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Localized air foci in the lower thorax in the patients with pneumothorax: Skip pneumothoraces

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ABSTRACT

Purpose: To investigate the characteristics and imaging features of localized air foci in the lower thorax in patients with pneumothorax using thin-section multidetector computed tomography.
Materials and methods: Of 10,547 consecutive CT examinations comprising the chest, the CT scans of 146 patients with ordinary pneumothoraces were identified and retrospectively evaluated. The study group included 110 male and 36 female patients (mean age, 50 years; range, 1–93 years). All examinations were performed at our institution between January 2009 and December 2009. Cause of pneumothorax was classified as traumatic or non-traumatic. Localized air foci in the lower thorax were defined as being localized air collections in the lower thorax that did not appear to be adjacent to the lung. If these criteria were met, the shape, size, location laterality, and number of foci were evaluated. Associations with trauma, sex, severity of the pneumothorax, and laterality were evaluated using the χ^2 test. All P values <0.05 were considered significant.
Results: Localized air foci in the lower thorax presented as slit-like or small ovoid air collections in the lowest part of the pleural space. These foci were observed in 79/146 (54.1%) patients. The traumatic pneumothoraces group showed a higher prevalence of these features than the non-traumatic group. Some foci that were situated in the anterior part mimicked the appearance of free intraperitoneal air.
Conclusion: Patients with pneumothorax commonly had localized air foci in the lower thorax. Because such foci can mimic pneumoperitoneum, accurate recognition of them is required to avoid confusion with free intraperitoneal air, especially in traumatic cases.

1. Introduction

The term *pneumothorax* refers to air in the pleural cavity [1], and this condition is usually classified as traumatic or nontraumatic (spontaneous) based on its causes [2]. In a large study of 1199 cases of pneumothorax, spontaneous pneumothoraces occurred in 723 (60.3%), and traumatic pneumothorax occurred in 403 (33.6%) patients, 73 (6.1%) of whom had iatrogenic pneumothorax [3].

At present, CT scanning is regarded as the "gold standard" in the detection of small pneumothoraces [1]. The development of multidetector computed tomography (MDCT) scans has advanced radiologists' ability to detect very small abnormalities.

Recently we have observed that MDCT could show localized air foci in the lower thorax, an observation that we refer to as LAFLT, with these foci not appearing to be adjacent to the lung in those patients with pneumothorax. To the best of our knowledge, this observation has never been reported. These findings could be similar in appearance on CT to free intraperitoneal air when these localized foci of air are located anteriorly. In the case of *high-impact trauma*, the patient may have a brain *injury and may have multiple traumas; of additional concern is the fact that signs of abdominal trauma are often easy to miss in patients experiencing a loss of consciousness.* We feel that accurate and early identification of LAFLT is of significant clinical significance, as this information can inform clinical decisionmaking following pneumothorax. Such a diagnosis is especially important in traumatic-injury cases in which the patient has lost consciousness and is not capable of providing valuable details (e.g., location and extent of pain) to the treatment team. The aim of this study was to investigate the characteristics and imaging features of LAFLT in patients with pneumothorax by employing thin-section MDCT.

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2. Materials and methods

Our institutional review board approved this retrospective record review and waived the requirement for informed patient consent.

2.1. Patient group

Between January 2009 and December 2009, 10,547 consecutive CT examinations comprising the chest were performed at our institution. By reviewing the associated radiological reports, 219 patients with pneumothoraces were retrospectively identified. Seventy-three patients with conditions thought to preclude an accurate analysis of localized pneumothorax in thin-section CT were excluded from the study group. These conditions included extensive chest wall damage, iatrogenic or tension pneumothoraces, or inadequate CT examination, for example, when CT scanning did not extend through the rib cage. Of the remaining patients with pneumothoraces, 146 were included in this study. The study group included 110 males and 36 females, with a mean age of 50 years (range, 1–93 years). The causes of pneumothoraces were divided into trauma ($n = 43$) and non-trauma ($n = 103$). If a patient had multiple CT examinations during this period, the first scan with pneumothorax was selected for study. Indications for chest MDCT varied among the patients. For each case, the cause of pneumothorax was classified as either traumatic or non-traumatic.

2.2. Imaging technique

All CT examinations were performed with a Somatom Definition or Somatom Sensation 64-slice MDCT system (Siemens Medical Solutions, Forchheim, Germany) during end-inspiratory breath-hold with or without contrast medium, and 2 mm-thick axial images were reconstructed. Standardized imaging and reconstruction parameters (collimation, 64 × 0.6 mm; reconstruction interval, 2 mm; kernel B70f, very sharp and kernel B31f medium, smooth+) were applied to all images, with the field of view being individually adapted to each patient's physique.

2.3. Image interpretation and evaluation

All images were reviewed and evaluated using our department picture archiving and communicating system (PACS) on liquid crystal display monitors. All of the CT images were reconstructed using lung parameters (kernel B70f, very sharp) and were reviewed with a lung window (width, 1600 HU; level, −600 HU). To enhance the sensitivity of CT to gas detection, CT images were reconstructed using mediastinal and abdominal parameters (kernel B31f medium smooth+) and were reviewed with an adapted window setting (width, 500 HU; level, −50 HU) to allow air densities to be differentiated from fat densities, as recommended by Delabrousse et al. [4].

The acquired axial images were then transferred to a workstation for analysis and underwent post-processing into multiplanar-reformatted (MPR) and three-dimensional volume-rendering (3D VR) images for evaluation. Two radiologists (with 24 and 4 years of experience) reviewed all CT images, being free to use axial slices as well as MPR and 3D VR images. They independently reviewed all CT images, and noted the presence or absence of localized air foci close to the chest wall at the lowest part of the rib cage, where the parietal pleura contacts the diaphragmatic pleura and where no lung is expected to be found. The readers were blinded to the patients' clinical information and conditions with the exception of the presence of ordinary pneumothorax. Localized air foci were defined as a discontinuous air collection situated in the lower thorax that did not appear to be adjacent to the lung. After independent evaluation of the presence of the lesions, a consensus was reached regarding any disagreements on individual cases before the next evaluation session.

Fig. 1. Locations of localized air foci in the lower thorax (LAFLT) were divided into anterior (blue line), lateral (yellow line), and posterior (red line) parts in the transaxial plane.

If localized air foci in the lower thorax were identified, the number of them and their shape, size (the largest diameter on the transaxial plane), and location laterality were evaluated in consensus. The location was assigned by consensus to one of three groups on the transaxial plane: anterior, lateral, or posterior parts of the chest wall (Fig. 1). If there was more than one observation in the same patient, the locations of each focus were also assigned. The severity level of the pneumothorax was classified by the extent of lung collapse as mild (less than 30%) or severe (greater than 30%) using CT findings.

If follow-up CT studies were performed in patients with LAFLT, any changes to the observed foci were also investigated.

2.4. Statistical analysis

The differences between the localized air foci in the lower thorax and patient age were evaluated using the Student's *t*-test. Associations with trauma, sex, severity of the pneumothorax, and laterality were evaluated using the χ^2 test. A difference was considered significant if the *P* value was less than 0.05.

Inter-observer agreement between the two readers regarding the presence of skip pneumothorax was calculated by the Kappa statistic *k*, which indicated poor ($\kappa = 0$), slight ($\kappa = 0$–0.20), fair ($\kappa = 0.21$–0.40), moderate ($\kappa = 0.41$–0.60), substantial ($\kappa = 0.61$–0.80), or almost perfect ($\kappa = 0.81$–1.00) agreement [5].

3. Results

LAFLT presented as slit-like or small ovoid air collections on MDCT (Fig. 2).

A total of 79/146 (54.1%) patients showed LAFLT (Kappa value = 0.74, indicating substantial agreement). Observed foci ranged in size from 2 to 32 mm (mean, 9 mm) and numbered from 1 to 10 (mean, 2.5). LAFLT were seen in 34/43 (79.1%) patients with traumatic pneumothorax (Table 1). There was no significant relationship between the presence of lesions and the severity of the pneumothorax, laterality, sex, or age ($P > 0.05$).

Twenty-four patients with spontaneous pneumothorax before treatment also had LAFLT. All of the incidences of LAFLT were