

Long-term and short-term evaluation of esophageal reconstruction using the colon or the jejunum in esophageal cancer patients after gastrectomy

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SUMMARY. For esophageal cancer patients, the gastric tube is the first choice as an esophageal substitute, with the colon or the jejunum being used when the stomach cannot be used. We retrospectively compared these two methods from the viewpoint of peri-operative complications and long-term bodyweight alteration. From 1998 to 2005 53 patients who had undergone subtotal esophagectomy due to thoracic esophageal cancers were given reconstruction with the colon (28 cases) or the jejunum (25 cases). Both intestines were reconstructed via the subcutaneous route and were anastomosed to the internal mammalian artery and vein for a supercharged blood supply. There was no difference in operating time and blood loss. Compared with the colon reconstruction group, the hospital stay of the jejunum reconstruction group was significantly shorter (65 days vs 45 days, $P = 0.0120$) and the incidence of anastomotic leakage tended to be less (13 cases, 46% vs 6 cases, 24%, $P = 0.1507$), while other operative morbidity did not differ between the two groups. Bodyweight loss, which is a serious postoperative sequela after esophagectomy, was less in the jejunum group than in the colon group, showing a significant difference at 12 months after surgery. Our retrospective study revealed the jejunum to be superior to the colon for the reconstruction after esophagectomy along with gastrectomy, with respect to anastomotic leakage and bodyweight loss. The next step will be to conduct a prospective large cohort study.

KEY WORDS: esophageal cancer, gastrectomy, reconstruction, supercharged anastomosis.

INTRODUCTION

As an esophageal replacement for the reconstruction after subtotal esophagectomy, the first choice is the gastric tube. However, the stomach sometimes cannot be used due to a prior gastrectomy or the coincidence of gastric disorder, including gastric cancer and esophageal cancer invasion into the stomach. According to Japanese reports, reconstruction using organs other than the stomach accounted for 10–15% of all esophageal cancer patients undergoing surgical treatment.¹ The postoperative survival rate of esophageal cancers with a history of gastrectomy is not less than for cases without such a history,² therefore surgical treatment is recommended for these patients. However, esophageal reconstruction

other than with the gastric tube involves a complicated surgical procedure and shows higher operative morbidity and mortality rate than gastric tube reconstruction.^{3,4}

Either the jejunum or the colon can be employed as a substitute for the gastric tube. In our institution, the right colon including the terminal ileum had been used as the first choice. The most serious complication, although rare, was necrosis of the pedicled colon due to insufficient blood supply. This disappeared after we began using a supercharged blood supply by anastomosing the ileocecal artery and vein to the internal mammalian artery and vein.⁵ The pedicled jejunum is limited with respect to extension length due to poor connection of marginal vessels, and it was therefore used for lower anastomosis, for example, intra-thoracic anastomosis after partial resection of the lower esophagus. We introduced a supercharge technique to the jejunal reconstruction, anastomosis of internal mammalian vessels with jejunal vessels, which allows us to obtain a sufficient length of the pedicled jejunum

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with sufficient blood flow for cervical anastomosis.⁶ In our institution, supercharge anastomosis was introduced for colon reconstruction in 1998 and then widely applied to jejunum reconstruction after 2000. Either the colon or the jejunum was used between 2000 and 2003, but after 2004, the jejunum has been the first choice. This conversion occurred over an extended period as this operation is not frequently performed and the benefit of jejunum reconstruction was not well recognized. At present most surgeons in our institution consider jejunal reconstruction to be superior to that using the colon on several points. We therefore performed this retrospective study to compare the peri-operative and long-term results of these two procedures.

PATIENTS AND METHODS

Patients

From 1998 to 2005 a total of 412 patients underwent subtotal esophagectomy with reconstruction due to thoracic esophageal cancer in our department. Fifty-seven (11%) of them had reconstruction with organs other than the stomach. Fifty-three patients, excluding one who died within one month due to

liver failure with anastomotic leakage after colon reconstruction, and three who died within 6 months due to esophageal cancer, were enrolled in this retrospective study. The reconstruction had been done with the pedicled intestine using either the right colon, including the terminal ileum (colon group, 28 patients, 53%) or the jejunum (jejunum group, 25 patients, 47%).

The significant difference between the two groups was the period of surgery. The first jejunal reconstruction was performed at the end of 1999. Until then, the colon was the first choice when the stomach could not be used. After 2004, the jejunum has been chosen as the primary reconstruction organ. Thirty-eight patients (72%) underwent gastrectomy before esophagectomy, while the stomach was simultaneously removed with the esophagus in the other cases (15 patients, 28%) (Table 1). The former cases involved distal gastrectomy with Billroth-I (20 patients) or Billroth-II (15 patients) reconstruction or total gastrectomy with Roux-en-Y reconstruction (three patients). The reasons for not being able to use the stomach included gastric cancer (27 patients, 51%) or gastroduodenal peptic ulcer (21 patients, 40%) or involvement of the stomach due to esophageal cancer (five patients, 9%). All

Table 1 Background of esophageal cancer patients given esophageal reconstruction using the colon or the jejunum

	Esophageal reconstruction		Total	P-value*
	Colon	Jejunum		
Gender				
Male	26	23	49	> 0.9999
Female	2	2	4	
Age				
Average	63.5 + 7.2	66.5 + 7.8		0.1370
Cancer stage†				
0	2	2	4	0.7541
I	5	2	7	
II	7	10	17	
III	10	5	15	
IV	4	6	10	
Adjuvant therapy‡				
None	17	15	32	0.9741
Preoperative	9	8	17	
Postoperative	2	2	4	
Operation period				
–1999	9	1	10	0.0019
2000–03	17	16	33	
2004–	2	8	10	
Period of gastrectomy				
Synchronous	5	10	15	0.1257
Metachronous	23	15	38	
Reason for gastrectomy				
Gastric cancer	11	16	27	0.0894
Peptic ulcer	15	6	21	
ESCC involvement	2	3	5	
Total	28	25	53	

*Fisher's exact test for gender and period of gastrectomy, χ^2 test for adjuvant therapy and reason for gastrectomy, Student's *t*-test for age and Mann-Whitney *U*-test for cStage and operation period.

†TNM classification.

‡Adjuvant therapy includes 11 cases of chemotherapy and 10 cases of chemoradiotherapy. ESCC, esophageal squamous cell carcinoma.

patients with peptic ulcers (17 out of 27 patients with gastric cancers but none with gastric involvement due to esophageal cancer) underwent prior distal gastrectomy before esophagectomy. The interval from the gastrectomy to esophagectomy in these patients averaged 22 years (4–37 years). Since gastrectomy due to peptic ulcers has been decreasing recently, the jejunum group tended to include more patients with gastric cancer and synchronous gastrectomy than the colon group. During this period our strategy for each stage of esophageal cancer has basically remained unchanged, and the distribution of the clinical tumor stage, according to TNM classification⁷ and the mode of adjuvant therapy was not different between the two groups. Other factors, including age, sex, tumor location and histological type, were similar in both groups.

Surgical procedure

At first, all patients underwent a right thoracotomy and thoracic node resection as a standard procedure.^{8,9} Next, upper abdominal lymph node dissection, including the peri-gastric and celiac nodes was performed, though most of the nodes had already been removed for patients who had had a gastric cancer operation. For 15 synchronous gastrectomy patients, the whole stomach was removed. For 35 patients after distal gastrectomy, a gastric remnant was preserved in 15 of 22 patients in the colon group, while it was removed in all 13 patients in the jejunum group. Cervical node dissection, i.e. three-field lymph node dissection, was performed for the upper esophageal tumor and those with upper mediastinal node metastasis, as we have previously reported.⁹

In the colon reconstruction group, the ileum and the right colon were mobilized from the retroperitoneum. The ileocecal artery and vein were resected from its beginning and the ileum was resected at the feeding lesion of this vessel. On resection of the right colic artery and vein, the ileum and the right colon were lifted using the middle colic artery and vein as a pedicle. In the jejunum reconstruction group, after resection of the second and the third jejunal artery and vein, the jejunum was lifted upward using the fourth jejunum vessels as a pedicle. For lifting via the subcutaneous route, the intestine was anastomosed at the anal end of the esophagus, mostly by circular stapling (22 mm or 25 mm diameter) or, rarely, by hand sewing (the Albert–Lembert method). There was no difference in the sewing procedure for the colon and jejunum groups. In the right anterior thorax, supercharge anastomosis of either the ileocecal or the second jejunal vessels to the internal mammalian vessels was performed under a microscope, as previously reported.^{2,5}

Going back to the abdominal field, in the colon group, the anal end of the pedicled colon was anastomosed to the remnant stomach when it was preserved, or to the jejunum when it was removed, or to the duodenum in synchronous total gastrectomy. Finally, the residual ileum and the colon were anastomosed. In the jejunum group, Roux-en-Y reconstruction was performed for all patients. Among three patients given prior total gastrectomy, reconstruction for one was done by interposition of the colon and for two by shifting the Roux-en-Y structure in an upward direction by resecting the jejunal vessels.

Mechanical ventilation was removed the following day after surgery, unless there was a pulmonary complication. Postoperative pulmonary complication was defined as occurring when mechanical ventilation was continued for more than 5 days or a temporary thoracostomy had to be done. Anastomotic leakage was diagnosed by clinical symptoms or esophagography. A major leakage was defined as a condition that could not be cured within 30 days. Other complications included recurrent nerve paralysis, arrhythmia and wound infection, although they were not life threatening nor did they have a significant effect on the length of stay in hospital.

Surveillance of bodyweight change

The physical condition of the patient after surgery was checked every month for the first six months, then every two months until one year and every 3 months thereafter. The patients' bodyweight data before and after surgery was retrospectively obtained from their charts. Tumor recurrence was surveyed every 3 months by a physical examination and serum tumor markers, every 6 months by computed tomography scan and abdominal ultrasonography, and every year by fiberoscopy, until tumor recurrence was evident. When tumor recurrence was diagnosed, bodyweight data was collected until 6 months before the recurrence and abandoned thereafter. The median follow-up period of all 53 patients was 4.8 years and the average was longer in the colon group than in the jejunum group (5.7 years *vs* 3.8 years, $P = 0.0055$).

Statistical analysis

Differences in the continuous values, including age, operative time, blood loss, bodyweight loss and hospital stay, were evaluated by Student's *t*-test. The association between two non-continuous parameters was evaluated by the Mann–Whitney's *U*-test, χ^2 test and Fisher's exact test. Overall survival rates were calculated by the Kaplan–Meier method and evaluated by the log-rank test. A *P* value of less than 0.05 was accepted as statistically significant.

RESULTS

Operative outcome

There was no significant difference in operative time, blood loss, or lymph node dissection between the two groups (Table 2). With respect to post-operative complications, anastomotic leakage tended to be observed more often in the colon group than in the jejunum group, though the difference was not statistically significant (13 cases *vs* six cases, $P = 0.1507$), while pulmonary and other complications, including recurrent nerve paralysis, were observed to the same extent in both groups. Major leakage, taking more than 30 days to heal before oral food intake could be started, tended to be more frequent in the colon group than in the jejunum group (8/13 cases [62%] *vs* 2/7 cases [29%]). Three cases in the colon group required re-operation, i.e. a musculo-cutaneous patch by pedicled major pectoral muscle, due to prolonged leakage. Anastomotic leakage was the most important factor delaying hospital discharge; the postoperative hospital stay was significantly longer for those with anastomotic leakage than those without it (85 days *vs* 38 days, $P < 0.0001$). There was no difference in the postoperative hospital stay between the colon and the jejunum group without anastomotic leakage (40 days *vs* 36 days), while it tended to be longer in the colon group than in the jejunum group when anastomotic leakage had occurred (94 days *vs* 65 days). In sum, postoperative hospital stay was significantly longer for the colon group than the jejunum group (65 days *vs* 45 days, $P = 0.0120$). With respect to survival, the overall 5-year survival rate was 45.8% in this series and there was no significant difference between the colon and the jejunum groups (Fig. 1).

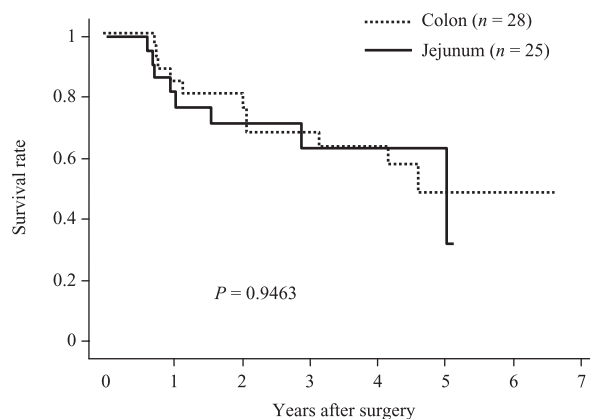


Fig. 1 Post-operative survival rate of esophageal cancer patients with colon or jejunum reconstruction. Fifty-three esophageal cancer patients could not have stomach reconstruction due to metachronous or synchronous gastrectomy. Their survival curves were plotted by the Kaplan Meier method for colon reconstruction (dotted line) and jejunum reconstruction (continuous line) groups. The difference between two curves was evaluated by log-rank test.

Bodyweight alteration

Since there was no significant difference in preoperative bodyweight between the colon and the jejunum groups (BMI 20.38 *vs* 20.05, $P = 0.345$), the percent bodyweight loss was used for the comparison (Fig. 2). During the hospital stay, the bodyweight loss was more significant in the colon group than in the jejunum group (-9.6% *vs* -6.7% , $P = 0.0422$) (Table 2). After discharge from the hospital, there was no difference until 6 months. After 6 months, bodyweight gain was observed in the jejunum group while it continued to decline in the colon group, leading to a significant difference at 12 months after surgery (-8.2% *vs* -14.3% , $P = 0.0315$) (Fig. 2a). After 18 months, the difference of

Table 2 Operative outcome of esophagectomy with reconstruction using the colon or the jejunum

	Esophageal reconstruction		P-value*
	Colon	Jejunum	
Operative time (min)	638 ± 102	666 ± 133	0.4005
Blood loss	1103 ± 531	1185 ± 589	0.5977
Lymph node dissection			
Two field	18	15	
Three field	10	10	0.7832
Post-operative complications			
Anastomotic leakage	13	6	0.1507
Pulmonary	2	2	> 0.9999
Others	5	3	0.7078
Hospital stay (days)			
All cases	65 ± 38	45 ± 23	0.0120
With leakage	94 ± 38	65 ± 18	0.1706
Body weight loss in hospital (%)	-9.6 ± 3.7	-6.7 ± 6.6	0.0422

*Student's *t*-test for operative time, blood loss, hospital stay and bodyweight loss. Fisher's exact test for lymph node dissection and each postoperative complication.

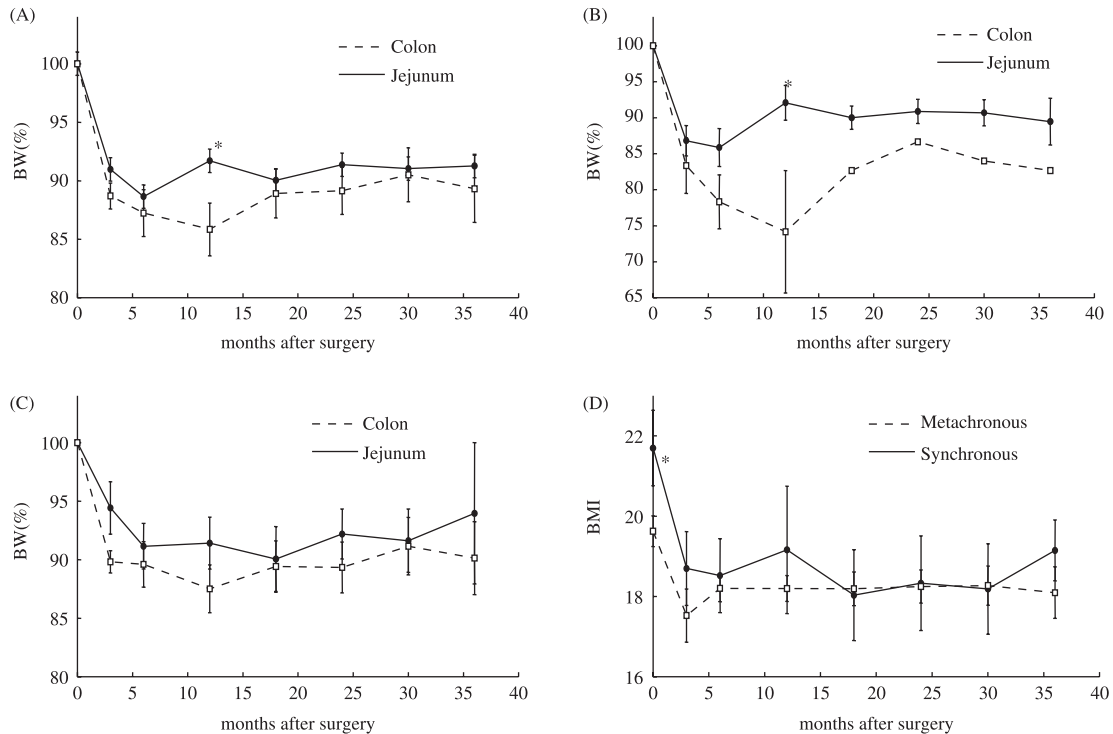


Fig. 2 Post-operative bodyweight alteration in colon and jejunum reconstruction groups of patients. (A) The post-operative bodyweight alteration after colon (dotted line) or jejunum (continuous line) reconstruction is indicated as a proportion of the preoperative value. The values were calculated according to the period of gastrectomy, i.e., either (B) synchronous or (C) metachronous. In (D), the absolute bodyweight (BMI) alteration is indicated for the synchronous (continuous line) and the metachronous (dotted line) gastrectomy. The difference in bodyweight between the two groups was evaluated at each time point using Student's *t*-test, indicating a *P* value smaller than 0.05 with an asterisk.

bodyweight loss was smaller and constant, i.e. 2% to 3% higher in the jejunum group, but not to a statistically significant extent. Since the period of gastrectomy, either metachronous or synchronous, affected bodyweight until 12 months after surgery (Fig. 2d), the bodyweight loss was compared for subgroups based on the period of gastrectomy. In the synchronous gastrectomy group there was a great difference of bodyweight loss at 12 months between the colon and the jejunum group (-7.9% vs -25.4% , $P = 0.0105$), while in the metachronous gastrectomy group, the difference between two groups was smaller and not statistically significant (Fig. 2c). With respect to preservation of the remnant stomach, there was no significant difference of bodyweight loss between 15 cases with preservation of the remnant stomach and seven without it in the colon group patients undergoing prior distal gastrectomy.

DISCUSSION

In this retrospective study, the jejunum reconstruction was superior to the colon reconstruction on several points; the anastomotic leakage tended to be less frequent, the hospital stay was shorter and the

postoperative bodyweight loss was less in the jejunum reconstruction group. Since surgical procedure generally depends on the surgeon's preference and this type of operation is not frequently performed, this is the first study to compare esophageal reconstruction using the colon and the jejunum.

Various factors are usually implicated in anastomotic leakage, including blood supply, physical tension, surgical procedure (hand or staple sewing) and systemic nutrition.^{10–12} In this study, the blood supply seemed to have been sufficient in both groups because of the supercharge anastomosis. There was no difference in surgical procedure and nutrition status. The tensile force to the anastomosis, which should be stronger for the jejunal reconstruction than for the colon type, cannot explain why the leakage was more frequent in the colon group. Another possible factor causing a difference between the two types of reconstruction is the presence of intestinal bacteria, which prosper more in the colon and terminal ileum than in the jejunum¹³ and may affect the healing of the anastomotic leakage or expose minor sub-clinical leakage. Minor leakage is usually encapsulated and cured by the surrounding connective tissue. In the absence of such surrounding tissue, the healing of minor leakage may be prolonged with subcutaneous anastomosis. Taken

together, infection of the surrounding tissue by intestinal bacteria may cause or worsen the status of anastomotic leakage in the colon group. A high incidence of anastomotic leakage in the colon reconstruction by the subcutaneous route was also observed in the previous study.¹⁴ In the present study, jejunum reconstruction partly reduced the incidence of leakage, but it was still more frequent than the gastric tube reconstruction by the posterior mediastinal route, accounting for less than 10% in our institution. In future work, the influence of route of reconstruction should be considered.

Bodyweight loss is one of the most serious sequela after esophagectomy; strongly affecting postoperative quality of life as well as immune function, infection and survival.¹⁵⁻¹⁷ Since appetite, emotional and metabolic condition should not be different between the two groups, one possible reason for weight loss is the reduction of oral intake due to early satiety, which is very difficult to evaluate in an objective and reproducible fashion. Patients with a previous history of gastrectomy suffer less from bodyweight loss after esophagectomy than those without it. These patients had already experienced a 5 to 10% bodyweight loss after gastrectomy¹⁸ their intestine had adapted well to the dumping syndrome and they had learned how to eat slowly. In this study, synchronous gastrectomy was more frequent in the jejunum reconstruction group and the difference from the colon group was prominent at 12 months with a synchronous gastrectomy but not with a metachronous gastrectomy. Attempts have been made to produce a pouching space to increase oral intake, but its contribution to bodyweight has not always been successful.^{19,20} With respect to subcutaneous reconstruction for esophageal cancer patients, the volume of the lumen was greater in the colon than in the jejunum. In addition, the residual stomach was preserved for many of the colon group but had been removed for those of the jejunum group in which the Roux-en-Y reconstruction method had been used. Thus, reasons other than the reservoir space may be the underlying factors influencing oral intake after esophagectomy. In general, continuous anterograde peristalsis was stronger in the jejunum than in the colon¹³ which is well preserved after Roux-en-Y reconstruction.^{21,22} This characteristic of the jejunum enables the consumption of more at a slow and continuous pace during a meal, while stasis results in a lesser total oral intake although the reserve space in the colon group is greater than that in the jejunum group. Alternatively, the presence of Bauhin's valve in the terminal ileum may have caused the food stasis in the colon group. Another possibility might be diarrhea, which is often observed along with bodyweight loss after gastrectomy. Although we could not obtain the data of stool frequency in this

retrospective study, the colon group might have had more frequent stools because the subcutaneous right colon is not likely to have contributed to water absorption. Further work is needed on this issue.

The length of lifted jejunum is the most practical problem for reconstruction. Since the marginal vessels do not develop well after the fifth jejunal artery and vein, we lifted the jejunum using the fourth jejunal artery and vein as a pedicle, in which the top of the lifted jejunum is located around the sternal notch. We and others have reported that esophageal cancers after distal gastrectomy are frequent in the lower esophagus.^{2,23} Therefore, in most cases we can leave enough of the oral esophagus around or below the sternal notch. However, for upper thoracic esophageal cancers in which the oral margin often reaches the cervical esophagus, the colon should be employed for reconstruction. Intraepithelial spread, intramural metastasis and multiple cancers frequently disturb the oral margin of esophageal cancer patients during operation. Thus, the presence or absence of cancers at the oral edge should be checked before deciding on the reconstruction organ. Although no significant difference in operative time was noted, the operative procedure is slightly more complicated for the colon group than the jejunum group. Three anastomoses are necessary for colon reconstruction, while Roux-en-Y reconstruction using the jejunum usually requires two anastomoses or only one anastomosis, when prior Roux-en-Y reconstruction has been done.

An esophagectomy, especially one involving construction with an organ other than the stomach, is one of the most difficult types of gastrointestinal surgery with high operative morbidity and mortality. Many factors, including operative time, surgical stress, preoperative complications and cancer curability, are considered in deciding on the operative procedure. The final decision for each operation is left to the surgeon, according to his or her knowledge and experience. In our institution it took three years to change the standard procedure from colon reconstruction to jejunum reconstruction, which was retrospectively analyzed in this study. Although a prospective randomized trial is necessary to prove the true benefit and superiority of jejunum reconstruction, it would require much time and great effort to perform this kind of trial because of the limited number of patients and long follow-up period for quality of life evaluation. We hope our findings can help surgeons who attempt this complicated surgery to make better informed decisions.

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