Retrospective Cohort Study

Long-term outcomes of postgastrectomy syndrome after total laparoscopic distal gastrectomy using the augmented rectangle technique

Suguru Yamauchi, Hajime Orita, Jun Chen, Hiroki Egawa, Yutaro Yoshimoto, Akira Kubota, Ryota Matsui, Yukinori Yube, Sanae Kaji, Shinichi Oka, Malcolm V Brock, Tetsu Fukunaga

Suguru Yamauchi, Hajime Orita, Jun Chen, Hiroki Egawa, Yutaro Yoshimoto, Akira Kubota, Ryota Matsui, Yukinori Yube, Sanae Kaji, Shinichi Oka, Tetsu Fukunaga, Department of Gastroenterology and Minimally Invasive Surgery, Juntendo University Hospital, Tokyo 113-8431, Japan

Malcolm V Brock, Department of Surgery, The Johns Hopkins University School of Medicine, Baltimore, MD 21205-2196, United States

Corresponding author: Suguru Yamauchi, MD, Doctor, Surgeon, Department of Gastroenterology and Minimally Invasive Surgery, Juntendo University Hospital, 3-1-3 Hongo, Bunkyo-ku, Tokyo 113-8431, Japan. s.yamauchi.gk@juntendo.ac.jp

Abstract

BACKGROUND

For total laparoscopic distal gastrectomies for gastric cancer, the reconstruction method is critical to the clinical outcome of the procedure. However, which reconstruction technique is optimal remains controversial. We originally reported the augmented rectangle technique (ART) as a reconstruction option for total laparoscopic Billroth I reconstructions. Still, little is known about its effect on long-term outcomes, specifically the incidence of postgastrectomy syndrome and its impact on quality of life.

AIM

To analyze postgastrectomy syndrome and quality of life after ART using the Postgastrectomy Syndrome Assessment Scale-37 (PGSAS-37) questionnaire.

METHODS

At Juntendo University, a total of 94 patients who underwent ART for Billroth I reconstruction with total laparoscopic distal gastrectomies for gastric cancer between July 2016 and March 2020 completed the PGSAS-37 questionnaire. Multidimensional analysis was performed, comparing those 94 ART cases from our institution (ART group) to 909 distal gastrectomy cases with a Billroth I reconstruction from other Japanese institutions who also completed the PGSAS-37 as part of a larger national database (PGSAS group).
RESULTS
Patients in the ART group had significantly better total symptom scores in all the symptom subscales (i.e., esophageal reflux, abdominal pain, meal-related distress, indigestion, diarrhea, constipation, and dumping). The loss of body weight was marginally greater for those in the ART group than in the PGSAS group (-9.3% vs -7.9%, \( P = 0.054 \)). The ART group scored significantly lower in their dissatisfaction of ongoing symptoms, during meals, and with daily life.

CONCLUSION
ART for Billroth I reconstruction provided beneficial long-term results for postgastrectomy syndrome and quality of life in patients undergoing total laparoscopic distal gastrectomies for gastric cancer.

Key Words: Laparoscopic distal gastrectomy; Postgastrectomy syndrome; Augmented rectangle technique; Billroth I; Postgastrectomy Syndrome Assessment Scale-37

©The Author(s) 2022. Published by Baishideng Publishing Group Inc. All rights reserved.

INTRODUCTION
The postgastrectomy syndrome (PGS) is an almost inevitable functional disorder after a radical gastrectomy for gastric cancer[1-3]. In addition to precipitating weight loss because of a reduction in the size (or loss) of the stomach, PGS can also induce systemic disturbances, such as dumping syndrome. These problems can lead to deterioration of a patient’s long-term postoperative quality of life (QOL)[4, 5]. Determining if there is a correlation between an increased risk of PGS and certain gastrectomy reconstruction techniques will ensure the optimal selection of appropriate surgical approaches to prevent and treat PGS. Importantly, it is appropriate to question how widely employed contemporary minimally invasive surgeries, such as laparoscopic gastrectomy, contribute to the risk of developing PGS.

Total laparoscopic distal gastrectomy (TLDG) for gastric cancer has evolved from a conventional laparoscopic-assisted gastrectomy to a more complex procedure incorporating more sophisticated techniques and instruments. Fukunaga et al[6] originally described the augmented rectangle technique (ART) as a novel Billroth I reconstruction after TLDG. ART for Billroth I reconstruction has been reported to have good short-term results, but no long-term PGS and QOL results have been reported.

The Postgastrectomy Syndrome Assessment Scale-37 (PGSAS-37) was developed by the Japanese Postgastrectomy Syndrome Working Party (JPGSWP) in 2015 to serve as an integrated questionnaire designed to assess postgastrectomy-specific clinical symptoms and QOL[7]. JPGSWP also initiated a multi-institutional nationwide surveillance program to investigate medium to long-term symptoms, living status, and QOL following various types of gastrectomies. The JPGSWP felt that it was necessary to create a standard tool to assess postoperative QOL after any surgical procedure performed at any facility in Japan. This also allowed the statistical analysis of national data collected for each gastrectomy performed at numerous institutions throughout Japan. A “PGSAS statistical kit” was also created to allow free access that allowed individual institutions to compare their own patient outcomes to those PGS outcomes from patients undergoing gastrectomy procedures anywhere else in Japan.

This study investigated the impact on PGS and QOL in patients at Juntendo University in Japan who underwent ART for Billroth I reconstruction compared to a national database of patients who
underwent other reconstruction techniques from multiple institutions throughout Japan and who completed the PGSAS-37 form.

**MATERIALS AND METHODS**

**Patients**

From 238 patients who underwent gastrectomy for gastric cancer at Juntendo University Hospital from July 2016 to March 2020, 115 (48.3%) had received a TLDG using ART for Billroth I reconstruction. A PGSAS-37 questionnaire was administered to all patients. Completed or nearly completed questionnaires were retrieved from 94 (81.7%) patients, and these patients were selected for inclusion in this retrospective study (Figure 1). Clinical, perioperative, pathological, and PGSAS-37 questionnaire data were collected and analyzed. Clinicopathological variables included postoperative observation period, age, sex, preoperative body mass index, pathological stage, approach, extent of lymph node dissection, and combined resection. Pathological stage was described according to the Japanese Classification of Gastric Carcinoma[8]. Perioperative outcomes included operative time, intraoperative blood loss, and conversion to open surgery. Postoperative complications, stratified using the Clavien-Dindo classification system[9], included postoperative hospital stay and adjuvant chemotherapy. The study protocol was approved by the ethics committee of the Juntendo University Hospital (Approval No. 20-192). The need for informed consent was waived in view of the retrospective and observational nature of the study. An opt-out approach was used by accessing a written disclosure on the study’s website (URL: https://www.gcprec.juntendo.ac.jp/kenkyu/files/6379827945f9a62a8f32ec.pdf).

**ART**

ART is an anastomosis technique that uses three linear staplers (LS) for TLDG. After gastrectomy, an insertion hole is made in the duodenum and the remnant stomach stump on the greater curvature side. The thinner and thicker 60-mm jaws of the LS are inserted into the greater curvature ends of both the duodenum and remnant gastric stump. The lesser curvature end of the stapled duodenal stump is rotated externally 90°, and the device is closed and fired. After the initial suturing of the stomach and duodenum, the posterior wall and cranial wall form a V-shape. A 30-mm LS is used to close the insertion holes up to the closest side of the duodenal resection margin. This suture creates the third side, which is the caudal wall. Finally, the entire stapled duodenal resection is removed, using a 60-mm LS to create the fourth side that makes up the rectangular anterior wall. This series of operations creates an augmented rectangular gastroduodenal anastomotic stoma.

**PGS & QOL assessment**

The PGSAS-37 is a multidimensional QOL questionnaire based on the Gastrointestinal Symptom Rating Scale[10,11]. The PGSAS-37 questionnaire consists of 37 questions with 15 items from the Gastrointestinal Symptom Rating Scale, and 22 clinically relevant items selected and added by the JPCSWP (Table 1). These additional items consist of eight assessing overall symptoms, two dumping syndrome, five meal quantity, three meal quality, one work status, and three life dissatisfaction. These items are aggregated into nine subscales, for a total of seventeen main assessable outcomes. Nine subscales are derived from the average score of the corresponding items and include an evaluation of esophageal reflux, abdominal pain, meal-related distress, indigestion, diarrhea, constipation, dumping, quality of ingestion, and dissatisfaction with daily life. The total symptoms score is calculated from the average of the seven symptoms subscale scores. The main outcome consists of three categories, namely symptoms, living status, and QOL (Table 2). In the PGSAS-37 questionnaire, high scores denote favorable outcomes regarding ingested amounts of food per meal, ingested amounts of food per day, appetite, hunger, satiety, the quality of food, and change in body weight. Low scores on most of the other items and for symptom subscales indicate favorable outcomes.

The questionnaire was distributed to all patients who underwent gastrectomy for gastric cancer by a doctor or nurse at the time of outpatient treatment. Questionnaires were conducted at 1 mo, 3 mo, 6 mo, 12 mo, and 24 mo after surgery. The most recent questionnaire data collected for each patient was used in this study. The questionnaire was collected and managed by a medical clerk, and the data were blindly scored.

**Study method**

This is a retrospective cohort study. We compared it to a national database of 909 patients with distal gastrectomies and Billroth I reconstructions who completed the PGSAS-37 questionnaire. The primary endpoint of our study was to compare the long-term patient outcomes between the two groups in terms of prevalence of PGS and QOL.

**Statistical analysis**

Continuous data are presented as average and standard deviations. Independent-sample t-tests were
## Table 1 Postgastrectomy Syndrome Assessment Scale-37 evaluation items

| Item | Subscales |
|------|-----------|
| **Symptom** | |
| 1 | Abdominal pains | Esophageal reflux subscale (items 2, 3, 5, 16) |
| 2 | Heartburn | Abdominal pain subscale (items 1, 4, 20) |
| 3 | Acid regurgitation | Meal-related distress subscale (items 17-19) |
| 4 | Sucking sensations in the epigastrium | Indigestion subscale (items 6-9) |
| 5 | Nausea and vomiting | Diarrhea subscale (items 11, 12, 14) |
| 6 | Borborygmus | Constipation subscale (items 10, 13, 15) |
| 7 | Abdominal distension | Dumping subscale (items 22, 23, 25) |
| 8 | Eructation | |
| 9 | Increased flatus | Total symptom score (more than seven subscale) |
| 10 | Decreased passage of stools | |
| 11 | Increased passage of stools | |
| 12 | Loose stools | |
| 13 | Hard stools | |
| 14 | Urgent need for defecation | |
| 15 | Feeling of incomplete evacuation | |
| 16 | Bile regurgitation | |
| 17 | Sense of foods sticking | |
| 18 | Postprandial fullness | |
| 19 | Early satiation | |
| 20 | Lower abdominal pains | |
| 21 | Number and type of early dumping symptoms | |
| 22 | Early dumping, general symptoms | |
| 23 | Early dumping, abdominal symptoms | |
| 24 | Number and type of late dumping symptoms | |
| 25 | Late dumping symptoms | |
| **Living status** | |
| 26 | Ingested amount of food per meal<sup>1</sup> | |
| 27 | Ingested amount of food per day<sup>1</sup> | |
| 28 | Frequency of main meals | |
| 29 | Frequency of additional meals | |
| 30 | Appetite<sup>1</sup> | Quality of ingestion subscale (items 30-32)<sup>1</sup> |
| 31 | Hunger feeling<sup>1</sup> | |
| 32 | Satiety feeling<sup>2</sup> | |
| 33 | Necessity for additional meals | |
| 34 | Ability for working | |
| **Quality of life** | |
| 35 | Dissatisfaction with symptoms | Dissatisfaction with daily life subscale (items 35-37) |
| 36 | Dissatisfaction at the meal | |
| 37 | Dissatisfaction with working | |

<sup>1</sup>Higher scores indicate a better condition. In items or subscale without <sup>1</sup>, higher scores indicate a worse condition. Each subscale and total symptom score is calculated as the average of its composite items or subscale score.
Table 2 Main outcomes consisting of three categories

| Category              | Main outcome measure                                      |
|-----------------------|-----------------------------------------------------------|
| Symptoms              |                                                           |
| Subscale              |                                                           |
| Esophageal reflux subscale |                                                       |
| Abdominal pain subscale |                                                       |
| Meal-related distress subscale |                                                   |
| Indigestion subscale  |                                                       |
| Diarrhea subscale     |                                                       |
| Constipation subscale |                                                       |
| Dumping subscale      |                                                       |
| Total                 | Total symptom score                                      |
| Living status         |                                                           |
| Body weight           | Change in body weight (%)^1                             |
| Meals (amount)        | Amount of food ingested per meal (%)^1                  |
| Meals (quality)       | Necessity of additional meals                           |
| Work                  | Quality of ingestion subscale^1                         |
| Quality of life       | Ability for working                                     |
| Dissatisfaction       | Dissatisfaction with symptom                            |
|                       | Dissatisfaction at the meal                             |
|                       | Dissatisfaction at working                              |
|                       | Dissatisfaction with daily life subscale                |

^1Higher scores indicate a better condition. In items or subscale without ^1, higher scores indicate a worse condition.

RESULTS

Patient characteristics

Table 3 shows the patients’ clinicopathological characteristics. There were 94 patients in the ART group and 909 patients in the PGSAS group. The postoperative observation period was significantly longer in the PGSAS group than in the ART group (40.7 ± 30.7 mo vs 27.1 ± 12.2 mo, respectively; P < 0.001). Age was significantly higher in the ART group than in the PGSAS group (70.0 ± 11.0 vs 61.6 ± 9.1, respectively; P < 0.001). Sex and preoperative body mass index showed no significant differences between the two groups. Patients in the ART group had significantly more advanced-stage cancer than those in the PGSAS group. The mean tumor size was 30.7±15.6 mm in the ART group. Laparoscopic surgery was performed in all cases in the ART group, but in only 45.6% of patients in the PGSAS group. Patients in the PGSAS group had a significantly higher rate of combined resection than those in the ART group.

Perioperative outcomes

Perioperative outcomes are shown in Table 4. The average operative time was 285 min, and the intraoperative blood loss was 21.1 mL. No cases were converted to open surgery. Postoperative complications included Clavien-Dindo ≥ 3 in 3 patients (3.1%), anastomotic leakage in 1 patient (1.0%), and anastomotic bleeding in 2 patients (2.1%). The average postoperative hospital stay was 14.5 d with adjuvant chemotherapy performed in 17 patients (18.1%).
Table 3 Patients’ clinicopathological characteristics

|                      | ART group | PGSAS group | P value |
|----------------------|-----------|-------------|---------|
| Number of patients   | 94        | 909         |         |
| Postoperative period in mo | 27.1 ± 12.2 | 40.7 ± 30.7 | < 0.001 |
| Age in yr            | 70.0 ± 11.0 | 61.6 ± 9.1  | < 0.001 |
| Sex                  |           |             | 0.333   |
| Male                 | 57        | 594         |         |
| Female               | 37        | 311         |         |
| Preoperative BMI in kg/m² | 22.7 ± 3.4 | 22.7 ± 3.0  | 1.000   |
| Stage                |           |             | < 0.001 |
| I                    | 70        | 909         |         |
| II                   | 16        | 0           |         |
| III                  | 8         | 0           |         |
| IV                   | 0         | 0           |         |
| Approach             |           |             | < 0.001 |
| Open                 | 0         | 489         |         |
| Laparoscopic         | 94        | 415         |         |
| Extent of lymph node dissection (D1 >/D1/D2) | 0.135    |             |         |
| D1 >                 | 0         | 4           |         |
| D1                   | 70        | 586         |         |
| D2                   | 24        | 319         |         |
| Combined resection (absence/presence) | 0.001    |             |         |
| Absence              | 89        | 743         |         |
| Presence             | 5         | 166         |         |

ART: Augmented rectangle technique; BMI: Body mass index; PGSAS: Postgastrectomy Syndrome Assessment Scale.

Main outcomes

A total of 17 main outcomes in three categories (symptoms, living status, and QOL) are shown in Tables 5 and 6, along with the results of the univariate analysis comparing the ART and the PGSAS groups. For the symptoms category, patients in the ART group had significantly lower scores (indicating a better physical condition) in all symptom subscales (esophageal reflux, abdominal pain, meal-related distress, indigestion, diarrhea, constipation, and dumping) and in the total symptoms score (1.6 ± 0.4 vs 2.0 ± 0.7; P < 0.001). Regarding the living status category, the loss of body weight was marginally greater for the ART group than the PGSAS group, (-9.3% vs -7.9%; P = 0.054). The ingested amount of food per meal was statistically lower (indicating a worse physical condition) in the ART group compared to the PGSAS group (6.3 ± 1.9 vs 7.1 ± 2.0; P < 0.001). Although the need for additional meals was not different between the two groups, the quality of ingestion subscale was significantly lower in the ART group compared to the PGSAS group (3.3 ± 1.0 vs 3.8 ± 0.9; P < 0.001). Regarding the QOL category, the ART group was significantly lower (indicating a better physical condition) in the subscale of dissatisfaction with symptoms, meals, and daily life (except for the work related item). Furthermore, almost the same results were obtained if the same eligible patient criteria for PGSAS was applied (Supplementary Tables 1 and 2).

DISCUSSION

This is the first report to evaluate PGS and QOL after a TLDG reconstructed with the novel Billroth I method of ART. Importantly, we compared our results to patients from the Japanese national PGSAS study who did not receive ART. We analyzed PGS and QOL in patients who did and did not receive an ART and found that ART was beneficial. This is important because in Japan a distal gastrectomy is the
Table 4 Perioperative outcomes

| Operation time in min | ART, n = 94 |
|-----------------------|-------------|
| 285 ± 84 |

| Intraoperative blood loss in mL | ART, n = 94 |
|----------------------|-------------|
| 21.1 ± 16.4 |

| Conversion to open surgery | ART, n = 94 |
|---------------------------|-------------|
| 0 (0%) |

| Postoperative complication | ART, n = 94 |
|----------------------------|-------------|
| CD ≥ 3 | 3 (3.1%) |

| Anastomotic-related complication | ART, n = 94 |
|----------------------------------|-------------|
| Anastomotic leakage | 1 (1.0%) |
| Anastomotic bleeding | 2 (2.1%) |
| Anastomotic stenosis | 0 (0%) |
| Delayed gastric emptying | 0 (0%) |

| Non-anastomotic-related complication | ART, n = 94 |
|-------------------------------------|-------------|
| Pancreatic fistula | 4 (4.2%) |
| Surgical site infection | 4 (4.2%) |
| Pneumonia | 1 (1.0%) |
| Postoperative hospital stay in day | 14.5 ± 14.9 |
| Adjuvant chemotherapy | 17 (18.1%) |
| Adjuvant radiation therapy | 0 (0%) |

ART: Augmented rectangle technique; CD: Clavien-Dindo.

Table 5 Main outcomes in symptoms categories

| Symptom | ART group, n = 94 | PGSAS group, n = 909 | Cohen’s d | P value |
|---------|------------------|----------------------|----------|--------|
| Esophageal reflux subscale | 1.4 (0.6) | 1.7 (0.8) | 0.30 | < 0.001 |
| Abdominal pain subscale | 1.5 (0.5) | 1.7 (0.7) | 0.26 | 0.003 |
| Meal-related distress subscale | 1.7 (0.7) | 2.1 (0.9) | 0.35 | < 0.001 |
| Indigestion subscale | 1.6 (0.6) | 2.0 (0.8) | 0.43 | < 0.001 |
| Diarrhea subscale | 1.8 (0.7) | 2.1 (1.1) | 0.27 | 0.001 |
| Constipation subscale | 1.9 (0.7) | 2.2 (1.0) | 0.32 | < 0.001 |
| Dumping subscale | 1.5 (0.7) | 2.0 (1.0) | 0.41 | < 0.001 |
| Total symptoms score | 1.6 (0.4) | 2.0 (0.7) | 0.45 | < 0.001 |

ART: Augmented rectangle technique; PGSAS: Postgastrectomy Syndrome Assessment Scale; SD: Standard deviation.

most commonly performed surgical procedure for gastric cancer.

Billroth I is our preferred post-distal gastrectomy reconstruction method because of its technical simplicity and its restoration of normal anatomy[12]. Our patient questionnaire regarding reconstruction methods after distal gastrectomies in Japan showed that Billroth I was selected as the first choice in 77% of Japanese institutions[13]. In recent years, the number of laparoscopic gastrectomies performed in Japan has dramatically increased, resulting in the publication of multiple reports on various reconstruction techniques[14-17]. However, all of these reported techniques are technically challenging, requiring a certain degree of skill and experience and are associated with complications, such as obstruction due to torsion or stenosis at the anastomotic site.

In 2013, we developed ART as a simpler reconstruction technique after TLDG and currently utilize it for all Billroth I reconstruction methods. Importantly, we also reported a low rate of anastomotic-related complications in the short-term after surgery[6]. There was a concern, however, that in the long-term, there would be a high prevalence of esophageal reflux and dumping symptoms because of the large
Table 6 Main outcomes in living status and quality of life categories

|                         | ART group, n = 94 | PGSAS group, n = 909 | mean  | SD   | mean  | SD   | Cohen’s d | P value |
|-------------------------|-------------------|----------------------|-------|------|-------|------|-----------|---------|
| Living status           |                   |                      |       |      |       |      |           |         |
| Change in body weight (%) 1 | -9.3              | 6.4                  | -7.9  | 8.1  | 0.17  | 0.054|           |         |
| Amount of food ingested per meal (%) 1 | 6.3              | 1.9                  | 7.1   | 2.0  | 0.41  | < 0.001|           |         |
| Necessity of additional meals | 1.8              | 0.7                  | 1.9   | 0.8  | 0.00  | 0.977|           |         |
| Quality of ingestion subscale 1 | 3.3              | 1.0                  | 3.8   | 0.9  | 0.52  | < 0.001|           |         |
| Ability for working | 1.8               | 0.9                  | 1.8   | 0.9  | 0.13  | 0.261|           |         |
| Quality of life         |                   |                      |       |      |       |      |           |         |
| Dissatisfaction with symptoms | 1.6              | 0.7                  | 1.8   | 0.9  | 0.21  | 0.022|           |         |
| Dissatisfaction during meals | 1.8              | 0.9                  | 2.2   | 1.1  | 0.29  | 0.004|           |         |
| Dissatisfaction during work | 1.6               | 0.7                  | 1.7   | 0.9  | 0.03  | 0.774|           |         |
| Dissatisfaction with daily life subscale | 1.7             | 0.6                  | 1.9   | 0.8  | 0.21  | 0.016|           |         |

1Higher scores indicate a better condition. In items or subscale without 1, higher scores indicate a worse condition. ART: Augmented rectangle technique; PGSAS: Postgastrectomy Syndrome Assessment Scale; SD: Standard deviation.

Gastrectomy for gastric cancer 238

ART for Billroth I
In totally laparoscopic distal gastrectomy 115 (46.3%)

Questionnaire given 115 (100%)

Not retrieved 21 (18.3%)

Retrieved 94 (81.7%)

Analysis

Figure 1 Flow diagram for study inclusion. ART: Augmented rectangle technique.

Unexpectedly, patients in the ART group fared significantly better in all symptom subscales (esophageal reflux, abdominal pain, meal-related distress, ingestion, diarrhea, constipation, dumping) and in the total symptom scores than the patients in the PGSAS group. Symptoms such as regurgitation and dumping, presumably due to the large anastomosis, were significantly fewer than the national average. This result suggests that ART may be beneficial in reducing these symptoms after gastrectomy. It is not clear why the symptoms subscale and the total score categories both improved. Postoperative anastomotic complications cause a variety of complaints, so our low anastomotic complication rates associated with ART may have contributed to our better PGSAS-37 scores than the national average.
Moreover, the reason for this may not only be due to the anastomosis technique but also due to the fact that patients received postoperative continuous nutritional guidance (especially avoiding overeating), ready treatment for any complaint, life guidance as well as psychiatric care. At the very least, this study shows that the large rectangular anastomosis, which is a characteristic of ART, does not cause various complaints.

Focusing on the category of living status, the rate of weight loss in patients was marginally greater in the ART group than observed nationally ($P = 0.054$). Since the data suggest no additional meals consumed, a smaller amount of food per meal in the ART group may be one of the causes of weight loss. Another reason may be related to the shorter length of the postoperative observation period in our study. The average postoperative observation period was 40.7 mo in patients in the national PGSAS database but only 27.1 mo in patients with ART. In addition, the ART group included 17 patients (18.1%) who received postoperative adjuvant chemotherapy, which is also a factor that can lead to weight loss.

There are several reports on the relationship between PGS and the size of the gastric remnant after a distal gastrectomy with a Billroth I reconstruction. Nomura et al[18] reported that in cases of early gastric cancer patients who maintained half of their gastric remnant showed improved food intake, little postoperative weight loss, and few abdominal symptoms, such as diarrhea and abdominal pain, compared to those who only had one-third of their gastric remnant after a distal gastrectomy with a Billroth I reconstruction. On the other hand, there are reports that there is no relationship between the size of the gastric remnant and weight loss[19].

Japanese gastric cancer guidelines recommend at least two-thirds of the stomach be removed during a distal gastrectomy. We also followed the Japanese gastric cancer treatment guidelines and perform a complete gastric dissection. Misawa et al[19] evaluated PGS with and without a Kocher maneuver during distal gastrectomy with a Billroth I reconstruction. They reported that the Kocher maneuver resulted in poor PGSAS scores in the quality of ingestion subscale, which evaluates appetite, hunger, and satiety. We found the same result in our study. ART also slightly mobilizes the duodenum during reconstruction, although not to the same extent as a Kocher maneuver. This may be one of the reasons why this aspect of the PGSAS score in the quality of ingestion subscale was worse than the national average. The superior score for patients in the ART group, for the subscales of dissatisfaction with symptoms, diet, and with daily life, indicates that patients are in good shape physically. This also suggests that the lack of ART post-gastrectomy symptoms contributes to maintaining a good QOL on a daily basis. It is difficult to conclude that the infrequency of post-gastrectomy symptoms was due to an anastomosis technique alone but may also reflect appropriate decision making regarding the type of surgical procedure as well as the attentive postoperative management.

This study has several limitations. Specifically, this was a retrospective study in which there were substantial differences between the two groups making some direct comparisons problematic. For example, it is not possible to accurately match patients’ preoperative physical conditioning. Also, since the data published by the PGSAS database are limited, it is again not possible to analyze certain variables that may have impacted outcome. However, almost the same results were obtained if the same eligible patient criteria for PGSAS were applied (Supplementary Tables 1 and 2). Further prospective research is needed to examine the effects of preoperative factors, including age, sex, body mass index, stage, etc. on PGS and QOL. Another limitation is that it was difficult to provide a rational explanation for all results. PGS varies widely among individuals and is influenced by a variety of physical and functional factors. There have been no studies of a specific Billroth I technique for TLDG that have examined as many symptoms as in this study. In particular, chronological changes are thought to be the most important issue in evaluating a patient’s QOL after gastrectomy. However, we mainly focused on a certain variable, QOL, at the average postoperative observation period of 27.1 mo after gastrectomy. Kobayashi et al[20] reported that patients rarely had any subsequent changes in their QOL more than 1 year after gastrectomy. The average observation period in our study is, by definition, appropriate. At present, PGSAS-45, which is PGSAS plus SF-8, is often used for QOL evaluations after gastrectomy. SF-8 was not measured in this study, and further follow-up studies are needed with this instrument.

**CONCLUSION**

From this retrospective evaluation, we concluded that the results of an ART reconstruction produced beneficial long-term results with regards to PGS and postoperative QOL. Further investigation involving a larger number of patients comparing ART with other anastomotic techniques and evaluating long-term patient outcomes is needed to validate the benefits of ART reconstruction after TLDG.
ARTICLE HIGHLIGHTS

Research background
For total laparoscopic distal gastrectomies for gastric cancer, the reconstruction method is critical to the clinical outcome of the procedure. We originally reported the augmented rectangle technique (ART) as a reconstruction option for total laparoscopic Billroth I reconstructions. Yet, little is known about its effect on long-term outcomes, specifically the incidence of postgastrectomy syndrome (PGS) and its impact on quality of life (QOL).

Research motivation
Reducing the prevalence of PGS and improving the QOL after gastrectomy for gastric cancer patients has become an important technical challenge for surgeons. ART shows good short-term results, but long-term results in terms of PGS and quality of life should be reported.

Research objectives
To analyze PGS and QOL after ART using the Postgastrectomy Syndrome Assessment Scale-37 (PGSAS-37) questionnaire.

Research methods
At Juntendo University, 94 patients who underwent ART for Billroth I reconstruction with total laparoscopic distal gastrectomies for gastric cancer between July 2016 to March 2020 completed questionnaires. Multidimensional analysis was performed comparing those 94 ART cases from our institution (ART group) to 909 distal gastrectomy cases with a Billroth I reconstruction from other Japanese institutions who also completed the PGSAS as part of a larger national database (PGSAS group).

Research results
Patients in the ART group had significantly better total symptom scores in all the symptom subscales (esophageal reflux, abdominal pain, meal-related distress, indigestion, diarrhea, constipation, and dumping). The loss of body weight was marginally greater for those in the ART group than in the PGSAS group (-9.3% vs -7.9%; P = 0.054). The ART group scored significantly lower in their dissatisfaction of ongoing symptoms, during meals, and with daily life.

Research conclusions
The use of ART for Billroth I reconstruction produced beneficial long-term results with regards to PGS and QOL in patients undergoing total laparoscopic distal gastrectomies for gastric cancer.

Research perspectives
Further investigation of the mechanism underlying the usefulness of ART in terms of PGS and QOL is needed. Prospective studies are also needed on the involvement of factors other than the anastomotic method.

FOOTNOTES
Author contributions: Yamauchi S, Orita H Matusi R, Yube Y, Kaji S, Orita H, Brock MV and Fukunaga T contributed to writing of the manuscript; Yamauchi S, Orita H, Jun C, Egawa H, Yoshimoto Y, Yube Y, Kaji S and Oka S contributed to performing the procedures and analyzing the data; Yamauchi S and Yoshimoto Y contributed to statistical review; Orita H, Fukunaga T and Brock MV contributed to the conception and design of this work.

Institutional review board statement: The study was conducted according to the guidelines of the Declaration of Helsinki, and approved by the Ethics Committee of Juntendo University Hospital (Approval No. 20-192).

Informed consent statement: The study design was retrospective and a noninterventional study. Patients were not required to give informed consent to the study because the analysis used anonymized clinical data that were obtained after each patient agreed to treatment by written consent. We also applied an opt-out method to obtain consent for this study. The opt-out approach was used with website disclosure (URL: https://www.gcprec.juntendo.ac.jp/kenkyu/files/63798279459a62a8f32ec.pdf).

Conflict-of-interest statement: The authors declare having no conflicts of interest.

Data sharing statement: The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request. The data is not publicly available due to patient privacy and the General Data Protection Regulation.
STROBE statement: The authors have read the STROBE Statement-checklist of items, and the manuscript was prepared and revised according to the STROBE Statement-checklist of items.

Open-Access: This article is an open-access article that was selected by an in-house editor and fully peer-reviewed by external reviewers. It is distributed in accordance with the Creative Commons Attribution NonCommercial (CC BY-NC 4.0) license, which permits others to distribute, remix, adapt, build upon this work non-commercially, and license their derivative works on different terms, provided the original work is properly cited and the use is non-commercial. See: https://creativecommons.org/Licenses/by-nc/4.0/

Country/Territory of origin: Japan

ORCID number: Suguru Yamauchi 0000-0003-3185-3333; Hajime Orita 0000-0002-8263-7069; Jun Chen 0000-0003-1127-3824; Hiroki Egawa 0000-0003-1934-5918; Yutaro Yoshimoto 0000-0003-2354-5604; Akira Kubota 0000-0002-7869-4511; Ryota Matsui 0000-0003-3185-3332; Yukinori Yube 0000-0002-0289-8892; Sanae Kaji 0000-0002-1372-4468; Shinichi Oka 0000-0002-3820-1394; Malcolm V Brock 0000-0003-2961-851X; Tetsu Fukunaga 0000-0003-4802-8945.

S-Editor: Wang LL
L-Editor: A
P-Editor: Wang LL

REFERENCES

1. Davis JL, Ripley RT. Postgastrectomy Syndromes and Nutritional Considerations Following Gastric Surgery. Surg Clin North Am 2017; 97: 277-293 [PMID: 28525187 DOI: 10.1016/j.suc.2016.11.005]
2. Bolton JS, Conway WC. Postgastrectomy syndromes. Surg Clin North Am 2011; 91: 1105-1122 [PMID: 21889032 DOI: 10.1016/j.suc.2011.07.001]
3. Curvajal SH, Mulvihill SJ. Postgastrectomy syndromes: dumping and diarrhea. Gastroenterol Clin North Am 1994; 23: 261-279 [PMID: 8079112]
4. Kim AR, Cho J, Hsu YJ, Choi MG, Noh JH, Sohn TS, Bae JM, Yun YH, Kim S. Changes of quality of life in gastric cancer patients after curative resection: a retrospective cohort study in Korea. Ann Surg 2012; 256: 1008-1013 [PMID: 23154395 DOI: 10.1097/SLA.0b013e3182766c9]
5. Karanicolas PJ, Graham D, Gönen M, Strong VE, Brennan MF, Coit DG. Quality of life after gastrectomy for adenocarcinoma: a prospective cohort study. Ann Surg 2013; 257: 1039-1046 [PMID: 23665970 DOI: 10.1097/SLA.0b013e31828c4a19]
6. Fukunaga T, Ishibashi Y, Oka S, Kanda S, Yube Y, Kohira Y, Matsuo S, Mori O, Mikami S, Enomoto T, Otsubo T. Augmented rectangle technique for Billroth I anastomosis in totally laparoscopic distal gastrectomy for gastric cancer. Surg Endosc 2018; 32: 4011-4016 [PMID: 29919585 DOI: 10.1007/s00464-018-6266-1]
7. Nakada K, Ikeda M, Takahashi M, Kinani S, Yoshida M, Uenosono Y, Kawashima Y, Oshio A, Suzukamo Y, Terashima M, Kodera Y. Characteristics and clinical relevance of postgastrectomy syndrome assessment scale (PGSAS)-45: newly developed integrated questionnaires for assessment of living status and quality of life in postgastrectomy patients. Gastric Cancer 2015; 18: 147-158 [PMID: 24515247 DOI: 10.1007/s10120-014-0344-4]
8. Japanese Gastric Cancer Association. Japanese classification of gastric carcinoma: 3rd English edition. Gastric Cancer 2011; 14: 101-112 [PMID: 21573743 DOI: 10.1007/s10120-011-0401-5]
9. Dindo D, Demartines N, Clavien PA. Classification of surgical complications: a new proposal with evaluation in a cohort of 6336 patients and results of a survey. Ann Surg 2004; 240: 205-213 [PMID: 15273542 DOI: 10.1097/01.sla.0000133083.54933.ac]
10. Svedlund J, Sjödin I, Dotvell G. GSRs—a clinical rating scale for gastrointestinal symptoms in patients with irritable bowel syndrome and peptic ulcer disease. Dig Dis Sci 1988; 33: 129-134 [PMID: 3123181 DOI: 10.1007/BF01535722]
11. Wiklund IK, Junghard O, Grace E, Talley NJ, Kamm M, Veldhuyzen van Zanten S, Paré P, Chiba N, Leddin DS, Bigard MA, Colin R, Schoenfeld P. Quality of Life in Reflux and Dyspepsia patients. Psychometric documentation of a new disease-specific questionnaire (QOLRAD). Eur J Surg 1998; 583: 41-49 [DOI: 10.1007/s10120-9800199-6]
12. Kim BJ, O’Connell T. Gastroduodenostomy after gastric resection for cancer. Am Surg 1999; 65: 905-907 [PMID: 10515531]
13. Kumagai K, Shimizu K, Yokoyama N, Aida S, Arima S, Aikou T; Japanese Society for the Study of Postoperative Morbidity after Gastrectomy. Questionnaire survey regarding the current status and controversial issues concerning reconstruction after gastrectomy in Japan. Surg Today 2012; 42: 411-418 [PMID: 22391980 DOI: 10.1007/s00595-012-0419-2]
14. Kanaya S, Gomi T, Momoi H, Tamaki N, Isobe H, Katayama T, Wada Y, Ohtoshi M. Delta-shaped anastomosis in totally laparoscopic distal gastrectomy for gastric cancer. Surg Endosc Percutan Tech 2008; 18: 54-58 [PMID: 18287984 DOI: 10.1097/SLE.0b013e3181515e63]
15. Ikeba T, Kawano H, Hisamatsu Y, Ando K, Sasaki H, Oku E, Ohga T, Kakeji Y, Tsujitani S, Kohnoe S, Maelara Y. Progression from laparoscopic- assisted to totally laparoscopic distal gastrectomy: comparison of circular suture (d-IST)
and linear stapler (BBT) for intracorporeal anastomosis. Surg Endosc 2013; 27: 325-332 [PMID: 22733199 DOI: 10.1007/s00464-012-2433-y]

17 Byun C, Cui LH, Son SY, Hur H, Cho YK, Han SU. Linear-shaped gastroduodenostomy (LSGD): safe and feasible technique of intracorporeal Billroth I anastomosis. Surg Endosc 2016; 30: 4505-4514 [PMID: 26895918 DOI: 10.1007/s00464-016-4783-3]

18 Nomura E, Lee SW, Bouras G, Tokuhara T, Hayashi M, Hiramatsu M, Okada J, Tanigawa N. Functional outcomes according to the size of the gastric remnant and type of reconstruction following laparoscopic distal gastrectomy for gastric cancer. Gastric Cancer 2011; 14: 279-284 [PMID: 21519869 DOI: 10.1007/s10120-011-0046-0]

19 Misawa K, Terashima M, Uenosono Y, Ota S, Hata H, Noro H, Yamaguchi K, Yajima H, Nitta T, Nakada K. Evaluation of postgastrectomy symptoms after distal gastrectomy with Billroth-I reconstruction using the Postgastrectomy Syndrome Assessment Scale-45 (PGSAS-45). Gastric Cancer 2015; 18: 675-681 [PMID: 25091080 DOI: 10.1007/s10120-014-0407-6]

20 Kobayashi D, Kodera Y, Fujiwara M, Koike M, Nakayama G, Nakao A. Assessment of quality of life after gastrectomy using EORTC QLQ-C30 and STO22. World J Surg 2011; 35: 357-364 [PMID: 21104250 DOI: 10.1007/s00268-010-0860-2]
