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CHEST RADIOGRAPH VS. COMPUTED TOMOGRAPHY SCAN IN THE EVALUATION FOR PNEUMONIA

Geoffrey E. Hayden, MD and Keith W. Wrenn, MD

Department of Emergency Medicine, Vanderbilt University Medical Center, Nashville, Tennessee
Reprint Address: Geoffrey E. Hayden, MD, Department of Emergency Medicine, Vanderbilt University, 703 Oxford House, Nashville, TN 37232

□ **Abstract—To determine, in an Emergency Department (ED) population, the incidence of pneumonia diagnosed on thoracic computed tomography (CT) in the setting of negative or non-diagnostic chest radiographs (CXR). This is a retrospective chart review of all ED visits of adult patients ultimately diagnosed with ″pneumonia″ in whom both CXR and CT were obtained. We note cases in which the CXR was either negative or non-diagnostic for pneumonia and the CT noted a definitive infiltrate consistent with pneumonia. Of the 1,057 patients diagnosed with pneumonia, both CXR and CT were performed in 97 cases. Of this group, there were 26 patients (27%), in whom the CXR was either negative or non-diagnostic, but the CT noted an infiltrate/consolidation consistent with pneumonia. In our retrospective review of ED patients, we find that in 27% of cases in which both a CXR and a CT scan were performed in the work-up of varied chief complaints, pneumonia was demonstrated on CT in the face of a negative or non-diagnostic CXR. This analysis demonstrates the need for further studies regarding the appropriate radiographic evaluation of pneumonia, particularly in high-risk patients. © 2009 Published by Elsevier Inc.**

□ **Keywords—pneumonia; computed tomography (CT); chest X-ray (CXR); diagnosis; Emergency Department**

INTRODUCTION

In the United States, there are over 5 million cases of community-acquired pneumonia (CAP) each year, with approximately 2 million requiring hospitalization; almost 50,000 deaths are attributed to CAP (sixth leading cause of death from infectious diseases). The estimated annual cost of treatment is over $20 billion (1).

Chest radiography is the usual standard for diagnosing pneumonia in the Emergency Department (ED), and virtually all studies looking at the diagnosis and disposition of patients have used plain chest X-ray study interpretation (by a Radiology attending) as the reference standard (2,3). Further, the standard of care in the ED is to treat adult patients with radiographic evidence of an infiltrate with antibiotics, because this illness continues to have an overall high mortality (4). When patients with cough or fever have a normal lung examination and a negative chest X-ray study, "pneumonia" is ruled out and oftentimes "bronchitis" is diagnosed. The use of antibiotics to treat "bronchitis" in adults is discouraged (5). Our study was performed to assess the incidence of pneumonia diagnosed on thoracic computed tomography (CT) scan in the setting of negative or non-diagnostic chest radiographs (CXR).

Unfortunately, chest radiography, the most common imaging modality in the diagnosis of pneumonia, has been shown to be somewhat unreliable in the definitive diagnosis of pneumonia. Although the significance of this is unknown, there is a demonstrable superiority of thoracic CT scan over CXR in the diagnosis of pneumonia in particular patient populations. Studies have favorably compared CT scan vs. CXR in populations of im-

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munocompetent children, neutropenic patients, and patients with human immunodeficiency virus (HIV) (6–8). At present, there have been no studies that specifically look at an ED population with regard to pneumonia evident on thoracic CT scan in the setting of a negative or non-diagnostic chest X-ray study.

MATERIALS AND METHODS

Study Design

This was a hypothesis-forming, retrospective chart review conducted to study an ED patient population with apparent pneumonia; the goal was to assess how often CT scan detects infiltrate or consolidation when chest X-ray studies are either negative or non-diagnostic. Our hospital's institutional review board approved the study protocol on an "exemption" status, based on the collection of existing data, with removal of any protected health information.

Study Setting and Participants

This study was based in the ED of the Vanderbilt University Medical Center (Nashville, TN), an academic ED with an annual patient census of 80,000. Adult patients (aged $\geq$ 18 years) presenting to the ED during the period from February 2003 to December 2004 who received an ICD-9 (International Classification of Diseases and Related Health Problems) diagnosis code of pneumonia were eligible for data analysis. The final study group comprised eligible patients with a diagnosis of pneumonia, for whom both a chest radiograph (either portable anterior-posterior [AP] or posterior-anterior [PA] and lateral; viewed using digital radiographs) and computed tomography scan (using a GE Lightspeed 8-slice CT scanner, images viewed at 2.5–5 mm thickness) were obtained.

Methods of Measurement and Data Collection

The primary investigator conducted a chart review (via a pre-existing structured data collection form) to record pertinent clinical and demographic data. These included age, gender, chief complaint, temperature, oxygen saturation, and co-morbidities of the eligible patients. The final radiographic interpretations of the CXR or CT by attending radiologists were then recorded.

A CXR study, by the standards of the review, was termed negative if the interpretation described no cardiopulmonary disease. It was termed "non-diagnostic" based on an interpretation that failed to describe a definitive pneumonia; these interpretations lacked a description of an "infiltrate" or "consolidation" or "opacity" that was consistent with pneumonia. Conversely, a CT scan that was "diagnostic" of pneumonia included an interpretation noting a definitive infiltrate or consolidation consistent with pneumonia. No radiologic interpretation of a CXR in the Results section recommended a follow-up CT scan for further delineation of pathology. As per review of the medical record, all patients with CT scan findings consistent with pneumonia were treated with antibiotics.

Primary Data Analysis and Outcome Measures

The results were presented as strict numbers of negative or non-diagnostic chest radiographs in the setting of diagnostic CT scans. A percentage was similarly obtained.

RESULTS

During the study period, a total of 1057 records contained the diagnosis code for pneumonia; both CXR studies and CT scans were performed in 97 cases. In 26 of these cases, the final radiologic interpretation included a negative or non-diagnostic CXR study and a definitive infiltrate/consolidation was seen on CT scan (Table 1). All of these patients were subsequently treated for pneumonia.

The age range of the patient population in these 26 cases was 18–79 years. There was a great range of comorbidities, including chronic obstructive pulmonary disorder (n = 5), leukemia (n = 3), post-lung surgery (n = 2), lung cancer (n = 1), history of pulmonary embolism/deep vein thrombosis (n = 2), asthma (n = 3), HIV (n = 1), diabetes mellitus (n = 7), end-stage renal disease (n = 1), history of pneumonia (n = 5), coronary artery disease (n = 3), and congenital heart disease (n = 1).

Based on the radiologic interpretation, in 27% of the patients who underwent both CXR study and CT scan, the CXR study was interpreted as negative or non-diagnostic, whereas the CT scan was notable for an infiltrate or consolidation; all of these patients received a final diagnosis of pneumonia and were treated with antibiotics. The disparity between the CXR findings and the chest CT scan is illustrated in the CXR study and CT scan in Figure 1. In that case, a 37-year-old man with a history of HIV, unknown last CD4 count, presented with fevers and chills. The presentation vital signs included a normal blood pressure, elevated pulse rate of 115 beats/min, tachypnea with a respiratory rate of 18 breaths/min, an oral temperature of 40.2°C, and a room air saturation of 98%. He appeared somewhat ill, and cachectic. The physical examination was significant for right basilar

Table 1. The 26 Patients with Discordant Chest X-Ray Study and CT Scan Findings

Age, Years	Gender	Chief Complaint	Temp	Oxygen Sat	Comorbidities	Chest X-Ray Study Findings	CT Scan Findings
44	F	Fever, CP	37.3°C (99.2°F) PO	97% RA	None	Adenopathy	LUL infiltrate (anterior)
67	M	Cough, dyspnea	36.3°C (97.4°F) PO	84% RA	COPD	Negative	RLL/LLL infiltrate
71	M	CP	37.7°C (99.8°F) PO		COPD, lung surgery	COPD	RUL infiltrate
30	F	Epigastric, CP	38.7°C (101.6°F) PO	100% RA	None	Negative	Upper lobe infiltrate
20	F	Cough			Congenital disease	Negative	Lingular infiltrate
26	F	Cough, SOB	37.2°C (99.0°F) PO	94% RA	ALL, asthma	Atelectasis in bases	LLL/RUL/lingula infiltrate
63	M	Right flank pain	36.6°C (97.9°F) PO	95% 2 L/NC	None	Atelectasis	RUL consolidation
19	F	CP	36.7°C (98.0°F) PO	98% RA	None	Negative	LLL infiltrate
36	M	Fever, SOB	37.3°C (99.2°F) PO	93% RA	COPD, h/o DVT	Pulm vascular congestion	RLL/RUL/LUL infiltrate
24	F	Abdominal pain	37.5°C (99.5°F) PO	100% RA	Chronic aspiration.	Negative.	RLL/RML pneumonia
79	M	Cough	36.7°C (98.1°F) PO	100% RA	CVA	Negative	RML infiltrate
21	M	SOB	37.2°C (99.0°F) PO	96% RA	Asthma	Basilar atelectasis	RML/LLL pneumonia
37	M	Fever	40.2°C (104.4°F) PO	97% RA	HIV, h/o pneumonia	Negative	RLL/RUL/LUL pneumonia
62	M	CP, SOB	37.1°C (98.7°F) PO	96% RA	h/o pneumonia	Bibasilar atelectasis	LLL infiltrate
66	M	SOB, hypoxia	35.8°C (96.4°F) PO	100% NRB	IPF, lung transplant	Left basilar atelectasis	RUL consolidation
25	F	Cough, asthma	37.3°C (99.2°F) PO	91% RA	None	Negative	RML consolidation
53	F	Left-sided CP			None	Negative	LLL infiltrate
78	M	SOB	37.1°C (98.8°F) R	98% NRB	CVA	Left basilar atelectasis	Left/Right lung infiltrate
76	M	SOB	36.1°C (97.0°F) PO	76% RA	Lung cancer	Rib erosions, negative	RLL/RUL consolidation
34	F	Right CP	37.1°C (98.7°F) PO	98% RA	None	Negative	RLL pneumonia, effusion
26	F	Cough	Afebrile	94% RA	s/p Delivery	Negative	Bilateral infiltrates
68	F	SOB	38.2°C (100.8°F) PO	92% RA	COPD	Negative	RML/RLL infiltrates
49	M	Left CP			ALL	Negative	Bilateral basilar infiltrates
34	F	SOB	Afebrile	83% 4 L/NC	Eisenmenger, h/o PE	Pulm vascular congestion	Parenchymal infiltrates
18	F	Cough, SOB			Asthma	Adenopathy	RLL infiltrate
64	F	CP, SOB	38.3°C (101°F) PO	92% RA	ESRD	Pulm HTN, atelectasis	Left/right basilar infiltrate

CP = chest pain; PO = by mouth; RA = room air; COPD = chronic obstructive pulmonary disease; RUL = right upper lobe; LUL = left upper lobe; RLL = right lower lobe; LLL = left lower lobe; ALL = acute lymphocytic leukemia; SOB = shortness of breath; PE = pulmonary embolus; DVT = deep venous thrombosis; h/o = history of; RML = right middle lobe; HIV = Human Immunodeficiency Virus; s/p = status-post; ESRD = end-stage renal disease; CVA = cerebrovascular accident; IPF = idiopathic pulmonary fibrosis; HTN = hypertension.

crackles and a diffusely tender abdomen, particularly over the periumbilical region. The anterior-posterior CXR study was interpreted as "negative for cardiopulmonary disease." An abdominal CT scan was ordered (and obtained within 4 h of the initial CXR study) due to his continued discomfort. It demonstrated no intra-abdominal pathology, only a dense infiltrate of the right lower lobe consistent with pneumonia. He was treated for bacterial pneumonia.

Of the 97 cases in which both CXR study and CT scan were performed, there were 60 PA/lateral studies and 37 portable AP studies. Of the CXR study-negative and CT scan-positive group, there were 12 PA/lateral studies and 14 portable AP studies. There was a suggestion that the AP film was less likely (as compared to PA/lateral films) to show an infiltrate compared to CT; however, even among those with PA/lateral films, 20% were CT scan-positive and CXR study-negative.

Also, the time lapse between CXR study and CT scan averaged 205 min, with a standard deviation of 128 min. Of the 26 studies, a CT scan was performed within 5 h (300 min) of the initial CXR study in 22 (85%) cases.

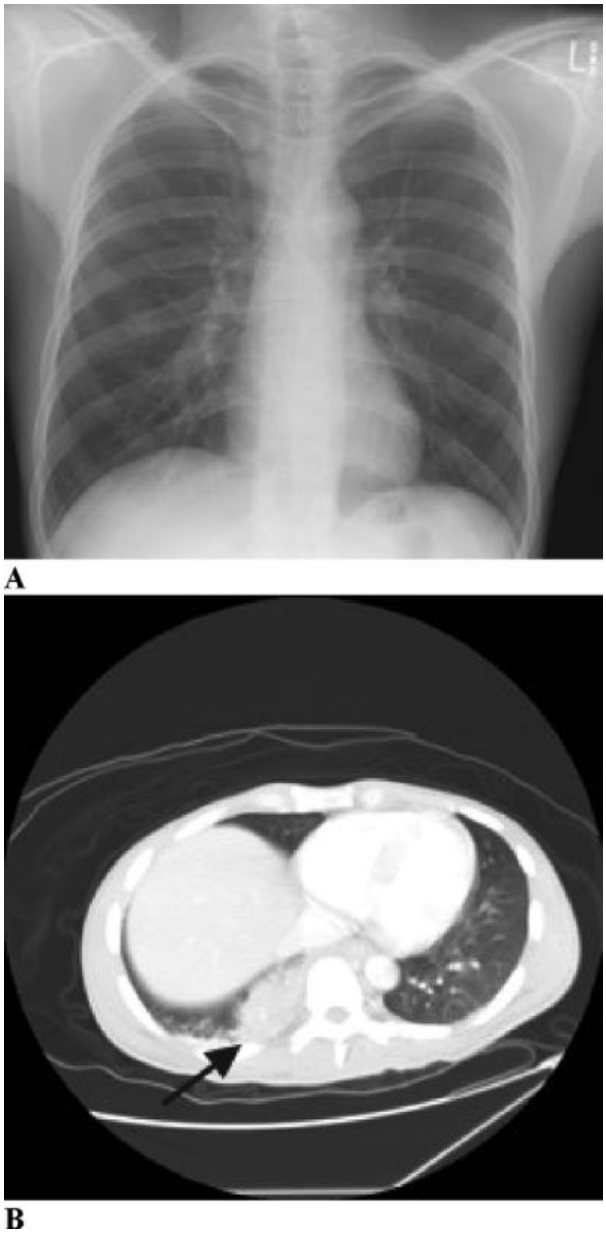

Figure 1. (A) Anterior-posterior chest X-ray study and (B) CT scan: 37-year-old HIV-positive man with fever and chills. The arrow indicates the right lower lobe consolidation noted on the abdominal CT scan.

DISCUSSION

With the growing recognition of the value of a CT scan, consideration of its use in common medical conditions is warranted. Pneumonia has historically been evaluated by chest radiography as the primary imaging modality. However, there have been several articles that have addressed the superiority of a CT scan over a CXR study in particular patient populations. Kendrick et al., in their study of 42 immunocompetent children admitted with community-acquired pneumonia, found that a CT scan is superior to a CXR study in demonstrating the parenchymal and pleural complications of pneumonia in these children (6). The patient population was selected based on lack of improvement in their clinical status at 7–10 days of admission; further radiographic study was then indicated in the form of a CXR study and a CT scan.

An article by Heussel et al. also describes improved diagnostic yield from thoracic CT scans as compared to CXR studies in the evaluation of febrile neutropenic patients not responding promptly to broad-spectrum antibiotics (7). The CXR studies showed abnormalities in approximately 10% of patients, whereas thoracic CT scans allowed the detection of lung infiltrates in almost 50% of these patients.

In a study of HIV patients with suspicion for pneumocystis carinii pneumonia (PCP), Richards et al. studied a group of patients with normal CXR studies; all patients underwent high-resolution CT scanning and bronchoalveolar lavage (BAL) to further identify PCP (8). Four of the 13 patients had "patchy ground-glass opacities" consistent with PCP, which all correlated with the BAL results. Their conclusion is that the use of high-resolution CT scanning may avoid unnecessary delays in the diagnosis and treatment of PCP.

In our hypothesis-forming, retrospective review of patients presenting to the ED, we found that in 27% of cases in which both a CXR study and a CT scan were performed in the work-up of varied chief complaints, pneumonia was demonstrated on a CT scan in the face of a negative or non-diagnostic CXR study. Although some of the patients were otherwise healthy, there were many individuals whose precarious health status may have been adversely affected by a false-negative CXR study and no medical therapy. When the chief complaint is fever/cough/chest pain in those with serious comorbidities (e.g., neutropenia, immunosuppression, sickle cell disease, prior lung disease, HIV), obtaining a CT scan in the setting of a negative CXR study would seem to be necessary.

LIMITATIONS

The study is limited both in the small sample size and its retrospective nature. There may be some degree of selection bias as those patients with a normal or non-diagnostic CXR study still underwent further study. The physician may have felt that the clinical status of the patient demanded more extensive imaging; many of these CXR/CT scan work-ups aimed to rule out pulmonary embolism as an explanation for the symptoms. Further, the methodology of the study allows us to determine the prevalence of negative CXR study

only in the presence of a CT scan positive for pneumonia; it does not allow us to determine the prevalence of a positive CT scan in the presence of a negative CXR study.

Additionally, the time lapse between CXR study and CT scan might complicate the findings, as interval evolution of the infiltrate may have occurred. However, as noted in the Results section, the time between initial CXR study and the subsequent CT scan was, in general, brief. Finally, the presence of an infiltrate on a CT scan but not on a CXR study does not necessarily indicate a bacterial infection that requires antibiotics. However, it would be difficult and possibly unethical to do a study in which antibiotics are withheld.

CONCLUSIONS

This brief retrospective analysis demonstrates the common finding of a pneumonia diagnosed on a CT scan in the face of a negative or non-diagnostic chest X-ray study. Due to the limitations of our study, it would not be appropriate to blindly generalize our results to a population in whom there is a concern for pneumonia. Certainly, in the setting of a high clinical probability of pneumonia, empiric treatment is a reasonable course even with a negative chest X-ray study. However, it would suggest that in certain patient populations, either immunosuppressed or those with significant comorbidities, a CT scan may be warranted when the CXR study is negative or non-diagnostic. The current analysis underscores the need for further studies regarding the appropriate radiographic evaluation of pneumonia, particularly in high-risk patients. A prospective study in which every patient suspected of pneumonia undergoes both a CXR study and a CT scan would more fully validate our findings. This is an area for future research.

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