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CURRENT TOPICS REVIEW ARTICLE

Reconstruction after esophagectomy for esophageal cancer patients with a history of gastrectomy

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Abstract Pedicled jejunal flap and colon graft interposition are choices for esophageal reconstruction in patients with a history of gastrectomy or those who have undergone synchronous esophagogastrectomy. However, the optimal conduit in this situation is still being debated. We reviewed the literature concerning esophageal reconstruction using a conduit other than the stomach. Approximately 10 % of esophagectomized patients undergo esophageal reconstruction using pedicled jejunum or colon interposition in Japan. The jejunal graft and colon graft are selected evenly, although the percentage of jejunal graft use is gradually increasing. Microvascular supercharge was performed in most of the reports of pedicled jejunal graft reconstruction, whereas vascular enhancement was not popularly used in the reports of colon graft interposition. Although the incidences of graft loss and anastomotic leakage were comparable between grafts, mortality rates seem to be higher in patients who undergo colon graft reconstruction than in those who undergo reconstruction with a jejunal graft. Prospective comparisons of short-term outcomes as well as long-term quality of life are needed to identify the best method of reconstruction.

Keywords Esophageal reconstruction · Pedicled jejunum · Colon interposition

Introduction

Synchronous or metachronous occurrence of gastric cancer is frequently observed in esophageal cancer patients. A recent report of the nationwide registry in Japan revealed that synchronous occurrence of gastric cancer was observed in 4.3 % of esophageal cancer patients treated in 2007 [1]. In addition, 3.1 % of esophageal cancer patients in this registry had a history of treatment for gastric cancer prior to the diagnosis of esophageal cancer [1]. In relation, peptic ulcer used to be a common disease in Japan because of the high incidence of *Helicobacter pylori* (HP) infection. Until eradication therapy for HP dramatically decreased the recurrence rate of peptic ulcer, gastrectomy was the standard treatment for perforated peptic ulcers.

Pedicled jejunum and colon graft interposition are choices for esophageal reconstruction in patients after gastrectomy or for those who undergo synchronous esophagogastrectomy. In Japan, every year for two decades, approximately 10 % of patients have undergone esophageal reconstruction after oncologic esophagectomy using conduits other than the stomach [1–11]. Although colon interposition was selected for 60 % of these patients in the late 1980 s, the use of the pedicled jejunal graft has been gradually increasing and has recently reached more than 50 % [1–11] (Fig. 1). However, the optimal conduit for patients who undergo esophagectomy and have a history of gastrectomy or for those who undergo synchronous esophagogastrectomy is still being debated. In this article, we reviewed the literature concerning esophageal reconstruction using a conduit other than the stomach.

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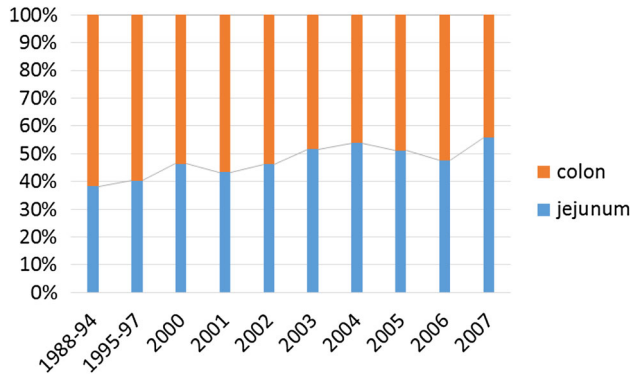

Fig. 1 Trend of the reconstructive organ other than the gastric conduit used for esophageal reconstruction. Data were obtained from references 1–11

Esophageal reconstruction using a pedicled jejunal graft

There are three main patterns of reconstruction using a pedicled jejunal graft depending on the extent of esophagectomy (Fig. 2). After a lower esophagectomy, Roux-en-Y reconstruction with anastomosis between the mid-esophagus and jejunum is performed. Usually, a cut of the second jejunal vessels is sufficient to elongate the graft. After a subtotal esophagectomy, an intrathoracic anastomosis between the upper esophagus and elongated jejunal graft can be selected [12]. In this case, transections of the second and third jejunal vessels are usually needed. Alternatively, cervical anastomosis between the cervical esophagus along with the elongated jejunal graft being pulled-up through the subcutaneous or retrosternal route can be performed. With this method, a longer graft should be created and transections of the second and third jejunal vessels, occasionally with fourth jejunal vessels, are needed. Microvascular anastomosis between the jejunal branches and the internal thoracic vessels or cervical vessels (supercharge) is frequently used in this type of reconstruction [13].

Esophageal reconstruction with colon interposition

The colon has been used to replace the esophagus since 1911 [14]. There are two main types of grafts traditionally used for esophageal reconstruction (Fig. 3). The right colon graft is created using the middle colic vessels as a pedicle; this usually involves dividing the right colic and ileocolic vessels. A segment from the terminal ileum to the ascending colon is interposed isoperistaltically. A left colon graft is created using the ascending branch of the left colic artery and the inferior mesenteric vein as a pedicle. The middle colic vessels are divided, preserving the communication between the right and left branches of these vessels. A segment from the transverse colon to the splenic flexure is used for interposition in an isoperistaltic fashion. An alternative to these traditional grafts is the ileocolic graft, which uses the ileocolic vessels as a pedicle [15]. Reconstruction with this graft is very similar to that using a right colon graft, but it uses a longer segment of the terminal ileum than the right colon graft does.

Advantages and disadvantages of right and left colon grafts are summarized in Table 1. Because the Bauhin valve prevents regurgitation, reflux esophagitis seldom occurs after reconstruction using a right colon graft. Due to the large caliber of the cecum, a reservoir-like capacity may exist. Anastomosis between the terminal ileum and cervical esophagus is easy because their diameters are very similar. However, unstable blood vessel communication around the ileocecal region is a major problem when using a right colon graft, and ischemia or congestion is occasionally observed in the terminal ileum of the graft. The

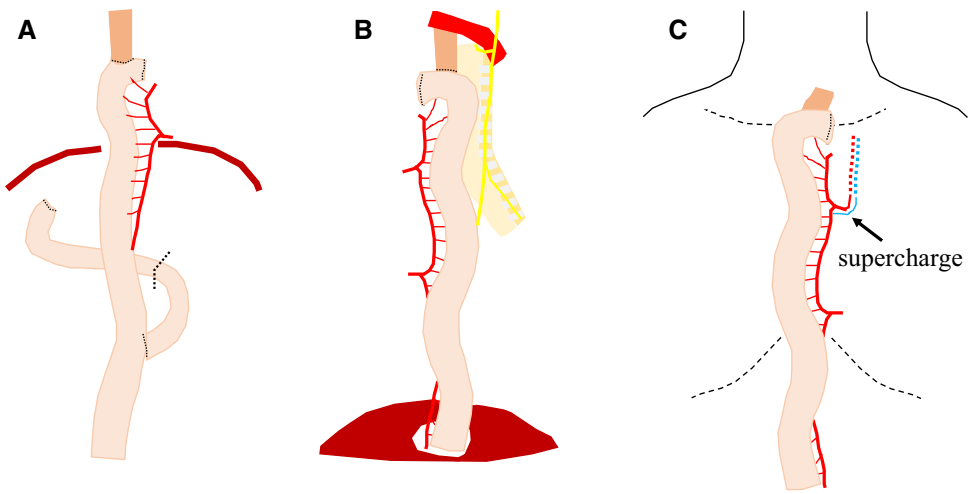

Fig. 2 Esophageal reconstruction using a pedicled jejunal flap. **a** Roux-en-Y reconstruction with anastomosis between the middle esophagus and pedicled jejunum. **b** Intrathoracic anastomosis with upper esophagus and elongated pedicled jejunum. **c** Cervical anastomosis using supercharged jejunal pedicle

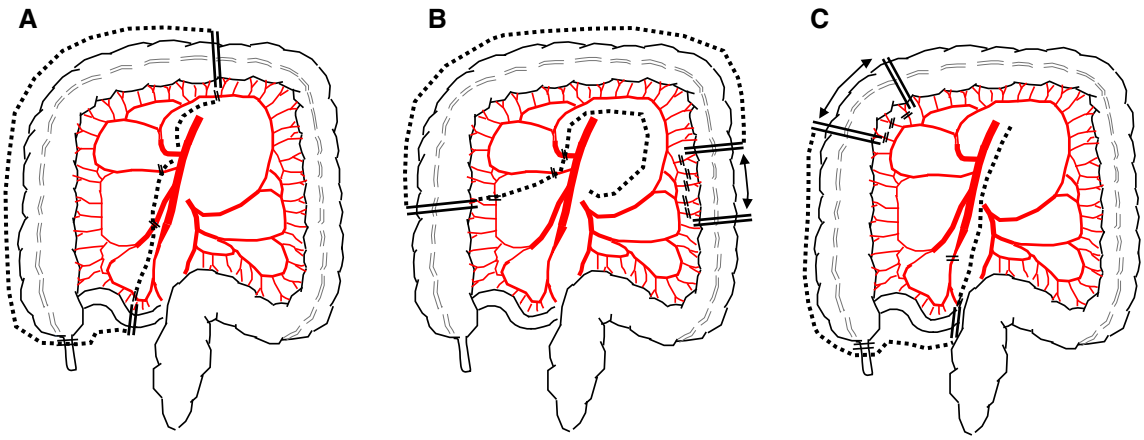

Fig. 3 Grafts for colon interposition. **a** Right colon graft using middle colic vessels as a pedicle. **b** Left colon graft using left colic artery and inferior mesenteric vein as a pedicle. **c** Ileocolon graft using ileocolic vessels as a pedicle. ↔ Intestinal resection for elongating the mesocolon

Table 1 Advantages and disadvantages of right and left colon grafts

	Right colon graft	Left colon graft
Advantages	Bauhin valve prevents regurgitation	More reliable blood supply
	Reservoir-like capacity of the cecum	Adequate length for reconstruction
	Close match in the diameters of the esophagus and the ileum	Smaller diameter
Disadvantages	High variation in blood vessels	Possible atherosclerosis of the inferior mesenteric artery
	Larger diameter	More frequent regurgitation

large caliber of the cecum may disturb the pulling-up process through the mediastinal or retrosternal route. The left colon graft has a more reliable blood supply than the right one, mainly because the left colic artery is almost always exist, whereas the right colic artery is absent in up to 20 % of individuals [16]. In addition, although two collateral networks including the marginal artery of Drummond and the meandering mesenteric artery clearly exist between the middle colic and left colic artery [17], the collateral circulation between the middle colic and right colic artery is not constant [16]. When using the left colon graft, we can create a long segment graft from the root of the left colic vessels to the territory of the middle colic vessels. Meanwhile, the length of right colon graft is limited due to dense mesenteric arcade of the terminal ileum. The pulling-up process of the left colon graft is easier than that for the right colon graft because of the smaller diameter of the transverse colon. A major problem of the left colon graft is that the inferior mesenteric artery is sometimes affected by atherosclerosis. Occlusion or impaired blood flow of this artery may cause graft ischemia. Regurgitation after reconstruction using a left colon graft occurs more frequently than after right colon graft reconstruction because there is no backflow prevention provided by the Bauhin valve.

Advantages of the ileocolic graft are very similar to those of the right colon graft. The ileocolic graft has a more abundant blood supply than the right colon graft, but the graft length is restricted by the length of ileocolic mesentery.

Advantages and disadvantages of jejunal and colon grafts

Advantages and disadvantages of jejunal and colon grafts are summarized in Table 2. Only two intestinal anastomoses are needed for jejunal graft reconstruction, whereas three or four intestinal anastomoses are required for colon reconstruction. Vigorous peristalsis of the jejunum enables comfortable food intake and prevents regurgitation. Malignancies are rarely observed in the jejunum. However, the length of the jejunal graft is restricted by mesenteric arcade, and making a long segment of jejunal graft may cause ischemia. Therefore, supercharge is frequently performed for this type of reconstruction to augment blood flow. There is no reservoir in a pedicled jejunal graft reconstruction. A major advantage of the colon graft compared to the jejunal graft is that a long graft is available. Colon graft interposition can replace the defect after

Table 2 Advantages and disadvantages of pedicled jejunal flap and colon graft interposition

	Jejunal graft	Colon graft
Advantages	Fewer anastomoses	Long graft is available
	(only 2 anastomoses are needed)	Less reflux
	Vigorous peristalsis	Reservoir-like capacity
	Rare malignancies	
Disadvantages	Graft length is restricted by mesenteric arcade	Variation of mesenteric vessels may cause ischemia
	No reservoir	Complicated procedures
	Ischemia or congestion may occur in a long graft	(3 or 4 anastomoses are needed)
		Polyps or cancers are sometimes observed

pharyngolaryngectomy with total esophagectomy. However, frequent variation in mesenteric vessels and lack of communication around the ileocecal area in particular may cause graft ischemia. Because polyps and malignancies are frequently observed in the colon, colonoscopic evaluation is strongly recommended before using a colon graft.

Outcomes of esophageal reconstruction using a pedicled jejunal or colon graft

The outcomes of esophageal reconstruction with a pedicled jejunal flap [12, 18–26] and colon interposition [15, 22, 27–38] are summarized in Tables 3 and 4, respectively. All the reports of outcomes of using a pedicled jejunal flap were published after 2000, and many of them were case series of esophageal reconstruction with a supercharged jejunal flap. This corresponds to the increasing trend of reconstruction using the jejunal graft after 2000, as shown in Fig. 1. The supercharged jejunal grafts are pulled-up through the retrosternal or subcutaneous route. In this review, references regarding reconstruction with colon interposition were limited to those involving patients who underwent oncologic esophagectomy and that were published after 2000 to enable comparisons between the outcomes of both reconstructive methods. Although supercharge was not usually performed with colon graft interposition, the incidences of graft loss and anastomotic leakage were comparable between both grafts. However, mortality rates seem to be higher in patients who underwent colon graft reconstruction than in those who underwent reconstruction with the jejunal graft. There is, of course, no conclusive evidence because there is no randomized controlled study comparing the outcomes of both grafts. However, the complicated surgical procedures, which may prolong operation time and increase intraoperative blood loss, and abundant bacterial flora may influence the increased mortality after colon graft reconstruction.

The indication for vascular supercharge depended on the institutes or surgeons and there are few reports elucidating the recommendation for adding the vascular anastomosis. Recently, several authors have reported the usefulness of indocyanine green fluorescence imaging for assessment of perfusion of the gastric conduit for esophageal reconstruction [39, 40]. The intraoperative evaluation technique for

Table 3 Outcomes of pedicled jejunal flap reconstruction

Authors and references	Year of publication	No. of cases	Route (major)	Supercharge	Mortality (%)	Leak (%)	Graft loss (%)
Ninomiya et al. [12]	2014	13	IT	Not performed	0	0	0
Iwata et al. [16]	2012	27	SC	Performed	0	7.4	0
Blackmon et al. [17]	2012	60	RS	Performed	5.0	32.7	8.3
Poh et al. [18]	2011	51	RS	Performed	0	19.6	5.9
Barzin et al. [19]	2011	5	RS	Performed	NR	20.0	0
Doki et al. [20]	2008	25	SC	Performed	0	24.0	NR
Ueda et al. [21]	2007	27	SC	Performed	0	11.1	NR
Ascioti et al. [22]	2005	26	RS	Performed	0	19.2	7.7
Chana et al. [23]	2002	11	SC	Performed	NR	36.4	0
Maier et al. [24]	2002	35	RS	Not performed	5.7	11.4	0

IT intrathoracic anastomosis, *SC* subcutaneous route, *RS* retrosternal route, *NR* not reported

Table 4 Outcomes of reconstruction with colon graft interposition

Authors and references	Year of publication	No. of cases	Segment (major)	Route (major)	Supercharge (major)	Mortality (%)	Leak (%)	Graft loss (%)
Kesler et al. [24]	2013	11	Right	RS	Performed	9	9	NR
Saeki et al. [25]	2013	21	Right	SC	Performed	0	23.8	0
Hamai et al. [26]	2012	40	Right	PM	Not performed	2.5	17.5	5.0
Klink et al. [27]	2010	43	Left	PM	Not performed	16.3	30.2	9.3
Mine et al. [28]	2009	95	Right	RS	Not performed	5.3	12.6	0
Kawano et al. [14]	2009	22	Ileocolon	SC	Not performed	4.5	18.2	0
Doki et al. [19]	2008	28	Right	SC	Performed	0	46.4	0
Motoyama et al. [29]	2007	34	Right	RS	Not performed	0	8.8	0
Shirakawa et al. [30]	2006	51	Right	SC	Performed	0	7.8	0
Briel et al. [31]	2004	163	NR	NR	Not performed	3.5	6.1	NR
Davis et al. [32]	2003	42	Right	SC	Not performed	16.7	14.3	2.4
Fürst et al. [33]	2001	53	Left	NR	Not performed	9.4	12	3.8
Hagen et al. [34]	2001	72	Left	NR	Not performed	5.6	13	5.6
Kolh et al. [35]	2000	38	Left	IT	Not performed	2.5	0	0

RS retrosternal route, *SC* subcutaneous route, *PM* posterior mediastinal route, *NR* not reported, *IT* intrathoracic anastomosis

perfusion may become a tool for decision on adding supercharge in the near future, although there is not enough evidence in jejunal or colon graft.

Recommendation for graft choice

In our opinion, we recommend a left colon graft for cases in which long distance is needed to interpose, such as reconstructions after pharyngolaryngectomy with total esophagectomy. In the other cases, we recommend a right colon graft rather than a left side one because of the following reasons: first the Bauhin valve can prevent regurgitation, second the cecum may work as a reservoir, and third the anastomosis between esophagus and ileum is easier than that between esophagus and colon. A pedicled jejunal graft may be a promising option because fewer anastomoses are needed for the reconstruction compared to the colon grafts. However, to create a sufficient length of jejunal graft is sometimes difficult, especially in cases with thick mesentery by obesity. To ensure the graft perfusion, vascular supercharge is recommended for these reconstructive methods. If a surgeon who has microvascular anastomotic technique was unavailable, we recommend trying to use an ileocolic graft.

Diagnosis and management of conduit necrosis or anastomotic leakage

Graft loss due to conduit necrosis has been observed in 0–9.3 % of patients who underwent esophageal reconstruction using jejunal or colon graft (Tables 3 and 4). Many of the patients with graft necrosis develop symptoms of sepsis, such as tachycardia, tachypnea and hypotension. Dark and stinking fluid is observed in the nasal tube inserted into the conduit for decompression. Diagnosis of the graft necrosis or leakage in cases reconstructed through subcutaneous route can be made easily by opening the cervical wound and looking at the graft. In cases reconstructed through retrosternal or posterior mediastinal route, computed tomography with contrast enhancement is useful in diagnosing the anastomotic complications. Lack of contrast enhancement in the graft is a sign of graft ischemia. Fluid collection with air bubbles around the anastomotic site strongly suggests the existence of anastomotic leakage. Endoscopic evaluation is useful in differentiating graft necrosis from anastomotic leakage without ischemia [41].

Urgent surgical exploration is mandatory when any signs of graft necrosis are observed. All necrotic tissue should be removed and then a cervical esophagostomy is created, in preparation for a secondary reconstruction. For the subcutaneously reconstructed conduits, the oral end of conduit can be simply closed. For grafts reconstructed through retrosternal or posterior mediastinal route, the remaining conduit is returned to the abdomen or is replaced to the subcutaneous space of the anterior thorax.

A secondary reconstruction is performed when the signs of infection have disappeared and nutritional status of the patients has been improved. Free jejunal transfer or musclocutaneous flap is usually used for reconstruction of intestinal continuity.

For minor anastomotic leaks, adequate drainage through the cervical wound is effective for control of infection as well as reducing inflammation. Nutritional support is

needed to enhance wound healing. A refractory enterocutaneous fistula sometimes occurs, especially in the subcutaneously reconstructed conduit. Although surgical repair is required in such cases, direct suture of the leak frequently fails and fistula recurs. The coverage with a pectoralis major muscle flap over the repair site has been reported to be a simple and effective method for preventing the development of recurrent leakage after repair operation.

Long-term quality of life after esophageal reconstruction

There is no study comparing quality of life for those with pedicled jejunal grafts with that of those with interposed colon grafts. Recently, according to a novel comprehensive conduit assessment tool [42], it has been reported that supercharged pedicled jejunal interposition is comparable with a gastric conduit after esophagectomy. In terms of graft function and patient satisfaction, colon interposition was reported to be superior to gastric pull-up [43]. Other authors also reported that long-term alimentary satisfaction and quality of life were excellent after colon interposition [44]. Conversely, in terms of quality of life evaluated by the SF-36® (RAND corp., Santa Monica, CA, USA) questionnaire, patients who underwent colon interposition were reported to have poor general quality of life [45].

Conclusion

Approximately 10 % of esophagectomized patients undergo esophageal reconstruction using pedicled jejunum or colon interposition in Japan. Both jejunal and colon grafts are selected evenly, although the percentage of jejunal graft use is gradually increasing. The progress and popularization of microvascular surgical techniques may improve the outcomes of esophageal reconstruction with grafts other than the gastric conduit. Prospective comparisons of short-term outcomes as well as long-term quality of life are needed to identify the best reconstructive method.

Compliance with ethical standards

Conflict of interest The authors have declared that no conflict of interest exists.

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