

# Diagnosing Left Lower Lobe Pneumonia: Usefulness of the 'Spine Sign' on Lateral Chest Radiographs

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**BACKGROUND.** Left lower lobe pneumonia may be obscured by the heart on the postero-anterior (PA) chest radiograph. In such cases, the lateral projection may be helpful, especially if it exhibits the "spine sign," which is an interruption in the progressive increase in lucency of the vertebral bodies from superior to inferior. We investigated whether the spine sign would help family physicians diagnose left lower lobe pneumonia on chest radiographs.

**METHODS.** We selected the chest radiographs of all patients with left lower lobe pneumonia who were seen between 1983 and 1995 at a family practice training program (N=78) and an equal number of chest radiographs of patients without pneumonia. Six family physicians read these radiographs under two viewing conditions: PA only vs PA and lateral. We used receiver operating characteristic (ROC) curve methodology to compare the two viewing conditions.

**RESULTS.** There was no significant difference in performance between the two viewing conditions. The lateral view was helpful in some patients but misleading in others. Among patients with pneumonia, the lateral view was helpful when the spine sign was present, but it was misleading when the spine sign was absent.

**CONCLUSIONS.** In this study of family physicians, the lateral chest radiograph did not improve overall diagnostic accuracy in patients with left lower lobe pneumonia. Among pneumonia patients with the spine sign, however, the lateral view was often helpful.

**KEY WORDS.** Pneumonia; ROC curve; thoracic radiography; diagnostic imaging; physicians, family. (*J Fam Pract* 1996; 43:242-248)

The value of the routine lateral chest radiograph has been the subject of controversy among radiologists. Most authors recommend routinely obtaining both postero-anterior (PA) and lateral chest projections.<sup>1-6</sup> In studies of unselected populations, however, the lateral chest projection was rarely useful to experienced radiologists.<sup>1,3,7</sup> These studies may have lacked sensitivity because the lateral view is likely to be most helpful in patients whose pathologic processes are hidden by the heart or diaphragms on the PA projection.

Although left lower lobe pneumonias may be obscured by the heart on the PA projection, they are often visible on the lateral view.<sup>8,9</sup> On the normal lateral chest view, the apparent density of the vertebral bodies gradually decreases from superior to inferior (Figure 1).<sup>9</sup> Any interruption in this progression, making the lower vertebrae appear more dense, may indicate a pathologic process in the lungs, even if the process is not seen on the PA view (Figure 2).<sup>2,8-10</sup> This finding on the lateral view is known as the "spine sign" or "vertebral fade off sign,"<sup>8</sup> and is often present in patients with left lower lobe pneumonia.<sup>8,10</sup>

The purpose of this study was to determine the usefulness of the lateral projection and the usefulness of the spine sign to family physicians who interpret chest radiographs with left lower lobe pneumonia. If the lateral chest projection was found to be useful to family physicians, recommen-

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dations to include only the PA projection<sup>11</sup> should be resisted.

## METHODS

We selected the chest radiographs of all University of Iowa Family Practice Clinic patients who received a radiologic diagnosis of left lower lobe pneumonia between January 1, 1983, and April 1, 1995 (N=78). For each of these abnormal films, we selected a chest radiograph of a different patient with no pneumonia that was taken in the same year. For simplicity, we refer to these no-pneumonia patients as "normal," although some had other abnormalities, such as emphysema or cardiomegaly. For all patients, the stated reason for obtaining the radiograph was "rule out pneumonia" or "rule out infiltrate."

In this study, we developed the "gold standard" for left lower lobe pneumonia by combining clinical findings with two radiologists' interpretations. All radiographs were initially read by a University of Iowa radiology faculty member ("original radiol-

ogist") at the time the films were taken. At the beginning of the study, a different faculty radiologist ("second radiologist"), who was blinded to the original readings, repeated the interpretations and judged whether the spine sign was present. The second radiologist disagreed with the original radiologist about the presence of a left lower lobe infiltrate in 19 (12%) of the 156 patients. A third radiologist, who was blinded to the first two readings, read these 19 radiographs and served as a tie-breaker. The presence of the spine sign was determined solely by the second radiologist.

Clinical information was obtained from the patients' medical records. Five clinical findings have been found to independently predict pneumonia on chest radiographs: temperature  $>37.8^{\circ}\text{C}$  ( $100^{\circ}\text{F}$ ), pulse  $>100$  beats per minute, rales, decreased breath sounds, and absence of asthma.<sup>12</sup> Except for a history of asthma, most patient records contained information about the other four clinical findings. A patient was defined as having left lower lobe pneumonia if two radiologists independently read pneumonia on the chest film,

FIGURE 1

Normal chest radiographs. On the lateral view, note the progressive increase in lucency of the vertebral bodies from superior to inferior.

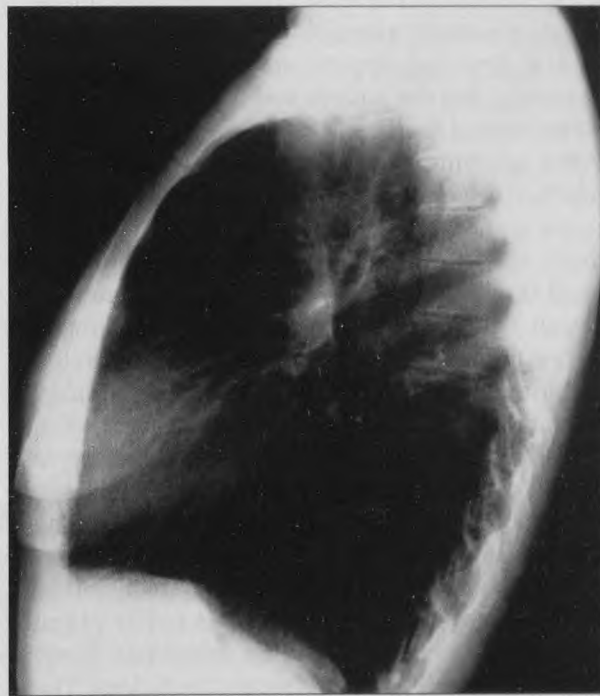


FIGURE 2

On the postero-anterior view (*left*), the left lower lobe infiltrate is difficult to see because it is retrocardiac. The lateral view (*right*) exemplifies the "spine sign": an interruption in the progressive increase in lucency of the vertebral bodies from superior to inferior.



and the patient had at least one of the five clinical findings. A patient was defined as having no pneumonia if two radiologists agreed there was no pneumonia, and the patient had fewer than four of the five clinical findings.

After applying these criteria, our final sample comprised 65 patients with pneumonia and 83 patients with no pneumonia (Figure 3). We excluded from all analyses eight patients with no positive clinical findings but with left lower lobe pneumonia read by two radiologists. Seven radiographs included in the analysis were originally interpreted as left lower lobe pneumonia but were reclassified as normal after applying the gold-standard criteria. Two radiographs included in the analysis were originally interpreted as normal but were reclassified as left lower lobe pneumonia after applying the gold-standard criteria.

The radiographs were presented to a convenience sample of six board-certified family physicians in two separate reading sessions. These physicians had no extra training in radiology. The physician readers were given no clinical informa-

tion except that the radiographs were taken to rule out pneumonia. During the first session, the reader was presented with either the PA view alone or with both PA and lateral views. During the second session, the readers saw only the PA view if they had seen the PA and lateral views during the first session, or the PA and lateral views if they had seen only the PA view during the first session. Using computer-generated random numbers, we determined the order of presentation and whether the PA only or the PA and lateral views were shown at the first session. The two reading sessions were conducted 4 months apart to allow physicians time to forget the appearance of the radiographs they had seen during the first session.

The physician readers were asked to judge the probability of left lower lobe pneumonia on a standard 5-point scale, ranging from 1=definitely or almost definitely no left lower lobe pneumonia to 5=definite or almost definite left lower lobe pneumonia.<sup>13-15</sup> In addition, each reader was asked to state whether the spine sign was present. Before each session, the physician readers were shown a



normal chest radiograph and an example of the spine sign. They were also reminded that it is possible to have left lower lobe pneumonia without a spine sign and to have a spine sign without left lower lobe pneumonia.

A traditional method for evaluating the performance of a diagnostic system (or reading condition) is to construct a two-by-two table that crosses the reader's interpretation with a gold standard. This table is used to calculate the sensitivity and specificity of the system. The problem with this method is that it assumes a fixed threshold for deciding whether a case is abnormal. By varying the threshold for abnormal, the true-positive rate (sensitivity) can be increased simply by allowing the false-positive rate (1-specificity) to increase.<sup>16</sup>

The advantage of receiver operating characteristic (ROC) curve methodology is that it measures the performance of a diagnostic system unconfounded by the decision threshold.<sup>15,16</sup> An ROC curve is constructed by plotting true-positive and false-positive rates as the threshold for abnormal varies (Figure 4). A practical method for obtaining these rates involves the use of confidence ratings. For example, the reader is asked to rate confidence in the presence of left lower lobe pneumonia: 5=definite or almost definite pneumonia, 4=probable pneumonia, 3=possible pneumonia, 2=probably no pneumonia, and 1=definitely or almost definitely no pneumonia. The ratings are grouped in four ways to obtain four decision

thresholds: 5=pneumonia and 1, 2, 3, 4=normal; 4, 5=pneumonia and 1, 2, 3=normal; 3, 4, 5=pneumonia and 1, 2=normal; 2, 3, 4, 5=pneumonia and 1=normal. The ROC curve is constructed from the true-positive and false-positive rates that result from these groupings.

If the reader randomly selected one of the five ratings without regard to the appearance of the radiograph, the ROC curve would tend to form a diagonal line from the lower left corner to the upper right corner (Figure 4). The area under this line is 0.50, which indicates a performance neither better nor worse than chance. Any curve above the diagonal line will have an area greater than 0.50; the greater the area under the curve, the better the performance. The performance of the two viewing conditions (PA only vs PA and lateral) was compared by measuring the difference in the areas under their ROC curves (Figure 4).

We used the Dorfman/Berbaum/Metz methodology,<sup>17</sup> which calculates accuracy scores (analogous to areas under ROC curves) for each patient and compares these scores using analysis of variance. The *t* test and chi-squared statistic were used to compare demographic characteristics of patients.

## RESULTS

The mean age of patients with left lower lobe pneumonia was  $40.0 \pm 19.0$  years (range, 9 to 88 years),

FIGURE 3

Selection of study radiographs using the gold standard criteria.

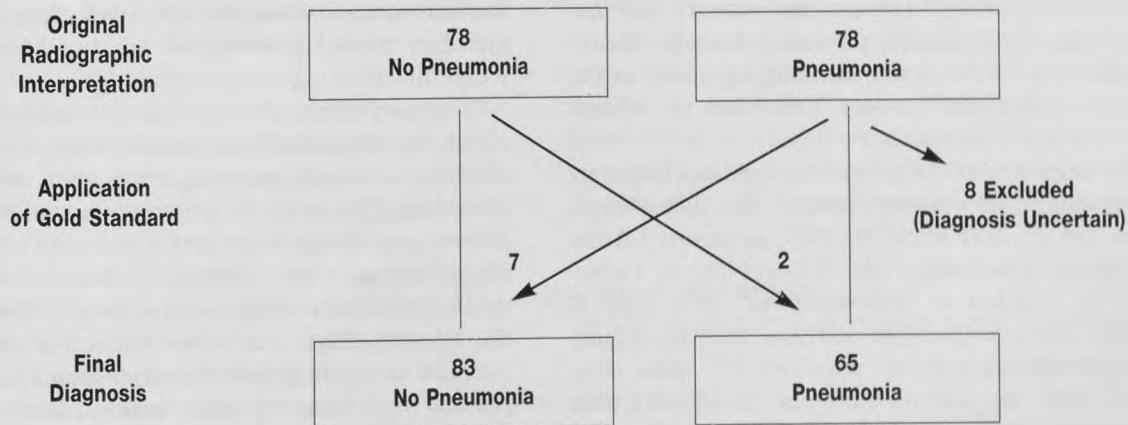
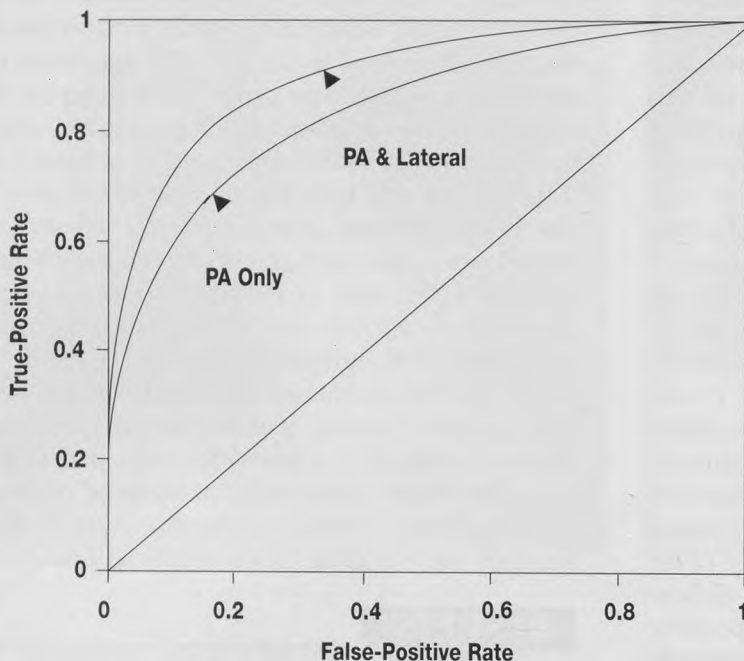


FIGURE 4

Receiver operating characteristic curves for one of the family physician readers. In this example, the area under the PA-and-lateral curve (0.8235) is greater than the area under the PA-only curve (0.8108), indicating that the lateral view was helpful to the physician reading the radiograph. The difference, however, was not statistically significant (area difference =  $0.8235 - 0.8108 = 0.0127$ ; 95% confidence interval, -0.0593 to 0.0847).



and the mean age of normal patients was  $43.1 \pm 18.2$  years (range 10 to 96 years) ( $P=.31$ ). Forty pneumonia patients (61.5%) and 53 normal patients (63.9%) were female ( $P=.77$ ). Based on the second radiologist's reading, 43 pneumonia patients (66.2%) and none of the normal patients had the spine sign. The six family physician readers reported presence of the spine sign slightly more often than the radiologist (mean, 72.8%), but the difference was not significant ( $P=.45$ ).

The presence of the lateral view did not improve the radiographic interpretation: the mean area under the PA-only curve (0.8535) subtracted from the mean area under the PA-and-lateral curve (0.8553) yielded a difference of only 0.0018 ( $P=.92$ ). We repeated the analysis after including only pneumonia patients who had the spine sign ( $n=43$ ) and all normal patients ( $n=83$ ). In this analysis, the difference between the PA-and-lateral viewing condition and the PA-only condition increased, but failed to reach statistical signifi-

cance: the mean area under the PA-and-lateral curve (0.9265) minus the mean area under the PA-only curve (0.8928) was 0.0337 ( $P=.13$ ). A typical pair of ROC curves is illustrated in Figure 4.

The lateral view was more helpful in some chest studies than it was in others; ie, there was a patient-by-viewing-condition interaction in which the effect of the lateral view depended on the patient ( $F_{147,735}=1.6$ ,  $P<.001$ ). To explore this interaction further, we reviewed all patients with ROC area differences greater than 0.2. A positive difference indicated a helpful lateral view, and a negative difference indicated a misleading lateral view. Among normal patients, the lateral view was helpful in 11 cases and misleading in 3 cases. Among pneumonia patients, the lateral view was helpful in 18 cases and misleading in 10 cases.

Among pneumonia patients with the spine sign, the lateral view was helpful in 13 cases and misleading in 3 cases; whereas in pneumonia patients without the spine sign, the lateral view was helpful in 5 cases and misleading in 7. Therefore, when reading chest radiographs with left lower lobe pneumonia, the physicians tended to benefit from the lateral view when the spine sign was present, but they were often misled by the lateral view when the spine sign was absent.

In most pneumonia patients with helpful lateral views, the pneumonia was retrocardiac on the PA view, and a classic spine sign was seen on the lateral view (Figure 2). In pneumonia patients with misleading lateral views, the spine sign was often absent because the infiltrate was anterior to the spine. In normal patients with helpful lateral views, the PA projection was often difficult to interpret because the radiograph was underpenetrated, the patient was obese, or there was cardiomegaly. In normal patients with misleading lateral views, prominent but normal pulmonary veins mimicked the spine sign.

## DISCUSSION

Overall, the lateral chest projection was not helpful to family physicians who interpreted radiographs with left lower lobe pneumonia. There was, however, a patient-by-viewing-condition interaction in which the lateral projection was helpful in some patients but misleading in others. When viewing both PA and lateral projections, the performance of the six readers was high in relation to the gold standard, with an average area under the ROC curve of 0.86. This finding is consistent with other studies of radiographic interpretation, which found high levels of performance among family physicians.<sup>18,19</sup>

In children, the lateral chest projection was found to be unhelpful to radiologists<sup>7,20-22</sup>; in adults, the lateral view is only occasionally crucial to the diagnosis of serious radiographic abnormalities.<sup>1,3</sup> For example, in a study of 16,000 adult outpatients and inpatients, there were 24 cases in which the lateral view was of "primary value" in detecting a pathologic process.<sup>1</sup> In a second study, only one of 1855 radiographs of 20- to 39-year-old patients had a serious abnormality that could be seen only on the lateral view.<sup>3</sup> Among 3689 patients over age 40 years, 33 radiographs (0.9%) had serious abnormalities that were detected only on the lateral view. These studies prompted the World Health Organization to recommend against the use of routine lateral chest radiographs.<sup>11</sup> When an abnormality is seen on the PA view, however, there is general agreement that the lateral view is helpful in localizing and characterizing the abnormality.<sup>1,3,9</sup> In many settings, it may be impractical to wait until a radiologist has read the PA view before deciding whether to obtain a lateral view.

Our findings should be interpreted cautiously because we studied a small group of family physicians who interpreted radiographs from a single office setting. These physicians did not have access to clinical information that normally would have been available to them. At the beginning of each reading session, we showed examples of the spine sign and a normal lateral chest view to the readers. We emphasized that left lower lobe pneumonia may be present without a spine sign, but we provided no such examples during the initial instructions. If we had provided more comprehensive training in the interpretation of the lateral

chest view, we might have found improved accuracy with the lateral view. Finally, we focused on interpretive accuracy rather than patient outcomes. Physicians may prescribe antibiotics based on clinical findings, even if they "miss" a pneumonia on the chest radiograph.

Although the lateral view did not appear to improve diagnostic accuracy in this study, our methods may have lacked sufficient sensitivity. For example, if we had included more patients with subtle pneumonias, we might have found a significant difference between the two viewing conditions. Also, our findings cannot be applied to pathologic processes other than left lower lobe pneumonia. For example, the lateral view can be helpful in diagnosing pulmonary nodules that are obscured by the heart or diaphragms on the PA projection.<sup>1,3</sup>

In this study, the lateral chest projection was helpful in some patients and misleading in others. The spine sign was most helpful in patients with retrocardiac pneumonias. Overall, the lateral view did not affect the accuracy of radiographic interpretations in patients with left lower lobe pneumonia. It is possible that eliminating the routine lateral chest view in selected populations could decrease health care costs without having an impact on the quality of care. Even if quality were adversely affected, it would be reasonable to ask whether the cost-effectiveness of the lateral view is comparable to that of other interventions. A more comprehensive study using ROC methodology appears to be justified. We cannot recommend against the routine use of the lateral view because we studied only one disease (left lower lobe pneumonia) that was interpreted by only six family physicians and because the lateral view can be helpful in localizing and characterizing lesions seen on the PA view. For now, both PA and lateral views should be included in the radiographic chest examination of patients with suspected pneumonia.

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