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Reconstructive

Reconstructive Surgery for Bronchopleural Fistula and Empyema: New Application of Free Fascial Patch Graft Combined with Free Flap

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Background: Postoperative bronchopleural fistula (BPF) and empyema are not uncommon after lung cancer surgery. Some patients require reconstructive surgery to achieve wound healing. In this report, we describe a novel method of reconstructive surgery for BPF and empyema.
Methods: From 1996 through 2014, we performed reconstructive surgery for the treatment of BPF and empyema in 13 cases. BPF or a pulmonary fistula was present in 11 patients at the time of reconstruction. Of these, a free fascial patch graft combined with a free soft tissue flap was used to close the fistula in 6 cases. In the other 5 cases, primary fistula closure or direct coverage of the fistula with a transferred flap was performed. Medical records were retrospectively reviewed, and postoperative results were compared for these methods.
Results: All the flaps were transferred successfully except in 1 case. Although postoperative air leakage was observed in 5 cases, most of these healed with conservative management. Of 11 fistulas, 8 were successfully controlled. Although differences were not statistically significant, a higher success rate of fistula closure was obtained in patients with a fascial patch graft (100% vs 40%). As a result, 9 patients could be discharged from the hospital, but 4 died during their hospital stay.
Conclusion: Although the incidence of in-hospital mortality was high, fistula closure with a fascial patch graft combined with free flap transfer was effective for the treatment of BPF and empyema, compared with other procedures. *(Plast Reconstr Surg Glob Open 2017;5:e1199; doi: 10.1097/GOX.0000000000001199; Published online 17 January 2017.)*

Postoperative bronchopleural fistula (BPF) and empyema are not uncommon complications after lung cancer surgery. The overall incidence of postoperative BPF after lung cancer surgery is reportedly 1.3% to 3.1% or higher.[1–4] A relatively small BPF can be controlled with open-window thoracotomy alone or with endobronchial occlusion with fibrin glue by bronchoscopy.[5,6] On the other hand, reconstructive surgery is needed in patients with a persistent fistula or a large empyema cavity. The management of BPF and empyema has advanced in recent years with the use of a variety of local or free flaps. However, a previous study indicated that salvage surgery is related to major complications, with a mortality rate as high as 71%,[2] and remains a challenging problem. In this report, we described our method of surgical treatment of BPF and empyema using a fascial patch graft and musculocutaneous flap transfer.

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PATIENTS AND METHODS

From 1996 through 2014, soft-tissue transfer for the treatment of BPF and empyema after lung cancer surgery was performed in 13 cases, including 11 males and

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2 females, with a mean age of 64.7 years. Medical records were retrospectively reviewed, and postoperative results were analyzed. This study was conducted after approval of the institutional review board of the national cancer center (research ID: 2016-113). Initial pulmonary resection for primary or metastatic lung cancer was performed with lobectomy in 10 patients and pneumonectomy in 2 patients, and chest wall resection for osteoradionecrosis was performed in 1 patient. The pathological lung cancer diagnosis was squamous cell carcinoma in 5 patients and adenocarcinoma in 3 patients. Three patients had undergone radiotherapy previously, and 1 patient received postoperative adjuvant chemotherapy. BPF and empyema were diagnosed at a median of 15 days postoperatively, and the initial intervention for BPF and empyema was open-window thoracotomy in most cases. Open-window thoracotomy was performed by thoracic surgeons immediately after diagnosis of BPF and empyema in most cases. Additionally, an omental flap was simultaneously transferred in 1 patient (case 1). Eleven patients were referred to the department of plastic and reconstructive surgery for delayed salvage surgery after conservative treatment for thoracic infection. Another 2 were referred for emergency surgery, one was to control severe air leakage from BPF (case 10), and the other one was prophylactic coverage of bronchial suture stamp (case 13) using a pedicled serratus anterior muscle flap. BPF or pulmonary fistula was present in 11 patients at the time of reconstructive surgery, including 2 emergency cases. The median period from initial lung cancer surgery to reconstructive surgery was 81 days (Table 1).

After thorough debridement of granulation tissue, reconstructive surgery was performed in patients with persistent BPF. A free fascial patch graft was used to close the fistula in 6 cases, primary fistula suture was employed in 2 cases, and direct plugging coverage with a transferred flap over the small pulmonary fistula was performed in 3 cases. A fascial patch graft was harvested from the anterior rectus sheath while harvesting rectus abdominis musculocutaneous (RAMC) flap or from the deep fascial of thigh while harvesting anterior lateral thigh flap. After closure of the fistula was accomplished, soft tissue was placed to eliminate empyema dead space. The RAMC flap was transferred in 9 cases, a serratus anterior muscle flap in 2 cases, an anterolateral thigh flap combined with vastus lateralis muscle in 1 case, and a latissimus dorsi musculocutaneous flap in 1 case. Most of these flaps (10 cases) were transferred with a microvascular anastomosis technique. The recipient vessel varied with the fistula location, and the thoracodorsal artery and vein were preferably used (Table 2). Flap positioning was as follows: at first, muscular part of the flap was placed directly upon the fistula and roughly sutured with surrounding tissue using monofilament absorbable sutures. Second, remaining muscle and subcutaneous fat tissue was used for eliminating dead space of empyema. Third, a part of the skin island was deepithelized if necessary, and the remaining skin paddle was sutured with surface skin.

Surgical outcomes of BPF treatment with fascial patch grafts were compared with those of other procedures. Fisher's exact test was used to compare surgical outcome. Significance was defined a priori as P value less than 0.05. All statistical analyses were performed using IBM SPSS Version 22.0 (IBM Corp., Armonk, N.Y.).

RESULTS

All flaps were transferred successfully, except for 1 case in which total flap necrosis developed because of superior vena cava syndrome, requiring further surgical treatment with thoracoplasty (case 12). The most frequent complication after reconstructive surgery was air leakage from a BPF, which developed in 5 cases. Of these, 3 healed with conservative treatment. As a final result of treatment, 8 of 11 patients obtained fistula closure (Table 2), and 9 could be discharged from the hospital at a median of 63 days postoperatively. Another 4 patients died during their hospital stay. The causes of in-hospital mortality were myocardial infarction, acute exacerbation of interstitial pneumonia, brain infarction, and cardiopulmonary arrest of unknown cause in 1 case, respectively. The average follow-up period was 700 days postoperatively, and recurrence of fistula was not observed at the final follow-up (Table 3).

Representative Case

A 68-year-old male was diagnosed with T3N2 right lung cancer and underwent right lower lobectomy combined with mediastinal lymph node dissection under thoracoscopic assistance in November 2013. Although the postoperative course was uneventful, the patient developed dyspnea at 19 days postoperatively. Chest x-ray and computed tomography 28 days postoperatively revealed a BPF at the right bronchial stump (Fig. 1). Window thoracotomy with seventh and eight rib resection was carried out 29 days postoperatively. After infection was controlled, the patient was referred to our department for the treatment of BPF and empyema (Fig. 2). At 76 days postoperatively, surgical debridement, closure of the fistula with a fascial patch graft, and free RAMC flap transfer were performed (Fig. 3). The vascular pedicle of the RAMC flap was anastomosed with the thoracodorsal artery and vein using 9-0 nylon suture. After completion of the microvascular anastomosis, the RAMC flap was inserted in the pleural cavity. The muscular part of the flap was faced toward the fascial patch graft and firmly fixed with 4-0 monofilament absorbable sutures (Fig. 4). There were no postoperative complications, and the patient was discharged from the hospital 16 days after reconstructive surgery. At the last follow-up 3 months postoperatively, the patient had no dyspnea or recurrence of BPF (Fig. 5).

DISCUSSION

Treatment of BPF and empyema remains challenging because of difficulty in obtaining sufficient closure of the fistula and control of pleural infection. Spontaneous closure of the fistula can rarely be obtained with window thoracotomy,[6] and additional treatment such as musculocutaneous flap transfer or thoracoplasty is required. Our strategy to close the fistula is as follows: direct suturing is employed for a small bronchiolar fistula or pulmonary

Table 1. Details of Patients

Patient	Sex	Age (y)	Pathological Diagnosis	Previous RT (RT Dose)	Initial Surgery	Time from Initial Surgery to (d)		
						Empyema Diagnosis	Window Thoracotomy	Reconstruction
1	M	55	Adenocarcinoma	—	R-inf. lobectomy	15	15	92
2	M	80	NSC lung carcinoma	—	R-up. lobectomy	13	13	40
3	M	70	Adenocarcinoma	—	R-inf. lobectomy	30	30	75
4	M	50	Pleomorphic carcinoma	—	R-up. middle lobectomy	9	15	81
5	M	68	Small cell lung carcinoma	—	R-inf. lobectomy	28	29	76
6	M	66	SqCC	Yes (72 Gy)	R-inf. middle lobectomy	15	15	139
7	M	44	ORN	Yes (72 Gy)	R-chest wall resection	450	1,200	1,347
8	F	57	Adenocarcinoma	—	R-up. middle lobectomy	72	134	395
9	M	78	SqCC	—	R-inf. middle lobectomy	8	8	21
10	M	70	SqCC	—	R-pneumonectomy	4	4	10
11	F	78	Adenosquamous carcinoma	—	R-inf. lobectomy	2	9	91
12	M	49	SqCC	Yes (68 Gy)	R-up. lobectomy	240	253	483
13	M	76	SqCC	—	R-upper lobectomy	6	6	8

F, female; M, male; NSC, nonsmall cell; ORN, osteoradionecrosis; R-inf, right inferior; R-up, right upper; RT, radiation therapy; SqCC, squamous cell carcinoma.

Table 2. Postoperative Results after Reconstructive Surgery

Patient	Fistula	Closure of Fistula	Transferred Flap	Recipient A/V	Wound Complications	Treatments	Fistula Result
1	Bronchial	Fascial patch	Free RAMC	TDA/TDV	—	—	Healed
2	Bronchial	Fascial patch	Free ALT with VL muscle	Internal mammary A/V	Artery thrombus	Reanastomosis	Healed
3	Bronchial	Fascial patch	Free RAMC	Intercostal A/V	Leakage	Conservative	Healed
4	Bronchial	Fascial patch	Free RAMC	Thoracoacromial A/V	—	—	Healed
5	Bronchial	Fascial patch	Free RAMC	TDA/TDV	—	—	Healed
6	Bronchial	Fascial patch	Free RAMC	TDA/TDV	Leakage	PMMC	Healed
7	Pulmonary	Plugged with flap	Free RAMC	STA/IJV	—	—	Thoracoplasty
8	Pulmonary	Plugged with flap	Free RAMC	TDA/TDV	Partial necrosis	Conservative	Healed
9	Pulmonary	Plugged with flap	Pedicled RAMC	—	Leakage	Conservative	Pneumonectomy
10	Bronchial	Direct suture	Pedicled SA muscle	—	—	—	Healed
11	Pulmonary	Direct suture	Free RAMC	TDA/TDV	Leakage	Conservative	Fistula remained
12	—	—	Free LD	Intercostal A/V	Total necrosis	Debridement + thoracoplasty	Healed
13	—	—	Pedicled SA muscle	—	Leakage	Conservative	Healed

A/V, artery/vein; ALT, anterolateral thigh flap; IJV, internal jugular vein; LD, latissimus dorsi musculocutaneous flap; PMMC, pectoralis major musculocutaneous flap; RAMC, rectus abdominis musculocutaneous flap; SA, serratus anterior; STA, superior thyroid artery; TDA, thoracodorsal artery; TDV, thoracodorsal vein; VL, vastus lateralis.

Table 3. Systemic Conditions after Reconstructive Surgery and Status at the Last Follow-up

Patient	Systemic Complications	Discharge from Hospital after Reconstruction (d)	Follow-up Period from Reconstruction (d)	Status
1	—	30	407	Died of lung carcinoma
2	—	110	100	Disease free survival
3	—	31	266	Died of lung carcinoma
4	—	19	798	Alive with lung carcinoma
5	—	16	380	Disease free survival
6	—	108	408	Disease free survival
7	—	195	823	Died of lung carcinoma
8	—	23	3,314	Disease free survival
9	AMI	34 (in-hospital death)	34	Died of AMI
10	Interstitial pneumonia	9 (in-hospital death)	9	Died of pneumonia
11	—	304 (in-hospital death)	304	Died of brain infarction
12	—	23	2,364	Died of tracheal bleeding
13	CPA	97 (in-hospital death)	97	Died of CPA

AMI, acute myocardial infarction; CPA, cardio pulmonary arrest.

fistula, and a fascial patch graft is used for larger fistulas when applicable. However, direct soft-tissue plugging of the fistula is the only option in patients with a fragile fistula that is difficult to suture. In our series, a fascial patch graft was used in 6 patients, and the fistula was closed without any air leakage in 4 of these patients. Although the other 2 developed air leakage postoperatively, 1 healed with conservative management. In the other patient, air leakage was controlled with a pectoralis major musculocutaneous flap transfer. Although the statistical difference was not significant, a higher success rate of fistula closure was obtained in patients with fascial patch grafts (100%

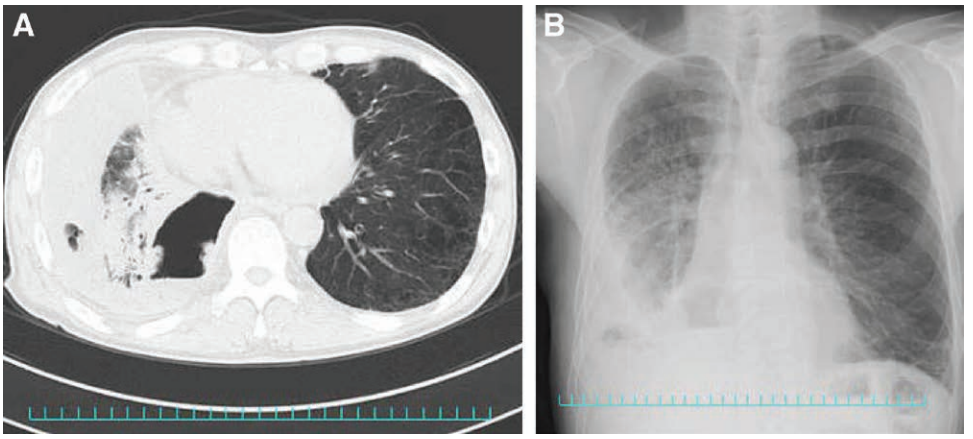

Fig. 1. Findings at the time of diagnosis of bronchopelural fistula and empyema. A niveau and pleural dead space were detected on the computed tomographic image (A) and chest x-ray (B).

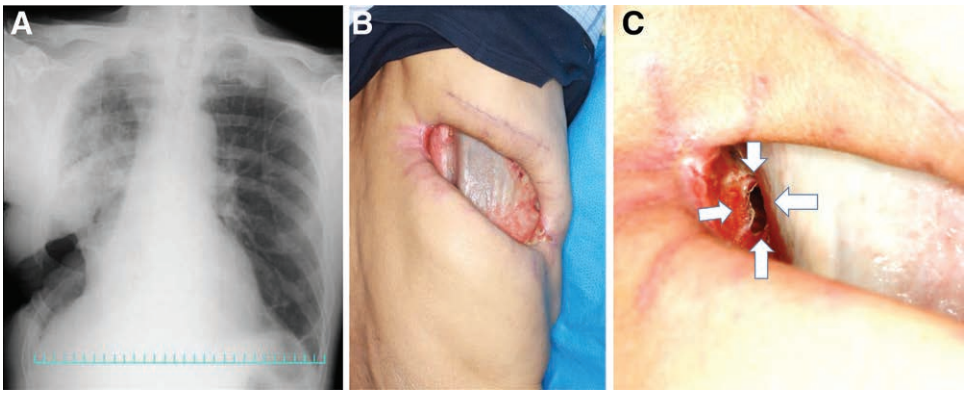

Fig. 2. Open-window thoracotomy was performed 29 d after right lower lobectomy. Findings are shown for the first visit in the department of plastic and reconstructive surgery. A large dead space (A and B) and bronchopleural fistula (C, *arrows*) were observed.

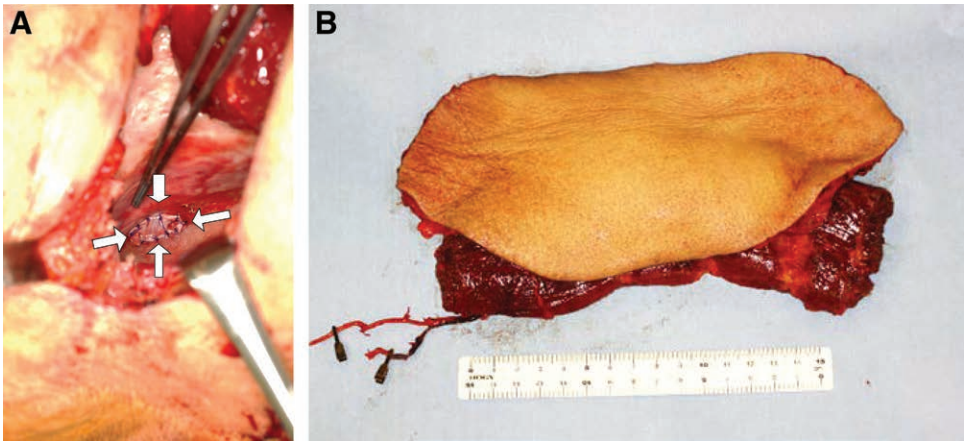

Fig. 3. The fascial patch graft was sutured with 4-0 monofilament absorbable sutures (A, *arrows*), and a free rectus abdominis musculocutaneous flap was transferred (B).

vs 40%; Table 4). As a patch graft, Kamei et al[7] reported the use of gastric seromuscular patch for BPF; however, the application of a fascial patch graft for the treatment of BPF has not been reported previously.

Another important factor in obtaining successful closure of a BPF and empyema is to control pleural infection before reconstructive surgery. Open-window thoracotomy and drainage were employed to control infection in most cases, and the procedures were usually performed by thoracic surgeons immediately after diagnosis of empyema. In previous reports, the average interval between open-window thoracotomy and reconstructive surgery was

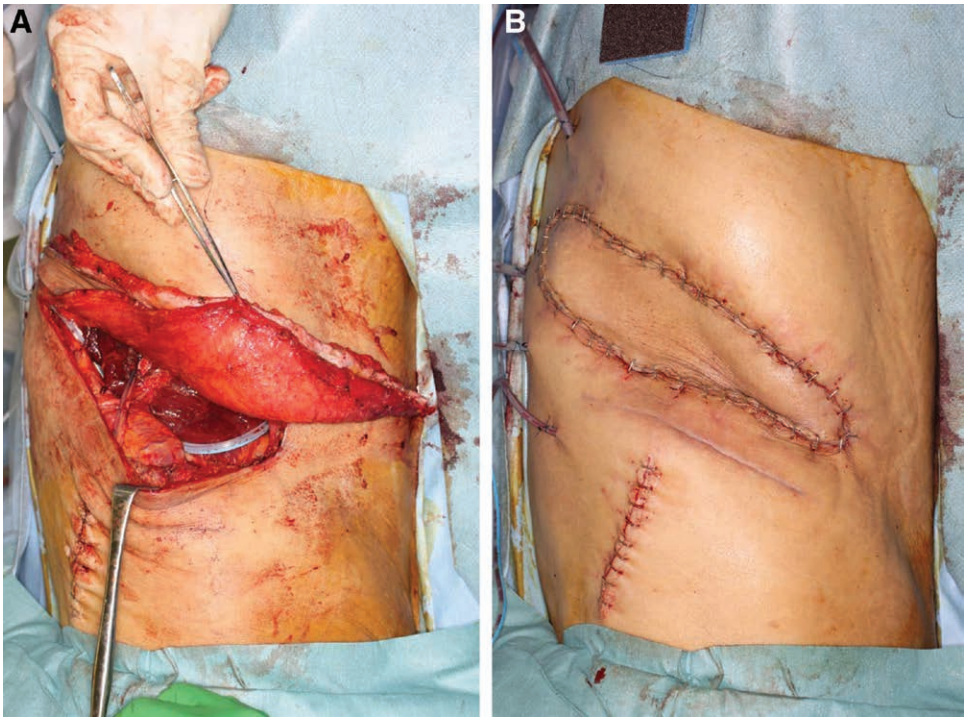

Fig. 4. The fascial patch graft was covered firmly with muscular tissue (A), and the dead space was eliminated with flap volume (B).

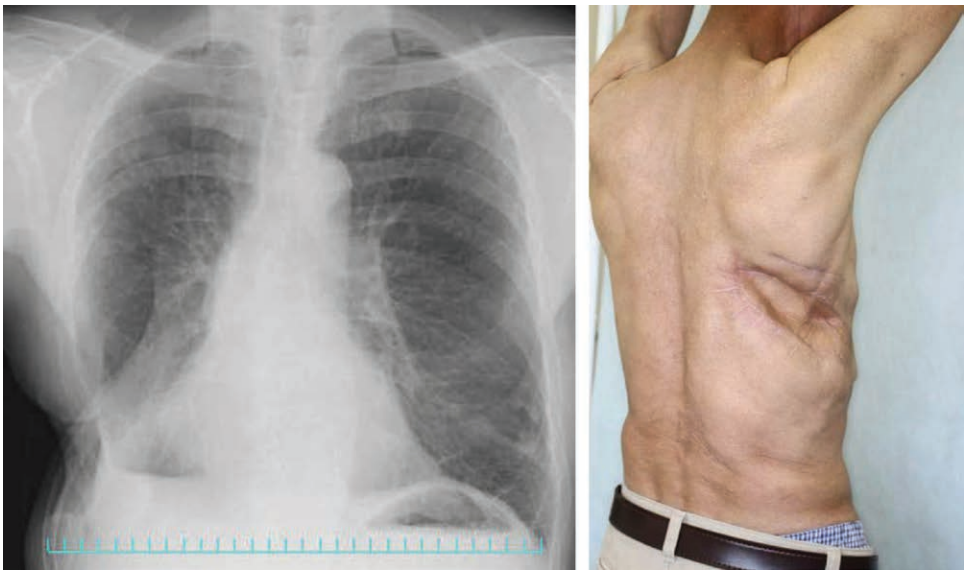

Fig. 5. Findings at 3 mo after reconstructive surgery. No recurrence of fistula or empyema was observed.

3 months.[8,9] Although drainage through thoracotomy is considered the most effective treatment to control pleural infection, healing is usually prolonged. In our series, the median interval between initial surgery and reconstructive surgery was 81 days, which was comparatively shorter than that in previous reports. Furthermore, perioperative mortality was observed in only 1 patient, which was a significant improvement compared with previous reports.[2,8] We believe that open-window thoracotomy immediately after diagnosis of empyema contributed to a shortened preparation time and better prognosis, as previously reported.[10]

Since the application of extrathoracic skeletal muscle into the pleural space was reported in 1989,[11] an omental flap, RAMC flap, and latissimus dorsi musculocutaneous flap have been reported. Muscular tissue transfer eliminates dead space, brings vascularity to the surrounding tissues, and prevents bacterial inoculation.[12,13] In our fascial patch graft method for the clo-

Table 4. Effectiveness of Fascial Patch for BPF

	Successful Closure of BPF	
	Yes	No
Fascial patch	6	0
Primary closure/flap coverage	2	3

$P = 0.061$ (Fisher's exact test).

sure of a BPF, well-vascularized muscular tissue transfer is essential for providing neovascularization to the fascia. To promote neovascularization across the interface, attention should be given to firmly attach the muscle flap to the inner wall of the empyema cavity. Although postoperative leakage was the most common early complication, this was successfully treated with conservative management in most patients. These findings also suggest that transferred muscle provides consistent vascularity for damaged tissue, helps prevent infection, and gradually seals the fistulas.

On the other hand, the omentum has been preferably used by thoracic surgeons because of its ability to improve conditions in an established infected area, as demonstrated by its natural role in the abdomen.[14,15] However, an omental flap may not be available for use in reconstruction when the omentum has been used for BPF surgery or previous abdominal surgery. Furthermore, an omental flap has a limited arc of rotation of the vascular pedicle and less flap volume. Moreover, it may be associated with iatrogenic intraperitoneal infection. In contrast, free musculocutaneous flaps have the advantage of easy flap insertion and bulky flap volume to fill pleural dead space.[12]

BPF has a reported incidence of 1.3% to 3.1% in patients who undergo lung cancer surgery, and most develop after right pneumonectomy. Other known risk factors are perioperative mechanical ventilation, previous irradiation, preoperative infectious lung disease, and diabetes.[2,4] In our series, all of the patients had a right-side BPF. Three patients had previous irradiation, and 1 had a history of diabetes; we could not determine the relationship between fistulas and previous irradiation or diabetes because of the small sample size. Furthermore, wider resection including pneumonectomy is a known risk factor for BPF compared with lobectomy or wedge resection,[2,16] and most of our cases underwent lobectomy. This may be the result of patient selection bias. The most common procedure for lung cancer surgery is lobectomy in our institution, and total pneumonectomy is rarely performed. Furthermore, only patients with an indication for reconstructive surgery were included in this study.

One of the limitations of the present study is patient selection bias. In this study, patients with different condition and severity were merged into 1 group and compared with those of fascial patch graft. As a result, it may be difficult to obtain a firm conclusion. Although the other inherent limitations such as small sample size and retrospective nature are existing in this study, reconstructive surgery for BPF and empyema using a fascial patch graft combined with free flaps can provide a solution for severe complications after lung cancer surgery.

CONCLUSION

We believe that free soft-tissue transfer combined with a fascial patch graft can be the first choice for treatment of BPF and empyema when adequate recipient vessels can be found. Although 1 patient died perioperatively, our method can be a solution for difficult cases.

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