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Utility of chest CT after a chest X-ray in patients presenting to the emergency department with non-traumatic thoracic emergencies

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ABSTRACT

Background: Chest radiography is the initial choice for thoracic imaging. However, the wide availability of computed tomography (CT) has led to a substantial increase in its use in the emergency department (ED). We evaluated the utility of chest CT after a chest X-ray in patients presenting to the ED with non-traumatic thoracic emergencies, and determined if the diagnosis and management decision changed after CT.
Methods: The study enrolled 500 consecutive patients with both chest X-rays and CT who presented to the ED with non-traumatic complaints. Chest X-rays and CT images obtained within 12 h before any definitive treatment were randomly evaluated in consensus by two radiologists blinded to the clinical information.
Results: The chest X-ray and CT image findings were concordant in 49.2% of the 500 patients and this concordance was negatively correlated with patient age. Leading diagnosis and management decisions based on the chest radiograph changed after CT in 35.4% of the study group and this finding was also correlated with age. In 55% of 205 patients, pneumonic infiltrations were undiagnosed with radiography. Pulmonary edema was the most specific (93.3%) and sensitive (85.4%) radiography finding. Posteroanterior chest radiographs taken in the upright position had higher concordance with CT than anteroposterior (AP) radiographs taken in the supine position.
Conclusions: Chest CT may be an appropriate imaging choice in patients presenting to the ED for non-traumatic reasons, particularly for elderly patients and when the radiograph is taken with the AP technique in a supine position.

1. Introduction

Chest radiography is the initial choice for thoracic imaging because it offers simplicity, a large amount of information, and lower costs [1]. Thoracic ultrasonography has been shown to be an imaging modality comparable with portable chest X-rays since it can be used bedside, has high accuracy and no exposure to radiation as well as minimal low cost. Nevertheless, the usefulness of computed tomography (CT) in thoracic radiology is recognized. The remarkable development and wide availability of CT have led to a substantial increase in its use in the emergency department (ED) [2]. Recent studies have reported that CT is more useful than chest radiography for detecting traumatic pathologies, while the clinical utility of chest CT for non-traumatic emergencies has not been described [2,3].

CT also has disadvantages, such as the relatively higher exposure to ionizing radiation, higher costs, and risk of nephrotoxicity when contrast medium is used [2]. Furthermore, a CT examination in ED conditions is time-consuming and may slow ED throughput [2]. Therefore, the indications for chest CT should be reevaluated [4]. Medical knowledge, routine workload, health policies, and patient expectations all play roles in the physician's selection of radiological examinations. However, the fundamental role of radiological and laboratory examinations is to contribute to the diagnosis and patient management [5].

This study evaluated the utility of chest CT after a chest radiograph in patients presenting to the ED with non-traumatic thoracic emergencies and determined if the diagnosis and management decisions changed after the CT examination. These data will better help clinicians decide whether to order chest CT in the ED for non-trauma patients.

2. Methods

This retrospective study was approved by the ethics committee of our institution. The study enrolled 500 consecutive patients (225 females, 275 males; mean age 70 [range 18–97] years) who presented to the ED with non-traumatic thoracic emergencies and had both a chest X-ray and subsequent chest CT within 12 h. The patients whose

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CT examination were obtained ≥12 h after X-ray were not included in the study for the reason that new problems might have been added after this period of time. The patients who were younger than 18 years or who received definitive treatment before the chest CT were not included in the study since the treatment would influence imaging findings. Chest X-rays were taken with the posteroanterior (PA) technique in the upright position or with the anteroposterior (AP) technique in a supine position using a portable machine. CT imaging was performed using a multi-detector CT scanner (Brilliance 64 Philips; Philips Medical Systems©, Eindhoven, The Netherlands). The routine scanning parameters were voltage 120 kVp, current 120 mA, and slice thickness of 2 mm. CT was performed without intravenous or oral contrast.

The chest radiographs and CT images were randomly evaluated in consensus by two radiologists blinded to the clinical information. Chronic findings, such as chronic bronchitis or emphysema, were not considered. Emergency pathology findings including pulmonary edema, pneumonic infiltration, pleural effusion, atelectasis, pneumothorax, and fractures were noted as imaging findings in each modality separately. The radiologists also recorded nonspecific suspicious radiographic findings such as hilar or mediastinal widening that required further investigation. The concordance of the detection of pathology by chest radiography and CT imaging were assessed, after which misconceptions were determined. For each imaging finding, we compared the sensitivity and specificity of radiography with those for CT. After the radiological evaluation, each patient's hospital records were investigated for clinical details to assess the impact of chest CT (after chest X-ray) on the patient's diagnosis and management in the ED. Patients whose hospital records were missing or incomplete were excluded from the study.

Mediastinal enlargement, pulmonary nodules (<3 cm), and masses (>3 cm) detected by radiography were recorded because they required further investigation with CT. The concordance of the detection of mediastinal masses, pulmonary nodules, and masses by chest radiography and CT imaging was evaluated. The sensitivity and specificity of radiography for the detection of nodules and masses compared to CT were also analyzed.

The statistical analyses were performed using SPSS 20.0 for Windows (IBM, NY, USA). Continuous data are expressed as the mean ± standard deviation, whereas categorical data are presented as the number of patients and percentages. Continuous variables were compared between groups using the independent samples *t*-test. Correlations between different variables were examined using the Pearson correlation coefficient. Subgroup analysis also compared the PA and AP radiography groups for concordance with CT, impact on diagnosis/management, sensitivity, specificity, positive/negative predictive value, and positive/negative likelihood ratio. A p value <0.05 indicated statistical significance.

3. Results

Chest radiography was taken with the PA technique in 56% of the patients and with the AP technique for the remaining 44% patients. The patients in the PA group were significantly younger than those in the AP group (67.3 ± 16.9 vs. 75.2 ± 11.3 years, $p < 0.001$). According to the radiologists' consensus decision, 208 (41.6%) of the radiographs were normal or had chronic findings. Among the remaining 292 (58.4%) radiographs, the most frequently detected finding was pleural effusion ($n = 133$, 45.6%), followed by pulmonary edema ($n = 120$, 41.1%) and pneumonic infiltration ($n = 34$, 33.9%). Of the 500 CT images, 129 (25.8%) were normal or had chronic findings. Among the remaining 371 (74.2%) CT images, the most frequent finding was pneumonic infiltration ($n = 205$, 55.3%) followed by pleural effusion ($n = 168$, 45.3%) and pulmonary edema ($n = 110$, 29.7%). Table 1 summarizes the imaging findings.

Table 1
Characteristics of study population, imaging findings detected by radiography and CT

Age (years)	70 (±15.2)
Gender	
Female	225 (45)
Male	275 (55)
Type of chest radiography	
AP	222 (44)
PA	278 (56)
Total number of abnormal radiographs*	292 (58)
Chest radiography findings	
Pleural effusion	133 (45.6)
Pulmonary edema	120 (41.1)
Pneumonic infiltration	99 (33.9)
Pulmonary mass	25 (8.6)
Pneumothorax	5 (1.7)
Mediastinal widening	4 (1.4)
Multiple nodules	4 (1.4)
Solitary nodule	3 (1)
Atelectasis	3 (1)
Costal fracture	2 (0.7)
Hilar widening	2 (0.7)
Total number of abnormal CTs*	371 (74)
Chest CT findings	
Pneumonic infiltration	205 (55.3)
Pleural effusion	168 (45.3)
Pulmonary edema	110 (29.7)
Pulmonary mass	25 (6.7)
Solitary nodule	23 (6.2)
Multiple nodules	10 (2.7)
Pneumothorax	6 (1.6)
Costal fracture	6 (1.6)
Atelectasis	4 (1.1)
Mediastinal mass	1 (0.3)
Mediastinal lymphadenopathy	1 (0.3)
Pulmonary nodule(s) or mass(s) suggesting malignancy	33 (11.3)

Data are presented as mean ± SD or n (%); * Abnormal findings: Radiography or CT which is not evaluated as normal or which is presenting findings other than chronic and sequel fibrotic changes, chronic obstructive pulmonary disease or emphysema. AP, anteroposterior; PA, posteroanterior; CT, computed tomography.

Mediastinal widening was also recorded in four patients, and may be a sign of a malignant pathology that needs further investigation with CT. In those cases, CT examination showed that one patient had an actual mediastinal mass, which was subsequently diagnosed as thymic carcinoma; one patient had a right perihilar central pulmonary mass; and one patient had multiple lymphadenopathy related to lymphoma while one of them was a false image and the mediastinum was normal.

With CT imaging, pulmonary masses or nodules that were highly suspicious for malignancy and required further investigation were detected in 33 (6.6%) of the 500 patients. In comparison, radiography detected a mass or nodule in only eight (24%) of these patients. The radiographic findings were concordant in 246 (49.2%) of the 500 patients and this concordance was negatively correlated with patient age ($p = 0.025$, $r = -0.1$). The leading diagnosis and management decisions according to chest radiography changed after CT in 177 (35.4%) patients of the study group and this finding was also correlated with age ($p = 0.002$, $r = 0.138$). With radiography, pneumonic infiltration was undiagnosed in 113 (55%) of 205 patients and pulmonary edema in 15 (14%) of 109 patients; in addition, 22 patients were misdiagnosed with pneumonic infiltration, while 5 patients were misdiagnosed with pulmonary edema. Radiography failed to diagnose pneumothorax in four of six patients. There were six patients with costal fractures and three of them had accompanying pleural effusions compatible with hemothorax, but only two of them were diagnosed with radiography, two were reported as normal, and two were only diagnosed with pleural effusions.

Pulmonary edema was the most sensitive (85.4%) and specific (93.3%) finding of radiography. The sensitivity of radiography for detecting atelectasis, pneumothorax, pleural effusion, mass, pneumonic infiltration, and fractures was 75%, 66.7%, 60.1%, 60%, 37.7%, and 33.3%,

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