Functional outcomes at 6–12 months

Comparison of the postoperative/preoperative body weight ratios (Fig. 1a) revealed better preservation of postoperative body weight among those with a larger remnant stomach (the 1/2B1ML and 1/2B1IC groups). The postoperative/preoperative food intake ratio was also significantly higher in the 1/2B1ML group than those in the 1/3B1ML and 1/3RYIC groups (Fig. 1b). Complaints of postprandial symptoms were significantly more common after the 1/3B1ML and 1/3RYIC procedures than after the 1/2B1IC procedure (Fig. 1c). Abdominal pain (24%) and diarrhea (18%) were frequent in the 1/3B1ML group, and abdominal pain (20%) and nausea (15%) were frequent in the 1/3RYIC group, while these symptoms were rarely observed in patients with a large gastric remnant. In summary, 1/2B1ML was significantly superior to the 1/3B1ML and 1/3RYIC procedures in terms of the amount of food intake ($p = 0.031$ and $p = 0.013$, respectively), and it was significantly superior to the 1/3RYIC procedure in terms of preservation of body weight ($p = 0.0002$), while 1/2B1IC was superior to the 1/3B1ML and 1/3RYIC procedures regarding body weight ($p = 0.017$ and $p \leq 0.0001$, respectively) and the incidence of abdominal symptoms ($p = 0.0003$ and $p = 0.0034$, respectively). Thus, better functional outcomes were observed in patients with large gastric remnants, while no major differences were observed between B-1 and RY when the remnant stomach was small. Although not performed in all patients, endoscopy revealed that the incidence of reflux esophagitis in the 1/3B1ML group ($n = 14$) was significantly higher than that in the 1/3RYIC group ($n = 33$) (Fig. 2). Gastritis was observed in 2 of 14 patients in the 1/2B1ML group, 4 of 14 patients in the 1/3B1ML group, 4 of 30 patients in the 1/2B1IC group, and 3 of 33 patients in the 1/3RYIC group. Of these, ≥Grade 2 residue was observed in 2, 2, 4, and 3 patients, respectively.

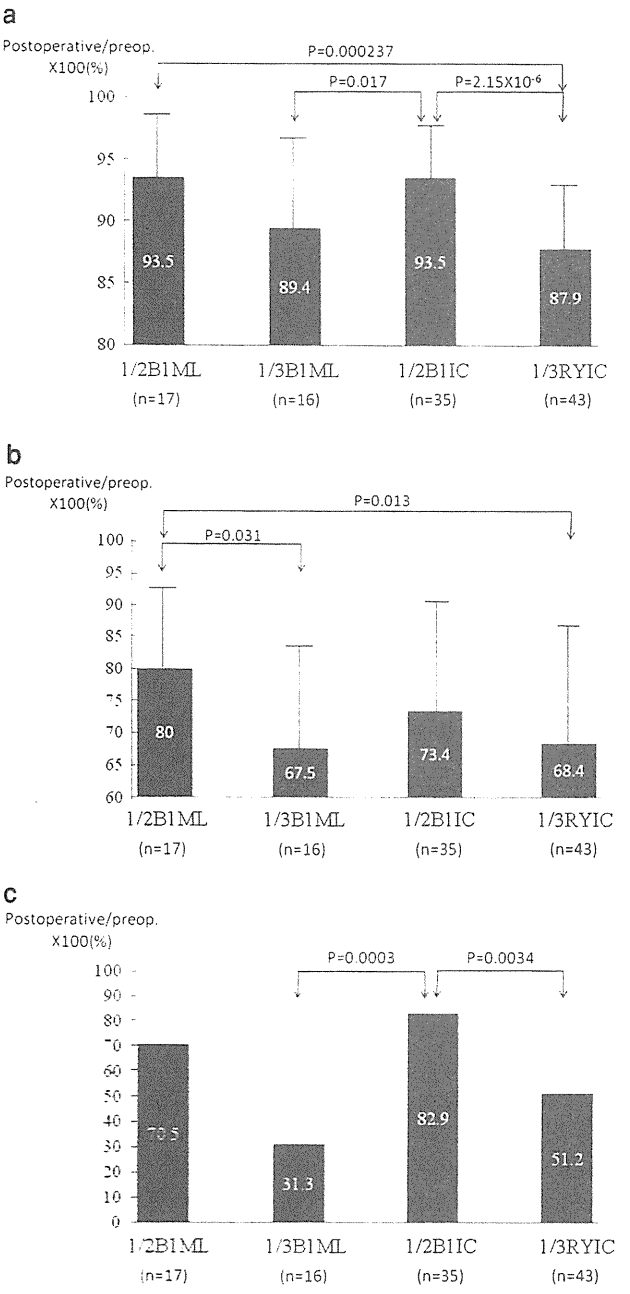

Fig. 1 Functional outcomes following laparoscopic distal gastrectomy according to type of reconstruction. a Postoperative/preoperative body weight ratios (%). b Postoperative/preoperative meal intake ratios (%). c Percentages of patients who had none of the abdominal symptoms listed in the questionnaire (Table 1). *1/2B1ML* B-1 reconstruction through a mini-laparotomy wound for 1/2 remnant stomach, *1/3B1ML* B-1 reconstruction through a mini-laparotomy wound for 1/3 remnant stomach, *1/2B1IC* intra-corporeal B-1 for 1/2 remnant stomach, *1/3RYIC* intra-corporeal RY for 1/3 remnant stomach

Discussion

Since laparoscopic distal gastrectomy was first introduced in Japan, B-1 reconstruction has been the preferred method and it has been performed commonly either through a mini-laparotomy [2] or intra-corporeally [9]. In addition to preservation of the duodenal passage, which may in theory be beneficial, B-1 has an advantage in that it can be completed with only one anastomosis [13]. Recently, RY has been adopted by several Japanese institutions to counter anastomotic leakage and duodenogastric reflux [14, 15]. In RY, the gastrojejunostomy can be performed without any tension even when the remnant stomach is small, and the anastomoses are distant from any potential pancreatic fistula-related collections that may arise from extensive lymph node dissection. In the light of the various types of reconstructive modalities available and through the evolution of our own surgical technique under the laparoscopic approach, we have achieved herein our

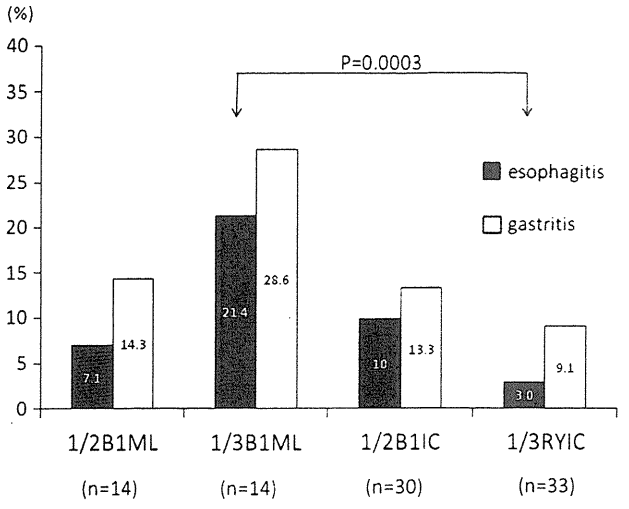

Fig. 2 The incidence of esophagitis and remnant gastritis

objectives of comparing functional outcomes according to the type of reconstruction, although this was done in a non-randomized and retrospective fashion.

In terms of complications, the B1ML groups had the highest incidence of anastomotic leakage, although there were no statistically significant differences among the groups. This leakage may be related to the limited access for hand-sewn anastomosis through an epigastric mini-laparotomy 4–6 cm in size. In contrast, intra-corporeal reconstruction offers a wide field of view with ample access and space to create the anastomosis. Furthermore, intra-corporeal B-1 was actually associated with significantly smaller blood loss compared to the other 3 groups. One could argue that the decrease in the incidence of anastomotic leakage and the smaller amount of blood loss may have reflected improvements in technical expertise in laparoscopic surgery rather than the benefit of the procedure per se. Our experience suggests, nevertheless, that the intra-corporeal anastomosis, which may, at a glance, seem complex is actually safe and technically feasible once sufficient experience with the laparoscopic surgery is attained. In addition, there is a potential for increased wound pain due to excessive stretching of the abdominal muscles during retraction. Tanimura et al. [16] suggested that totally laparoscopic gastrectomy was useful particularly for older patients with poor respiratory function.

In our previous experience, RY with a large remnant stomach was often associated with postoperative gastric stasis. The "RY syndrome", which reportedly occurs in about 30% of patients who undergo this mode of reconstruction [17] has been attributed to a disturbance of jejunal peristalsis [18]. This observation may be important when considering stasis from RY with large remnants, where gastric emptying occurs predominantly by gravity. When the remnant stomach is filled with food, it is apt to descend below the antecolic gastrojejunostomy, rendering gastric emptying through gravity difficult. Weakness in the peristalsis of the jejunum immediately aboral to the anastomosis would further hinder adequate passage of the food. Although a retrocolic gastrojejunostomy with the anastomosis fixed to the mesocolon may be useful to counter this problem, this is not an easy procedure to perform under the laparoscopic approach, particularly in patients with a thick mesocolon. On the other hand, Fujita et al. [15] analyzed 701 patients who underwent standard distal gastrectomy (defined as resection of more than 2/3 of the stomach) with RY reconstruction by open surgery, and reported that delayed gastric emptying occurred only in 14 (1.9%) patients. Our results also suggest that gastric emptying is unlikely to be a problem when the gastric remnant is small.

Fukuhara et al. [19] reported that the incidence of reflux symptoms such as epigastralgia, abdominal discomfort, and heartburn correlated well with the exposure of the gastric remnant to bile. Our results showing a decreased incidence of esophagitis in those reconstructed by RY agree with the increasing body of evidence that RY prevents bile reflux. In our previous analysis of open surgery for early gastric cancer, reduction of the extent of gastrectomy and preservation of the vagal branches and of the pyloric ring were associated with better quality of life [7]. The present data have shown that patients treated by the laparoscopic approach also benefit from a smaller 1/2 resection. It can easily be speculated that the reservoir function of the remnant stomach is preserved in the 1/2 resection group, leading to improved nutritional status and body composition. There is a potential weakness of the present study that internationally validated questionnaires were not used to evaluate the patient-reported outcomes. In this study, we evaluated the patients with the questionnaire format shown in Table 1 because the established instruments are not necessarily focused on specific postgastrectomy symptoms such as the dumping syndromes that we often encounter, and these instruments may not be sufficiently sensitive to detect subtle differences caused by small differences in the mode of reconstruction. In the present study, inconsistency in the intervals between surgery and the acquisition of functional data, ranging from 6 to 12 months, could also be criticized. It has been reported, however, that functional scores, symptom scales, and body composition tend to recover by 6 months after gastrectomy, with little difference thereafter, whereas these outcomes clearly reveal the worst values when evaluated at 1 month postoperatively [20, 21].

In conclusion, patients with early-stage cancer located in the lower-third of the stomach actually benefit from 1/2 gastrectomy rather than the typical 2/3 gastrectomy. B-1 reconstruction is appropriate for patients with a large gastric remnant, and intra-corporeal reconstruction in

experienced hands is associated with no apparent disadvantages, while offering a favorable cosmetic result.

References

1. Maehara Y, Kakeji Y, Oda S, Takahashi I, Akazawa K, Sugimachi K. Time trends of surgical treatment and the prognosis for Japanese patients with gastric cancer. Br J Cancer. 2000;83:986–91.
2. Kitano S, Shiraishi N, Fujii K, Yasuda K, Inomata M, Adachi Y. A randomized controlled trial comparing open vs laparoscopy-assisted distal gastrectomy for the treatment of early gastric cancer: an interim report. Surgery. 2002;131:306–11.
3. Maki T, Shiratori T, Sugawa K. Pylorus-preserving gastrectomy as an improved operation for gastric ulcer. Surgery. 1967;61:838–45.
4. Kameyama J, Ishida H, Yasaku Y, Suzuki A, Kuzu H, Tsukamoto M. Proximal gastrectomy reconstructed by interposition of a jejunal pouch. Eur J Surg. 1993;159:491–3.
5. Nomura E, Shinohara H, Mabuchi H, Lee SW, Sonoda T, Tanigawa N. Postoperative evaluation of the jejunal pouch reconstruction following proximal and distal gastrectomy for cancer. Hepatogastroenterology. 2004;51:1561–6.
6. The Japanese Gastric Cancer Association. Guidelines for the treatment of gastric cancer. Tokyo: Kanehara-Shuppan; 2001.
7. Nomura E, Isozaki H, Fujii K, Toyoda M, Niki M, Sako S, et al. Postoperative evaluation of function-preserving gastrectomy for early gastric cancer. Hepatogastroenterology. 2003;50:2246–50.
8. Kitano S, Iso Y, Moriyama M, Sugimachi K. Laparoscopy-assisted Billroth 1 gastrectomy. Surg Laparosc Endosc. 1994;4:146–8.
9. Kanaya S, Gomi T, Momoi H, Tamaki N, Isobe H, Katayama T, et al. Delta-shaped anastomosis in totally laparoscopic Billroth 1 gastrectomy: new technique of intraabdominal gastroduodenostomy. J Am Coll Surg. 2002;195:284–7.
10. Takaori K, Nomura E, Mabuchi H, Lee SW, Agui T, Miyamoto Y, et al. A secure technique of intracorporeal Roux-Y reconstruction after laparoscopic distal gastrectomy. Am J Surg. 2005;189:178–83.
11. Japanese Gastric Cancer Association. Japanese classification of gastric carcinoma. 2nd English edition. Gastric Cancer 1998;1:10–24.
12. Kubo M, Sasako M, Gotoda T, Ono H, Fujishiro M, Saito D, et al. Endoscopic evaluation of the remnant stomach after gastrectomy: proposal for a new classification. Gastric Cancer. 2002;5:83–9.
13. Kim BJ, O'Connell T. Gastroduodenostomy after gastric resection for cancer. Am Surg. 1999;65:905–7.
14. Nunobe S, Okaro A, Sasako M, Saka M, Fukagawa T, Katai H, et al. Billroth1 versus Roux-en-Y reconstructions: a quality-of life survey at 5 years. Int J Clin Oncol. 2007;12:433–9.
15. Fujita T, Katai H, Morita S, Saka M, Fukagawa T, Sano T. Short-term outcomes of Roux-en-Y stapled anastomosis after distal gastrectomy for gastric adenocarcinomna. J Gastrointest Surg. 2010;14:289–94.
16. Tanimura S, Higashino M, Fukunaga Y, Kishida S, Ogata A, Fujiwara Y, et al. Respiratory function after laparoscopic distal gastrectomy—an index of minimally invasive surgery. World J Surg. 2006;30:1211–5.
17. Tu BN, Kelly KA. Motility disorders after Roux-en-Y gastrojejunostomy. Obes Surg. 1994;4:219–26.
18. Mathias JR, Fernandez A, Sninsky CA, Clench MH, Davis RH. Nausea, vomiting, and abdominal pain after Roux-en-Y anastomosis: motility of the jejunal limb. Gastroenterology. 1985;88:101–7.
19. Fukuhara K, Osugi H, Takada N, Takemura M, Higashino M, Kinoshita H. Reconstructive procedure after distal gastrectomy for gastric cancer that best prevents duodenogastroesophageal reflux. World J Surg. 2002;26:1452–7.
20. Kobayashi D, Kodera Y, Fujiwara M, Koike G, Nakayama G, Nakao A. Assessment of quality of life after gastrectomy using EORTC QLQ-C30 and STO22. World J Surg. 2011;35:257–62.
21. Abdiev S, Kodera Y, Fujiwara M, Koike M, Nakayama G, Ohashi N, et al. Nutritional recovery after open and laparoscopic gastrectomies. Gastric Cancer. 2011 (in press).

Comparative Analysis of Station-specific Lymph Node Yield in Laparoscopic and Open Distal Gastrectomy for Early Gastric Cancer

George Bouras, MRCS, Sang-Woong Lee, MD, PhD,† Eiji Nomura, MD, PhD,† Takaya Tokuhara, MD, PhD,† Soichiro Tsunemi, MD, PhD,† and Nobuhiko Tanigawa, MD, PhD, FACS†*

Background: Randomized trials and cohort studies show that laparoscopic distal gastrectomy (LDG) achieves similar oncological results to open distal gastrectomy (ODG). However, studies have consistently demonstrated lower lymph node yield (LNY) for laparoscopic lymphadenectomy. Analysis of station-specific LNY may be useful in evaluating the reasons behind this difference.

Objectives: Comparison of station-specific LNY, surgical, and oncological outcomes between LDG and ODG for early gastric cancer.

Methods: Patients who underwent R0 distal gastrectomy with histologically confirmed early gastric cancer were eligible for the study. All consecutive cases of LDG since the beginning of our experience with laparoscopic gastrectomy and synchronous cases of ODG with R0 resection were included in the study. Demographic, operative, histopathologic, and follow-up data were recorded in all patients.

Results: A total of 259 cases of LDG and 95 cases of ODG were performed between 2000 and 2009. Patients undergoing LDG had longer operations but less bleeding ($P < 0.05$). Postoperative complications were similar in both groups. The preoperatively planned extent of lymphadenectomy was D1 (stations 1, 3, 4sb, 4d, 5, 6, and 7), D1+ (D1with stations 8a and 9), or D2 (D1+ with stations 11p and 12a). During surgery, dissection of stations 3, 4d, 5, 6, and 7 was performed in all cases of LDG and ODG. Dissection of stations 1, 4sb, 8a, 9, 11p, and 12a was performed more frequently during ODG than during LDG. Consequently, the total LNY was 26.71 and 31.43 for LDG and ODG, respectively. Station-specific LNY was significantly lower for LDG than for ODG in the common hepatic artery nodes only ($P < 0.05$). The mean follow-up was 43.6 months. Lymph node metastases, metastatic-to-resected lymph node ratio, recurrence, and cancer-related deaths were similar for LDG and ODG.

Conclusions: LDG was associated with less extensive lymph node dissection compared with ODG. Station-specific LNY was similar in all nodal stations except for the common hepatic artery nodes. In our experience, laparoscopic sub-D2 lymphadenectomy was adequate in the context of early gastric cancer and represents the future of gastric cancer resection in Japan.

Key Words: laparoscopy, distal gastrectomy, gastric cancer, lymphadenectomy, surgical technique

(*Surg Laparosc Endosc Percutan Tech* 2011;21:424–428)

Distal gastrectomy for early gastric cancer is the most commonly performed type of gastric resection. Randomized trials show that laparoscopic distal gastrectomy (LDG) takes longer to perform but is associated with less bleeding, less pain, shorter recovery, and improvement in perioperative quality of life when compared with open distal gastrectomy (ODG).[1–4] Large cohorts from Asia confirm these findings and are also supportive of the long-term oncological efficacy of LDG.[5–14] In light of this, increasing numbers of laparoscopic gastric resections are being performed worldwide.[15–24] Interestingly, these accounts consistently demonstrate lower lymph node yield (LNY) by laparoscopy compared with open surgery. A recent meta-analysis of randomized trials confirms this difference to be in the region of 4 lymph nodes.[25]

LNY has received considerable attention because of differences between western and Japanese staging systems.[26–28] The most recent modification of the Japanese gastric cancer staging classification has markedly changed lymph node staging in Japan from the anatomic (tier-based) system used historically to a numerical (number of involved nodes) system similar to western tumour, nodes and metastases to facilitate the comparison of clinical outcomes internationally.[29] Although the emphasis in staging has moved away from tiers of lymph node stations, the quality of surgical resection for gastric cancer will continue to be determined according to anatomic levels of lymphatic drainage (D1 to D2). The Japanese system of station-specific lymph node dissection offers unique anatomic information on the intent of lymphadenectomy and is being increasingly adopted by western surgeons.

We previously reported on the curability of laparoscopic gastrectomy in 391 consecutive resections including 170 cases of LDG.[30] Similar to other accounts in the literature, we found that LNY was significantly lower for laparoscopic surgery compared with open surgery. Here we present the results from our comparison of station-specific LNY in synchronous cohorts of LDG and ODG to evaluate the adequacy of laparoscopic lymphadenectomy for early gastric cancer.

PATIENTS AND METHODS

Patients

Patients who underwent R0 distal gastrectomy for early gastric cancer were eligible for the study. Currently at our unit, laparoscopic gastrectomy is routine for early

Received for publication November 25, 2010; accepted August 5, 2011.
From the *Upper Gastrointestinal Surgery Unit, Queen Elizabeth Hospital, Birmingham, UK; and †Department of General and Gastroenterological Surgery, Osaka Medical College, Takatsuki, Japan.
The authors declare no conflicts of interest.
Reprints: George Bouras, MRCS, Upper Gastrointestinal Surgery Unit, Queen Elizabeth Hospital, 10 East Pathway, Birmingham B17 9DN, UK (e-mail: georgebouras@hotmail.com).

TABLE 1. Surgical Outcomes From Laparoscopic and Open Distal Gastrectomy for Early Gastric Cancer

	Laparoscopic n = 259	Open n = 95
Mean operation time (min) (range)*	304 (150-570)	252 (130-620)
Mean operative blood loss (mL) (range)*	84.9 (5-800)	310.2 (20-2240)
Thirty-day hospital mortality (%)	0.4	0
Anastomotic leakage (%)	3.0	2.8

*$P < 0.05$.

gastric cancer. Those with preoperative estimation of advanced disease undergo open gastrectomy. Distal gastrectomy is indicated for distal and middle third gastric cancers. Tumor margins of at least 2 cm are considered adequate in early gastric cancer. All consecutive cases of LDG since the beginning of our laparoscopic experience and concurrent cases of ODG that were later classified as having early gastric cancer by histologic assessment were included in the analysis. Patients who underwent a modified resection such as pylorus-preserving or segmental gastrectomy were excluded from the study because of the lack of systematic lymph node dissection in some of the cases.[31]

Data Collection

Preoperative data included patient demographics. Operative data included extent of lymphadenectomy, operation time, bleeding, and postoperative complications. Histopathologic data included tumor stage, lymph node metastases, and station-specific LNY. Patients were followed up in the outpatient clinic twice annually for 5 years.

Lymph Node Dissection

In all cases, lymph node dissection was performed according to the endoscopic depth of invasion of the primary tumor guided by Japanese treatment guidelines.[32–34] The preoperatively planned extent of lymphadenectomy was categorized as D1 (stations 1, 3, 4sb, 4d, 5, 6, and 7), D1 + (D1with stations 8a and 9), or D2 (D1 + with stations 11p and 12a) in accordance with the most recent Japanese classification for lymphadenectomy in early gastric cancer.[35]

Surgical Technique for LDG and Laparoscopic Lymphadenectomy

The patient is positioned with hips abducted for the primary surgeon who stands in between the patient's legs. The paraumbilical optical port is accompanied by operative ports placed at a handbreath width laterally and slightly higher than the optical port (12-mm right hand, 5-mm left hand) and 2 further ports for the 2 assistants (both 5 mm) placed laterally below the costal margins. After insertion of a liver retractor, greater curve mobilization is initiated by dividing the gastrocolic ligament distal to the gastroepiploic arcade to enter the lesser sac. The omentum is freed proximally until the proximal resection line is reached, taking the proximal greater curve nodes (station 4sb) in the process. The left gastroepiploic vessels are then divided and the corresponding lymph nodes taken on the side of the resection. Distally, the same plane is followed until the duodenum is reached, taking distal greater curve nodes (station 4d) in the process. The infrapyloric nodes (station 6) around the right gastroepiploic vessels are then dissected off the head of the pancreas. A window is created behind the duodenum, which is then transected with a stapler. This allows for better access to the lesser curve nodes, and the dissection is started by taking the suprapyloric nodes (station 5) around the right gastric vessels. More lateral dissection toward the hepatic hilum allows for dissection of the hepatic artery proper nodes (station 12a). The plane along the artery is then followed medially to dissect the common hepatic artery nodes (station 8a) and to reach the left gastric artery nodes (station 7). The dissection is continued further to the patient's left along the splenic artery for the proximal splenic artery nodes (station 11p). After dividing the left gastric artery, the celiac artery nodes (station 9) are dissected off the celiac trunk and the right diaphragmatic crus. Finally, the proximal and distal lesser curve nodes (station 1 and 3) are dissected before proximal gastric transection with a linear stapler. Once the specimen is retrieved, reconstruction is performed by either Billroth-1 or Roux-en-Y reconstruction depending on the size of the remnant stomach.[36] Recently, we have been performing intracorporeal stapled gastroduodenostomy and gastrojejunostomy as part of our laparoscopic approach for reconstruction.[37–39]

Statistics

Data were analyzed using MedCalc software for windows. Comparison of groups was performed by the Student t test after confirming normal distribution of continuous numerical variables. $P < 0.05$ was considered statistically significant.

RESULTS

Between January 2000 and December 2009, 465 cases of distal gastrectomy were performed at our unit. A total of 259 cases of LDG and 95 cases of ODG were performed for early gastric cancer according to the 7th Edition of the UICC Classification of malignant tumors.[40] The mean age

TABLE 2. Lymph Node Yield According to Planned Extent of Lymph Node Dissection for Laparoscopic and Open Distal Gastrectomy

	Laparoscopic		Open	
Level of Lymph Node Dissection	No. Patients (%)	Lymph Node Yield (SD)	No. Patients (%)	Lymph Node Yield (SD)
D1	45 (17.4)	18.23 (9.60)	12 (12.6)	21.30 (10.33)
D1+	188 (72.6)	27.89 (12.07)	39 (41.1)	30.66 (9.83)
D2	26 (10.0)	32.30 (13.94)	44 (46.3)	34.14 (13.32)
All	259 (100)	26.71 (12.64)	95 (100)	31.43 (14.14)

TABLE 3. Station-specific Lymph Node Yield and Frequency of Dissection for Laparoscopic and Open Distal Gastrectomy for Early Gastric Cancer

	Laparoscopic (n = 259)		Open (n = 95)	
Lymph Node Station	Dissection Performed (%)	Lymph Node Yield Mean (SD)	Dissection Performed (%)	Lymph Node Yield Mean (SD)
1	69	2.53 (2.65)	78	2.43 (2.30)
3	100	6.02 (4.55)	100	5.98 (4.19)
4sb	81	1.41 (2.08)	98	1.67 (1.69)
4d	100	5.90 (3.55)	100	6.37 (4.85)
5	100	1.34 (1.50)	100	1.44 (1.06)
6	100	3.212 (2.25)	100	3.43 (2.74)
7	100	2.95 (2.66)	100	3.27 (2.31)
8a*	94	2.18 (1.88)	100	3.22 (2.75)
9	68	1.71 (1.36)	100	2.02 (1.60)
11p	36	1.49 (1.73)	100	1.75 (1.84)
12a	20	1.31 (0.71)	48	1.42 (1.67)

*$P < 0.05$

of the patients was 65.1 years (range, 30 to 88 y) and 64.9 years (range, 32 to 85 y) for LDG and ODG, respectively. The male-to-female ratio was 1.75 for LDG and 1.79 for ODG.

LDG was associated with significantly less bleeding and longer operation times compared with ODG, whereas complications occurred at similar frequencies in both groups (Table 1). There was 1 perioperative death in the laparoscopic group related to severe postoperative pancreatitis.

The preoperatively planned extent of lymph node dissection for LDG was 17.4% D1, 72.6% D1+, and 10.0% D2, whereas for ODG it was 10.33% D1, 41.1% D1+, and 46.3% D2 (Table 2). LNY and frequency of dissection of the 11 numbered nodal stations for LDG and ODG (Table 3) showed that dissection of nodal stations 3, 4d, 5, 6, and 7 was performed in all cases of LDG and ODG, whereas dissection of stations 1, 4sb, 8a, 9, 11p, and 12a was performed more commonly during ODG compared with LDG. Consequently, total LNY was lower at 26.71 (SD 12.64) for LDG and 31.43 (SD 14.14) for ODG. Station-specific LNY was similar in all nodal stations except for station 8a, which showed a significantly lower LNY for LDG. On the basis of our previous analysis of the learning curve for LDG,[41] comparison of total LNY between cases during (< 60 cases) and after (> 90 cases) the learning curve period revealed no significant difference between early and late experience (Table 4).

Histopathology and follow-up revealed that there were no significant differences in lymph node metastases, metastatic-to-resected lymph node ratio (defined as the total number of metastatic lymph nodes harvested over the total LNY), recurrence, and cancer-related death between LDG and ODG for early gastric cancer (Table 5).

TABLE 4. Total Lymph Node Yield for Laparoscopic Distal Gastrectomy Before (<60 Cases) and After (> 90 Cases) End of Learning Curve

	Experience During Learning Curve Case No. < 60	Experience Beyond Learning Curve Case No. > 90
Total lymph node yield	29.38 (15.44)	26.19 (11.76)

DISCUSSION

Increasing efforts are being made to internationally standardize the oncological approach to lymph node dissection for gastric cancer. With developments in laparoscopic surgery, comparative cohorts have consistently demonstrated lower LNY for LDG compared with ODG.[5–24] These accounts are invariably skewed as patients with advanced disease are less likely to undergo laparoscopic resection. A meta-analysis of randomized trials has shown that the laparoscopic LNY is on average 4 lymph nodes less than open surgery even when the effect of uneven groups is accounted for.[25] We postulate that station-specific LNY analysis will be useful in determining which nodal stations yield less lymph nodes by laparoscopy. To make a fair comparison, we analyzed LNY and the frequency of dissection for each nodal station to compare laparoscopic and open lymphadenectomy in patients with early gastric cancer. Through this data set, we aim to demonstrate the adequacy of laparoscopic lymphadenectomy through comparison with the gold standard of open surgery.

Similar to other reports, the overall LNY in the present study was lower for LDG compared with ODG. Station-specific LNY of the 11 lymph node stations analyzed showed that 5 stations were dissected in all cases of LDG and ODG, whereas the remaining 7 stations were dissected more frequently during ODG. Although the routinely dissected stations were perigastric nodes, the selectively dissected stations were extraperigastric and dissected more frequently as part of more radical lymphadenectomy. For some very distal cancers, dissection of the proximal perigastric nodal stations 1 and 4sb was not performed routinely. The only nodal station that showed a statistically significant difference in yield between LDG and ODG was the common hepatic artery nodes. It is feasible that laparoscopy offers a view and angle of instrumentation leading to a shallow dissection over and above the pancreas resulting in low LNY. In contrast, access through a laparotomy allows for the surgeon to adjust his or her

TABLE 5. Lymph Node Metastases, Nodal Ratio, Recurrence, and Cancer-related Deaths After Laparoscopic and Open Distal Gasatrectomy for Early Gastric Cancer

	Mean Follow-up Months (SD)	Patients With Metastases (%)	Metastatic-to-resected Lymph Node Ratio (%)	Patients With Recurrence (%)	Cancer-related Deaths (%)
Laparoscopic	43.3 (30.2)	15 (5.8)	0.3	2 (0.8)	2 (0.8)
Open	44.1 (27.9)	7 (7.4)	0.4	1 (1.1)	1 (1.1)

body position and instrumentation to achieve a deeper dissection with ease. Although no difference was seen in survival, the results observed here deserve attention in future studies, particularly in the context of advanced disease in which resection of these nodes may influence outcome.

Overall, laparoscopic lymphadenectomy achieved similar LNY to open surgery for 10 of the 11 nodal stations analyzed. The total LNY for LDG was 26.71 nodes. Accounts in the literature report between 8 and 43 nodes depending on the origin of the data and disease stage in the cohorts.[1–24] We previously demonstrated the learning curve for LDG to be between 60 and 90 cases.[41] Our results suggest that laparoscopic lymphadenectomy, when performed systematically, is adequate during the learning curve phase of this procedure. A shift toward less radicality has also been observed over the years. Our station-specific LNY analysis has shown that some initiative is needed to achieve a quality of laparoscopic lymph node dissection over the common hepatic artery, which is as extensive as open surgery. The shallow angulation of instruments should be taken into account, and the assistant can help by rolling the pancreas ventrally for exposure. The right-sided operative ports may be inserted higher for deep abdomens to improve the angulation of instrumentation in this area. Switching the energy device from one hand to the other facilitates efficient and ergonomic dissection in difficult cases.

The results show that the attitude toward radicality of lymph node dissection in gastric cancer is ever changing. In Japan, the concept of selective sub-D2 lymphadenectomy for early gastric cancer has been present for some time. The latest classification system moves away from the old D1 + α (D1 and 7) and D1 + β (D1 and 7, 8a, 9) to the new D1 + (D1 and 8a, 9), wherein 7 is included as part of D1.[35] Our data highlight the fact that dissection of the proximal stations 1 and 4sb was not routinely performed until recently, as guidelines classified them as D2 in the past.[42] It is also noted that 11p is often taken in the absence of 12a dissection, both of which are needed to qualify the dissection as D2. This audit has helped us reiterate the importance of continuously evaluating our practice to ensure that it is in line with the most up-to-date clinical evidence and treatment guidelines available. Ultimately, lymph node dissection for gastric cancer must be tailored to the individual, taking into account patient and tumor characteristics to determine the appropriate level of lymphadenectomy at the time of surgery.

In this study, we were able to utilize station-specific LNY to make useful comparisons between LDG and ODG. We observed that certain stations were omitted more frequently by laparoscopy. We have cautiously introduced laparoscopic gastrectomy into our practice by approaching the less radical resections first with a systematic approach to lymph node dissection that mirrors our open surgical technique. The magnified view, together with improvements in coagulation devices, ensures further development in this area. In the advent of technological advances such as robotic surgery,[43] the introduction of new instrumentation and delivery of dissection through an interface must not compromise the quality of operative procedures. New technologies must be introduced to facilitate development of a dissection technique using instruments with greater freedom of movement and 3-dimensional vision. As our results highlight potential technical restrictions in conventional laparoscopic instrumentation, robotic surgery may be the next step in the evolution of minimally invasive gastrectomy to overcome such hurdles.

In conclusion, LDG was associated with less extensive lymphadenectomy compared with ODG. Station-specific LNY revealed the extent of lymphadenectomy to be similar between LDG and ODG in all nodal stations, except for the common hepatic artery nodes. In our experience, laparoscopic sub-D2 lymphadenectomy was adequate in the context of early gastric cancer and represents the future of gastric cancer resection in Japan.

REFERENCES

1. Kitano S, Shiraishi N, Fujii K, et al. Randomized controlled trial comparing open vs laparoscopy-assisted distal gastrectomy for the treatment of early gastric cancer: an interim report. *Surgery*. 2002;131(1 suppl):S306–S311.
2. Huscher CG, Mingoli A, Sgarzini G, et al. Laparoscopic versus open subtotal gastrectomy for distal gastric cancer: five-year results of a randomized prospective trial. *Ann Surg*. 2005;241: 232–237.
3. Hayashi H, Ochiai T, Shimada H, et al. Prospective randomized study of open versus laparoscopy-assisted distal gastrectomy with extraperigastric lymph node dissection for early gastric cancer. *Surg Endosc*. 2005;25:3061–3068.
4. Kim YW, Baik YH, Yun YH, et al. Improved quality of life outcomes after laparoscopy-assisted distal gastrectomy for early gastric cancer: results of a prospective randomized clinical trial. *Ann Surg*. 2008;248:721–727.
5. Lee SW, Nomura E, Bouras G, et al. Long-term oncological outcomes from laparoscopic gastrectomy for gastric cancer: single-centre experience of 601 consecutive resections. *J Am Coll Surg*. 2010;211:33–40.
6. Adachi Y, Shiraishi N, Shiromizu A, et al. Laparoscopy-assisted Billroth 1 gastrectomy compared with conventional open gastrectomy. *Arch Surg*. 2000;135:806–810.
7. Yano H, Monden T, Kinuta M, et al. The usefulness of laparoscopy-assisted distal gastrectomy in comparison with that of open distal gastrectomy for early gastric cancer. *Gastric Cancer*. 2001;4:93–97.
8. Tanimura S, Higashino M, Fukunaga Y, et al. Laparoscopic distal gastrectomy with regional lymph node dissection for gastric cancer. *Surg Endosc*. 2005;19:1177–1181.
9. Mochiki E, Kamiyama Y, Aihara R, et al. Laparoscopic assisted distal gastrectomy for early gastric cancer: 5 years' experience. *Surgery*. 2005;137:317 322.

10. Noshiro H, Nagai E, Shimizu S, et al. Laparoscopically assisted distal gastrectomy with standard radical lymph node dissection for gastric cancer. *Surg Endosc.* 2005;19:1592–1596.
11. Shiraishi N, Yasuda K, Kitano S. Laparoscopic gastrecomy with lymph node dissection for gastric cancer. *Gastric Cancer.* 2006;9:167–176.
12. Mochiki E, Nakabayashi T, Kamimura H, et al. Gastrointestinal recovery and outcome after laparoscopy-assisted versus conventional open distal gastrectomy for early gastric cancer. *World J Surg.* 2002;26:1145–1149.
13. Kitano S, Shiraishi N, Kakisako K, et al. Laparoscopy-assisted Billroth-I gastrectomy (LADG) for cancer: our 10 years' experience. *Surg Laparosc Endosc Percutan Tech.* 2002;12:204–207.
14. Lee WJ, Wang W, Chen TC, et al. Totally laparoscopic radical BII gastrectomy for the treatment of gastric cancer: a comparison with open surgery. *Surg Laparosc Endosc Percutan Tech.* 2008;18:369–374.
15. Sarela AI. Entirely laparoscopic radical gastrectomy for adenocarcinoma: lymph node yield and resection margins. *Surg Endosc.* 2009;23:153–160.
16. Feliu-Pala X, Besora-Canal P, Claveria-Puig R, et al. Laparoscopic gastrectomy in the treatment of gastric cancer. *Cir Esp.* 2006;79:231–236.
17. Guzman EA, Pigazzi A, Lee B, et al. Totally laparoscopic gastric resection with extended lymphadenectomy for gastric adenocarcionoma. *Ann Surg Oncol.* 2009;16:2218–2223.
18. Weber KJ, Reyes CD, Gagner M, et al. Comparison of laparoscopic and open gastrectomy for malignant disease. *Surg Endosc.* 2003;17:968–971.
19. Dulucq JL, Wintringer P, Stabilini C, et al. Laparoscopic and open gastric resections for malignant lesions: a prospective comparative study. *Surg Endosc.* 2005;19:933–938.
20. Carboni F, Lepiane P, Santoro R, et al. Laparoscopic surgery for gastric cancer: preliminary experience. *Gastric Cancer.* 2005;8:75–77.
21. Varela JE, Hiyashi M, Nguyen T, et al. Comparison of laparoscopic and open gastrectomy for gastric cancer. *Am J Surg.* 2006;192:837–842.
22. Topal B, Leys E, Ectors N, et al. Determinants of complications and adequacy of surgical resection in laparoscopic versus open total gastrectomy for adenocarcionoma. *Surg Endosc.* 2008;22:980–984.
23. Singh KK, Rohatgi A, Rybinkina I, et al. Laparoscopic gastrectomy for gastric cancer: early experience among the elderly. *Surg Endosc.* 2008;22:1002–1007.
24. Pugliese R, Maggioni D, Sansonna F, et al. Total and subtotal laparoscopic gastrectomy for adenocarcinoma. *Surg Endosc.* 2007;21:21–27.
25. Memon MA, Khan S, Yunus RM, et al. Meta-analysis of laparoscopic and open distal gastrectomy for gastric carcinoma. *Surg Endosc.* 2008;22:1781–1789.
26. Maruyama K, Gunven P, Okabayashi K, et al. Lymph node metastases of gastric cancer. General pattern in 1931 patients. *Ann Surg.* 1989;210:596–602.
27. Zhang M, Zhu G, Ma Y, et al. Comparison of four staging systems of lymph node metastasis in gastric cancer. *World J Surg.* 2009;33:2383–2388.
28. Marchet A, Mocellin S, Ambrosi A, et al. The ratio between metastatic and examined lymph nodes (N ratio) is an independent prognostic factor in gastric cancer regardless of the type of lymphadenectomy: results from an Italian multicentric study in 1853 patients. *Ann Surg.* 2007;245:543–552.
29. Japanese Gastric Cancer Association, Japanese Classification of Gastric Cancer, Kanehara & Co. Ltd, Tokyo, Japan, 14th edition, 2010.
30. Zhang X, Tanigawa N, Nomura E, et al. Curability of laparoscopic gastrectomy for gastric cancer: an analysis of 10 years' experience. *Gastric Cancer.* 2008;11:175–180.
31. Lee SW, Bouras G, Nomura E, et al. Intra-corporeal stapled anastomosis following laparoscopic segmental gastrectomy for gastric cancer: technical report and surgical outcomes. *Surg Endosc.* 2009;24:1774–1780.
32. Shimada Y. JGCA (The Japan Gastric Cancer Association). Gastric cancer treatment guidelines. *Jpn J Clin Oncol.* 2004;34:58.
33. Nakajima T. Gastric cancer treatment guidelines in Japan. *Gastric cancer.* 2002;5:1–5.
34. Yasuda K, Shiraishi N, Suematsu T, et al. Rate of detection of lymph node metastasis is correlated with the depth of submucosal invasion in early stage gastric carcinoma. *Cancer.* 1999;85:2119–2123.
35. Japan Gastric Cancer Association. Treatment guidelines for lymphadenectomy in early gastric cancer (3rd Edition). (Japanese) Kanehara Shuppan, October 2010.
36. Nomura E, Lee SW, Bouras G, et al. Functional outcomes according to the size of gastric remnant and type of reconstruction following laparoscopic distal gastrectomy for gastric cancer. *Gastric Cancer.* 2011;14:279–284.
37. Kanaya S, Gomi T, Momoi H, et al. Delta-shaped anastomosis in totally laparoscopic Billroth I gastrectomy: new technique of intra-abdominal gastroduodenostomy. *J Am Coll Surg.* 2002;195:284–287.
38. Takaori K, Nomura E, Mabuchi H, et al. A secure technique of intracorporeal Roux-Y reconstruction after laparoscopic distal gastrectomy. *Am J Surg.* 2005;189:178–183.
39. Bouras G, Lee SW, Nomura E, et al. Surgical outcomes from laparoscopic distal gastrectomy and Roux-en-Y reconstruction: evolution in a totally intra-corporeal technique. *Surg Laparosc Endosc Percutan Tech.* 2011;21:37–41.
40. Sobin L, Gospodarowitcz M, Wittekind C. 7th Edition of the UICC (International Union Against Cancer) Classification of Malignant Tumours. Wiley-Blackwell 2009.
41. Zang X, Tanigawa N. Learning curve of laparoscopic surgery for gastric cancer, a laparoscopic distal gastrectomy-based analysis. *Surg Endosc.* 2009;23:1259–1264.
42. Japanese Gastric Cancer Association. Japanese classification of gastric carcinoma. *Gastric cancer.* 1998;1:10–24.
43. Song J, Oh SJ, Kang WH, et al. Robot-assisted gastrectomy with lymph node dissection for gastric cancer: lessons learned from an initial 100 consecutive procedures. *Ann Surg.* 2009;249:927–932.

Laparoscopic Technique and Initial Experience with Knotless, Unidirectional Barbed Suture Closure for Staple-Conserving, Delta-Shaped Gastroduodenostomy after Distal Gastrectomy

Sang-Woong Lee, MD, PhD, Eiji Nomura, MD, PhD, Takaya Tokuhara, MD, PhD, Masaru Kawai, MD, PhD, Nobuhisa Matsuhashi, MD, PhD, Kazutake Yokoyama, MD, Hiroya Fujioka, MD, Masako Hiramatsu, MD, PhD, Junji Okuda, MD, PhD, FACS, Kazuhisa Uchiyama, MD, PhD

Since laparoscopy-assisted distal gastrectomy was first reported by Kitano and colleagues in 1994,[1] laparoscopic gastrectomy (LG) for early gastric cancer (EGC) has been increasing rapidly and gaining popularity worldwide because it is associated with earlier patient recovery compared with open surgery.[2-9] Improvements in instruments and laparoscopic technique have allowed for widespread acceptance of LG, not only for various types of gastric resection but also for totally laparoscopic procedures.[10-14]

In general, LG can be divided into laparoscopy-assisted and totally laparoscopic techniques. With laparoscopy-assisted gastrectomy, although lymph node dissection is performed laparoscopically, transection of the stomach and the anastomosis are performed thorough an epigastric minilaparotomy. Performing the anastomosis in the narrow and restricted space is frequently difficult, especially for obese patients with thick abdominal walls or for patients with a small remnant stomach. Avoiding minilaparotomy also improves cosmesis, and performing all of the processes laparoscopically, including reconstruction of the digestive tract intracorporeally using laparoscopic linear stapling devices, offers the prospect of further improvements in quality of life. Recent results of retrospective studies have demonstrated the feasibility, safety, and efficiency of totally laparoscopic gastrectomy (TLG) when performed by high-volume laparoscopic surgeons, even with a relatively prolonged operating time.[10,13,15] However, TLG has the disadvantages of technical difficulties in intracorporeal anastomosis and additional costs associated with the use of linear stapler cartridges.[10] In addition, laparoscopic intracorporeal suturing and knot tying for anastomosis are considered the most difficult laparoscopic skills to master.

Barbed sutures have recently been proposed to facilitate laparoscopic suturing. One of these novel sutures, the V-Loc 180 (Covidien) consists of a barbed absorbable thread, armed with a surgical needle at one end and a loop at the other end, which is used to secure the suture (Fig. 1). The barb and loop end make it possible to approximate the tissues without the need to tie surgical knots. The efficacy and suitability of barbed sutures have been reported in gynecologic and urologic surgery to date,[16,17] but there have been no reports for bowel anastomosis, especially after gastrectomy in humans.

Our hypothesis was that barbed suture could potentially improve the efficiency of the intracorporeal reconstruction of the digestive tract after TLG with reduced cost by closing the entry hole of the stapler instead of stapling, and with less time needed to suture by resisting slippage and precluding the requirement for constant traction. In this article, we present our initial experience of 6 consecutive totally laparoscopic distal gastrectomies (LDG) with intracorporeal staple-conserving delta-shaped gastroduodenostomy.

METHODS

Six patients with EGC who underwent LDG with staple-conserving delta-shaped Billroth I reconstruction from April to July 2011 were enrolled in this study. All patients were informed of the study design according to the Ethical Committee on Clinical Investigation of Osaka Medical College Hospital and consented in writing to participate in this study. At our unit, LG is indicated for gastric cancer up to stage T2N1.[14] Distal gastrectomy is indicated for distal and middle third gastric cancers in which tumor margins of at least 2 cm for early and 3 to 5 cm for advanced lesions can be taken. Some patients with very early disease may have a more limited resection such as pylorus-preserving or segmental gastrectomy.[12]

Disclosure information: Nothing to disclose.

Received August 22, 2011; Revised September 2, 2011; Accepted September 2, 2011.

From the Department of General and Gastroenterological Surgery, Osaka Medical College, Takatsuki, (Lee, Nomura, Tokuhara, Kawai, Yokoyama, Fujioka, Hiramatsu, Okuda, Uchiyama) and the Department of Surgery, Gifu Prefectural General Medical Center, Gifu, Japan (Matsuhashi).

Correspondence address: Sang-Woong Lee, MD, PhD, Department of General and Gastroenterological Surgery, Osaka Medical College, 2-7 Daigaku-Machi, Takatsuki, Osaka 569-8686, Japan. email: sur079@poh.osaka-med.ac.jp

ISSN 1072-7515/11/$36.00
doi:10.1016/j.jamcollsurg.2011.09.004

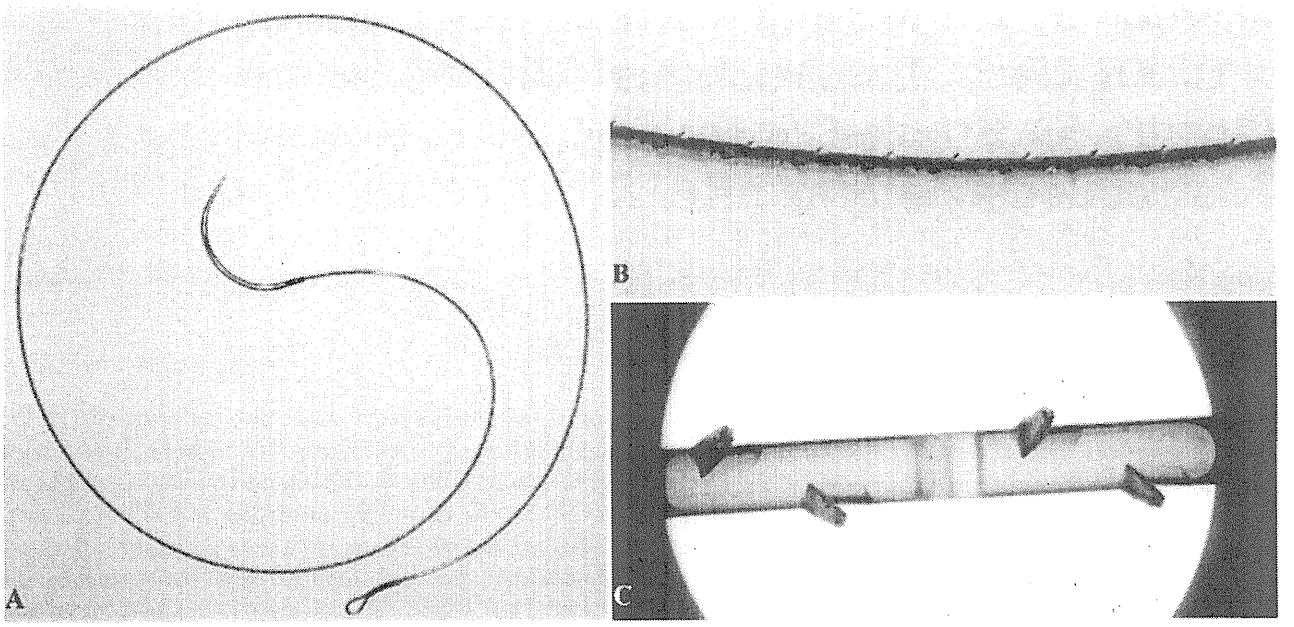

Figure 1. Thirty-centimeter 3-0 V-Loc 180 suture on a V-20 needle (26 mm tapered): (A) no barbs in the first 2 cm of the suture, allowing for readjustment of the throw without adverse effects, and a loop at the other end for passing the needle to secure the suture; (B) a close-up of unidirectional barbed suture; (C) micrograph of the laser-etched barbs.

Lymph node dissection is performed depending on the endoscopic depth of invasion of the primary tumor and radiologic lymph node involvement. The preoperatively planned extent of lymphadenectomy was categorized as D1 (stations 1, 3, 4sb, 4d, 5, 6, and 7), D1+ (D1 with stations 8a and 9), or D2 (D1+ with stations 11p and 12a), according to the latest Japanese treatment guidelines.[18] Patients with T1-2N1 and T2N0 received D2 lymph node dissection, and patients with T1N0 received D1+.[18]

In terms of reconstruction after LDG, patients with large remnant stomachs, which allow for tension-free primary gastroduodenostomy, undergo Billroth I reconstruction by the delta-shaped method using linear staplers.[19] The tension is assessed by pulling the greater curvature of the gastric stump toward the duodenum before reconstruction. The remaining patients with small remnant stomachs undergo Roux-en-Y reconstruction, for which the gastrojejunostomy is performed by our earlier described intracor-

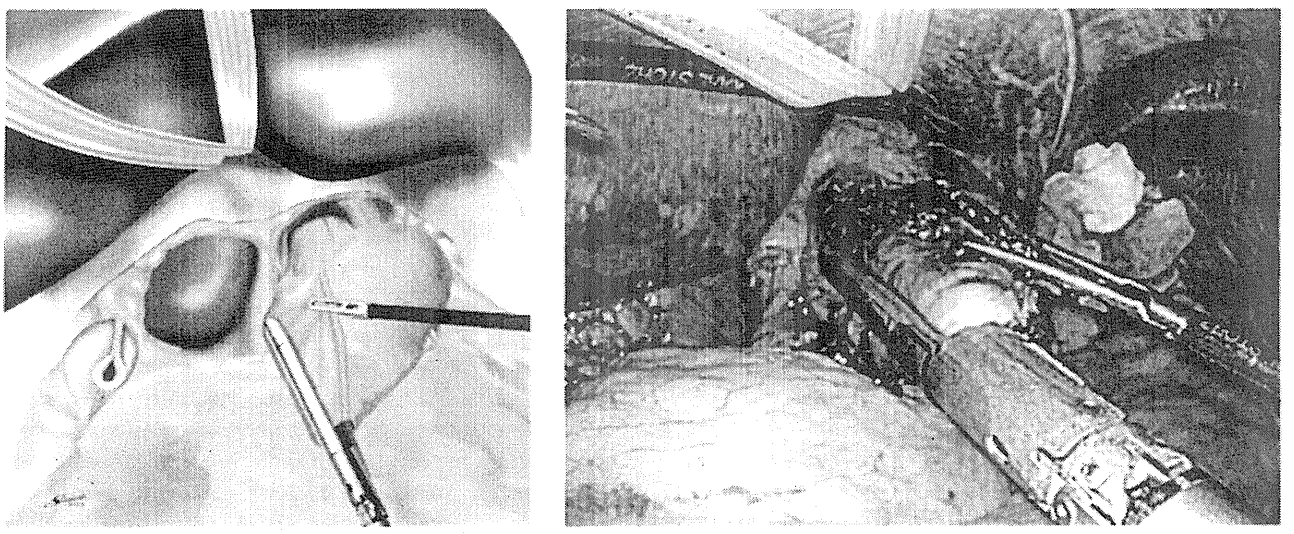

Figure 2. Insertion of a cartridge fork into the gastrostomy along the posterior wall of the gastric stump.

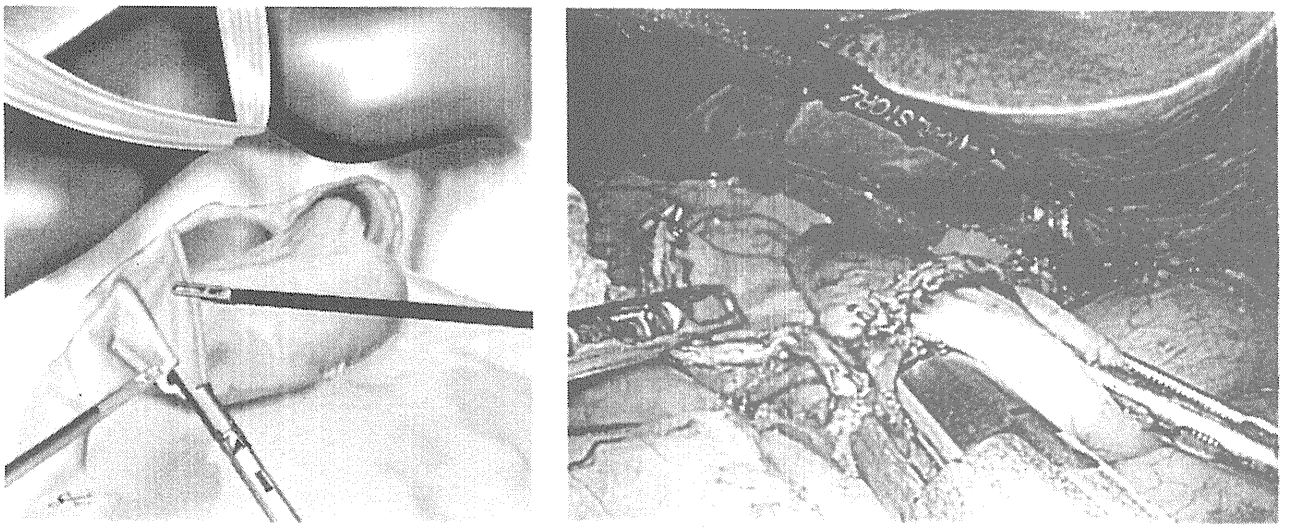

Figure 3. Insertion of an anvil fork into duodenal stump, with each fork positioned to join the posterior walls together.

poreal technique using linear staplers.[20,21] Since April 2011, we have been introducing knotless, unidirectional barbed sutures into intracorporeal delta-shaped gastroduodenostomy after LDG.

The V-Loc 180 closure device is a unidirectional barbed variant of the absorbable copolymer polyglyconate (Maxon, Covidien). It has the same material and degradation properties as a Maxon (monofilament polyglyconate) suture; tissue closing strength is approximately 50% at 30 days, with complete absorption in 180 days. Although etching the barbs reduces the core diameter of these sutures, they have been sized according to their postetching diameter, and 3-0 V-Loc suture has the same tensile strength as 3-0 Maxon. A loop at the end of the suture can be used for knotless suturing, and the first 2 cm of the suture are without barbs to allow throws to be readjusted before the barbs are engaged (Fig. 1).

Surgical techniques for stapler-conserving delta-shaped gastroduodenostomy

As shown in Figures 2 to 7, for cases of LDG reconstructed by Billroth I anastomosis, the duodenum was transected just distal to the pylorus using an endoscopic linear stapler introduced through the left lower port. The duodenum is rotated by pulling the posterior wall of the gastric antrum from below and rotating the stomach upward. This is done to apply a "twist" to the duodenum so that it is divided in a posterior to anterior direction rather than in a purely

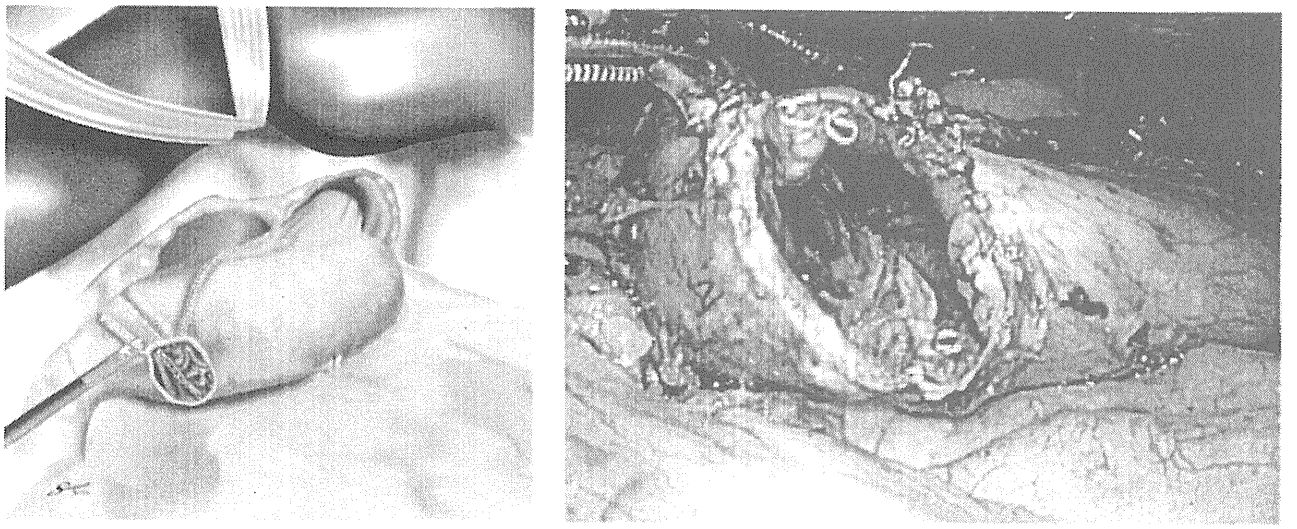

Figure 4. V-shaped stapler entry hole between the stomach and the duodenum.

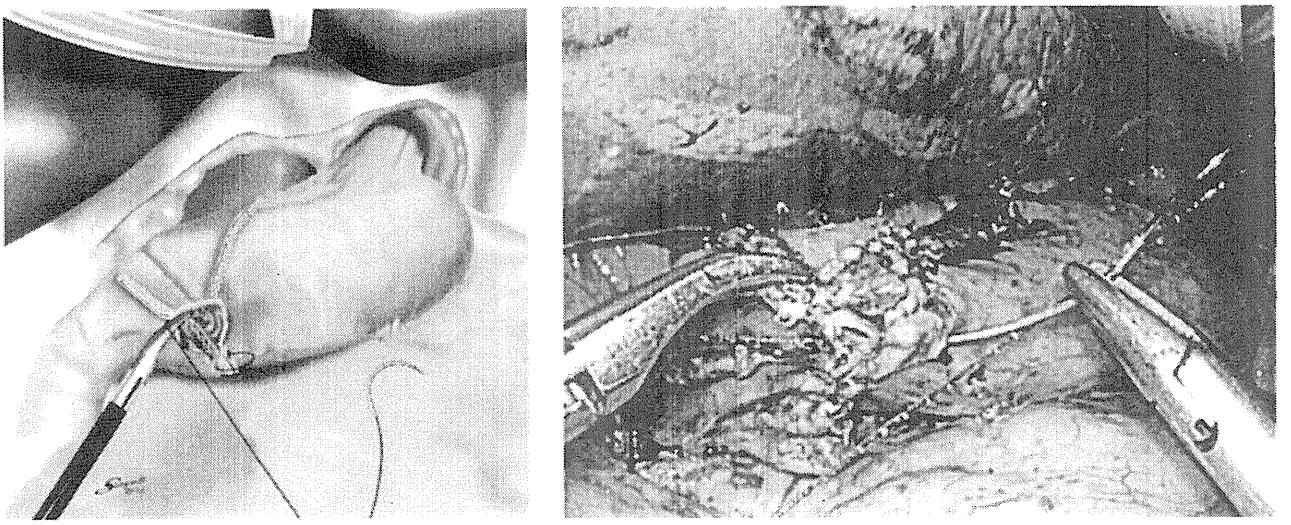

Figure 5. Step 1 of the intracorporeal suture closure of the common enterotomy hole for the stapler showing the full-thickness inner layer closure using a knotless unidirectional barbed suture, starting from the corner of the great curvature.

greater curvature to lesser curvature direction. This facilitates subsequent stapled gastroduodenostomy in order to maintain a favorable blood supply to the anastomosis line. After distal gastrectomy with lymph node dissection, the specimen is retrieved through the umbilical wound extended to 3 cm. Pneumoperitoneum is then re-established by partial reclosure of the wound before reconstruction.

A small hole is made on the greater curvature corner of the staple line on the remnant stomach and on the posterior tip of the duodenal stump. The cartridge fork of the linear stapler is inserted into the gastric remnant. While the staple line of the remnant stomach is pulled anteriorly (Fig. 2), the stapler with the stomach is slowly shifted toward the duodenum. Next, the anvil fork of the stapler is inserted into the duodenum. Before firing, the staple line on the remnant stomach is rotated to the left side and the staple line on the duodenum stump is rotated to the right side to form a side-to-side gastroduodenostomy between the posterior wall of the remnant stomach and the posterosuperior wall of the duodenum (Fig. 3). After checking for bleeding in the V-shaped anastomotic line, which was made on the posterior wall (Fig. 4), the entry hole for a linear stapler is closed with the Albert-Lembert 2-layer suture using a knotless, unidirectional barbed suture.

Using a 30-cm 3-0 V-Loc 180 suture on a V-20 needle (26 mm tapered) for both layers, the full-thickness inner

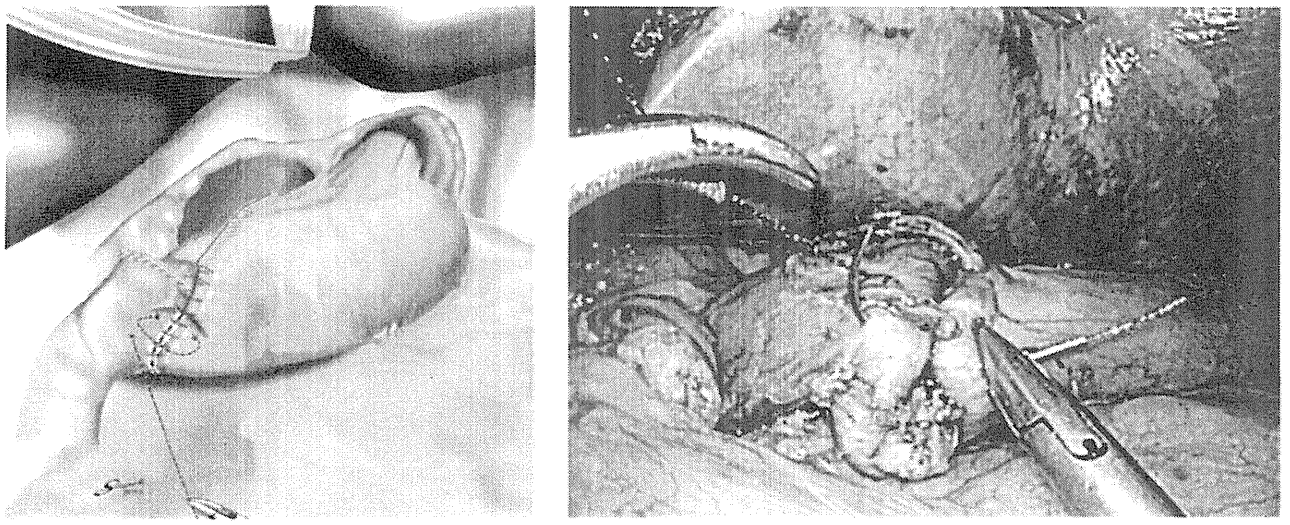

Figure 6. Step 2 of the intracorporeal suture closure of the common enterotomy hole for the stapler showing the second seromuscular layer closure using the same suture, returning from the lesser curve.

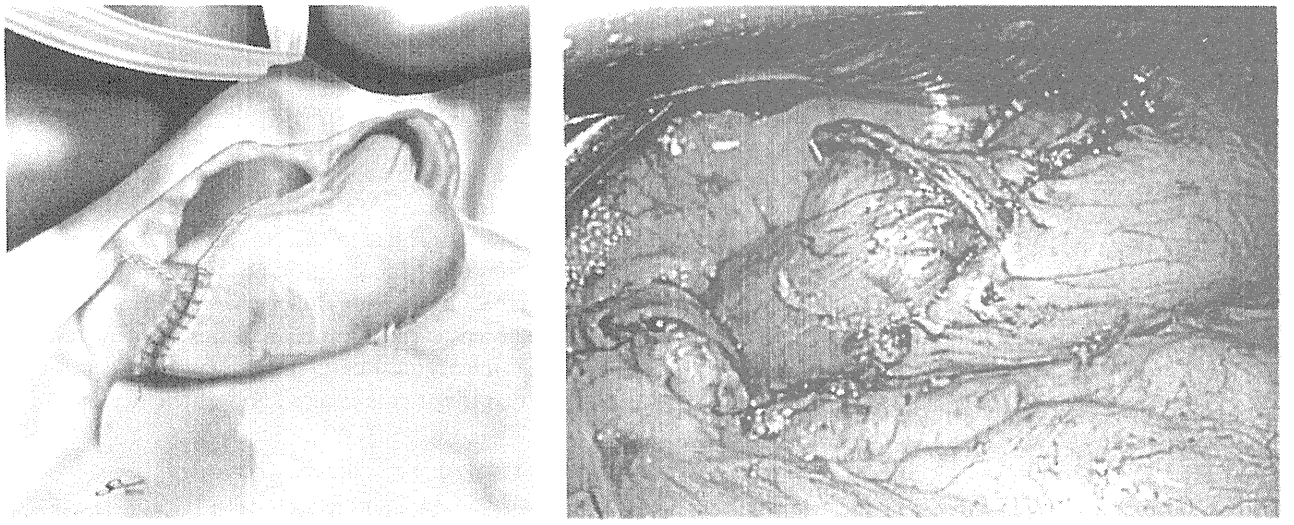

Figure 7. Completed staple-conserving delta-shaped gastroduodenostomy.

layer closure is started from the corner of the great curvature toward the lesser curvature with a continuous technique (Fig. 5). Once the full-thickness layer is complete, the second seromuscular layer is commenced, returning back toward the greater curvature using the same barbed suture (Fig. 6). After the last stitch, the suture is simply cut, without the need for any knots to anchor the last throw. The intra-abdominal Billroth I anastomosis is then accomplished (Fig. 7).

RESULTS

Table 1 shows patient demographics and postoperative outcomes. Mean age was 65.1 ± 13.8 years, and 4 men and 2 women underwent LDG with delta-shaped Billroth I reconstruction using the knotless, unidirectional barbed suture device. All cases were successfully performed without any intra- or postoperative complications. No conversion to other procedures was required. Mean total operation time was 238 minutes (range 205 to 275 minutes) and mean anastomosis time was 18.5 minutes (range 15 to 22 minutes). The total number of linear stapler cartridges intraoperatively used was 4.2 (range 4 to 5), and 1 stapler cartridge was used for the anastomosis in each patient. The patients tolerated a liquid diet at 4.3 days (range 4 to 5 days) after operation, and the mean hospital stay was 11.2 days (range 9 to 14 days). Figure 8 is an upper gastrointestinal contrast study on postoperative day 3 that shows the shape of the gastroduodenostomy and the absence of obstruction or leakage.

Table 1. Patient Demographics and Postoperative Outcomes

Characteristics	Values (n = 6)
Age, y	65.1 ± 13.8
Male:female	4:2
Body mass index, kg/m^2	23.4 ± 3.1
Linear stapler cartridges used, n	4.2 ± 0.4
Anastomotic time, min	18.5 ± 2.0
Blood loss, mL	18 ± 15
Operation time, min	238 ± 22
Time to liquid diet, d	4.3 ± 0.5
Hospital stay, d	11.2 ± 1.7
Complications, %	0

Continuous variables are presented as mean ± standard deviation.

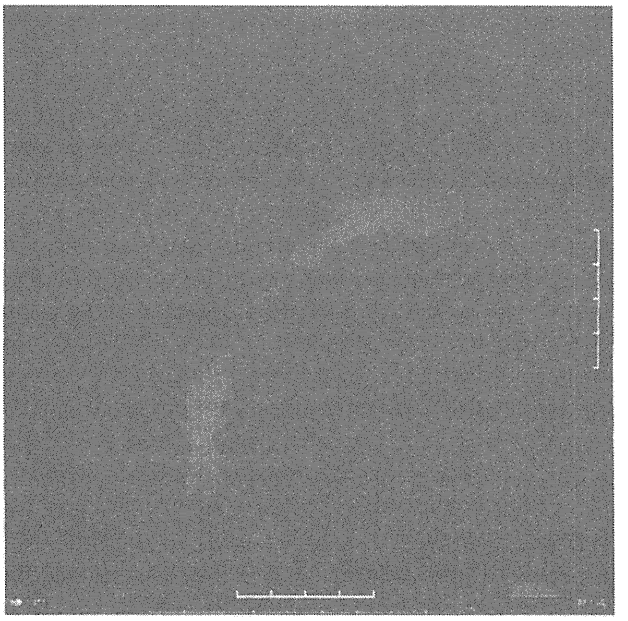

Figure 8. Upper gastrointestinal contrast study showing patency and shape staple-conserving gastroduodenostomy.

DISCUSSION

Between April 2000 and July 2011, we performed LGs with regional lymph node dissection on 738 gastric cancer patients. Laparoscopic resections consisted of 425 (57.6%) distal gastrectomies, 160 (21.7%) pylorus-preserving gastrectomies, 47 (6.4%) segmental gastrectomies, 46 (6.2%) proximal gastrectomies, 34 (4.6%) total gastrectomies, and 26 (3.5%) wedge resections. Most of the procedures in our early experience were laparoscopy-assisted but since November 2003, we have introduced total laparoscopic procedures starting with stapled intracorporeal reconstruction after distal gastrectomy.[14] We have noticed through our experience that TLG may have advantages, including reduced invasiveness, safer anastomosis, and small wound size.[12,21]

The laparoscopic staple-conserving technique for delta-shaped gastroduodenostomy presented here is a modification of the delta-shaped Billroth I anastomosis first described by Kanaya and colleagues,[19] which revolutionized laparoscopic mechanical reconstruction after distal gastrectomy. Similar to the technique for totally intracorporeal gastrojejunostomy from our institute, described by Takaori and associates,[20] delta-shaped Billroth I anastomosis was basically derived from the application of the functional end-to-end technique of the anastomosis. Although it is a simple, easy, and time-conserving technique, the disadvantage of this procedure lies in the additional cost incurred by using many linear stapler cartridges.[10,11,19] This higher cost for the operation represented a significant challenge. In April 2011, with the hope of overcoming the drawbacks of the stapled reconstruction, we incorporated a knotless, unidirectional barbed suture into the staple-conserving technique for delta-shaped gastroduodenostomy after LDG. In our initial experience, application of a knotless, unidirectional barbed suture to delta-shaped Billroth I anastomosis enabled us to reduce the number of stapler cartridges used.

The knotless, unidirectional barbed suture enabled the surgeon to work efficiently with both hands and focus exclusively on subsequent stitch placement, without the need to maintain tension on preceding throws to prevent slippage. This device also distributed tension evenly across the suture line, allowing for good tissue apposition. The knotless, unidirectional barbed suture reduced the time required to close the entry hole, compared with a continuous braided polyglactin suture with intracorporeal knots (data not shown). In addition, in this series, mean anastomotic time was 18.5 minutes—comparable to accounts of the original delta-shaped method using only linear staplers reporting anastomotic times in the range of 17 to 33 minutes.[11,19]

The V-Loc 180 absorbable wound closure device was initially studied for skin closure. Subsequent studies on porcine enteric anastomoses by Demyttenaere and colleagues[22] demonstrated closure equivalence with Maxon, equivalent histopathologic inflammatory response at 3, 7, and 14 days, but faster anastomosis times. To date, this barbed suture device has had limited application in gynecologic and urologic surgery.[16,17] In this report, we describe a new stapler-conserving technique for delta-shaped gastroduodenostomy after LDG. Our study is the first to report on the use of the knotless, unidirectional barbed suture for the intracorporeal digestive anastomosis during LG. We noted several advantages of this barbed suture device for intracorporeal delta-shaped gastroduodenostomy, finding that it was cost effective and time efficient.

CONCLUSION

In conclusion, although the impact of the new closure device on LG still needs to be evaluated in detail, use of the knotless unidirectional barbed suture is safe and efficacious for intracorporeal delta-shaped gastroduodenostomy after LDG, and adoption of this suture device may be cost effective.

Author Contributions

Study conception and design: Lee, Nomura, Uchiyama
Acquisition of data: Lee, Tokuhara, Kawai, Matsuhashi
Analysis and interpretation of data: Lee
Drafting of manuscript: Lee, Uchiyama
Critical revision: Lee, Nomura, Yokoyama, Fujioka, Hiramatsu, Okuda

REFERENCES

1. Kitano S, Iso Y, Moriyama M, et al. Laparoscopy-assisted Billroth I gastrectomy. Surg Laparosc Endosc 1994;4:146–148.
2. Kitano S, Shiraishi N, Fujii K, et al. A randomized controlled trial comparing open vs laparoscopy-assisted distal gastrectomy for the treatment of early gastric cancer: an interim report. Surgery 2002;131(1 Suppl): S306–311.
3. Mochiki E, Nakabayashi T, Kamimura H, et al. Gastrointestinal recovery and outcome after laparoscopy-assisted versus conventional open distal gastrectomy for early gastric cancer. World J Surg 2002;26:1145–1149.
4. Kim MC, Kim KH, Kim HH, et al. Comparison of laparoscopy-assisted by conventional open distal gastrectomy and extraperigastric lymph node dissection in early gastric cancer. J Surg Oncol 2005;91:90–94.
5. Huscher CG, Mingoli A, Sgarzini G, et al. Laparoscopic versus open subtotal gastrectomy for distal gastric cancer: five-year results of a randomized prospective trial. Ann Surg 2005;241: 232–237.
6. Hayashi H, Ochiai T, Shimada H, et al. Prospective randomized study of open versus laparoscopy-assisted distal gastrectomy with extraperigastric lymph node dissection for early gastric cancer. Surg Endosc 2005;19:1172–1176.

7. Dulucq JL, Wintringer P, Stabilini C, et al. Laparoscopic and open gastric resections for malignant lesions: a prospective comparative study. Surg Endosc 2005;19:933–938.
8. Naka T, Ishikura T, Shibata S, et al. Laparoscopy-assisted and open distal gastrectomies for early gastric cancer at a general hospital in Japan. Hepatogastroenterology 2005;52:293–297.
9. Kim YW, Baik YH, Yun YH, et al. Improved quality of life outcomes after laparoscopy-assisted distal gastrectomy for early gastric cancer: results of a prospective randomized clinical trial. Ann Surg 2008;248:721–727.
10. Song KY, Park CH, Kang HC, et al. Is totally laparoscopic gastrectomy less invasive than laparoscopy-assisted gastrectomy?: prospective, multicenter study. J Gastrointest Surg 2008; 12:1015–1021.
11. Kim JJ, Song KY, Chin HM, et al. Totally laparoscopic gastrectomy with various types of intracorporeal anastomosis using laparoscopic linear staplers: preliminary experience. Surg Endosc 2008;22:436–442.
12. Lee SW, Bouras G, Nomura E, et al. Intracorporeal stapled anastomosis following laparoscopic segmental gastrectomy for gastric cancer: technical report and surgical outcomes. Surg Endosc 2010;24:1774–1780.
13. Ikeda O, Sakaguchi Y, Aoki Y, et al. Advantages of totally laparoscopic distal gastrectomy over laparoscopically assisted distal gastrectomy for gastric cancer. Surg Endosc 2009;23:2374–2379.
14. Lee SW, Nomura E, Bouras G, et al. Long-term oncologic outcomes from laparoscopic gastrectomy for gastric cancer: a single-center experience of 601 consecutive resections. J Am Coll Surg 2010;211:33–40.
15. Strong VE, Devaud N, Allen PJ, et al. Laparoscopic versus open subtotal gastrectomy for adenocarcinoma: a case-control study. Ann Surg Oncol 2009;16:1507–1513.
16. Alessandri F, Remorgida V, Venturini PL, et al. Unidirectional barbed suture versus continuous suture with intracorporeal knots in laparoscopic myomectomy: a randomized study. J Minim Invasive Gynecol 2010;17:725–729.
17. Sammon J, Petros F, Sukumar S, et al. Barbed suture for renorrhaphy during robot-assisted partial nephrectomy. J Endourol 2011;25:529–533.
18. Japanese Gastric Cancer Association. Japanese gastric cancer treatment guidelines 2010 (ver. 3). Gastric Cancer 2011;14: 113–123.
19. Kanaya S, Gomi T, Momoi H, et al. Delta-shaped anastomosis in totally laparoscopic Billroth I gastrectomy: new technique of intraabdominal gastroduodenostomy. J Am Coll Surg 2002; 195:284–287.
20. Takaori K, Nomura E, Mabuchi H, et al. A secure technique of intracorporeal Roux-Y reconstruction after laparoscopic distal gastrectomy. Am J Surg 2005;189:178–183.
21. Bouras G, Lee SW, Nomura E, et al. Surgical outcomes from laparoscopic distal gastrectomy and Roux-en-Y reconstruction: evolution in a totally intracorporeal technique. Surg Laparosc Endosc Percutan Tech 2011;21:37–41.
22. Demyttenaere SV, Nau P, Henn M, et al. Barbed suture for gastrointestinal closure: a randomized control trial. Surg Innov 2009;16:237–242.