Surgical approaches for bronchopleural fistula

Guilherme Dal Agnol[1], Arthur Vieira[2], Ricardo Oliveira[2], Paula Antonia Ugalde Figueroa[2]

[1]Department of Thoracic Surgery, Americas Medical Center, Rio de Janeiro, Brazil; [2]Department of Thoracic Surgery, Research Centre, Institut universitaire de cardiologie et de pneumologie de Québec, Université Laval, (IUCPQ-UL), Chemin Sainte-Foy, Quebec City, Canada

Contributions: (I) Conception and design: G Dal Agnol; (II) Administrative support: All authors; (III) Provision of study materials or patients: PA Ugalde Figueroa; (IV) Collection and assembly of data: G Dal Agnol; (V) Data analysis and interpretation: All authors; (VI) Manuscript writing: All authors; (VII) Final approval of manuscript: All authors.

Correspondence to: Guilherme Dal Agnol, MD. Av. Henrique Dumont, 68/203, Rio de Janeiro, 22410-060, Brazil. Email: gdalagnol@yahoo.com.br.

Abstract: Bronchopleural fistula (BPF) is defined as a direct communication between the bronchus and the pleural space. The low incidence of tuberculosis added to the development of technical and surgical thoracic equipment has greatly decreased its incidence. However, despite surgical refinement, postpneumonectomy BPF is still a severe postoperative complication with high rates of morbidity and mortality. Postlobectomy BPF, however, occurs in less than 1% of patients and has a much lower mortality rate. The clinical suspicion of BPF obligates an urgent and objective investigation that allows proper decision-making for the management of this highly morbid complication. Despite all medical and technical advances, BPF remains a challenge to the thoracic surgeon. The focus of this chapter is to review the surgical approaches to BPF.

Keywords: Bronchopleural fistula (BPF); approaches for BPF; treatment of BPF

Received: 11 June 2017; Accepted: 30 June 2017; Published: 13 July 2017.
doi: 10.21037/shc.2017.06.01
View this article at: http://dx.doi.org/10.21037/shc.2017.06.01

Introduction

Bronchopleural fistula (BPF) is defined as a direct communication between the bronchus and the pleural space. BPF can be classified as central, which are fistulous connections between the trachea or a lobar bronchus and the pleural space, or peripheral, which are fistulous connections between the distal airway (segmental bronchi or lung parenchyma) and the pleural space.

In the mid 1950s to early 1960s, the vast majority of BPFs were secondary to pulmonary tuberculosis infection. As drug therapy for tuberculosis has improved, this complication has considerably decreased (1). Currently, complications during bronchopulmonary procedures are the leading cause of BPF despite refinements in surgical techniques and surgical equipment (2-4). Postpneumonectomy BPF is a severe postoperative complication with high rates of morbidity and mortality (5,6). Postlobectomy BPF, however, occurs in less than 1% of patients and has a much lower mortality rate (1,7,8). More rarely, benign pathologies, such as necrotizing pneumonia, empyema, tuberculosis, aspergillosis, granulomatosis with polyangiitis, rheumatologic conditions and pulmonary sarcoidosis, can cause BPF (9).

The clinical suspicion of BPF obligates an urgent and objective investigation that allows proper decision-making for the management of this highly morbid complication. Despite all medical and technical advances, BPF remains a challenge to the thoracic surgeon. In this chapter we will discuss the management of central BPF.

Presentation

Modern lung surgery relies on staplers to transect and seal the bronchus. This strategy has decreased the likelihood of an early postoperative BPF as compared with the hand-sewn techniques used previously. Bronchial fistulas are detected most frequently between the 1st week and 3rd month postoperatively (10) with a peak in incidence between the 8th and 12th postoperative days (8,11). The diagnosis of BPF can be a clinical challenge, but a combination of imaging techniques and invasive procedures, such as bronchoscopy with or without surgical exploration, are used to define the

Table 1 Symptoms and signs of BPF according to clinical presentation

Acute
Tension pneumothorax
Subcutaneous emphysema
Sudden expectoration of purulent sputum
Acute cough
Dyspnea
Mediastinal and tracheal shifts
Acute decrease of the pleural liquid level
Subacute and chronic
Empyema
Productive cough
Fever
Leukocytosis
Progressive clinical deterioration

BPF, bronchopleural fistula.

location and the clinical presentation of BPF.

The clinical presentation of a BPF can be acute, subacute, or chronic depending on the timing of surgery (*Table 1*). This differentiation is important in selecting the proper treatment. In an acute case due to a massive air leak, the patient will present with a tension pneumothorax and subcutaneous emphysema. If the chest tube still in place, an important air leak will be seen at the water seal (12). Sudden expectoration of purulent sputum, acute cough, dyspnea, and mediastinal and tracheal shifts are also common findings. In postpneumonectomy patients, an acute decrease in the pleural liquid level is the common presentation (13). The subacute and chronic clinical presentations of BPF are usually associated with an infected pleural space (empyema) and present with more insidious symptoms with productive cough, fever, leukocytosis, and progressive clinical deterioration with varying levels of respiratory compromise (13).

Risk factors

There are several known clinical risk factors for postoperative BPF including the patient's clinical condition preoperatively and the technical features of the surgical procedure performed (*Table 2*). Diabetes mellitus and chronic obstructive pulmonary disease (COPD) are independent risk factors for postoperative BPF (14,15). Age (>70 years), anemia, adult respiratory distress syndrome, poor nutrition, hypoalbuminemia, systemic use of steroids, empyema, neoadjuvant therapy with chemotherapy or radiation, and tracheostomy have also been described as risk factors for BPF (8,16-23).

Table 2 Risk factors for BPF

Systemic
Poor nutrition
Sepsis
Immunosuppression
Diabetes mellitus
COPD
Anemia
Local
Neoadjuvant therapy
Poor blood supply
Active infection
Long bronchial stump
Extended lymph node dissection
Residual or recurrent cancer at the bronchial stump
Devascularization of bronchial stump
Other
Postoperative mechanical ventilation
Steroid use
Right pneumonectomy
Bronchial stump by hand-sewn
Tracheostomy
Smoking

BPF, bronchopleural fistula; COPD, chronic obstructive pulmonary disease.

Technical mistakes that can ultimately result in a BPF include a long bronchial stump, disrupted bronchial blood supply, inadequate stump closure, and extended bronchial resection (24). Residual carcinoma at the bronchial stump also increases the chances of BPF (25). BPF is 4 to 5 times more likely after right pneumonectomy as compared with left pneumonectomy (20,26). It is not clear why postpneumonectomy fistulas are more common on the right side than on the left. However, the decreased mediastinal tissue coverage of the right bronchial stump and lack

Figure 1 A small BPF identified by bronchoscopy after a right lower lobectomy. BPF, bronchopleural fistula.

of a dual blood supply to the right main bronchus may contribute to the increased incidence of BPF after right pneumonectomy. Therefore, coverage of the bronchial stump with a well-vascularized flap is strongly suggested (27). Additionally, postoperative ventilator assistance can affect stump healing and the incidence of dehiscence (17,18,20).

Investigation

When investigating a possible BPF, the objective is to estimate the size and precise location of the BPF, understand its relationship to adjacent mediastinal structures, and identify any secondary complications.

Bronchoscopy

Bronchoscopy is essential for BFP diagnosis and therapeutic planning and can establish the location and size of a BPF with precision (*Figure 1*). Definitive treatment can sometimes be administered through an endobronchial approach.

Chest radiography

A chest X-ray is the simplest and easiest test to investigate a BPF. The presence of increased intrapleural air space, the appearance of an air-fluid level, and the development of a tension pneumothorax are classical findings of BPF (10,28). A new or larger pneumothorax—commonly noted as a decrease in the air-fluid level, a shift of the mediastinum contralateral to the surgical side, and subcutaneous emphysema—is suggestive of a BPF and warrants a thorough investigation (29). The diagnosis of BPF is

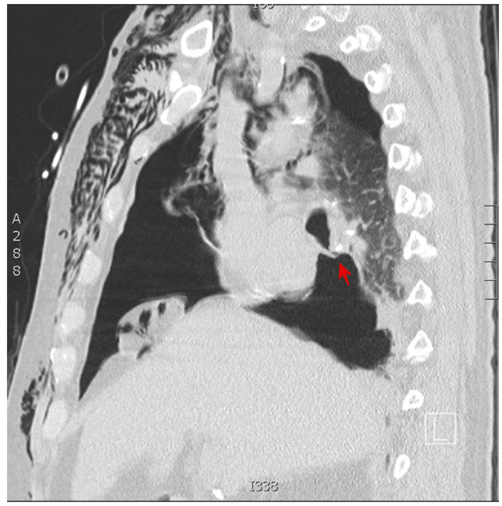

Figure 2 BPF after lung resection. BPF, bronchopleural fistula.

an exclusion diagnosis related to postoperative pleural fluid shifts (30). Rarely, a decrease in the air-fluid level in the postpneumonectomy cavity will not be associated with BPF.

Chest computed tomography (CT)

A chest CT scan should be acquired with intravenous contrast to define the anatomic relationship of the fistula with adjacent vasculature, mediastinal structures, pleural space, and the diaphragm (*Figure 2*). A chest CT can also identify peripheral rind enhancement and air-fluid levels suggestive of localized or multi-loculated empyema (9) (*Figure 3*).

Virtual bronchoscopy

Virtual bronchoscopy is a 3-dimensional reconstruction of 2-dimensional, helical CT images that provides a simulated, noninvasive, intraluminal tracheo-bronchial evaluation (9). This test essentially allows a complete view of the airway beyond any obstruction. Virtual bronchoscopy can be used prior to endobronchial procedures such as bronchial stent placement. Acute angles in the tracheo-bronchial tree can be studied extensively when planning stent deployment and when evaluating airway complications after stent placement (31,32). Virtual bronchoscopy can also be a useful method for monitoring the healing process (33,34) and evaluating the internal diameter of the bronchial stump prior to the application of sealants.

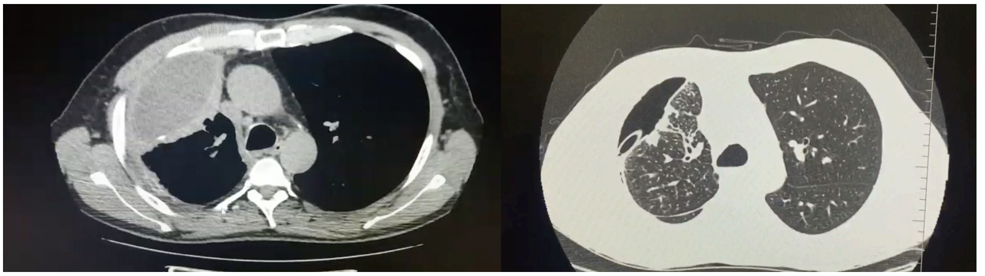

Figure 3 BPF and empyema after wedge resection in patient with lung cancer. BPF, bronchopleural fistula.

Nuclear medicine

Nuclear medicine can be considered when CT scans and bronchoscopy cannot identify or sufficiently characterize a fistula (35,36). In one study of ventilation scintigraphy in 28 postpneumonectomy patients, this nuclear medicine technique using 99 m Tc-diethylenetriamine penta-acetate aerosol had a sensitivity of 78% and a specificity of 100% for the detection of BPF, with 86% accuracy (35).

Management

Preventative steps

To reduce the risk of BPF development, the majority of the studies recommend prophylactic bronchial stump coverage in patients with known preoperative risk factors for fistula. The benefit of prophylactic bronchial stump coverage has not been proved by randomized trials, and some of the data in the literature is controversial. In a recent meta-analysis, the incidence of BPF in patients considered at high risk for BPF who received bronchial stump coverage was only slightly higher as compared with patients considered at low risk for BPF who did not undergo prophylactic stump coverage (6.3% *vs.* 4.0%) (37). In another study, Sfyridis and colleagues randomized patients with diabetes mellitus who underwent pneumonectomy to either resection with reinforcement of the bronchial stump with an intercostal muscle flap or to a conventional resection. The patients who received an intercostal muscle flap had a lower incidence of BPF as compared with the patients who underwent conventional resection (0% *vs.* 17.1%) (38).

Initial management

Patients with BPF are at high risk of bronchial aspiration, aspiration pneumonia, acute respiratory distress syndrome, and mortality (3,23,39). Protecting the contralateral lung from spillage of pleural fluid is the single most important action when BPF is suspected (9). It is then imperative to rapidly diagnose and manage the BPF.

Appropriate management of a BPF depends on the type of fistula and the clinical condition of the patient. In undernourished patients with chronic BPF and empyema, nutritional rehabilitation has to start before planning a definitive fistula repair (40). Conversely, in patients with acute fistulas, rapid intervention to close the bronchial stump and obliterate the residual pleural space should be performed (1,41,42). Independent of the timing of the BPF, broad-spectrum antibiotics, aggressive nutritional supplementation, and adequate pleural drainage are key to recovery, because almost 80% of patients with BPF have pleural empyema (43).

Noninvasive treatment

On occasion, conservative treatment with antibiotics, nutritional support and proper pleural drainage may allow spontaneous closure of BPF. This noninvasive option is simple; however, the safety of the patent must be ensured. It is particularly useful in patients with postlobectomy fistulas when there is minimal residual pleural space and the air leak progressively decreases (1).

Patching a BPF

BPF are frequently patched with a muscle flap. The principles for a complete closure include (I) antibiotics for pleural sterilization; (II) completed drainage of the pleural space before reoperation; (III) preserving the integrity of the blood supply to the chest wall muscles; (VI) wide debridement and removal of all granulation tissue; (V) identification and closure of the fistula; and (VI) filling the residual space with a vascularized flap (44-47). Several anatomic structures have been used to patch BPFs (*Table 3*).

Table 3 Anatomic structures used to patch BPF

Anatomic structure	Comments
Azygous vein	Used in rare cases
Diaphragm	A diaphragmatic flap can be used to reduce the pleural cavity by elevating the remaining diaphragm (48-50)
	Used in rare cases
Epicardial fat	Used in rare cases
Intercostal muscle	One of the most used muscle grafts due to its wide availability, simplicity to harvest, good vascularization, and length
	A single intercostal flap or multiple intercostal flaps may be used to reinforce a fistula suture and fill the residual space (51)
Latissimus dorsi	Excellent option
	A bulky muscle that is easy to harvest
	Blood supply is from the thoracodorsal artery
	One of the most frequently used flaps due to its ability to protect the stump and fill the residual space (52,53)
Omentum	A good choice for the obliteration of the fistula and the pleural space due to its bulkiness and optimal vascular supply
	The omentum is passed through the substernal space. Due to its singular vascular supply, great care must be taken not to twist the omentum when entering the pleural cavity (54-59)
Parietal pleura	Used in rare cases
Pectoralis major	A particularly good option
	Dual vascularization from the internal mammary and the thoracoabdominal artery (60)
Rectus abdominis	Excellent vascular muscle flap
	Bilateral option
	Vascularization from the inferior epigastric artery
Serratus anterior	Small and thin muscle
	Vascularization from the lateral thoracic artery
	Easy utilization and insertion in the pleural cavity (61)

The serratus anterior and the latissimus dorsi muscles have been described in the treatment of infected residual spaces (1,61-66), with or without BPF (52) without significant addition of morbidity (67). However, use of these muscles as a patch is contraindicated if the muscle was previously divided (15,68).

Management of the pleural space

When caring for patients with BPF or attempting to avoid BPF in high-risk patients, reduction of the pleural space enables resolution of any empyema and facilitates the closure of small peripheral BPFs. Several procedures have been described to manage the pleural space including pleural tenting, pneumoperitoneum, phrenic nerve block, the Clagett procedure, and open-window thoracotomy (69,70).

Pleural tenting

During the history of general thoracic surgery, many methods have been tried to prevent residual air spaces after thoracic surgery, especially after lung resection for inflammatory lung disease. Pleural tenting is an old method, first described by Miscall and colleagues (71) and Hansen (72), that has recently regained popularity (73-75). This technique is used to reduce the apical pleural space and requires dissection of the parietal pleura off the endothoracic fascia, from the thoracotomy incision towards the apex of the chest cavity. The mobilized parietal pleura

Figure 4 Open-window thoracotomy.

are then tented over the residual lung by suturing the border of the pleura to the lower edge of the thoracotomy (72). Importantly, chest tubes should to be placed under the tent. A recent meta-analysis defined pleural tenting as simple and easy to perform. Also, tenting did not prolong the duration of the operation and was not associated with greater morbidity as compared with upper lobectomy without tenting (76).

Pneumoperitoneum

Pneumoperitoneum is the injection of air into the abdominal cavity, causing an elevation of the hemi-diaphragm and thus reducing the residual pleural space postoperatively. In 1924, Reich and colleagues first described the use of pneumoperitoneum for patients with emphysema (77); Carter and colleagues later confirmed the safety of the procedure (78). The main indications for institution of pneumoperitoneum are postoperative residual pleural space, incomplete lung re-expansion after empyema decortication, and severe pleural space problems in adult patients (79). It is also indicated as an adjunct to block major air leaks. Pneumoperitoneum is a safe and effective procedure (79,80) performed with the aid of imaging exams to guide the introduction of air. A catheter is left in place to progressively inject air in the abdomen (79-81).

Phrenic nerve block

Phrenic nerve block is a simple technique that allows temporary reduction of the pleural cavity by raising the dome of the diaphragm. The phrenic nerve block is performed with bupivacaine (0.5%) without epinephrine at the neurovascular pedicle at the level of the pericardium (82). The effect usually lasts 24 hours. This procedure is contraindicated in patients with limited lung function (82).

Clagett procedure

In 1963, Clagett and Geraci (61) described a technique for the management of postpneumonectomy empyema. The technique was a 2-stage procedure: open pleural drainage for control of the septic cavity and closure of BPF and then obliteration of the pleural cavity with antibiotic solution. The Clagett procedure has been reported to be effective in 88% of patients, with failures resulting from persistent or recurrent BPF (83). In an attempt to address these failures, Pairolero and Arnold (84) described the transposition of a well-vascularized extrathoracic muscle as an intermediate step. This modification of the "Clagett" procedure was designed to further reinforce the bronchial stump and to decrease the size of the pleural cavity.

Open-window thoracotomy

The open-window thoracostomy (*Figure 4*) is an ideal method for draining the septic pleural cavity in patients with empyema after a pulmonary resection (61,85,86), especially in patients with a postpneumonectomy BPF with empyema (87). Open-window thoracostomy was first described by Robinson in 1916 (88) in patients with nontuberculous empyema, and was subsequently revised in 1935 by Eloesser (89) for patients with tuberculous empyema. The Eloesser procedure added the resection of 2-to-3 rib segments and the creation of a skin flap used to epithelialize the entryway in the pleural space. The window should be placed, low and anterior in the chest to facilitate drainage (89).

The timing of attempting to close the window created during open-window thoracostomy is usually dictated by the condition of the pleural cavity and the prognosis of the patient (90). When the pleural space is clean, as characterized by the presence of healthy granulation tissue,

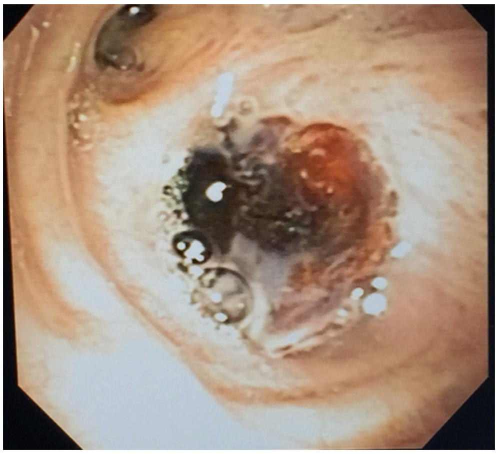

Figure 5 Use of bioglue in small BPF. BPF, bronchopleural fistula.

it can be closed (66). There is some controversy on the timing for closing the window, but in most cases closure is warranted ~6 months after thoracostomy (90).

Endoscopic treatment

History and indications

Although it is primarily used for diagnostic purposes, flexible bronchoscopy has been gaining ground as a therapeutic modality in patients with BPF and has evolved to treat central BPF, primarily after lobectomy and less frequently after pneumonectomy. In 1983, Roksvaag and colleagues (91) reported two cases of postpneumonectomy BPF closure with synthetic tissue glue applied endoscopically. Several other cases have been reported since then, and endoscopic techniques are considered a safe and feasible alternative to open surgery for management of BPF (92,93).

Despite the fact that surgery is the standard of care for a central BPF when properly indicated, a less invasive approach can be a bridge to a definitive treatment in fragile patients. The primary objective of endoscopic BPF closure is to reduce a potentially life-threatening air leak, prevent aspiration of pleural fluid, and decrease secondary pleural contamination. Once the patient's clinical condition and nutritional status improve definitive surgical treatment can be attempted (13). Eventually endoscopic treatment can potentially result in long-term BPF closure and complete empyema resolution without requiring permanent-tube thoracostomy or open pleural drainage (92).

Different techniques through flexible or rigid bronchoscopes are available and can be performed under conscious sedation or general anesthesia. These approaches mainly differ in the material used to close the fistula. Success rates reported in retrospective series range widely—from 22.5% to 96.9% (94). This might indirectly represent the lack of standard practices in the endoscopic management of BPF.

Fistula size

Fistula size is one factor that determines whether an endoscopic approach is an appropriate treatment. Smaller fistulas are more suitable for endoscopic closure (92,94,95). In a retrospective series of 35 patients who underwent bronchoscopic repair of BPFs after pneumonectomy, repair was successful in 92.3% of patients with BPFs ≤2 mm in size, 71.4% for BPF >2 and <3 mm, 80% for BPF >3 and <6 mm, and only 33.3% in patients with BPF >6 mm (96). The BPFs ≤2 mm in size were treated with mechanical abrasion causing local inflammation. BPF >2 and <3 mm were treated with submucosal injection of polidocanol; BPF >3 and <6 mm were treated with n-butyl-2-cyanoacrylate glue (Histoacryl) instillation. BPF >6 mm were treated via insertion of an expandable substance filled with fluid n-butyl-2-cyanoacrylate glue to occlude the fistula (94). Before applying any endoscopic therapy, it is advisable to clear secretions and debris from the bronchial stump (97). Mucosa necrosis has been described as an indication for surgical treatment (94).

Biological glues

Several types of biological glues with different components have been used for endoscopic BPF closure including fibrin-based glues, cyanoacrylate-based glues (e.g., Histoacryl, TissueSeal, Ann Arbor MI), and albumin-glutaraldehyde tissue adhesive (BioGlue, BioLife Inc., Kennesaw, GA) (96,98-100). Regardless of the glue type, the application technique is very similar. A catheter (e.g., Fogarty n°5) is inserted through the working channel of a flexible bronchoscope and placed just above the fistula. The glue is then injected into the fistula, and after a few seconds, it creates a plug that occludes the fistula (*Figure 5*). Alternatively, some authors (96) have injected the glue in the submucosa with a 21G needle in favor of a theoretically more effective closure due to less glue displacement. An air-leak interruption through the chest tube should be immediately observed. Close clinical and endoscopic surveillance is important for identification of failure to plug the fistula. The need for repeated endoscopic glue applications for successful closure is not uncommon (91). Following mechanical occlusion, the glue induces scar tissue formation, which helps achieve long-term BPF closure (101).

The application of biological glues has some positive aspects, such as (I) potentially providing an instantaneous closure of the BPF, which plays a key role in preventing the development of pleural space infection or treating an empyema that is already onset and (II) using a tool (biological glue) that is already widely applied on humans in a variety of procedures with low risks of complications.

Sclerosing agents

Endoscopic submucosal injection of sclerosing substances or direct application of these agents over the mucosa of the bronchial stump can be used to close BPF by promoting local edema and tissue-healing processes (93,102). Silver nitrate causes cellular damage, because it burns the superficial layer and induces local inflammation and scar tissue formation. The application of sclerosing agents requires the expertise of a skilled endoscopist to avoid injury to surrounding tissues. It can be applied through rigid or flexible bronchoscopy (103). Stratakos and colleagues (104) reported an 81.8% success rate using this technique in a small series of 11 patients with postpneumonectomy or postlobectomy BPF ≤5 mm in size. They applied melted silver nitrate through a flexible bronchoscope until blanching and edema of the mucosa appeared around the fistula. The procedure was repeated up to 10 times at 5- to 7-day intervals until effective sealing was achieved. Boudaya and colleagues (102) successfully treated 16 of 17 patients with postoperative BPFs, mostly ≤5 mm (a success rate of 94.1%). Liquid silver nitrate (1%) was applied around the stump mucosa under direct vision with a catheter through the working channel of a flexible bronchoscope. A solution of 100% carbolic acid has also been used with similar technique, mechanism of action and results for BPF with a median diameter of 4.5 mm (105).

Video-assisted thoracic surgery (VATS)

Several reports have described video-assisted surgery for the closure of BPF. The main benefits of VATS are better visualization, which allows more secure fixation of the vascularized grafts, and a decreased need for intervention as compared with the open approaches discussed below.

Open surgical treatment of BPF

Dehiscence of the bronchial stump after anatomic resection remains the most common cause of BPF (9). Therefore, prevention through complete preoperative evaluation and safe decision-making during surgery is the best way to avoid this complication (11). Standard procedures to reduce the likelihood of BPF in patients at risk include ensuring an appropriate vascular supply to the stump, creating a bronchial stump <1 cm long, and prophylactically covering the bronchial stump with a vascularized flap (1).

Treatment principles

Only a small percentage of BPF will spontaneously close, typically BPF that occur after anatomic segmentectomy or lobectomy where the residual pleural space is small in patients who are healthy otherwise (1). BPF is habitually accompanied by empyema, which can range from exudative pleural effusion to a more chronic fibrinopurulent effusion. So ideally, the repair of the fistula should be performed once the pleural cavity is clean. Ignoring this rule will most certainly result in poor outcome (61,65).

Early BPF

Initial management of a BPF that occurs early after surgery (within 2 weeks) is dependent on drainage of the pleural space with a large chest tube (32F or higher) and positioning the patient in the reverse Trendelenburg position with the affected side down to prevent compromising the contralateral lung. Fluid cultures must be requested, and broad-spectrum antibiotics should be started immediately and continued until culture results are available to dictate a more specific antibiotic range (84).

Early postoperative stump leaks require urgent intervention. After initial bedside management is initiated, an individualized strategy must be planned, and a surgical procedure must take place after the infection is under control (106). Classical surgical management consists of thoracotomy (opening of the previous incision), inspection and searching for the leaking site, debridement of fibrin and infected pleural residue, irrigation of the cavity with antibiotic solution, resection of necrotic tissue around the stump, reclosure with non-absorbable sutures , and reinforcement of the suture with a vascularized pedicle patch (1,82). The most commonly used vascularized patches are derived from the intercostal muscles, serratus anterior, latissimus dorsi, pectoralis major, omental flap, or rectus abdominalis. If a long stump is noticed, it must be resected to its origin and restapled, if possible. Pleurostomy may be performed depending on the size of the fistula, state of infection of the cavity or in poor surgical candidates.

Late BPF

Late postoperative BPF (2 weeks and more after surgery) may require a longer course of treatment. After initial drainage, definitive treatment should be delayed until the infection is under control and the nutritional status of the patient is optimal. Several techniques have been described for the treatment of a BPF occurring late after surgery, ranging from open thoracostomy (Eloesser Flap) to the Clagett or modified Clagett procedure (61,65).

The Clagett procedure, a two-step procedure, begins with open pleural drainage (through an open-window thoracostomy) and resuturing of the bronchial stump followed by packing the space one or two times a day with dressings imbibed with quarter-strength Dakin's solution or povidone-iodine solution diluted 20:1. After the cavity is judged clean, a second stage takes place that consists of the filling the pleural space with an antiseptic solution (Dab's solution—0.5 g of neomycin, 0.1 g of polymyxin B sulfate and 80 mg of gentamicin per liter of saline) followed by water-tight wound shutting (61). Zaheer and colleagues demonstrated a rate of success of over 80% with this technique (6).

A transsternal transpericardial approach for BPF repair was initially described by Abruzzini in 1961 and is an option that avoids entering a previous manipulated cavity (107). A full sternotomy is used to access the anterior pericardium, which is then opened. The pulmonary artery is mobilized, allowing opening of the posterior pericardium, and finally, exposure of the carina. The bronchial stump is identified, divided, and closed. A vascularized patch of pericardium is then used to reinforce the suture. Ginsberg and collaborators reported successful management in 77% of patients in their series using this approach (108).

Conclusions

In modern thoracic surgery, the incidence of BPF has substantially decreased due to improvements in preoperative evaluation and surgical techniques. However, BPF still represents a major complication in thoracic surgery that demands proper and accurate management.

Acknowledgments

Funding: None.

Footnote

Provenance and Peer Review: This article was commissioned by the Guest Editors (Marco Scarci, Alan D.L. Sihoe and Benedetta Bedetti) for the series "Open Thoracic Surgery" published in *Shanghai Chest*. The article has undergone external peer review.

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at http://dx.doi.org/10.21037/shc.2017.06.01). The series "Open Thoracic Surgery" was commissioned by the editorial office without any funding or sponsorship. The authors have no other conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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doi: 10.21037/shc.2017.06.01
Cite this article as: Dal Agnol G, Vieira A, Oliveira R, Ugalde Figueroa PA. Surgical approaches for bronchopleural fistula. Shanghai Chest 2017;1:14.

