Original Investigation

# Added Value of Bone Subtraction in Dual-energy Digital Radiography in the Detection of Pneumothorax: Impact of Reader Expertise and Medical Specialty

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**Rationale and Objectives:** This study aimed to determine the value of dual-energy thoracic radiography in the diagnosis of pneumothorax considering the reader's experience.

**Materials and Methods:** Forty patients with a suspected pneumothorax, imaged with dual-energy chest radiographs, were divided into two groups: those with pneumothorax as the final diagnosis ($n = 19$) and those without ($n = 21$). The images were analyzed by 36 readers (5 interns, 16 residents, 15 senior physicians) for the presence or absence of pneumothorax during three readout sessions at 2-week intervals: standard images alone (session 1), dual-energy images with bone subtraction alone (session 2), and a combination of the two (session 3).

**Results:** The number of correct responses increased 13.3% between sessions 1 and 2 ($P < .001$) and 9.4% between sessions 1 and 3 ($P < .001$). The mean sensitivity for pneumothorax detection was higher in sessions 2 (82%) and 3 (79%) compared to session 1 (70%). There was no statistically significant difference in specificity between the sessions. The number of correct responses for small volume pneumothoraces was higher in sessions 2 ($10.6 \pm 1.8$) and 3 ($10.1 \pm 2.0$) than in session 1 ($8.9 \pm 2.3$), with a statistically significant difference between sessions 1 and 2 ($P = .002$) and between sessions 1 and 3 ($P = .048$).

**Conclusion:** Bone subtracted dual-energy thoracic radiographs improve the detection sensitivity of pneumothorax, including in cases of small pneumothoraces, regardless of the reader's level or expertise.

**Key Words:** Pneumothorax; Dual-energy; bone substraction; digital radiography.



## INTRODUCTION

Pneumothorax is a common condition, affecting an estimated 17 of 100,000 people in France (1) and 34.8/100,000 in England (2). It requires precise and rapid diagnosis, and conventional radiography is usually the initial imaging method of choice. However, pneumothorax detection, particularly in cases of small pneumothoraces, may be difficult and sometimes requires the use of additional techniques, such as computed tomography (CT).

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Dual-energy radiography is an expanding technique, thanks to an increase in the availability of flat panel detectors. Diagnostic improvement offered by this technique has been demonstrated in the detection of calcified and noncalcified lung nodules, and calcified thoracic lesions (mediastinal, pleural, or pulmonary) (3–7). Although no studies could be found in the literature analyzing the contribution of dual-energy digital radiography for the detection of pneumothorax, it seems that diagnostic performance could be improved by this technique because it can suppress bone structures of the thoracic wall, reducing superimposition and allowing a finer delimitation of lung contours.

The main objective of this study is to determine whether bone subtraction with dual-energy digital radiography improves the detection of pneumothorax. The secondary objective is to determine whether the reader's experience influences diagnostic performance. This information could improve the management of patients with suspected pneumothorax, and reduce the need for confirmation of radiographic findings on CT.

## MATERIALS AND METHODS

### Population

This is a retrospective study of 40 patients who underwent a dual-energy chest digital radiography in our institution from June 2014 to June 2016, selected from our database by keyword search of imaging studies and surgical reports aiming for the presence or absence of pneumothorax. All patients with pneumothorax confirmed clinically or surgically who had dual-energy radiographs performed were included (group 1). Then a similar-sized control group with confirmed pneumothorax absence was selected randomly in the same time period (group 2). Groups 1 and 2 were composed of 19 and 21 patients, respectively. The final diagnosis of pneumothorax or its absence was established based on the analysis of patient records at the time of discharge, considering the reports of any investigations or treatments performed following initial radiographs. In group 1 pneumothorax confirmation was surgical (drainage, bullectomy, pleural abrasion) in 12 cases and by CT confirmation in four. In three patients the diagnosis was confirmed at radiographic follow-up, which demonstrated a pneumothorax reabsorption. The absence of pneumothorax in group 2 was confirmed by the lack of clinical or imaging signs of pneumothorax and a favorable clinical course.

Pneumothorax volume was estimated by the Choi/Rhea method (8), which involves three measures of the interpleural distance in centimeters: the first at the apex of the lung (distance a), the second at the midpoint of the upper half of the thorax (distance b), and the third at the midpoint of the lower half of the thorax (distance c). The pneumothorax volume in percent was then calculated using the formula 4 + 9 ((a + b + c)/3) (Fig 1). Pneumothorax volumes were classified in two categories: small (<20%), and medium/large (>20%). Pneumothorax estimation was performed by a radiologist with 2 years of clinical experience (AU).

In our institution, ethics committee approval is not required for a retrospective study using anonymized patient data.

### Radiographic Technique

Images were obtained, with the patient in a standing or sitting position, using direct digital radiography with a flat panel detector with 70 lines/cm (Definium 8000, General Electric Medical Systems, GE Healthcare, Buc, France). An aluminum grid containing 40 μ of lead was used and the target distance was 180 cm. Two successive exposures with a 200 ms interval were acquired: one at high energy (130 kV and 500 mA) and the other at low energy (70 kV and 800 mA). After the second exposure, postprocessing of dual-energy data with a subtraction algorithm yielded three images: a standard radiograph from the high-energy exposure, a "bone" image with soft tissue suppression, and a "soft tissue" image with suppression of the osseous structures (here termed dual-energy with bone subtraction [DEBS]). All the radiographs were performed by senior technicians of our institution's radiology department.

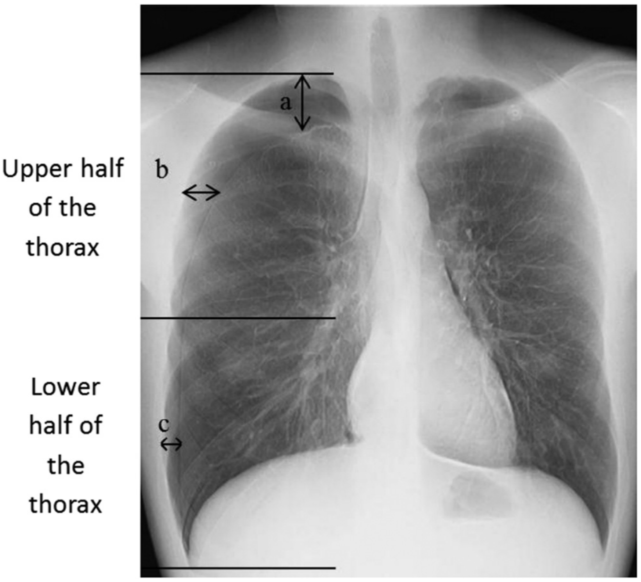


**Figure 1.** Chea/Rhoi method of estimating the volume of a pneumothorax. Chest DEBS radiography of an 18-year-old man, with chest pain showing a low-volume right apical-lateral pneumothorax. Three interpleural distances are measured: the first at the apex of the lung (**a**); the second at the midpoint of the upper half of the thorax (**b**); the third at the midpoint of the lower half of the thorax (**c**). From these three measurements an estimate of the volume of the pneumothorax in percentage is obtained by the formula: 4 + 9 ((a + b + c)/3). Here, a = 1.7 cm; b = 1.3 cm, c = 0.6 cm, that is, 4 + 9 ((1.7 + 1.3 + 0.6)/3) = 14.8%; this a small pneumothorax.

### Reading and Analysis

Thirty-six readers analyzed the images: 5 medical student interns, 16 residents (9 radiology residents, 2 pneumology residents, and 5 general medicine residents), and 15 senior physicians (4 radiologists and 11 emergency physicians). The medical student participants were in an ongoing internship in our institution's imaging department and were, hence, confronted with the analysis of dual-energy chest radiographs in their practice. Data analysis was performed considering reader expertise (interns, residents, and senior physicians) and medical specialty (radiologists and nonradiologists).

Readouts were performed using WUXGA-formatted video projector (16:10 resolution, 1920 × 1200 pixels) calibrated to provide an optimal image identical to that of a picture archiving and communication system (PACS) station, and room lighting was similar to that of our reading room with dimmed lights. Readers were located approximately 200–250 cm from the projection screen. Fifteen seconds separated the display of each image. Readers were asked to fill in a binary grid: pneumothorax, yes or no.

Three reading sessions were organized at 2-week intervals: during the first session, the classic radiographs were displayed alone (session 1). In the second, DEBS radiographs were displayed alone (session 2), and in the third, both images (classic and DEBS radiographs) were displayed side-