The Prognostic Value of Loculations in Parapneumonic Pleural Effusions*

Ronald B. Himelman, M.D.;† and Peter W. Callen, M.D.‡

Forty-eight patients with pleural effusions who had sonographically directed thoracocentesis were evaluated retrospectively for radiologic findings, pleural fluid chemistries, and outcome. Loculation was found to be a radiologic marker of diagnostic and prognostic significance. The presence of loculations correlated with exudative pleural fluid chemistries, but no radiologic finding was specific for empyema. "Extreme" pleural fluid chemistries were associated with loculation, but not with empyema. Patients with loculated effusions had larger effusions, longer hospitalizations, and more frequent tube thoracostomy procedures than patients with nonloculated effusions. Light's criteria for tube thoracostomy were found to be unreliable in patients with loculated parapneumonic effusions or in patients treated with prolonged antibiotic therapy prior to thoracocentesis.

In 1980, Light et al1 proposed a set of chemical criteria for tube thoracostomy of parapneumonic effusions based on the results of the initial thoracocentesis. In order to identify patients with bacterial pneumonias and effusions who would need early tube thoracostomy, they ordered bilateral decubitus chest radiographs within 72 hours and performed thoracocentesis when pleural fluid layered to more than 10 mm. Patients with loculated effusions or sterilized empyemas due to prolonged treatment with antibiotics were thus excluded. Light et al recommended that purulent fluid, organisms present on Gram stain, pleural fluid glucose below 40 mg/dl, and pH below 7.0 were absolute indications for tube thoracostomy, whereas pH of 7.0 to 7.2 or lactate dehydrogenase (LDH) above 1,000 IU/L were relative indications. A pleural fluid pH above 7.2 with the LDH below 1,000 IU/L constituted an "uncomplicated" effusion, and serial monitoring by thoracocenteses or tube thoracostomy was unnecessary. Recently, newer radiologic methods, including ultrasound and computed tomography (CT) scanning, have been applied to diagnosis of pleural effusions. We undertook a retrospective analysis of 48 pleural effusions sampled under ultrasound in order to apply the criteria of Light et al retrospectively to patients with loculated or partially sterilized effusions and to correlate the radiologic appearance of pleural effusions with pleural fluid chemistries and clinical outcome. Loculation of pleural fluid was found to be a useful radiologic sign for diagnostic and prognostic purposes.

Material and Methods

We studied all 48 patients who underwent successful thoracocen-

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teses, pneumothorax, respiratory compromise due to the effusion, and persistent fevers on antibiotics attributed to sterile empyema.

Statistical methods included chi-square analysis and the Student's t-test for two independent means. When skew values were present, the t-test was confirmed by the Wilcoxon rank sum test.

**RESULTS**

**Demographics and Etiology**

The average age of the 48 patients was 50 years; 31 patients were male and 17 were female. Fifteen effusions were large (as defined above), 26 were moderate, and seven were small. Eleven effusions (23 percent) were transudates, 28 (58 percent) were exudates, and nine (19 percent) were empyemas. Fifty-four percent of effusions were associated with pneumonias (parapneumonic); others were associated with congestive heart failure (15 percent), unknown etiology (10 percent), malignancy (6 percent), pulmonary emboli (4 percent), and trauma (4 percent).

**Bacteriology**

Organisms isolated from pneumonias and empyemas included *Staphylococcus aureus*, anaerobes, Streptococcus pneumonias, and Gram-negative rods. The bacteriology was similar to that found in previous series in the antibiotic era.4• Thoracocenteses were performed on parapneumonic effusions an average of eight days after therapy with antibiotics had been started. Patients with positive parapneumonic pleural fluid cultures had been treated with antibiotics for an average of three days prior to thoracocentesis (range: 0 to 9 days), whereas patients with negative culture findings had been treated for an average of 12 days (range: 3 to 30 days).

**Radiology**

Of the radiologic findings associated with pleural effusions, loculations were demonstrated in 35 percent of the cases, lung cavitation in 10 percent, pleural gas on CT scan in 8 percent, multiple internal pleural echoes on ultrasound in 6 percent, and iodinated contrast-enhancement of the pleura on CT scan in 2 percent. None of these findings was noted in any patient with a transudate (p<0.001); also none was specific for empyema.

Seven of nine empyemas (78 percent) and ten of 28 exudates (36 percent) were loculated. Excluding transudates, loculated effusions were more often "large" than nonloculated effusions (Table 1). Radiographs demonstrated loculated fluid in 12 of the 17 (70 percent) loculated effusions. Among the radiographic findings of loculation were incomplete layering on decubitus views (seven effusions), scalloped effusion contours (three effusions), and fixed apical fluid (two effusions).

Since decubitus views were not performed with ultrasound, this method cannot be compared to radiographs for sensitivity in exhibiting loculations. However, there were four cases in which ultrasound demonstrated loculations which were not seen on chest radiographs. Specific findings on ultrasound included septations (five effusions), internal pleural echoes (three effusions), and fixed apical fluid (one effusion). Figure 1 shows a sonogram of a large transudate; Figure 2 exemplifies each of several exudates with internal pleural echoes, septations, and abnormal effusion contours, respectively.

CT scans demonstrated loculations not observed on radiograph or ultrasound in only one case. CT scans were useful for differentiating lung abscess from empyema.

**Table 1—Comparison of Loculated and Nonloculated Effusions (excludes Transudates)**

<table>
<thead>
<tr>
<th></th>
<th>Nonloculated</th>
<th>Loculated</th>
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<tbody>
<tr>
<td>No. patients</td>
<td>20</td>
<td>17</td>
</tr>
<tr>
<td>Mean pleural fluid chemistry results</td>
<td></td>
<td></td>
</tr>
<tr>
<td>pH</td>
<td>7.9±0.5*</td>
<td>7.2±0.3†</td>
</tr>
<tr>
<td>protein (mg/dl)</td>
<td>3.7±0.9</td>
<td>4.0±0.9</td>
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<tr>
<td>glucose (mg/dl)</td>
<td>116±30</td>
<td>75±42†</td>
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<tr>
<td>LDH (IU/L)</td>
<td>226±315</td>
<td>1,400±2,060†</td>
</tr>
<tr>
<td>WBC count (per cu mm)</td>
<td>7,560±9,600</td>
<td>12,500±21,000</td>
</tr>
<tr>
<td>% polys</td>
<td>37±24</td>
<td>59±34</td>
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<tr>
<td>Effusion size</td>
<td></td>
<td></td>
</tr>
<tr>
<td>large</td>
<td>2</td>
<td>9†</td>
</tr>
<tr>
<td>moderate</td>
<td>13</td>
<td>7</td>
</tr>
<tr>
<td>small</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>Hospital course</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. hospital days</td>
<td>7±6</td>
<td>14±10†</td>
</tr>
<tr>
<td>response to conservative therapy</td>
<td>18</td>
<td>5‡</td>
</tr>
<tr>
<td>chest tube</td>
<td>2</td>
<td>9†</td>
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<tr>
<td>sclerosis or surgery</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>death</td>
<td>0</td>
<td>3</td>
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</table>

*Mean±SD
†P<0.05 compared with nonloculated effusions
‡P<0.01 compared with nonloculated effusions
§P<0.001 compared with nonloculated effusions

**Figure 1.** Right parasagittal sonogram of a large nonloculated transudate* (*) superior to the right hemidiaphragm (D). Li=Liver.
Pyema and for assessment of chest tube position.\textsuperscript{7-10}
Findings on CT scan included pleural gas in two exudates and two empyemas, cavitation in the lung (five effusions), fixed posterior fluid (three effusions), air-fluid levels (one effusion), and iodinated contrast enhancement of the pleura in one empyema. Figure 3 shows a CT scan of an empyema associated with a cavitating lung abscess.

\textit{Pleural Fluid Chemistry}

Excluding transudates, loculated effusions had lower mean values for pleural fluid pH (p<0.01), and glucose (p<0.01) and higher mean values for LDH (p<0.05) than nonloculated effusions (Table 1). Extreme values for pleural fluid chemistries were not diagnostic for empyema (Table 2). However, loculations were present in most of the effusions with extreme pleural fluid chemistries. All patients with pleural fluid pH below 7.2 (p<0.05), six of seven patients with LDH above 1,000 U/L (p = 0.06), six of seven patients with protein above 5.0 mg/dl (p = 0.06), and all three patients with glucose below 40 mg/dl (p>0.10) had loculated effusions. Only extreme pleural fluid white blood cell counts did not follow this trend, with two patients each having loculated and nonloculated effusions.

\textit{Hospital Course}

Of the exudates and empyemas, the patients with loculated effusions fared worse than patients with nonloculated effusions, with longer hospital stays (p<0.05) and more chest tubes (p<0.05). Only 30 percent of patients with loculated effusions responded to conservative measures, as compared to 90 percent of patients with nonloculated effusions. Also, more patients with loculated effusions died from sepsis or underwent sclerosis and decortication procedures, but these numbers were small.

Overall, chest tubes were placed in 11 patients—seven with empyemas and four with noninfected exudates. Chest tubes were placed in nine of 17 (53 percent) loculated effusions, but in only two of 31 (6 percent) nonloculated effusions (p = 0.01), and these latter two tubes were placed for pneumothoraces. Similarly, for the parapneumonic effusions, significantly more patients with loculated effusions than with
nonloculated effusions underwent tube thoracostomy. The only two empyemas successfully managed without chest tubes were nonloculated. The combination of loculations and infection in the pleural space predicted a poor outcome of conservative therapy. All seven patients with loculated empyema underwent tube thoracostomy; three patients had multiple tubes, and two underwent decortication surgery.

**Criteria of Light et al**

The algorithm of Light et al for tube thoracostomy was applied retrospectively to the patients with parapneumonic effusions in this study. Of the eight patients with parapneumonic effusions who received chest tubes (all had loculated effusions), only six met the criteria of Light et al. Four patients qualified for chest tubes with purulent fluid or positive Gram stain results and two patients qualified with chemical criteria. These six patients had been treated with antibiotics for an average of three days (range: 0 to 9 days) prior to thoracocentesis, while the two patients who did not meet the criteria of Light et al were treated for seven days. Their criteria also predicted need for tube thoracostomy in three additional patients who were successfully managed conservatively.

**Discussion**

In this study, 48 patients with parapneumonic effusions who had undergone sonographically directed thoracocenteses were analyzed for radiologic findings, pleural fluid chemistries, and clinical outcome. The criteria of Light et al for tube thoracostomy were applied retrospectively. Although this select group represents only 20 percent of all thoracocenteses done at these hospitals, their chemical criteria were intended to apply to all patients with parapneumonic effusions.

Despite limited success of previous authors in predicting pleural fluid chemistries from radiologic analysis of the pleural space, we found that certain radiologic findings (loculations, cavitation in the lung, pleural gas by CT scan, or multiple internal pleural echoes by ultrasound) could distinguish exudates from transudates. However, no radiologic finding was specific for empyema. Loculated effusions were more often large in size than nonloculated effusions. Radiographs with decubitus views served as a reasonable initial test for loculations, but loculations were demonstrated only by ultrasound or CT scan in 30 percent of the loculated effusions.

Loculated effusions had lower mean values for pH and glucose and higher values for LDH than nonloculated effusions. Extreme values for pleural fluid chemistries correlated with loculations, but not with empyema. Good et al suggested that loculations form when pleural fluid becomes sufficiently acidic (pH below 7.3), independent of whether the effusion fulfills the criteria for empyema. All five patients in this study with pleural fluid pH below 7.3 had loculated effusions. In the nonloculated group, which included two empyemas, all pH values were above 7.4. Loculations were also present in all effusions with low values for pleural fluid glucose, and in most patients with high values for pleural fluid protein or LDH.

Traditional therapy for empyema, as summarized by the American Thoracic Society, derives from the concept that parapneumonic effusions evolve through three overlapping stages. The exudative stage represents the immediate response of the pleura to adjacent inflammation, with an outpouring of thin pleural fluid of low cellular content. At this point, primary therapy is antimicrobial, and thoracocentesis is an adjunct. In the fibropurulent stage, large quan-
tities of frank pus and fibrin accumulate in the pleural space, leading to progressive loculation. In the organizing stage, fibroblasts grow into the exudate from the pleural surfaces, producing an inelastic “peel” which compresses the lung. Effusions in the exudative stage may be treated with antibiotics and thoracocentesis, whereas the viscous, loculated fluid of the fibrinopurulent stage often requires tube thoracostomy. Organizing effusions may require decortication surgery.

By the above scheme, loculation should be a valuable radiologic marker for the progression of a parapneumonic effusion from the exudative to the fibrinopurulent stage. Our study confirms the prognostic significance of loculation. Patients with loculated effusions fared worse than patients with nonloculated effusions, with significantly longer hospitalization and more frequent tube thoracostomy. The only patients with empyemas managed without chest tubes had nonloculated effusions. The patients with loculated empyemas were the most difficult to manage—all of these patients underwent tube thoracostomy and several required multiple tubes and decortication surgery.

Although Light et al found an excellent correlation between initial pleural chemistries and the need for chest tube drainage, they did not comment on loculation and prior prolonged antibiotic therapy in their algorithm. Loculated effusions were probably infrequent in their series, since decubitus films were done within 72 hours and thoracocentesis was performed only when pleural fluid layered to more than 10 millimeters. In this study, patients with loculated effusions comprised more than one-third of the cases. Often they had been treated with antibiotics for more than one week prior to thoracocentesis. Loculations were present in all parapneumonic effusions that underwent tube thoracostomy. The criteria of Light et al, when applied retrospectively to this group, did not accurately predict the need for tube thoracostomy, probably because these loculated effusions were inhomogeneous or were partially treated by antibiotics. Due to sampling error, a serous loculus with a high glucose or pH might conceal its neighboring purulent loculus with low values. Corser and Baughman found that the determination of pleural fluid pH and LDH were of limited value in patients with parapneumonic effusions.

In conclusion, we found that certain radiologic findings on radiographs, sonograms, and computed tomography scans could be used to differentiate exudates from transudates, but no signs were diagnostic for empyema. Loculation was the most important radiologic sign for diagnostic and therapeutic purposes. Patients with loculated effusions had larger effusions, longer hospitalizations, and more frequent tube thoracostomies than patients with nonloculated effusions. Extreme pleural fluid chemistries correlated with loculations, but not with empyemas. When applied retrospectively to this group of patients, the criteria of Light et al for tube thoracostomy were found to be unreliable, probably because of a majority of loculated or partially-sterilized effusions.

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