Jejunal interposition reconstruction with a stomach preserving esophagectomy improves postoperative weight loss and reflux symptoms for esophageal cancer patients[1]

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Abstract

Background: Conventional reconstruction after an esophagectomy uses a gastric tube which commonly causes several postoperative complaints such as gastric acid reflux in long term survival cases. Intestinal interposition between the remnant esophagus and the stomach is an option to reduce complaints, and in this study the advantages of jejunal interposition reconstruction with a stomach preserving esophagectomy (SPE) were assessed.

Materials and methods: Eleven cases of jejunal interposition with an SPE and 16 cases with gastric tube reconstruction as a control were subject to a comparison of operation time, amount of bleeding, postoperative QOL and endoscopic findings.

Results: The SPE group had a longer operation time (SPE: 560 ± 121 min, control 414 ± 83 min, $P = 0.038$), whereas there was no significant difference in blood loss. Postoperative weight loss was significantly recovered in the SPE group (SPE vs control = 94.0 ± 5.4% vs 87.5 ± 4.7% at 3 months, $P = 0.017$; 97.2 ± 7.5% vs 85.0 ± 5.2% at 6 months, $P = 0.010$) and there was a significant decrease in the occurrence of reflux symptoms such as heartburn, odynophagia and cough when jejunal interposition with an SPE was done. Furthermore, reflux esophagitis and Barrett's epithelium were found in 6 out of 12 cases (50%) of the control group by postoperative endoscopy, while no cases in the SPE group had either condition ($P < 0.01$).

Conclusions: This reconstruction method is a promising option to improve postoperative QOL, mainly due to the long-term elimination of reflux esophagitis, which assists in the recovery of postoperative weight loss.

Key Words: esophageal cancer; jejunal interposition reconstruction; stomach preserving esophagectomy; postoperative QOL; reflux esophagitis.

Introduction

Surgical treatments for esophageal cancer are highly invasive, and esophageal cancer often has perioperative complications [1-3]. Additionally, conventional reconstructions, such as gastric tube reconstruction, have more than a few cases with a low quality of life (QOL) and weight loss even in long-term survival cases. The low QOL cases are due to gastrointestinal symptoms such as heartburn caused by dysphagia and the back-flow of gastric acid [4]. The weight loss is due to the difficulty of oral intake [4, 5]. Furthermore, there are some cases in which complications from under-nutrition and pneumonia have caused death.

There are reports about colonic interpositions which preserved gastric functions after an esophagectomy. Reports have shown that colonic interposition is advantageous due to a higher calorie intake and better postoperative body weight recovery [6]. It is not difficult to imagine that the small intestine can be an alternative tissue for interposition after an esophagectomy and our team has performed this technique for middle and lower esophageal cancers called a Stomach Preserving Esophagectomy (SPE). An SPE is a reconstruction method done by interposing the pedunculated jejunum in the posterior mediastinal route and elevating the jejunum. This surgical method interposes the jejunum so that the direct back-flow of gastric acid to the remnant esophagus can be controlled and therefore alleviate reflux symptoms. Compared to gastric tube reconstruction, from the point of view of gastric emptying and the capability of the stomach, this method also increases the amount of oral intake because gastric function is highly preserved. Therefore, an improvement in postoperative QOL and the preservation of digestive and absorptive functions are possible.

In this paper, a detailed description of our version of the SPE surgical procedure and data obtained from the procedure are shown. Additionally, both postoperative QOL and nutritional status were compared with gastric tube reconstruction surgeries retrospectively, and the significance of SPE was examined.

Materials and Methods

Indication and surgical procedure for SPE

The indication of SPE is based upon the site of primary tumor, which should be below the middle of the thoracic esophagus. This limitation is because the anastomosis of the remnant esophagus to the jejunum should be lower than the aortic arch. In addition, suspicious lymph nodal metastases in the superior mediastinal area are an exclusion criterion. Obviously, cases whose tumors have massively invaded the stomach and those with stomach cancer are not candidates for SPE.

A surgical procedure for SPE consists of two steps, namely removal of the esophagus and reconstitution;

Removal procedures: The patient's body was fixed onto an operating table with the left side angled downward 45 degrees. When operating on the patient's abdominal and thoracic areas, the table was rotated to be capable of a simultaneous approach to both the thoracic and abdominal areas, and this body positioning is useful when lifting the jejunum into the thoracic cavity. The Skin incision in the abdomen is from the xiphoid process to the navel and in the thoracic area there is usually a small anterior axillary incision (8 to 10 cm) from the 4th segment of the ribs. First, in the supine position, dissect the lymph nodes around the stomach. Then dissect the left gastric artery and vein in due form and then remove the anal side (gastric side) at the gastric cardia. Next is the lower mediastinal manipulation. After ligating and dissecting the left subdiaphragmatic vein, open up the esophageal hiatus and perform the lymph node dissection and removal of the esophagus as close to the cephalic side as possible while compressing the pericardium and parietal pleura. For cases that require cervical lymph node dissection, abdominal manipulation is necessary at the same time. After the lower mediastinal dissection of the transdiaphragmatic hiatus, rotate the table to bring the body to a supine position with the left side down, and proceed with the thoracic manipulation.

In most cases, the dissection of the esophagus is completed close to the tracheal

bifurcation due to the previous dissection of the transdiaphragmatic hiatus in the abdominal area. Therefore, the area of esophagus removed by the thoracic procedure is small. Lymph node dissection in the thoracic cavity is performed as in due form and then move the gastric cardia was moved up into the thoracic cavity in order to prepare for the reconstruction.

Reconstruction procedures: Bring the body to a supine position again to treat the jejunum. Before taking care of the blood vessels, isolate the small intestine membrane from the ileocecal region to the Treitz ligament (Fig. 1A). At this time in the procedure, it is important to remove the superior mesenteric artery and vein completely to the pancreatic dorsum (Fig. 1B). Following the same procedure, elevating the jejunum often becomes advantageous because it can give an extra 5 to 8 cm for the later suture procedure, and the lifting of the reconstructed intestinal tract into the thoracic cavity can also be performed safely. When treating the blood vessels of the jejunum, the second and third jejunal arteries and veins are often dissected (Fig. 1C). After the vessel treatment, use an autosuture to dissect the jejunum that is appropriate for elevating 20 cm from the Treitz ligament (Fig. 1D). Then lift the jejunum into the thoracic cavity using the transhiatus approach through the transverse mesocolon and the back of the stomach (Fig. 1E).

The esophageal jejunum suture is performed by overlapping sutures using a variable laparoscopic linear stapler (Fig. 2A-C). Representative intraoperative pictures for Fig. 2A-C are also shown as Fig. 2D-F, respectively. When closing up the chest leave the thoracic drainage tube in. Then the stomach-jejunum suture and the jejunum-jejunum suture are done, adding a finger fracture pyloromyotomy as is also done for gastric tube reconstructions. Finally, a drainage tube is inserted after constructing a jejunal fistula.

The schematic view of a completed reconstruction of jejunal interposition for SPE is shown in Fig. 3. In this study, we did not dare to preserve the vagus nerve due to full lymph node dissection.

Assessment of long-term postoperative QOL in comparison to conventional reconstruction

with a gastric tube

Between October 2006 and May 2009, eleven patients had a stomach preserving esophagectomy (SPE) following the indications for an SPE; 1) below the middle of the thoracic esophagus, 2) no lymph nodal metastasis in the superior mediastinal area, 3) informed consent for SPE. Sixteen patients with esophageal cancer below the middle of the thoracic esophagus who had a conventional gastric tube reconstruction during the same period were used as the control group. We measured the operation duration and the amount of bleeding to compare between the SPE group and the control group. In order to evaluate the function of gastric absorption, albumin, total protein values and body weight decrease were monitored once a month for six months after surgery. To evaluate the QOL, a questionnaire from the European Organization for Research and Treatment of Cancer (EORTC) for assessing the quality of life for patients with esophageal cancer (QLQ-OES18) was used as a reference [7,8], and data was collected by phone survey on reflux symptoms, vomiting, heartburn, dysphagia, odynophagia, cough and aspiration. The phone survey was conducted at a single time point in February, 2010. This means that the follow-up time from the operation varies between 9-36 months for the 27 cases enrolled in this study.

Endoscopic evaluation of postoperative reflux esophagitis after an esophagectomy

An upper gastrointestinal endoscopy was done for cases with postoperative reflux symptoms. The level of mucosal damage in the esophagus, small intestine, the anastomosis area of the esophagus and the stomach was evaluated according to the Los Angeles classification [9], and the existence of residual dross was also examined.

Statistical analysis

JMP5.0.1J software was used to perform a *t*-test and a chi-square test, with a $P < 0.05$ considered to be significant.

Results

Jejunal interposition with a stomach preserving esophagectomy preserves postoperative gastric peristalsis

A postoperative esophagogram showed that the sutured site of the residual esophagus and pedunculated jejunum is positioned at the subcarinal level. Contrast agent flowed smoothly from the pedunculated jejunum to the preserved stomach (Fig. 4A). Of note, the contrast agent temporarily pooled in the stomach, and then gradually flowed to the duodenum (Fig. 4B), suggesting that the preserved stomach appeared to maintain its peristaltic action regardless of possible damage to the vagus nerve from lymph node dissection.

Comparison of long-term postoperative QOL with gastric tube reconstruction

Table 1 shows the details of the cases enrolled in this study. The male-female ratio of the SPE group was 5:6, and 9:7 for the control group. The average age was 65.3 ± 11.6 years old for the SPE group, and 56.9 ± 11.0 years old for the control group, meaning the control group tended to be younger (P = 0.02). The SPE group had more cases whose tumors infiltrated only down to the submucosal layer, whereas the control group contained some deeper invasive cases. However, there was no significant difference regarding the depth of invasion. There were no clear tendencies in lymph node metastasis or histological types (Table 1).

The operative duration of the SPE group and the control group were 506 ± 121 minutes and 414 ± 83 minutes, respectively, indicating that the SPE needed more time to be completed (P = 0.038). The amount of bleeding in the SPE and control groups were 579 ± 403 ml and 558 ± 353 ml, respectively, with no significant difference (P = 0.895).

There was not a significant difference in the total protein and albumin values (Fig. 5A and B). Interestingly, the difference in the recovery of body weight after surgery was significant at both 3 months and 6 months (3 months: SPE vs control = 94.0 ± 5.4% vs 87.5% ± 4.7%, P = 0.017; 6 months: SPE vs control = 97.2% ± 7.5% vs 85.0% ± 5.2%, P = 0.010; Fig. 5C).

We performed a phone survey to assess the subjective symptoms related to upper gastrointestinal function based upon the EORTC questionnaire (QLQ-OES18). The phone survey response rate was 81.5% (22 out of 27 cases). Eight of 11 SPE cases responded (72.7%) and 14 of 16 control cases replied to the survey (87.5%). Among the respondents, reflux symptoms, vomiting, dysphagia and aspiration did not show a significant difference between the SPE and control groups. However, the SPE group had fewer symptoms that are characteristic of reflux esophagitis such as heartburn, odynophagia and cough (Table 2 and Supplementary Figure).

Furthermore, there was no endoscopic finding of reflux esophagitis in the SPE group, whereas mucosal damage due to reflux esophagitis appeared in the control group ($P = 0.05$). Of note, no Barrett's epithelium appeared in the SPE group while this mucosal change significantly occurred in the control group (SPE: 0 out of 6 endoscopic cases, control: 6 out of 12 cases; $P < 0.01$) (Table 3 and Fig. 6). These observations suggest that jejunal interposition for SPE seems to improve some of the major postoperative complaints, body weight loss, and reflux esophagitis and its related symptoms.

Discussion

Our SPE method, which is a novel technique because of the elevation of the pedunculated jejunum to the anastomosis site for reconstruction, can be good for the control of reflux symptoms. This procedure is mainly adapted for lower thoracic esophageal cancer, but is also suitable for Barrett's esophageal cancer, which is more common in North America and Europe [10-12]. In consideration of intestinal continuity after an esophageal resection, it is technically difficult to elevate the pedunculated jejunum to the high thoracic or cervical position in the mediastinum, thus from the perspective of the degree of free elevation, ileocolic interposition is often adapted [13, 14].

There was not a significant difference regarding the amount of bleeding, but the operative duration of the SPE group was significantly longer. This is likely because an SPE has three anastomosis parts whereas a gastric tube reconstruction only has a single anastomosis. Also treatments for blood flow of the reconstructed small intestine differ slightly depending on each case due to the variety of body figures and vascularity, and this can also be considered as a factor for the longer operation time.

The number of esophageal cancer cases that survive more than five years after an esophagectomy is increasing, however little is known of the functional status and QOL of long-term survivors after a curative resection for esophageal cancer. McLarty et al. surveyed 359 cases that underwent an esophagectomy, and showed that the overall 10-year and 15-year survival was less than the expected survival of a normal population. The postoperative QOL survey showed that 60% of patients had heartburn, 29% required antacid for the relief of heartburn, 37% ate less, and 49% never regained body weight that they lost after the operation [4]. Some reports also showed that colonic interposition with cervical anastomosis reduced the incidence of reflux and relieved the weight loss after the operation [5]. Akiyama et al. showed gastric function preserving intestinal continuity after an esophageal resection through a blunt esophagectomy with vagus nerve preservation [15]. Ando et al. also reported on colonic

interposition preserving stomach function with a vagotomy, and the study showed that their colonic interposition maintained a superior QOL because the procedure enabled patients to take in more calories and prevented postoperative body weight loss [6].

Similar to these previous studies, our current study also revealed a significant improvement of postoperative body weight loss in the SPE group compared to the control group (Fig. 5C). When Doki et al. studied the reconstruction of the small intestine after an esophagectomy by the subcutaneous reconstruction route and compared it to ileocolic reconstruction, the body weight decrease was less for the reconstruction of the small intestine than the ileocolic reconstruction [16]. Since an unintentional decrease in weight of 10-15% within 3-6 months is considered to be malnutrition [17] and it is well recognized that malnutrition affects increased rates of complication, mortality, morbidity and the poor quality of life after surgery, the improvement of postoperative body weight should contribute to a better quality of life with reduced complications after surgery. In this study, the postoperative body weight recovery in the SPE group was significantly better than in the control group, possibly contributing to less complications and a better quality of life compared to those in gastric tube group.

Reflux symptoms, vomiting, dysphagia and aspiration did not show a significant difference between the groups, but heartburn, odynophagia and cough showed a significant decrease in the SPE group. These symptoms are highly associated with reflux esophagitis, and these results also corresponded with the endoscopic findings. Reflux symptoms often cause a loss of appetite, which is possibly one of the reasons for the difficulty regaining body weight after an esophagectomy with conventional reconstructions. Thus, an SPE is a promising option to overcome these complaints.

In support of the questionnaire results, the endoscopic findings also showed that the SPE group had a significant decrease in the development of reflux esophagitis. It is possible that using antacid can have a long-term protective effect on the remnant esophagus and the development of Barrett’s epithelium in the SPE cases. In the control group, there were severe

esophagitis cases that needed strong antacid treatment. In the endoscopic therapeutic course of these cases, most of the regrown epithelium was replaced by Barrett's epithelium and spread circularly from the anastomosis upwards. Therefore, in regard to the range of the development of Barrett's epithelia, the SPE group showed less reflux acid exposure than the control group.

As a point of reference, D'Journo et al. reported that mucosal damage in the remnant esophagus at a cervical anastomosis is pathologically different from that of an intrathoracic anastomosis [18]. Although the mucosa of the remnant esophagus was found to be freer of damage over time in patients with a cervical anastomosis than those with an intrathoracic anastomosis, they also reported that all patients showed a graded gastric-type and cardiac-type metaplasia and also showed intestinal metaplasia regardless of the kind of anastomosis. If the mucosal status of the remnant esophagus indicates reflux esophagitis, it can be considered that jejunal interposition prevents the remnant esophagus from developing reflux esophagitis, and the fact that jejunal interposition for SPE keeps normal mucosa in the long term indicates a superior postoperative long-term QOL improvement.

It is important to note that this SPE procedure is limited to approximately 20% of esophageal cancer cases due to our current indications that the tumor location should be below the middle of the thoracic esophagus and that there should be no lymph nodal metastasis in the superior mediastinal area. It is unlikely that these anatomical properties can be overcome in the near term.

In conclusion, the fact cannot be evaded that an SPE is a technically complicated procedure and has an increased operation time. However, it has enough advantages to cover these disadvantages, and an SPE can improve postoperative gastrointestinal symptoms and prevent reflux esophagitis. Moreover, an SPE significantly contributes to improving postoperative body weight loss. Therefore, an SPE is considered to be a superior procedure for patient's postoperative QOL compared to more conventional procedures.

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Table 1. Clinicopathologic characteristics of esophageal cancer cases in this study

		SPE (n = 11)	Control (n = 16)	Total (n = 27)	*p*
Sex	Male	5	9	14	0.1548
	Female	6	7	13	
Age*		65.3 ± 11.6	56.9 ± 11.0	62.9 ± 17.3	0.0293*
Main location†	Cervical	0	0	0	0.8089
	Ut	0	2	2	
	Mt	5	11	16	
	Lt	7	4	11	
	Abdominal	3	1	4	
Depth of invasion	m・sm	8	11	21	0.6881
	mp	1	0	1	
	adv	2	5	7	
Lymph node metastasis	N0	7	10	17	0.6184
	N1	2	1	3	
	N2	2	5	7	
Stage	1A	6	9	15	0.6077
	1B	1	0	1	
	2A	0	1	1	
	2B	2	2	4	
	3A	1	2	3	
	3B	1	2	3	
Histology	SCC	9	16	25	0.7937
	Adeno	1	0	1	
	SCC＋Adeno	1	0	1	

* Indicates significance ($P < 0.05$) .

† Cases invading multiple regions were calculated for each region.

Abbreviations: Ut: upper thoracic, Mt: middle thoracic, Lt: lower thoracic, m: mucosa, sm: submucosa, mp: muscularis propria, adv: adventitia, SCC: squamous cell carcinoma, Adeno: adenocarcinoma, SPE: stomach preserving esophagectomy.

N0: No lymph node metastasis, N1: Metastasis involving only Group 1 lymph nodes, and N2: Metastasis to Group 2 lymph nodes. Definitions of Lymph node groups and Stage are according to the Japanese Classification of Esophageal Cancer (Tenth edition) edited by the Japan Esophageal Society [19].

Table 2. Postoperative quality questionnaire results

	SPE (n = 8)		Control (n = 14)		*p*
Reflex symptoms	3	(37.5%)	9	(64.3%)	0.22
Vomiting	2	(25%)	4	(28.6%)	0.85
Heart burn	1	(12.5%)	8	(57.1%)	0.03*
Dysphagia	5	(62.5%)	9	(64.3%)	0.93
Odynophagia	0	(0%)	4	(28.6%)	0.04*
Cough	1	(12.5%)	8	(57.1%)	0.03*
Aspiration	1	(12.5%)	5	(35.7%)	0.22

*Indicates significance.

Table 3. Endoscopic findings of the residual esophagus and anastomosis

		SPE (n = 8)	Control (n = 12)	*p*
Residue		2(25.0%)	4(33.3%)	0.53
Barrett`s epithelium		0(0%)	6(50.0%)	0.005*
Reflux Esophagitis	A	0(0%)	3(25.0%)	
(Los-Angeles classification)	B	0(0%)	2(16.7%)	
	C	0(0%)	1(8.3%)	
	D	0(0%)	0(0%)	0.05

*Indicates significance.

Figure legends

Figure 1. Schematic views of preparing the pedunculated jejunum for reconstruction

Several key steps of the surgical procedure for the preparation of the pedunculated jejunum to be elevated to the intrathoracic anastomosis site are shown in graphics (A-C). Schematic images of elevating the pedunculated jejunum are also shown in D and E.

Figure 2. Schematic process of intrathoracic esophago-jejunal anastomosis of jejunal interposition for a stomach-preserving esophagectomy

Several key steps of anastomosis between the remnant esophagus and the elevated pedunculated jejunum are shown in graphics (A-C) as well as in the corresponding intraoperative photos (D-F).

Figure 3. Schematic view of the reconstruction with jejunal interposition for a stomach preserving esophagectomy (SPE)

After the esophagectomy, the pedunculated jejunum is elevated via the posterior mediastinum route for reconstruction with the remnant esophagus and preserved stomach.

Figure 4. Radiographic contrast imaging of jejunal interposition for an SPE

Contrast agent flowed smoothly from the pedunculated jejunum to the preserved stomach (A), temporarily pooled in the stomach, and then gradually flowed to the duodenum with apparent gastric peristalsis (B).

Figure 5. Postoperative change of nutrition status and body weight

The serum concentrations of total protein (A) and albumin (B) were tracked every month after surgery. Six months after surgery, the value of total protein was; SPE: 6.95 ± 0.07 g/dl, Control: 6.65 ± 0.38 g/dl, $P = 0.33$. Six months after surgery, the value of albumin was;

SPE: 4.05 ± 0.35 g/dl, Control: 4.00 ± 0.33 g/dl, P = 0.86. (C) The body weight of each participant was also tracked every month to compare the SPE and the control. Three months after surgery, the recovery rate of each group was; SPE: 94.0 ± 5.4 %, control: 87.5 ± 4.7 %, P = 0.017, and after six months; SPE: 97.2 ± 7.5 %, control: 85.0 ± 5.2 %, P = 0.010.

Figure 6. Endoscopic findings around the anastomosis

Conventional gastric tube reconstruction developed Barrett's epithelium eight months after surgery (A and B), whereas jejunal interposition for an SPE showed a clear anastomosis line and no reflex epithelium change by endoscopic observation (C and D).

Supplementary figure. Comparison of numeric scores for the grading or intensity of the postoperative quality questionnaire (QLQ-OES18)

The actual numeric scores from the answers to the postoperative quality questionnaire (QLQ-OES18) are illustrated in a histogram to compare between patients with gastric tube reconstruction (A) and those with an SPE (B). Each numeric score represents the following answers; 1 for "not at all", 2 for "a little", 3 for "quite a bit", and 4 for "very much".

Figure1

Figure 1

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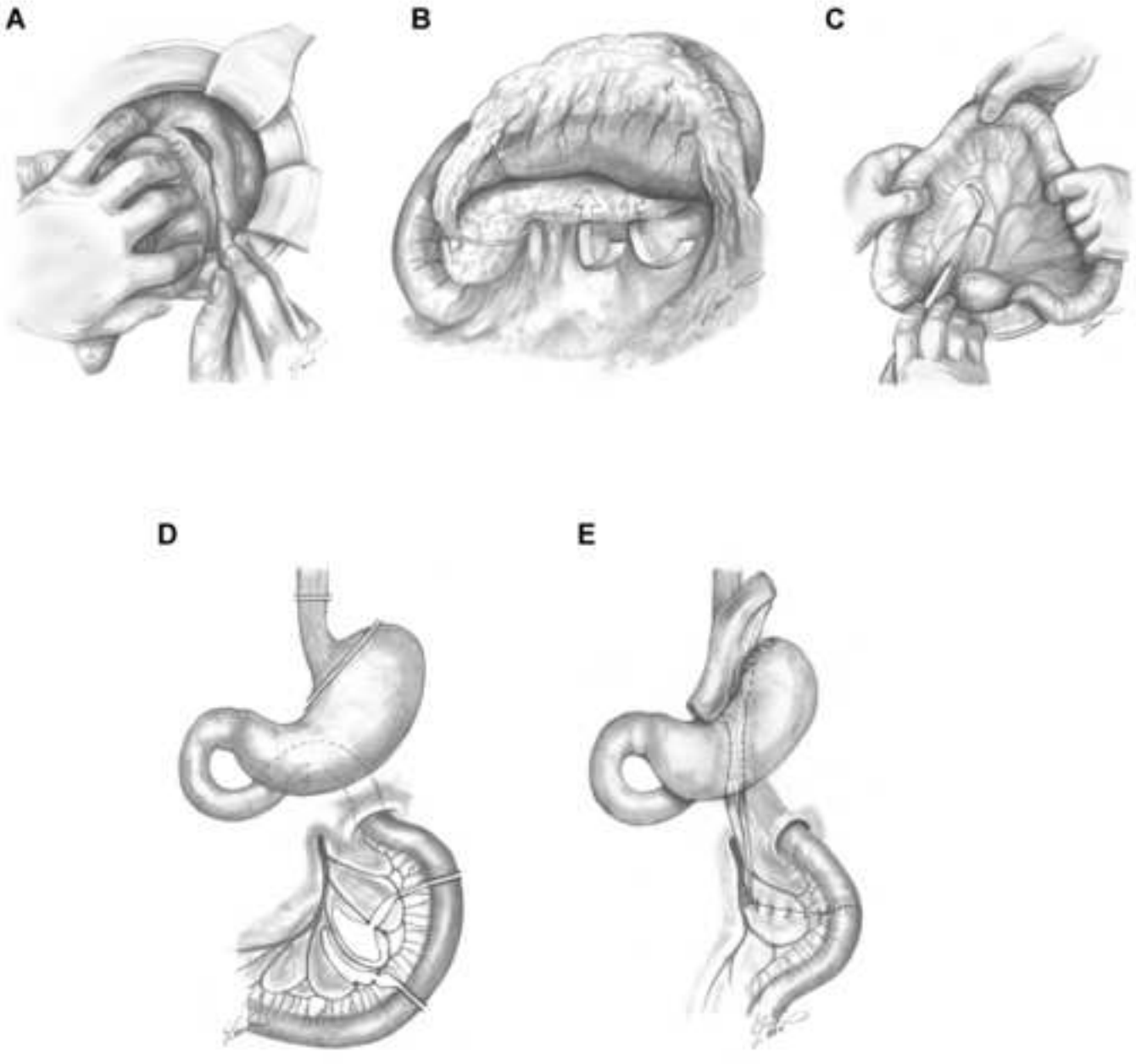

Figure 2

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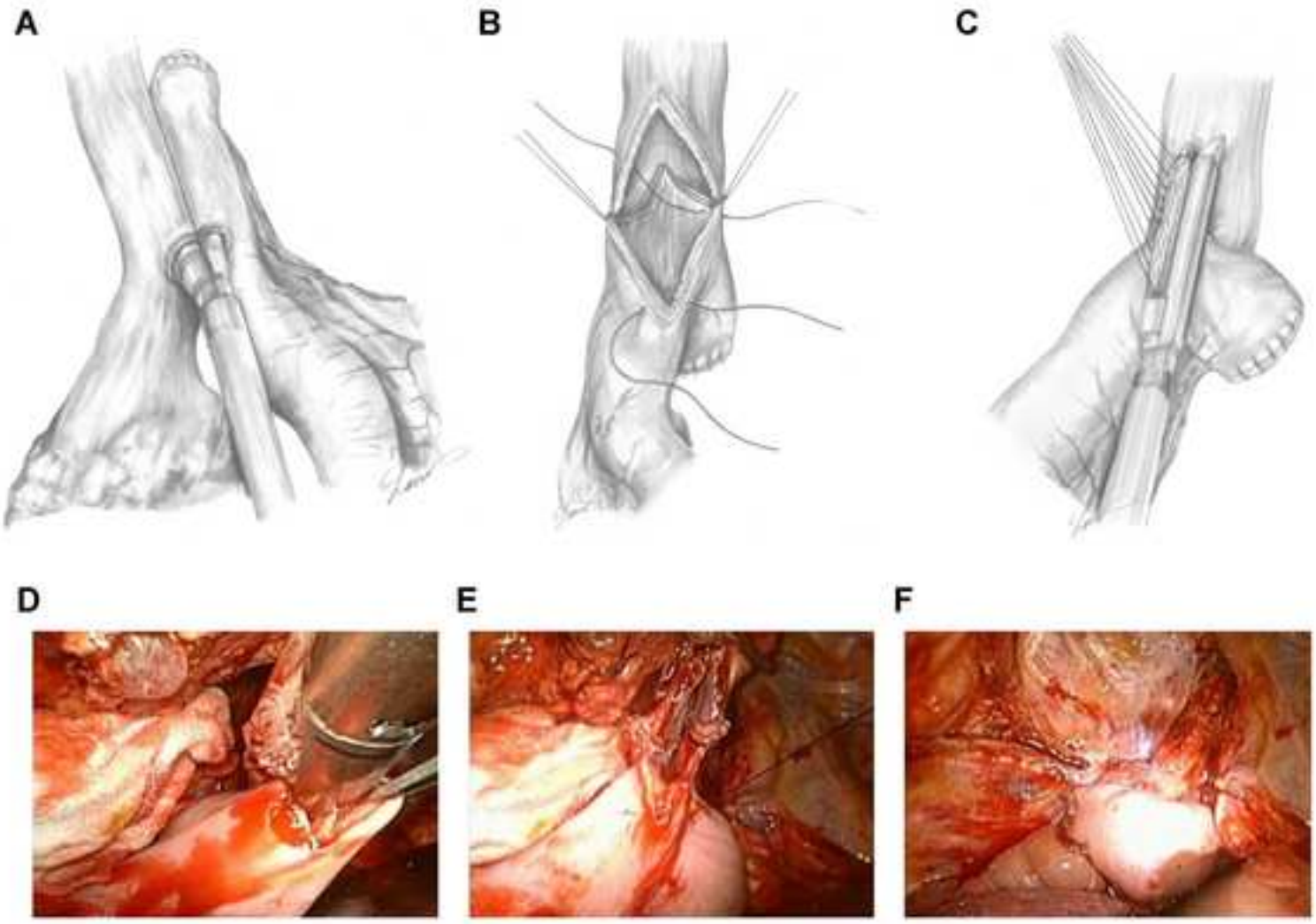

Figure3

Figure 3

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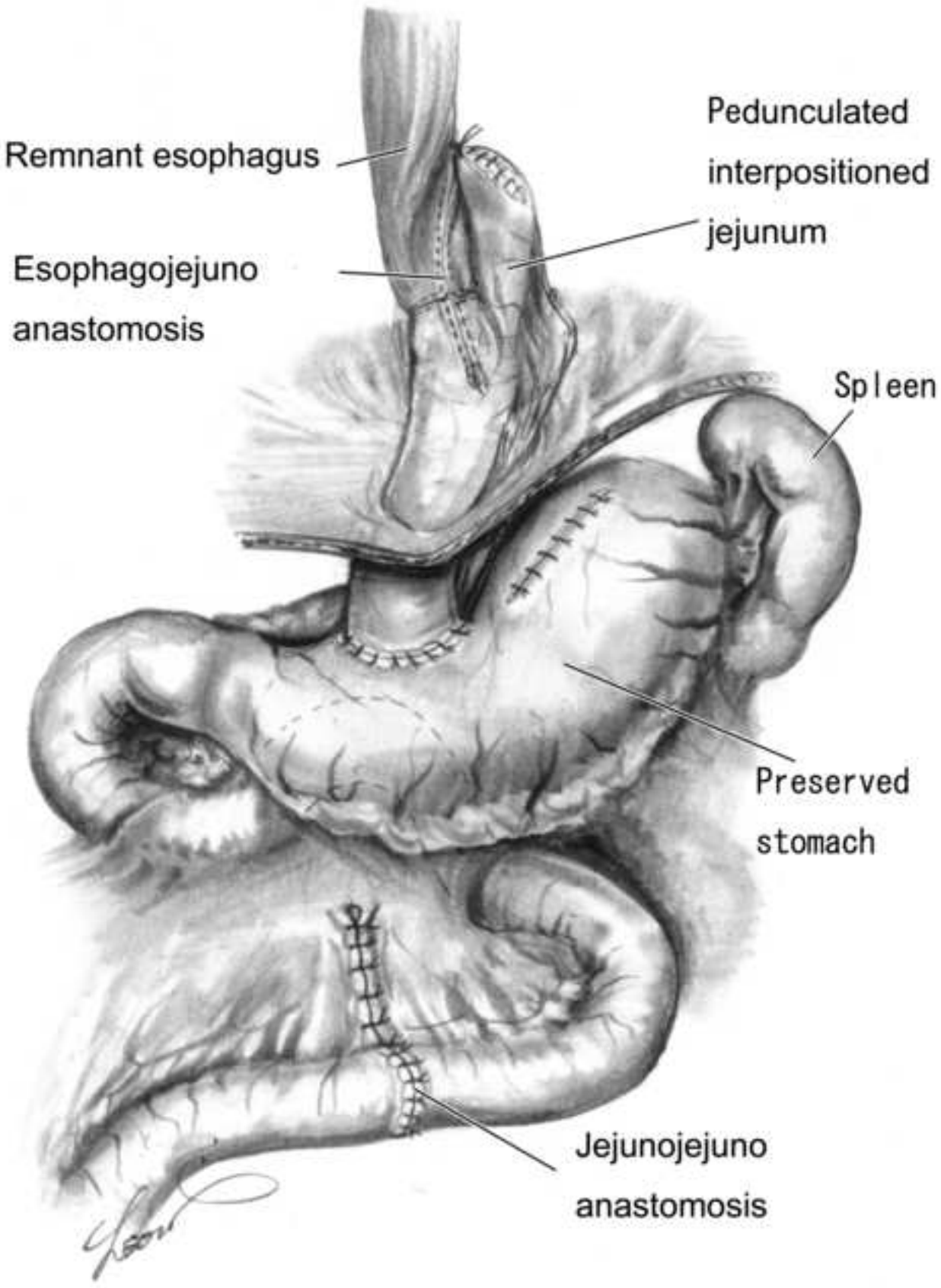

Figure4

Figure 4

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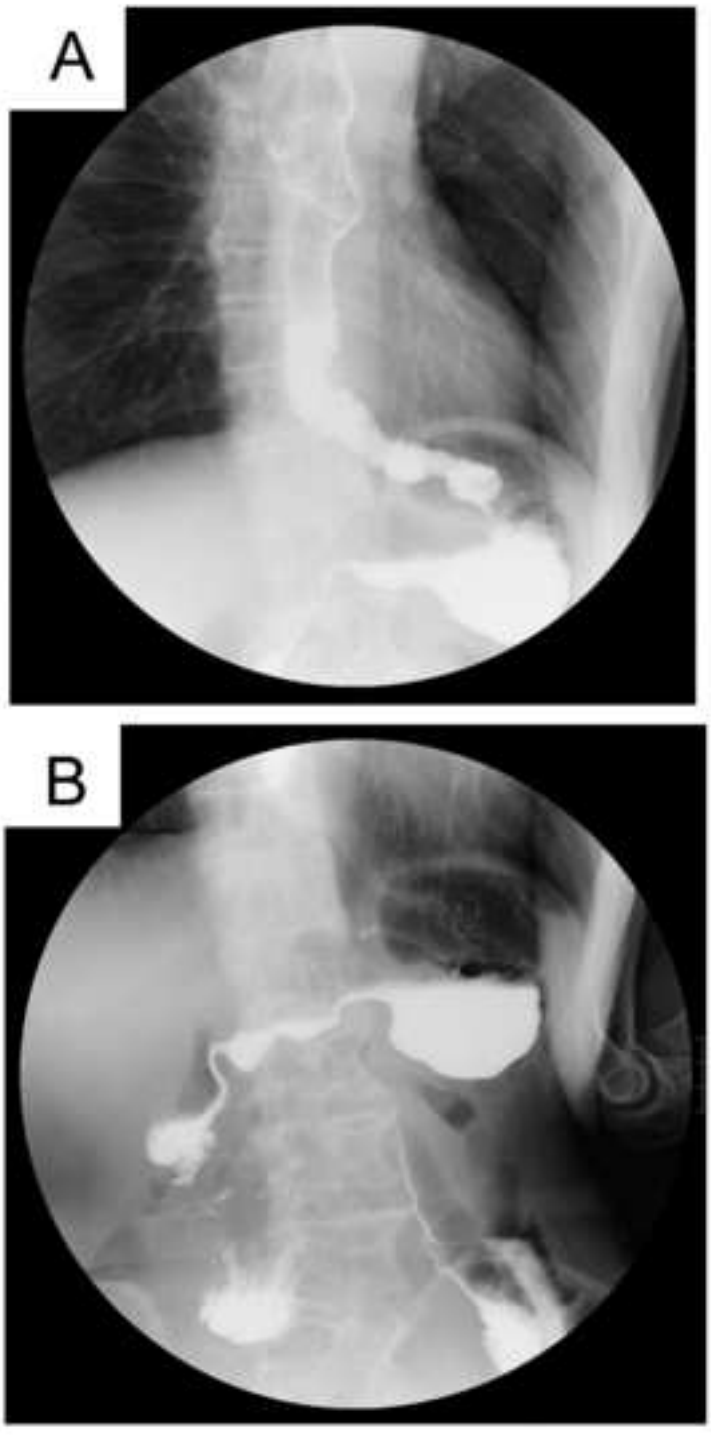

Figure5

Figure 5

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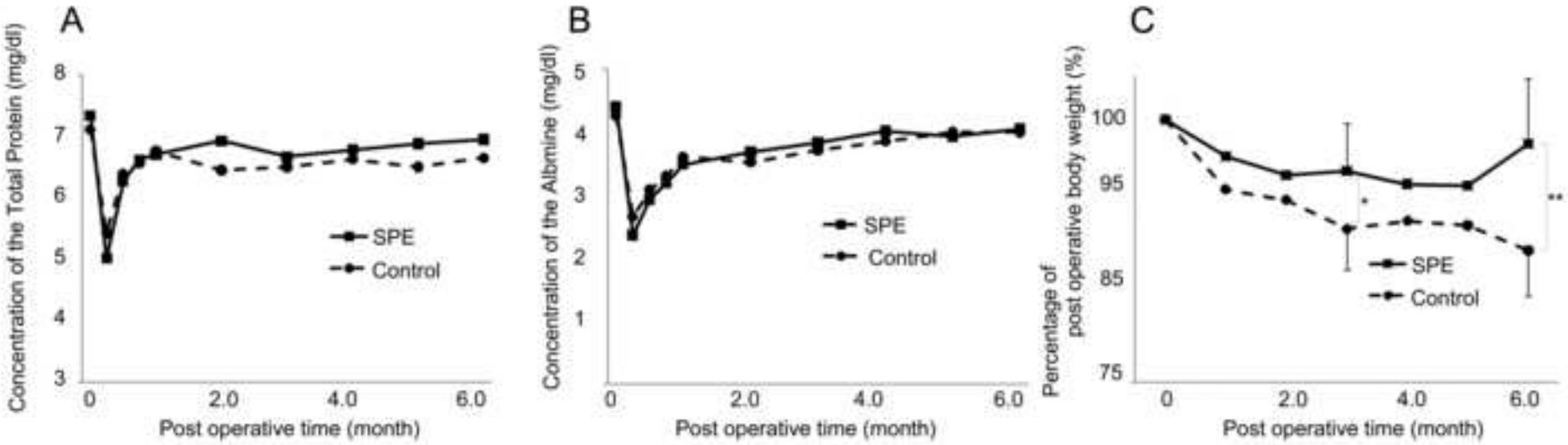

Figure6

Figure 6

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