

Investigation of Suitability of Devascularized Upper Half of the Whole Stomach as Replacement for the Esophagus

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ABSTRACT

One hundred and fifteen patients with esophageal cancer underwent esophageal replacement with the stomach. The patients were divided into group A (52 patients, stomach tube, ante- or retro-sternal route) and group B (54 patients, devascularized upper half of the whole stomach, posterior mediastinal route). The post-operative complications, post operative symptoms and nutritional status were investigated in both groups. Lung complications tended to occur more frequently in group A (28.8% versus 22.2%), showing no significant difference. The incidence of other complications did not show a remarkable difference between either group except for leakage at the site of anastomosis. Major leakage occurred in 11.5% and 5.6%, and minor leakage in 30.8% and 18.5%, respectively. Postprandial fullness, nausea, heart burn and diarrhea were found to be somewhat higher in Group B. Change of oral intake, body weight and other indices of nutritional status were investigated and compared with pre-operative data. The amount of oral intake and levels of serum albumin was higher in group B than in group A between one and 12 months. These results demonstrate the superiority of the devascularized upper half of the whole stomach as an esophageal substitute.

Key words: *Esophageal cancer, Esophageal substitute, Stomach tube, Whole stomach*

The prognosis of esophageal cancer patients remains poor. There has been, however, a gradual improvement showing a more than 30% 5-year survival rate and a few cases surviving over 10 years^{1,7,14}. The quality of life of survivors is not, however, always good, with problems in the oral intake being commonly seen. The method of reconstruction of the upper gastrointestinal tract is, therefore, of major importance in these patients. We chose the stomach as an esophageal substitute when the stomach was not involved with tumor. In this study, we compared the ante- or retro-sternal stomach tube to the devascularized upper half of the whole stomach in the posterior mediastinum with respect to their post-operative complications, symptoms and nutritional status.

MATERIALS AND METHODS

Two hundred and sixty eight patients with esophageal cancer were treated from 1976 to 1989. 153 cases were resected and 116 (75.8%) were replaced with stomach, 19 (12.4%) with jejunum and 3 (2.0%) with colon. Cases of cervical esophageal cancer were excluded from this analysis. Fifty two (88.1%) of 59 cases with stomach tubes had them passed via the ante- or the retro-sternal route (group A) and 54 (94.7%) of 57 cases

with devascularized upper half of the whole stomachs through the posterior mediastinal route (group B). Group A consisted of 52 cases and group B of 54 cases (Table 1). Table 2 shows the characteristics of these two groups. They revealed no significant difference in the characteristics, whereas two groups were not prospectively randomized. The average operation time was 285 and 287 minutes in Group A and B, respectively. Average blood loss was 1250 and 813ml in Group A and B, respectively ($p < 0.01$). The post-operative nutritional status was investigated for those patients who showed no swallowing disturbance preoperatively, survived over one year without recurrence and who had no severe complication or second cancer. There were 21 and 18 such cases in group A and B, respectively. The amount of oral intake was monitored from a clinical chart.

Figures 1 and 2 show the operative procedures used to construct the stomach tube and employment of the devascularized upper half of the whole stomach. To make the stomach tube, the lesser curvature was resected from the junction of the right and left gastric arteries to the apex of the fundus of the stomach. The width of the stomach tube was 6 to 7cm. The left gastroepiploic artery and short gastric arteries were preserved carefully by resec-

Table 1. Management of 268 Esophageal Cancer Cases between 1976-1989

1. Esophageal Resection	153
Substitute for reconstruction	
stomach	116
a. stomach tube	59
ante-sternal >(group A)	16 >52
retro-sternal	36
posterior mediastinal	7
b. devascularized upper half of the whole stomach	57
ante- or retro-sternal	3
posterior mediastinal (group B)	54
colon	3
jejunum	19
others	5
*carcinoma of cervical esophagus	10
2. Bypass Operation	92
3. Others	23
Total	268

Table 2. Characteristics of Group A and B

	Group A (52 cases)	Group B (54 cases)
Age		
-50	6 (11.5)	7 (13.0)
51-60	17 (32.7)	14 (25.9)
61-70	25 (48.1)	24 (44.4)
71-	4 (7.7)	9 (16.7)
stage		
0	9 (17.3)	15 (27.8)
I	5 (9.6)	3 (5.6)
II	1 (1.9)	5 (9.3)
III	20 (38.5)	16 (29.6)
IV	17 (32.7)	15 (27.8)
curability		
C0	8 (15.4)	14 (25.9)
CI	9 (17.3)	4 (7.4)
CII	8 (15.4)	11 (20.4)
CIII	27 (51.9)	25 (46.3)

C0: Absolute non-curative resection,

CI: Relative non-curative resection,

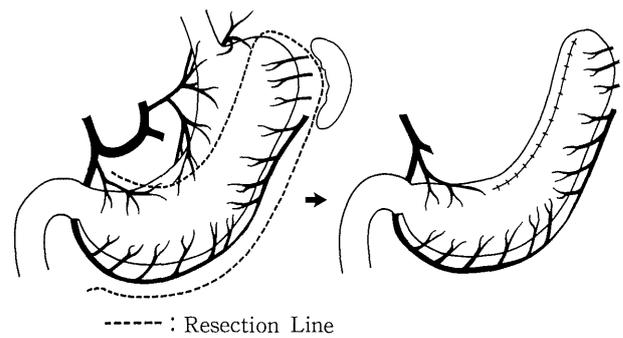
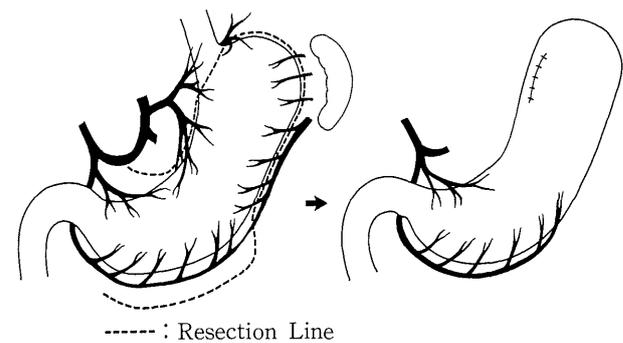
CII: Relative curative resection,

CIII: Absolute curative resection

*All these abbreviations were according to the Guide Lines for the Clinical and Pathologic Studies on Carcinoma of the Esophagus¹⁶⁾

No significant difference between Group A and B

tion of the vessels close to the spleen. For the devascularized upper half of the whole stomach substitute, the stomach was divided at the gastroesophageal junction; the vessels of the left gastric artery, short gastric arteries and left gastroepiploic artery were divided. That is, the upper half part of the whole stomach was devascularized completely. In both substitutes, the resection mar-

**Fig. 1.** Schema of the procedure to make the stomach tube**Fig. 2.** Schema of the procedure to make the devascularized upper half of the whole stomach

gin was closed immediately and the apex of the substitute was used to anastomose to the cervical esophagus. The anastomosis was performed using Albert-Lembert sutures and all patients underwent pyloroplasty.

The length of substitute from the site of pyloroplasty to the tip of the substitute was measured during the operation. The average length of the stomach tube and devascularized upper half of the whole stomach was 31.0cm and 30.6cm, respectively.

Statistical analysis was made by means of chi square evaluate differences in the characteristics of the two groups and by t test for evaluating differences between the two groups.

RESULTS

Complications: Lung complications tended to occur more frequently in group A than in group B (28.8% versus 22.2%). Adult Respiratory Distress Syndrome (ARDS) occurred in 7.7% and 1.9% in groups A and B, respectively. The incidence of other complications did not show a remarkable differences in either group except for leakage at site of the anastomosis (Table 3). Major leakage, defined as requiring surgical treatment or prevention of oral intake for more than one month, occurred in 11.5% and 5.6% of groups A and B, respectively. Minor leakage occurred in 30.8% and 18.5% of groups A and B, respectively (Table 4).

Table 3. Complications after Operation

Complications	Group A (52 cases)	Group B (54 cases)
Pneumothorax*	7 (13.5)	4 (7.4)
Pyothorax	5 (9.6)	4 (7.4)
Pneumonia	3 (5.8)	3 (5.6)
ARDS**	4 (7.7)	1 (1.9)
Hemothorax	1 (1.9)	0
Atelectasis	0	1 (1.9)
lung complications	15 (28.8)	12 (22.2)
Leakage	22 (42.3)	13 (24.1)
Hoarseness	4 (7.7)	5 (9.3)
Stenosis of anastomosis	7 (13.5)	6 (11.1)
Mediastinitis	2 (3.8)	1 (1.9)
Liver dysfunction	1 (1.9)	1 (1.9)
Others	2 (3.8)	4 (7.4)
none	16 (30.8)	25 (46.3)

*Pneumothorax indicate operative pleural injury during blunt dissection or preparing of the substernal tunnel except for the site of thoracotomy

**Adult Respiratory Distress Syndrome

No.(%). No significant difference between Group A and B

Table 4. Leakage of Anastomosis

	Group A	Group B
No leakage*	30 (57.7)	41 (75.9)
Minor leakage	16 (30.8)	10 (18.5)
Major leakage	6 (11.5)	3 (5.6)
Total	52	54

No.(%). * p<0.05

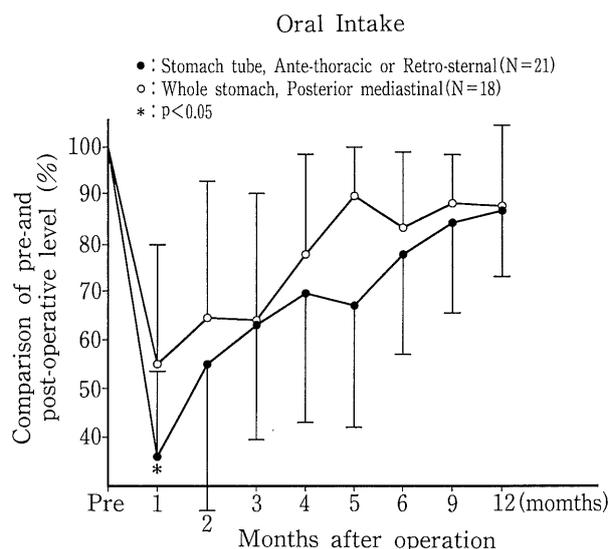
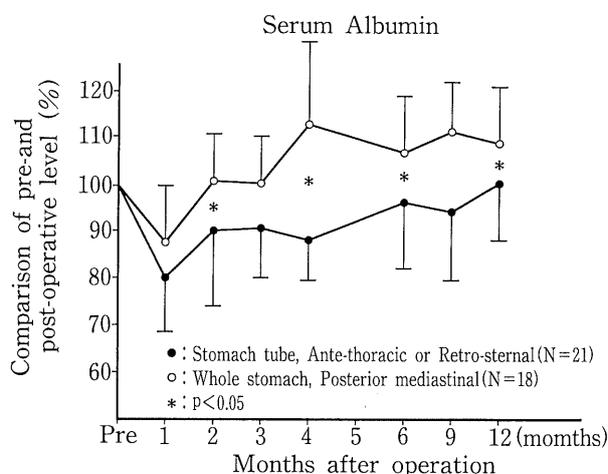
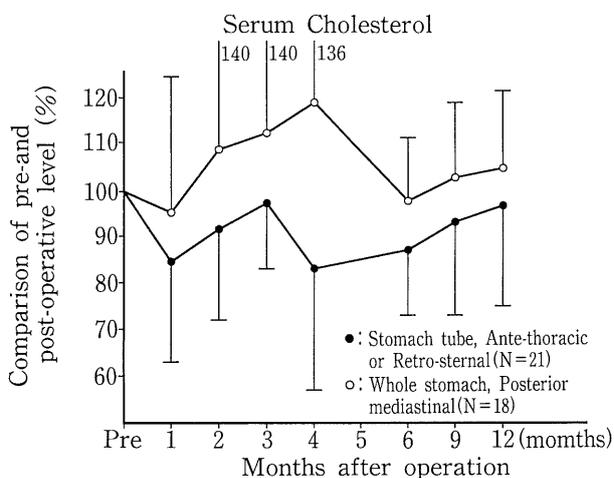
Table 5. Complaints after Operation

	21 cases in group A	18 cases in group B	Total (39 cases)
Stenotic sensation in cervical esophagus	12 (57.1)	10 (55.6)	22 (56.4)
Postprandial fullness	4 (19.0)	4 (22.2)	8 (20.5)
Nausea	2 (9.5)	3 (16.7)	5 (12.8)
Heart burn	2 (9.5)	2 (11.1)	4 (10.3)
Diarrhea	2 (9.5)	3 (16.7)	5 (12.8)
none	5 (23.8)	5 (27.8)	10 (25.6)

No.(%). No significant difference between Group A and B

Complaints: Cervical dysphagia was felt in more than half of the patients in both groups. Postprandial fullness of the substitute occurred in 19.0% and 22.2%, respectively. Nausea, heartburn and diarrhea occurred infrequently. There were no complaints in 23.8% and 27.8% of groups A and B, respectively (Table 5).

Nutritional status: The change of oral intake, body weight and other indices of nutritional statuses were investigated, comparing preoperative and postoperative levels. The amount of oral intake

**Fig. 3.** Change of oral intake**Fig. 4.** Change of serum albumin**Fig. 5.** Change of serum cholesterol

and serum levels of albumin, cholesterol and cholinesterase were higher in group B than in

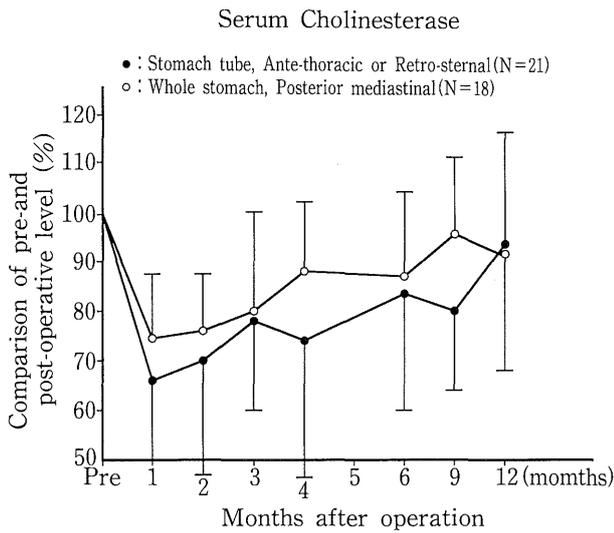


Fig. 6. Change of cholinesterase

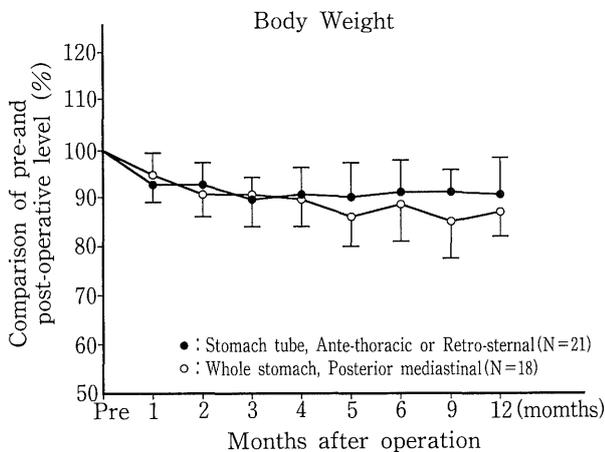


Fig. 7. Change of body weight

group A between one to 12 months. An amount of oral intake at one month and the level of serum albumin at 2,4,6 and 12 months revealed a significant difference. A change of body weight was similar (Figs. 3,4,5,6 and 7).

DISCUSSION

After the removal of the esophagus, the substitute should be selected from the viewpoint of the function, cure rate, safety and simplicity of the surgery. For benign esophageal disease, function is a matter of greatest importance with many authors preferring the colon. DeMeester et al⁴⁾ reported that the postprandial pressure sensation and early satiety which most patients with the intrathoracic stomach experience was less common. This is probably due to the remaining stomach being retained in the abdomen and the interposed colon providing an additional reservoir function. Miller et al¹²⁾ investigated the intraluminal pressure in the stomach, jejunum and colonic loops used to replace the esophagus. The authors found propagated pressure

waves in jejunal and colonic substitute when water was swallowed but no such contraction was seen in patients with stomach replacements.

Another disadvantage of using the stomach is the combination of duodenogastric reflux and poor gastric empty leading to gastric mucosal damage^{4,6,16)}. This relates to postprandial pressure and fullness with gastric substitutes. This was observed in 20.5% of patients in our study.

In malignant esophageal diseases, cure is most important. Akiyama and Tsurumaru²⁾ investigated the incidence of lymphatic metastasis of esophageal cancer patients in detail. They reported that when the tumor is located in the upper, middle and lower esophagus, 31.8%, 32.8% and 61.5% of patients demonstrated lymphatic metastasis in the superior gastric area, respectively. The frequency of metastasis in this area was the highest of every lymph node group. The superior gastric lymph nodes should, therefore, be dissected meticulously in each case. This is not always done with colonic substitute.

Curability using the stomach tube is superior to the whole stomach because the lymph nodes of the superior gastric area are resected completely. However we have not experienced lymph node recurrence in this area or that of the stomach wall in 56 cases, following meticulous lymph node dissection around the left gastric artery in the devascularized upper half of the whole stomach.

When the stomach is used as the substitute, most authors prefer a stomach tube. Baulieux and Maillet³⁾ propose four advantages. Firstly it straightens the greater curvature of the stomach and optimizes the length of the esophagoplasty. Secondly, it provides a well vascularized organ for forming the esophagoplasty. Thirdly, it allows removal of coronary lymph nodes, as well as the upper aspect of the lesser curvature which is often involved in the malignant process, and fourthly, it aids respiratory function by lowering the risk of gastric distention. This may be present if the whole stomach is placed in the chest.

Ikeda⁸⁾ constructed 4 types of stomach tube in dogs. The whole stomach and stomach tubes with 6, 3 and 1.5cm width measuring tissue blood flow 3cm oral from the uppermost pulsation of the right gastroepiploic artery. He concluded that the stomach tube of 3cm width showed the best blood flow. However, our angiogram data of the resected human stomachs, not shown in this paper, revealed a worse blood supply to the apex of the stomach tube than the devascularized upper half of the whole stomach although there was a small number of examinations. Actually, our data revealed the reduction of anastomotic leakage in patients to whom the whole stomach was used, presumably due to a better blood supply than in those with a stomach tube. Miyoshi¹³⁾ measured the tissue oxygen tension at the tip of stomach in dogs and

reported that ligation of both the right gastric and short gastric arteries reduced it to 53mmHg, whilst the resection of the lesser curvature reduced it greatly to 36mmHg from 62mmHg on average. The good communication of the left and right gastropiploic arteries did not contribute to the increase of the tissue oxygen tension. These data supported the justification for the devascularized upper half of the whole stomach. Moreover, the excess omentum may disturb the pulling up to the neck at the thoracic outlet in the posterior mediastinal route and a division of the short gastric arteries may reduce the risk of injury of the spleen to make the operative procedure easy.

The length of the stomach tube and whole stomach was similar. The whole stomach was long enough to be used for reconstruction to the cervical esophagus.

Baulieux and Maillet³⁾ referred to the respiratory dysfunction by gastric distention when the whole stomach is placed in the chest. In our study, lung complications occurred in 28.8% and 22.2% of patients in group A and group B, respectively. Postprandial dyspnea or tachycardia were not experienced by any of our patients. Some authors avoid the posterior mediastinal route because recurrence in the mediastinum may disturb oral intake. However, Orringer¹⁵⁾ found this in only one of 143 cases.

DeMeester et al⁴⁾ pointed out that dysphagia was the most common complaint when the stomach was used to replace the esophagus. In our study, 22 of 39 patients (56.4%) complained of a stenotic sensation in the neck, of whom 4 required dilatation. This may be related to decreased gastric motility or a rise in intragastric pressure of the vagotomized stomach¹²⁾. Garvin⁵⁾ reported that the reversed gastric tube, with its relatively smaller lumen, showed a complex range of increased pressure activities associated with swallowing, whereas the intrathoracic stomach did not respond to the swallow. In our study, the whole stomach showed a slightly higher incidence of postprandial fullness and nausea than the stomach tube group. This may be related to the difference in lumen size. Lam et al¹⁰⁾ noted atrophic gastritis of the intrathoracic stomach in 13 of 19 patients. The gastritis of the esophageal substitute may be due to the vagotomy, duodenogastric reflux and/or poor gastric emptying^{6,10,11)}. Differences in the degree of gastritis or motility of the substitute were not investigated in this study. Our study suggests that the whole stomach in the posterior mediastinum is superior to the gastric tube in some nutritional aspects and may be due to better oral intake. This might be simply due, also, to the larger size lumen of the substitute.

We conclude that the devascularized upper half of the whole stomach placed in the posterior mediastinum makes an excellent esophageal substitute

as regards function, curability, safety and simplicity.

(Received February 10, 1992)

(Accepted April 20, 1992)

REFERENCES

1. Akiyama, H., Tsurumaru, M., Watanabe, G., Ono, Y., Udagawa, H. and Suzuki, M. 1984. Development of Surgery for carcinoma of the esophagus. *Am. J. Surg.* **147**: 9-16.
2. Akiyama, H. and Tsurumaru, M. 1988. Basic principles of resectional therapy for cancer of the esophagus, p. 605-610. *In* G.G. Jamieson (ed.), *Surgery of the Esophagus*, Churchill Livingstone Inc., New York.
3. Baulieux, T. and Maillet, P. 1988. Combined abdominal and right thoracic approach for oesophagogastrectomy, p. 665-669. *In* G.G. Jamieson (ed.), *Surgery of the Esophagus*, Churchill Livingstone Inc., New York.
4. DeMeester, T.R., Johansson, K.E., Franze, I., Eypasch, E., Tailu, C., McGill, J.E. and Zaninotto, G. 1988. Indication, surgical technique, and long-term functional results of colon interposition or bypass. *Ann. Surg.* **208**: 460-474.
5. Garvin, P.G. and Kamiuski, D.L. 1980. Extrathoracic esophagectomy in the treatment of esophageal cancer. *Am. J. Surg.* **140**: 772-778.
6. Hinder, R.A. 1976. The effect of posture on the emptying of the intrathoracic vagotomized stomach. *Br. J. Surg.* **63**: 581-584.
7. Iizuka, T., Ide, H., Kakegawa, T., Sasaki, K., Takagi, I., Ando, N., Mori, S., Arimori, M. and Tsugane, S. 1988. Preoperative radioactive therapy for esophageal carcinoma -Randomized evaluation trial in eight institutes-. *Chest* **93**: 1054-1058.
8. Ikeda, M. 1983. Experimental studies on blood flow in the gastric tube for esophageal reconstruction. *Nippon Geka Gakkai Zasshi* **84**: 404-417. (Eng. Abstr.)
9. Japanese Society for Esophageal Diseases. 1976. Guide lines for the clinical and pathological studies on carcinoma of the esophagus. *Jap. J. Surg.* **6**: 69-78.
10. Lam, K.H., Lim, S.T.K., Wong, J., Lam, S.K. and Ong, G.B. 1979. Gastric histology and function in patients with intrathoracic stomach replacement after esophagectomy. *Surgery* **85**: 283-289.
11. Mannell, A., Hinder, R.A. and San-Garde, B.A. 1984. The thoracic stomach : a study of gastric emptying, bile reflux and mucosal change. *Br. J. Surg.* **71**: 438-441.
12. Miller, H., Lam, K.H. and Ong, G.B. 1975. Observation of pressure waves in stomach, jejunal and colonic loops used to replace the esophagus. *Surgery* **78**: 543-551.
13. Miyoshi, H. 1986. Experimental and clinical studies on the viability of stomach roll for esophageal reconstruction. *Nippon Geka Gakkai Zasshi* **87**: 499-509. (Eng. Abstr.)
14. Mori, S. and Nakayama, K. 1986. Esophageal carcinoma cases surviving for more than ten years in Japan. *Semin. Surg. Oncol.* **2**: 45-49.
15. Orringer, M.B. and Orringer, J.S. 1983.

- Esophagectomy without thoracotomy : a dangerous operation? J. Thorac. Cardiovasc. Surg. **85**: 72-80.
16. **Skinner, D.B. and Belsey, R.H.R.** 1967. Surgical management of esophageal reflux and hiatus hernia : long term results with 1030 patients. J. Thorac. Cardiovasc. Surg. **53**: 33-54.