Abstract. We report an option for delta-shaped gastroduodenostomy in totally laparoscopic distal gastrectomy (TLDG) for gastric cancer. We detail a single-layer sutting technique for the endoscopic linear stapler entry hole using knotless barbed sutures combined with the application of additional knotted sutures. From June 2013 to February 2017, we performed TLDG with delta-shaped gastroduodenostomy in 20 patients with gastric cancer. The linear stapler was closed and fired to attach the posterior walls of the remnant stomach and the duodenum together. After creating a good view of the greater curvature side of the entry hole for the stapler by retracting the knotted suture on the lesser curvature side toward the ventral side, we performed single-layer entire-thickness continuous suturing of this hole using a 15-cm-long barbed suture running from the greater curvature side to the lesser curvature side. We placed the second and third stitches between the seromuscular layer of the remnant stomach and the entire-thickness layer of the duodenum while suturing the duodenal mucosa as minutely as possible. In addition, we routinely added one or two entire-thickness knotted sutures at the site near the greater curvature side. We placed similar additional knotted sutures at the site with a broad pitch. TLDG with this reconstruction technique was successfully performed in all patients with no occurrences of anastomotic leakage or intraabdominal abscess around the anastomosis. It is suggested that this method can be one option for delta-shaped gastroduodenostomy in TLDG due to its cost-effectiveness and feasibility.

Introduction
Since laparoscopic-assisted distal gastrectomy was first reported by Kitano et al. (1), the effectiveness for laparoscopic distal gastrectomy in the treatment of early gastric cancer has been established in several clinical studies (2-6). Moreover, in the past 15 years, totally laparoscopic distal gastrectomy (TLDG), in which all surgical procedures including lymph node dissection, gastric resection, and anastomosis are performed in a wide laparoscopic visual field, has been developed due to improvements in laparoscopic devices and techniques (7-18). Therefore, we introduced TLDG with Roux-en-Y reconstruction or Billroth-I (B-I) reconstruction in 2013. Antecolic Roux-en-Y reconstruction with antiperistaltic gastrojejunostomy was used when the remnant stomach was small or the first portion of the duodenum was short (8,11,16,17). On the other hand, B-I reconstruction was used when the tension in the gastroduodenostomy was low.

Since intracorporeal delta-shaped B-I reconstruction, in which a functional end-to-end gastroduodenostomy was performed using endoscopic linear staplers, was first described by Kanaya et al., this technique has been accepted worldwide (7,9-15,17,18). However, the disadvantage of this procedure is the higher cost because it requires many linear stapler cartridges (7,9,10,12). Furthermore, Noshiro et al reported that one knotted suture was added on the greater curvature side of the closed entry hole for the stapler to prevent not only anastomotic leakage but also intraabdominal abscess around the anastomosis (15).

V-Loc 180 Wound Closure device (Covidien, Mansfield, MA, USA) consists of a barbed unidirectional absorbable thread with a needle at one end and a loop at the other end. This design causes the tissues to adhere at many points without the need to tie surgical knots (19,20). Here, to reduce the number of linear stapler cartridges used in the...
intracorporeal delta-shaped gastroduodenostomy, we present a
double-layer entire-thickness suturing technique for the stapler
entry hole using 3-0 V-Loc 180 (VLOCL0604; taper point,
1/2 circle/26 mm; length, 15 cm). In addition, to prevent both
anastomotic leakage and intraabdominal abscess around the
anastomosis, we describe our initial experience combining
the application of additional knotted sutures of 3-0 Prolene (Ethicon Endo-Surgery, Cincinnati, OH, USA).

Materials and methods

From June 2013 to February 2017, 20 patients underwent
TLDG with delta-shaped gastroduodenostomy with the
combined application of 3-0 V-Loc 180 of 15 cm in length
and 3-0 Prolene at Otori Stomach and Intestines Hospital.
The indication for TLDG at our institution is T1N0M0 gastric
cancer, according to the Japanese classification of gastric
carcinoma (21), that is located in the middle or lower third of
the stomach and is not a candidate for endoscopic submucosal
dissection. B-I reconstruction was performed when the tension
in the gastroduodenostomy was low.

Patients were placed in the modified lithotomy position. The
operator stood between the patient's legs, with the first assis-
tant operating the laparoscope on the left side and the second
assistant on the right side. After five trocars were placed in
the upper abdomen including the umbilicus and a Nathanson's
retractor was inserted from just below the xiphoid process to
retract the round ligament and the lateral segment of the liver,
lymphadenectomy based on the Japanese treatment guidelines
was performed under a pneumoperitoneum (22). The duodenal
bulb was transected in a posteroanterior direction using one
endoscopic linear stapler during lymphadenectomy. Proximal
gastric resection with reference to preoperative endoscopic
marking was carried out (23), and the specimen was removed
through the extended umbilical wound using a large plastic
bag. Pneumoperitoneum was re-established before the recon-
struction.

A small hole was made on the greater curvature side of
the remnant stomach and the posterior side of the duodenum.
A 45-mm linear stapler was introduced through a left lower
port, with one jaw in each hole. The stapler was closed and
fired to attach the posterior walls of the remnant stomach and
the duodenum together. After confirming that there was no
bleeding in the intraluminal anastomotic line, the entry hole
for the stapler was closed by the single-layer entire-thickness
sutting technique using a knotless barbed suture combining
with the application of additional knotted sutures.

An entire-thickness suture with 3-0 Prolene was placed on
the lesser curvature side of the entry hole using the extra-
corporeal slip knot technique (Roeder's knot) (Fig. 1). After
creating a good view of the greater curvature side by retracting
this knotted suture toward the ventral side (Fig. 2), continuous
sutting with a 15-cm 3-0 V-Loc 180 device was carried out from
the greater curvature side to the lesser curvature side.

The first entire-thickness stitch was positively placed on the
greater curvature side, and the needle was passed through
the loop (Fig. 3). The second and third stitches were made
between the seromuscular layer of the remnant stomach and
the entire-thickness layer of the duodenum, with the duodenal
mucosa being sutured as minutely as possible (Figs. 4 and 5) to
avoid extroversion of the mucosa of the alimentary tract near
the greater curvature side (Fig. 6). Thereafter, single-layer
entire-thickness continuous suturing was performed until the
suture crossed over the knotted suture on the lesser curvature
side (Fig. 7). The suture end was then cut simply, as short as
possible, without the need for a knot. Routinely, one or two
entire-thickness knotted sutures with 3-0 Prolene were added
at the site near the greater curvature side to reinforce this site
and avoid loosening of the 3-0 V-Loc 180 (Fig. 8). Similar
additional sutures were made on the site with a broad pitch.
The intracorporeal B-I reconstruction was then accom-
plished (Fig. 9).

Results

Patient characteristics and operative outcomes are shown in
Table 1. In all patients (13 men and 7 women), TLDG with this
reconstruction technique was successfully performed without
any intraoperative complications. The mean patient age was
64.4±7.8 years (45-77 years), and the mean body mass index was
21.6±1.8 kg/m² (19.3-24.6 kg/m²). The mean operation time was
249±23 min (205-273 min), and the mean estimated blood loss
was 22.5±4.6 ml (20-30 ml). The mean number of linear stapler
cartridges used intraoperatively was 4.4±0.5 (4-5). The overall
mean suturing time of the stapler entry hole was 14.8±1.6 min
(12.0-18.1 min). The mean suturing time involving the 3-0
V-Loc 180 was 9.4±1.6 min (7.4-13.0 min), and the mean
number of additional knotted sutures placed was 2.9±0.9 (2-4).
According to the postoperative complications related to the
anastomosis, neither anastomotic leakage nor intraabdominal
abscess around the anastomosis, were encountered. However,
in one patient, anastomotic hemorrhage at the vertex of the
V-shaped staple line requiring endoscopic hemostasis occurred
on postoperative day 1, which was categorized as grade IIIa
according to the Clavien-Dindo classification (24). There
were no other complications, including anastomotic stenosis,
pancreatic fistula, and intestinal obstruction. The mean
postoperative hospital stay was 13.8±1.5 days (12-17 days).
Fig. 10 is a typical upper gastrointestinal fluoroscopic image
on postoperative day 3 that shows no anastomotic leakage and
stenosis.

Discussion

To securely perform TLDG for gastric cancer, establish-
ment of safe and reproducible intracorporeal reconstruction
is essential in addition to precise lymph node dissection and
accurate proximal gastric resection. In B-I reconstruction
for TLDG, the delta-shaped gastroduodenostomy using only
endoscopic linear staplers has been accepted worldwide due
to its safety and simplicity (7-9,15,17,18), but the disadvantage
of this technique is its higher cost (7,9,10,12). On the other
hand, some authors have reported the efficacy of the knotless
barbed unidirectional absorbable suture in gastrointestinal
reconstruction (25-29), and especially, Nemec et al stated
that single-layer entire-thickness sutures of the alimentary
tract with 3-0 V-Loc 180 had higher bursting pressures
than those with 3-0 monofilament in a cadaver study (27).
Therefore, to reduce the number of linear stapler cartridges
used in the delta-shaped gastroduodenostomy, a single-layer
entire-thickness continuous suturing technique for the stapler entry hole using a 15-cm-long 3-0 V-Loc 180 device was applied because it was not only effective for gastrointestinal reconstruction but also easy to handle in the abdominal cavity. In this patient series, no linear stapler cartridges were used to close the entry hole.

Noshiro et al reported that among the initial 71 patients undergoing delta-shaped gastroduodenostomy using linear staplers, 6 experienced anastomotic leakage and 2 developed intraabdominal abscess around the anastomosis, and in all of these patients, the affected site was the greater curvature side of the closed entry hole for the stapler (15). They indicated two possible reasons for these complications. First, the procedure for closing the greater curvature side of the entry hole was uncertain because this site tended to roll backward behind the linear stapler. Next, the extroverted gastroduodenostomy sometimes directly contacted the pancreatic head after infrapyloric lymph node dissection, and so even minimal leakage of pancreatic juice might be activated by the attachment of mucosa of the alimentary tract. They added one
knotted suture on the greater curvature side of the closed entry hole in the last 71 patients and neither anastomotic leakage nor intraabdominal abscess around the anastomosis occurred among these patients. Thus, to stabilize the outcomes of the delta-shaped gastroduodenostomy with 3-0 V-Loc 180, we standardized the procedure by adding knotted 3-0 Prolene sutures using the extracorporeal slip knot technique (Roeder's knot). The steps of this procedure include: i) retracting the knotted 3-0 Prolene suture on the lesser curvature side toward the ventral side to create a good view of the greater curvature side of the entry hole for the stapler; ii) performing single-layer entire-thickness continuous suturing of the entry hole using 3-0 V-Loc 180 from the greater curvature side to the lesser curvature side; iii) placing the second and third stitches of

Figure 5. The second and third stitches with 3-0 V-Loc 180 are made on the entire-thickness layer of the duodenum, with the duodenal mucosa being sutured as minutely as possible.

Figure 6. There is no extroversion of mucosa of the alimentary tract near the greater curvature side of the stapler entry hole.

Figure 7. The single-layer entire-thickness continuous suture of the entry hole with 3-0 V-Loc 180 is performed until it crosses over the knotted 3-0 Prolene suture on the lesser curvature side.

Figure 8. One or two entire-thickness knotted 3-0 Prolene sutures are routinely added at the site near the greater curvature side of the stapler entry hole.
3-0 V-Loc 180 between the seromuscular layer of the remnant stomach and the entire-thickness layer of the duodenum by suturing the duodenal mucosa as minutely as possible to avoid extroversion of mucosa of the alimentary tract near the greater curvature side; iv) routinely adding one or two entire-thickness knotted sutures with 3-0 Prolene at the site near the greater curvature side to reinforce this site and avoid loosening of the 3-0 V-Loc 180; and v) placing similar additional knotted sutures on the site with a broad pitch. In this patient series, this reconstruction procedure resulted in no incidences of anastomotic leakage or intraabdominal abscess around the anastomosis. These results were comparable to those of the last 71 patients reported by Noshiro et al.

The knotless barbed suture is assumed to make intracorporeal digestive anastomoses easier to perform because it does not require any knots and the tension is self-maintained during the running suture, with no need for continuous traction (28). In addition, the extracorporeal knotted suturing technique such as Roeder’s knot could be carried out more easily than the intracorporeal ligation technique. Therefore, it is considered that a single-layer suturing technique for the stapler entry hole using 3-0 V-Loc 180 combined with the application of additional knotted sutures of 3-0 Prolene is not difficult to master for the gastrointestinal surgeons.

Although there is a concern that the free tail of the barbed suture might cause intestinal obstruction (30-32), this complication was not encountered in this series. For this reason, it could be considered that we cut the suture end as short as possible and the free tail located at the lesser curvature side of the closed entry hole was covered by the liver.

In conclusion, it is suggested that a single-layer entire-thickness suturing technique for the stapler entry hole using 3-0 V-Loc 180 with a length of 15 cm combined with the application of additional knotted sutures of 3-0 Prolene can be one option for delta-shaped gastroduodenostomy in TLDG due to its cost-effectiveness and feasibility. Examination of a larger number of patients needs to be performed to draw a conclusion on the utility of this reconstruction technique.

Table I. Patient characteristics and outcomes.

| Characteristics and outcomes | Data |
|------------------------------|------|
| Cases, n                     | 20   |
| Age, years                   | 64.4±7.8 |
| Sex                          |      |
| Male                         | 13   |
| Female                       | 7    |
| BMI, kg/m²                   | 21.6±1.8 |
| Operative time, min          | 249±23 |
| Blood loss, ml               | 22.5±4.6 |
| Linear stapler cartridges used, n | 4.4±0.5 |
| Overall suturing time, min   | 14.8±1.6 |
| V-Loc suturing time, min     | 9.4±1.6 |
| Additional knotted sutures, n | 2.9±0.9 |
| Postoperative hospital stay, d | 13.8±1.5 |
| Postoperative complications, n |         |
| Anastomotic leakage          | 0    |
| Intraabdominal abscess       | 0    |
| Anastomotic hemorrhage       | 1    |
| Anastomotic stenosis         | 0    |
| Pancreatic fistula           | 0    |
| Intestinal obstruction       | 0    |

Data are presented as the mean ± SD. BMI, Body Mass Index.

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