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ARAŞTIRMA / RESEARCH

Omentoplasty in the treatment of bronchopleural fistula after pulmonary resections

Akciğer rezeksiyonları sonrası gelişen bronkoplevral fistül tedavisinde omentoplasti

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Abstract

Purpose: Bronchopleural fistula (BPF) is a complication that can occur after pulmonary resections onset may be early or late. This study aims to present our results using omentoplasty in the treatment of BPF.

Materials and Methods: We retrospectively evaluated the data of patients who developed BPF after pulmonary resection between 2010 and 2020. The results of the patients who underwent omentoplasty during surgical revision for BPF were analyzed in terms of surgical methods used, timing of the procedure, and surgical success.

Results: BPF formed in 52 (2.1%) of 2486 patients who underwent anatomical lung resection. Fourteen (26.9%) of the patients with BPF were treated with omentoplasty. All of the patients were men and the median age was 58 years (range, 27-75 years). Among the patients who underwent omentoplasty, the median time from pulmonary resection to BPF development was 22 days (range, 4-221 days). The median time from BPF development to omentoplasty was 9.5 days (range, 4-485 days). Seven (50%) of the patients developed BPF after pneumonectomy and the other 7 (50%) after lobectomy. Most post-pneumonectomy BPFs occurred after right pneumonectomy (n=6, 85.7%). BPF developing after right pneumonectomy constituted 43% of all BPFs (n=6). Surgical success was achieved in 13 (92.9%) of the 14 patients who underwent BPF closure with omentoplasty.

Conclusion: Omentoplasty has low complication and high success rates and can be used safely for the treatment of BPF.

Keywords: Bronchopleural fistula, omentoplasty, stoma, revision

Öz

Amaç: Bronkoplevral fistül (BPF), akciğer rezeksiyonları sonrasında erken veya geç dönemde oluşabilen bir komplikasyondur. Bu çalışmanın amacı, BPF tedavisinde omentoplasti kullanım sonuçlarını sunmaktır.

Gereç ve Yöntem: 2010-2020 yılları arasında akciğer rezeksiyonu sonrası BPF gelişen hastaların verilerini retrospektif olarak değerlendirdik. BPF nedeniyle cerrahi revizyon sırasında omentoplasti yapılan hastaların sonuçları, kullanılan cerrahi yöntemler, işlemin zamanlaması ve cerrahi başarısı açısından analiz edildi.

Bulgular: Anatomik akciğer rezeksiyonu yapılan 2486 hastanın 52'sinde (%2.1) BPF gelişti. BPF olan hastaların 14'ü (%26,9) omentoplasti ile tedavi edildi. Hastaların tamamı erkekti ve ortanca yaş 58 (aralık 27-75) idi. Omentoplasti yapılan hastalarda akciğer rezeksiyonundan BPF gelişimine kadar geçen medyan süre 22 gündü (aralık 4-221 gün). BPF gelişiminden omentoplasti işlemine kadar geçen medyan süre 9.5 gündü (aralık 4-485 gün). Hastaların yedisinde (%50) pnömonektomiden sonra BPF gelişirken, diğer 7'sinde (%50) lobektomiden sonra BPF gelişti. Pnömonektomi sonrası BPF'lerin çoğu sağ pnömonektomiden sonra meydana geldi (n=6, %85.7). Sağ pnömonektomi sonrası gelişen BPF, tüm BPF' lerin %43' ünü oluşturmaktaydı (n=6). Omentoplasti ile BPF'ü kapatılan 14 hastanın 13'ünde (%92,9) cerrahi başarı elde edildi.

Sonuç: Omentoplasti düşük komplikasyon ve yüksek başarı oranları ile BPF tedavisinde güvenle kullanılabilir.

Anahtar kelimeler: Bronkoplevral fistül, omentoplasti, stoma, revizyon

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INTRODUCTION

Bronchopleural fistula (BPF) can occur after pulmonary resection when the bronchial stump or anastomosis opens to form a passage to the thoracic cavity [1]. Communication between the airway and thoracic cavity results in pneumonia and empyema in the early postoperative period. The incidence of BPF ranges from 0.4% to 4% after lobectomy and 1.5% to 15% after pneumonectomy [2]. In general, mortality rates after BPF are reported to be between 15% and 70% [3]. Therefore, early diagnosis and selection of appropriate treatment methods are life-saving. Risk factors for BPF formation include severe devascularization of the bronchial stump or anastomotic line during resection, leaving a long stump, presence of residual tumor tissue in the stump, neoadjuvant therapies, steroid use, presence of diabetes mellitus, early postoperative pneumonia or empyema, and prolonged postoperative mechanical ventilation [4-6].

Although many treatment protocols have been described, BPF remains one of the most dreaded complications after pulmonary resections and there is still no definitive treatment. The treatment strategy is shaped by the diameter of the fistula, timing of development, and the patient's clinical presentation. Treatment options consist of medical follow-up with tube thoracostomy or open thoracostomy drainage (stoma); endobronchial closure using fibrin glue or stent; and surgical revision of the fistula site, reinforced with vascularized tissues. Omentum is a tissue that has been used successfully for years in general surgery as well as cardiovascular and thoracic surgery, both in primary surgeries for prophylactic purposes and in revision surgeries to treat complications, due to its extensive vascular network, fatty structure, and phagocytic properties [7, 8]. Many methods have been used successfully to close the BPF with the omentum, including the video thoracoscopic approach and the multimodal approach (tracheobronchial conical stent placement, open pleural packing, and closure of the bronchial stump with omentoplasty) [9, 10].

We think that fixation of the omentum on the revised stump with the standard rethoractomy approach is an effective treatment method for closure of BPF after stoma in late-stage cases or without stoma in early stage cases. Therefore with this study we aimed to retrospectively evaluate our success using omental flaps to reinforce the revised fistula site (omentoplasty) in the treatment of patients with BPF after pulmonary resections over the last 10 years, in comparison with the literature data.

MATERIALS AND METHODS

Data pertaining to 52 patients who developed BPF after anatomical lung resections between January 2010 and January 2020 were retrospectively analyzed from the hospital archive. Treatment approaches other than omentoplasty and the study inclusion criteria are summarized in Figure 1. A total of 14 patients treated with omentoplasty were included in the study. Their age, sex, diagnosis, primary surgery, timing of BPF detection and omentoplasty revision surgery, operative details, complications, and outcome of revision surgery, and length of hospital stay were recorded.

Timing of BPF formation was defined as early if within the first 7 days, intermediate if between 8 and 30 days, and late if more than 30 days after pulmonary resection [11]. Complete fistula closure after omentoplasty was considered success, while reopening of the fistula in the early period was classified as failure. Persistence of existing empyema or development of new empyema after revision was considered a complication. Length of hospital stay was defined as the time from omentoplasty until hospital discharge.

This study was conducted with the permission of the hospital management and was approved by the ethics/scientific committee of Yedikule Chest Diseases and Thoracic Surgery Training and Research Hospital (24/02/2021-286-6).

Preoperative period

Patients who developed BPF after pulmonary resection were evaluated by multidisciplinary surgical councils. The decision to perform revision surgery and the surgical method were determined based on the patient's general condition, fistula diameter and time of onset, comorbidities, and infection status. In all cases, BPF was diagnosed by fiberoptic bronchoscopy (FOB) examination. In general, the approach in our clinic is to perform revision surgery for fistulas that develop within the first 7 days (early-onset) and omentoplasty is added to revision surgery for selected cases.

For intermediate- and late-onset BPF, tube thoracostomy is performed followed by FOB examination. For fistulas smaller than 8 mm in

diameter, bronchoscopic tissue glue application or conservative follow-up with appropriate antibiotherapy is attempted first. Treatment for larger fistulas or small fistulas for which conservative treatment failed was determined based on the patient's general condition and presence of infection. For patients whose general condition precluded revision surgery and those with empyema, the initial treatment approach was to create a stoma for effective cleaning and drainage of the thoracic cavity.

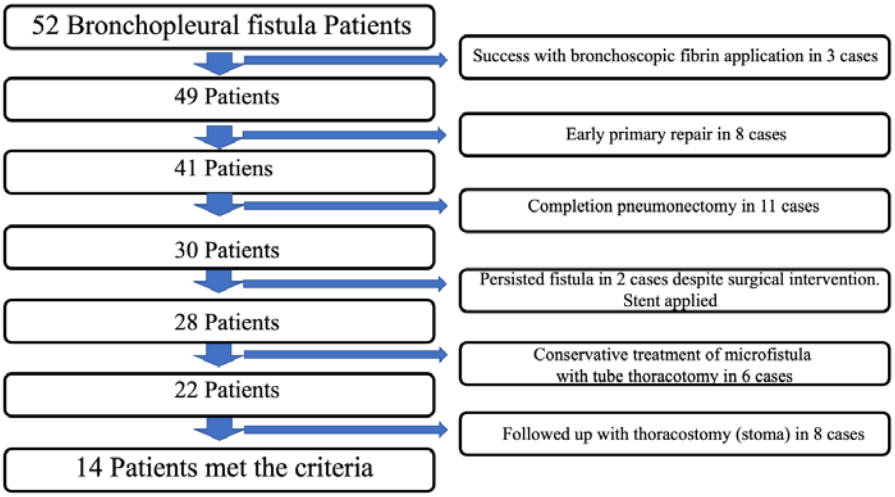

Figure 1. Inclusion flowchart

After eliminating the infection in the thoracic cavity, the patient was reevaluated in terms of surgical fistula closure. If the patient's general condition was not deemed good enough for surgery, they were followed up with a long-term stoma. For revision surgery, completion pneumonectomy, carinal sleeve resection, sleeve anastomosis, or primary repair was selected to repair the BPF area on an individual basis. The decision to support the revised stump or anastomosis line with an omental flap was made by the multidisciplinary surgical council.

Since granulation is more common in late BPF cases, the omentum is a planted tissue to increase the blood supply to this region and to ensure the development of new granulation tissue. For this reason, omentoplasty is more often preferred in the treatment of late BPF cases. It can also be used to support the anastomosis line made after carina resection, especially for the treatment of BPF after right pneumonectomy.

The main qualification criteria for omentoplasty in late-onset BPF were the absence of pus and the presence of healthy granulomatous tissue in the thoracic cavity [12]. Other than omental flap, other surgical options were reinforcement with parietal pleura, pericardial fat pad, intercostal muscle, or other muscle structure. Our clinical approach to patients with empyema before revision surgery was to combine omentoplasty with thoracomyoplasty to ensure maximal obliteration of the thoracic cavity or to create a stoma after omentoplasty to allow effective cleaning of the thoracic cavity postoperatively.

Surgical procedure

In all cases, surgery was initiated by performing a 4-5 cm median laparotomy with the patient in supine position. After mobilizing the omentum in the abdomen, it was placed under the diaphragm. The patient was then moved to a lateral position and the thorax was accessed from the previous incision site or by enlarging the stoma incision. The BPF site was exposed and revised either by cutting and resuturing the stump with nonabsorbable 3/0 suture or division

by stapling if there was adequate distance to use the stapler. In cases with insufficient clearance, the fistula site was repaired using sleeve anastomoses.

In patients with post-lobectomy BPF not considered amenable to primary repair, completion pneumonectomy was performed for the purpose of stump revision. An incision was then made through the diaphragm to access the abdomen, and the omentum flap was moved into the thoracic cavity. In the thorax, the omentum was fixed to the thoracic cavity and the revised stump. Thoracomyoplasty or stoma creation was added in patients with pre-existing empyema. In patients for whom postoperative irrigation of the thoracic cavity was planned (n=6 cases), a second chest tube was placed through the anterior second intercostal space. In patients for whom no additional procedure was considered, a single drain was placed and the chest was closed primarily.

Postoperative period

In the early postoperative period, daily stoma care was performed for patients with stoma. The patient's relatives were educated on this subject before discharge. In patients who received double chest tubes, the thoracic cavity was irrigated twice a day with 500 cc saline for 5 days. Irrigation was performed by administering saline through the apical drain and allowing it to evacuate from the basal drain. The drains were removed after obtaining a negative culture result. Single drains were removed when the daily drainage volume decreased to less than 100 cc. The decision to discharge was made after drain removal and demonstration of negative culture and regression of the infection parameters in laboratory tests.

Statistical analysis

The patients' demographic and clinical characteristics and collected data were analyzed using IBM® SPSS® Statistics version 23.0 (IBM Corp, Armonk, NY). Descriptive statistics of mean, maximum, and minimum values were used to characterize continuous variables, and percentage values were used for qualitative variables. Shapiro-Wilk test was used to evaluate whether the data were normally distributed ($p<0.05$ indicates non-normal distribution). Normally distributed variables were reported as mean ± standard deviation (SD) and non-normally distributed variables as median values and interquartile range (IQR; 25^{th}-75^{th} percentile values).

RESULTS

In the last 10 years, a total of 2486 pulmonary resections were performed due to malignant and benign causes. Of these, 2063 (83%) were lobectomies and 423 (17%) were pneumonectomies. A total of 52 patients (2.1%) developed BPF. The rate of BPF was 1.6% (n=33) after lobectomy and 4.4% (n=19) after pneumonectomy. Onset of BPF was early (1-7 days) in 15 patients (28.8%), intermediate (8-30 days) in 21 patients (40.4%), and late (>30 days) in 16 patients (30.8%).

Revision with omentoplasty was performed in 14 (26.9%) of the 52 patients with BPF. All of the patients were men and the median age was 58 years (IQR, 15.5; range, 27-75 years). Pulmonary resection was performed due to benign causes in 3 of these patients and malignant causes in 11 patients. BPF was more common after right-sided resections (n=10, 71.4%). Seven (50%) of these patients developed BPF after pneumonectomy (1 left side, 14.3%; 6 right side, 85.7%) and 7 (50%) developed BPF after lobectomy (3 left lower, 3 right lower, 1 sleeve right lower lobectomy). Of the 14 patients who underwent omentoplasty, 2 had received neoadjuvant chemotherapy and 3 had diabetes mellitus. One patient who underwent right pneumonectomy developed postoperative respiratory failure and received invasive mechanical ventilation for 4 days.

The general characteristics of the patients are summarized in Table 1.

In revision surgery, omentoplasty was combined with carinal sleeve resection in 2 patients, completion pneumonectomy in 2 patients, and thoracomyoplasty in 3 patients. In 1 patient, the chest was not completely closed and the procedure was concluded by creating a stoma. Early postoperative complications were observed in 4 patients (28.5%). Wound site infection occurred in 2 patients, while 1 patient with preoperative empyema had persistent empyema postoperatively. A stoma was later created in this patient. One patient underwent revision due to hemorrhage on postoperative day 1. The bronchial artery was identified as the source of the bleeding and a hemostatic clip was applied. Complete BPF closure was achieved in 13 patients (92.9%), while the BPF persisted in the early postoperative period in 1 patient (7.1%). This patient remains under follow-up with a long-term stoma. Patients whose BPF closure with omentum was successful had no subsequent airway-related pathology.

The surgical approaches used in combination with omentoplasty, the complications, and the surgical outcomes are summarized in Table 2. Mean fistula diameter measured by FOB was 1 cm (range, 0.8-25 mm). The median time from pulmonary resection to BPF development was 22 days (IQR, 41.50; range, 4-221 days). Early BPF was detected in 4 patients. One of these patients underwent completion pneumonectomy, while 2 patients underwent simple stump revision. A patient who underwent right pneumonectomy and developed respiratory distress in the intensive care unit postoperatively underwent stoma surgery, followed by carinal sleeve resection. Before omentoplasty, 4 patients (28.6%) underwent stoma surgery for thoracic drainage and cleaning. The median time from BPF detection to omentoplasty was 9.5 days (IQR, 17.50; range, 4-485 days). The median time from omentoplasty surgery to hospital discharge was 7 days (IQR, 9.25, range, 6-25 days). The timing of BPF development, revision surgery, and discharge in the patients is shown in Table 3.

Table 1. General characteristics of patients who underwent omentoplasty

Variable	**Number**	**%**	**Median (IQR)**
Age (years)			58 (15.5)
<60	9	64.2	
≥60	5	35.8	
Sex			
Male	14	100	
Female	0	0	
Disease			
Malignant	11	78.6	
Benign	3	21.4	
Side			
Right	10	71.4	
Left	4	28.6	
Primary surgery			
Pneumonectomy	7	50	
* Right	*6	*85.7	
* Left	*1	*14.3	
Lobectomy	7	50	
* Left lower lobectomy	*3	*42.8	
* Right lower lobectomy	*3	*42.8	
* Right sleeve lower lobectomy	*1	*14.4	
Cofactors for BPF			
No	8	57.1	
Yes	6	42.9	
*Neoadjuvant therapy	2		
*Diabetes mellitus	3		
*Prolonged mechanical ventilation	1		

BPF: Bronchopleural fistula, IQR: Interquartile range

Table 2. Concurrent surgical procedures, complications, and outcomes of omentoplasty

Patient	Procedures combined with omentoplasty	Complication	Results
1	Carinal sleeve	None	Success
2	Completion pneumonectomy	Wound site infection	Success
3	Thoracomyoplasty	Wound site infection	Success
4	Stoma	None	Success
5	Completion pneumonectomy	None	Success
6	Simple stump revision	None	Success
7	Simple stump revision	None	Success
8	Simple stump revision	None	Success
9	Thoracomyoplasty	Empyema (Stoma)	Success
10	Thoracomyoplasty	None	Success
11	Carinal sleeve	None	Success
12	Simple stump revision	None	Success
13	Simple stump revision	Hemorrhage (Revision)	Success
14	Simple stump revision	None	Failure (Stoma)

Table 3. Timing of bronchopleural fistula onset, revision, and discharge

Parameter	N	Minimum	Maximum	Median (IQR)
Time to BPF onset (days)	14	4	221	22 (41.50)
Time from BPF development to revision (days)	14	4	485	9.5 (17.50)
Time from revision to discharge (days)	14	6	25	7 (9.25)

BPF: Bronchopleural fistula, IQR: Interquartile range

DISCUSSION

Bronchopleural fistula is a serious problem that can still occur after pulmonary resections despite advances in thoracic surgery technology and suturing techniques[13]. The main parameters determining a surgical or conservative treatment strategy are the patient's general condition, fistula diameter and onset time, and presence of infection[14]. Empyema, which can develop as a result of communication between the airway and thoracic cavity via the BPF, complicates treatment and increases mortality rates[15,16]. Omental tissue facilitates healing of the fistula because it has an extensive vascular network and releases vascular endothelial growth factor. In addition, its phagocytic properties allow it to absorb the infected effusion[17,18]. The right main bronchus is wider than the left main bronchus, which causes

greater resistance to closure. Furthermore, because the right main bronchial stump is less embedded after resection compared to the left main bronchial stump, the formation of granulation tissue occurs later. The single bronchial artery feeding it is another risk factor in terms of blood supply[19]. In our case series, most of the patients who developed BPF and underwent omentoplasty were primary right pneumonectomy patients, consistent with the literature.

BPF that develops within the first postoperative week is considered early and is usually the result of errors in surgical technique. Therefore, early surgical revision is recommended in these cases[20]. Intermediate and late BPF (occurring more than 1 week after surgery) is caused by patient-related factors that may cause insufficient blood supply to the bronchial stump[21].In 3 of the 4 patients with early fistula, we performed revision surgery within 1 week. Patients with late BPF nearly always present with empyema and poor general condition. In these cases, BPF is usually caused by chronic ischemia of the stump or tumor recurrence[22]. The primary goal in these cases is to provide effective drainage and improve the patient's general condition by controlling the infection. For this purpose, it is recommended to first create a stoma[22].

In 4 of our patients with late BPF, we created a stoma before omentoplasty to clean the thoracic cavity and aimed for the patients' general condition to be ready for surgery. To avoid BPF formation, reinforcing the bronchial stump with adjacent vascularized tissues such as intercostal muscle, parietal pleura, and pericardial adipose tissue can be considered in selected pulmonary resection patients, especially those undergoing right pneumonectomy. Large series have shown that reinforcing the stump or anastomosis line, particularly if the patient has received neoadjuvant therapy, reduces BPF development[23]. In our clinic, we reinforce the anastomosis line or bronchial stump with vascularized tissues in selected cases.

In a recent retrospective analysis of 3832 lung resection patients, the rate of BPF after pulmonary resection was 1.4% and 77% were early onset[24]. As early BPF is usually caused by surgical technical problems, simple repair and reinforcement with adjacent tissue during revision is sufficient, whereas the treatment of late BPFs is more complex and omentoplasty is preferred in these cases[25]. In the present study, although most BPFs were early and intermediate, most of the patients who underwent omentoplasty had late BPFs.

Other reinforcement options in BPF revision surgery are intercostal muscle, parietal pleura, and pericardial adipose tissue. In some studies on this subject, pedicled omental flaps were found to be superior to muscle flaps [26, 27]. Success rates with omental flap in the treatment of BPF in these studies ranged from 72% to 100%. In our study, we achieved success in 92.9% of patients with BPF repair using omental flap.

Revision of the BPF site in patients with empyema does not mean that the empyema is treated [28]. Empyema may recur after revision surgery[29]. In our case series, we placed a double drain in 6 patients for postoperative irrigation of the thoracic cavity and created a stoma while closing the chest in 1 patient to ensure effective cleaning of the thoracic cavity. In previous studies, the mean length of hospital stay after omentoplasty surgery varies between 12 and 15 days (range, 11-55 days)[30-32]. In our series, the median time from revision surgery to discharge was 7 days.

Our study was a retrospective, single-center study. Due to the long study period, the operations were performed by different surgeons. Because our study focused on BPF treated using omentoplasty, our analysis did not include cases in which risk analyses in terms of BPF, conservative follow-up, or other treatment options were applied. Therefore, this method could not be compared with cases in which the stump was reinforced using intercostal muscle, pericardial adipose tissue, or parietal pleura. However, we believe that mentioning the concurrent fistula closure methods in the revision surgery details and thoroughly analyzing the preoperative and postoperative process are strengths of this study. Another strength of the study is that we are an experienced center in BPF closure with omentoplasty[33].

In conclusion, BPF is among the major complications that can occur after pulmonary resections. Although many stump/anastomosis reinforcement and revision methods have been described for its treatment, there is still no clear consensus on the treatment strategy. Omental flap reinforcement of a repaired BPF in revision surgery is a valuable method for ensuring adequate blood flow, protecting, and fighting infection at the site. We believe that omentoplasty is a method with low complication and high success rates and can be used safely in the treatment of BPF.

Yazar Katkıları: Çalışma konsepti/Tasarımı: VE; Veri toplama: Öİ; Veri analizi ve yorumlama: AP; Yazı taslağı: VE; İçeriğin eleştirel incelenmesi: MM; Son onay ve sorumluluk: VE, CA, AP, SE, YA, Öİ, MM; Teknik ve malzeme desteği: SE; Süpervizyon: MM; Fon sağlama (mevcut ise): yok.
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