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Original Article

Effects of a Gelled Water on Gastroesophageal Reflux and Gastric Emptying after Percutaneous Endoscopic Gastrostomy

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ABSTRACT

Introduction: For patients who received percutaneous endoscopic gastrostomy (PEG), semisolid enteral nutrients have recently been utilized with the expectation of reducing the risk of gastroesophageal reflux (GER), which is still controversial. The aim of the present study is to evaluate the GER-preventive effects and gastric emptying of gelled water in post-PEG patients with dysphagia using scintigraphy.

Methods: This was a crossover study in which a test using either plain water or gelled water was performed utilizing gastric emptying scintigraphy to investigate the risk of GER and to determine the gastric half-emptying time ($T_{1/2}$).

Results: Radioactivity was detected in the esophageal region, namely GER, in three (12%) patients with plain water, whereas no GER was observed in patients with gelled water ($p = 0.235$). With respect to gastric emptying time, the median $T_{1/2}$ was longer in patients with gelled water than in those with plain water (31 min vs. 15 min, $p < 0.0001$).

Conclusions: Gelled water tends to remain in the stomach for a longer period of time than plain water, leading to a lower risk of GER and rapid gastric emptying. To verify the prevention of aspiration pneumonia and diarrhea, further study with more subjects is warranted.

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KEYWORDS: gastrostomy, gastric emptying, gastroesophageal reflux, scintigraphy, gelled water

Introduction

Percutaneous endoscopic gastrostomy (PEG) is a low-invasive procedure used to establish an enteral feeding route in patients with dysphagia, who are prone to developing gastroesophageal reflux (GER). GER may cause critical aspiration because most patients with PEG for dysphagia are elderly and frail, generally bedridden.[1, 2] Semisolid enteral nutrients have recently been used with the expectation of reducing the risk of GER. However, there is still a controversy as to the effectiveness of semisolid nutrients (with high viscosity) in preventing GER: although some studies have reported that they reduce the risk of GER,[3–5] others have suggested that they are not effective.[6, 7] These previous reports evaluated the efficacy of reducing GER by semisolid nutrients. Apart from semisolid agents, there are solid agents that are associated with low viscosity and high breaking strength. Solid nutri-

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Table 1 Patients' characteristics

Variable	(n = 25) Data
Age, median [IQR]	78 [57, 97]
Gender (male), n	12
KPS, median [IQR]	40 [30, 40]
Underlying diseases for dysphagia	
Cerebrovascular disease	15
Neuromuscular disease	6
Dementia	4
History of pneumonia	9
Diabetes	5
Use of prokinetic agents	0
Hiatal hernia	15
Reflux esophagitis (≥ grade A)	0
Number of days between each test, median [IQR]	2 [1, 24]

IQR: interquartile range; KPS: Karnofsky's performance status.

ents, including gelled water, may have different behavior in the gastrointestinal tract as compared with semisolid nutrients. In addition to enteral nutrients, patients with dysphagia usually require a water supply through a gastrostomy tube for proper hydration control. Water supplied via a PEG tube may also cause GER.[8]

The aim of the present study is to evaluate the GER-preventive effects and gastric emptying of gelled water in post-PEG patients with dysphagia using scintigraphy.

Methods

Study design

This was a crossover study in which a test using either plain water or gelled water was performed utilizing gastric emptying scintigraphy to investigate the risk of GER and to determine the gastric half-emptying time ($T_{1/2}$).

Patients

The study was conducted in 25 patients with dysphagia who had undergone a PEG between June 2006 and June 2008 (Table 1). Those who were 20 years of age or older, had undergone a PEG for dysphagia, and had unimpaired gastrointestinal function accepting enteral nutrition and water through a PEG tube were eligible for the study. Those who had undergone a PEG for decompression for gastrointestinal obstruction were excluded from the study. Written informed consent was obtained from the patients and/or their families. The study was approved on December 10, 2004 by the Ethics Committee of the Toho University Ohashi Medical Center.

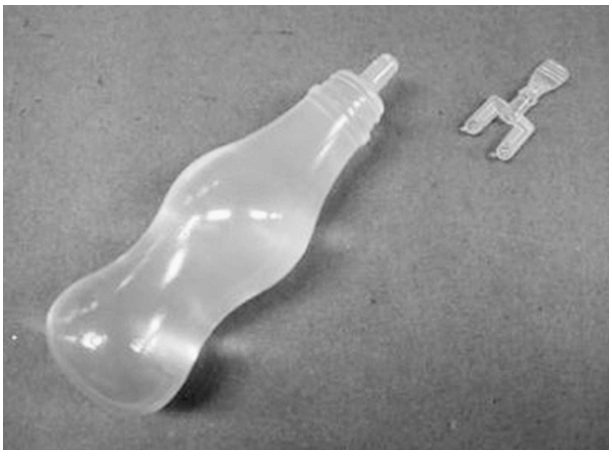

Fig. 1 Aquagel® (Otsuka Pharmaceutical Factory Inc.)

Technique

We ensured that the patients were able to take in food and water through a gastrostomy tube. Plain water labeled with ^{99m}Tc-diethylene triamine pentaacetic acid (^{99m}Tc-DTPA) was administered through the PEG tube, and dynamic imaging of the water in the gastrointestinal tract of patients over time was evaluated with scintigraphy. At least one day after the first examination, gelled water (Aquagel®, Otsuka Pharmaceutical Factory, Inc., Tokushima, Japan) (Fig. 1) labeled with ^{99m}Tc-DTPA was administered through the PEG tube, and scintigraphic image analysis was conducted in the same way as the former test using plain water. In principle, a test using plain water was initially conducted followed by one using gelled water as the second test (a crossover study).

Scintigraphic image analysis

Placing markers containing ^{99m}Tc-DTPA over the suprasternal notch and xiphoid is helpful in determining the level of reflux in the esophagus. A mixture of ^{99m}Tc-DTPA and 300 mL of plain or gelled water was administered by bolus infusion through the PEG tube using a syringe. The region of interest (ROI) between the suprasternal notch and stomach was imaged over time using a gamma camera (E. CAM; Toshiba Medical Systems, Tokyo, Japan) in the supine position at 30 s intervals for 120 min (Fig. 2).

Assessment 1: To evaluate whether GER occurred or not, we analyzed the presence of nuclide-labeled water in the esophageal region. The esophagus was divided into three parts, and esophageal reflux in the lowest and other parts was determined to be mild or severe in accordance with the method described by Balan et al.[9]

Assessment 2: To evaluate gastric emptying, the half-

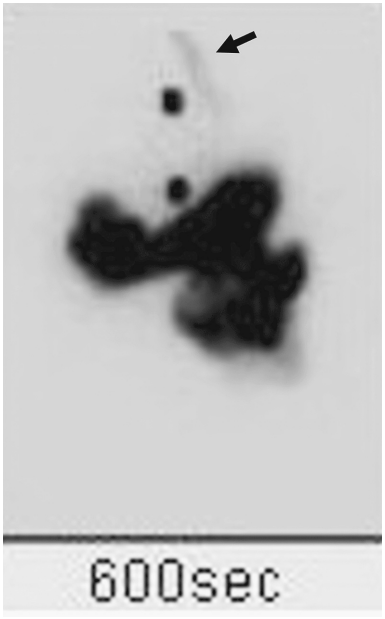

Fig. 2 Scintigram image: GER was detected 600 s after the start of the test (arrow)

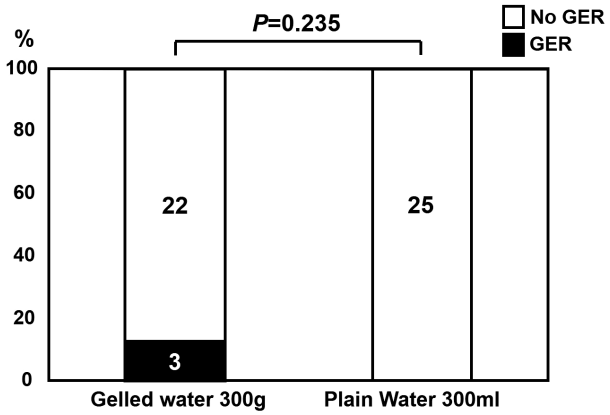

Fig. 3 Frequency of GER

emptying time ($T_{1/2}$) needed for 50% radioactivity transferred from the stomach into the small intestine was also measured.

Statistical analysis

The median (interquartile range [IQR]) was calculated for continuous variables. Comparisons of the risk of GER were performed using the Fisher exact probability test, and comparisons of $T_{1/2}$ were conducted using the Wilcoxon signed-rank test. $p < 0.05$ was considered significant.

Results

The median time between PEG placement and the measurements was 19 [IQR: 14, 23] days. Only two patients underwent the test with gelled water, whereas the remaining 23 patients underwent the test with plain water.

Radioactivity was detected in the esophageal region, namely GER, in three (12%) patients who were administered plain water: it was severe in one patient and mild in two patients. However, no GER was observed in patients who were administered gelled water ($p = 0.235$) (Fig. 3). All three patients with GER had hiatal hernia, whereas 12 patients had hiatal hernia among the remaining 22 patients ($p = 0.654$). With respect to gastric emptying time, the median $T_{1/2}$ was longer in patients administered gelled water than in those administered plain water (31 min vs. 15 min, $p < 0.0001$) (Fig. 4).

Complications

No dysphagia, fever, or other test-related complications were observed during or after testing.

Discussion

The present scintigraphic analyses in post-PEG patients indicated that gelled water infused via the PEG tube tended to remain in the stomach longer compared with plain water. Gelled water was less likely to cause GER than plain water, despite no statistical significance. In addition, gastric emptying was slower in patients with gelled water, with a longer $T_{1/2}$ (31 min vs. 15 min, $p < 0.0001$).

Liquid enteral nutrients are the main food source used for tube feeding. However, liquid enteral nutrients may cause various problems, including GER-associated aspiration pneumonitis, diarrhea, leakage from a PEG fistula, long periods of sitting during administration of liquid enteral nutrients, and their related decubitus.[5] Studies have reported that semisolid enteral nutrients are useful in reducing the risk of GER and pneumonia[3–8, 10–12, 14] and are widely used in clinical practice, particularly in Japan. Semisolid enteral nutrients can be administered quicker than liquid enteral nutrients. This may be helpful in avoiding long periods of sitting and, consequently, in lowering the burden on caregivers. Most PEG patients with dysphasia have to receive hydration as well as feeding via a PEG catheter, due to the inability to swallow. Thus, both water supply and administration of medicine should be carried out through the PEG tube. In the present study, GER was observed in three (12%) patients with plain water, despite no GER in any patients with gelled water. This suggests that with respect to water supply, gelled water may be

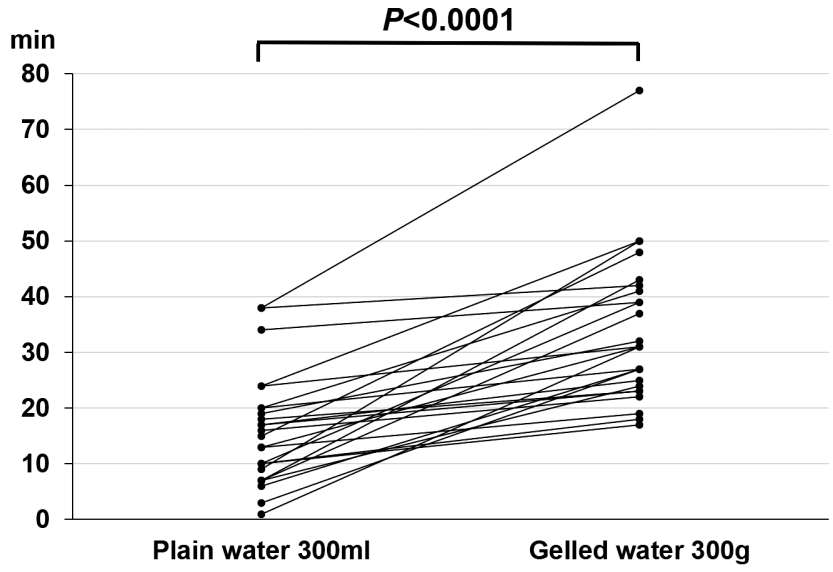

Fig. 4 Gastric half-emptying time ($T_{1/2}$)

useful in reducing the risk of GER.

Solid food intake immediately induces extension of the gastric wall and relaxation of the stomach. In contrast, a study reported that this does not occur with liquid food intake.[13] Additionally, water does not induce gastric adaptive relaxation and tends to pass into the duodenum without staying for an optimal duration in the stomach. In the present study, gelled water significantly lengthened the gastric emptying time compared with plain water. This may indicate that gelled water induces gastric adaptive relaxation.

In addition, liquid nutrients and water reportedly make gastric emptying faster compared with solid nutrients.[13] Rapid gastric emptying may cause diarrhea and bloating. To avoid these symptoms, liquid nutrients and water should be slowly administered through the PEG tube, leading to staying in bed for long periods of time. The present result showed that gelled water tended to remain in the stomach for a longer period of time than plain water, even by bolus infusion. Preventing rapid gastric emptying with gelled water may be beneficial in allowing patients to be free from long periods of bed rest.

Semisolid enteral nutrients are classified based on their viscosity. A study reported that the optimal viscosity is 20,000 mPa・s and that those with a viscosity of 2,000 mPa・s or less have no effect on preventing GER.[14] Previously published studies[5, 7, 8, 12] to evaluate the GER prevention effect with semisolid nutrients demonstrate the said tendency, although there has been no consensus. Because the gelled water used in the present study is a gel (containing gellan gum as the gelling agent) rather than a paste, it seems reasonable to classify it according to its breaking (collapsing) strength rather than viscosity. The breaking strength of the gelled water used in the present study is 2,200 N/m^2, which is greater than that of other commercially available gelled water such as Aqua Gelee® (460 N/m^2; FoodCare Co., Ltd., Kanagawa, Japan) and Isotonic Jelly (340 N/m^2; Nutri Co., Ltd., Mie, Japan).[15] Gelled water is hard to break and is likely to remain in the stomach for a longer period of time. This property may be helpful in preventing the risk of GER and rapid gastric emptying.

The strengths of this study are analysis of GER and the gastric emptying of gelled water, whereas previous studies have dealt with semisolid nutrients. The study indicates that gelled water tends to stay in the stomach longer than plain water. However, there are several limitations in this study. First, despite the crossover design, the number of patients participating was rather small. Second, although post-PEG patients in clinical practice are generally required to be in a sitting position during tube feeding, patients in the present study were kept in a supine position. Despite these limitations, the results suggest that gelled water is better than ordinary plain water for the rehydration of post-PEG patients in terms of reducing the risk of GER and diarrhea.

In conclusion, gelled water tends to remain in the stomach for a longer period of time than plain water, leading to a lower risk of GER and rapid gastric emptying. To verify

the prevention of aspiration pneumonia and diarrhea, further study with more subjects is warranted.

Conflicts of interest: None declared.

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