tube inward 2 weeks after PEG tube insertion, when the tract has matured, to prevent BBS (strength of recommendation: expert consensus; level of evidence: not applicable).

In BBS, the internal PEG bumper, which should remain in the gastric cavity, migrates into the abdominal wall owing to the induction of pressure necrosis in the gastric wall caused by excessive traction between the internal bumper and gastric mucosa, resulting in a regenerative epithelium covering the internal bumper. BBS occurs in 1% to 4% of patients[81,82] and is more likely to occur in patients with obesity, weight gain, or chronic cough. Proper positioning of the external fixation device is the most important factor in preventing BBS. A gap of approximately 10 mm should be maintained between the skin and the external fixation device, although the safety of a 10 mm gap and tight positioning of the external fixation device over 4 days to avoid leakage is controversial.[83,84] However, after the PEG tract is mature (2 weeks after PEG tube insertion), the external fixation device should be positioned to maintain a gap of approximately 10 mm.[74] According to the recommendations by the European Society of Gastrointestinal Endoscopy, BBS may be prevented by loosening the external fixation device, pushing the PEG tube inward, and rotating it 360° on a daily basis after the PEG tract has matured.[12] Ulcers may develop in patients with balloon-type tubes due to the internal fixation balloon. Therefore, the balloon should not be too tight. Once the PEG tract matures, loosely positioning the balloon and pushing the PEG tube inward will help prevent BBS in these patients.

Key question 8. Is endoscopic PEG tube removal effective in patients with BBS?

Recommendation 8. We suggest removing PEG tube in the presence of BBS (strength of recommendation: weak; level of evidence: very low).

Clinical considerations: In patients with incomplete BBS (when the internal bumper is visible, and the PEG tube is intact), the PEG tube should be removed either by pushing the internal bumper inward or by pulling it from the inside using forceps. In patients with complete BBS, an endoscopic incision aids PEG tube removal.

BBS is diagnosed by direct observation of the internal bumper via gastroscopy or by detection of internal bumper dislodgement into the abdominal wall on abdominal computed tomography. BBS is classified as incomplete (the internal bumper is visible on gastroscopy, and the PEG tube is intact) or complete (the internal bumper is completely embedded in the abdominal wall). In a retrospective study of 82 patients with BBS, both incomplete and complete BBS were successfully treated endoscopically.[85] Bougie, grasp, needle-knife, and papillotome methods were used to treat BBS, and 85.4% of patients did not experience any tube placement-related complications.[86] In another study, five patients with BBS were successfully treated via an incision using a needle-knife and did not experience any complications.[82] Pain, gastric content leakage, bleeding, peritonitis, and abscess formation may occur if BBS is not treated. Therefore, the PEG tube should be removed using an appropriate method once the diagnosis of BBS is made.[87] Endoscopic treatment (via the bougie, grasp, needle-knife, or papillotome method) is appropriate because the success rate is high, and few tube placement-related complications occur.[88] However, all studies included in the review were retrospective studies, and no randomized controlled studies have been reported; therefore, the level of evidence was very low (Supplementary Table 6, Supplementary Fig. 6). If the internal bumper is of an easily folded material, it can be removed by carefully pulling it toward the exterior surface of the abdominal wall. If the internal bumper is completely buried and difficult to remove endoscopically, it should be surgically removed. However, an appropriate method should be selected based on the hospital's conditions and endoscopist's skill.

6. PEG tube replacement and removal

Key question 9. When should the PEG tube be replaced in patients requiring chronic enteral nutrition?

Recommendation 9-1. We do not suggest routine replacement of internal bolster-type PEG tubes in the absence of infection, tube breakage, dislodgment, occlusion, or leakage (strength of recommendation: weak; level of evidence: low).

Recommendation 9-2. We suggest regularly replacing balloon-type PEG tubes once every 3 to 6 months or according to the manufacturer's recommendation (strength of recommendation: weak; level of evidence: low).

We analyzed five articles regarding PEG tube replacement and found that the level of evidence was low. Four of the five studies were retrospective studies, whereas the other was a prospective cohort study (Supplementary Table 7, Supplementary Fig. 7).[89-93] In one study that reviewed complications after the replacement of internal bolster-type PEG tubes in 1,092 patients, there were no significant differences in tube placement-related complications in patients who underwent routine versus as-needed replacements. Tube placement-related complications, including fistula disruption (0.7%), bleeding (0.4%), and tube breakage (0.1%), occurred in 1.2% of patients who underwent routine replacement.[89] A recent study observed the complications associated with routine replacement of balloon-type PEG tubes once every 6 months and found no tube placement-related complications. The tubes were replaced by trained nurses at home rather than at healthcare institutions.[90] However, the findings of this study should be interpreted carefully because the study was conducted in a Western country where it was not easy for patients to visit healthcare institutions, whereas in real clinical practice in Korea, a proportion of patients are transferred to specialized healthcare institutions to ensure safe tube placement.[91] There were no differences in late complications such as tube dislodgement, occlusion, and leakage between patients who underwent early (within 6 months) versus late (beyond 6 months) replacement,[92,93] although the occurrences of tube placement-related mechanical complications such as esophageal laceration and microperforation were significantly higher among patients who underwent early PEG tube replacement.[92] However, the definitions of early and late replacement were not totally consistent with the definitions of routine and as-needed replacement. In summary, the tube placement-related complication rate was not significantly different between patients who underwent the routine replacement of internal bolster-type PEG tubes and those who underwent as-needed replacement, whereas the rate of mechanical complications was higher in patients who underwent early replacement compared to that in patients who underwent late replacement. As PEG tubes were replaced on a routine basis rather than as-needed basis in most patients in the early replacement group, it can be inferred that the risk of routine replacement of internal bolster-type PEG tubes is higher than its benefits. However, if a significant infection, tube breakage, dislodgment, occlusion, or leakage is observed, replacement of the internal bolster-type tubes should be considered. In contrast, few tube placement-related complications associated with routine replacement of balloon-type PEG tubes have been reported, and we suggest that balloon-type PEG tubes should be replaced every 3 to 6 months or according to the manufacturer's recommendation and at the endoscopist's discretion. In addition, routine replacement of balloon-type PEG tubes is advantageous because the first inserted internal bolster-type PEG tube can be safely replaced with balloon-type PEG tubes if the patient's general condition is poor. However, further studies are needed to investigate several perspectives including number of patient visits, cost-effectiveness, physician labor, and risk-benefit. Although the optimal timing of PEG tube replacement varies widely depending on the endoscopist's preference, the current statements are expected to promote safe PEG tube replacement and reduce the risk of complications due to frequent and unnecessary tube replacement, as most patients with PEG tubes have serious underlying comorbidities. However, the number of studies in the systematic review was small; most were single-center retrospective studies, and the definitions of the timing of tube replacement were inconsistent. Therefore, the strength of the recommendation is low.

Key questions 10. Is the cut-and-push technique appropriate for the removal of internal bolster-type PEG tubes?

Recommendation 10. We suggest using the cut-and-push technique for the removal of internal bolster-type PEG in patients without GI stenosis, a history of abdominopelvic surgery, or decreased GI motility (strength of recommendation: weak; level of evidence: very low).

Clinical considerations: We do not suggest using this technique in pediatric patients; and, it may be considered if endoscopic removal of PEG tubes is difficult. If PEG tubes are not naturally excreted within 2 weeks after performing the cut-and-push technique, endoscopic or surgical removal should be considered.

The cut-and-push technique was introduced in Western countries in 1991 to remove internal bolster-type PEG tubes. This technique involves cutting the PEG tubes under the external fixation device at skin level and pushing them into the gastric cavity to allow them to be excreted naturally. However, due to the risk of failure to naturally excrete the tube, this technique is contraindicated in patients with GI stenosis, a history of abdominopelvic surgery, or decreased GI motility.[94] We investigated five articles regarding the clinical outcomes of this technique; however, the studies have limitations: they were all single-arm studies conducted in Western countries and did not include control groups (Supplementary Table 8, Supplementary Fig. 7).[94-98] The PEG tubes naturally passed through the GI tract in 84% to 97% of patients who underwent the cut-and-push technique, and complications such as GI obstruction (due to incomplete excretion of the tubes) and abdominal pain were relatively low, occurring in 1.6% to 2.7% of the patients. There was a case of endoscopic removal of a cut PEG tube due to persistent GI obstruction,[94] and another case discussed the surgical removal of a PEG tube that was embedded in the abdominal wall.[95] The physical removal of the tubes was performed within 2 weeks after the cut-and-push technique was performed in both patients.[94,95]

In summary, although complications are rare in patients who underwent internal bolster-type PEG tubes removal using the cut-and-push technique, endoscopic or surgical removal of PEG tubes from the GI tract or abdominal walls is sometimes necessary. However, the endoscopic PEG tubes removal or the traction method for internal bolster-type PEG tubes removal is commonly performed in Korea, and PEG bolsters are soft and easy to pass through the insertion opening by gentle external manual traction. Therefore, we suggest considering the cut-and-push method for patients with poor health conditions in whom esophagogastroduodenoscopy is difficult to perform. However, no studies have reported the use of the cut-and-push technique in pediatric patients, and we do not suggest this technique in pediatric patients owing to the risk of GI obstruction, although the internal fixation devices used in children are smaller than those used in adults.[99] As all studies included in this systematic review were single-center observational studies conducted in Western countries, the strength of the recommendation is low.

7. Effects of carbon dioxide during PEG

Pneumoperitoneum, the presence of gas in the abdominal cavity, occurs in 40% to 56% of patients following PEG.[100] Pneumoperitoneum occurs after PEG owing to ambient air entering the body during tube placement. Most patients are asymptomatic and recover from pneumoperitoneum without treatment. Pneumoperitoneum is detected on abdominal computed tomography with the patient in a standing or supine position. In most patients, the gas is absorbed, and pneumoperitoneum resolves within 2 to 3 weeks. Pneumoperitoneum was observed in nine out of 24 patients who underwent PEG with air insufflation, although the patients were asymptomatic and had no signs of peritonitis.[101] Allen *et al.*[102] reported no differences in the occurrence of pneumoperitoneum on post-tube placement day 1 between patients who underwent air insufflation and those who did not undergo air insufflation. However, patients presenting with peritonitis signs should be managed carefully. A previous study reported that 55.5% of patients had clinically significant peritonitis signs, including fever, abdominal pain, and an increased white blood cell count; the study included two patients with severe pneumoperitoneum in whom pneumonia and sepsis co-occurred.[103] A retrospective study of 722 patients who underwent PEG reported that pneumoperitoneum was observed in 39 patients, including 33 who were asymptomatic and five who presented with peritonitis symptoms.[104] In a large-scale study of 281 patients in the intensive care unit, pneumoperitoneum was detected in 45 patients, including eight who required emergency surgical or endoscopic treatment after PEG.[105]

Carbon dioxide (CO_2) insufflation during PEG may reduce the incidence of pneumoperitoneum. In a study by Murphy *et al.*,[106] pneumoperitoneum occurred in 14.3% of patients who underwent CO_2 insufflation and 53.3% of the patients who underwent air insufflation. However, the visual analog scale scores for abdominal distention, pain, and bloating did not differ between the groups. In a study conducted in Japan, pneumoperitoneum was detected in patients who underwent air insufflation (air group) but not in patients who underwent CO_2 insufflation (CO_2 group). In a previous study, the incidence of small bowel distention was significantly decreased in the CO_2 group compared to that in the air group at 10 minutes and 24 hours post-PEG, although the incidence of large bowel distention did not differ between the groups.[107] No randomized controlled studies regarding pneumoperitoneum following PEG have been conducted, and the evidence in the literature is insufficient (Supplementary Table 9, Supplementary Fig. 6). Therefore, the use of CO_2 during PEG cannot be recommended. The Committee for the Development of Clinical Practice Guidelines for Percutaneous Endoscopic Gastrostomy drafted a preliminary recommendation to determine the expert opinion: "The use of CO_2 during PEG may reduce the occurrence of pneumoperitoneum." Initially, 68.4% of experts consented to the first version of the recommendation. The draft was revised to "The use of CO_2

during PEG performed in patients with poor health may reduce the occurrence of pneumoperitoneum and prevent secondary complications." Only 64.7% of the experts consented to the revised draft, resulting in the recommendation being excluded from the current guidelines. Therefore, further studies regarding the use of CO_2 during PEG are warranted. Surveys on the operating room environment should be performed to determine CO_2 insufflators that can be used during PEG.

CONCLUSIONS

The Clinical Practice Guidelines for Percutaneous Endoscopic Gastrostomy are the first PEG clinical practice guidelines developed in Korea. Guidelines were developed to provide evidence-based recommendations reflecting the current domestic situation in Korea. However, there are limitations in encompassing diverse healthcare environments and various clinical considerations. The Committee for the Development of Clinical Practice Guidelines for Percutaneous Endoscopic Gastrostomy presents recommendations of low strength and based on expert consensus, as domestic or foreign studies providing high-level evidence are lacking. Therefore, there is an urgent need for studies reflecting the domestic healthcare environment to provide evidence regarding PEG, so that guidelines can be revised appropriately.

Despite the limitations of these guidelines, the Committee aimed to create flexible guidelines that could be applied in a variety of clinical settings by conducting a survey study of clinicians and increasing the clinical usefulness of the recommendations by holding expert discussions regarding the topics low levels of evidence. The current clinical guidelines can be used in clinical practice to provide high-quality healthcare for patients who undergo PEG.

CONFLICTS OF INTEREST

No potential conflict of interest relevant to this article was reported.

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ORCID

Chung Hyun Tae https://orcid.org/0000-0002-0764-7793
Ju Yup Lee https://orcid.org/0000-0003-0021-5354
Moon Kyung Joo https://orcid.org/0000-0001-6050-3695
Chan Hyuk Park https://orcid.org/0000-0003-3824-3481
Eun Jeong Gong https://orcid.org/0000-0003-3996-3472
Cheol Min Shin https://orcid.org/0000-0003-2265-9845
Hyun Lim https://orcid.org/0000-0001-6581-6420
Hyuk Soon Choi https://orcid.org/0000-0002-4343-6950
Miyoung Choi https://orcid.org/0000-0002-2424-9965
Sang Hoon Kim https://orcid.org/0000-0003-3548-1986
Chul-Hyun Lim https://orcid.org/0000-0002-8347-8979
Jeong-Sik Byeon https://orcid.org/0000-0002-9793-6379
Ki-Nam Shim https://orcid.org/0000-0003-4004-6292
Geun Am Son https://orcid.org/0000-0003-2100-8522
Moon Sung Lee https://orcid.org/0000-0002-7486-259X
Jong-Jae Park https://orcid.org/0000-0002-4642-5405
Oh Young Lee https://orcid.org/0000-0002-6025-530X

SUPPLEMENTARY MATERAILS

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