Bronchoscopy in the Management of Bronchopleural Fistula*

MAJ John E. McManigle, M.D.; MAJ Gardner L. Fletcher, M.D.; and COL Michael F. Tenholder, M.D., F.C.C.P.

The management of persistent bronchopleural fistula is one of the most complex challenges encountered by the chest physician. Bronchopleural fistulae most commonly arise as a postoperative complication, but can occur in other clinical settings, such as inflammatory disease of the lung, blunt chest trauma, and barotrauma.1,2 Necrotic lung and BPF are also increasingly being recognized as a sequela to current aggressive chemotherapy and radiation therapy for lung cancer.3 The incidence of this disorder has decreased markedly with the availability of more effective chemotherapeutic agents for tuberculosis, improved antimicrobials, and advanced surgical technique. The current incidence of BPF following pulmonary resection is generally reported as 2 to 5 percent. One recent article reports a 12.5 percent incidence of BPF following pneumonectomy for non-small lung cancer.4 Two large series from the 1970s report a mortality rate from this complication of 23.1 and 19.1 percent, respectively.1,2 When BPF occurs, the healing and repair process is still associated with substantial morbidity and mortality, prolonged hospitalization, and great expense.

Patients with BPF can present in an acute, life-threatening fashion due to pulmonary flooding or tension pneumothorax. These fistula can also have a subacute, insidious clinical course. The acute clinical presentation is recognized by the onset of sudden dyspnea, expectoration of purulent material, subcutaneous emphysema, and disappearance of fluid level on chest roentgenogram (if postoperative). A persistent air leak postoperatively, without evidence of a technical problem in the pleural drainage apparatus, also indicates a BPF. When a fistula occurs outside the perioperative period (no chest tube in place), the diagnosis must be suspected in the face of fever, cough productive of purulent sputum, and new or increasing air fluid level in the pleural space. Further diagnostic studies such as selective bronchography or instillation of methylene blue into the bronchial tree, with its subsequent appearance in the chest tube drainage, can help confirm the BPF location.

The first principle of BPF management must be to address any immediate, life threatening conditions—commonly pulmonary flooding or tension pneumothorax. This is accomplished by placing the patient with affected side down and performing a pleural drainage procedure. If a major bronchial stump dehiscence occurs during the first week after pulmonary resection, immediate resuture and reinforcement of the bronchial stump is the procedure of choice.3,8,9 However, most BPF present subacutely or as a chronic air leak. These patients initially receive conservative management with dependent drainage and reduction of the pleural space, antimicrobials, optimal ventilator management,12 and nutritional supplementation. If these conservative measures fail to close the fistula in one to three weeks, surgical intervention is usually considered the next step in management.

Unfortunately, many of these patients are poor surgical candidates unable to tolerate a major thoracic procedure. Application of silver nitrate through the rigid bronchoscope has been used successfully to treat stump fistulae.6 The advent of flexible bronchoscopy has improved localization of smaller peripheral fistula. In cases with difficult localization or marked anesthesia risk, the bronchoscopist can now use several nonoperative techniques to attempt endobronchial closure of BPF. These modalities include endobronchial occlusion with (1) tissue glue,13-17 (2) fibrin glue,18-22 (3) Gelfoam,23 (4) lead plugs,24 (5) balloon catheter,25,26 or (6) autologous blood patch.27 If successful, these techniques eliminate the risk of general anesthesia and

*From the Division of Pulmonary Disease, Department of Medicine, Uniformed Services University of the Health Sciences, Bethesda, MD; and Pulmonary Disease and Critical Care Medicine, Department of Medicine, Walter Reed Army Medical Center, Washington, D.C.

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Reprint requests: Dr. McManigle, Rm A3060 Department of Medicine, USUHS, 4301 Jones Bridge Road, Bethesda 20814-4799
major reconstructive thoracic surgery. We will discuss these various techniques for use in selective patients when conservative management of BPF has been unsuccessful.

**Technique**

The first step in the evaluation of a BPF being considered for endoscopic closure is to determine whether the lesion might be amenable to bronchoscopic techniques. To do this, one must either directly visualize the BPF proximally or demonstrate that occlusion of a distal BPF significantly decreases or stops the air leak. If neither of these conditions is present, attempts at endobronchial control of BPF will be futile and therefore should not be attempted.

A proximal BPF, directly visible through the rigid or flexible bronchoscope (Fig 1), is seen when a small fistula forms at the bronchial stump following lobectomy or pneumonectomy. We routinely record the exact anatomic location on videotape for review with our surgical colleagues. A peripheral BPF, not directly visible with a rigid endobronchial examination, presents a greater challenge both in identification and characterization of the fistula. These are commonly seen with inflammatory lung disease, blunt trauma, barotrauma, or following segmental or wedge resection in patients with underlying lung disease. To locate a peripheral BPF, the bronchoscopist systematically examines the segmental bronchi on the involved side.

Air bubbles can sometimes be seen arising from the affected bronchus (but can also be seen arising from normal bronchi). Respiratory maneuvers (i.e., cough) may accentuate the bubbling in the involved segment.

If not, washing the suspected area with normal saline solution can enhance localization of the air leak. The bronchoscopist then passes a balloon catheter (Microvasive occlusion catheter, No. 5 Fogarty embolectomy catheter, Swan-Ganz catheter, or other similar catheter) through the suction channel of the fiberoptic bronchoscope to sequentially occlude all suspicious lung segments. The catheter is advanced into second, third, or fourth order bronchi, and the occlusion balloon inflated while an assistant carefully observes the air leak. A marked reduction of the air leak will accompany successful occlusion of the BPF. If significant reduction of the air leak cannot be demonstrated during balloon occlusion of distal BPF, endoscopic closure should not be attempted. It must be emphasized that the catheter be advanced under direct visualization—never blindly. Overly aggressive passing of the catheter can open a fistula and lead to tension pneumothorax.

Acrylate tissue glue (Histoacryl) is primarily used to seal corneal perforations and embolize vascular malformations. It is also useful for endobronchial closure of proximal bronchopleural fistulas. The fistula is located with the rigid or fiberoptic bronchoscope and the surrounding area cleared of any mucus or other debris. A thin plastic or Teflon catheter is then passed through the suction channel of the bronchoscope and positioned near the fistula. Next, 0.5 to 1 ml of acrylic tissue glue is injected through the catheter to the fistula site (Fig 2). If incomplete closure of the BPF occurs, the procedure can be repeated at the same sitting or later. The tissue glue mechanically occludes the fistula and induces a local reactive proliferation of the bronchial mucosa. This prolifera-

**Figure 1.** Endobronchial view of a proximal bronchopleural fistula at a bronchial stump. The catheter through which tissue glue will be injected, can be seen adjacent to the fistula.

**Figure 2.** Tissue glue (Histoacryl) injected through a catheter onto the bronchopleural fistula seen in Figure 1.
tive process is responsible for long-term closure of the fistula. The main technical considerations are as follow: (1) the glue must not be injected directly through the suction channel but rather through a catheter to avoid damaging the bronchoscope; and (2) the glue solidifies rapidly (in about 10 seconds), making rapid injection necessary.

Fibrin glue is used to seal both proximal and peripheral BPF. For proximal BPF, the fistula is identified and a catheter passed through the suction channel as described for tissue glue occlusion. One milliliter of concentrated fibrinogen is injected through the catheter, followed immediately by 1 ml of topical thrombin (1,000 units/ml). As the components mix, a fibrin clot forms over the fistula in several minutes. Concentrated fibrinogen is prepared by the blood bank from the patients’ own plasma which eliminates the risk of bloodborne infection. For peripheral BPF, the balloon catheter occlusion technique is used to locate the leaking bronchus. The catheter is then placed in the bronchus and the balloon inflated. The fibrin glue is injected as described above and the balloon is left inflated for several minutes while the glue solidifies. The long-term fate of fibrin glue in the lung is not known. In one animal study, fibrin glue was applied to the pleural side of a BPF. Histologic examination, performed at three months, indicated that the glue was totally resorbed and no foreign body reaction was discernible.

Gelfoam can also be used to occlude a peripheral BPF. The segments leading to the BPF are identified as previously described. Gelfoam is then cut into small strips (0.25 × 0.5 × 2.0 cm), moistened with saline solution, placed into the suction channel of the flexible bronchoscope (with the aid of forceps), and flushed with saline solution into the affected segmental bronchus. This is repeated until the bronchus is completely occluded with a Gelfoam plug. The placement of Gelfoam can be more easily accomplished through a rigid bronchoscope which can be used for accessible fistula. Pleural suction at 30 cm H₂O is maintained for at least five days to allow full lung expansion. The theoretic advantages to the use of Gelfoam in this situation include its availability, ease of administration, and that it is completely phagocytized within one month.

Endobronchial placement of a lead shot plug has been successful in the occlusion of a peripheral BPF in a patient on mechanical ventilation. The technique described by the authors is as follows: (1) the subsegment leading to the BPF is identified as previously described; (2) a guide wire is passed through the suction channel of the fiberoptic bronchoscope into the affected bronchus; (3) the bronchoscope is then withdrawn over the guidewire; (4) a No. 3.0 split shot fishing weight is sterilized in gluteraldehyde, crimped over a short strand of mersilene suture (to facilitate bronchoscopic retrieval of the lead shot), and perforated with an 18 gauge needle; (5) the lead shot is then advanced over the guidewire and pushed into place by the bronchoscope (which is also threaded over the guidewire). It can later be removed by bronchoscopy to avoid any long-term sequelae. Lead is reported by these authors to cause only minimal tissue reaction.

Balloon catheter occlusion of BPF has also been proposed. An experimental study has shown satisfactory occlusion of peripheral BPF in dogs with detachable balloons. However, we are not aware of the use of detachable balloons in humans. A technique has been described using an atrial septostomy catheter to occlude a peripheral BPF until surgery could be performed. The catheter was fluoroscopically guided into each of the segmental bronchi on the affected side. Trial inflations of the balloon were performed in each of the segmental bronchi until the air leak stopped. The balloon was then inflated with a minimal amount of dilute contrast material and left in place. The balloon was deflated every 24 hours for two hours, then reinflated.

Selective intrabronchial injection of doxycycline and autologous blood can also occlude peripheral BPF. In the reported case, 1 ml (20 mg) of doxycycline was injected and immediately followed by 15 ml of blood. This healed a bronchopleural air leak that had been unresponsive to three months of conservative therapy. The authors do not specifically address their management of pleural suction during the procedure. We maintain pleural suction at 20 cm H₂O during the procedure. Once the air leak is stopped, we discontinue suction and put the chest tube to underwater seal. This decreases the likelihood of the blood patch being dislodged and the BPF re-opened.

Any of the above techniques can be used in patients on mechanical ventilation. These patients are usually on positive pressure ventilation (with attempts to control peak pressure and PEEP) on high-frequency jet ventilation. They should be adequately sedated, under optimum cough control, and have ventilatory and oxygenation requirements maintained during the procedure. Again, the equalization of pressure across the BPF may be a factor in keeping the sealant in place during the reparative process.

Conclusions

In 1977, Ratliff and colleagues first reported successful control of a BPF by endobronchial occlusion with a lead shot. That same year, Hartmann and Rausch described, "A new therapeutic application of the fiberoptic bronchoscope," closure of a BPF by endoscopic application of tissue glue. Since that time, numerous case reports and small series of patients have documented successful endobronchial
control of BPF with the fiberoptic bronchoscope.

Conservative management, rigid bronchoscopy, and surgical intervention are first line therapy for the majority of patients with BPF. Unfortunately, some who fail to heal with conservative management are also extremely poor surgical/anesthesia risks due to respiratory compromise, comorbid medical conditions, or generalized debilitation. We have outlined several therapeutic options that can be utilized in these difficult clinical settings. While there are no large series to document efficacy of these procedures, we are encouraged by reports of successful application in select patients. Further experience with these techniques, both positive and negative, will clarify their exact role in the bronchoscopist’s armamentarium.

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