The Bronchial Leak Squeak:
A New Sign for the Physical Diagnosis of Bronchopleurocutaneous Fistula

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We describe a unique physical diagnostic sign that we have observed in seven patients with bronchopleurocutaneous fistulas. Such patients have a high-pitched squeak over the affected chest area during sustained Valsalva maneuver. We postulate that turbulence across the bronchial fistula due to high transbronchial pressure gradient during the Valsalva maneuver produces the squeaking sound. The pitch of the leak squeak sign is higher in smaller fistulas than in larger fistulas; decreases in intensity and increases in pitch occurred in two patients in whom the bronchial fistula slowly closed. The absence of the leak squeak sound in patients with spontaneous pneumothorax suggests that this sign can be used to differentiate central airways from alveolar air leaks.

We have observed a simple auscultatory sign in seven patients with bronchopleurocutaneous fistulas (BPFC) that permits noninvasive serial observations of the size of the air leak. We call this sign the bronchial leak squeak.

MATERIALS AND METHODS

Patients thought to have BPFC are instructed to inspire to total lung capacity and then close their glottis and strain (the Valsalva maneuver). During this period of increased intrathoracic pressure, the examining physician listens with a stethoscope over the hemithorax of interest. A high-pitched sustained squeaking sound indicates the presence of a bronchial air leak.

In patients with bronchial leaks venting to atmospheric pressure via chest tubes, the bronchial squeak sign can be reduced in intensity or eliminated by clamping the tube before performing the Valsalva maneuver.

CASE REPORTS

CASE 1

A 44-year-old man was admitted to the Martinez Veterans Administration Medical Center for recurrent deep-vein thrombophlebitis. Left pneumonectomy had been performed three months previously for benign disease, and a left pleural window had been created six weeks earlier for drainage of an empyema cavity. Chest roentgenogram showed an air-filled left hemithorax and a large pleurocutaneous fistula (Fig 1). During cough or Valsalva maneuver, we noted a continuous, high-pitched, squeaking sound, localized over the anterior third left intercostal space. With increasing force of the Valsalva maneuver, the pitch of the squeak increased. The squeak had a hollow character, suggesting resonance within the pleural cavity. A fishmouth opening was observed in the left main stem bronchus during fiberoptic bronchoscopy. Methylene blue dye placed in the left bronchus disappeared rapidly and appeared at the skin opening.

Quantitation of the leak was carried out in this patient (Fig 2). Functional residual capacity was established by a spirogram during tidal breathing, and after a 7.5-second Valsalva maneuver, a 1.0-L change in this level was observed. Bronchial leak flow was therefore 0.14 L/sec. A transbronchial gradient of pressure of 10 cm H2O (p mouth - p left chest cavity) was recorded during the Valsalva maneuver using a differential pressure transducer. Bronchial leak resistance was therefore calculated to be 75 cm H2O/L/sec. A microphone placed over the left hemithorax recorded an increase in the integrated sound energy (filtered between 500 and 2,500 Hz) during the Valsalva maneuver.

FIGURE 1. PA chest roentgenogram, case 1, postpneumonectomy cavity and cutaneous fistula in lower left hemithorax.

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MEASUREMENT OF BRONCHIAL LEAK FLOW AND RESISTANCE

![Diagram of measurement of bronchial leak flow and resistance](http://journal.publications.chestnet.org/pdfaccess.ashx?url=/data/journals/chest/21199/)

CASE 2

A 49-year-old man was admitted to the Martinez Veterans Administration Medical Center with a right lung abscess. Bronchoscopic biopsy revealed adenocarcinoma, and subsequently the patient underwent right pneumonectomy. Postoperatively serial chest x-ray films showed the expected accumulation of fluid in the right hemithorax. Three weeks after the pneumonectomy, the patient had fever and productive cough. Chest x-ray film then showed diminution in the air field level, suggesting the diagnosis of bronchopleural fistula. A chest tube was placed for drainage. Defects in the distal right bronchial stump were seen during repeated fiberoptic bronchoscopy, and injected methylene blue dye was observed to disappear into the stump. 133Xenon ventilation lung scan showed activity in the right hemithorax. Physical examination at that time disclosed the left lung field to be normal. The bronchial leak squeak sign was absent when the thoracostomy tube was clamped, but upon venting the chest tube to atmospheric pressure during a Valsalva’s maneuver, a high-pitched squeak was audible over the right lung field.

CASES 3 to 7

We have observed the bronchial leak squeak sign in five additional patients with BPCF after lung surgery; four patients had undergone lung resection for bronchogenic carcinoma, and one had undergone palliative resection for suppurative lung disease. In several of these cases we observed that the pleural pressure must be similar to atmospheric pressure during the Valsalva maneuver in order to produce the leak squeak sign. In one patient with a persistent BPF, a high-pitched squeak could be elicited over the right chest during Valsalva maneuver, if the patient’s chest tube was placed under 2 cm of water seal. However, when the chest tube was placed under 20 cm of water seal, no leak squeak sign was present. The driving pressure producing the air leak across the BPF is airway pressure minus pleural pressure, as shown in Fig 2. Since the leak squeak sign disappeared at higher water seal pressures, we concluded that leak resistance must be high: in that patient. The leak squeak sign should be sought, using low water seal pressures in patients with chest tubes. The pitch of the squeak during the Valsalva maneuver appeared to correlate with the size of the bronchial fistula: low-pitched sounds occurred in patients with large fistulas, while high-pitched squeaks occurred in small fistulas. The leak squeak sign increased in pitch, decreased in intensity, and finally disappeared even with large increases in intra-thoracic pressure during the Valsalva maneuver in two of these patients; we interpreted this to indicate closure of their BPF. The pleural window was closed using the Clagett procedure in one patient, and by granulation of the pleural space in the second.

DISCUSSION

The bronchial leak squeak sign is, in our experience, a useful indicator of BPCF and is a valuable aid in the follow-up and management of these patients.

We postulate that this auscultatory sign is caused by turbulent eddies of air generated by the flow of air through a narrow aperture in the airway under high driving pressure. As shown in Fig 3, the bronchial leak sign depends on passage of air from the remaining lung to the atmosphere via a cutaneous window or through a chest tube, as discussed in cases 3 to 7. When no access to atmospheric pressure is present, the Valsalva maneuver produces an increase in both airway and pleural cavity pressures and results in a small leak driving pressure (transbronchial pressure gradient); thus, no leak squeak sign is apparent.

The bronchial leak squeak is a new physical diagnostic sign. No mention of this sign or the examination of the chest during the Valsalva maneuver are found in recent textbooks that discuss physical examination of the chest. However, Winckler and Sattler1 are reported to have described the use of auscultation over the lung apex during the Valsalva maneuver to detect pulmonary cavities of small size in areas of tuberculous fibrosis. Thomas Mann, in his novel *The Magic Mountain*, concerning a tuberculosis sanitorium, described the characteristics of a
The diagnosis of a BPF should be suspected in postthoracotomy patients who do not progressively resorb the postoperative air within the chest cavity or who have fever, hemoptysis, purulent sputum after lung surgery, or any of these. Other methods to document the presence of a BPF have been reported. Direct visualization during bronchography or thoracoscopy can confirm the size and anatomic site of the lesion directly. Xenon equilibration scans have been used to demonstrate passage of gas into the area of previous lung resection as we reported in case 2. However, this technique is expensive, requires radiation exposure, and may be falsely interpreted if the other lung herniates across the mid line (false-positive result) or if equilibration time is not long enough to wash high concentrations of Xenon into the affected hemithorax (false-negative result). The methylene blue dye test may also be falsely negative in small leaks and requires the insertion of dye into the cavity. Since these tests are relatively invasive, they are less suitable for serial observation than the auscultatory sign we describe.

Successful closure of an empyema cavity after dependent rib resection or Eloesser flap drainage can be accomplished by the Clagett procedure. However, this procedure first requires the closure of the BPCF. Slow spontaneous healing of a BPCF may occur by granulation of the fistula, or a muscle flap interposition may be needed to close the leak. It is therefore of clinical importance to be able serially to assess the size of a BPCF in these patients.

The bronchial leak squeak sign offers the advantage of being easy to perform, reproducible on serial examination, and inexpensive. The leak squeak sign can be used to follow up patients with chronic BPCF as they close spontaneously and may be able to assess the integrity of muscle flap closures of BPF in the immediate postoperative period.

ACKNOWLEDGMENT: This work was supported by the Medical Service of the Veterans Administration. The assistance of Mrs. Elaine Yeager and Mrs. Bette Laccoare in manuscript typing is recognized. Dr. J. Alix y Alix, Madrid, provided reference 1, and Robert G. Loudon, M.D., University of Cincinnati, provided the quote in reference 2.

REFERENCES

1. Winckler Y, Sattler P. Un nuevo signo auscultatorio de cavinas apilces. Archivos de Medicina, Cirugia, y Especialidades, Madrid, Spain, 1933.
Technical Assessment Forum

The National Center for Health Care Technology (Center), in collaboration with the National Heart, Lung and Blood Institute, will conduct a technical assessment forum to address the economic, ethical, legal and social issues related to coronary artery bypass surgery. The forum will be held April 21-23 at the Sheraton Washington Hotel, Washington, D.C. There is no registration fee. For technical information, contact Michael Eliastam, M.D., Special Assistant to the Director, National Center for Health Care Technology, Parklawn Building, Room 17A-29, 5600 Fishers Lane, Rockville, Maryland 20857.

6 Belcher JR, Sturridge MF. Thoracic surgical management, 4th ed. Baltimore: Williams & Wilkins, 91-95
11 Eloesser L. An operation for tuberculosis empyema. Surg Gynecol Obstet 1935; 60:1098