CLINICAL INVESTIGATIONS

Does the Lateral Chest Radiograph Help Pediatric Emergency Physicians Diagnose Pneumonia? A Randomized Clinical Trial

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Abstract

Objectives: To determine whether the addition of the lateral chest radiograph to the frontal view influences the pediatric emergency physician's diagnosis and management of patients with pneumonia. **Methods:** A randomized clinical trial was conducted, involving 570 patients, 1–16 years of age, visiting a pediatric emergency department (ED) for whom frontal and lateral chest radiographs were ordered for the clinical suspicion of pneumonia. Pediatric emergency physicians reviewed the frontal film alone in group 1 and both the frontal and the lateral films in group 2. The interpretation of each radiograph was then compared with consensus interpretation by pediatric radiologists who interpreted both views. **Results:** There were 604 eligible children; 34 families declined to participate. Three hundred three were randomized into group 1, whereas 267 were randomized into group 2. The clinicians' interpretations were equal in sensitivity for group 1 at 91% and 87% in group 2 ($p = 0.321$) and equal in specificity for group 1 at 58% and 57% in group 2 ($p = 0.888$). **Conclusions:** The addition of the lateral chest radiograph to the frontal view did not improve the sensitivity or specificity of pediatric emergency physicians in their diagnosis of pneumonia in children. **Key words:** pneumonia; children; radiograph; lateral. ACADEMIC EMERGENCY MEDICINE 2004; 11:625–629.

Children presenting to the emergency department (ED) often have symptoms and signs of pneumonia. For these patients, radiographic imaging of the chest contributes largely to their management in the pediatric ED because of the lack of clear predictive factors in the clinical detection of pneumonia.[1] Traditionally, both the frontal and lateral views have been considered standard views.[2] The lateral view is recommended to ensure that left lower lobe pneumonias are correctly diagnosed.[2] Furthermore, a lateral view may ensure that hyperinflation is detected especially during the first two years of life.[3] However, this extra view is associated with twice the radiation exposure of a frontal view,[4] an increased expense, and increased personnel time. In addition, the lateral view often may need to be repeated because it can be technically more difficult to obtain.

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A review of the published literature through the Medline database (1966–2003) was conducted to assess the evidence for the additive diagnostic value of the lateral chest radiograph to the frontal view in children (0–17 years) with suspected pneumonia. Four studies were retrieved,[4–7] none of which were randomized clinical trials. None of these studies examined the diagnostic value of the lateral chest radiograph in a clinical setting.

In the context of pediatric pneumonia, the utilization of two views of the chest is pervasive. Before the commencement of this study, a survey of all Canadian pediatric EDs was conducted. Imaging of two views of the chest was routinely obtained in all centers except one (Colbourne M, personal communication, 1997; O'Byrne ML, personal communication, 1997; Tennenbein M, personal communication, 1997; Warren D, personal communication, 1997; Gouin S, personal communication, 1997; Pitters C, personal communication, 1997; Lynch T, personal communication, 1997; Khalil E, personal communication, 1997).

The purpose of our study was to determine whether the additional lateral chest radiograph influenced the pediatric emergency physician's diagnosis and management of patients with pneumonia. The hypothesis tested was that the addition of the lateral chest radiograph to the frontal view would significantly ($p < 0.05$) improve the sensitivity and specificity of pediatric emergency physicians' diagnoses in children with suspected pneumonia.

METHODS

Study Design. This was a randomized clinical trial. The study was approved by our institutional review board.

Study Setting and Population. The trial was conducted at the ED of a tertiary care urban pediatric hospital with approximately 75,000 patient visits per year. Pneumonia is listed as a discharge diagnosis in approximately 3% of these patients.

Any child, aged 1–16 years, who presented to the ED and had a chest radiograph ordered for the clinical suspicion of pneumonia from May 18, 1998, to December 15, 1999, while one of the participating physicians was attending, was eligible for enrollment in this study. Patients less than 1 year of age were excluded due to the higher likelihood of having a diagnosis of bronchiolitis, and the resultant variation and difficulties in chest radiograph interpretation.[3] Patients were excluded if they had chronic respiratory disease (e.g., cystic fibrosis, bronchopulmonary dysplasia), congenital or complex cardiac disease, gastroesophageal reflux disease, malignancy, immunodeficiency, sickle cell anemia, or spastic quadriplegia. Children with asthma were excluded if they were having an acute exacerbation requiring more than one bronchodilator treatment or systemic steroids at the time of their visit in the ED. Patients were also excluded if they had had pneumonia, confirmed by radiography, in the previous eight weeks or if patients were taking antibiotics or had received any in the previous two weeks. Finally, patients were excluded if they were critically ill, because only a portable chest radiograph is obtained in such situations.

Study Protocol. All consecutive patients were recruited by ten designated, full-time attending board-eligible/board-certified pediatric emergency physicians and one clinical fellow in pediatric emergency medicine. Once inclusion and exclusion criteria were confirmed and informed consent was obtained by the recruiting physician, subjects were assigned to one of two groups based on a block randomization schedule (groups of six). All of the study patients had both frontal and lateral chest radiographs taken. Patients in group 1 returned from the radiology department to the ED with only their frontal view for pediatric emergency physician interpretation. The lateral views of group 1 patients remained in the radiology department. Patients in group 2 had both their frontal and lateral radiographs returned to the pediatric emergency physician for interpretation. All of the patients were discharged from the ED before the radiologists' interpretations of the radiographs.

The pediatric emergency physicians' interpretations were then compared with the criterion standard, which was taken as a consensus agreement of two out of three separate pediatric radiologists' interpretations. Radiology review consisted of one of seven pediatric radiologists who reported the films in real time and was blinded to the emergency physician's interpretation and a single, blinded study radiologist who reviewed all study films (most often within 48 hours of the visit). If the initial two readings were discordant with respect to the diagnosis of pneumonia, then a third reading was done by a second blinded study radiologist. Pneumonia was defined as the presence of air space disease.[6]

Outcome Measures. The primary outcome variable was the difference in the sensitivity and specificity of the emergency physicians' interpretations of chest radiographs with access to two views (frontal and lateral) versus one view (frontal) for children with suspected pneumonia. A secondary outcome included the change in management provided by the review of the two views by the radiologist.

At the time of patient recruitment, baseline demographic and clinical variables were collected prospectively by a study questionnaire. The ED charts of all the patients seen during the study period were also reviewed to ascertain the number of missed and excluded subjects.

Data Analysis. The sample size was calculated based on a desired confidence level of 0.95 (two-tailed), a power of 0.90, an estimated diagnostic error rate of 10% with two views, and a minimal detectable between-group difference in accuracy of 10% (two proportions power analysis). In the literature, the rates of agreement on the interpretation of chest radiographs between pediatric emergency physicians and radiologists range from to 71% to 91%.[7–12] These parameters thus yielded a sample size of 266 in each group.

Data were analyzed with SAS, version 6.12 (SAS Institute, Cary, NC). Continuous data were analyzed with the Student's t-test statistic, while categorical data were analyzed with the chi-square statistic. A p-value of less than 0.05 was considered significant. Criterion validity (sensitivity, specificity, and positive and negative predictive values) was calculated. A 2 × 2 table was constructed showing the criterion standard or official radiologists' interpretations of positives and negatives versus the test or clinicians' interpretations of positives and negatives. True negatives were cases in which the clinician agreed with the radiologist that pneumonia was absent, and true positives were cases when the clinician agreed with the radiologist that pneumonia was present.

RESULTS

During the study period, 1,704 chest radiographs were ordered by the 11 recruiting physicians for the clinical suspicion of pneumonia. Of these, 604 patients

TABLE 1. Excluded Patients (*N* = 1,100)

Reason for Exclusion	Number
Age	541
Asthma	216
Antibiotics	112
Pneumonia	55
Respiratory disease	40
Critically ill	36
Sickle cell anemia	27
Cardiac	24
Malignancy	18
Spastic quadriplegia	15
Immunodeficiency	12
Gastroesophageal reflux disease	4

were found eligible for study enrollment with 570 patients/parents who consented to participate in the study (303 randomized into group 1 and 267 randomized into group 2). Thirty-four patients declined to participate.

Eleven hundred patients were excluded. Five hundred forty-one patients were excluded based on age alone, which was the most common cause for exclusion (Table 1). Subjects entered into the study were compared with those who declined to participate in terms of demographic (age, gender) and clinical (fever, cough, respiratory rate, heart rate, oxygen saturation, and findings on auscultation) characteristics. There were no significant differences demographically or clinically between the study subjects and these 34 patients who declined study participation.

Similarly, there were no significant differences in demographic characteristics between group 1 and group 2 patients. Clinically, a greater proportion of group 1 subjects were short of breath (6% vs. 2%, $p < 0.02$), and they also had a lower mean heart rate (123 beats/min vs. 139 beats/min, $p < 0.001$) (Table 2). In terms of patient disposition, 97% of patients were discharged home and 3% were admitted in each group. No patients were admitted to the intensive care unit.

TABLE 2. Patients' Clinical Characteristics

Variable	Group 1 (*N* = 303)	Group 2 (*N* = 267)	p-value
Fever (%)	84	84	0.996
Cough (%)	85	86	0.847
Coryza (%)	27	28	0.843
Shortness of breath (%)	6	2	0.02
Chest pain (%)	5	5	0.671
Mean temperature (°C)	37.9	38.0	0.410
Mean respiratory rate (breaths/min)	31	30	0.32
Mean heart rate (beats/min)	123	130	<0.001
Mean O_2 saturation (%)	97	97	0.720
Decreased breath sounds (%)	47	49	0.753
Crackles (%)	35	30	0.244
Wheezes (%)	7	8	0.788
Bronchial sounds (%)	6	5	0.699
Retractions (%)	3	2	0.291

TABLE 3. Criterion Validity between Group 1 and Group 2 Physicians

Variable	Group 1 (1 View)	Group 2 (2 Views)	p-value
Sensitivity (%)	91	87	0.321
Specificity (%)	58	57	0.888
PPV (%)	56	51	0.360
NPV (%)	92	89	0.537

PPV = positive predictive value; NPV = negative predictive value.

The sensitivity for group 1 was 91% and 87% in group 2 ($p = 0.321$), whereas the specificity for group 1 was 58% and 57% in group 2 ($p = 0.888$) (Table 3).

The rates of change in the clinical management of these patients provided by the review of the two views by the radiologist were not clinically significant between the two groups. False-negative readings occurred 3.3% (10/303) of the time in group 1 (Table 4) and 4.5% (12/267) of the time in group 2 (Table 5). There were only five patients in group 1 and six patients in group 2 who required a change in their ED management after review of their films by a radiologist. These patients were then prescribed antibiotics after contacting them over the telephone, and none required admission. The other 11 patients with false-negative readings had already been prescribed an adequate antibiotic for a separate infectious focus.

DISCUSSION

This randomized, controlled trial has shown that the addition of the lateral chest radiograph to the frontal chest radiograph did not improve the sensitivity or specificity of the pediatric emergency physicians in their ability to diagnose pneumonia in children and did not significantly change the management of these patients. They were equal in sensitivity and specificity in their diagnoses of pneumonia whether they had access to the frontal and lateral views or the frontal view alone.

Two previous studies have addressed the role of the chest radiograph in a retrospective fashion.[4,5] Kennedy et al.[4] determined that the lateral film provided additional diagnostic information to the frontal view in only nine of 414 children aged 1–12 years referred to their radiology department with suspected pneumonia. However, the authors commented that

TABLE 4. Group 1 (1 View) 2 × 2 Table (*N* = 303)

	Radiologist Positive	Radiologist Negative
Clinician positive	102	80
Clinician negative	10	111

TABLE 5. Group 2 (2 Views) 2 × 2 Table (*N* = 267)

	Radiologist Positive	Radiologist Negative
Clinician positive	79	75
Clinician negative	12	101

the ultimate management of these nine patients did not change when reviewed retrospectively. As well, Lamme et al.[5] concluded that the addition of the lateral view in 179 patients aged 1–10 years with an acute pulmonary illness did not improve diagnosis in a clinically significant manner when reviewed retrospectively. Again, both of these studies failed to examine the clinician's interpretation of the films and resultant management prospectively. This is important because the ED management is principally influenced by the initial reading of the radiographs by the emergency physician. In many centers, the films are reviewed by the radiologist in the ensuing days, while in others, the radiographs are reviewed by radiologists only if requested by the emergency physicians.[8–10]

More recently, Patenaude et al.[6] prospectively reviewed 373 children aged 0–17 years sent to the radiology department in a clinical context of pulmonary infection by comparing a single radiologist's interpretation of the frontal view with the interpretation of both the frontal and lateral views by three radiologists. They found that the level of agreement between the radiologist interpreting the frontal view alone and a radiologist interpreting both views was comparable to the level of agreement between the radiologists interpreting two views. Although this study prospectively reviewed patients, pediatric emergency physicians were not directly involved in prospective film interpretation. By combining the results of these previous three studies along with a fourth,[7] it was approximated that 38 lateral chest radiographs are required to detect one additional case of pneumonia.

The advantages of this study include its randomized clinical trial design and its applicability to an actual pediatric ED situation. It also evaluated whether a cost-incurring test improves patient management. It is the first study to our knowledge that prospectively assessed the impact of obtaining one view versus two views of the chest in the clinical management of pediatric patients who present to the ED with suspected pneumonia. Also, it is the first study to address the criterion validity of the pediatric emergency physician's interpretation of one versus two views of the chest.

LIMITATIONS

The two groups were of different sizes despite block randomization. This was because of the fact that 23 group 1 patients and 36 group 2 patients were subsequently withdrawn after recruitment given that they were found to meet the exclusion criteria on further review. All of these 59 patients were excluded from the study before the interpretation comparison between the pediatric emergency physician and the radiologist.

There was a strong tendency to overcall the presence of pneumonia, and this tendency was nearly equal in both groups. The specificity and positive predictive values were lowered because of this relatively large number of false positives in both groups. However, the concept that clinical manifestations of pneumonia may appear sooner than radiologic indicators of pneumonia has been previously entertained.[11]

We did not attempt to compare the exact locations of the infiltrates identified by the pediatric emergency physicians and the radiologists. For example, if left lower lobe pneumonias were to be determined only, then the power of the present study would be much lower.

Another limitation of the study affecting generalizability is that only full-time pediatric emergency physicians were selected to participate in the study. It is uncertain whether findings could be extrapolated to all emergency physicians working in general EDs. As well, we did not conduct a formal cost analysis.

CONCLUSIONS

It appears from the radiologic literature that radiologists have equal abilities to diagnose pneumonia with access to either one or two views of the chest. This study assessed the ability of the pediatric emergency physician in the front line making timely decisions regarding patient management.

The results of this study demonstrate that the addition of the lateral chest radiograph does not improve the sensitivity or specificity of pediatric emergency physicians in diagnosing pneumonia in a selected group of patients.

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