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Original Article

Gastric emptying scan after distal subtotal gastrectomy: Differences between Billroth I and II and predicting the presence of food residue at endoscopy

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Abstract: Purpose: We investigated whether gastric emptying scans (GESs) showed different emptying patterns between patients after different types of laparoscopic distal subtotal gastrectomies. We also investigated whether the presence of food residue via endoscopy can be predicted by GESs. Materials and Methods: We retrospectively enrolled patients who had GESs within postoperative week 1 after a Billroth I or Billroth II operation. Diabetic patients were excluded. GESs were done with a solid test meal. Percent emptying at each scan time was analyzed. The presence of food residue in the stomach and gastrointestinal symptoms at the outpatient clinic were also analyzed. Results: In total, 46 patients were enrolled (Billroth I: Billroth II = 21:25). Sixteen patients underwent a second GES (postoperative 3-6 months). Both groups showed delayed gastric emptying at the postoperative 1 week scan, but group I showed much slower emptying. However, this difference disappeared by the second scan. Based on endoscopies conducted 6 months after the operation, 73.2% of patients had significant amounts of food residue, which hindered an accurate evaluation. The proportion of patients with food residues did not differ between the groups. Receiver Operating Characteristic (ROC) curve analysis revealed that a cut-off value of ≤ 30% emptying at 100 min and 120 min in postoperative 3-6 month scans was both highly sensitive and specific for predicting the presence of food residue (90.91% and 75% for 100 min and 91.67% and 75% for 120 min, respectively). Conclusions: GESs within a week after distal subtotal gastrectomy show slower emptying of Billroth I than II. At a ≤ 30% emptying threshold, a GES can predict subtotal gastrectomy patients who might have a significant amount of food residue in their stomach even after following typical fasting instructions to prepare endoscopy.

Keywords: Gastric emptying, radionuclide imaging, gastroenterostomy

Introduction

The standard treatment for gastric cancer is surgical resection. Early recurrence may be caused by microcarcinomas in the remaining gastric wall and the frequency of synchronous cancer is reported to be 6-14% [1-4]. Thus, endoscopic evaluation is important in follow-up of gastric cancer after surgery [1].

However, accurate evaluation by endoscopy can fail due to the presence of food residues in the stomach. Jung et al. [5] reported that the incidence of food retention was 55.5% for patients who had distal subtotal gastrectomies in endoscopies performed at 3 months after surgery. After a subtotal gastrectomy, gastric emptying can be delayed for many reasons, such as surgery-associated gastric hypomotility, subacidity, pyloric function loss, hormones, innervation, and functional resistance of the duodenum [1, 6, 7].

The gold standard method for evaluating gastric emptying is gastric emptying scintigraphy [8]. This technique uses a solid or liquid meal mixed with radiopharmaceuticals. Analyses of regions of interest (ROIs) in serial images of the stomach can provide a physiological, noninvasive, and quantitative measurement of gastric emptying [8, 9]. Several studies have reported differences in gastric emptying according to operation techniques [1, 10-14]. However, there is little information on gastric emptying in patients after gastric surgical procedures [8].

Here, we investigated whether gastric emptying scans (GESs) showed different patterns of emptying between patients after different types of laparoscopic distal subtotal gastrectomies. We also investigated whether the presence of food residue at endoscopy can be predicted by the scans.

Materials and methods

Patients

This was a retrospective study. From 2011 December to 2014 June, a total of 231 GESs were performed after early gastric cancer surgery at our institution. Among them, we enrolled patients with postoperative week 0-1 scans after a laparoscopic distal subtotal gastrectomy (Billroth I or II). Diabetic patients were excluded. Patients with only scans 0-4 days after the operation were also excluded. When patients underwent a second scan, we also analyzed those data retrospectively. Patients were categorized into two groups according to the reconstruction method: Billroth I and II. This protocol was approved by the institutional review boards of our institution.

Gastric emptying scintigraphy

Gastric emptying scintigraphy with a solid meal was performed according to the protocol of our institution, which was designed for patients after gastrectomy. Patients were fasted overnight (at least 8 h). The test meal was prepared from 65-70 g whole egg, 37 MBq ^{99m}Tc pertechnetate, and 100 mL water. A pinch of salt was added to improve the taste. The labeled mixture was heated in a microwave for 3 min in a shielded non-stick dish. The meal was 85 calories (6 g protein, 6 g fat, and traces of sugars and starch). The patients were instructed to eat the entire meal within 15 min, and then have three sips of water. Then the scan was performed using a dual-head gamma camera (INFINIA GP3, GE, USA) with a low-energy, high-resolution collimator; the photo peak was 140 keV with a 20% window (128 × 128 matrix).

Scanning was started in a supine position within 1 min of the completion of eating the test meal (defined as 0 min of scan timing). Subsequent images were obtained at 15, 30, 45, 60, 75, 90, 100, and 120 min. Some patients also underwent scanning at 240 min. Anterior and posterior static images were taken at each scan time.

Percent emptying

ROIs were drawn manually around the activity in the entire stomach in anterior and posterior views. The geographic mean (the square root of the product of counts in the anterior and posterior ROIs) was used. We analyzed percent emptying by calculating the percentage of irradiated food evacuated from the stomach at each specific time point. Data were corrected for radioactive decay.

Endoscopy procedure

Patients were given written instructions on how to prepare before the procedure. They were instructed to have a soft diet (white-rice porridge) for the last meal on the day before the endoscopy. After that, patients were recommended to fast for more than 12 h before having an endoscopy according to the protocol of our institution. The endoscopy procedures were performed between 9:00 a.m. and 12.00 p.m.

Food residue data

The results of endoscopy were assessed retrospectively. We recorded the presence of food residues as negative or positive. The decision was based on the success/failure of the entire examination of the stomach by endoscopy and the need to repeat the endoscopy. When an endoscopic evaluation of the entire surface of the remaining stomach failed due to remaining food, and thus it was necessary to repeat the procedure, we recorded it as positive for food residue.

Statistical analysis

For normality testing, we used the Kolmogorov-Smirnov test. With data from the postoperative 1 week scan, comparison of percent emptying between groups was made with the Mann-Whitney U-test. For patients who underwent a second scan, comparisons between groups were made using *t*-tests (except for the data at 75 min and 240 min, which did not pass the normality test). Paired comparisons of percent emptying between the first and second scans were made using the Wilcoxon test. We used the χ^2 test and t-test to analyze food residue and clinical factors (gender, age, and interval

Table 1. Patient characteristics

	Total (*n* = 46)	Billroth I (*n* = 21)	Billroth II (*n* = 25)	*P* value
Age (mean ± SD)	59.37 ± 14.30	61.95 ± 11.23	59.60 ± 13.25	0.5240 (t-test)
Gender (male: female)	30:16	13:8	17:8	0.9032 (χ^2)
First gastric emptying scan interval from surgery	median 7.0 (range 4-9)	median 7 day (range 4-9)	median 7 (5-9)	0.4637 (Mann-Whitney)
Patients who had second scan (n)*	16	6	10	0.7706 (Fisher's exact test)
Second gastric emptying scan interval from surgery (month)	median 3.3 (range 2.4-6.5)	median 3.35 (range 2.4-3.6)	median 3.3 (range 3.1-6.5)	0.8706 (Mann-Whitney)
Patients who had first endoscopy within 6 months after surgery (*n*)	41	21	20	0.0536 (Fisher's exact test)
Endoscopy interval from surgery (month)	median 3 (range 1-6)	median 3 (range 1-5)	median 3 (range 3-6)	0.9495 (Mann-Whitney)

Notes: SD, standard deviation: *n*, number; data that failed the Kolmogorov-Smirnov normality test were compared using non-parametric tests such as the Mann-Whitney U-test; *Second gastric emptying scan at 3-6 months postoperatively.

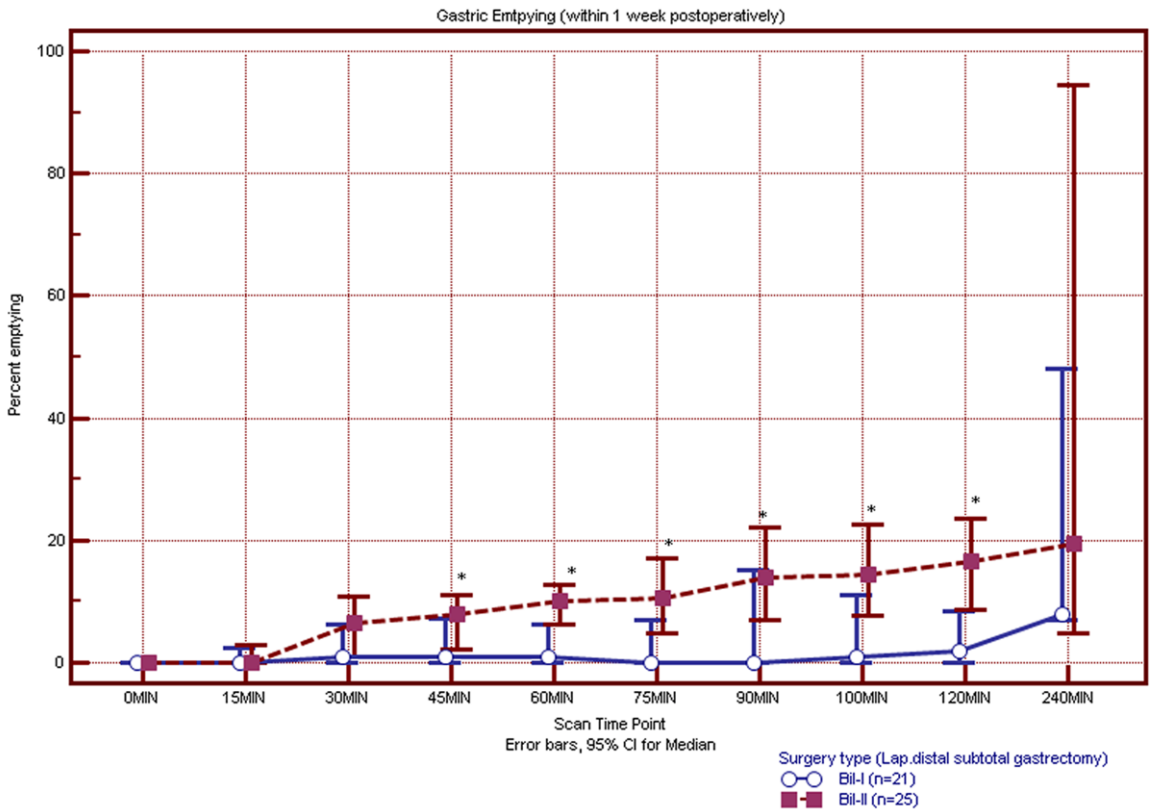

Figure 1. Comparison of percent gastric emptying between Billroth I and II patients. Scans were done within 1 week after the operation (asterisks indicate $P < 0.05$). Notes: A). Kolmogorov-Smirnov tests rejected normality at each scan time point for each group. The comparison was made with the Mann-Whitney U-test. B). Most patients did not undergo a scan at 240 min (patients with 240 min scan: Bil-I [$n = 9$] and Bil-II [$n = 6$]). *Abbreviations: Bil-I, laparoscopic distal subtotal gastrectomy with Billroth I reconstruction, Bil-II, laparoscopic distal subtotal gastrectomy with Billroth II reconstruction.

from operation to endoscopy). Percent emptying was compared between patients who had food residues and those who did not using the Mann-Whitney U-test. ROC curve analyses and comparisons of ROC curves were done to find the threshold of percent emptying for detecting the presence of food residue. SPSS (ver. 19; IBM Corp., Armonk, NY, USA) and Medcalc software (ver. 13.3.3.0; Medcalc, Inc., Ostend, Belgium) were used for analyses. *P* values < 0.05 were considered to indicate statistical significance. Graphs of percent emptying were made using the clustered multiple comparison graph function of the Medcalc program.

Results

General information

In total, 46 patients were enrolled (Billroth I = 21 and Billroth II = 25). In all patients, distal subtotal gastrectomy was performed with truncal vagotomy. Patient characteristics are described in **Table 1**. There were no significant differences in age, gender, or interval between scan and surgery between the groups. Sixteen patients underwent second GESs. The proportion of patients who underwent a second scan (postoperative 3-6 months) did not differ between groups. Endoscopic examinations were performed in 41 patients.

Gastric emptying and operation type

In the GESs at postoperative 1 week, both groups showed severely delayed gastric emptying. However, emptying was significantly faster in the Billroth II group than the Billroth I group (**Figure 1**). At 120 min, the median value of percent emptying was 2% in group I (95% CI for median was 0-10.5) and 16.5% (7.5-29.5) in group II. In the second scans, at postoperative 3-6 months, both groups again showed delayed gastric emptying. However, there were no sig-

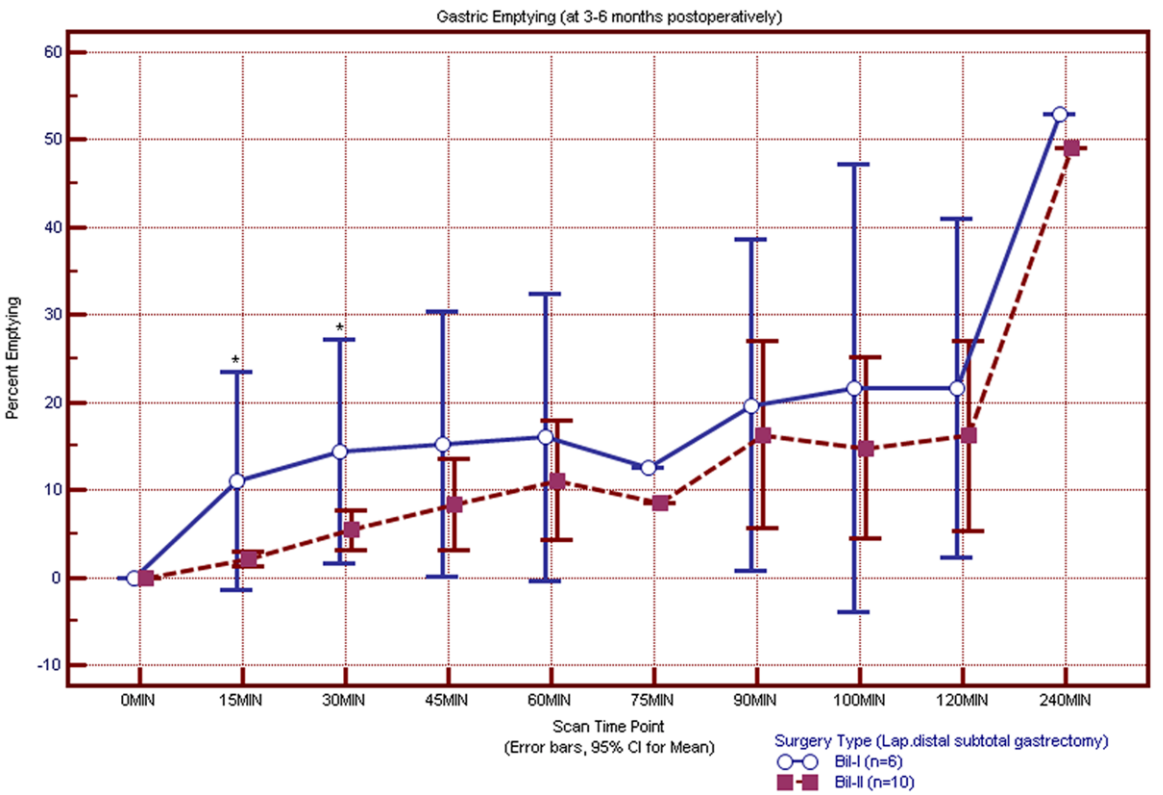

Figure 2. Comparison of percent gastric emptying between Billroth I and II patients. Scans were done 3-6 months after the operation (asterisks indicate $P < 0.05$). Notes: The data at 75 min and 240 min failed the Kolmogorov-Smirnov normality test. Thus this comparison graph at 75 min and 240 min uses the median value.

nificant differences between the groups (**Figure 2**). Nonetheless, group I showed more emptying at very early time points (15, 30 min), but the difference disappeared in later scans.

In paired comparisons, there were no significant changes between the first and second scans at any time point. Within-group analyses showed no significant changes between scans.

Presence of food residue at endoscopy

Among the 46 patients, 41 underwent endoscopy at 6 months after the operation (**Table 1**). Of these, 30 (73.2%) patients had a significant amount of food residue in the stomach hindering evaluation of the gastric wall. They had to schedule another endoscopy for later. Eleven (26.8%) patients did not have any food residues.

The proportion of patients with food residue did not significantly differ between the groups (51.2% in Billroth I group and 48.8% in Billroth II group, $P = 0.92$, χ^2 test). Other clinical factors (gender, age, and interval between operation and endoscopy) were not significantly different between patients with and without food residue.

Food residue at endoscopy and GES

Between patients with and without food residue at endoscopy, there were no significant differences in percent emptying at the postoperative 1 week scan at any time point. Among those who underwent endoscopy, 16 patients had a second GES. At the second GES, the percent emptying differed between patients with and without the presence of food residue at endoscopy (**Figure 3**). However, the difference was not statistically significant.

ROC analysis revealed that a cut-off value of ≤ 30% emptying at 100 and 120 min in the second GES (postoperative 3-6 month scan) was both highly sensitive and specific for predicting the presence of food residue at endoscopy (90.9% and 75% for 100 min, 91.7% and 75% for 120 min, respectively; **Table 2**). At other

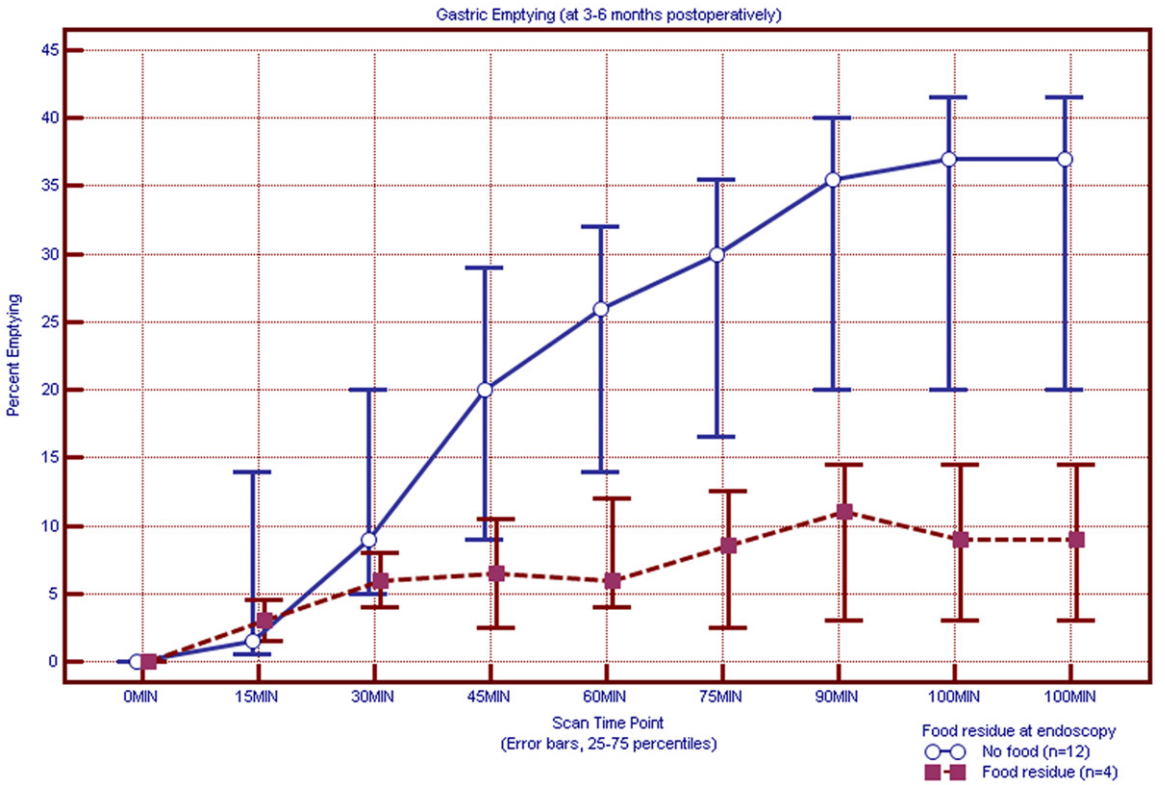

Figure 3. Comparison of percent gastric emptying between patients who had food residue based on endoscopies performed within 6 months after the laparoscopic distal subtotal gastrectomy. Notes: The Kolmogorov-Smirnov test rejected normality at every scan time point in each group. Thus comparisons were made using the Mann-Whitney U-test. At 100 min and 120 min, *p* values were 0.0673 and 0.0687 respectively. In other scan time points, *p* values were all over 0.1. Statistical comparison at time point 240 min could not be made due to small number of patients (n = 3).

time points, percent emptying did not show a statistically significant difference (data not shown). Between 100 and 120 min, there was no difference in AUC (**Table 2**).

Discussion

The Billroth I group showed slower gastric emptying than the Billroth II group at postoperative 1 week (**Figure 1**). However, this difference disappeared by the scan 3-6 months later. Only a few studies have compared GESs between Billroth I and Billroth II groups [11, 15]. D'Amato et al. [11] reported that patients in both groups showed incomplete emptying and slower emptying than a Roux-en-Y group. Lukasiewicz et al. [15] reported that more Billroth I and II patients showed postoperative gastric retention than Roux-en-Y patients. There is an inadequate amount of scintigraphic data available to make comparisons between Billroth I and II patients.

In comparisons between operation types, some studies have used endoscopy but without GESs [1, 5, 16, 17]. Watanabe et al. [16] reported that Billroth I reconstruction was an independent risk factor for the presence of food residue at endoscopy. Jung et al. [5] reported that the total incidence of food retention, based on endoscopy, was 55.5% at 3 months after a distal subtotal gastrectomy. Patients who had Billroth I operations showed more food retention than those with Billroth II operations, based on early endoscopy after the operation (postoperative 3 months); however, this difference disappeared later (at postoperative months 12 and 24), similar to our results. Cho et al. [17] reported that independent risk factors for food residue at endoscopy were endoscopy at 3 months, diabetes mellitus, a body mass index of < 19.5, and laparoscopic surgery. In their study, reconstruction type (Billoth I/II) was not a risk factor [17]. Jung et al. [5] and Watanabe et al. [16] reported that patients with food retention did not have specific symptoms in partial gastrectomy patients. Patients without specific symptoms could still have food resi-

Table 2. Comparison of ROC with percent emptying at the postoperative 3-6 months scan and the presence of food residue at endoscopy

	AUC	SE	95% CI	Criterion	Sensitivity (95% CI)	Specificity 95% CI	+LR	-LR	P	Comparison of AUC
100 min	0.818	0.141	0.539 to 0.965	≤ 30	90.91 (58.7-99.8)	75.00 (19.4-99.4)	3.64	0.12	0.0237	P = 1
120 min	0.818	0.128	0.539 to 0.965	≤ 30	91.67 (61.5-99.8)	75.00 (19.4-99.4)	3.67	0.11	0.0185	

Abbreviations: SE, standard error: CI, Confidence interval: +LR, positive likelihood ratio: -LR, negative likelihood ratio.

dues. Thus, even a lack of symptoms related to delayed gastric emptying does not guarantee a successful endoscopic evaluation.

In our study, we found that the presence of food residue at endoscopy in patients who underwent subtotal gastrectomies could be predicted by GES using a threshold of ≤ 30 percent emptying at 100 and 120 min in scans taken at postoperative 3-6 months (**Table 2**). Both of these times showed sensitivities greater than 90% (**Table 2**).

Jung et al. [18], who compared gastric emptying in healthy people between scintigraphy on one day and endoscopy after X-ray on the next day, reported that there was no significant correlation between the results of GESs and the presence of food residues in the stomach [18]. However, they used radiopaque materials in their tests, which were consumed together with a solid meal 3 h before the endoscopy. Differences between an indigestible (radiopaque materials) and digestible meal might be the reason of different emptying patterns.

There are many factors that should be considered when comparing results of studies about gastric emptying. Collins et al. [19] reported that gastric emptying was related to the volume, weight, content (fat, protein, carbohydrate), acidity, particle size, and caloric density of a meal. Thus, differences in test meals might also cause differences between studies. Gastric emptying is also influenced by various factors such as innervation, muscles, hormones, and functional resistance of the duodenum [7]. Thus, gastric emptying of patients who have undergone a subtotal gastrectomy would not be expected to be the same as that of a normal healthy person. Jung et al. [5] reported that the total incidences of food retention were 55.5%, 31.9%, and 20.9% at 3, 12, and 24 months after distal subtotal gastrectomy, respectively [5]. Therefore, the interval from the operation to the scan is also important.

In our study, emptying was severely delayed at both postoperative week 1 (14.2 at 120 min) and at 3-6 months (18.3 at 120 min; **Figures 1**, **2**). This is much slower than the results of previous studies on partial gastrectomy patients [10, 13, 14, 20]. However, there were many differences between the studies in terms of test meals, operation types, scan positions, and intervals from operation to scan. Thus, direct comparisons of the results cannot be made. More data are needed on gastric emptying of post-subtotal gastrectomy patients.

In this study, the size of the test meal was relatively small [1, 5, 21, 22]. Previously, at our institution, we had given a larger test meal to patients who underwent subtotal gastrectomies. However, most of them failed to eat the whole meal within the instructed time. Considering the relatively short interval from operation to scan, we reduced the size of the meal for these subtotal gastrectomy patients. This could help explain the differences in the results. Further studies on the appropriate test meal protocols for patients who have had recent subtotal gastrectomies are needed, with consideration of the interval between operation and scan.

This study had several limitations. First, analyses using scans with a longer interval from operation to scan could not be done. Second, we only compared Billroth I and II patients. Finally, there was a small number of enrolled patients and a lack of a 4 h scan in most cases.

Despite these limitations, our data indicate that gastric emptying differs between operation types. In addition, at a threshold of ≤ 30% emptying, GESs can be used to significantly predict the presence of food residue which can hinder accurate endoscopic evaluations.

A GES within 1 week after a distal subtotal gastrectomy showed slower emptying in the Billroth I group than in the Billroth II group. At a percent

emptying threshold of ≤ 30% at 120 min, a GES can significantly predict the presence of food residue in subtotal gastrectomy patients even after following typical fasting instructions. For these patients, stricter instructions, such as a longer fasting period, should be applied.

Disclosure of conflict of interest

None.

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References

[1] Ahn JY, Jung HY, Bae SE, Jung JH, Choi JY, Kim MY, Lee JH, Choi KS, Kim do H, Choi KD, Song HJ, Lee GH, Kim JH and Han S. Proper preparation to reduce endoscopic reexamination due to food residue after distal gastrectomy for gastric cancer. Surg Endosc 2013; 27: 910-917.

[2] Bearzi I and Ranaldi R. Multifocal early gastric cancer: morphology and histogenesis. Pathol Res Pract 1986; 181: 144-147.

[3] Kosaka T, Miwa K, Yonemura Y, Urade M, Ishida T, Takegawa S, Kamata T, Ooyama S, Maeda K, Sugiyama K, et al. A clinicopathologic study on multiple gastric cancers with special reference to distal gastrectomy. Cancer 1990; 65: 2602-2605.

[4] Otsuji E, Kuriu Y, Ichikawa D, Okamoto K, Hagiwara A and Yamagishi H. Clinicopathologic characteristics and prognosis of synchronous multifocal gastric carcinomas. Am J Surg 2005; 189: 116-119.

[5] Jung HJ, Lee JH, Ryu KW, Lee JY, Kim CG, Choi IJ, Kim YW and Bae JM. The influence of reconstruction methods on food retention phenomenon in the remnant stomach after a subtotal gastrectomy. J Surg Oncol 2008; 98: 11-14.

[6] Rider JA, Foresti-Lorente RF, Garrido J, Puletti EJ, Rider DL, King AH and Bradley SP. Gastric bezoars: treatment and prevention. Am J Gastroenterol 1984; 79: 357-359.

[7] Bouras EP and Scolapio JS. Gastric motility disorders: management that optimizes nutritional status. J Clin Gastroenterol 2004; 38: 549-557.

[8] Abell TL, Camilleri M, Donohoe K, Hasler WL, Lin HC, Maurer AH, McCallum RW, Nowak T, Nusynowitz ML, Parkman HP, Shreve P, Szarka LA, Snape WJ Jr and Ziessman HA. Consensus recommendations for gastric emptying scintigraphy: a joint report of the American Neurogastroenterology and Motility Society and the Society of Nuclear Medicine. Am J Gastroenterol 2008; 103: 753-763.

[9] Parkman HP, Hasler WL and Fisher RS. American Gastroenterological Association technical review on the diagnosis and treatment of gastroparesis. Gastroenterology 2004; 127: 1592-1622.

[10] Takahashi T, Endo S, Nakajima K, Souma Y and Nishida T. Effect of rikkunshito, a chinese herbal medicine, on stasis in patients after pylorus-preserving gastrectomy. World J Surg 2009; 33: 296-302.

[11] D'Amato A, Montesani C, Cristaldi M, Giovannini C, Pronio A, Santella S, Ventroni G, Ronga G and Ribotta G. [Restoration of digestive continuity after subtotal gastrectomy: comparison of the methods of Billroth I, Billroth II and roux en Y. Randomized prospective study]. Ann Ital Chir 1999; 70: 51-56.

[12] Michalsky D, Dvorak P, Belacek J and Kasalicky M. Radical resection of the pyloric antrum and its effect on gastric emptying after sleeve gastrectomy. Obes Surg 2013; 23: 567-573.

[13] Li DS, Xu HM, Han CQ and Li YM. Effects on the pouch of different digestive tract reconstruction modes assessed by radionuclide scintigraphy. World J Gastroenterol 2010; 16: 1402-1408.

[14] Michiura T, Nakane Y, Kanbara T, Nakai K, Inoue K, Yamamichi K and Kamiyama Y. Assessment of the preserved function of the remnant stomach in pylorus-preserving gastrectomy by gastric emptying scintigraphy. World J Surg 2006; 30: 1277-1283.

[15] Lukasiewicz S and Jonderko K. Partial gastric resection for peptic ulcer--comparison of the effect of variant reconstructive procedures on gastric emptying, gastric acid secretion and gastrin release in the early postoperative period II. Billroth-I gastroduodenostomy and comparison versus gastroenteroanastomotic procedures. East Afr Med J 1994; 71: 414-420.

[16] Watanabe H, Adachi W, Koide N and Yazawa I. Food residue at endoscopy in patients who have previously undergone distal gastrectomy: risk factors and patient preparation. Endoscopy 2003; 35: 397-401.

[17] Cho SB, Yoon KW, Park SY, Lee WS, Park CH, Joo YE, Kim HS, Choi SK and Rew JS. Risk factors for food residue after distal gastrectomy and a new effective preparation for endoscopy: the water-intake method. Gut Liver 2009; 3: 186-191.

[18] Jung IS, Kim JH, Lee HY, Park H and Lee SI. Endoscopic evaluation of gastric emptying and effect of mosapride citrate on gastric emptying. Yonsei Med J 2010; 51: 33-38.

[19] Collins PJ, Horowitz M, Cook DJ, Harding PE and Shearman DJ. Gastric emptying in normal subjects--a reproducible technique using a single scintillation camera and computer system. Gut 1983; 24: 1117-1125.

[20] Nakane Y, Michiura T, Sakuramoto K, Kanbara T, Nakai K, Inoue K and Yamamichi K. Evaluation of the preserved function of the remnant stomach in pylorus preserving-gastrectomy by gastric emptying scintigraphy. Gan To Kagaku Ryoho 2007; 34: 25-28.

[21] Donohoe KJ, Maurer AH, Ziessman HA, Urbain JL, Royal HD, Martin-Comin J; Society for Nuclear Medicine; American Neurogastroenterology and Motility Society. Procedure guideline for adult solid-meal gastric-emptying study 3.0. J Nucl Med Technol 2009; 37: 196-200.

[22] Vasavid P, Chaiwatanarat T, Pusuwan P, Sritara C, Roysri K, Namwongprom S, Kuanrakcharoen P, Premprabha T, Chunlertrith K, Thongsawat S, Sirinthornpunya S, Ovartlarnporn B, Kachintorn U, Leelakusolvong S, Kositchaiwat C, Chakkaphak S and Gonlachanvit S. Normal Solid Gastric Emptying Values Measured by Scintigraphy Using Asian-style Meal:A Multicenter Study in Healthy Volunteers. J Neurogastroenterol Motil 2014; 20: 371-378.