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Innovations for Cervical Esophagogastrostomy in Thoracic Esophageal Cancer Operations

TAKESHI SHIMAKAWA, YOSHIHIKO NARITAKA, SHINICHI ASAKA, MIKI MIYAZAWA, MINORU MURAYAMA, KENTARO YAMAGUCHI, TAKEBUMI USUI, HAJIME YOKOMIZO, KAZUHIKO YOSHIMATSU, SHUNICHI SHIOZAWA and TAKAO KATSUBE

Department of Surgery, Tokyo Women's Medical University, Medical Center East, Tokyo, Japan

Abstract. *Three-field lymph node dissection is now performed in operations for advanced thoracic esophageal cancer, with an associated improvement in outcomes. However, reconstructive surgery following resection of the esophagus is frequently associated with the occurrence of anastomotic leakage. Once it occurs, major problems can arise such as decreased quality of life, protracted hospitalization, or even death. This is why there has been a large number of innovations in and modifications to reconstructive surgery. The standard procedures in our Department for advanced thoracic esophageal cancer are subtotal esophagectomy and three-field lymph node dissection. The thin gastric tube along the greater curvature is used as the reconstructed organ in reconstructive surgery, performing a cervical esophagogastrostomy. Innovations have been made to reconstructive surgery in order to prevent anastomotic leakage. This procedure markedly reduces anastomotic leakage, and also reduces anastomotic stricture, which likely makes it an extremely useful procedure that any surgeon can perform.*

Three-field lymph node dissection is performed for advanced thoracic esophageal cancer, with an associated improvement in outcomes (1-3). However, reconstructive surgery following resection of the esophagus is frequently associated with the occurrence of anastomotic leakage. This is why there has been a large number of innovations in and modifications to reconstructive surgery (4, 5). Since 1989, the standard procedures in our Department for advanced thoracic esophageal cancer in patients 75 years and younger have been subtotal esophagectomy through a right thoracotomy and three-field lymph node dissection. The thin gastric tube along the greater curvature is used as the reconstructed organ in reconstructive surgery, performing a cervical esophago- gastrostomy that passes through the retrosternal route. Innovations have been made to the reconstructive surgery to prevent anastomotic leakage.

We examined changes in the frequency of anastomotic leakage and anastomotic stricture due to changes in reconstructive surgery and examined the utility of current reconstructive surgery.

Correspodence to: Dr. Takeshi Shimakawa, Department of Surgery, Tokyo Women's Medical University Medical Center East, 2-1-10 Nishiogu Arakawa-ku, Tokyo 116-8567, Japan. Tel: +81 338101111, Fax: +81 338945493, e-mail: simakasu@twmu.ac.jp

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Patients and Methods

Patients. The subjects of this study were 304 cases of thoracic esophageal cancer. We examined the frequency of anastomotic leakage and anastomotic stricture in the 32 cases from 1989 to 1994 (group A), the 127 cases from 1994 to 2005 (group B), and the 145 cases from 2006 to 2017 (group C) associated with changing innovations in reconstruction procedures. No differences were recognized in the background factors of groups A, B, and C.

Operative procedures. The basic procedure of this Department is to split staff into a cervical team and abdominal team ahead of reconstructive surgery in order to reduce surgery time and start simultaneously. In the cervical sequence, after cervical lymph node dissection, the left side of the anterior cervical muscles at the superior margin of the sternum is severed, and the retrosternal route is separated as much as possible. Next, the cervical esophagus is severed at the thoracic inlet such that enough of the esophagus remains. In the abdominal sequence, either a laparotomy is performed with an upper median incision, or the operation is carried out by hand-assisted laparoscopic surgery. The omentum is severed from the transverse colon to preserve the network of gastroepiploic vessels. The root of the left gastroepiploic vessels is tied off at the lower pole of the spleen. The short gastric vessels are tied off along the spleen. The left gastric artery along the lesser curvature is tied off, and two branches of the right gastric artery adjacent to the pylorus are preserved. The esophagus is severed at the section directly above the esophagogastric junction, the stomach is removed from the skeleton, and the team moves on to creating a thin gastric tube along the greater curvature.

The procedure for creating the gastric tube in group A was to use about six linear staples, and to create a 4.0 cm thin gastric tube along the greater curvature (Figure 1a). In the process, the stomach was pulled in the direction of the long axis sufficiently to create a longer gastric tube. The severed stumps from the stapler were reinforced with 4-0 absorbable threads by seromuscular suture. After applying pyloroplasty, the gastric tube was elevated to the cervix by the retrosternal route, and the anastomotic site was positioned for good blood flow to the posterior wall of the gastric tube. The anastomosis procedure was performed using a 25 mm circular stapler by end-to-side anastomosis. The gastric tube stump was closed with the linear stapler and reinforced with 4-0 absorbable thread by seromuscular suture (Figure 2a).

Improvements for group B were making the diameter of the thin gastric tube along the greater curvature 3. 5 cm and creating a longer gastric tube along the greater curvature (Figure 1b). This further improved the capability to elevate the gastric tube and allowed for creation of the anastomosis in the gastric tube closer to the anus. Furthermore, it allowed for preservation of one vessel along the gastric tube stump of the anastomosis and secured sufficient blood flow along the gastric tube stump. If securing the blood vessels along the gastric tube stump reveals blood flow damage in the vicinity of the anastomosis, the same blood vessels can perform super drainage and super charge between the blood vessels of the cervix. In addition, the anastomosis site was changed from the posterior wall of the gastric tube to near the greater curvature of the posterior wall with better blood flow. After completing anastomosis, the anastomosis site was covered with the omentum, to prevent leakage (Figure 2b).

Most causes of anastomotic leakage in group B were likely due to gastric tube compression and congestion of the gastric tube stump caused by the sternoclavicular joint of the thoracic inlet. Therefore, in group C when the width of the thoracic inlet was less than three fingerbreadths, the left sternoclavicular joint was resected, and the thoracic inlet was dilated (Figure 3a). In addition, the gastric tube stump was closed with three rows of linear stapler in group C instead of two in order to suture more densely (Figure 3b). Furthermore, gastric tube fistulas were created in all cases of group C, and enteral alimentation was started in the early postoperative period.

Potential anastomotic leakage was evaluated in all three groups in the postoperative period by checking the condition of the cervical wound and cervical drain as well as for inflammatory responses. When there were no issues, a jelly diet was started on the seventh postoperative day. Then around the tenth postoperative day, a postoperative upper gastrointestinal series was run, patients were monitored for potential anastomotic leakage and anastomotic stricture, and food was upgraded. When anastomotic leakage was confirmed, the cervical wound was partially opened, drainage was performed, and the patient was treated with conservative treatments such as fasting and management of enteral alimentation. Endoscopic balloon dilatation was performed on anastomotic strictures.

Results

Anastomotic leakage was seen in five cases (15.6%) in group A (32 cases), among which one was a major leakage (gastric tube stump), and the rest were minor leakage (anastomosis site). Minor leakage improved conservatively, but the case of major leakage required repeat surgery (change of reconstruction organ and reconstruction route). There were only five cases (3.9%) of minor leakage in group B, a marked decrease in the frequency of anastomotic leakage compared with group A. There was a significant reduction to four cases (2.7%) of minor leakage in group C. Anastomotic leakage in group B and group C improved conservatively. Statistical significance of differences in anastomotic leakage and stricture between groups was evaluated using Fisher's exact test. The rates of anastomotic stricture in groups A (4 cases, 12.5%), and B (16 cases, 12.6%) were similar, but the rate was significantly reduced in group C (13 cases, 8.9%). Moreover, all of these cases of anastomotic stricture improved with endoscopic balloon dilatation (Table I).

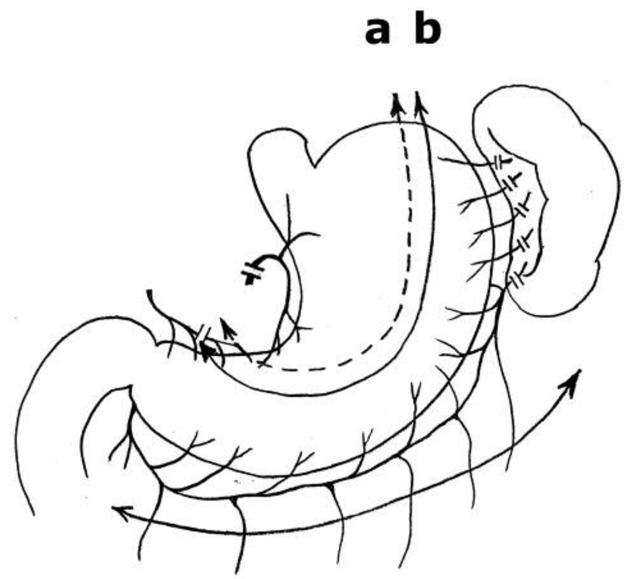

Figure 1. *The procedure for creating the gastric tube. a: Group A: 4.0 cm thin gastric tube was created along the greater curvature (dotted line). b: Improvements for Group B and C (solid lines) included making the diameter of the thin gastric tube along the greater curvature 3.5 cm and creating a longer gastric tube.*

Discussion

Operations on esophageal cancer can now safely be performed, but the reconstructive operation after esophagectomy is the procedure with the highest occurrence of anastomotic leakage among gastrointestinal anastomoses (1-3, 6, 7). Furthermore, advanced anastomotic leakage is a serious complication which leads to surgery-related and hospital mortality caused by pyothorax, mediastinitis, tracheal fistula, arterial fistula, septicemia, or multiple organ failure (8-10). As might be expected, the period of hospitalization is also therefore greatly extended (4, 5, 11). One report indicated that

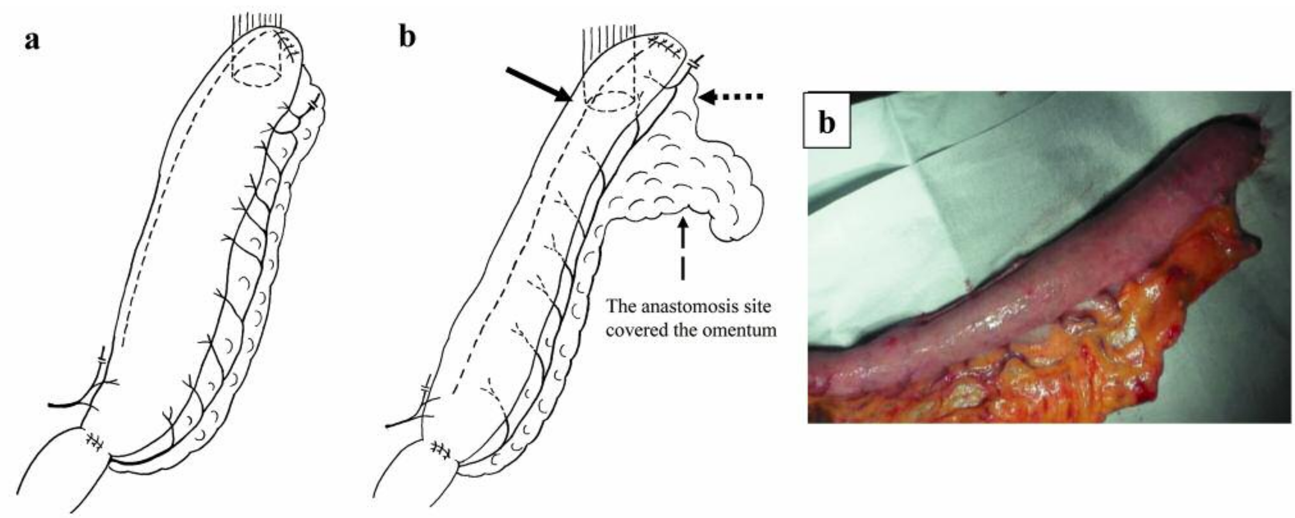

Figure 2. *The procedure of anastomosis. a: Group A: The anastomotic site was positioned at the posterior wall of the gastric tube. The anastomosis was performed using a 25 mm circular stapler by end-to-side anastomosis. b: Group B and C: Changes allowed for preserving one vessel along the gastric tube stump of the anastomosis (dotted line). The anastomosis site was changed from the posterior wall of the gastric tube to near the greater curvature of the posterior wall (solid line).*

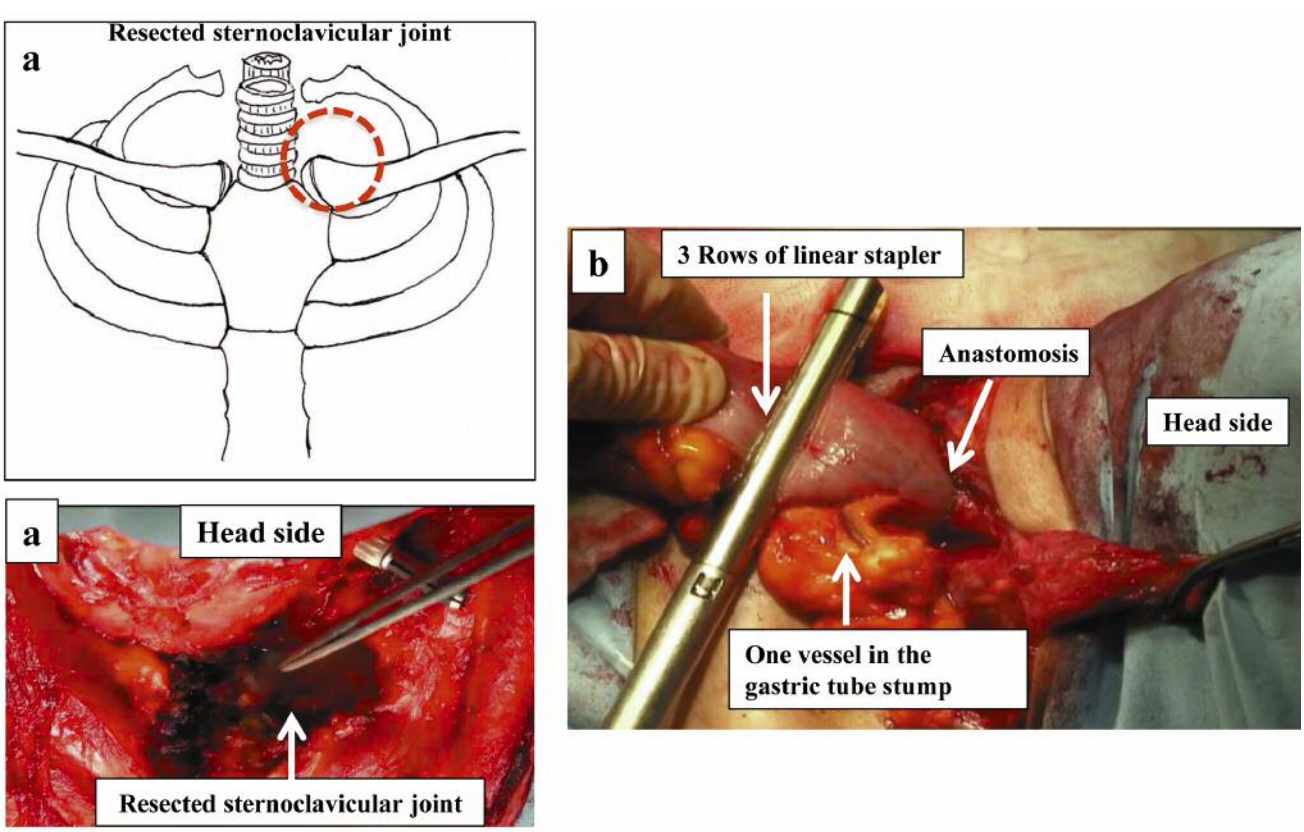

Figure 3. *The procedure of anastomosis in Group C. a: The left sternoclavicular joint was resected, and the thoracic inlet was dilated. b: The gastric tube stump was closed with three rows of linear staplers.*

Table I. *Postoperative complications.*

	Group A	Group B	Group C	*p*-Value*
Anastomotic leakage	5/32 (15.6%)	5/127 (3.9%)	4/145 (2.7%)	0.006
Anastomotic stricture	4/32 (12.5%)	16/127 (12.6%)	13/145 (8.9%)	0.58

*Fisher's exact test.

9.5% of 2653 cases of esophageal cancer operations were associated with anastomotic leakage, of which 5.7% (14/246 cases) ended in mortality (12). In particular, some reports indicate a 30 to 34% rate of anastomotic leakage when three-field lymph node dissection is performed, making it an extremely problematic complication (5, 13).

Anastomotic leakage is likely caused by a complex combination of systemic and local factors (4). Systemic factors include malnutrition, diabetes, hepatic dysfunction, renal dysfunction, and hypoxemia, as well as administration of steroids, anticancer drugs, and immunosuppressants. On the other hand, local factors largely depend on the anastomosis skills of the practitioner; other major factors include tissue blood flow and oxygen concentration within the tissue at the anastomosis site, tension and compression at the anastomosis site, as well as infection around it. Advances in instruments used for anastomosis are also highly relevant. Out of the different factors at play, systemic factors now make up a smaller percentage thanks to progress in modern perioperative management. Local factors as causes of anastomotic leakage can likely be prevented by adequately supplying blood flow to the end of the gastric tube to improve tissue repair at the esophagogastrostomy site and gastric tube stump (13-18). Therefore, it is important to supply blood flow to the gastric tube from outside the wall, and to preserve sufficiently the arcades of the left and right gastroepiploic vessels which function as discharge routes, as well as the short gastric vessels. Based on this idea, the gastric tube creation procedure used in group B reduced the occurrence of anastomotic leakage from 15.6% to 3.9% in comparison with the procedure used in the earlier group A. One surgical procedural reason is the gastric tube diameter was reduced, and a longer gastric tube along the greater curvature was used. This further improved the ability to elevate the gastric tube and allowed for preservation of one vessel along the gastric tube stump of the anastomosis site and secured sufficient blood flow along the gastric tube stump. If blood flow is impaired along the gastric tube stump, the same blood vessels can be used to perform super drainage and super charge. In addition, Kitagawa *et al.* reported on another method of objectively evaluating blood flow in the gastric tube, namely administering indocyanine green fluorescence into the gastric tube and visualizing the network of blood vessels with the HyperEye Medical System, thereby reducing anastomotic leakage from 17.9% to 4.4% (19).

Another procedural innovation was elevating the adequately formed omentum together with the gastric tube to the cervix and covering the anastomosis site. The reason we did this was that animal experiments indicated that the omentum functions as a source for the biological viable plug, granulation tissue, and neovascularization (5, 20-23). This likely prevents anastomotic leakage and rapidly repairs leakage if it happens to occur. Moreover, we infer that when a leakage occurs, the covered omentum prevents inflammation from spreading to the mediastinum and chest cavity. There were no cases in groups B and C of leakage from the cervix occurring with mediastinitis and pyothorax. The above procedural innovations likely markedly reduced anastomotic leakage in group B.

The majority of leakages in group B were caused by congestion of the gastric tube stump. The reason is likely that the gastric tube is compressed by the sternoclavicular joint at the thoracic Inlet. Shimanuki *et al.* also reported that in cases in which anastomotic leakage developed, the thoracic inlet was significantly narrower in preoperative computed tomography (24). Therefore, in group C when the width of the thoracic inlet was less than three fingerbreadths, the left sternoclavicular joint was resected, and the thoracic inlet was dilated to prevent compression. In addition, thanks to the improvement of instruments, the gastric tube stump was closed with three rows of linear staplers instead of two to create a denser closure. Furthermore, gastric tube fistulas were created in each row in group C to allow for enteral alimentation at an earlier period. This preserved the nutritional status, and improvement in a short time would be expected even if a leakage occurred. All cases of anastomotic leakage that actually occurred in group C were minor and resolved in a short time using only conservative treatment. There were also significantly fewer anastomotic strictures in group C, and cases easily improved with endoscopic balloon dilatation.

Conclusion

The reconstruction procedure after esophagectomy currently performed in this Department does not usually require for special instruments or special procedures such as angiostomy.

However, this procedure does markedly reduce anastomotic leakage, and also reduces anastomotic stricture, which likely makes it an extremely useful procedure which any surgeon can perform.

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