Right-sided approach for management of left-main-bronchial stump problems

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Abstract

Objective: Although the incidence of bronchopleural fistula (BPF) has decreased in the past decades, it remains a serious complication following pulmonary resection. The management of left-sided bronchial stump fistulas is difficult and depends on the choice of the approach. In contrast to several surgical procedures published in the past, herein we report our experience managing five left-main-bronchial stump (LMBS) problems through a right thoracotomy route.

Methods: Five women, who underwent left pneumonectomy and later developed BPF, were managed with this novel procedure at our Institution. BPF appeared between 12 days and 24 years after pneumonectomy. Diagnosis of BPF or bronchoesophageal fistula (BEF) was made by computed tomography (CT) scan and fiberoptic bronchoscopy. Through a right posterolateral thoracotomy incision, the LMBS was re-stapled and covered with pedicled flaps in all cases. In patient #4, carinal resection was performed also, with temporary extracorporeal membrane oxygenation (ECMO) application.

Results: The main results are depicted in the table. In all cases, encircling of the LMBS and stapling at the level of the carina was performed without difficulties. In patients #1, #2 and #3, resection of the bronchial stump remnant was also done and, in patient #4, carinal resection was also performed. All patients are doing well, with no evidence of recurrence of fistula.

Conclusions: We advocate the right posterolateral thoracotomy route for the management of left-sided BPFs as an alternative to transternal transpericardial and transthoracic closures. It is a safe, feasible and time-efficient approach that provides control of central structures and avoids previously manipulated or infected operative fields.

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Keywords: Bronchopleural fistula; Bronchial stump problems; Bronchoesophageal fistula; Post-pneumonectomy empyema

1. Introduction

Problems arising from the left-bronchial stump after pneumonectomy comprise bronchopleural fistula (BPF) resulting either from chronic inflammation or tumor relapse in bronchial margins or, less frequently, fistulas from the stump into the esophagus (BEF). The BPF is a life-threatening complication after lung cancer surgery, with a reported incidence of 0.8—15% [1—3], and a high mortality rate [4]. Although the incidence of BPF has decreased in the past decades, it remains a serious complication following pulmonary resection. In rare situations, the fistula arising from the bronchial stump does not communicate with the post-pneumonectomy cavity but rather with the esophagus, on the basis of chronic erosion and inflammation within the mediastinum. Patients usually present with symptoms related to eating or drinking, such as coughing on ingestion or recurrent episodes of aspiration.

The management of left-sided bronchial stump fistulas is difficult and depends on the choice of the approach. Treatment options include a variety of strategies for fistula control and also, management of the associated empyema. The surgical procedure consists on two separate steps: re- closure of the stump and, eventually sterilization of the pleural cavity. Several surgical procedures have been published in the past, including standard ipsilateral re-thoracotomy, the transpericardial route through an anterior thoracotomy, reported by Padhi [5], the transternal transpericardial approach developed by Abruzzini [6], and the recently described transcervical approach with the aid of video-assisted mediastinoscopy (VATS) [7]. However, all these methods have inherent advantages and disadvantages.

In contrast to that, a contralateral access through the right posterolateral thoracotomy to treat left-mainstem bronchus insufficiency has only been mentioned once in the
literature [8]. However, a combination of left-sided pneumonectomy either by VATS or thoracotomy, together with a right-sided approach for carinal resection has also been described for left-sleeve pneumonectomies [9,10].

Herein we present our experience managing five left-main-bronchial stump (LMBS) problems using this kind of approach.

2. Patients and methods

2.1. Patients

The subjects of this retrospective study were five patients (all women), who underwent left pneumonectomy and later developed BPF, being managed by right posterolateral thoracotomy approach at our Institution. Signs and symptoms at diagnosis were chest pain (patient #1), dyspnea and fever due to aspiration pneumonia (patient #2), respiratory failure (patient #3), asymptomatic (patient #4) and putrid secretion, and fever and respiratory failure (patient #5). The mean age was 40 years (range 5—60). The diagnosis that led to pneumonectomy was lung cancer (patients #1 and #4) and infectious diseases (patients #2, #3, and #5). Interval from pneumonectomy ranged from 12 days to 24 years. Pre-operative work-up consisted of chest X-ray, computed tomography (CT) and fiberoptic bronchoscopy. BPF was diagnosed in all patients except one, who had a BEF (patient #2). Hence, in this patient, an esophagoscopy was also performed to best characterize and typify the BEF.

2.2. Surgical procedure

Selective ventilation through a single-lumen tube was achieved to prevent soilage of the remaining lung. A protective ventilation strategy was used, based on pressure-controlled ventilation (PCV), limiting tidal volumes to 5—7 ml kg$^{-1}$, inspiration-to-expiration ratio of 1:2, fraction of inspired oxygen ($FI_O_2$) of 1.0, and adjusting the respiratory rate to maintain arterial partial pressure of carbon dioxide ($Pa_CO_2$) between 35 and 40 mmHg. Fluid overload was avoided, using less than 3 l of crystalloids in the first 24 h. In case hypoxemia occurred, recruitment maneuvers were initiated and, if not sufficient, a positive end-expiratory pressure (PEEP) of 5 mmHg was applied. Access to the right hemithorax through a right posterolateral thoracotomy was chosen in all cases. The lung was mobilized and retracted anteriorly, and the mediastinal pleura incised at the level of the subcarinal region.

In patient #1, the left-bronchial stump was encircled, taped and closed with a TA stapling device (Autosuture Company Division, United States Surgical Corporation, Norwalk, CT, USA). In addition, the stump was covered with a pedicled pericardial flap, as reported previously [11]. Despite the fact that Gram stains as well as bacteriological tests gave no evidence of infection, a prophylactic rinsing of the left pleura space was established by placing two large-bore catheters in the left hemithorax after closing the thoracotomy.

In patient #2, with a diagnosis of a BEF, a large-bore tube placed inside the esophagus aided the identification of this
structure during the dissection of the tracheal bifurcation. The azygos vein was ligated and divided, and the whole area of the carina and the esophagus was dissected. The remnant of the left bronchus was stapled parallel to the carina, cross-sectioned and the distal segment of the stump was then resected until its communication with the esophagus. Thereafter, the esophageal ending of the fistula was stapled. In addition, a pedicled flap of mediastinal tissue was sectioned and the distal segment of the stump was then stapled parallel to the carina, cross-sectioned and the distal segment of the stump was then resected until its communication with the esophagus. Thereafter, the esophageal ending of the fistula was stapled. In addition, a pedicled flap of mediastinal tissue was attached to the suture lines (Fig. 1).

In patient #3, primary repair of a BPF through the aforementioned incision was performed. Dissection of the subcarinal region allowed the identification of a long left-bronchial stump, which was transected at the level of the carina using a TA stapling device and subsequently resected. The remaining small cavity of the left pleural space was managed by debridement and drainage also from the right approach.

Patient #4 underwent induction chemotherapy followed by left pneumonectomy 4 years ago. Thereafter, she was diagnosed with left BPF due local recurrence of neuroendocrine carcinoma at the tip of the remaining bronchial stump. A right posterolateral thoracotomy was performed, and central extracorporeal membrane oxygenation (ECMO) cannulation was established to provide intra-operative stability, especially when dissecting the carinal area. En bloc resection of the LMBS together with the carina, and a tangential resection of the esophageal wall were performed. At the end of the procedure, systematic mediastinal lymphadenectomy and coverage of the anastomosis using a pedicled omental flap was done. Total ECMO time was 135 min.

Patient #5 underwent a left pneumonectomy and mediastinal lymphadenectomy due to atelectasis of infectious origin (malignancy was suspected; however, definite pathology revealed tuberculosis as the underlying cause). Twelve days postoperatively, a diagnosis of BPF was made. Again, a right-sided procedure via a posterolateral thoracotomy was chosen. After opening the mediastinal pleura, the LMBS was re-stapled parallel to the carina (without shortening) and covered with pericardial fat pad and mediastinal tissue. Preoperative cultures revealed the presence of pleural empyema associated with the BPF. Hence, the left pleural space was drained and sterilized with a mixture of antibiotics, and the wound infection treated by means of a VAC® system.

### 3. Results

The main results are depicted in Table 1. In all cases, encircling of the LMBS and stapling at the level of the carina were performed without difficulties. All patients were extubated in the operating room, and the postoperative course was uneventful. The duration of the pleural irrigation system was 7 days in patients #1 and #5, and they were both removed after repeated negative bacteriological tests. During the whole period of follow-up, no evidence of BPF has been documented in any patient, who are all doing well with excellent general condition. Only patient #5 had a solitary skin metastasis removed 1 year later.

### 4. Discussion

The surgical approach for management of LMBS problems is difficult, especially as a direct access to the LMBS through the post-pneumonectomy cavity owns major disadvantages. There are a number of different indications for re-operation on an LMBS. The most frequent indication is a benign fistula into the post-pneumonectomy cavity. In such a situation, interventions in presence of empyema have to be differed from interventions when the post-pneumonectomy cavity is not yet infected. In rare cases, a fistula can also communicate with the thoracic esophagus. Finally, there are very few patients, who might present with a well-localized tumor recurrence on the bronchial stump after a history of former pneumonectomy.

The natural approach to the LMBS would of course be through the left post-pneumonectomy cavity. However, this approach is difficult and owns specific risks at the same time. In presence of an early postoperative BPF and acute empyema, any re-suturing, re-stapling or coverage of a BPF is difficult and frequently results in fistula recurrence, due to the manipulation within an infected space. In chronic cases, the already existing scarifications and the dense cortex in the pleural cavity significantly increase the difficulties of the surgical dissection. Not surprisingly, there are no clear published data about the results of such an approach, and therefore the expected success rate must be estimated considerably low.

### Table 1. Patients’ clinical features.

<table>
<thead>
<tr>
<th>Symptoms</th>
<th>Patient 1</th>
<th>Patient 2</th>
<th>Patient 3</th>
<th>Patient 4</th>
<th>Patient 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chest pain</td>
<td>Aspiration pneumonia, fever, dyspnea</td>
<td></td>
<td>Respiratory failure</td>
<td>Asymptomatic</td>
<td>Fever, putrid secretion, respiratory failure 60</td>
</tr>
<tr>
<td>Age</td>
<td>48</td>
<td>28</td>
<td>5</td>
<td>57</td>
<td>5</td>
</tr>
<tr>
<td>Gender</td>
<td>Adenoc. lung</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Disease</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type of fistula</td>
<td>BPF</td>
<td>BEF</td>
<td>BPF</td>
<td>BPF</td>
<td>BPF</td>
</tr>
<tr>
<td>Interval from pneumonectomy</td>
<td>6 months</td>
<td>24 years</td>
<td>1.5 years</td>
<td>4 years</td>
<td>12 days</td>
</tr>
<tr>
<td>Procedure</td>
<td>Stump resection + pericardial flap</td>
<td>Stump resection + fat pad</td>
<td>Stump resection + fat pad</td>
<td>Stump + carinal resection + omental flap</td>
<td>Stump stapling + pericard. flap</td>
</tr>
<tr>
<td>Outcomes</td>
<td>No recurrence of fistula</td>
<td>No recurrence of fistula</td>
<td>No recurrence of fistula 1 year</td>
<td>No recurrence of tumor 2 years</td>
<td>No recurrence of fistula</td>
</tr>
<tr>
<td>Follow-up</td>
<td>7 months</td>
<td>6 years</td>
<td></td>
<td></td>
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</tbody>
</table>

BPF: bronchopleural fistula; and BEF: bronchoesophageal fistula.
Padhi and Lynn [5], in 1960, described for the first time an alternative access route, the so-called transpericardial approach for management of bronchial stump fistulas, by performing an anterior thoracotomy with division of several costal cartilages. One year later, Abruzzini [6] developed the transternal transpericardial approach, which was popularized thereafter by Perelman and Ambatiello [8] (Table 2).

The value of this technique was re-emphasized by De la Riviere [12], Misthos [13] and Topcuoglu [14], recently, due to the advantages of working in an aseptic and previously untouched operative field. Another proposed benefit is that the transternal route interferes little with the ventilation of the residual lung. However, the procedure demands both high technical skills and the presence of a long bronchial stump. Retraction of the superior vena cava and the aorta may cause an intra-operative decrease in systolic arterial pressure or cardiac arrhythmias. In addition, posterior pneumonec-tomy mediastinal displacement can make the access to the left hilum very difficult; and problems with sternal wound healing might arise afterwards.

With the introduction of trans-mediastinal video-assisted mediastinoscopy, a new route for accessing the LMBS became available. Azorin, in 1996 [7], described for the first time such a procedure. This approach is clearly less invasive compared with the transpericardial or transthoracic routes. However, it needs a minimum length of 10 mm of the bronchial stump to allow closure by re-stapling. A good exposure of the left-bronchial stump is difficult to achieve, and placement of a stapling device might also be difficult in the presence of chronic inflammation of the surrounding tissue. Most importantly, it is not possible to gain complete control of great vessels due to the limited exposure, which makes surgical handling of arising bleeding complications difficult.

For all these reasons, the so-far-described major limitations of a direct or a trans-mediastinal approach to the LMBS suggest an alternative route through the right hemithorax. In fact, carinal resection from the right side is an established procedure and its feasibility has been demonstrated repetitively, as it provides widespread and convenient access to the tracheobronchial bifurcation [15]. Furthermore, left-tracheal-sleeve pneumonectomies through a right posterolateral thoracotomy have been described for tumors located in the LMBS extending proximally. It is therefore surprising that management of the LMBS problems through the right thorax has been reported in the literature only once. This contribution again results from Perelman, who published, in 1970, his experience with this procedure [8].

In our institution, the right posterolateral approach for LMBS problems has been used for several years. In this retrospective review, we summarize our experience in a total of five cases with different indications.

All cases had in common the straight formal access to the LMBS through the formerly untouched area of the right hemithorax. Encircling of the bronchial stump and stapling at the level of the carina were performed without any difficulties. If indicated, the resection of the bronchial stump remnant was added, with the major advantage of direct visibility and control of neighboring vascular structures. Definitely, this complete control in our opinion is one of the most important arguments in favor of such an approach. On the contrary, in patients in whom extrathoracic muscles’ transposition or tailored thoracoplasties are expected to be needed due to the presence of large fistulas, obviously, the right thoracotomy does not represent the best access.

Although in most of our cases the bronchial stump was long enough to allow encircling and placing of a stapling device, this approach can as well be applied in the situation of a very short stump with the fistula arising close to the main carina, as complete control of the carinal area is provided. In fact, in patient #4 an en bloc resection of the LMBS and the carina was performed through the right-sided route.

Ventilation of the patients during the procedure was performed without problems. A single-lumen tube was used and the right lung was pushed into an anterior position. A protective ventilation strategy was used, based on PCV, limiting tidal volumes to 5–7 ml kg\(^{-1}\), inspiration-to-expiration ratio of 1:2, \(\text{FiO}_{2}\) of 1.0, and adjusting the respiratory rate to maintain \(\text{PaCO}_2\) between 35 and 40 mmHg. Fluid overload was avoided, using less than 3 L of crystalloids in the first 24 h. In case of hypoxemia, recruitment maneuvers were initiated and, if not sufficient, a PEEP of 5 mmHg was applied. This provided complete hemodynamical and ventilatory stability during the whole operative procedure, which lasted between 70 and 120 min. Only in case #4, in which the whole carina until the orifice of the right upper lobe bronchus was resected, a temporary cardiopulmonary support with central ECMO application was chosen to provide the necessary intraoperative stability. The use of ECMO in this patient was only to prevent from any possible destabilization, especially when resecting the carina. However, the authors acknowledge that the need of any circulatory assist might have been obviated with the transternal transpericardial approach.

Another important issue is the coverage of the resected stump. Several types of pedicled flaps deriving from pleura, intercostal muscle, pericardial fat pad, diaphragm, azygos vein and pericardial pedicles have been used for bronchial stump reinforcement. Such a procedure is strongly recommended in all patients, but even more in patients after prior chemo-/radiotherapy, pleural infection, malnutrition, or prolonged mechanical ventilation. Due to its easy handling and high biological quality, the use of the pedicled pericardial flap has become the preferred coverage method in our department [15]. In patients #1 and #5, such a pedicled

<table>
<thead>
<tr>
<th>Author</th>
<th>Year</th>
<th>Procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Padhi and Lynn</td>
<td>1960</td>
<td>Transpercardial approach</td>
</tr>
<tr>
<td>Abruzzini</td>
<td>1961</td>
<td>Transternal transpericald approach</td>
</tr>
<tr>
<td>Clagett and Geraci</td>
<td>1963</td>
<td>Chronic open window for managing empyema</td>
</tr>
<tr>
<td>Perelman and</td>
<td>1970</td>
<td>Contralateral thoracotomy</td>
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<td>Ambatiello</td>
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<tr>
<td>Pairello et al.</td>
<td>1990</td>
<td>Modified Clagett procedure</td>
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<tr>
<td>Azorin et al.</td>
<td>1996</td>
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pericardial flap was used to reinforce the bronchial stump. However, in patients #2 and #3, a simple mediastinal fat tissue flap was used, and a pedicled omental flap was attached in patient #4.

What remains to be discussed is the management of the residual post-pneumonectomy space. This has to be done according to the specific situation in each case. If a frank empyema is present, a separate approach through a left lateral incision for cleaning of the empyema becomes necessary. Depending on the situation, this can result either in open/closed management [16] or in conventional open window thoracotomy. However, in the two cases of BPF with associated empyema, the infection was minimal and therefore the cavity was only rinsed, or there was a small cavity that was easily cleaned from the right side. Nevertheless, the major advantage of the right-sided approach lies in the fact that both problems, closure of the stump and cleaning of the cavity, can be managed separately.

Another question of concern is regarding possible complications of thoracotomy that could obviously occur within the operative field postoperatively, such as hemothorax or empyema. One should keep this in mind when dissecting the mediastinum; hence, expeditious hemostasis is of key importance. However, in the present series, the authors did not find any complication related either with the approach or with the procedure itself, which emphasizes its feasibility and low morbidity compared with the direct approach through the infected pneumonectomy cavity or the transternal transpericardial approach, which implicates the manipulation of pericardium and great vessels and the risks of performing a sternotomy.

In conclusion, we advocate the right posterolateral thoracotomy route for management of left-sided BPFs as an alternative to transternal transpericardial and transthoracic closures, especially when extensive fibrosis and shrinkage of the mediastinum is expected or after several attempts to treat a BPF. Its feasibility and excellent immediate and midterm results support the rediscovery of this time-honored procedure in selected patients. It comprises the advantages of being a time-efficient method, of being a very safe approach where complete control of all central structures can be achieved and, in addition, it avoids infected or previously manipulated areas, the risk of sternum infection and all other sorts of risks combined with handling of the bronchial stump through a contaminated field.

References