

## RESEARCH ARTICLE

# Nondiagnostic Pediatric Chest X-rays are Common: Correlate Clinically for Pneumonia

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## Abstract

**Introduction:** Although chest x-rays (CXRs) are frequently ordered to confirm the diagnosis of pneumonia in pediatric patients, the findings on CXR are sometimes nondiagnostic --- neither confirming nor refuting the diagnosis of pneumonia. The primary objective of this study was to determine the frequency of pediatric CXRs that are nondiagnostic. Secondly, we sought to measure how often pediatric patients in the emergency department (ED) receive antibiotics for possible pneumonia when they have a nondiagnostic CXR.

**Methods:** We performed a retrospective chart review on all children seen in the pediatric ED in 2015 on whom a CXR was performed. Every CXR that was interpreted by a radiologist was reviewed to see if it fit our criteria as “nondiagnostic”. If it was determined that the CXR was likely ordered to assess for pneumonia, the patient’s medical records were reviewed and further analysis was done.

**Results:** In total, 2060 CXR interpretations were reviewed, and 572 (27.8% [95% CI 25.8 to 29.8%]) of these had an interpretation by the radiologist that was nondiagnostic. In total 1402 patients met criteria for the antibiotic analysis, and among those in that group who had nondiagnostic CXRs, 29.1% (95% CI 24.8 to 33.8%) received antibiotics for possible pneumonia. Among those patients with nondiagnostic CXRs, those whose read was “perihilar opacities” or “perihilar infiltrates” were most likely to receive antibiotics (38.1% of the time).

**Conclusion:** Pediatric CXRs are often non diagnostic. In the majority of cases, children with nondiagnostic CXR readings do not receive antibiotics for pneumonia, reinforcing the importance of the other aspects of the clinical assessment for pneumonia.

**Keywords:** Pediatric chest x-rays; Nondiagnostic

## Introduction

Clinicians are frequently faced with the decision as to whether or not to order a chest x-ray (CXR) on a child with symptoms that could be indicative of pneumonia. Although there have been previous studies that have identified some clinical factors that predict the presence of radiographic pneumonia, there is still no validated clinical rule that informs the clinician as to which patients should get a CXR [1,2].

Even when a CXR is ordered, as rates of agreement for the diagnosis of pneumonia can be low [3]. Pediatric CXRs, in particular, are difficult to interpret due to both obtaining true inspiratory films and the change in lung structures with age [4]. There are actually no clear criteria as to what represents radiographic pneumonia, and prior studies evaluating pediatric pneumonia have used the overall clinical impressions of radiologists rather than any predetermined criteria to define pneumonia [2].

Sometimes positive findings on CXR are nondiagnostic, neither confirming nor refuting the diagnosis of pneumonia [5-7]. Examples of such non diagnostic findings include “perihilar opacities” and “interstitial infiltrates”. The clinical significance of these nondiagnostic CXR findings in regards to determining if a patient has a pneumonia and whether or not the patient requires antibiotics has not been elucidated. The primary objective of this study was to determine the percentage of pediatric CXRs that are nondiagnostic. Secondly, we sought to determine how often antibiotics are given for possible pneumonia when the child has a nondiagnostic CXR and if there are certain nondiagnostic findings that are more associated with antibiotic use than others.

## Methods

This was a retrospective review of medical records using the attending radiology reports from all CXRs done in 2015 from a county, academic pediatric emergency department (ED) in Las Vegas, Nevada. The annual census of our pediatric ED is approximately 35,000. The CXRs from our pediatric ED are rapidly read 24 hours per day by a private group that currently employs 64 radiologists, including five pediatric radiologists who read some but not all the CXRs in this study. Ten different clinicians (nine physicians and one nurse practitioner) worked in the pediatric ED during this study. This study was approved by our hospital's institutional review board.

Our primary objective was to determine the percentage of pediatric CXRs that were nondiagnostic. We defined a radiology interpretation as being nondiagnostic if the attending radiologist's "impression" was either (or both) of the following: perihilar opacities/infiltrates or interstitial opacities/infiltrates.

We also defined an interpretation as being nondiagnostic if the read was equivocal for pneumonia such as if it listed a differential diagnosis that included "pneumonia" or "focal infiltrate/opacity", but did not specify that pneumonia was most likely. For example, "atelectasis versus infiltrate" was counted as equivocal, but "probable right lower lung pneumonia" was considered to be specific for pneumonia.

A radiology impression including one of the above listed nondiagnostic phrases was considered to be diagnostic, overall, if it also included the acknowledgement of a focal opacity/infiltrate or committed to at least a likely or probable pneumonia.

The second part of the study was designed to identify the percentage of those pediatric patients with nondiagnostic CXRs who received antibiotics for presumed pneumonia. In order to do so, we chose a subset of pediatric patients from those who had a CXR in 2015 in whom it was likely the CXR was ordered to evaluate for pneumonia. Therefore, we chose children from age of 3 months old to 18 years old who had a CXR in the pediatric ED and who did not meet any of the following exclusion criteria: history of HIV, history of leukemia, history of cystic fibrosis, tracheostomy present, traumatic injury within the last week, patient already on antibiotics, history of foreign body ingestion or aspiration, suspected bacterial infection other than pneumonia, or arrived to the ED in cardiac arrest.

The medical records of all patients meeting the inclusion criteria and not meeting these above exclusion criteria were further analyzed to see which patients received antibiotics. This group of patients will be herein referred to as our "antibiotic analysis group".

In general, the methods of this study were similar to those suggested by Gilbert, *et al.* for chart reviews [8]. The investigators for this study trained two research assistants who used a standardized data collection form with an associated data dictionary. Periodic meetings were held with the abstractors to address any uncertainties. A sample of 50 charts was reviewed by both abstractors to determine interrater reliability ( $\kappa$ ), which was 0.88 for all data points and 0.96 for the determination of nondiagnostic or not.

## Results

In total, 2060 CXR interpretations were reviewed, and 572 (27.8% [95% CI 25.8 to 29.8%]) of these had a radiology interpretation that was nondiagnostic. Table 1 shows the distribution of CXR reads.

Interpretation	Number (%)	# Receiving Antibiotics (%)
Perihilar opacities/infiltrates	84 (5.4%)	32 (38.1%)
Interstitial opacities/infiltrates	36 (2.6%)	11 (30.6%)
Other nondiagnostic reads	285 (19.8%)	53 (18.5%)
Normal/no acute disease	635 (46.3%)	80 (12.6%)
Pneumonia/focal opacity	182 (12.6%)	149 (81.9%)

**Table 1:** Demonstrates the percentage of CXRs from patients in the antibiotic analysis group with each of the specified interpretations and the associated percentage of patients with each of those reads who received antibiotics.

Note that if a CXR was, overall, nondiagnostic, and it included one of the pre-specified nondiagnostic findings but also included other findings (for example, atelectasis, hyperinflation, etc.), the CXR was counted toward the "other nondiagnostic" group

In total, there were 1402 patients in the antibiotic analysis group, and of those, 383 of the patients (27.3%) received antibiotics. In comparison, 118 patients out of the 405 nondiagnostic CXRs (29.1% [95% CI 24.8 to 33.8%]) in this group received antibiotics. Indeed, the results of a chi-square test demonstrated that the presence of a nondiagnostic CXR read did not affect the rate of antibiotic prescribing ( $p=0.48$ ). Amongst the pre-specified nondiagnostic phrases, patients with "perihilar opacities/infiltrates" were most likely to receive antibiotics (Table 1).

## Discussion

To our knowledge, this is the first study to estimate the frequency with which CXRs are nondiagnostic. One prior study found 7% of CXRs to be “equivocal for pneumonia,” but our study more broadly looks at the percentage of CXRs that have abnormal findings that are of uncertain clinical significance [9]. The fact that over a quarter of CXRs had nondiagnostic interpretations in our study suggests that CXRs are frequently not helpful in making a specific diagnosis, especially for pneumonia.

The disutility of CXRs when evaluating for pneumonia has also been suggested in other recent studies. While we are certainly not advocating for frequent CT use to evaluate for pneumonia, CT is far more sensitive than CXR for finding pulmonary opacities [10]. Moreover, one study found that in children in which there was a high suspicion for pneumonia, CXRs rarely changed the initial plan to give antibiotics [11]. This finding is also supported by our study in that even when the radiologist read the CXR as being normal, about 13% of patients still received antibiotics for pneumonia.

With so many pediatric CXRs having nondiagnostic interpretations, it is important to try to determine how to manage these patients. While the data from this study are not sufficient to make strong recommendations about which patients with nondiagnostic CXR reads should receive antibiotics for pneumonia, there is not sufficient data anywhere in the literature to make such recommendations. Therefore, it is noteworthy that the providers in our ED were selective about the use of antibiotics in patients with nondiagnostic CXRs. We hope that all acute care providers recognize that an opacity on CXR does not necessitate antibiotics.

## Limitations

First, this was a retrospective chart review, and therefore, it was limited by the typical disadvantages of retrospective studies, including the potential for confounding. Secondly, it was difficult to define what constitutes a CXR that is nondiagnostic, and our definition could be debated. Finally, while our sample size was large, this was a single-center study, and there may be differences in how CXRs are interpreted or antibiotics are prescribed at other facilities. At some facilities, pediatric imaging studies are only read by pediatric radiology specialists. This is not the case at our facility. While one could argue that this is a weakness of the study, we believe it is a strength since most emergency departments do not have pediatric radiology specialists interpreting all their CXRs. That being said, a multicenter trial would have improved our ability to account for local differences in CXR interpretation and antibiotic prescribing.

## Conclusion

Radiologist interpretations of pediatric CXRs are often nondiagnostic, neither ruling in or ruling out pneumonia. In the majority of cases, children with nondiagnostic CXR readings do not receive antibiotics for pneumonia, reinforcing the importance of the other aspects of the clinical assessment for pneumonia. In the future, a prospective evaluation of antibiotic use for nondiagnostic CXR interpretations might provide more information about when antibiotics are needed in these cases.

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