A 67-year-old woman underwent right pneumonectomy for non-small-cell carcinoma of the right lung. Her postoperative course was uneventful, and she was discharged from the hospital on the fifth day.

Subsequently, she underwent chemotherapy. Six weeks later, she was admitted with a complaint of shortness of breath. She denied fever, chills, rigors, and excess sputum production.

The patient was in obvious distress, with a respiration rate of 22 breaths per minute and the use of accessory muscles. She was afebrile. Her heart rate was 102 beats per minute and her blood pressure was 110/82 mm Hg. No clubbing or cyanosis was noted.

Heart sounds were normal. Air entry was decreased in the fields of the left lung, with slight unilateral wheezing. The abdominal and neurologic examinations were unremarkable.

The patient's white blood cell count was 10,000/µL, with 73% neutrophils, 22% lymphocytes, and 5% monocytes. Her hemoglobin level was 14.1 g/dL, and hematocrit was 36%. Other laboratory parameters were within normal ranges, with the exception of an elevated alkaline phosphatase level of 240 IU/L (normal level, 20 to 140 IU/L). The arterial blood gas levels on room air were pH, 7.42; PCO₂, 31 mm Hg; and PO₂, 62 mm Hg.

A chest radiograph was obtained (Figure 1).

What is the likely diagnosis? How would you proceed? Discussion

In the normal postpneumonectomy chest, residual large spaces in the pleural cavity are filled in one of the following ways: entry of fluid, increased expansion of the remaining lung, or a shift of the mediastinum/diaphragm toward the newly created space. When fluid enters the cavity, it increases until the pneumothorax is obliterated.

When fluid in the cavity decreases and is replaced by air, as in our patient, a BPF from the stump is indicated. Thus, the characteristic radiologic signs of postpneumonectomy BPF include failure of the potential pleural space to fill with liquid, inspiratory shifting of the mediastinum to the contralateral (nonoperated) side, and an abrupt decrease in the gas-liquid level of more than 2 cm (0.8 in).

A BPF is a sinus tract between the bronchus and the pleural space that results from a necrotizing infection or trauma. The most common traumatic cause is failure to obtain good bronchial closure and healing after partial or complete resection of the lung (Table). Failure to heal may result from improper initial closure, inadequate blood supply, infection at the bronchial stump, or a residual malignant tumor at the bronchial stump.

BPF typically presents 7 to 15 days following resection, although delayed BPFs have been reported. With delayed BPF, a new air-fluid level appears in a previously opacified hemithorax. Cough and changes in the air-fluid pattern on the chest radiograph are critical warning signs of BPF. Other manifestations include fever with serosanguineous or purulent sputum. Acute respiratory distress may occur if a large BPF results in aspiration to the contralateral lung or if a tension pneumothorax develops.

BPF can lead to empyema formation. In our patient, there was no evidence of infection at the bronchial stump or in the pleural space and there was no evidence of recurrent cancer at the bronchial stump.

The incidence of BPF is about 4.5% to 20% after pneumonectomy and 0.5% after lobectomy. BPF can cause significant morbidity, prolonged hospitalization, and mortality. A multivariate analysis of the risk of BPF in patients undergoing resections for lung cancer identified right-sided resection, pneumonectomy (especially right pneumonectomy), mediastinal lymph node resection, highdose preoperative radiation therapy, and residual or recurrent carcinoma at the bronchial stump as predisposing factors. Nonoperative risk factors included diabetes mellitus, hypoalbuminemia, cirrhosis, and administration of corticosteroids.
When BPF is not clearly visible on bronchoscopy, bronchography or ventilation scintigraphy can be used to localize the site. Instillation of methylene blue into the bronchial tree, with its subsequent appearance in the chest drainage, can confirm BPF location. The site can also be determined by bronchoscopic guidance of a balloon-tipped catheter into selected airways and subsequent inflation of the balloon. If the bronchus contributes to the BPF, balloon occlusion decreases or eliminates the air leak.

Capnography can also be used to identify the bronchial segment associated with the BPF. End-tidal carbon dioxide is measured by connecting a capnograph to a polyethylene catheter that is passed through the bronchoscopic channel and placed systematically into different bronchi. The absence of a capnographic tracing in a particular segment or subsegment suggests the presence of a BPF.

Postpneumonectomy BPF is a serious complication. Drainage of the pleural space via a chest tube is a critical first step for all patients, in order to limit endobronchial contamination and prevent drowning. If conservative management with tube drainage, antibiotics, and nutritional support fails to close the BPF, surgical intervention should be considered. In general, suture reclosure of the bronchial stump with vascularized flap coverage alleviates acute BPF, which usually occurs less than 2 weeks after surgery. Appropriate timing and correct application of available techniques are of primary importance in obtaining optimal results.

Postpneumonectomy patients who present with delayed BPF are unlikely to have direct reclosure of the BPF. These patients may have closure of the BPF by an anterior transpericardial approach or thoracotomy with muscle flap to fill the pleural space, or muscle flap coverage of the BPF with a limited thoracoplasty to obliterate the pleural space. However, these procedures are associated with high morbidity, mortality, and cost. Since many of these patients are poor candidates for a second thoracic operation of this magnitude, they may be treated with endoscopically placed tissue adhesives to seal the BPF.

Various endoscopic options have been successful in about 60% to 100% of BPF cases, significantly reducing morbidity and mortality. These include endoscopic placement of a glutaraldehyde-sterilized lead shot, a balloon catheter (occlusion), gel foam and tetracycline, an autologous blood patch, vascular embolization coils, N-butyl-2-cyanoacrylate, fibrin adhesive material, and a gelatin-resorcinol mixture plus cryoprecipitate fibrin glue to obliterate the BPF.

Varoli and colleagues reported successful endoscopic treatment with multiple submucosal injections of polidocanol-hydroxypropilidodecane on the margins of the BPF by using an endoscopic needle inserted through a flexible bronchoscope. Some have used adhesive glue to close post-traumatic peripheral BPF. Others have reported successful endobronchial closure with vascular occlusion coils and cyanoacrylate glue via flexible bronchoscopy or angiography catheters passed through tracheostomy tubes. Baumann and associates have studied the use of human spongiosa and fibrin sealant in successful closures of BPF.

These bronchoscopic procedures are more successful in closing small BPFs of less than 5 mm, as in our patient. The flexible bronchoscope is more advantageous than the rigid bronchoscope, because the former provides superior access to a greater portion of the bronchial tree. Although video-assisted thoracoscopic placement and CT-guided percutaneous transthoracic application of fibrin sealant have been used to seal pulmonary air leaks, they are invasive procedures.

Each sealant acts first as a plug that mechanically seals the leak and later as an inducer of an inflammatory process with mucosal proliferation and fibrosis that creates a permanent seal. It has also been shown that repair of a BPF occurs by organization of granulation tissue caused by foreign bodies. Epithelialization with typical respiratory epithelium has been reported. While there are no large controlled trials to document the efficacy of endobronchial procedures that use various tissue adhesives to close the fistula, multiple case reports and series suggest their effectiveness in selected patients.

As an alternative, the Nd:YAG laser has been used to close small BPFs, but this technique has not been widely reported. Other methods include placement of a stent in the bronchial stump to prevent air leaks and to close the BPF and use of intrabronchial valves.

Bronchoscopic closure eliminates the risk of general anesthesia and major reconstructive surgery. The BPF can be closed endoscopically when there is no evidence of infection in the pleural cavity. Persons without infection do not require prior drainage of the pleural cavity. If the patient has empyema, insertion of a chest tube to drain the infected pleural space is advisable before endoscopic closure is attempted. Bronchoscopic closure can be used in patients on mechanical ventilation or in debilitated persons who are at high risk with use of general anesthesia. Outcome in this case
Closure of the BPF was performed by injecting 2-component fibrin-cryoprecipitate glue through a catheter inserted via the operative channel of a bronchoscope. Calcium gluconate, cryoprecipitate, and topical thrombin (1000 IU/mL) created a fibrin clot that occluded the BPF. A total of 1 mL of each of these solutions was injected. Cryoprecipitate was obtained from the blood bank, and thrombin was obtained from the pharmacy.

The fibrin sealant that we used is a dual-component biologic adhesive. Its action mimics the final stage of clotting, whereby fibrinogen (in the form of cryoprecipitate) in the presence of factor XIII, thrombin, and calcium—polymerizes to form a fibrin clot, which is gradually adsorbed by fibrinolysis. It is important to note that the 2 fibrin components should be applied directly to the BPF site and allowed to mix, because clot formation begins within seconds.

The patient’s dyspnea improved markedly, and the air leak in the chest tube stopped, indicating occlusion of the BPF. Over the next few days, the right side of the pleural cavity filled with fluid, further indicating closure of the BPF. The chest tube was removed 5 days after the procedure, and the patient was discharged. The BPF had completely healed by 2 weeks after the procedure.

References: REFERENCES

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