Limited Utility of Chest Radiograph After Thoracentesis*

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Study objective: To assess the utility of chest radiograph (CXR) immediately after routine thoracentesis.

Design: Prospective cohort study.

Setting: Multispecialty clinic/teaching hospital.

Participants: All outpatients and inpatients undergoing thoracentesis in the procedure area from October 1995 to January 1998.

Measurements: Immediately after thoracentesis, the physician completed a questionnaire assessing the likelihood of a complication. CXRs were obtained at physician discretion. Patient demographics, indications for thoracentesis, use of ultrasound guidance, level of training, radiographic interpretation, and eventual patient outcome were recorded.

Results: Two hundred eighteen patients were enrolled for a total of 278 thoracenteses. Two hundred fifty-one procedures performed on 199 patients could be prospectively evaluated. A complication was suspected in 30 procedures; immediate CXR confirmed such in 9 (30%). There were 221 procedures with no clinical suspicion or indication of a complication. Ninety CXRs were obtained immediately after the procedure; the remaining 131 procedures had no CXR. The complication rates were 3.3% and 2.3%, respectively, for these groups. Four postthoracentesis radiographs demonstrated additional findings regardless of the indication for the radiograph.

Conclusions: In the absence of a clinical indication of a complication, chest radiography is not indicated immediately after routine thoracentesis. Aspiration of air strongly correlates with the occurrence of pneumothorax, whereas pain, hypotension, and dry tap do not. Use of a vacuum bottle to withdraw fluid obscures the appreciation of this finding and was identified as a risk factor for subsequent pneumothorax. Additional radiographic findings are rarely detected and may not contribute to clinical management.

Key words: chest radiograph; complication; pneumothorax; thoracentesis

Abbreviations: CXR = chest radiograph; OR = odds ratio

It is common practice to obtain a chest radiograph (CXR) immediately subsequent to thoracentesis. This standard has persisted unchallenged until the recent emphasis on cost-effective medical treatment. Whether the CXR is universally indicated after thoracentesis remains unsettled.

The growing interest in this question has been reflected in recent studies. The American College of Chest Physicians 61st Annual International Scientific Assembly produced two independent retrospective studies that suggest CXRs may not be needed after thoracentesis. A 1996 publication identified retrospectively a subgroup of hospitalized patients that should not require a CXR. These patients were identified as requiring only one needle pass during the procedure, having no aspiration of air, remaining stable throughout, demonstrating no other signs of pneumothorax, and having no prior history of chest irradiation. However, there are no prospective outpatient studies specifically addressing this issue.

Routine CXRs are usually obtained to exclude a possible complication. The anticipated complications would include pneumothorax, hemothorax, re-expansion pulmonary edema, and organ laceration. Of these, only pneumothorax is likely to be revealed by immediate CXR. The incidence of pneumothorax is variably reported as 4% to 30%. The number that require subsequent intervention is significantly less, up to 3.9% of all patients undergoing thoracentesis, or up to 33% of those with demonstrated pneumothorax. Hemothorax occurs rarely, with one report of 1.2% occurrence. Hemothorax after thora-
centesis would usually be diagnosed by monitoring vital signs in the postprocedure period. Likewise, organ laceration is rare as is re-expansion pulmonary edema. These complications will not be discovered on immediate CXR but rather suspected from subsequent clinical deterioration.

Some reports have suggested that the CXR is useful for the evaluation of structures previously concealed by pleural fluid or for documentation of the postprocedure fluid level. However, there are no studies addressing the clinical application of these findings. The last major indication for obtaining a postthoracentesis CXR is medicolegal. In the current atmosphere of litigation, many physicians may consider the radiograph essential documentation even in those patients who clinically show no need for concern. Again, there are no outcome studies demonstrating that a postthoracentesis CXR enhances the safety of the procedure or influences outcome.

From November 1995 to January 1998, we prospectively studied all thoracenteses performed in the procedure area that serves both the hospital and clinic patients. We hypothesized a limited utility of routine CXR in patients undergoing thoracentesis in the absence of physician suspicion or clinical signs of a complication. We further proposed insufficient information is gained to justify a postthoracentesis CXR ostensibly performed to evaluate thoracic structures or determine postprocedure fluid level.

Materials and Methods

Subsequent to approval by the institutional review board, all patients having thoracentesis performed in the treatment area from October 1995 until January 1998 were prospectively enrolled. As this study constituted comparison of two accepted regimens (process research), consent was not required, and the study was transparent to the physicians and patients. Exclusion criteria included thoracentesis outside the treatment room, concomitant tube thoracostomy, or positive-pressure ventilation.

The decision to perform thoracentesis was made by the patient’s primary physician or consultant before enrollment in the study. The method used was left to the discretion of the performing physician, although the vast majority used a catheter over a needle (Arrow-Clark Pleural Seal Thoracentesis Kit; Reading, PA). The CXR was obtained as deemed prudent by the performing or supervising physician. Afterward, the performing physician and assisting nurse each completed a questionnaire. Data collection included the indication for procedure, technique used, level of physician experience, physician evaluation for possible complication, clinical indicators of possible complications, and the rationale for CXR if requested. The performing physician indicated if the procedure was intended to be solely diagnostic, therapeutic, or both. The physician was also unrestrained in his definition of a complication.

All radiographs were reviewed by a member of the research team for evidence of a complication as well as additional findings. For the purpose of this study, a pneumothorax was defined as any air demonstrated in the pleural space on any radiographic study.

The interpretation of the independent radiologist was also correlated with the opinion of the research team. In two cases, an arbitrating radiologist was asked to reconcile a difference in interpretation. Finally, charts and radiograph files were reviewed on all patients after 3 months to assess the possibility of a late complication and determine final diagnosis and outcome. The daily census for the treatment area was reviewed periodically to capture those procedures for which the physician did not complete a questionnaire. This was to ensure against a selection bias excluding possible complications despite the intended transparent nature of the study.

Comparisons of proportions were made using the chi-squared test or Fisher’s Exact Test. Odds ratios (OR) were computed to compare the risk of pneumothorax in the presence of a risk factor to the risk in the absence of that factor. Probability values < 0.05 indicated statistical significance.

Results

A total of 278 thoracenteses were performed on 218 patients. Complete data allowed for evaluation of 251 procedures on 199 patients. Those data were evaluated to assess the utility of the CXR. The physician declined to complete the questionnaire for 27 procedures performed on 25 patients; because of multiple procedures, six patients appear in both groups. The data on the 27 procedures are only included in the determination of overall rates of complications and associated risk factors. No patients were lost to follow-up.

The study sample consisted of 112 men and 106 women with a mean age of 66 ± 16 years. There were 156 outpatient procedures and 122 inpatient procedures. One hundred seventy-four patients had only one thoracentesis; 44 patients had multiple procedures (range, 2 to 5 procedures). The predominant causes of the effusion were malignancy (41.7%), parapneumonic effusions/empyema (15.5%), congestive heart failure (12.9%), no definitive diagnosis (8.3%), and postoperative effusions (7.6%).

Thoracentesis was performed by an experienced staff physician (n = 15, 9 pulmonologists, 3 thoracic surgeons, 3 other staff physicians) in 142 of 278 cases (51%). Pulmonary fellows (n = 6) performed 90 of 278 procedures (35.6%), and the remainder were performed by residents or medical students (37 of 278 procedures or 13.3%). Ultrasound guidance was obtained in 36 of 278 cases (13%). Staff physicians were less likely to use ultrasound (12 of 142 procedures or 8.5%), than fellows (17 of 99 procedures or 17%) and residents (7 of 37 procedures or 18.9%; p = 0.06). However, for those procedures in which no complication was suspected, staff physicians were more likely than fellows, but not residents, to order a CXR (46 of 110 procedures [41.8%], 27 of 80 procedures [33.8%], and 15 of 29 procedures [51.7%], respectively; p = 0.16). A vacuum bottle was used to withdraw fluid in 25 of 251 cases (10%).
Three staff physicians accounted for 19 of those 25 procedures. For all procedures, the performing physician indicated that the intent was therapeutic in 60 of 278 procedures (21.7%), diagnostic in 126 of 278 procedures (45.3%), both in 89 of 278 procedures (32%), and uncertain or unavailable in 3 cases.

The overall rate of postthoracentesis pneumothorax for all patients enrolled was 18 of 278 procedures (6.5%). The other complications noted in the study were dry tap in 19 of 278 procedures (6.8%) and pain and symptomatic hypotension in 3 each of 278 procedures (1.1%).

Complete data collection allowed for prospective evaluation of 251 procedures (Table 1). This group did not differ significantly from the whole in terms of performing physicians, diagnoses, or rates of complications. However, procedures indicated as being both diagnostic and therapeutic were more likely (97%) to have complete data than those that were only diagnostic (87%) or therapeutic (88%) (p = 0.03). In 30 of 251 procedures, the physician indicated some likelihood of a complication, suspected pneumothorax in 15, dry tap in 11, and pain or hypotension in 4. The only reason indicated by the performing physician for a suspected pneumothorax was the return of air through the catheter system (13 of 15 cases). For the other two procedures, no reason was listed for suspecting a pneumothorax. Immediate CXR was obtained in all 15; pneumothorax could be detected in 9. In each of these nine patients, free aspiration of air was noted by the performing physician. Tube thoracostomy for treatment of pneumothorax was required in four of these patients. When the suspected complication was other than pneumothorax, a CXR was obtained in only 4 of the 15 procedures. Follow-up visits and subsequent radiographic studies did not reveal any further complication in those patients.

In an additional 90 procedures, a CXR was obtained immediately after the procedure, although no complication was suspected. A pneumothorax was detected in three, and a chest tube was required in two for resolution of the pneumothorax. A vacuum bottle had been used in all three cases of unsuspected immediate pneumothorax.

There was no CXR obtained after the remaining 131 procedures. Three subsequent pneumothoraces were detected in follow-up. For two patients, a CXR was obtained at subsequent evaluation but showed no pneumothorax. However, CT scans performed immediately thereafter demonstrated air in the pleural space. For the third, the patient presented to the emergency department the following day with a resolved transient neurologic deficit. Admission CXR was obtained when the patient had a hypotensive episode while in the emergency department. A moderate pneumothorax was demonstrated; however, deep venous thrombosis of the thigh was also diagnosed. The exact cause of the hypotension was never ascertained. None of these three patients required intervention for the pneumothorax.

Only four radiographs performed immediately after thoracentesis revealed a new finding. In three, the radiologist commented on new or increased atelectasis or infiltrate. In the fourth, a right hilar mass was revealed. In none of these cases was this information essential to establish the diagnosis (amyloid, postoperative effusion, parapneumonic effusion, and lung cancer).

Discussion

This study represents the first prospective evaluation of the role of immediate CXR after thoracentesis for both inpatients and outpatients. The overall rates of complication were similar to those of previously published series, as was the requirement for subsequent tube thoracostomy.4 The rate of pneumothorax was similar for experienced staff physician (9 of 142 procedures, 6.3%) and the fellows (5 of 99 procedures, 5.0%) but was slightly higher for the residents/medical students (4 of 37 procedures, 10.8%) (p = 0.49). This finding agrees closely with a prior study as well.4 Other apparent risk factors for pneumothorax in this study included the use of a vacuum bottle (OR, 4.6; p < 0.01), a prior thoracentesis (OR, 2.4; p = 0.08), ultrasound guidance (OR, 2.8; p = 0.05), and pleural biopsy (OR, 2.6; p = 0.22).

Table 1—Utilization of CXR After Thoracentesis*

<table>
<thead>
<tr>
<th>Performing physician, No. of procedures</th>
<th>Suspected Complication</th>
<th>CXR obtained—no suspected complication</th>
<th>No CXR—no suspected complication</th>
</tr>
</thead>
<tbody>
<tr>
<td>Staff physician, 129</td>
<td>Suspected pneumothorax</td>
<td>7 (5)</td>
<td>48 (3)</td>
</tr>
<tr>
<td>Felloes, 91</td>
<td></td>
<td>6 (2)</td>
<td>27</td>
</tr>
<tr>
<td>House Officers, 31</td>
<td>Other suspected complication</td>
<td>5</td>
<td>15</td>
</tr>
<tr>
<td>Totals</td>
<td></td>
<td>15 (9)</td>
<td>90 (3)</td>
</tr>
</tbody>
</table>

*All thoracenteses, n = 251; numbers in parentheses indicate pneumothorax detected.
It is interesting to note that each of the three unsuspected pneumothoraces was associated with the use of a vacuum bottle. Perhaps such a vacuum device prevents the detection of aspiration of free air. As recently reported, prior thoracentesis was also identified as a risk factor for pneumothorax in this study. It may be that the chronicity of the pleural effusion, adhesions, or altered compliance of the pleura and lung are more germane to the development of the pneumothorax than the actual cause of the pleural effusion per se. We likewise were unable to show a correlation between pneumothorax and specific diagnosis.

The use of ultrasonic guidance did not appear to offer protection, because 5 of 36 cases performed with ultrasound resulted in a pneumothorax as opposed to only 13 of 242 cases performed without ultrasound (p = 0.05). This is quite the opposite from the study of Raptopoulos et al, who described an 18% rate of pneumothorax without ultrasound guidance. We postulate that the use of ultrasound in our study is more likely a marker of a difficult procedure and, thus, a higher risk patient rather than a factor leading to the development of pneumothorax. It might also be that ultrasound guidance confers some degree of false assurance leading to more aggressive advancement of the needle.

Pleural biopsy was performed in only a few cases (14 of 278 procedures). However, the rate of pneumothorax was substantial (2 of 14 procedures, 14.3%). Both cases were prospectively identified by aspiration of free air at the end of the procedure. Our study suggests that if aspiration of the pleural space after pleural biopsy yields no air, then a CXR would be unlikely to demonstrate a pneumothorax.

Fifteen patients were prospectively thought to have a pneumothorax; aspiration of air was the clinical indication in 13. Of those, nine (69%) had a pneumothorax. When not suspected at the time of the thoracentesis, 6 of 236 patients were ultimately found to have a pneumothorax. In two patients, the pneumothorax was an incidental finding on subsequent CT, although the CXR did not demonstrate pleural air. In one patient, the pneumothorax may or may not have been a delayed event. For each of the other three, it is suspected that the use of the vacuum bottle either increased the likelihood of pneumothorax or obscured the finding of aspiration of free air.

As in other studies, few patients with subsequent pneumothorax (5 of 18 procedures, 28%) required tube thoracostomy. However 3 of 5 pneumothoraces (60%) after use of a vacuum bottle were pneumothoraces (15.4%) not associated with use of a vacuum bottle required a chest tube (p = 0.10). This suggests that use of a vacuum bottle for removal of pleural fluid possibly increases the severity of complication.

The rate of pneumothorax was similar whether the procedure was intended to be simply diagnostic, therapeutic, or both (5.6%, 6.67%, and 7.9%, respectively; p = 0.80). The combined rate for all procedures intended to be either solely therapeutic or simultaneously diagnostic and therapeutic was also not significantly different (7.3%). A recent study by Colt et al also found no association between the intent of the procedure and subsequent pneumothorax. This is in contradistinction to the study by Raptopoulos et al, who reported an 18% pneumothorax rate with therapeutic procedures but only a 6% rate with diagnostic procedures. A critical distinction from our study is the experience of the performing physician. In that study, >90% of procedures were performed by physicians in training, a factor that has been shown in our study as well as others to strongly influence complication rates. We observed no re-expansion pulmonary edema associated with therapeutic thoracentesis. One patient had transient hypotension without any other complication during a therapeutic thoracentesis on two separate occasions. However, that number is too small to be significant. Overall, therefore, it would appear that the rate of complication of a therapeutic thoracentesis is not significantly different from a diagnostic procedure; thus, in and of itself, a therapeutic thoracentesis is not an indication for a postprocedure CXR. This observation runs counter to the guidelines proposed by the American Thoracic Society.

Finally, we questioned the utility of the CXR for demonstrating findings that were previously obscured by the pleural fluid. Excluding the detection of pneumothorax, there were only 4 new findings for the 105 prospectively evaluated films. None was required to establish the diagnosis nor did the information affect the management. We did not have a case in which the entire hemithorax was completely opacified by pleural fluid. Perhaps in such a case, CXR immediately after thoracentesis might direct management; however, our experience suggests this to be a rare event.

It is much more difficult to clarify the relevancy of a baseline film to judge the rate of recurrence of fluid. More often, the decision to repeat a therapeutic thoracentesis will be based on the severity of dyspnea rather than a specific level of fluid in the thorax. Thus, comparison to a prior postthoracentesis film would not seem crucial. Nor is it evident that the determination of the degree of residual pleural fluid immediately after thoracentesis aids in diagnosis, speeds the resolution of an effusion, or significantly lengthens the interval between therapeutic thoraco-
centeses. Because of the rather subjective nature of such decision making, our study could not define the utility of a baseline film. However, physician behavior throughout the study would suggest it was not believed to be critical. In the first two quartiles of the study, a routine CXR, in the absence of a suspected complication, was obtained immediately after thoracentesis 63.6% (35 of 55 procedures) and 50.9% (28 of 55 procedures) of the time. However, in the third and fourth quartile, the rates of routine films were 23.6% (13 of 55 procedures) and 26.4% (14 of 53 procedures) (p < 0.001), even though the rates of CXR for suspected complications remained fairly constant at 10.9% (6 of 55 procedures) for each quartile. This trend held for both the staff and house officers, although not to the same degree for each physician. We suspect behavior changed once physicians realized that the value of a postthoracentesis CXR was limited in many cases.

There are some shortcomings to our study. By retrospective review of discharge coding and medical records, we were able to identify 105 inpatient thoracenteses performed at the bedside during this study. Fifty-four were performed after hours at which time the procedure area was not available. The remaining 51 patients did not differ from the study group in terms of demographics, diagnoses, or intent of the procedure. Four pneumothoraces were identified (3.8%); none required a chest tube.

Our study could not distinguish the impact of the supervising physician on the decision by house officers to order CXR. It may have been that staff physicians encouraged obtaining a CXR after procedures performed by house officers because of decreased confidence in the house officers’ ability. The same argument would apply to the use of ultrasound guidance. In view of the consistent finding that pneumothorax rates are increased when thoracentesis is performed by house officers, this does not appear to be an unreasonable attitude. It should be noted, however, that the pulmonary fellows had no higher rates of complication then did staff physicians.

**CONCLUSION**

In the absence of suspicion or clinical indication of a complication, chest radiography immediately after thoracentesis is not warranted in the vast majority of cases either for the identification of pneumothorax or detection of new diagnostic information. This is independent of the intention (diagnostic or therapeutic) of the thoracentesis. The use of a vacuum bottle to withdraw fluid negates this finding and increases the risk of complication. The use of such vacuum devices to withdraw pleural fluid should be strongly discouraged. Otherwise, the occurrence of a clinically significant immediate pneumothorax was always identified by the aspiration of free air. Outpatient thoracentesis per se does not require subsequent CXR. That decision should be based on physician experience, confidence, and clinical observations. Official guidelines may need amending to reflect what is already becoming customary practice.13,14

**REFERENCES**

9 Synder RW, Mishel HS, Bosse CG. Routine chest radiography after thoracentesis [letter]. Ann Intern Med 1997; 126:491
10 Blair GP. Routine chest radiography after thoracentesis [letter]. Ann Intern Med 1997; 126:491