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Microvascular Reconstruction of Free Jejunal Graft in Larynx-preserving Esophagectomy for Cervical Esophageal Carcinoma

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Background: Losing the ability to speak severely affects the quality of life, and patients who have undergone laryngectomy tend to become depressed, which may lead to social withdrawal. Recently, with advancements in chemoradiotherapy and with alternative perspectives on postoperative quality of life, larynx preservation has been pursued; however, the selection of candidates and the optimal reconstructive procedure remain controversial. In this study, we retrospectively reviewed our experience with free jejunal graft for larynx-preserving cervical esophagectomy (LPCE), focusing on microvascular reconstruction.

Methods: Seven patients underwent LPCE for cervical esophageal carcinoma, and defects were reconstructed by free jejunal transfer subsequently. We collected preoperative and postoperative data of the patients and assessed the importance of the procedure.

Results: We mostly used the transverse cervical artery as the recipient, and a longer operative time was required, particularly for the regrowth cases. The operative field for microvascular anastomosis was more limited and deeper than those in the laryngectomy cases. Two graft necrosis cases were confirmed at postoperative day 9 or 15, and vessels contralateral from the graft were chosen as recipients in both patients.

Conclusions: Microvascular reconstruction for free jejunal graft in LPCE differed in several ways from the procedure combined with laryngectomy. Compression from the tracheal cartilage to the pedicle was suspected as the reason of the necrosis clinically and pathologically. Therefore, we should select recipient vessels from the ipsilateral side of the graft, and careful and extended monitoring of the flap should be considered to make this procedure successful. *(Plast Reconstr Surg Glob Open 2016;4:e632; doi: 10.1097/GOX.0000000000000613; Published online 3 March 2016.)*

For the treatment of cervical esophageal carcinoma, laryngectomy, in addition to the esophageal carcinoma resection, has been considered to be necessary.[1] Laryngectomy is performed to obtain a safe upper surgical margin; however, if the larynx is preserved in patients with high-cervical esophageal carcinomas, the duration of intubation and the risk of fatal pneumonia increase because of persistent postoperative aspiration.[1,2] However, losing the ability to speak severely decreases postoperative quality of life. Danker et al[3] reported that half of the interviewed pa-

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tients rarely talked to their relatives or refused to go where they had to talk. Patients tend to become socially isolated and subjectively perceived poor speech quality, and depression may lead to social withdrawal.[3]

Surgical defects after esophagectomy are generally repaired by using a variety of methods, such as gastric pull-up, colon interposition, skin flaps, or a free jejunal graft.[4] For restoration of the voice after laryngectomy, esophageal speech and electrolaryngeal methods are common, and voice prosthetics have recently been shown to provide better quality of voice.[5] However, even with recent advancements in voice restoration methods, substitute speech by itself still has lower intelligibility.[6,7]

With advancements in chemoradiotherapy (CRT), including induction chemotherapy, and alternative perspectives on postoperative quality of life, larynx preservation has been pursued recently[8–10]; however, the selection of candidates and the optimal reconstructive procedure remain controversial.[2]

Although patients with cervical esophageal carcinoma are treated with both laryngectomy and esophagectomy, poor prognoses have been reported, and similar survival rates have been reported in patients who underwent cervical esophagectomy regardless of whether laryngectomy was performed.[11,12] Therefore, if preservation of the larynx is possible without decreasing the survival rate, postoperative quality of life would be improved.[13]

Recently, Kadota et al[2] reported that using free jejunal grafts for the reconstruction of larynx-preserving cervical esophagectomy (LPCE) enabled them to obtain acceptable results even in high-cervical esophageal carcinomas involving the hypopharynx. However, this approach has not been commonly used for high-cervical esophageal carcinomas, and we considered that microvascular reconstruction, which is an important factor for achieving successful free jejunal transfer, in LPCE is slightly different from what we experience in esophagectomy with laryngectomy.

In this study, we reviewed our experience with 7 patients who underwent free jejunal transfer for LPCE and described the difficulties or pitfalls to perform microvascular reconstruction for free jejunal graft in LPCE.

PATIENTS AND METHODS

LPCE was performed in 7 patients who had cervical esophageal carcinomas; all were men of age ranging from 46 to 83 years (Table 1). Three of the patients were local regrowth cases after CRT that included 60 or 66 Gy of radiation therapy as primary treatment; if the patient had no history of CRT, radiation therapy was used as a preoperative treatment except in 1 case. The indication of LPCE was decided based on the following criteria: the proximal extent of tumor invasion was more than 16 to 18 cm from the incisor tooth line, trachea was not invaded by the tumor and could be separated from esophagus, and if the patient wished to preserve their voice or refused laryngectomy.

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Surgical Procedure

The esophagectomy (extirpation of the tumor) and cervical lymph node dissection were performed by an esophageal surgeon. After completion of the dissection, the recipient vessels for microsurgical anastomosis were selected by a plastic surgeon for evaluation of their diameter, pulsation, and softness. The effect of preoperative radiation or clinical course was also considered for the selection of the vessels. Then, a section of the jejunum was harvested with an appropriate vessel (mostly secondary jejunal vessels). Pharyngojejunostomy was performed using layer-to-layer anastomosis technique; however, incompatibilities of caliber were addressed by longitudinal incision of the jejunum or side-to-side anastomosis. The anal side of the jejunal conduit was then trimmed so that the jejunal graft would be pulled straight with moderate tension after complete enteric anastomosis, and jejunoesophagostomy was performed using layer-to-layer anastomosis technique.

After finishing the jejunal suture, vessels were prepared for microvascular anastomosis. First, the recipient artery was exposed to allow it to reach the donor artery (jejunal artery). Transverse cervical artery was mostly selected as a recipient artery, and by distally dissecting and transecting it around the side of the neck, we could obtain sufficient length for anastomosis. After exposing 1 round of the internal jugular vein and creating a certain space between the jugular vein and the vagus nerve, we flipped the transverse cervical artery and passed it through the space we had created to make it easily accessible to the donor artery. Then, the recipient vein was prepared (mostly the internal jugular vein); however, if the recipient vein could not reach the donor vein, the donor vein (jejunal vein) was separated from the artery, and some arc was created to enable it to reach the recipient vein.

Microvascular anastomosis was performed under an operative microscope (end to end for arteries and end to side for veins). The operative field for microvascular anastomosis was narrow and deep, and an

Table 1. Patient Status, Condition, Operation Time, and Complications

Subject	Age (y)	History	TNM	Primary/ Recurrence	CRT	Recipient Artery	Recipient Vein	Microvascular Anastomosis (min)	Oral Intake (POD)	Secondary Tracheal Intubation	Complications (Graft)	Complications (Systemic)
1	50 (M)	HU	T2N1M0	Primary	Preoperative (60 Gy)	TC	IJ (ETS)	175	14			
2	63 (M)	HT	T3N1M0	Recurrence	Half year earlier (66 Gy)	TC	IJ (ETS)	130	11			
3	63 (M)	None		Recurrence	1 y 4 mo earlier (60 Gy)	ST	IJ (ETS)	154	33	Yes; tracheotomy on POD1	Bowel anastomosis leakage	
4	83 (M)	HT, HU, BPH	T2N0M0	Primary	Preoperative (40 Gy)	TC	IJ (ETS)	96	14			Lymphorrhea
5	59 (M)	None	T3N0M0	Primary	Preoperative (40 Gy)	TC	IJ (ETS)	106	11	Yes; POD2		Lymphorrhea; temporary cardiac arrest (POD2)
6	75 (M)	AMI (27 y ago)	T2N0M0	Primary	None	TC	IJ (ETS)	55		Yes; POD3	Graft necrosis POD9	Hypotension after secondary intubation (required dopamine)
7	46 (M)	None	T1N0M0	Recurrence	1 y 4 m earlier (60 Gy)	TC	EJ (ETE)	93	30	Yes; POD1	Graft necrosis POD15	Postural hypotension (POD4)

AMI, acute myocardial infarction; BPH, benign prostatic hypertrophy; EJ, external jugular vein; ETE, end-to-end anastomosis; ETS, end-to-side anastomosis; HU, hyperuricemia; HT, hypertension; IJ, internal jugular vein; M, male; POD, postoperative day; ST, superior thyroid artery; TC, transverse cervical artery; TNM, tumor, node, and metastases.

initial setting for anastomosis, such as the position of the microscope or forearm, is important for successful vascular reconstruction. After making anastomosis, the revascularization of the graft was checked by monitoring the color recovery and jejunal bowel movement. If laryngectomy was performed, it was easy to monitor vascularization of the jejunal graft through a skin-slit window just above the graft; however, if the larynx was preserved, the graft was located below the larynx, and it was difficult to observe through the slit. We monitored the flap by using Doppler ultrasound for arterial anastomosis and endoscopy to check the color of the graft.

We collected the data on patient status, selected vessels for recipient, operative time, and postoperative complications.

RESULTS

We mostly used the transverse cervical artery (85%, 6 of 7 cases) as the recipient artery and chose the internal jugular vein in 6 cases (86%) as the recipient vein (Table 1).

The average operative time required for preparation and anastomosis for microvascular reconstruction was 115 minutes, and the average operative time for jejunal anastomosis was 138 minutes. Both vascular and jejunal anastomosis required longer times in the regrowth cases (Table 2).

The operative field for microvascular anastomosis tends to be more limited and deeper than those in the cases with laryngectomy (Fig. 1). Gentle manipulation was required in deep limited space, and it was even more difficult in the recurrent cases after CRT, because all vessels were fibrotic and stiff.

With respect to complications, 4 (57%) cases had dyspnea mainly because of postoperative laryngeal edema and required secondary tracheal intubation at 1 to 3 days after the surgery. One patient required tracheotomy, and another patient experienced cardiac arrest but recovered within a few minutes. One patient experienced minor jejunal anastomotic leakage, and 2 other patients developed lymphorrhea; however, all patients were treated conservatively (Table 1).

Necrosis of the graft was seen in 2 patients and was confirmed at postoperative day 9 or 15. One patient had an episode of dropping blood pressure at the time of secondary tracheal intubation and required administration of continuous dopamine drip, and total ischemic time of the graft for this patient was 195 minutes, which was the shortest ischemic time among our series. However, in both patients, the condition of the recipient vessels was better at the contralateral side of the grafted jeju-

Table 2. Operative Time (Primary N = 4, Recurrence N = 3)

	Primary (min)	Regrowth (min)	Average (min)
Microvascular anastomosis time	108±24.9	125±17.7	115
Jejunal anastomosis time	133±11.2	144±11.3	138

nal vessel, and the vascular pedicle needed to cross behind the larynx (Fig. 2). After detecting necrosis of the graft, 1 patient underwent reconstruction by gastric pull-up with the removal of the esophagus and preservation of the larynx. However, in another patient, laryngectomy was performed, and the defect was reconstructed by performing a newly harvested free jejunal graft. When we performed laryngectomy, the mesentery from the transferred jejunal vessel was compressed with the posterior surface of the tracheal cartilage, and the mesentery at the anastomosis side became edematous (Fig. 3). Pathological findings showed that the grafted jejunal and mesentery vessels located just behind the tracheal cartilage were completely necrotized (Fig. 4). In contrast, the distal mesentery vessel that was close to the anastomosis did not undergo necrosis, and the vessels around this area were expanded (Fig. 4).

Six patients could begin oral intake from 11 to 14 postoperative days after evaluating the condition of the jejunal anastomosis, and even 1 patient who experienced minor anastomotic leakage was able to start oral intake 1 month after the operation. None of the patients experienced aspiration pneumonia after starting oral intake, and most of them were discharged within 2 to 3 weeks.

DISCUSSION

We reviewed our experience with microvascular reconstruction for free jejunal graft for LPCE and noted several differences from the procedure combined with laryngectomy.

In the esophageal operation, a variety of methods are used to reconstruct defects after esophagectomy,[4] and among these methods, the gastric pull-up and jejunal graft, which have often been compared with each other, are preferred.[4,14] The advantages of gastric pull-up are that a single intestinal anastomosis, secure vascularity, and sufficient margins can be obtained even for carcinomas in the thoracic esophagus because the entire esophagus is removed.[2] However, fatal cardiopulmonary complications because of manipulation of the mediastinum and loss of lower esophageal sphincter function that may result in persistent aspiration pneumonia in larynx-preserving cases because of reflux of digestive fluid are the disadvantages.[14–16]

Conversely, free jejunal graft requires 2 intestinal anastomoses in the neck, and laparotomy is required for harvesting the graft. However, it could be less invasive than mediastinum manipulation, and the graft can be safely harvested even in older patients or patients who have undergone abdominal surgery.[17] Free jejunal graft can also provide favorable passage of food because of its self-lubricating surface and not only preserves the function of the lower esophageal sphincter[2] but also works as a valve to prevent digestive fluid from gastroesophageal reflux.[16] Those factors can reduce postoperative complications, especially for larynx-preserving surgery[4,13]; thus, free jejunal graft would be more appropriate reconstruction in these cases.

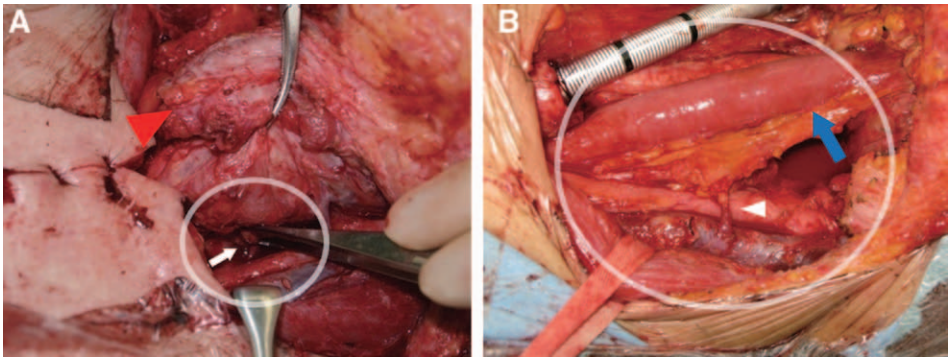

Fig. 1. The operative field for microvascular anastomosis in free jejunal transfer (white circle: operative field). A, Larynx-preserving case (red triangle: preserved larynx; white arrow: arterial anastomosis). The operative field tends to be limited and deep in the larynx-preserving cases. The transferred jejunal graft is located behind the preserved larynx (white arrow); it is difficult to monitor directly from the skin slit. B, Laryngectomy case (blue arrow: jejunal graft; white triangle: venous anastomosis). A wide operative field is maintained for jejunal transfer, and it is easy to monitor the graft directly through the skin slit.

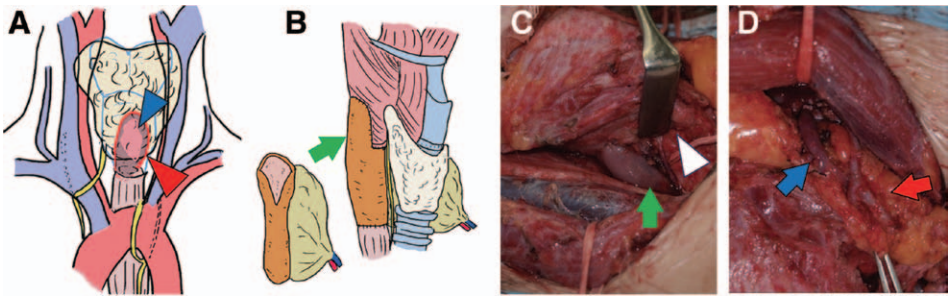

Fig. 2. Schematic description and intraoperative pictures of case 7. A, Schematic description of the tumor (blue triangle: tumor; red arrow: the field of excision). The tumor is mainly located at the posterior wall of the hypopharynx. B, Schematic description of the surgery. Pharyngojejunostomy was performed by incising the oral side of the jejunum longitudinally to adjust the caliber. The mesentery, including the pedicle, crossed behind the tracheal cartilage. C, Intraoperative view from the right side (green arrow: jejunal graft; white triangle: preserved larynx). D, Intraoperative view from the left side (red arrow: arterial anastomosis; blue arrow: venous anastomosis). The left transverse cervical artery and external jugular vein were anastomosed with the jejunal artery and vein in an end-to-end fashion. The graft was on the contralateral side, and it cannot be seen from this side.

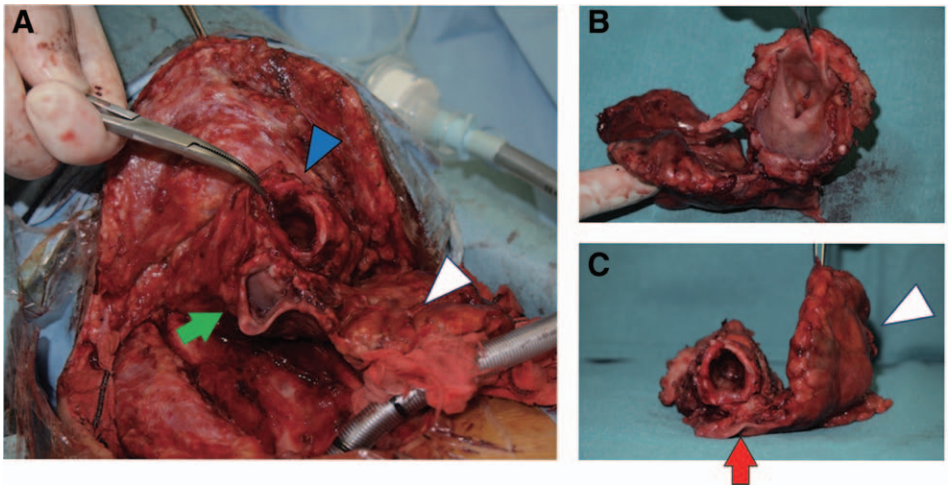

Fig. 3. Clinical findings of a necrotic transferred jejunum. A, Intraoperative picture at reoperation in case 7 (blue triangle: tracheal cartilage; green arrow: necrosis jejunum; white triangle: the mesentery). We performed laryngectomy during the reoperation and checked the condition of the transferred jejunum. The mesentery from the transferred jejunal vessel is compressed with the posterior surface of the tracheal cartilage and is edematous. B, Removed larynx and the graft from the oral side. C, Removed larynx and the graft from the caudal side (red arrow: compression point; white triangle: edematous mesentery).

One main concern regarding free jejunal graft is that microvascular reconstruction is required. Greater than 95% success rates for microsurgical anastomosis in head and neck reconstruction have been reported recently[18]; however, the situation would be different if preoperative radiation was performed or if the operation is a salvage procedure because of local regrowth.

In this study, we reviewed our experience with free jejunal graft in LPCE. In fact, we performed free jejunal graft for the treatment of defects of esophagectomy with laryngectomy in 25 other patients during the same period (Table 3). We selected the transverse cervical artery in 64% (16/25) of the cases and the superior thyroid artery in 28% (7/25) of the cases. In contrast, the transverse cervical artery was mostly chosen as the recipient vessel in larynx-preserving cases (86%). The rate of CRT has been higher in larynx-preserving cases (larynx-preserving cases, 86%; laryngectomy, 64%), and this may affect the choice of the vessel because we tend to select the vessels that are less affected by the radiation.

The average operative time of preparation and anastomosis for microvascular reconstruction was

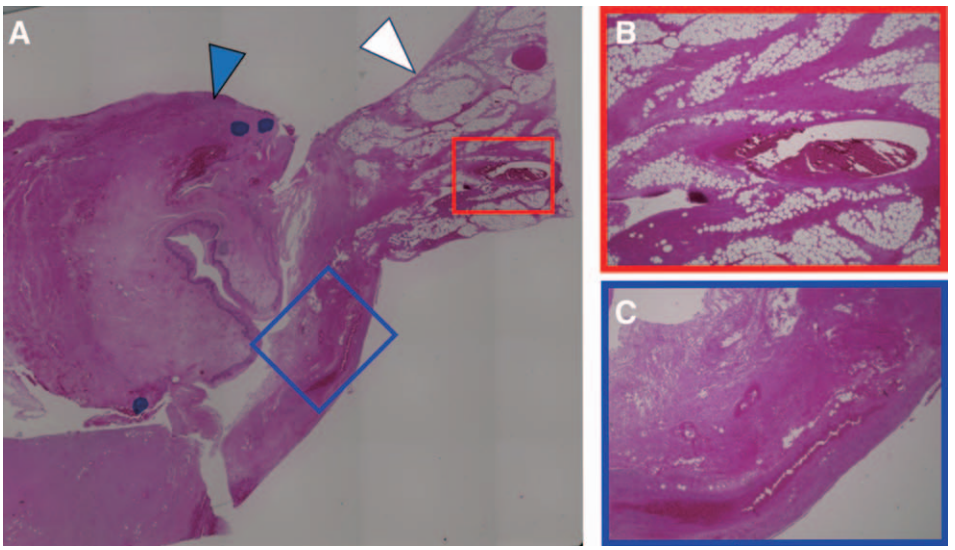

Fig. 4. Pathological findings. A, Low-magnification image of a removed transferred graft and trachea [blue triangle: tracheal cartilage; white triangle: the mesentery; red square (B); blue square (C)]. B, High-magnification image of the distal mesentery. The vessel around this area is expanded, and the area is edematous but not necrotic. C, High-magnification image of the mesentery just behind the tracheal cartilage. The whole mesentery is completely necrotized.

115 minutes in the larynx-preserving cases, which was not different from that in the laryngectomy cases. However, the operative field for microvascular anastomosis tends to be more limited and deeper in the larynx-preserving cases (Fig. 1). The regrowth cases required more time than did the primary cases, and fibrosis, adhesion, or lack of vessel extension because of secondary procedures or preoperative radiation could increase the time. Therefore, the larynx-preserving cases were judged to be technically more difficult, particularly in regrowth cases, and gentle manipulation and cautious selection of the recipient vessels were important because finding alternative vessels could be challenging in a limited field.

Jejunal anastomosis was also difficult in the larynx-preserving cases, and we performed jejunal anastomosis before microvascular anastomosis because microvascular anastomosis would not only have restricted the position of the graft in limited

Table 3. Side-by-Side Comparison Between Larynx-preserved Patients and Laryngectomy Patients

	Larynx-preserved (7 cases)	Laryngectomy (25 cases)
Age (y), mean	63.0 y (male, 7)	66.8 y (male, 20; female, 5)
Extension of the tumor (TNM classification)	T1: 1 case T2: 3 cases T3: 2 cases Unknown: 1 case	T1: 3 cases T2: 1 case T3: 7 cases T4: 10 cases
Primary/recurrence	Primary: 4 cases Recurrence: 3 cases	Primary: 17 cases Recurrence: 8 cases
CRT	Definitive CRT: 3 cases Preoperative CRT: 3 cases None: 1 case	Definitive CRT: 8 cases Preoperative CRT: 8 cases None: 9 cases
Recipient artery (anastomosis)	TC (ETE): 6 cases ST (ETE): 1 case	TC (ETE): 16 cases ST (ETE): 7 cases IT (ETE): 2 cases
Recipient vein (anastomosis)	IJ (ETS): 6 cases EJ (ETE): 1 case	IJ (ETS): 22 cases Branch of IJ (ETE): 1 case EJ (ETE): 2 cases
Complication (postoperation)	Laryngeal edema: 4 cases Lymphorrhea: 2 cases Anastomotic leakage: 1 cases	Subcutaneous abscess: 3 cases Skin necrosis, fistula: 3 cases Anastomotic leakage: 2 cases
Graft necrosis	2 cases	2 cases

EJ, external jugular vein; ETE, end-to-end anastomosis; ETS, end-to-side anastomosis; IJ, internal jugular vein; IT, inferior thyroid artery; ST, superior thyroid artery; TC, transverse cervical artery; TNM, tumor, node, and metastases.

space but also cause peristalsis and bleeding from the graft. Sometimes, an unusual anastomosis, such as a side-to-side procedure, was required for pharyngojejunostomy, which sometimes makes the jejunal anastomosis even more difficult. Therefore, the graft ischemic time became longer in the larynx-preserving cases, and it would be significant in the recurrence cases.

Sarukawa et al[19] reported that the tentative total time for ischemic jejunal graft should be 180 minutes, and the time could cause postoperative complications such as jejunal anastomosis leakage or bowel stenosis. If the ischemic time was >4 hours, necrosis of membranes or muscularis could occur. In our study fortunately, no patients experienced postoperative bowel stenosis, and 1 patient experienced minor leakage in the early postoperative period. However, the ischemic time was almost beyond the limit in our series (for 3 patients, the ischemic time was less than 4 hours; however, in 4 cases, it was more than 4 hours); therefore, it needs to be reduced by performing microvascular anastomosis after finishing 1 side of the bowel anastomosis, or alternatively, larynx preservation should be reconsidered in cases that may involve a long ischemic time, such as in regrowth cases.

Graft necrosis occurred in 2 patients in the larynx-preservation group, and 1 of them was the case whose ischemic time was shortest among our series. However, in both patients, vascular anastomosis was performed on the contralateral side from the jejunal graft with crossing of the pedicle behind the larynx. In our series of free jejunal graft with laryngectomy, we experienced 2 cases of graft necrosis of 25 cases; however, 1 of them involved local infection caused by bowel anastomosis leakage 3 weeks postoperatively and was not related to the problems associated with microvascular anastomosis. Böttger et al[4] reported that compression caused thrombosis of the jejunal graft and recommended that surgeons should avoid skin tension or circumferential dressing as much as possible even in laryngectomy cases. Our necrotic graft in a larynx-preserving case clinically showed compression of the mesentery from the transferred jejunal caused by the tracheal cartilage. Pathological findings also suggested compression because total necrosis was observed in the transferred jejunal and mesentery located just behind the tracheal cartilage, and the distal mesentery showed expanded vessels without necrosis.

These observations imply that the mesentery behind the tracheal cartilage became edematous postoperatively, induced further compression, and gradually led to necrosis of the transferred jejunal.

In addition, nonocclusive mesenteric ischemia has been recently reported to be a cause of free jejunal graft necrosis without evidence of thrombosis into the vessels.[20] This ischemia is generally associated with hemodialysis[21] and cardiac or major aortic surgery[22]; however, Onoda et al[20] reported 2 cases of free jejunal necrosis that had episodes of preshock within a few postoperative days and subsequently developed necrosis of the graft a few days later. Both of our patients who showed necrosis developed low blood pressure after secondary tracheal intubation, and 1 required dopamine support for several days. Necrosis of the graft was obvious at postoperative day 9 or 15, and the aforementioned factors may have been related to the necrosis.

Therefore, more careful monitoring of the graft would be required in larynx-preserving cases. Several methods of monitoring buried grafts have been used, such as monitoring jejunal flap,[23,24] implanted devices, including laser Doppler,[25] or tonometry for measuring intramucosal pHi.[26] Each method has some risks or drawbacks, for example, false-positive results, monitor displacement, or device-handling difficulties.[27,28] However, a method that can evaluate a longer postoperative period than that in the laryngectomy cases seem to be necessary; therefore, we need to consider suitable monitoring methods in the future.

We also think that recipient vessels should be limited to the ipsilateral side of the graft to avoid compression from the tracheal cartilage, and complete preparation of the recipient vessels before the bowel anastomosis would make the procedure smoother and faster; as a result, it can reduce the ischemic time of the graft.

Finally, the long persistent postoperative laryngeal edema and requirement of secondary tracheal intubation are also problems associated with this procedure. Considering all of these factors, the indication and management for LPCE should be carefully decided, particularly in regrowth cases for which the procedure may become complicated and the graft ischemic time increases beyond the limit.

CONCLUSIONS

We reviewed our experience with microvascular reconstruction for free jejunal graft in LPCE. We more often chose the transverse cervical artery as the recipient artery, and the operative field for microvascular anastomosis tends to be limited, which is thought to increase the technical difficulty, particularly in regrowth cases. We experienced graft necrosis in 2 patients who underwent larynx preservation, and the vessels contralateral from the graft had been chosen as the recipients. Compression from the tracheal cartilage to the pedicle was suspected as the reason of the necrosis; therefore, recipient vessels

should be chosen from the ipsilateral side of the graft, and careful and extended monitoring of the flap and rearrangement of the surgical process to reduce the graft ischemic time should be considered to make this procedure more secure.

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