Localizing the Air Vents
Functional Imaging–Guided Diagnosis in Extensive Multilocal Subcutaneous Emphysema

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An 88-year-old woman required out-of-hospital cardiopulmonary resuscitation (return of spontaneous circulation 2 minutes) for third-degree heart block and was admitted to our intensive care unit. The patient underwent urgent implantation of a dual-chamber pacemaker. Three hours later, she developed extensive emphysema of her face with crepitation over the entire thorax, neck, and face. Single-plane chest x-ray confirmed subcutaneous emphysema but failed to identify the underlying pathology (Figure 1A). Just a few minutes later, the patient worsened, and subcutaneous emphysema rapidly progressed to neck, midface, eyelids, and fingertips; the decision for whole-body CT was made. CT revealed left-sided ventral pneumothorax and mediastinal and fingertips; the decision for whole-body CT was made. CT revealed left-sided ventral pneumothorax and mediastinal emphysema spreading over cervical structures into both arms (Figure 1B). Furthermore, on the contralateral side, CT showed fractures of the fourth and fifth ribs and ipsilateral multiple fragments of the clavicle. However, a direct lesion of the lungs, the large airways, or the esophagus as a potential main cause could be excluded.

Taking clinical findings into account, we discussed 3 possibilities for a pulmonary-subcutaneous air leakage: (1) post-traumatic pneumothorax after chest compression during cardiopulmonary resuscitation leading to fractures of ribs and sternum, (2) tracheal injury attributable to traumatic endotracheal intubation, or (3) iatrogenic pneumothorax in the course of pacemaker implantation using an infraclavicular approach for puncture of the subclavian vein.

To elucidate the origin of the leakage, a combination of a technetium (Tc)-99m-Techegas (Cyclomedica Germany GmbH, Salzgitter) single-photon emission CT (SPECT)–derived ventilation study and a low-dose CT scan were performed using an Symbia T2 hybrid SPECT-CT system (Siemens, Erlangen, Germany). A technically identical follow-up investigation was performed at the time of patient discharge.

Tc-99m-Techegas is an ultrafine aerosol of Tc-99m–labeled solid graphite particles with a diameter of 5 to 30 nm. It is produced at a high temperature (2500°C) in a dedicated generator containing a chamber with a graphite crucible filled with Tc-99m-pertechnetate.1–3 Since the mid-1980s, >1000 Technegas generators have been installed in diagnostic institutions throughout the world, and >2 million Technegas patient studies have been performed. Since then, it has been approved in Australia and Europe. A phase III study for its licensing is currently underway in the United States. When inhaled, this pseudogas shows a static alveolar deposition. After our patient had taken multiple breaths of Tc-99m-Techegas, a SPECT/CT investigation was performed by the time an adequate activity had been deposited in the lungs (≈20–50 MBq) and a sufficient count rate had been registered over the thorax. First, a low-dose CT of the thorax was acquired for 52 seconds using an x-ray current intensity of 70 mA (with Care Dose modulation) and a voltage of 130 kV. Subsequently, a continuous dual-head SPECT acquisition following the body contour was done with a matrix size of 128×128 for 21 minutes. The SPECT study was reconstructed iteratively, including attenuation and scatter correction. Because there was no indication for impaired pulmonary perfusion, additional scanning with Tc-99m–labeled macroaggregated albumin was omitted (see online-only Data Supplement Movie I).

Using this diagnostic approach, we identified the source of the pneumothorax as a singular leakage at the lower part of the left clavicle, resulting in focal trapping of the Technegas particles. It was concluded that this was caused by traumatic injury of the lung during pacemaker implantation (Figure 2). With the knowledge of precise localization, 2 thoracic drains were placed using a midclavicular (Monaldi) and a left lateral access.

During the further hospital stay, the emphysema slowly declined, and re-evaluation by ventilation SPECT/CT was performed on day 8 (see online-only Data Supplement Movie II). Focal air trapping suggesting pulmonary leakage was no longer detectable, and the emphysema was significantly reduced (Figure 2), so both drains were removed. This was interpreted...
as confirmation of the assumed underlying pathomechanism. During follow-up, the patient remained asymptomatic and was discharged from the hospital on day 14. On routine pacemaker follow-up after 1 month, the patient presented an excellent neurological outcome. Furthermore, no clinical signs of residual skin emphysema were present.

In conclusion, we suggest a benefit for the use of functional ventilation SPECT/CT in the detection, localization, and differentiation of potentially multifactorial airway injuries offering concerted treatment options.

Disclosures
None.

References

Key Words: subcutaneous emphysema • tomography, emission-computed, single-photon • tomography, X-ray computed

Figure 1. A, Single-plane chest x-ray showing the extensive emphysema but failing to identify the underlying pathology. B, Chest CT revealing left-sided ventral pneumothorax and a mediastinal and extensive subcutaneous emphysema spreading over the chest into both arms.

Figure 2. Left. (Admission) Low-dose CT showing severe emphysema of thoracic structures (A). Ventilation single-photon emission computed tomography (SPECT; B) and SPECT/CT (C) demonstrating retroclavicular singular leakage of inhaled technetium (Tc)-99m-Technegas and accumulation of nuclide activity at the apex of the left lung. Right. (Discharge) Low-dose CT showing a considerably regressive emphysema of the thoracic structures (A). Ventilation SPECT (B) and SPECT/CT (C) do not show any leakage of inhaled Tc-99m-Technegas anymore. Secondary finding: activity accumulations at both pulmonary hila are indicative of an obstructive airway component.
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