

Diagnosis of Childhood Pneumonia

Clinical Assessment Without Radiological Confirmation May Lead to Overtreatment

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Objectives: Consensus guidelines discourage the use of routine radiologic confirmation of clinically diagnosed pneumonia in children. The goal of the present study was to assess the degree of antibiotic overtreatment resulting from this approach.

Design: This was a prospective data collection.

Setting: This was performed in 5 urgent care clinics in Jerusalem, Israel.

Participants: This study was composed of previously healthy children between 2 months and 18 years of age who presented with a chief complaint of fever, cough, or dyspnea between August 1, 2007, and March 15, 2008, by for whom chest x-rays were obtained because of clinical suspicion of pneumonia.

Outcome Measures: Outcome measure was percentage of children with clinical findings associated with pneumonia (hypoxia, tachypnea, rales, dyspnea) who did not have radiological findings of pneumonia.

Results: With the exception of wheezing, 55% to 65% of children with specific signs and symptoms did not have radiologic pneumonia. A similar range of children with a combination of the signs did not have radiologic pneumonia. For wheezing, alone or in combination, the percentages were higher. On multivariate analysis, only fever was found to be predictive of pneumonia. Wheezing was found to be negatively predictive.

Conclusions: Treatment of childhood pneumonia on the basis of clinical parameters alone with no chest x-ray confirmation may lead to a large portion of children receiving unnecessary antibiotic therapy. In an era when the emphasis is to decrease antibiotic resistance, radiological confirmation of pneumonia should be obtained when possible.

Key Words: pneumonia, clinical diagnosis, chest x-ray

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Despite the prevalence of pneumonia in children, there is still significant debate regarding the optimal method for diagnosing this condition.^{1,2} For example, the 1997 Canadian diagnostic guidelines for pneumonia³ failed validation in an emergency room setting.⁴ A number of studies have tried to correlate clinical findings with positive x-ray results.^{5,6} However, many of these studies' clinical prediction rules lacked both sensitivity and specificity.⁷

In developing countries, because of insufficient medical resources and long distances to medical centers, treatment decisions are often made according to World Health Organization (WHO) guidelines, which are based solely on physical examina-

tion (with much emphasis placed on the respiratory rate).⁸ This purely clinical approach has been shown to reduce pneumonia-related morbidity and mortality among children in this setting.⁹

In developed countries, on the other hand, diagnostic facilities are generally readily available. Nevertheless, many current guidelines in developed countries suggest that when a child presents with symptoms such as fever and cough combined with the findings on physical examination of tachypnea, hypoxia, rales, or decreased air entry, diagnosis should be based on clinical grounds alone, and radiological examinations should be reserved for atypical circumstances.^{10–13}

A potential concern with the clinical approach is that it may lead to overdiagnosis. As no radiologic¹⁴ or laboratory feature¹⁵ can reliably predict the etiology of pneumonia, most children with pneumonia are treated with antibiotics.¹⁶ Therefore, although the approach of relying on clinical diagnosis alone is likely to reduce x-ray exposure for those children who do have pneumonia, it may lead to the overuse of antibiotics in those without pneumonia and thus potentially add to the growing resistance of pathogens to antibiotics.

The issue of overdiagnosis has been raised in the literature in the context of the developing world.¹⁷ A study from the Philippines showed that only 34% of children hospitalized and treated based on WHO guidelines actually had radiologically confirmed pneumonia.¹⁸

Overdiagnosis has not been addressed in the developed world, despite data from published studies that it may be a realistic concern. For example, in their retrospective review of emergency department charts, Murphy et al⁵ reported in chart form that 58.7% of children with clinical signs suggestive of pneumonia, in fact, had negative x-rays. Although this phenomenon was noted, the issue of potential overtreatment was not discussed.

The aim of our study was thus to assess the correlation between the clinical diagnosis of pneumonia and radiological findings to estimate the degree of overdiagnosis and thus potential overtreatment with antibiotics of pneumonia in children diagnosed on clinical grounds alone.

METHODS

Setting

This study was performed in a system of 5 urgent care centers (UCCs) located in and around Jerusalem, Israel. In all of these UCCs, radiological and laboratory services are available during all hours of operation. All the UCCs make use of an electronic medical record (EMR) system (developed in-house) that manages all elements of the clinical encounter including a digital archive of all x-ray studies.

Included in this study were previously healthy children between the ages of 2 months and 18 years who presented to any of the UCCs between August 1, 2007, and March 15, 2008, with 1 or more complaints of fever, cough, or difficulty breathing and

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who routinely underwent a chest x-ray examination in the UCCs because of clinical suspicion of pneumonia.

Excluded from the study were children in an immunocompromised state (such as current or recent chemotherapy or immunosuppressive therapy) or those having a chronic severe disease such as bronchopulmonary dysplasia. In practice, no children meeting these exclusion criteria were seen during the study period.

Four experienced senior pediatricians, unaware of the purpose of this study, examined all the study children and recorded symptoms, signs, and physical findings directly into a specially designed computerized form within the EMR. This was done in addition to manually recording in the patient chart those elements needed for the clinical care of the child.

The current general practice in these UCCs is that every child with suspected clinical pneumonia undergoes a chest x-ray examination (anterior-posterior and lateral views) for confirmation. Every chest x-ray in this study was interpreted by 2 senior radiologists blinded to the study. The first reading was by one of a group of radiologists employed by the UCCs who had access to the clinical chart. The second reading was by a pediatric radiologist from an unrelated hospital who was blinded to the diagnosis of the pediatrician. All film interpretations were based on full-resolution DICOM formatted x-ray studies. Diagnosis of pneumonia on chest x-ray was based on demonstration of lobar or alveolar consolidation or interstitial or bilateral bronchoalveolar or peribronchial infiltrates. Atelectasis alone was not considered as pneumonia if none of the other findings were present.¹⁶ Radiologic pneumonia was defined as those cases where both radiologists reading the study concurred that pneumonia was present.

Data Collection

The following data were abstracted from the computerized data collection form: respiratory symptoms, physical signs, and respiratory findings on physical examination such as rales, decreased air entry to lung areas, and wheezing on auscultation. The handwritten chart was studied for any additional signs or symptoms that may have been omitted on the computerized form. Demographic data (age, sex, discharge diagnosis) were abstracted from the standard EMR.

Hypoxia was defined as oxygen saturation less than 92% on room air. Tachypnea was defined as a respiratory rate of more than 50 breaths/min in children younger than 1 year and greater

than 40 breaths/min in children older than 1 year. The study was approved by the ethics committee of HaEmek Medical Center, Afula, Israel.

Statistical Analysis

All statistical computations and analyses were done using SPSS statistical software version 14.0.1 (copyright © SPSS Inc, Chicago, Ill). Fisher exact test was used to compare groups whenever a categorical outcome was examined. Multivariate logistic regression was performed as well.

RESULTS

Two hundred seventy-eight children were included in this study, of whom 116 (41.7%) were male, and 162 (58.3%) were female. The mean age was 2.5 years, with 246 (88.5%) being younger than 5 years. Two hundred forty children complained of both fever and cough. Of these, 90 (35%) were found to have pneumonia on chest x-ray examination. On univariate analysis of individual symptoms, a statistically significant association with radiologic pneumonia was found only for fever and for wheezing ($P = 0.001$ and $P = 0.025$, respectively). Table 1 lists combinations of symptoms that physicians may use to decide clinically that a child has pneumonia. Of these combinations, only the combination of fever and decreased air entry on auscultation was significantly associated with radiologically confirmed pneumonia ($P = 0.03$). On multivariate analysis, only fever (odds ratio [OR], 13.94; confidence interval [CI], 1.78–109.3; $P = 0.012$) and wheezing (OR, 0.56; 95% CI, 0.32–0.98; $P = 0.042$) were found to be significantly associated with radiologic pneumonia.

Table 1 also shows the percentage of children combination of sign/symptoms who did not have pneumonia. The percentages thus reflect the number of children who would most likely be treated with antibiotics if the clinical diagnosis was based on that finding. As can be seen, with the exception of combination with wheezing where the percentage was higher and the combination of tachypnea and decreased air entry where the percentage was lower, 55% to 65% of children with specific signs and symptoms did not have radiologic pneumonia. A similar range of children with individual signs or symptoms did not have radiologic pneumonia. With wheezing, the percentages were generally higher, ranging from 68% when combined with tachypnea to 75% alone or combined with dyspnea.

TABLE 1. Clinical Signs/Symptoms of Pneumonia and Association With Radiologic Pneumonia

Sign/Symptom	OR	95% CI	No. Children With the Clinical Findings	% of Group Without Pneumonia
Fever and cough	1.93	0.87–4.27	240	62.5
Fever and tachypnea	1.48	0.90–2.42	137	59.9
Fever and hypoxia	1.21	0.73–2.03	96	61.5
Fever and wheeze	0.68	0.40–1.19	84	72.2
Fever and dyspnea	1.39	0.76–2.54	55	58.2
Fever and rales	1.70	0.92–3.11	50	54.0
Fever and DAE	2.52	1.1–5.78	25	44.0
Tachypnea and hypoxia	0.96	0.54–1.71	66	65.2
Tachypnea and dyspnea	0.97	0.48–1.96	40	65.0
Tachypnea and rales	1.44	0.61–3.40	23	56.5
Tachypnea and DAE	1.56	0.65–3.76	22	54.5
Any 2 symptoms	1.34	0.65–2.78	213	64.3
Any 3 symptoms	1.05	0.63–1.74	138	63.0

DAE indicates decreased air entry.

DISCUSSION

The study results demonstrate that treating children for pneumonia based on clinical symptoms alone may lead to over-treatment of 55% to 75% of children, depending on which signs or symptoms impact on the clinical decision. Hearing wheezing further increases the probability that a child does not have radiologically confirmed pneumonia.

Our findings regarding the association between specific signs and symptoms differ somewhat from other reported studies. In 3 studies reviewed in by Wilkins and Wilkins,⁷ tachypnea was found to be significantly associated with the finding of pneumonia on chest x-ray. In contrast, in the present study, of 146 children who were tachypneic, only 55 (38%) had pneumonia. Had treatment been given based on tachypnea, as suggested by WHO guidelines, 91 children without radiologic pneumonia would have been treated. Furthermore, 44 (33%) of 132 children who were not tachypneic were shown to have pneumonia on chest x-ray.

A clear association between fever and radiological pneumonia was found in our study, similar to the findings of Zukin et al.⁶ The sensitivity of fever alone was 99.0%, and the negative predictive value was 95.2%. However, the positive predictive value of fever alone was relatively low, 38.1%. Because fever is associated with a large number of conditions in children, many of them viral, fever alone as an indication for antibiotic treatment is not clinically practical. Murphy et al⁵ reported that decreased air entry and rales were positively associated with pneumonia but not tachypnea, hypoxia, or respiratory distress. We found association with none of them.

Similar to Tanen et al,¹⁹ we found that a lack of hypoxia does not rule out pneumonia. In our study, of 99 children with radiologically confirmed pneumonia, 61 (61.6%) were not hypoxic. However, our study found more children with radiological pneumonia who were hypoxic (38.4% in our study vs 10% in Tanen's).

Lynch et al²⁰ found that the combination of fever with at least 1 additional symptom (crackles, decreased air entry, or tachypnea) could predict pneumonia. With the definition of pneumonia used for the study, we found an association only with decreased air entry ($P = 0.03$). If pneumonia were defined as a positive radiologic finding reported by either radiologist (as opposed to both), an association was found with fever and cough ($P = 0.04$) and fever and rales ($P = 0.003$). However, even with the strong association of fever and rales, using this combination to determine clinical pneumonia and the more liberal definition of pneumonia, 9 of 50 children would have been given antibiotics without radiological findings of pneumonia.

The yield of chest x-rays of children with wheezing has been shown to be low. A recent study²¹ showed that 4.5% of children with wheezing had pneumonia on chest x-ray. In our study as well, having wheezing increased the chances of not having pneumonia. However, in the current study, there were radiologic findings of pneumonia in 25.3% of wheezing children. Therefore, we cannot agree with the conclusion of Mathews et al²¹ that radiologic pneumonia among children with wheezing is uncommon. It is possible that the different countries in which these studies were conducted impact on the findings. In a location where pneumonia is more common than nonbacterial lower respiratory tract disease, the yield of pneumonia findings on x-ray could possibly be higher. Further research in multiple settings is needed.

Although it is often taught that clinical signs may precede the radiological findings, the evidence for this is only anecdotal.¹² Even if this unsubstantiated belief is true, it is likely to account for only a small percentage of the negative x-rays.

Similarly, it is anecdotally related that an infiltrate may not appear in a dehydrated children. We were not able to find any clinical studies on which to quantify this statement. However, based on the lack of administration of intravenous fluids to almost all of the study children, this is unlikely to account for the majority of negative radiologic examinations.

We feel that our data suggest the need for reconsideration of current clinical guidelines that recommend treatment based solely on clinical criteria without the need for radiological confirmation in the developed world. Although such guidelines reduce radiation exposure, they may well be markedly increasing unnecessary antibiotic use.

CONCLUSIONS

Clinical assessment alone leads to many children being treated in the absence of radiologically confirmed pneumonia. In an era when the emphasis is on the more judicious use of antibiotics to reduce antibiotic resistance, we must reconsider the need to obtain radiological confirmation of pneumonia, at least where x-ray services are readily available.

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