

Diagnosis and management of bronchopleural fistula



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Introduction

A bronchopleural fistula (BPF) is a communication between the bronchial tree and the pleural space. More than two thirds of BPFs are postresectional, with an incidence ranging from 1.5-28 % after pneumonectomy, and 0.5% after lobectomy. Postresectional BPF is associated with mortality of 20-50 %.[1]

BPFs can present early (1-7 days), intermediate (8-30 days), or late (more than 30 days) after pulmonary resection. Early fistulas are usually associated with dehiscence of the bronchial stump, while late fistulas are usually associated with failed healing or infection.[2] Besides postresectional etiology, BPFs may be idiopathic, or secondary to necrotizing lung infections, persistent spontaneous pneumothorax, thoracic trauma, Adult respiratory distress syndrome, Tuberculosis, or postprocedural e. g. lung biopsy or bronchoscopy.[3]

Diagnosis and management of BPF is a major challenge for clinicians.

Diagnosis and localization of BPF may require multiple chest computed tomography (CT) imaging and bronchoscopies.[4] A BPF is usually a manifestation of the underlying lung disease, therefore, measures to reduce the air leak are generally unsuccessful until the patient's underlying lung disease has improved. Once there is diminished need for mechanical ventilation, the BPF almost always resolves without specific therapy, apart from controlling active infection and draining the pleural space adequately. Definitive repair using surgery or various bronchoscopic methods has been used to close BPF if either conservative management fails, or is not expected to succeed.[5]

Case Description

A 69 year old male with squamous cell carcinoma of the right lower lobe (RLL) of the lung underwent thoracotomy and RLL resection. The patient was discharged home on the 6th postoperative day after an uneventful hospital course. The patient presented to the emergency department of an outside hospital ten days later with fever and respiratory distress. Chest X-ray showed a large pneumothorax, and a right sided chest tube was placed. Pleural fluid was sent for culture and sensitivity, and later grew staphylococcus aureus. The patient's breathing continued to be labored, and was intubated urgently after failing a short trial of non-invasive positive pressure ventilation (PPV). A large air leak was observed through the chest tube with each positive pressure breath, even after placing the chest tube on continuous suction. Placement of an endobronchial valve to minimize air leak was attempted in the interventional bronchoscopy suite, but failed and was reported to be technically difficult. The patient was subsequently transferred to our hospital for further management.

On admission, ventilatory management in the intensive care unit (ICU) was geared towards lowering the tidal volume and plateau airway pressure to minimize the air leak. This was accomplished by providing partial ventilatory support using low rate synchronized intermittent mandatory ventilation (SIMV) and a high inspiratory flow rate, as well as decreasing PEEP, inspiratory to expiratory (I/E) ratio, and the tidal volume of each ventilator delivered breath. We used the least amount of chest tube suction that maintains lung inflation, treated bronchospasm aggressively, and continued

appropriate antibiotics. We suspected that the patient had a RLL airway stump dehiscence resulting in a BPF, and complicated with staphylococcus aureus empyema. Chest CT (Figure 1) showed a properly placed right sided chest tube surrounded by residual hydropneumothorax. Bronchoscopy showed a defect in the suture line of the RLL airway stump.

The patient was taken to the operating room (OR) to close the BPF through a right thoracotomy after switching the single lumen endotracheal tube to a left sided double lumen tube. The abscess cavity was cleaned revealing a 0.6 cm airway stump opening at its base. The stump opening was sutured and mattressed with intercostal muscle pedicle. A Clagett window was created, the cavity was packed tightly, and a vacuum assisted closure dressing was applied. The patient was extubated in the OR to minimize PPV. Antibiotics and dressing changes were done until the patient was discharged from the hospital on the 6th postoperative day. The wound was ultimately closed five months later when the Clagett window decreased in size and healed appropriately.

Diagnosis

Signs and symptoms of BPF include fever, productive cough, hemoptysis, subcutaneous emphysema, and persistent air leak or purulent drainage from a chest tube. Late fistulas with empyema may be associated with nonspecific symptoms e. g. fever, cough, and shortness of breath. Chest radiographs usually demonstrate a new air-fluid level (hydropneumothorax) in the pleural space.[6]

Both chest CT and bronchoscopy are useful in establishing diagnosis, identifying the cause and localizing the bronchopleural fistulous track.[4] Chest CT can also define the empyema cavity and assess the severity of coexisting lung disease. Bronchoscopy can also be used to inspect the bronchial stump, obtain cultures, and assess the contralateral airway. In addition to direct visualization of central BPFs, bronchoscopy can localize peripheral ones by passing a balloon into suspected bronchial segments separately and then inflating for 30-120 seconds. A reduction in air leak through chest tubes would identify the bronchial segment communicating with the BPF.[7]

Management

Management of BPF is difficult and depends on the underlying cardiopulmonary reserve, nutritional status, fitness to undergo a major surgical procedure, surgical expertise available, and the size and location of the fistula.

Conservative management:

The primary goals of BPF management include treating the underlying lung disease, reducing the air leak through ventilator adjustments to minimize the tidal volume and plateau airway pressure, and avoiding contamination of the contralateral lung by either positioning the patient with the affected side down or controlling the airway with a double lumen endotracheal tube if needed.

Small fistulas can be managed conservatively if the patient's clinical condition is stable and the pleural space is well drained. This is achieved by insertion of a chest tube in the pleural cavity, with either minimal or no suction to allow the lung to expand without encouraging air leak through the fistula. Conservative management is safe as long as empyema is drained promptly, but might not be suitable for patients requiring prolonged mechanical ventilation.[8] The chest tube can be connected to a one-way valve and the patient can be treated as an outpatient.[9]

Ventilatory management: [9, 10]

Ventilatory management of BPF is geared towards keeping airway pressures below the critical opening pressure of the fistula by reducing the respiratory rate, tidal volume, inspiratory time, PEEP, plateau airway pressure, and transpulmonary pressure gradient. This can be achieved by implementing the following measures:

- Provide partial ventilatory support e. g. low rate SIMV or Pressure Support.
- Decrease the tidal volume of each ventilator-delivered breath (5 to 8 mL/kg)
- Use a high inspiratory flow rate e. g. 70 to 100 L/min.
- Decrease I/E ratio. Minimize inspiratory time to decrease mean airway pressure, avoid end-inspiratory pause and inverse-ratio ventilation.
- Minimize PEEP (both dialed-in and auto-PEEP).

- If previous adjustments are not possible or insufficient, a strategy of permissive hypercapnia is appropriate (decrease minute ventilation and allow arterial PCO₂ to rise).
- Use the least amount of chest tube suction that maintains lung inflation.
- Avoid patient positions that increase the leak, and keep patient heavily sedated (and paralyzed if needed) if spontaneous movement exacerbates air leak.
- Treat bronchospasm and other causes of expiratory airflow obstruction.
- Wean and extubate patients as soon as possible.
- If the measures mentioned above failed, consider unconventional ventilatory measures e. g. independent lung ventilation,[11] high-frequency jet ventilation,[12] or airway pressure release ventilation. [13]
- If ventilation continues to be problematic, veno-venous extracorporeal membrane oxygenation (ECMO) can be used temporarily until further bronchoscopic or surgical control of BPF is done.[14]

Bronchoscopic Management:

Interventional bronchoscopy is usually reserved for BPF in patients with high surgical risk and poor general condition, or small fistulas in stable patients after drainage of the pleural space has been achieved and infection is controlled.[15] These procedures are limited to isolated case reports or short case series; the current literature does not allow adequate comparison of different bronchoscopic techniques. Peripheral fistulas (post-lobectomy) tend

to be more amenable to this family of techniques compared with more centrally located fistulas (post-pneumonectomy).

Bronchoscopic management of BPF is based on the delivery of different materials and small devices into the BPF sites.[16] Examples include:

- A plug composed of Gel Foam, fibrin, autologous clot, or tissue glue.
- An endobronchial one-way valve. (Figure 2 & 3)
- An expandable endobronchial stent.
- Local application of silver nitrate.
- Coagulation of the injured site with the Nd: YAG laser.
- Antibiotics e. g. Doxycycline, or tetracycline injections.
- Silicone fillers, coils, and amplatzer devices.

Surgical Management:

Surgical management has a success rate of 80-95 %, but it is associated with high morbidity and mortality. Surgery can be performed as a one or two stage procedure. A one stage procedure is indicated when the BPF occurs within the first few days after surgery. Management usually includes closure of the BPF by reclosure of the bronchial stump reinforced with omental or pedicled flaps, and obliteration of the residual pleural space.[2, 17]

Management of late occurring fistulas or if an empyema is present involves a two-stage approach. Drainage of the pleural space and debridement of empyema cavity is followed by repair of the air leak once the pleural space is sterile (e. g. Modified Clagett Technique).[18, 19] Chronic empyema may need thoracoplasty with removal of a part of the chest wall.[5] If the BPF

cannot be identified, open window thoracotomy and daily dressing may be helpful. Success of surgical management is improved by ensuring appropriate antibiotic therapy, adequate nutritional support, and proper care of chest tubes, as inadvertent occlusion can be complicated by tension pneumothorax.[8]

Conclusion

BPFs offer many management challenges in a complex patient population. The aforementioned case report demonstrates the spectrum of morbidity associated with this serious problem. A post-resection occurrence is the most common etiology, and the diagnosis is usually confirmed with chest CT and bronchoscopy.

BPFs require a multimodal management strategy and should be handled in centers with experience with this complex problem. Management includes control of infection, pleural drainage, proper pain control, nutritional support, and ventilatory management tailored to minimize air leak. Both surgical and non-surgical options can be utilized for management of BPFs. Bronchoscopic procedures such as endobronchial valves are emerging as viable treatment options but should be used on a case-by-case basis.

Figure 1: Chest CT: Panel A shows a residual hydropneumothorax around a right sided chest tube. Panel B represents a coronal reconstruction that shows the BPF (The arrow points to the communication between the right lower lobe airway and the right pleural space). Image courtesy of Dr. Ahmed El-Sherief.

Figure 2: A bronchoscopic image from another patient with right upper lobe BPF. The image shows 2 endobronchial valves seated in the anterior and posterior segments of the right upper lobe. Image courtesy of Dr. Thomas Gildea.

Figure 3: The Spiration Valve System (SVS) is self expanding and conforms to the airway. During inspiration (A), the valve blocks distal airflow. During expiration (B), the valve allows trapped air and secretions to escape. Reduction in airflow may accelerate resolution of an air leak. Copyright © 2013 Spiration, Inc. Reprinted with permission.