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Original Article

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Closure of Petersen's Space Lowers the Incidence of Gastric Food Retention after Distal Gastrectomy with Gastrojejunostomy in Gastric Cancer Patients

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

ABSTRACT

Purpose: Delayed gastric emptying usually manifests as gastric food retention. This study aimed to evaluate the incidence of gastric food retention after distal gastrectomy with gastrojejunostomy in gastric cancer patients and identify the risk factors for its development.
Materials and Methods: We retrospectively enrolled 245 patients who underwent distal gastrectomy with gastrojejunostomy for gastric cancer at Boramae Medical Center between March 2017 and December 2019. We analyzed the presence of gastric food residue via computed tomography (CT) scans at 3 and 12 months postoperatively and analyzed the risk factors that may influence the development of gastric food retention.
Results: CT scans were performed on 235 patients at 3 months and on 217 patients at 12 months postoperatively. In the group that received closure of Petersen's space, the incidence of gastric food retention was significantly low as per the 3- and 12-month postoperative follow-up CT scans (P=0.028 and 0.003, respectively). In addition, hypertension was related to gastric food retention as per the 12-month postoperative follow-up CT scans (P=0.011). No other factors were related to the development of gastric food retention. In the multivariate analysis, non-closure of Petersen's space (hazard ratio [HR], 2.54; 95% confidence interval [CI], 1.20–5.38; P=0.010) was the only significant risk factor for gastric food retention at 3 months postoperatively, while non-closure of Petersen's space (HR, 2.81; 95% CI, 1.40-5.64; P=0.004) and hypertension (HR, 2.30; 95% CI, 1.14–4.63; P=0.020) were both significant risk factors for gastric food retention at 12 months postoperatively.
Conclusions: Closure of Petersen's space has an effect on decrease the incidence of gastric food retention after distal gastrectomy with gastrojejunostomy in gastric cancer patients.

Keywords: Stomach neoplasms; Gastric emptyng; Internal hernia

INTRODUCTION

Gastric cancer is the fifth most common cancer and the third most fatal cancer worldwide [1]. Although the incidence is decreasing, gastric cancer is still the second most common cancer among men and the third most common among women in Korea [2]. The disease-free

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survival rate of gastric cancer has increased over time; this is related to an increase in early gastric cancer diagnosis, a decrease in operative mortality, and the administration of adjuvant chemotherapy [3]. With the increased survival rate of gastric cancer, improving the quality of life (QoL) has been the main concern for patients who have undergone gastrectomy.

Even after recovery and discharge post-surgery, patients often experience post-gastrectomy syndromes, such as dumping syndrome, delayed gastric emptying (DGE), alkaline reflux gastritis, and anemia, which decrease the QoL [4]. After distal gastrectomy, the remnant stomach may play a critical role in post-gastrectomy syndrome, and DGE is a common post-gastrectomy syndrome after distal gastrectomy for gastric cancer. The major causes of DGE without the evidence of mechanical obstruction are diabetes and postsurgical and idiopathic issues [5]. Patients with the evidence of DGE on gastric emptying scans were frequently observed to have gastric stasis [6]. In outpatient clinics, clinicians usually observe DGE, which manifests as gastric food retention on computed tomography (CT) scans.

In this study, we evaluated the incidence of gastric food retention based on CT scans after distal gastrectomy with gastrojejunostomy in gastric cancer patients and analyzed the predictive factors for its development.

MATERIALS AND METHODS

Patients

The gastric cancer database of Seoul Metropolitan Government-Seoul National University (SMG-SNU) Boramae Medical Center was retrospectively reviewed. The inclusion criteria for this study were as follows: patients with histologically proven gastric cancer located in the lower or middle part of the stomach; distal gastrectomy with gastrojejunostomy, which included Billroth II gastrojejunostomy (B-II); B-II reconstruction with Braun jejunojejunostomy; and uncut Roux-en-Y. From March 2017 to December 2019, we selected data from 245 patients who underwent distal gastrectomy with gastrojejunostomy for gastric cancer. The study protocol was approved by the Institutional Review Board of the SMG-SNU Boramae Medical Center (No. 10-2021-90). Patient records were anonymized and de-identified after data collection.

Operative procedures

All operations were completed by two expert surgeons with an experience of performing more than 200 cases of laparoscopic distal gastrectomy. Distal gastrectomy was performed using an open or laparoscopic approach, and D1+ or D2 lymph node dissection was performed according to the clinical and surgical stages of gastric cancer.

After distal gastrectomy, antecolic antiperistaltic gastrojejunostomy was performed using a linear stapler. Gastrojejunostomy was performed at the wall posterior to the greater curvature. In conventional B-II gastrojejunostomy, gastrojejunostomy was performed approximately 15–20 cm away from the ligament of Treitz. Braun jejunojejunostomy was performed between the afferent loop, 5–10 cm away from the ligament of Treitz, and the efferent loop, 30 cm away from the site of gastrojejunostomy. Uncut Roux-en-Y was performed by blocking the afferent loop between the sites of gastrojejunostomy and jejunojejunostomy using a noncutting linear stapler.

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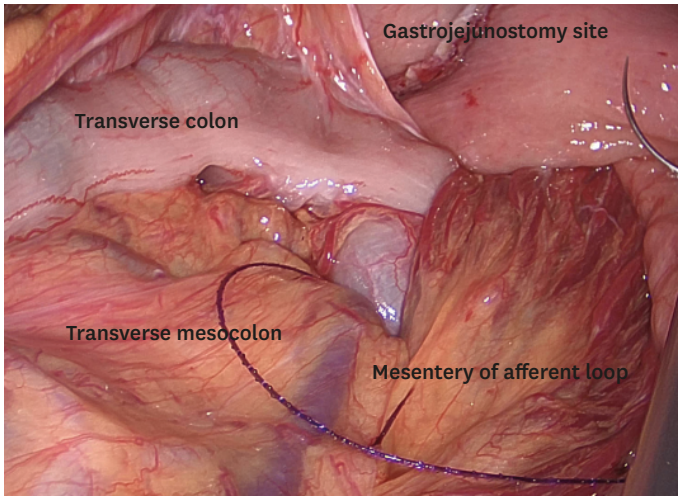

Fig. 1. Closure of Petersen's space: continuous suture between the transverse mesocolon and mesentery of the afferent loop.

In cases of Petersen's space closure, the procedure was performed with continuous suture of the transverse mesocolon and mesentery of the afferent loop using a non-absorbable suture material (**Fig. 1**).

Data collection and definition

Data regarding patient demographics, clinicopathological characteristics, and operative data were collected from the gastric cancer database. In the outpatient clinic, we performed regular CT scans to evaluate recurrence. All patients fasted for more than 6 hours prior to the CT scans. In this study, we evaluated gastric food retention at 3 and 12 months postoperatively. We categorized the quantity of food residue in the stomach on a grade of 0 to 2: grade 0, no food residue in the stomach; grade 1, food present with preserved stomach rugae; grade 2, stomach filled with food such that there are no rugae (**Fig. 2**). We checked the time of CT taken in each patient. CT findings were retrospectively reviewed by two surgeons having no other data or information about the patients.

Statistical analysis

Data are expressed as the mean ± standard deviation or number (%). The analysis of variance was used for continuous variables, and Pearson's χ^2 test or Fisher's exact test was used for categorical variables. For the multivariate analysis, a logistic regression model was used. Two-sided P-values of <0.05 were considered statistically significant. All statistical calculations were performed using IBM SPSS Statistics for Windows ver. 21 (IBM Corp., Armonk, NY, USA).

Fig. 2. Gastric food retention in computed tomography scans. (A) Grade 0: no food residue in the stomach. (B) Grade 1: presence of food with the stomach rugae preserved. (C) Grade 2: stomach filled with food such that there are no rugae.

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RESULTS

The clinicopathological characteristics of the patients are shown in **Table 1**. Among the 245 patients, 175 patients were men and 70 were women, with a mean age of 68.1±10.2 years. The majority (93.5%) of patients had American Society of Anesthesiologists (ASA) scores of 1 and 2. The number of patients diagnosed with diabetes mellitus (DM) and hypertension was 66 (26.9%) and 135 (55.1%), respectively. Adjuvant chemotherapy was administered to 47 patients (19.2%). Regarding surgical procedures, most surgeries were performed using a laparoscopic approach (93.9%), and the most common reconstruction method was B-II reconstruction with Braun jejunojejunostomy (94.3%). D1+ lymph node dissection was performed in 140 patients (57.1%). Regardless of the surgical method, closure of Petersen's space was performed in 187 patients (76.3%). The mean operative time was approximately 156 minutes.

The univariate analysis of risk factors for gastric food retention as per the 3-month follow-up CT scan is shown in **Table 2**. Among the 245 enrolled patients, a 3-month follow-up CT scan was performed for 235 patients. There were 160 patients with gastric food retention (68.1%), comprising of 108 patients with grade I (46%) and 52 patients with grade II (22.1%) retention. There was no significant difference in time of CT taken among the groups.
In the univariate analysis, the age, sex, ASA score, body mass index, underlying disease history, adjuvant chemotherapy history, approach method, lymph node dissection method, reconstruction method, operation time, and pathological factors were not found to be risk factors for gastric food retention. However, the closure of Petersen's space significantly decreased the incidence of gastric food retention (P=0.028). The logistic regression model showed that non-closure of Petersen's space (hazard ratio [HR], 2.54; 95% confidence interval [CI], 1.20–5.38; P=0.010) was the only significant risk factor for gastric food retention at 3 months postoperatively (**Table 3**).

The univariate analysis of risk factors for gastric food retention as per the 12-month follow-up CT scan is shown in **Table 4**. Among the 245 enrolled patients, a 12-month follow-up CT scan was performed for 217 patients. There were 52 patients with gastric food retention (24.0%), comprising of 49 patients with grade I (22.6%) and 3 patients with grade II (1.4%) retention. There was no significant difference in time of CT taken among the groups. In univariate analysis, non-closure of Petersen's space and hypertension were both significantly associated with the development of gastric food retention at 12 months postoperatively (P=0.003, P=0.011). None of the other variables were significant risk factors for gastric food retention. The logistic regression model also showed that non-closure of Petersen's space (HR, 2.81; 95% CI, 1.40–5.64; P=0.004) and hypertension (HR, 2.30; 95% CI, 1.14–4.63; P=0.020) were both significant risk factors for gastric food retention at 12 months postoperatively (**Table 3**).

DISCUSSION

Distal gastrectomy with gastrojejunostomy is commonly performed for lower- or middle-third gastric cancers. In the immediate postoperative period, the majority of patients experience a decreased QoL. Although most patients recover, one third experience a sustained decrease in the QoL after surgery [4]. The major causes of DGE are diabetes and postsurgical and idiopathic issues [5,7]. Numerous factors have been associated with DGE after gastrectomy, and DGE can be evaluated using a gastric emptying scan. Kim et al. [6]

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Table 1. Clinicopathological characteristics

Variables	Values (n=245)
Age (yr)	68.1±10.2
Sex	
Male	175 (71.4)
Female	70 (28.6)
ASA score	
1	46 (18.8)
2	183 (74.7)
3	15 (6.1)
4	1 (0.4)
BMI (kg/m^2)	24.5±3.4
Diabetes mellitus	
Absent	179 (73.1)
Present	66 (26.9)
Hypertension	
Absent	110 (44.9)
Present	135 (55.1)
Liver cirrhosis (Child–Pugh class)	
0	240 (98.0)
1	2 (0.8)
2	3 (1.2)
Pulmonary disease	
Absent	233 (95.1)
Present	12 (4.9)
Adjuvant chemotherapy	
Not completed	198 (81.8)
Completed	47 (19.2)
Approach method	
Open	15 (6.1)
Laparoscopic	230 (93.9)
Lymph node dissection	
D1+	140 (57.1)
D2	105 (42.9)
Reconstruction method	
B-II	9 (3.7)
B-II with Braun	231 (94.3)
Uncut Roux-en-Y	5 (2.0)
Closure of Petersen's space	
Not done	58 (23.7)
Done	187 (76.3)
Operation time (min)	155.6±43.8
Location of tumor	
Lower third	173 (70.6)
Middle third	72 (29.4)
T stage	
T1	174 (71.0)
T2	22 (9.0)
T3	23 (9.4)
T4	26 (10.6)
N stage	
N0	191 (78.0)
N1	19 (7.8)
N2	18 (7.3)
N3	17 (6.9)
Number of retrieved lymph nodes	36.8±13.9

Values are presented as mean ± standard deviation or number (%).
ASA = American Society of Anesthesiologists; BMI = body mass index; B = Billroth.

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Table 2. Univariate analysis of risk factors for gastric food retention on 3-month follow-up CT scans

Variables	Grade 0 (n=75)	Grade 1 (n=108)	Grade 2 (n=52)	P-value
Age (yr)	67.4±11.3	68.7±10.1	67.5±9.0	0.644
Sex				0.613
Male	55 (73.3)	77 (71.3)	34 (65.4)	
Female	20 (26.7)	31 (28.7)	18 (34.6)	
Time of CT taken (o'clock)	12.9±2.6	12.7±2.7	13.6±3.4	0.161
ASA score				0.538
1	15 (20.0)	19 (17.6)	12 (23.1)	
2	53 (70.7)	85 (78.7)	36 (69.2)	
3	6 (8.0)	4 (3.7)	4 (7.7)	
4	1 (1.3)	0 (0.0)	0 (0.0)	
BMI (kg/m^2)	24.5±3.5	24.8±3.3	24.6±3.4	0.436
Diabetes mellitus				0.857
Absent	57 (76.0)	78 (72.2)	39 (75.0)	
Present	18 (24.0)	30 (27.8)	13 (25.0)	
Hypertension				0.349
Absent	40 (53.3)	47 (43.5)	22 (42.3)	
Present	35 (46.7)	61 (56.5)	30 (57.7)	
Liver cirrhosis (Child-Pugh class)				0.475
0	72 (96.0)	107 (99.1)	51 (98.1)	
1	1 (1.3)	1 (0.9)	0 (0.0)	
2	2 (2.7)	0 (0.0)	1 (1.9)	
Pulmonary disease				0.863
Absent	72 (32.3)	102 (45.7)	49 (22.0)	
Present	3 (25.0)	6 (50.0)	3 (25.0)	
Adjuvant chemotherapy				0.361
Not completed	59 (78.7)	91 (84.3)	39 (75.0)	
Completed	16 (21.3)	17 (15.7)	13 (25.0)	
Approach method				0.836
Open	5 (6.7)	6 (5.6)	4 (7.7)	
Laparoscopic	70 (93.3)	102 (94.4)	48 (92.3)	
Lymph node dissection				0.635
D1+	40 (53.3)	62 (57.4)	28 (53.8)	
D2	35 (46.7)	46 (42.6)	24 (46.2)	
Reconstruction method				0.843
B-II	3 (4.0)	4 (3.7)	1 (1.9)	
B-II with Braun	70 (93.3)	101 (93.5)	51 (98.1)	
Uncut Roux-en-Y	2 (2.7)	3 (2.8)	0 (0.0)	
Closure of Petersen's space				0.028
Not completed	10 (13.3)	28 (25.9)	17 (32.7)	
Completed	65 (86.7)	80 (74.1)	35 (67.3)	
Operation time (min)	155.7±54.9	154.4±36.3	155.6±36.1	0.976
Location of tumor				0.254
Lower third	54 (72.0)	76 (70.4)	36 (69.2)	
Middle third	21 (28.0)	32 (29.6)	16 (30.8)	
T stage				0.356
T1	49 (65.3)	82 (75.9)	34 (65.4)	
T2	7 (9.3)	7 (6.5)	7 (13.5)	
T3	7 (9.3)	8 (7.4)	8 (15.4)	
T4	12 (16.0)	11 (10.2)	3 (5.8)	
N stage				0.700
N0	55 (73.3)	90 (83.3)	38 (73.1)	
N1	4 (5.3)	12 (11.1)	2 (3.8)	
N2	8 (10.7)	1 (0.9)	8 (15.4)	
N3	8 (10.6)	5 (4.6)	4 (7.7)	
Number of retrieved lymph nodes	39.2±13.9	36.0±14.0	36.4±14.2	0.292

Values are presented as mean ± standard deviation or number (%).
CT = computed tomography; ASA = American Society of Anesthesiologists; BMI = body mass index; B = Billroth.

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Table 3. Multivariate analysis of risk factors for gastric food retention on 3- and 12-month follow-up CT scans

Variables	HR	95% CI	P-value
3-month follow-up CT scan			
Non-closure of Petersen's space	2.54	1.20–5.38	0.010
12-month follow-up CT scan			
Non-closure of Petersen's space	2.81	1.40–5.64	0.004
Hypertension	2.30	1.14–4.63	0.020
Diabetes mellitus	1.61	0.79–3.28	0.189

CT = computed tomography; HR = hazard ratio; CI = confidence interval.

reported that 53.2% of patients had DGE after distal gastrectomy, which is related to the duration of the postoperative period and the laparoscopic method used. Gastric stasis was frequently observed in patients with DGE via a gastric emptying scan. In most studies, gastric food residues have been evaluated using endoscopic findings. However, endoscopy is routinely performed at most facilities within a year postoperatively. To evaluate the gastric food residue of patients at 3 months postoperatively, we utilized CT scans. In addition, to maintain consistency in our study, CT scans were also used during the 12-month follow-up.

In gastric cancer surgery, vagotomy is usually performed for lymphadenectomy, which can decrease the motility of the remnant stomach [8]. Some studies have reported underlying endocrine or metabolic disease and a Billroth I reconstruction history to be independent risk factors for food residue [9,10]. However, other studies have demonstrated that reconstruction methods after distal gastrectomy are not relevant to food retention [11]. In this study, cases of Billroth I anastomosis were not included in order to focus on closure of Petersen's space. Although DGE was observed in approximately 40% of patients with type 1 DM and 20% of patients with type 2 DM [12], we could not find a statistically significant difference between DM and non-DM patients in our study.

In our hospital, Petersen's space has been routinely closed in distal gastrectomy with gastrojejunostomy cases since 2018. Before 2018, one surgeon routinely closed Petersen's space, while the others did not. Closure of Petersen's space was performed for the purpose of preventing Petersen hernia that is a rare type of internal hernia that occurs when the small bowel slips in a potential space surrounded by the caudal surface of the transverse mesocolon, retroperitoneum, and mesentery of the gastrojejunostomy limb [13]. The incidence of internal hernia ranges between 0.9% and 4.5% [14,15]. Petersen hernia is characterized by abdominal pain, nausea, and vomiting. However, these symptoms may be transient and resolve on their own [16]. In our study, Petersen hernia was not observed in any of the 245 cases.

Interestingly, in the group that received closure of Petersen's space, there was a low percentage of gastric food retention observed via the CT scans performed at 3 and 12 months postoperatively. In the multivariate analysis, non-closure of Petersen's space was the only significant risk factor for gastric food retention at 3 months, while non-closure of Petersen's space and hypertension were both significant risk factors at 12 months postoperatively. Our hypothesis is that the rotation of the remnant stomach and gastrojejunostomy site without definite Petersen hernia might lead to gastric food retention. After surgery, the remnant stomach and gastrojejunostomy site could rotate to some degree, which might impede the passage of food material. Closure of Petersen's space might maintain the axis of the stomach and gastrojejunostomy site and induce the adhesion of the afferent loop to the transverse mesocolon without their axis being rotated. Furthermore, if Petersen's space is not closed,

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Table 4. Univariate analysis of risk factors for gastric food retention on 12-month follow-up CT scan

Variables	Grade 0 (n=165)	Grade 1 (n=49)	Grade 2 (n=3)	P-value
Age (yr)	67.6±10.6	68.7±7.6	73.7±11.2	0.367
Sex				0.439
Male	120 (72.7)	31 (63.3)	2 (66.7)	
Female	45 (27.3)	18 (36.7)	1 (33.3)	
Time of CT taken (o'clock)	11.4±2.4	11.4±1.8	12.3±4.0	0.784
ASA score				0.295
1	39 (23.6)	6 (12.2)	1 (33.3)	
2	118 (71.5)	40 (81.6)	2 (66.7)	
3	8 (4.8)	3 (6.1)	0 (0.0)	
BMI (kg/m^2)	24.8±3.4	25.3±3.1	24.7±3.6	0.313
Diabetes mellitus				0.088
Absent	128 (77.6)	31 (63.3)	2 (66.7)	
Present	37 (22.4)	18 (36.7)	1 (33.3)	
Hypertension				0.011
Absent	84 (50.9)	14 (28.6)	1 (33.3)	
Present	81 (49.1)	35 (71.4)	2 (66.7)	
Liver cirrhosis (Child–Pugh class)				0.828
0	163 (98.8)	49 (100.0)	3 (100.0)	
1	1 (0.1)	0 (0.0)	0 (0.0)	
2	1 (0.1)	0 (0.0)	0 (0.0)	
Pulmonary disease				0.693
Absent	160 (97.0)	47 (95.9)	3 (100.0)	
Present	5 (3.0)	2 (4.1)	0 (0.0)	
Adjuvant chemotherapy				0.168
Not completed	134 (81.2)	40 (81.6)	1 (33.3)	
Completed	31 (18.8)	9 (18.4)	2 (66.7)	
Approach method				0.233
Open	11 (6.7)	3 (6.1)	1 (33.3)	
Laparoscopic	154 (93.3)	46 (93.9)	2 (66.7)	
Lymph node dissection				0.615
D1+	92 (55.8)	29 (59.2)	1 (33.3)	
D2	73 (44.2)	20 (40.8)	2 (66.7)	
Reconstruction method				0.574
B-II	4 (2.4)	0 (0.0)	0 (0.0)	
B-II with Braun	157 (95.2)	49 (100.0)	3 (100.0)	
Uncut Roux-en-Y	4 (2.4)	0 (0.0)	0 (0.0)	
Closure of Petersen's space				0.003
Not completed	31 (18.8)	19 (38.8)	2 (66.7)	
Completed	134 (81.2)	30 (61.2)	1 (33.3)	
Operation time (min)	154.3±43.6	159.6±47.6	163.7±47.1	0.598
Location of tumor				0.632
Lower third	113 (68.5)	34 (69.4)	3 (100.0)	
Middle third	52 (31.5)	15 (30.6)	0 (0.0)	
T stage				0.922
T1	119 (72.1)	39 (79.6)	0 (0.0)	
T2	14 (8.5)	5 (10.2)	0 (0.0)	
T3	16 (9.7)	3 (6.1)	3 (100.0)	
T4	16 (9.7)	2 (4.1)	0 (0.0)	
N stage				0.408
N0	131 (79.4)	41 (83.7)	1 (33.3)	
N1	12 (7.3)	2 (4.1)	0 (0.0)	
N2	13 (7.9)	3 (6.1)	1 (33.3)	
N3	9 (5.5)	3 (6.1)	1 (33.3)	
Number of retrieved lymph nodes	38.5±13.7	35.1±13.1	41.3±18.8	0.280

Values are presented as mean ± standard deviation or number (%).
CT = computed tomography; ASA = American Society of Anesthesiologists; BMI = body mass index; B = Billroth.

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the gastrojejunostomy site would be movable by the peristaltic waves of the stomach. It is considered that the peristaltic waves of the stomach might be delivered directly to the gastrojejunostomy site and jejunum when the gastrojejunostomy site is fixed via closure of Petersen's space, which could facilitate gastric emptying. In addition, hypertension was related to gastric food retention as per the 12-month postoperative follow-up CT scan. However, we could not find any evidence supporting the relationship between hypertension and gastric food retention. One study investigating risk factors for food residue after distal gastrectomy showed that hypertension was not a risk factor for gastric food retention [17]. As time passed, the incidence of gastric food retention tended to decrease (3 months, 68.1%; 12 months, 24.0%). This phenomenon could be due to the improvement in gastric motility and edema of the gastrojejunostomy site [18].

This study had some limitations. First, patients' symptoms and QoL data could not be collected because of the retrospective nature of this study. Therefore, we could not analyze the relationship between CT findings and subjective symptoms. In the near future, we plan to analyze the relationship between gastric food retention observed via CT scans and subjective symptoms of patients. Second, although all patients fasted for more than 6 hours prior to the CT scans, the exact duration of each patient's fasting before the CT scans could not be collected. However, we did investigate the time of CT taken in each patient and found no significant difference among the groups. We therefore believe that there would also be no significant difference among the groups regarding the duration of fasting before the CT scans. To the best of our knowledge, this is the first study demonstrating the effect of Petersen's space closure on gastric food retention, despite the lack of an exact mechanism for this phenomenon.

In conclusion, the present study showed that closure of Petersen's space may decrease the incidence of gastric food retention after distal gastrectomy with gastrojejunostomy in gastric cancer patients. In addition, the incidence of gastric food retention was found to decrease over time.

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