

Use of Barbed Sutures in Laparoscopic Gastrointestinal Single-Layer Sutures

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ABSTRACT

Background and Objectives: Laparoscopic anastomotic methods are not commonly used because of the cumbersome laparoscopic intracorporeal sutures and tying involved. The barbed suture is one of the various devices developed to simplify the placement of intracorporeal sutures. However, barbed sutures are not commonly used during reconstruction after radical gastrectomy in cancer patients or for single-layer entire-thickness running suturing for intestinal anastomoses. We describe the procedure for using barbed sutures and report on the short-term surgical outcomes.

Methods: Between August 2012 and March 2014, 15-cm-long barbed sutures (V-Loc 180; Covidien, Mansfield, MA, USA) were used for laparoscopic intestinal anastomoses, including intestinal hole closure for esophagojejunal and gastrojejunal anastomoses after mechanical anastomoses and gastric wall closure after partial resection.

Results: In total, 38 patients underwent 40 laparoscopic anastomoses (esophagojejunostomies, 26; gastrojejunostomies, 7; and simple closure of gastric defect, 7); no cases required conversion to open surgery. Two cases exhibited positive air leak test results during surgery (1 case of esophagojejunostomy and 1 case of simple closure of gastric defect). Two cases of intestinal obstruction were noted; of those, one patient with postoperative intestinal paresis (grade II) was managed conservatively, and the other underwent repeat laparoscopic surgery (grade IIIb) for internal herniation unrelated to V-Loc use. No postoperative complications at the anastomosis site and no surgery-related deaths were noted.

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Conclusion: Single-layer entire-thickness running suturing with the V-Loc 180 barbed suture after stapled side-to-side intestinal anastomosis was found to be safe and feasible in the reported cases.

Key Words: Laparoscopic surgery, Surgical Anastomosis, Suture Techniques.

INTRODUCTION

Background

The use of laparoscopic gastrectomy has recently increased, and its indications have expanded to proximal and total gastrectomy. However, laparoscopic gastrointestinal anastomosis involves a high degree of difficulty and complexity. In gastrointestinal surgery, careful intestinal anastomosis—particularly in cases of esophagojejunal anastomosis—is important, as anastomotic leakage may occasionally be fatal.^{1,2} Various methods of esophagojejunal or residual stomach anastomosis have been proposed. Stapled anastomosis is a fundamental step in all these methods, although it involves a hand-sewn technique.³⁻⁷ Thus, anastomotic methods are not commonly used because of the cumbersome laparoscopic intracorporeal sutures and tying involved. However, various devices have been developed to simplify the placement of intracorporeal sutures, and barbed suture is one such device.

V-Loc 180 (Covidien, Mansfield, MA, USA) is a new device for wound closure, and consists of a unidirectional barbed absorbable thread. Evenly spaced barbs have high tissue-adhesion ability, as they attach to tissue at numerous points. Moreover, the loop-end design avoids the need for tying a surgical knot (**Figure 1**). Clinical efficacy and suitability of barbed sutures have been reported in dermal closure⁸ and orthopedic surgery,⁹ and their intracorporeal use has also been indicated in the fields of urology¹⁰ and gynecology.¹¹

Some reports have described the use of barbed sutures for digestive anastomosis, including gastric bypass surgery in

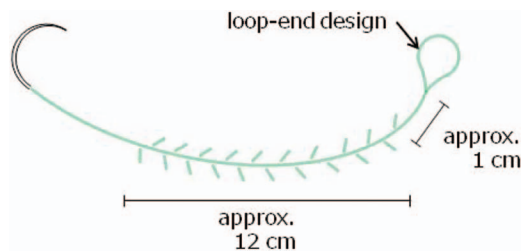


Figure 1. Image of V-Loc 180 wound closure device. The effective length, comprising the barbed portion, is approximately 12 cm, and no barbs are present in a length of ~12 cm from the loop-end.

obese patients.^{12,13} However, only a few have reported on the use of barbed sutures for reconstruction after radical gastrectomy in patients with cancer or for esophagojejunal anastomosis.^{14,15} Although single-layer entire-thickness running sutures are convenient and very cost-effective,¹⁶ several reports describe the use of double-layer running sutures to ensure safety.

Herein, we describe the surgical procedure for intracorporeal single-layer entire-thickness running suturing using the V-Loc 180 device in cases involving esophagojejunal anastomosis and report on the short-term surgical outcomes.

METHODS

Patients

In total, 38 patients (25 men and 13 women) underwent laparoscopic intracorporeal suturing with the V-Loc 180 device (VLOCL0604; taper point, 1/2 circle/26 mm; size, 3-0; length, 15 cm; Covidien) at Toyama Prefectural Hospital between August 2012 and March 2014. Two patients who underwent proximal gastrectomy with intracorporeal esophagojejunal and gastrojejunal anastomoses were also included. Thus, 40 cases undergoing laparoscopic intracorporeal suturing were included in this study.

The basic indication for laparoscopic gastrectomy in our department is cT1N0M0 cancer, and D1+ is the standard dissection range, based on the Japanese Classification of Gastric Carcinoma (fourth edition) and Japanese gastric cancer treatment guidelines.^{17,18} The gastric submucosal tumor was partially resected, in principle. The diagnosis was made based on the findings of preoperative examinations, including gastrointestinal endoscopy, upper gastrointestinal series, and abdominal computed tomography. The data were retrospectively collected from medical records, operative reports, and histopathologic reports.

Patient characteristics (age, sex, body mass index, indications, and operating procedures), surgery-related factors (operation time, blood loss, transition to laparotomy, intracorporeal suturing time, and additional suture), and operative factors (postoperative duration of hospital stay and intra-/postoperative complications) were analyzed. The Clavien–Dindo classification was used to categorize the postoperative complications; cases categorized as grade II and higher were regarded as having complications.

Surgical Procedures

Since 2012, laparoscopic total gastrectomy (LTG), laparoscopic proximal gastrectomy (LPG), and laparoscopy and endoscopy cooperative surgery (LECS) have been introduced and are performed based on the primary disease and localization of the tumor. For these procedures, the patient is placed in a reverse Trendelenburg position under general anesthesia. The first port is placed through the umbilicus by using an open method. A laparoscope is inserted via the umbilical port and 4 operating ports (bilateral subcostal and bilateral midabdominal). A Nathanson's liver retractor is placed just below the xiphoid process.

For LTG, the duodenum is divided with a regular 60-mm linear stapler, with a camel cartridge (Tri-Staple; Covidien), before the dissection of lymph node (LN) stations 7, 8a, and 9. After full mobilization of the stomach and completion of nodal dissection, the esophagogastric junction is divided with a regular 60-mm linear stapler, with a purple cartridge (Tri-Staple; Covidien). Thereafter, Roux-en-Y reconstruction is performed, including an esophagojejunal anastomosis according to the overlap method,⁶ with a 45-mm linear stapler, with a purple cartridge (Tri-Staple; Covidien). Single-layer entire-thickness running suturing with V-Loc 180 (Covidien) was used to close the intestinal hole. Furthermore, a side-to-side jejunojunosotomy was performed, including transumbilical minilaparotomy (usually 4 cm) using a 45-mm linear stapler, with a camel cartridge (Tri-Staple; Covidien), and hand-sewn sutures (3-0 Vicryl; Ethicon, Somerville, NJ, USA).

For LPG, the esophagus and stomach were divided with a 60-mm linear stapler, with a purple cartridge (Tri-Staple; Covidien). Thereafter, double-tract reconstruction was performed, and the jejunojunal anastomosis and esophagojejunal anastomosis were performed in the same manner as for LTG. With regard to gastrojejunostomy, the decision on whether the anastomosis should be made transumbilically or intracorporeally was left to the sur-

geon's discretion. A side-to-side gastrojejunostomy was performed with a 45-mm linear stapler, with a purple cartridge (Tri-Staple; Covidien). Only intracorporeal suturing with V-Loc 180 (Covidien) was used. The mesentery defect was closed using 3-0 Vicryl sutures (Ethicon, Somerville, NJ, USA), whereas Petersen's defect was not closed in the LTG and LPG cases.

For LECS, after the gastric wall was devascularized laparoscopically, we penetrated the entire stomach layer endoscopically. Thereafter, a partial resection was performed laparoscopically. Single-layer entire-thickness running suturing with the V-Loc 180 (Covidien) device was used to close the gastric wall defect. The air leak test, performed with a nasal gastric tube, was used in all cases.

Intestinal Hole Closure with Barbed Sutures

Gastrointestinal hole closures were roughly divided into 2 groups: stapler insertion hole closure and gastric wall defect closure. Single-layer entire-thickness running sutures were placed by using the following method in all cases.

The first step in intestinal hole closure is to pass a needle through a loop (Figures 2a, 3a). The first stitch may become loose, as there are no barbs adjacent to the loop. Therefore, at the start of the closure site, 1 or 2 additional bites may be needed (Figures 2b, 3b). Thus, single-layer entire-thickness running sutures are placed, which tightens at each bite (Figure 2c, 3c). At the end of the closure site, 1 or 2 seromuscular bites are added after completing the intestinal hole closure, following which the suture is cut flush to the bowel without the necessity for tying a knot (Figures 2d, 3d). In cases with a broad suturing pitch, additional knotted sutures are made by using 3-0 Monocryl (Ethicon) based on the surgeon's discretion.

Postoperative Management

An abdominal drain, bladder catheter, and nasal gastric tube were routinely placed. Moreover, a postoperative radiographic contrast study was performed in all the patients. A few sips of water, a semifluid diet, and a soft blended diet were given to patients on postoperative days 3, 4, and 6, respectively. After the patient consumed the semifluid diet, the abdominal drainage tube was removed. On the first and third postoperative days, the amylase levels in the drain fluid were measured for the detection of a postoperative pancreatic fistula.

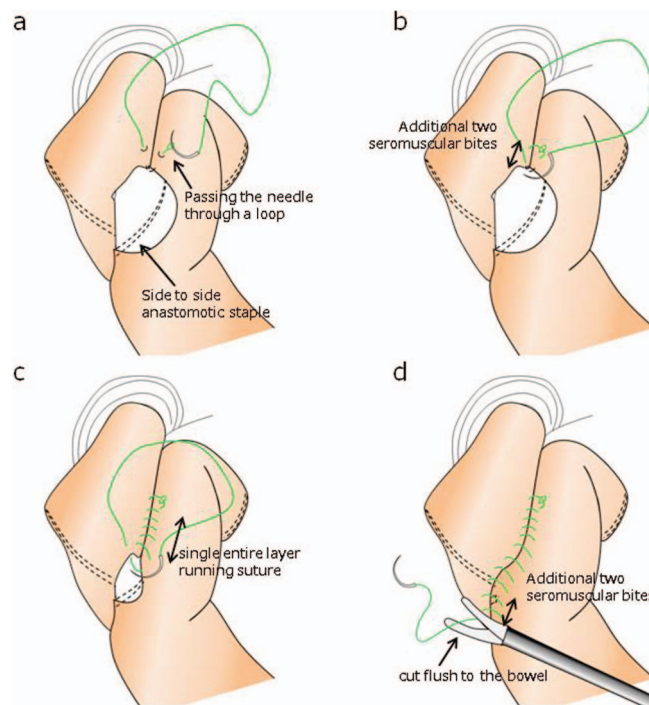


Figure 2. Schematic outline of intestinal hole closure in esophagojejunostomy using V-Loc 180 for single-layer entire-thickness running suturing. (a) After side-to-side anastomosis, intestinal hole closure is initiated by passing the needle through a loop. (b) At the start of the closure site, 1 or 2 bites are added before the edge of the intestinal hole is sutured. (c) Single-layer entire-thickness running suturing is performed, which tightens at each bite. (d) At the end of the closure site, 1 or 2 seromuscular bites are added after the completion of intestinal hole closure, and the suture is cut flush at the bowel, without the need for a knot.

RESULTS

The background data of the patients are summarized in Table 1. These patients had a mean age of 68.8 ± 11.8 y (range, 37–88) and a body mass index of 22.2 ± 11.8 (range, 15.0–28.1). Of those, 31 patients had gastric cancer (28 with early cancer and 3 with pyloric stenosis), and 7 had gastric submucosal tumor. In total, 12 underwent LTG with Roux-en-Y reconstruction, 2 underwent laparoscopic distal gastrectomy with Roux-en-Y reconstruction, 14 underwent LPG with double-tract reconstructions, 3 underwent gastrojejunal bypass, and 7 underwent partial gastrectomy. The anastomoses performed included esophagojejunostomies in 26, gastrojejunostomies in 7, and simple closures of gastric defect in 7 (Table 1). Of the 33 cases with esophagojejunostomies and gastrojejunostomies, additional knotted sutures were used in 13.

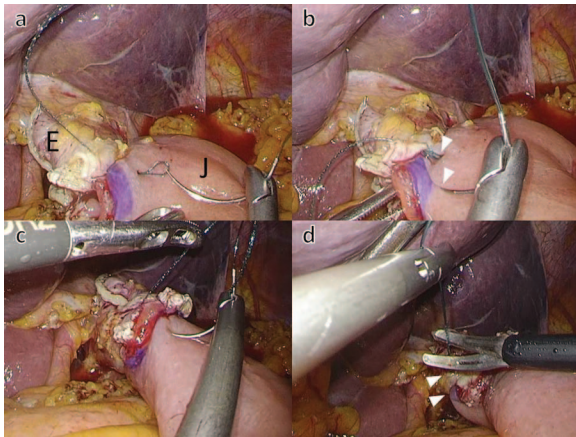


Figure 3. Intraoperative view during the esophagojejunal anastomosis using V-Loc. (a) Initiation of intestinal hole closure using V-Loc. By barely attaching the loop to the intestinal wall, the loop is fixed, and the thread is then passed through the needle. (b) One or 2 additional bites are needed before the edge of the intestinal hole is sutured (white arrowheads). (c) Single-layer entire-thickness running sutures are placed, which tighten at each bite. (d) One or 2 seromuscular bites are added after the completion of intestinal hole closure (white arrowheads), and the suture is cut flush to the bowel without a knot. E, esophagus, J, lifted jejunum.

The mean operative time for gastrectomy was 236 min (range, 155–340), and the estimated blood loss was 59 ml (range, 0–440). For partial gastrectomy (LECS) and gastrojejunal bypass, the mean operative times were 136 min (range, 72–200) and 90 min (range, 65–135), respectively. The mean duration of hospital stays for gastrectomy, LECS, and bypass were 14.1, 9.1, and 15 d, respectively (**Table 2**). No cases required conversion to open surgery. The overall mean suturing time was 10.5 min (range, 4.8–19.3). When considering only the suturing time involving V-Loc, the mean suturing time was 8.7 min (range, 4.8–13.8). In the 7 cases with gastric defects, knotted sutures were added in 4. The overall mean suturing time was 16.9 min (range, 9.1–21.2 min). The mean suturing time with V-Loc was 14.7 min (range, 9.1–34.9 min). No cases required conversion to open surgery.

Two cases with positive air leak test results (1 case of esophagojejunostomy and 1 case of simple closure of gastric defect) were noted during surgery after V-Loc suturing and were managed by adding knotted sutures. No gastrointestinal injuries and bleeding were noted during suturing.

When postoperative factors were examined, no complications related to the anastomosis site and no surgery-

Table 1.
Background of the Patients

Characteristic	Data
Patients, <i>n</i>	38
Intracorporeal anastomosis, <i>n</i>	40
Sex	
Male	25
Female	13
Mean age (years)	68.8 ± 11.8
Mean BMI (kg/m ²)	22.2 ± 3.2
Indications, <i>n</i>	
Gastric cancer	28
Gastric cancer with pyloric stenosis	3
Gastric submucosal tumor	7
Procedures, <i>n</i>	
TG (Roux-en-Y reconstruction)	12
DG (Roux-en-Y reconstruction)	2
PG (Double tract reconstruction)	14
Bypass (Billroth-II)	3
Partial gastrectomy	7
Closure site using V-Loc, <i>n</i>	
Esophagojejunostomy	26
Gastrojejunostomy	7
Gastric defect	7

BMI, body mass index; TG, total gastrectomy; DG, distal gastrectomy; PG, proximal gastrectomy.

related deaths were noted. Pancreatic fistula was observed in 1 case, which was classified as Clavien–Dindo grade II. Furthermore, 2 cases of intestinal obstruction were noted. Of these, 1 patient had postoperative intestinal paresis (grade II) and was managed conservatively, and the other was found to have internal herniation originating from a cord-like adhesion between the jejunojejunal anastomosis and colon (grade IIIb) and underwent repeat laparoscopic surgery (**Table 3**).

DISCUSSION

The barbed suture, which obviates the need for tying knots, has emerged as a new device for wound closure. It has recently attracted interest as being useful in laparoscopic suturing. In the present study, we used V-Loc 180, which is an absorbable copolymer composed of glycolic acid and trimethylene carbonate—the same materials that are used in Maxon (Covidien). The tensile strength is

Table 2.
Operative Data of Each Procedure: Surgery-Related Factors

Factor	Gastrectomy	LECS	Bypass
Patients, <i>n</i>	28	7	3
Mean operative time, min	236	136	90
Range	155–340	72–200	65–135
Estimated blood loss, ml (range)	59 (0–440)	4.4 (0–16)	Unmeasurable
Mean length of postoperative hospital stay, d (range)	14.1 (8–28)	9.1 (6–12)	15 (11–19)

Table 3.
Operative Data and Surgical Outcomes of Intestinal Hole Closure and Gastric Closure

Outcomes	Intestinal Hole Closure	Gastric Defect Closure
Cases, <i>n</i>	33	7
Additional knotted suture, <i>n</i> cases	13	4
Mean total suturing time, min	10.5 ± 3.3	20.6 ± 8.3
Mean V-Loc suturing time, min	8.7 ± 2.0	14.7 ± 3.5
Intraoperative complications, <i>n</i>		
Bleeding	0	0
Other organ injury	0	0
Positive air leak test	1	1
Postoperative complications, <i>n</i>		
Anastomotic leakage	0	0
Anastomotic hemorrhage	0	0
Anastomotic stenosis	0	0
Pancreatitis	1	0
Intestinal obstruction	2	0

maintained at ~50% at 21 d, and complete absorption is observed in 180 d. In the current cases, we used a thread length of 15 cm, and it had excellent operability and maneuverability in the abdominal cavity. The effective length, comprising the barbed portion, is ~12 cm.

Although cases wherein a gastric wall defect cannot be closed by a single thread due to a relatively short effective length have been noted, the use of a longer length of V-Loc may not be cost effective. Hence, we used a length of 15 cm due to the associated operability and to facilitate easy suturing.

The barb and loop-end design of this device enables its adherence to tissues without the need for tying a knot. However, V-Loc does not have any barbs within ~1 cm from the loop-end (**Figure 1**), which is disadvantageous, in that it does not permit tight tissue adhesion at the first bite. There-

fore, we initiated suturing from the seromuscular portion, and the third bite was placed at the start of the intestinal incision, to avoid loosening. As tying a knot is not recommended in the barbed portion, because the thread could be cut, the suturing was completed by adding 2 bites beyond the end of intestinal incision, after which the suture was cut without any knot. Because of the additional bites, the tissue adhesion ability became stronger. However, the presence of a long barbed suture outside of the bowel has been reported to cause intestinal obstruction,¹⁹ and therefore, cutting this suture flush at the bowel is important. In the present study, 1 case of grade IIIb intestinal obstruction was noted, because of the thread between the colon and jejunojunal anastomosis, and was not related to the use of V-Loc sutures.

The “knotless” concept is being widely accepted in surgical procedures in various body locations as well as in fragile

tissue, such as in cases of peritoneum closure.^{20–22} For intestinal anastomosis, this procedure has been shown to yield a shorter suturing time and similar bursting pressure, as compared to common monofilament sutures in preliminary research and animal models.^{23,24} Furthermore, its usefulness and safety have been described in several large-scale trials involving laparoscopic bypass in obese patients.^{15,25,26} In patients with gastric cancer, barbed sutures have been used as a device for intestinal hole closure after side-to-side intestinal stapled anastomosis.¹⁴ However, barbed sutures have primarily been used for gastrointestinal anastomosis as double-layer running sutures,^{14,15,26} and their safety has been described. Nevertheless, the use of single-layer entire-thickness running sutures is more desirable, considering the shorter surgical time and ease of suturing.¹⁶ Although the present study was not controlled, the suturing time was found to be relatively short, and no anastomotic leakage was observed. Furthermore, we conclude that single-layer entire-thickness running sutures are acceptable and safe, as they offer tight closure by barbed sutures. In addition, no anastomotic stenosis was observed, although we believe that this result is attributable to the side-to-side stapled anastomosis, not to the V-Loc device.

An important limitation of V-Loc use may be the development of anastomotic leakage due to seromuscular injury, when V-Loc has been used for staple line reinforcement.²⁷ However, single-layer entire-thickness running sutures with the V-Loc device showed a higher pressure and tightness test value (defined as the pressure that can be exerted by the thread until a balloon bursts) and no ruptures or leaks in a cadaver study.²⁸ These findings indicate that the unidirectional, evenly spaced barbs distribute the tension equally because they attach to the tissue at numerous points. Therefore, it appears that intestinal injury is a result of technical laparoscopy-related factors, such as the hand-sewn technique under direct vision, rather than a result of V-Loc itself.

In this report, 2 cases showed positive results in an intraoperative air leak test. We noted that surgeons encountered difficulty in suturing because the anastomotic hole became gradually smaller as suturing progressed. However, to obtain a more secure suture and to avoid a positive air leak test result, it is essential to ensure tight closure as suturing progresses. In addition, of all the 40 case series, additional knotted sutures were used in 17. We consider the double-layer method to provide the most reliable anastomosis possible; therefore, additional knotted sutures are added at the surgeon's discretion depending on intraoperative findings. We do not recommend the use of barbed suture alone; a reliable suturing method is

important. Thus, we note that there were no cases of anastomotic leakage.

CONCLUSION

Single-layer entire-thickness running suturing with the V-Loc 180 device after stapled side-to-side intestinal anastomosis is considered to be a safe and feasible option. However, a greater number of such cases and careful and longer follow-up are necessary.

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