Localization of Bronchopleural Fistula Using Ventilation Scintigraphy

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It can be difficult to localize or even lateralize the site of persistent bronchopleural fistula in patients who have undergone thoracotomy. If the site of persistent air leak can be identified noninvasively, it may be possible to repair the leak with thoracoscopic techniques and thereby avoid repeat thoracotomy. This article reports experience using ^{99m}Tc-DTPA ventilation scintigraphy to localize persistent bronchopleural fistulas in six patients. The site of bronchopleural fistula was identified in four patients. In the other two patients, no leak was identified, and the clinical course confirmed that a significant bronchopleural fistula did not exist.

Key Words: ventilation scintigraphy; bronchopleural fistulas; pneumothorax

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Bronchopleural fistulas are rare complications of thoracic surgery and of certain pulmonary diseases and trauma (*1–3*). It is reported to occur in 2% to 3% of thoracotomies. The death rate in different series ranges from 16% to 70%. In the cases presented here, the possibility of bronchopleural fistula was suggested by persistent pneumothorax or by persistent air leak from chest tubes. Early diagnosis and localization is important to reduce morbidity and death rates. The introduction of thoracoscopic techniques for repair of bronchopleural fistulas (*4*) makes precise localization even more important because of the possibility of avoiding thoracotomy.

The authors report their experience using ^{99m}Tc-DTPA (diethylenepentaacetic acid) ventilation scintigraphy to localize bronchopleural fistulas in six patients. The patients are ventilated with nebulized ^{99m}Tc-DTPA as in a standard ventilation scintigram. The nebulizer (MediNuclear Corp., Baldwin Park, CA) was loaded with 1480 to 2220 MBq of ^{99m}Tc-DTPA, and the activity delivered to the patient was about 150 MBq. The particle size was 0.3 μ mass median aerodynamic diameter (MMAD), according to information supplied by the manufacturer from an independent testing laboratory. Serial images of the lungs were obtained in multiple projections to identify foci of activity that projected outside the contour of the pulmonary parenchyma. To facilitate positioning, patients who are able to tolerate it were imaged while sitting on a swivel stool. If an area of suspected air leak was identified, then an external marker (a cotton-tipped swab labeled with ^{99m}Tc) was used to identify the skin overlying the site of air leak on several projections and that spot was marked with an indelible-ink marker pen. Patients who could not tolerate the seated position were imaged supine, but localization was more difficult because the number and orientation of projections was limited. SPECT can be useful in this situation. The patient must be able to cooperate with breathing the aerosol through a mouthpiece.

If a definite site of leakage is not identified on the initial images, delayed images taken about 1 hr later may show foci of activity that clear more slowly from the pleural space than from the airways.

CASE REPORTS

Patient 1

A 72-yr-old man had an episode of bleeding necessitating mediastinal reexploration following his third aortic valve replacement. On postoperative Day 5, his chest tubes continued to show an air leak. A ventilation scan localized the site of a bronchopleural fistula (Fig. 1), and video-assisted thoracoscopic wedge resection of a left upper lobe apical bleb was performed. The air leak resolved, and the patient was discharged home.

Patient 2

A 54-yr-old man with adenocystic carcinoma of the trachea had undergone resection and reconstruction but developed multiple pulmonary metastases. Following repeat thoracotomy to remove bilateral pulmonary nodules, the patient had an air leak that persisted for several days. A ^{99m}Tc-DTPA aerosol ventilation study identified leaks from the right apex and hilum (Fig. 2). The patient was brought back to the operating room where thoracotomy revealed a 2-mm opening in the lung close to the hilum posteriorly and two small air leaks at the apex. The leaks were oversewn, and there were no further air leaks.

Patient 3

A 36-yr-old man underwent heart and lung transplantation and developed bilateral pneumothoraces 11 days postoperatively. He tolerated this well for about 1 mo, but continuous slow air leakage necessitated bilateral thoracoscopy in an attempt to localize and

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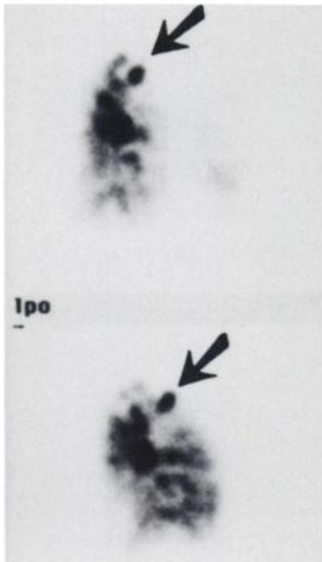

FIGURE 1. Ventilation scintiscans (left posterior oblique and left lateral projections) show a focal area of activity which projects outside of the contour of the pulmonary parenchyma at the left posterior apex, localizing the site of bronchopleural fistula.

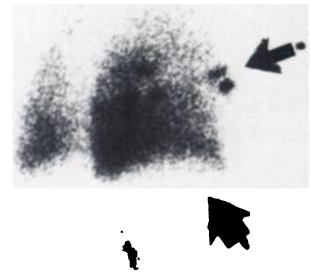

FIGURE 3. The ventilation scintiscan (right posterior oblique projection) shows two areas of focal tracer activity in the right upper lobe identified by the thin arrow. The thick arrow at the anterior base shows the location of the chest tube, demonstrating no leak at that site.

repair the air leak. Two blebs on the left upper lobe were resected and stapled. Postoperatively, a right-sided air leak persisted, and 8 days later, an aerosol ventilation scintigram localized the leak on the right side (Fig. 3). Three days later, along with the persistent right air leak, a small air leak appeared on the left side. The patient then underwent right thoracotomy with repair of a bronchopleural fistula near the minor fissure. Four days later, the patient underwent left thoracotomy with repair of a left upper lobe bronchopleural fistula and resolution of air leaks.

Patient 4

A 31-yr-old man presented to the emergency room with spontaneous pneumothorax. He underwent bilateral thoracoscopy with removal of apical blebs. He continued to have an air leak; therefore, 2 days later, he underwent ventilation scintigraphy, which demonstrated the air leaks. He subsequently underwent repeat thoracoscopy and thoracotomy on the left with identification of numerous apical blebs and air leaks, which were stapled and sewn over. His postoperative course was uncomplicated.

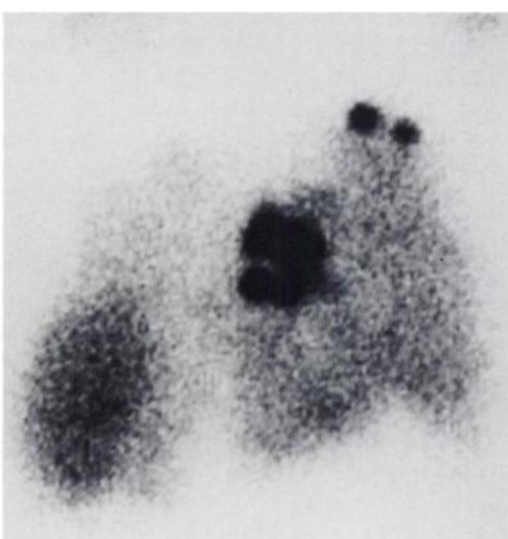

FIGURE 2. The ventilation scintiscan (right posterior oblique projection) shows two areas of focal tracer activity at the right apex and another area of tracer accumulation posteriorly near the hilum localizing the sites of bronchopleural fistulae.

Patient 5

A 34-yr-old female nurse's aide developed subcutaneous emphysema of the thorax, neck and face while restraining a patient. A chest radiograph showed pneumomediastinum but no pneumothorax. The subcutaneous emphysema progressed, and bronchoscopy showed evidence of submucosal tears involving the lingula and the apical segment of the upper lobe. She underwent thoracotomy, but no membranous tear was noted. There was no evidence of air leakage postoperatively. She was later hospitalized first with pneumonia and then with recurrent subcutaneous emphysema. A chest CT scan revealed a small pneumomediastinum and large amounts of subcutaneous emphysema in her neck and chest wall. She was referred to Stanford University Hospital for further evaluation of possible bronchopleural fistula. A ventilation scintigram did not reveal any evidence of air leak. There was no other clinical or laboratory evidence of a bronchopleural or bronchomediastinal fistula. The patient left the hospital without medical consent.

Patient 6

A 74-yr-old man with severe bullous emphysema underwent video-assisted left thoracoscopic bullectomy. Postoperatively, he had continued air leaks from the chest tubes, and chest radiography showed pneumothorax. A ventilation study did not reveal a bronchopleural fistula. Chest tubes eventually were successfully removed, and the patient was discharged home. He continued to do well on follow-up 1 mo following the operation.

DISCUSSION

Greyson et al. (*5*) reported on the use of ^{99m}Tc-labeled human serum albumin aerosol ventilation scintigraphy in the detection of postoperative bronchopleural fistulas. Several subsequent reports (*6–13*) have described the diagnosis but not the precise localization of bronchopleural fistulas on ventilation scintiscans. Some of these have been serendipitous findings on studies used to diagnose pulmonary embolism. In studies using ^{133}Xe, the persistence of the gas in the pleural space established the diagnosis of bronchopleural fistula, but localization of the site of leakage was not possible. The tendency of aerosols to settle on contact with surfaces may account for the improved localization in the authors' studies compared with earlier reports using gaseous ventilation agents, which more readily diffuse in the pleural space. This may also account for the absence of activity in the chest tubes in the examples here.

Other techniques for the diagnosis of bronchopleural fistulas include intrapleural methylene blue, bronchography, fiberoptic bronchoscopy and marker gas (*1,14–17*). Of these methods, fiberoptic bronchoscopy offers the most precise localization of the site of leakage and also the possibility of repair. However, the technique is not always successful, particularly in small leaks or leaks located distally in the bronchial tree. In some postsurgical patients, the left and right pleural spaces are in continuity, and lateralization of the site of leak using marker gases or methylene blue can be difficult.

Because of the availability of thoracoscopy at the authors' institution, they now place a premium on localization rather than determination of the presence of an air leak. This is not always an easy task, particularly in patients who are too sick to cooperate with rapid positioning. Considerable care is required to localize the leak precisely by triangulation using several projections. Precise localization may be facilitated by using SPECT in cases in which the patient is not able to be readily positioned for multiple planar views or when the planar views do not provide adequate localization. The technique can be used in patients whose respiration is supported by a ventilator. In the cases where SPECT was used, acquisition was performed after aerosol administration; therefore, changes in tracer distribution did not occur during acquisition. In patients with chronic obstructive pulmonary disease (COPD) and cystic fibrosis, it is recognized that aerosol ventilation scintiscans show a patchy appearance, making this technique less desirable for the diagnosis of pulmonary embolism. However, when diagnosing and localizing air leaks, the presence of radioactivity outside the contour of the lung can be determined even in the presence of COPD. Severe COPD, however, can make it difficult to delineate the contour of the lung on aerosol ventilation scintiscans; this is a limitation of the technique. It is also more difficult to identify leaks near the hila when there is a heavy deposition of aerosol in the airways. As noted previously, delayed images can be useful in this situation. When precise localization is possible, then the diagnosis of bronchopleural fistula is confirmed, and the leak can be repaired. Early in the authors' experience, thoracotomy was done, but with more experience, treatment by thoracoscopy is usually feasible. The procedure was also used to exclude the diagnosis (Patients 5 and 6). From this small series, no estimate of the true sensitivity of the technique can be made, nor is the minimum amount of air leak that is detectable known. Ventilation scintigraphy using ^{99m}Tc-DTPA aerosol offers a method of localizing bronchopleural fistulas in selected patients.

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