ORIGINAL ARTICLE

A simple screening tool for identification of community-acquired pneumonia in an inner city emergency department

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Objectives: To evaluate the performance of a simple screening tool for chest radiography for identification of community-acquired pneumonia (CAP) among emergency department (ED) patients who present with respiratory-related complaints. Our screening tool is a modification of a previously published guideline, which relied only on the presence of vital-sign abnormality (97% sensitivity, 19% specificity). We included respiratory symptoms to improve the specificity, defining our screening tool as the presence of any one respiratory symptom (cough, chest pain or shortness of breath) and any abnormality of the vital signs (temperature $>38^{\circ}\text{C}$, heart rate >100 beats/min, respiration rate >20 breaths/min, or pulse oximetry $<95\%$).

Methods: This was a 3-month retrospective chart review of all ED visits from an inner city teaching hospital. CAP was defined as the presence of a new radiographic infiltrate compatible with CAP. Patients with asthma were excluded.

Results: Of 8811 patient visits evaluated, 1948 presented with a respiratory symptom. Of these, 198 had definitive CAP. Sensitivity, specificity, positive and negative predictive values of the ED screening tool were 90% (95% CI 85% to 94%), 76% (95% CI 74% to 78%), 30% and 99%, respectively. Positive and negative likelihood ratios were 3.72 (95% CI 3.38 to 4.09) and 0.13 (95% CI 0.08 to 0.19), respectively.

Conclusions: A simple screening tool with high sensitivity and specificity was used in an urban inner city ED to decide on the requirement for chest radiographs for patients with respiratory symptoms for identification of CAP. Validation studies are required to determine the utility of this screening tool for improving time to diagnosis and treatment.

Community-acquired pneumonia (CAP) is a common disease, and is responsible for 10 million visits to doctors, 500 000 hospitalisations and 45 000 deaths annually in the USA.¹ Emergency department (ED) doctors frequently encounter patients with respiratory symptoms and need to differentiate between lower respiratory tract infections and benign upper respiratory tract infections. Because of the non-specific and variable presentation of CAP,² it is often challenging to identify which patients require further diagnostic evaluation, such as radiography, for confirmation of CAP. Radiography is the initial study of choice if CAP is suspected, as recommended by the Infectious Disease Society of America and the American Thoracic Association.³ Expediting radiographic diagnosis in the ED is a desirable goal as it has the potential to improve time to diagnosis, treatment and despatch of patients with CAP.

A recent published review in the *Journal of the American Medical Association* describing predictors of CAP concluded that there are no individual findings or combinations of clinical findings that can reliably diagnose this disease.⁴ One ED-based study by Gennis *et al.*, however, suggested that the presence of any vital-sign abnormality is 97% sensitive in detecting patients with CAP among those patients in whom pneumonia is suspected.⁵ Translation of these findings into practice is problematic, however, because of biases in patient selection, lack of prospective validation and poor specificity (19%) of vital-sign abnormality alone for CAP.³

The purpose of our study was to determine the sensitivity and specificity of an empirically derived ED screening tool to decide whether to obtain chest radiographs, based on a modification of the Gennis guideline, which would be helpful in identification of CAP among those patients presenting with respiratory symptoms to the ED.

METHODS

We evaluated an ED screening tool based on a published study, which relied solely on vital-sign abnormality for ordering chest radiographs in patients with suspected CAP.⁵ The screening tool was modified in order to improve specificity and practicality. Respiratory symptoms are known to be most commonly associated with CAP and they are easy to monitor in ED, thus these were incorporated into the screening tool criteria.^{4–6} The final screening tool criteria were thus defined as the presence of any one respiratory complaint including cough, chest pain or shortness of breath, in combination with the presence of at least one abnormality of the vital signs, including temperature $>38^{\circ}\text{C}$, heart rate >100 beats/min, respiration rate >20 breaths/min, or pulse oximetry $<95\%$ in room air. Pulse oximetry was not originally described by Gennis, but was incorporated as a fourth vital-sign abnormality here, as it is currently a standard of care measurement for patients presenting with respiratory complaints, and is known to be associated with CAP.⁷

This was a 3-month retrospective medical chart review of all adult (≥ 18 years of age) patients presenting to the ED, which was conducted at a large inner-city tertiary university teaching hospital with an annual patient census of 57 000, between December 2001 and February 2002. The study was approved by the hospital institutional review board.

A medical chart review was systematically carried out as described by Gilbert *et al.*⁸ Patients with at least one respiratory-related complaint at triage were included, and the ED medical charts of all such patients reviewed in detail. Patients for whom the ED medical charts were missing either the triage or doctor's

Abbreviations: CAP, community-acquired pneumonia; ED, emergency department

Table 1 Sensitivity and specificity of an ED screening tool among patients with respiration rate complaints

	CAP+	CAP–	Total
ED screen+	179	425	604
ED screen–	19	1325	1344
Total	198	1750	1948

Prevalence 10% (95% CI 8.9 to 11.6); sensitivity 90% (95% CI 85 to 94); specificity 76% (95% CI 74 to 78); positive predictive value 30% (95% CI 26 to 33); negative predictive value 99% (95% CI 98 to 99); positive likelihood ratio 3.72 (95% CI 3.39 to 4.09); negative likelihood ratio 0.13 (95% CI 0.08 to 0.19).

notes were excluded (<1%). Asthmatics, known to have a low frequency (2%) of radiographic findings,¹⁰ were also excluded, as they had been excluded from the original study by Gennis *et al.*³ We also reviewed charts of patients who had a radiographic infiltrate reported on the medical chart, without any respiratory-related complaints. CAP was operationally defined as any patient who had a final chest radiographic report of infiltrate compatible with pneumonia.^{5,6} Initial interpretation of the chest radiograph was made by a resident grade doctor and recorded on the patient's medical chart, which was confirmed by a radiology attending. The final radiographic report that was available in the electronic patient record was used for coding CAP in our study. Those reports, which described old or chronic infiltrates or congestive heart failure as interpreted by the attending radiology doctor, were not considered CAP cases.

Five research assistants were trained to perform systematic review of all medical charts. The following variables were recorded using standardised paper forms: age, gender, ethnicity, presence of respiratory symptoms and vital sign abnormalities,

and disposition (admission or discharge). For the patients who met the screening criteria but were not diagnosed with CAP, the information as to whether or not they received a chest radiograph was also recorded. This allowed determination of the number of "additional" radiographs that would have been ordered if every patient fulfilling the ED screening criteria had received a chest radiograph. All collected data were then transferred to electronic databases after unlinking patient identifiers. The final CAP cases were reviewed both by the study coordinator and by the principal investigator.

Outcome measures and analysis

Sensitivity and specificity was calculated for patients who presented with at least one respiratory complaint. Patients were grouped as follows: (a) patients who met the ED screening tool criteria and had definitive CAP (true positives), (b) patients who met the screening tool criteria and did not have CAP (false positives), (c) patients who did not meet the screening tool criteria, but had definitive CAP (false negatives), and (d) patients with at least one respiratory complaint who did not meet the screening tool criteria and did not have definitive CAP (true negatives). The statistical package SPSS V11 (SPSS Inc., Chicago, Illinois, USA) was used for data analysis.

RESULTS

Of the 8811 ED patients, 1948 (22%) presented with at least one respiratory-related condition, and 198 patients had definitive CAP. The mean (SD) age of the patients with CAP was 48 (17) years; 102 (51%) were female and 158 (80%) were African American. The most common respiratory complaint was cough (74%), followed by shortness of breath (70%) and chest pain (33%). A vital-sign abnormality was present in 179 (90%) patients in the ED, the most common being heart rate >100 beats/min (62%), followed by temperature >38 °C (46%), pulse oximetry <95% (44%), and respiration rate >20 breaths/min (42%). In total, 56 (28%) patients were discharged home.

Of the 198 patients with CAP, 179 fulfilled the screening tool criteria (true positives). Sensitivity of the screening tool was 90% (95% CI 85 to 94) and specificity was 76% (95% CI 74 to 78) for patients presenting with at least one respiratory complaint (table 1). Positive predictive value was 30%, and positive likelihood ratio was 3.72 (95% CI 3.39 to 4.09). Negative predictive value was 99% and negative likelihood ratio was 0.13 (95% CI 0.08 to 0.19).

In total, 19 patients with CAP did not meet the screening tool criteria (false negatives). We compared characteristics of true positives with false negatives (table 2). Both groups were similar in demographic details, triage level, radiographic findings and presence of individual respiratory symptoms ($p>0.05$). However, true positives and false negatives differed significantly ($p<0.01$) in presence of abnormal vital signs and disposition; all of the patients with CAP who did not meet the screening tool criteria had no abnormal vital signs, and nearly two-thirds of these received outpatient management.

In total, 604 patients fulfilled the screening tool criteria. Only 37 patients (approximately 6%) did not have a radiograph ordered by the treating doctor. This translates into approximately one extra chest radiograph every 3 days, on average. Two patients with CAP on chest radiograph presented without any respiratory-related complaints.

DISCUSSION

We modified a previously published guideline for identification of patients with CAP in the ED and evaluated its sensitivity and specificity for patients with respiratory complaints. Inclusion of respiratory-related symptoms predictably resulted in an

Table 2 Characteristics of true-positive versus false-negative CAP cases

Variable	True positives (n = 179)	False negatives (n = 19)	p Value*
Age (years), mean (SD)	48 (16)	52 (19)	0.3
Gender			0.4
Female	94 (53)	8 (42)	
Male	85 (47)	11 (58)	
Race			0.3
African American	143 (80)	15 (79)	
Caucasian	34 (19)	4 (21)	
Other	2 (1)	0	
Respiratory symptoms			
Cough	133 (74)	13 (68)	0.2
Shortness of breath	124 (69)	13 (68)	0.5
Chest pain	57 (32)	8 (42)	0.2
Abnormal vital signs			
HR >100 beats/min	123 (69)	0	
Feve r >38 °C	90 (50)	0	
Pulse oximetry <95%	87 (49)	0	
RR >20 breaths/min	83 (46)	0	
Description of infiltrate			0.6
Unilobar	130 (73)	15 (79)	
Multilobar	34 (19)	2 (10.5)	
Interstitial	15 (8)	2 (10.5)	
Outcome			<0.01
Discharged	43 (24)	13 (68)	
Admitted	136 (76)	6 (32)	
Triage level			0.06
I	33 (18)	0	
II	117 (65)	13 (68)	
III	24 (13)	5 (26)	
Unknown	5 (3)	1 (6)	

RR, respiration rate.

Data are n (%) unless otherwise stated.

* χ^2 test, two tailed t-test, Fishers exact test.

increase in the specificity of the screening tool (76%) compared with that reported by Gennis *et al* (19%), making it more practical for use. This increase in specificity was accompanied by only a moderate decrease in sensitivity (90%), compared with that of the Gennis rule (97%). A high sensitivity and specificity accompanied with a negative predictive value of 99%, makes this screening tool suitable for deciding to order chest radiographs in the ED.

Implementation of this ED screening tool would result in ordering of radiographs for patients who do not have CAP but do meet the criteria. Although these are technically false positives, we found that for almost all of these patients (~94%), a chest radiograph had been obtained at the doctor's discretion. The most frequently diagnosed medical conditions among these patients included upper respiratory infections, chronic obstructive pulmonary disease and congestive heart failure. Availability of earlier radiographic results for these patients would probably be helpful in narrowing the differential diagnosis. Importantly, obtaining a chest radiograph in patients who met the screening tool criteria would have captured the vast majority of patients with CAP without significantly increasing the number of extra chest radiographs.

A few limitations of our study warrant discussion. First, our working definition of CAP was the "presence of radiographic infiltrate compatible with CAP". This is a commonly accepted definition used in clinical settings for guiding treatment decisions.^{5,6,9} We may have missed patients who either presented to the ED during the initial phase of their illness when radiographic infiltrates may not yet be apparent, or those for whom chest radiographs were never ordered. The second limitation concerns the generalisability of our findings. We chose to perform our study during the peak pneumonia season and recognise that the clinical features of CAP may differ from one season to another. Other site-specific factors influencing the screening tool include the characteristics of the causative organisms based on geographical region, the demographic characteristics of the population and the presence of a nearby fast-track clinic. For example, our hospital primarily serves an African American, socioeconomically disenfranchised population with an estimated HIV seroprevalence of 11%.¹¹ Thus, this population may have had higher rates of CAP due to opportunistic infections such as *Pneumocystis carinii* pneumonia, which are less common in other populations. However, these factors are common to many inner-city EDs. It is also important to note that asthmatics, who were excluded from the original study of Gennis *et al*, were also excluded from our study. A previously published report found a low prevalence (2%) of radiographic abnormalities among asthmatics who present to the ED with respiratory complaints.¹⁰ Inclusion of asthmatics would have significantly diminished the specificity of our screen because nearly all have abnormal vital signs. To assess the applicability of our screening tool, future studies should include all seasons, sampling sites that represent different geographical regions, and a broader range of demographic patient groups. The third limitation concerns the sensitivity of the screening tool. Approximately 10% of patients with CAP were not captured by the screening tool. Our analysis of select symptoms and vital signs found no obvious presenting

characteristics that would be practically helpful in identifying these patients. It is important to keep in mind, however, that the intended use of the screening tool is as an aid in improving time to diagnosis, and not as a decision instrument for the purposes of final diagnosis. The final limitations are related to the methodology of the study. Neither inter-rater nor intra-rater agreement evaluation was performed. We chose not to evaluate these parameters because the variables abstracted here were strictly objective measures (e.g. vital signs) and thus not influenced by subjective interpretation. We were also unable to determine the effect of multiple ED visits on the performance of the screening tool, as we were constrained by the identity unlinked method of data abstraction used.

We conclude that this simple ED screening tool has high sensitivity (90%) and specificity (76%) and may be a useful aid when ordering chest radiographs for ED patients presenting with respiratory-related symptoms. Routine use offers the potential to improve time to definitive diagnosis and treatment but awaits performance of a prospective study to evaluate feasibility and effectiveness.

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