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BRIEF REPORTS

Clinical Value of Chest Computerized Tomography Scans in Patients Admitted With Pneumonia

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Patients admitted with pneumonia often receive a chest computed tomography (CT) scan for a variety of reasons. We conducted this study to evaluate our overall utilization and the clinical impact of CT scans in patients admitted to our institution with pneumonia. Patients admitted to our facility from January 2008 through November 2011 with a confirmed diagnosis of pneumonia were eligible for evaluation. Information related to patient demographics, performance of a CT scan, pneumonia-related procedures, severity of illness, and outcomes was collected. One hundred ninety-five patients met inclusion criteria. Sixty-nine patients had CT scans performed. CT scans were performed more often in younger patients (58.1 ± 19.0 vs 66.8 ± 18.6, $P = 0.002$), individuals with lower CURB 65 (Confusion, Urea, Respiratory rate, Blood pressure, Age > 65) scores (1.7 ± 1.4 vs 2.2 ± 1.4, $P = 0.037$), and those with no infiltrates or consolidation on plain radiographs (26.9% vs 7.1%, $P < 0.0001$). Patients who had a procedure performed had longer average length of stays (15.3 ± 11.9 vs 6.8 ± 4.1 days, $P = 0.016$). Pneumonia-related procedures were more likely performed in patients who had a CT scan. Specific guidelines and objective rules need to be developed to prospectively guide the use of advanced imaging techniques in pneumonia patients. *Journal of Hospital Medicine* 2014;9:447–450. © 2014 Society of Hospital Medicine

Pneumonia remains one of the most common indications for hospital admissions. In the United States in 2010, more than 1 million patients were discharged with a diagnosis of pneumonia.[1] A diagnosis of pneumonia is based on typical clinical findings with recommendations to identify a demonstrable infiltrate on appropriate imaging modalities.[2] Although computed tomography (CT) imaging of the chest is much more sensitive than plain radiography at detecting infiltrates, the greater cost and higher radiation exposure limits its use as a screening modality.[3,4] Additional imaging studies are recommended for patients who fail to respond to therapy.[2] There are, however, no published studies to determine the exact impact of chest CT scans on the management of pneumonia.

We conducted a retrospective assessment of CT scan use in patients admitted with a diagnosis of pneumonia. The study was designed to assess (1) the overall utilization rate of chest CT scans at our institution and (2) the impact of CT findings on patient management.

METHODS

This retrospective study was conducted at St. John Hospital and Medical Center, an 808-bed tertiary care community teaching hospital in Detroit. The study was approved by the St. John Hospital and Medical Center's institutional review board.

Patients admitted to our institution between January 1, 2008 and November 1, 2011 were evaluated for study inclusion by searching the hospital's computer database using the discharge International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM) codes for pneumonia, pleural effusion, and empyema. Patients were included for initial review if the appropriate ICD-9-CM codes were included within the list of discharge diagnoses and were not restricted based on hierarchy within that list. Patients were included in further analysis if they were ≥18 years of age, a diagnosis of pneumonia was made within 48 hours of admission, and records were available for review. Patients were excluded if they did not meet the above criteria or a diagnosis of pneumonia could not be confirmed by chart review. The electronic medical record was reviewed and patient demographics, hospital admission source, microbiology results, radiographic findings, and outcomes were recorded. Additional procedures such as thoracentesis, open lung biopsy and/or chest tube placement were recorded for patients if performed. The Charlson Weighted Index of Comorbidity and Confusion, Urea, Respiratory rate, Blood pressure, Age > 65 (CURB 65) scores were calculated as described elsewhere.[5,6] CT scans were assessed for time and date of study after admission along with all relevant findings.

Data Analysis

Descriptive statistics were generated for the overall population. The associations between categorical

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TABLE 1. Patient Demographics and Characteristics

Characteristics	Chest CT Scan Performed, n = 69 (35.4%)	Chest CT Scan Not Performed, n = 126 (64.6%)	*P* Value
Mean age, y ± SD	58.1 ± 19.0	66.8 ± 18.6	0.002
Gender, male	52.2% (36)	45.2% (57)	0.35
Average length of stay, d ± SD	8.6 ± 7.4	6.9 ± 4.5	0.08
Charlson Comorbidity Index ± SD	1.77 ± 2.0	2.02 ± 1.89	0.38
CURB 65 score on admission ± SD	1.7 ± 1.4	2.2 ± 1.4	0.037
Fever on admission	34.8% (24)	36.5% (46)	0.81
Sepsis within 48 hours of CT	81.2% (56)	78.6% (99)	0.67
ICU admission within 48 hours of admission	21.7% (15)	15.1% (19)	0.24
No consolidation or infiltrates on CXR, n = 67*	26.9% (18)	7.1% (9)	<0.0001
Procedure performed	21.7% (15)	3.1% (4)	<0.0001
Source of admission			
Home	92.8% (64)	78.6% (99)	0.011
Extended care facility	7.2% (5)	21.4% (27)	
Positive blood culture†	4.1% (2)	8.9% (7)	0.30
Positive sputum culture‡	11.1% (3)	11.4% (4)	0.97
Discharged alive§	91.3% (63)	88.9% (112)	0.60

NOTE: **Abbreviations:** CT, computed tomography; CXR, chest radiograph; ICU, intensive care unit; SD, standard deviation; CURB 65, Confusion, Urea, Respiratory rate, Blood pressure, Age > 65 calculation.

*Two patients had no CXR prior to the CT scan.

†Coagulase negative *Staphylococcus* was excluded.

‡Mixed flora and normal colonizers were excluded.

§Patients discharged to hospice were considered as a mortality.

variables and whether or not a CT scan was performed were assessed using the χ^2 test. Student *t* test or analysis of variance, followed by the Bonferroni correction of the *P* value, were used to compare mean values. Logistic regression was used to predict the probability of having a chest CT done, given the variables found to be related on univariate analysis. All data were analyzed using SPSS version 22.0 (IBM, Armonk, NY), and a *P* value of 0.05 or less was considered to indicate statistical significance.

RESULTS

A total of 264 patients were identified by discharge diagnosis, and 195 (73.9%) patients met the inclusion criteria. Among the 69 patients who were excluded, 37 patients were diagnosed more than 48 hours after admission, 19 patients did not have a radiographically demonstrable abnormality, 5 patients had an incomplete medical record, and 8 patients received no antibiotics. The overall mean age of the cases was 63.4 ± 19.1 years, with an average length of stay of 7.4 ± 5.7 days. Sixty-nine (35.3%) of the case patients had a chest CT scan performed. A CT scan was performed more often in younger patients (58.1 ± 19.0 vs 66.8 ± 18.6, $P = 0.002$) and in patients with lower CURB 65 scores (1.7 ± 1.4 vs 2.2 ± 1.4, $P = 0.037$). A CT scan was also performed more often in patients with no infiltrates or consolidation on plain radiographs (26.9% vs 7.1%, $P < 0.0001$). Patients were also more likely to have a procedure performed if they had a CT performed (21.7% vs 3.1%, $P < 0.0001$) and were admitted from home versus a long-term care facility or other healthcare institution (92.8% vs 78.6%, $P = 0.011$). Comparisons are shown in Table 1. After controlling for age, CURB 65 score on admission, admission source, and the presence of consolidation or infiltrates on initial chest radiograph (CXR), individuals were 4.76 times less likely to have a CT scan performed if the CXR showed consolidation and/or infiltrates (odds ratio: 0.21, $P = 0.001$; 95% confidence interval: 0.08-0.53) (Table 2).

TABLE 2. Logistic Regression for Probability of Performing a Computed Tomography Scan

Characteristic	Odds Ratio	*P* Value	95% CI
Age	0.99	0.29	0.97–1.01
CURB 65 at admission	0.89	0.41	0.67–1.18
Admission source (healthcare facility)	0.36	0.07	0.12–1.09
Consolidation or infiltrates	0.21	0.001	0.08–0.53

NOTE: **Abbreviations:** CI, confidence interval; CURB 65, Confusion, Urea, Respiratory rate, Blood pressure, Age > 65 calculation.

TABLE 3. Comparison of Cases With Chest Computed TomographyScan Performed and Performance of a Procedure

Characteristic	Procedure Performed, n = 15 (21.7%)	Procedure Not Performed, n = 54 (78.3%)	*P* Value
Mean age, y ± SD	56.9 ± 19.5	58.5 ± 19.1	0.77
Male gender	53.3% (8)	51.1% (28)	0.92
Average length of stay, d ± SD	15.3 ± 11.9	6.8 ± 4.1	0.016
Admission CURB 65 score, mean ± SD	1.7 ± 1.4	1.7 ± 1.5	0.98
Fever on admission	40% (6)	33.3% (18)	0.63
Sepsis within 48 hours of procedure	93.3% (14)	77.8% (42)	0.17
ICU admit within 48 hours of admission	26.7% (4)	20.4% (11)	0.60
No consolidation or infiltrates on CXR	21.4% (3)	7.8% (4)	0.65
Source of admission			
Home	15% (100)	90.7% (49)	NS*
Extended care facility	0% (0)	9.3% (5)	
Discharge alive†	80% (12)	94.4% (51)	0.08

NOTE: **Abbreviations:**CXR, chest radiograph; ICU, intensive care unit; SD, standard deviation; CURB 65, Confusion, Urea, Respiratory rate, Blood pressure, Age > 65 calculation.

**P* value cannot be calculated as there is a zero in values.

†Patients discharged to hospice were considered as a mortality.

Procedure Performed

Among the 195 patients, pneumonia-related procedures were performed on only 19 (9.7%) patients. The procedures performed included bronchoscopy (n = 4), percutaneous biopsy (n = 3), thoracentesis (n = 7), and open lung biopsy (n = 5). Fifteen (78.9%) of the patients who had a pneumonia-related procedure had a CT scan. Table 3 shows the characteristics of patients who had a procedure performed compared to those patients who did not have a procedure performed among all individuals who had a CT scan.

Only average length of stay differed significantly between these 2 groups of patients (15.3 ± 11.9 vs 6.8 ± 4.1, $P = 0.016$).

DISCUSSION

Chest radiography plays an essential role in diagnosing pneumonia. Chest CT scans are more sensitive in diagnosing pneumonia and may be more specific for certain pathogens, but objective indicators or guidelines regarding test performance are lacking.[7] There are few available studies that evaluate the benefit of chest CT scans in adults with pneumonia. Beall et al. noted 57% of immunocompetent hosts, 22% of human immunodeficiency virus (HIV) patients, and 45% of immunocompromised hosts had a new finding on CT.[8] In 40% of the cases, there was an overall change in management based on the findings. Nyamande et al. showed that high-resolution CT scans identified abnormalities missed on plain radiographs in 82% (n = 40) of HIV patients in sub-Saharan Africa.[9] A study by Syrjälä et al. highlights the fact that high-resolution CT scanning improves the diagnosis of community-acquired pneumonia in patients with negative chest radiographs.[10] In the right clinical setting, additional imaging, such as high-resolution CT scanning, is more sensitive at detecting abnormalities consistent with pneumonia.[10] We found that a CT scan was more likely to be performed in patients with no infiltrates or consolidation consistent with that finding. However, the authors did not attempt to evaluate improved clinical outcomes or management changes. Other investigators have tried to demonstrate unique or specific findings on CT scans compared to plain radiography for particular pathogens.[11–13]

We attempted to identify specific features of patients presenting with pneumonia that could assist clinicians in the decision-making process as it relates to ordering a CT scan. CT scans were performed more frequently on subjects who were younger, had lower severity of illness, and were admitted from the community. We were unable to assess the radiographic and/or clinical findings that led the providers to order the CT scans. It is interesting to note, however, that Metlay et al. demonstrated a decreasing prevalence of pneumonia-associated symptoms with increasing age.[14] One could speculate that patients who are younger and tend to have more symptoms may be more likely to get ancillary testing.

In our study, 35% of patients admitted with pneumonia had a CT scan performed that led to an additional procedure 22% of the time. We were unable to accurately evaluate the impact of CT on antibiotic modification, duration, or some outcomes. Although a number of studies demonstrated new or missed findings by CT compared to plain radiography, only Beall et al. reported outcome changes.[8–10,12] They found that 39% (21/54) of patients had a change in their treatment plan including antibiotic alterations.

A number of factors impact outcomes such as length of stay and mortality in patients admitted with community-acquired pneumonia. Empyema contributes to additional length of stay and pleural effusions are new findings identified by CT scans.[8,9,15,16] Unfortunately, the number of patients with pleural effusions and even empyema (data not shown) was too small for us to analyze. Better prospective observational studies will be necessary to define specific CT findings leading to actual changes in management. The optimal timing of CT scanning could also be determined from these studies. The retrospective nature of our study is a key limitation to our results. It is difficult to determine retrospectively the clinical decision-making process used when ordering additional diagnostic tests or procedures. Whether the CT scans ordered on our patients truly resulted in additional procedures or whether the procedures were preplanned cannot be elucidated. Our current electronic medical record and ordering process has significant "drop-down list" selection bias for test indications. A postorder research-based survey tool would be required to further evaluate the clinician's decision-making process. In addition, as a single center study, the decision to perform CT scans and pneumonia-related procedures reflects only the practice patterns among a relatively small number of physicians with a wide variety of practice levels and specialties. Although length of stay was not affected by performing a CT scan, patients who had a procedure did have a prolonged hospital stay consistent with a complicated course as confirmed by others.[16]

Our study results could be the first step in developing prospective studies to evaluate the indications and utility of ancillary imaging in patients with pneumonia. Prospective, multicenter observational studies, which include a clinical decision-making survey tool as noted above, would be tremendously beneficial. Pathogen-specific indications and outcomes will be facilitated by the deployment of more rapid and effective molecular diagnostic capabilities. Furthermore, the cost of the test, radiation exposure, impact on clinical outcomes, and overall risk/benefit would need to be calculated from these future studies.

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