**Indwelling Small Pleural Catheter Needle Thoracentesis in the Management of Large Pleural Effusions**

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**Study objectives:** To evaluate the clinical safety, efficacy, and cost of a small indwelling pleural catheter (7F, Turkel Safety Thoracentesis System [Sherwood, Davis, and Geck; St. Louis]) vs repeated needle thoracentesis or closed tube thoracostomy as a means to drain a large-volume pleural effusion.

**Setting:** Inpatients in a tertiary care university teaching hospital in urban Chicago.

**Design:** Prospective, consecutive patient comparative study using historical controls.

**Patients:** Fifty-seven therapeutic aspirations in 23 patients with large pleural effusions as defined by opacification of at least one third of the hemithorax on chest radiography. Patients were excluded if they had a history of thoracic surgery, documented loculations, structural chest abnormalities, severe coagulopathy, or refused to give informed consent.

**Measurements:** Volume of each pleural aspiration, total fluid removed, pleural fluid lactate dehydrogenase, protein, glucose, cytologic analysis, microbiologic stains, and cultures based on clinical indications.

**Results:** We found that initial thoracentesis and repeated pleural drainage using the indwelling catheter system is a safe, efficacious, and cost-effective procedure that may aid the evacuation and management of a large-volume pleural effusion. There were fewer adverse effects and complications such as pneumothorax, splenic laceration, hemopneumothorax, local pain, dry tap, and hematomas, as compared with previous reports. The overall complication rate was 12% (7/57). There were two pneumothoraces detected (3.5%), one of which required closed tube thoracostomy for treatment (1.75%). A further benefit comes in the form of a significant cost savings at our institution ($80 vs $240) when this needle-catheter system is used in place of closed tube thoracostomy in the drainage of a large-volume pleural effusion.

**Conclusion:** An indwelling pleural catheter with the Turkel safety needle-catheter (as described in the study) can be used to successfully drain the pleural space with reduced morbidity and a significant cost saving in comparison to repeated needle thoracenteses or closed tube thoracostomy.

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**Key words:** needle drainage; pleural effusion; pleural fluid; thoracentesis; tube thoracostomy

**Abbreviations:** PA = posteroanterior

Thoracentesis is an important procedure in the evaluation and management of pleural effusions. In many cases, biochemical and/or cytologic analysis can yield or strongly support a definitive diagnosis. Furthermore, drainage of large pleural effusions can improve subjective dyspnea, gas exchange, pulmonary mechanics and, in some cases of significantly elevated intrapleural pressure, can provide immediate hemodynamic stabilization.

The traditional method of thoracentesis entails the insertion of a sterile needle into the pleural space. While usually considered a very safe and effective procedure, needle thoracentesis is associated with a small but significant incidence of morbidity. The usual approach to a large-volume pleural effusion is with needle thoracentesis. However, when persistent or if there is a need to effect complete drainage, closed tube thoracostomy may be required.
Pneumothorax is one of the primary complications of thoracenteses. Despars et al. studied 90 cases of iatrogenic pneumothorax. The most common causes were transthoracic needle aspiration (39%), thoracentesis (33%), subclavian venipuncture (25%), and positive pressure ventilation (0.07%). Furthermore, 72% required therapeutic closed tube thoracostomy. Two patients died; one was associated with a staphylococcal empyema that was believed to be related to the chest tube. COPD is an important risk factor for iatrogenic pneumothorax. In a study by Brandstetter et al., patients with COPD had a 41.7% rate of pneumothorax after thoracentesis compared to 18.5% in those without COPD. Collins and Sahn found a 12% rate of pneumothorax in a series of 74 patients, three of whom required closed tube thoracostomy.

Seneff et al. evaluated 125 patients and found an overall complication rate of 46% with pneumothorax seen in 11% of procedures. Grogan et al. evaluated thoracentesis done in several manners (needle aspiration, needle-catheter system, and with ultrasound guidance). Overall, complications were seen in 46% and pneumothorax occurred in between 20% and 39% using these three methods.

We believe that repeated thoracenteses will lead to increased costs and risk of complications. Doyle et al. reported that the risk of pneumothorax was related to the number of passes made with the thoracentesis needle.

Our objective was to perform thoracentesis in patients with large-volume pleural effusions using a new safety catheter-needle system and to compare complication rates and cost to that of repetitive needle thoracenteses and closed tube thoracostomy. The needle-catheter system was designed to perform thoracentesis in a safer manner compared to traditional needle thoracentesis. Specific safety features of this needle-catheter system include a colored flag, an audible clicking mechanism designed to signal entry into the pleural space, and a spring-loaded blunt tip that extends as the needle passes through the parietal pleura, thus protecting the lung from the sharp needle tip. We hypothesized that this indwelling needle-catheter system could be placed with less morbidity and decrease the cost of draining a large pleural effusion as compared with historical control. In addition, we believed that the small catheter used for drainage would be more comfortable for the patient and would have a higher degree of successful complete drainage of the pleural space in comparison with repeated needle thoracenteses.

Materials and Methods

The protocol used in this study was approved by the Human Investigations Committee and the Institutional Review Board of Rush Presbyterian-St. Luke's Medical Center. Patients were recruited from the inpatient population of Rush Presbyterian-St. Luke's Medical Center, a tertiary care university hospital on Chicago's near west side.

Patients with a large pleural effusion who fulfilled the inclusion and exclusion criteria for study participation were enrolled between July 1, 1994 and June 30, 1995. The inclusion criteria included adult patients (age >18 years) who had a large free-flowing pleural effusion. A large effusion was defined by greater than one third opacification of the hemithorax on posteroanterior (PA) and lateral chest radiographs. Patients were excluded from entry if they had documented loculations, structural chest abnormalities, severe uncontrolled coagulopathy, or refused to give informed consent.

Thoracentesis

The thoracentesis was performed in an identical manner by the same individual (C.J.G.) using a thoracentesis tray (Turkel Safety Thoracentesis Tray; Sherwood, Davis, and Geck; St. Louis [Fig 1]). Prior to the procedure, PA and lateral chest radiographs were performed to establish the presence of a freely flowing pleural effusion. The patients were placed in the sitting position and allowed to drap their arms on a bedside table. In two patients, the procedure was performed in the lateral decubitus position because of physical limitations. Physical examination was used to determine the site for needle insertion. The skin was prepared with povidone-iodine (Betadine) solution and drape in a sterile fashion. Local anesthesia was accomplished with 1% lidocaine (1 to 5 mL) to the skin, subcutaneous tissue, bony peristemeum, and parietal pleura. After satisfactory local anesthesia was confirmed, the safety needle-catheter system was assembled: the protective sheath was removed and the needle-catheter system was connected via a three-way stopcock to drainage tubing and the collection bag to assure a closed system.

A small "cross"-shaped stab incision was made in the skin with the point of a No. 11 scalpel blade. With the stopcock in the "off"
position with regard to the patient, the blunt tip of the safety needle was then placed through the stab wound and carefully advanced. The initial goal was contact of the needle tip with the superior margin of the lower rib. The needle-catheter system was then aimed slightly cephalad, just superior to the upper edge of the inferior rib and advanced until entry into the pleural space. Penetration of the parietal pleura and entry into the pleural space was indicated by a change of the “flag” color from “red” to “green” and the “popping” sound of the spring-loaded valve system. One to 3 mL of fluid was aspirated to confirm that the tip of the needle was in the pleural fluid. The catheter was advanced slowly over the needle as the needle was carefully withdrawn. The catheter was advanced until the hub was flush with the chest wall. The syringe was then removed from the needle and placed on the open port of the stopcock. The stopcock was then opened and fluid was allowed to drain into the tubing/collection bag to an arbitrarily set maximum of 1,000 mL/d. If drainage was slow, fluid could be drained manually using the attached syringe. If persistent fluid was present after the drainage procedure, the catheter was secured in place and a dressing applied for continued intermittent drainage.

Subsequent drainage of the persistent pleural fluid was accomplished using the indwelling catheter system. If an additional liter of fluid was collected, drainage was stopped and continued evacuation was addressed the next morning. If <1 L was collected, a chest radiograph was done to assess the presence of residual pleural fluid. If the pleural space was dry, the catheter was subsequently removed. Postprocedure chest radiographs were performed to assess drainage and to identify the presence of complications such as pneumothorax.

Fluid Analysis

Pleural fluid was sent for routine chemistry analysis (lactate dehydrogenase and protein) to determine if it was a transudate or an exudate according to the criteria of Light. Additional studies were performed as clinically indicated (e.g., pH, cytology, Gram and acid-fast stain and culture).

Parameters Followed

A record was kept of complications (pneumothorax, bleeding, infection, pain, hematoma development, splenic laceration, cardiac arrhythmia, and need for closed tube thoracostomy), the number of aspirations for each patient and total for the group, the total volume of fluid removed in each patient, the number of days the catheter remained in the pleural space, patient complaints, and the ability to perform complete drainage of the pleural space.

RESULTS

A total of 23 patients were studied with a mean age of 57.7 years (range, 40 to 96 years). Comorbidities included the following: renal failure (two); congestive heart failure (five); respiratory failure (two); hypertension (three); end-stage liver disease (two); diabetes mellitus (three); sepsis (two, bacterial, fungal); cancer (six, lung, colon, breast, Kaposi’s sarcoma, renal cell, and non-Hodgkins lymphoma); inflammatory processes (postpericardiotomy syndrome, pancreatitis); AIDS; Budd-Chiari syndrome; chest trauma; and anemia. Of the 23 patients, 8 had transudative effusions and 15 patients had an exudative effusion. Table 1 summarizes the study population and the thoracentesis results.

The average number of aspirations required to drain the pleural space was 2.5 (a total of 57 aspiration procedures). The catheter was left in place for a mean of 3.0 days with removal of an average of 1.70 L per patient. One would expect that if the average number of days the catheter was present was 2.5, with the goal to remove 1 L/d, the total average of fluid removed should be close to 2.6 L. This discrepancy results from the presence of <1 L of fluid in the pleural space at the time of the final aspiration or because fluid continued to accumulate while a final chest radiograph was obtained but prior to catheter removal. In the latter group, aspiration of even this small residual fluid was deemed advantageous to the patient. Of the 23 subjects, 17 reported resolution of dyspnea during or soon after complete drainage of the pleural space; additionally, one patient reported increased ambulatory capacity.

The overall complication rate was 7 of 57 (12%). The incidence of major complications was 3.5% and reflects two patients who developed a pneumothorax. One of these patients (1.75%) required closed tube thoracostomy placement for management, whereas the other was treated by air aspiration using the indwelling pleural catheter. There was no detected empyema, hemothorax, splenic laceration, shearing of the catheter tip, cardiac arrhythmias, need for thoracotomy, or death related to the drainage thoracentesis procedure.

Minor complications occurred in 5 of 57 (8.7%) and were as follows. One (1.75%) patient complained of local pleuritic chest pain for the time the drainage catheter was in place. Two patients (3.5%) noted mild discomfort on placement of the pleural catheter. One (1.75%) patient complained of pain on instillation of lidocaine; a dry tap occurred on one (1.75%) occasion. A second procedure was necessitated in four patients owing to subsequent discovery of a loculated pleural effusion (two patients), clotting of the catheter (one patient), and a dry tap (one patient). There were no occurrences of subcutaneous hematoma or seroma, persistent cough, or inadequate fluid yield. A summary of the overall, minor, and major complications and a comparison with historical reports of complications encountered with both diagnostic and therapeutic thoracentesis are presented in Figures 2 to 4.

At our institution, the cost of this catheter and insertion kit is approximately $80. The cost of a single-use thoracentesis kit is also $80 while the cost associated with the insertion of a closed tube thoracostomy is $284. The cost of a daily chest radiograph is an additional charge. Although use of a simple needle and syringe would be much cheaper, prob-
<table>
<thead>
<tr>
<th>Patient No.</th>
<th>Days</th>
<th>Serial Aspirated Volumes, L</th>
<th>Total Volume Aspirated, L</th>
<th>Complications</th>
<th>Transudate/Exudate</th>
<th>Comorbidities</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4</td>
<td>1/1/2</td>
<td>2.2</td>
<td>None</td>
<td>Exudate</td>
<td>Renal failure, quadriplegia, respiratory failure, staghorn renal calculi, urosepsis, hypothermia</td>
</tr>
<tr>
<td>2</td>
<td>3</td>
<td>1/0.8</td>
<td>1.8</td>
<td>None</td>
<td>Transudate</td>
<td>CAD and CAGB, AF, CHF, NIDDM, HTN, cholecystectomy</td>
</tr>
<tr>
<td>3</td>
<td>5</td>
<td>0.8/0.5/0.25/0.165/0.21</td>
<td>1.925</td>
<td>Local erythema</td>
<td>Exudate</td>
<td>Colon cancer with liver metastases</td>
</tr>
<tr>
<td>4</td>
<td>2</td>
<td>0.9</td>
<td>0.9</td>
<td>None</td>
<td>Transudate</td>
<td>IBD, CAD, arthritis, CHF</td>
</tr>
<tr>
<td>5</td>
<td>3</td>
<td>0.5/0.3</td>
<td>0.8</td>
<td>Slight discomfort when lying on catheter</td>
<td>Exudate</td>
<td>Non-Hodgkin’s lymphoma</td>
</tr>
<tr>
<td>6</td>
<td>3</td>
<td>1/0.02</td>
<td>1.02</td>
<td>Catheter kinked, would not draw necessitating removal</td>
<td>Exudate</td>
<td>CHF, renal insufficiency, anemia, DM, MVR, PUD, RVD, AF</td>
</tr>
<tr>
<td>7</td>
<td>3</td>
<td>1/0.2</td>
<td>1.2</td>
<td>Pleuritic pain</td>
<td>Exudate</td>
<td>Lung cancer, HTN</td>
</tr>
<tr>
<td>8</td>
<td>5</td>
<td>1/0.5/0.4/0.425/0.5</td>
<td>2.825</td>
<td>None</td>
<td>Transudate</td>
<td>CHF, colon cancer</td>
</tr>
<tr>
<td>9</td>
<td>3</td>
<td>0.5/0.15/0.05</td>
<td>0.7</td>
<td>None</td>
<td>Exudate</td>
<td>Postpericardiotomy syndrome, CAD</td>
</tr>
<tr>
<td>10</td>
<td>2</td>
<td>1.0</td>
<td>1.0</td>
<td>None</td>
<td>Exudate</td>
<td>CHF, CAD, dyspnea</td>
</tr>
<tr>
<td>11</td>
<td>2</td>
<td>1.0</td>
<td>1.0</td>
<td>Difficulty lying on the back</td>
<td>Transudate</td>
<td>Cirrhosis</td>
</tr>
<tr>
<td>12</td>
<td>5</td>
<td>0.99/0.25/0.27/0.3</td>
<td>1.81</td>
<td>None</td>
<td>Transudate</td>
<td>None</td>
</tr>
<tr>
<td>13</td>
<td>2</td>
<td>1.0</td>
<td>1.0</td>
<td>None</td>
<td>Exudate</td>
<td>Hypoalbuminemia, pancreatitis, chyoidal hernatoma, fungemia, fungal elements in ascites fluid</td>
</tr>
<tr>
<td>14</td>
<td>2</td>
<td>0.750/0.25</td>
<td>1.0</td>
<td>None</td>
<td>Exudate</td>
<td>Lung cancer</td>
</tr>
<tr>
<td>15</td>
<td>4</td>
<td>1/0.1^1</td>
<td>1.1</td>
<td>Pneumothorax treated by air aspiration via same catheter</td>
<td>Transudate</td>
<td>HIV+, KS</td>
</tr>
<tr>
<td>16</td>
<td>3</td>
<td>1.2/1.1/1.2</td>
<td>3.5</td>
<td>None</td>
<td>Transudate</td>
<td>ESLD</td>
</tr>
<tr>
<td>17^</td>
<td>2</td>
<td>1.1/0.65</td>
<td>1.75</td>
<td>Slight pain on insertion of tube, loculation precluded full drainage, pneumothorax required chest tube</td>
<td>Exudate</td>
<td>CHF, arthritis</td>
</tr>
<tr>
<td>18</td>
<td>3</td>
<td>1.2/1.3/1.35</td>
<td>3.85</td>
<td>Pain on instillation of lidocaine, very histronic at the time</td>
<td>Exudate</td>
<td>Hepatic hydrothorax, Budd-Chiari syndrome</td>
</tr>
<tr>
<td>19</td>
<td>2</td>
<td>0.85/1.1</td>
<td>1.95</td>
<td>Pain on instillation of lidocaine; tube malfunction, needed to be replaced to adequately drain on day no. 2</td>
<td>Exudate</td>
<td>RCC metastatic to pleura/lung</td>
</tr>
<tr>
<td>20</td>
<td>3</td>
<td>1/0.275/.250</td>
<td>1.525</td>
<td>Slight pain on insertion; removed for impending cardioversion procedure</td>
<td>Transudate</td>
<td>CHF, MVR, AF, breast cancer, bradycardia</td>
</tr>
<tr>
<td>21</td>
<td>3</td>
<td>1/0.1.1/1.125</td>
<td>2.225</td>
<td>Tube clot after first night, then removed and replaced for days 2 and 3</td>
<td>Exudate</td>
<td>DM, CHF, diabetic retinopathy, LE occlusive disease</td>
</tr>
<tr>
<td>22</td>
<td>3</td>
<td>1/0.5/1.1</td>
<td>2.22</td>
<td>Flow stopped spontaneously at end of second aspiration</td>
<td>Exudate</td>
<td>Status post chest trauma with rib fracture, bronchitis</td>
</tr>
<tr>
<td>23^</td>
<td>1</td>
<td>1/2.0.4/0.075</td>
<td>1.675</td>
<td>Dry tap on first attempt with mild discomfort, second attempt successful without complication</td>
<td>Exudate</td>
<td>DM, anemia, VF/AICD with pocket infection, DVT, HTN, AF, CVA</td>
</tr>
</tbody>
</table>

Average 2.91 2.47 aspirations per patient

Footnotes:
- CAD = coronary artery disease; CAGB = coronary artery bypass graft; CHF = congestive heart failure; IBD = inflammatory bowel disease; AF = atrial fibrillation; DM = diabetes mellitus; NIDDM = noninsulin-dependent diabetes mellitus; HTN = hypertension; MVR = mitral valve replacement; PUD = peptic ulcer disease; RVD = right ventricular dysfuction; HIV+ = HIV infection; KS = Kaposi’s sarcoma; ESLD = end-stage liver disease; RCC = renal cell carcinoma; LE = lower extremity; VF/AICD = ventricular fibrillation/automatic implantable cardioverter defibrillator; DVT = deep venous thrombosis; CVA = cerebrovascular accident.

^Malignant effusion.
^Pneumothorax treated with aspiration of 180 mL of air via pleural catheter with full reexpansion of the lung. The catheter remained in place for an additional 3 days to ensure that the lung remained reinflated and then it was removed without further complication.
^It was discovered that there was a large loculated effusion not drained after removal of 1.75 L of fluid. Loculated effusion, upon retapping, caused iatrogenic pneumothorax requiring tube thoracostomy.
^Tube clotted overnight, required removal and replacement of a new catheter with subsequent full evacuation of the effusion; tube removal and replacement accomplished without morbidty.
lems, including the presence of the needle in the pleural space, need for continued separation of the syringe from the needle for drainage, difficulty assuring full evacuation of the pleural space, and lack of built-in drainage tubing can lead to clinical risk and cost that outweigh the cost and safety benefits of the needle-catheter system.

If the same number of thoracenteses had been carried out using a single-use thoracentesis kit for each aspiration, patients would have undergone 57 procedures as opposed to 27 using the Turkel Safety needle-catheter system. This would increase the chances for complications and translate into a cost savings of $2400 (30 procedures × $80). If a closed-
tube thoracostomy had been used for the same number of days as there were individual aspirations, the total cost would be approximately $284 (plus the cost of a daily portable chest radiograph) as compared with $80 for the Turkel Safety needle-catheter system (plus one to two chest radiographs per patient). In addition, a significant investment of time is required on the part of the medical and nursing staff for care of the apparatus.

Although not specifically tested as part of this trial, the use of this needle-catheter system could have allowed for multiple aspiration procedures throughout the day to effect more rapid clearance of the effusion while still protecting the patient from developing reexpansion pulmonary edema. In addition, the needle-catheter system could be used in outpatient management to effect even greater cost savings in comparison with inpatient care.

**DISCUSSION**

The goal of this study was to assess the efficacy of complete drainage of a large pleural effusion, the complication rate as compared with historical data, and the cost savings of allowing a small catheter to remain in place for serial taps until the pleural space is dry. We found that initial thoracentesis and repeated pleural drainage using an indwelling catheter system is a safe and cost-effective procedure that may aid the evacuation and management of a large pleural effusion.

Seneff et al. evaluated 125 thoracentesis procedures in 91 patients with pleural effusion. The overall complication rate was 58 of 125 (46%). Major complications included pneumothorax in 14 of 125 (11%) of which 3 of 125 (2.4%) required tube thoracostomy for management. One patient died precipitously. Splenic laceration occurred in 1 of 125 (0.8%), shearing of the catheter tip (requiring thoracotomy for removal) occurred in 1 of 125 (0.8%), and delayed discovery of a hemopneumothorax occurred in 1 of 125 (0.8%). Minor complications included pain in 28 of 125 (22%), cough in 14 of 125 (11%), dry tap in 16 of 125 (13%), development of a subcutaneous hematoma in 3 of 125 (2.4%), and seroma in 1 of 125 (0.8%).

Grogan et al. evaluated thoracentesis performed with a needle-catheter system (14-gauge needle through a 16-gauge catheter) in comparison with the traditional needle (20-gauge) procedure. Patients qualified for the study if a pleural effusion was demonstrated on PA chest radiograph that obliterated more than half of the hemidiaphragm and was freely flowing on a lateral decubitus radiograph. In 52 patients, 46% of the procedures were associated with at least one complication. Using their needle-catheter system pneumothorax occurred in 7 of 18 (39%) patients. Two of these patients required closed tube thoracostomy for management of uncomplicated large pneumothoraces. Minor complications occurred in 11 of 18 (61%) patients and included pain in 7 of 18 (38%), dry taps in 2 of 18
tion, the safety features of the needle-catheter system reduce the rate of complications. Situations in which single use may be attractive are the acute relief of dyspnea or chest pain, diagnostic thoracentesis in an undiagnosed pleural effusion (in the hospital or in the outpatient setting), serial aspirations for the purpose of microbiologic or cytologic study, and complete drainage of a small pleural effusion. Situations in which the catheter may be left indwelling include large pleural effusion (>1 L), persistent accumulation of pleural fluid (eg, hepatic hydrothorax, pancreatitis, nephrotic syndrome), or to facilitate pleurodesis.

This catheter may be useful in either the inpatient or outpatient setting. In the hospital, the catheter has important potential use in both the ICU and on the general medical floor. In the ICU, this catheter offers an additional option in the approach to pleural effusion for patients receiving mechanical ventilation. Positioning may be difficult in these patients and risk of pneumothorax carries the necessity for placement of a closed-tube thoracostomy. In our experience, aspiration of fluid with this apparatus was carried out without complication. Another potential use for this needle-catheter system is in the treatment of pneumothorax via air aspiration. This procedure was successfully performed in patient 15.

Another use of the needle-catheter drainage technique also has potential advantage in the outpatient setting, thus providing an even greater cost savings. Potential outpatient uses of this catheter include drainage of a malignant pleural effusion prior to pleurodesis, treatment of a persistent pleural effusion from cirrhosis, congestive heart failure, pancreatitis, or nephrotic syndrome, serial sampling of pleural fluid for cytologic analysis or culture in the appropriate clinical settings, and outpatient management of large pleural effusions.

Use of an indwelling catheter placed via the needle-catheter system (Turkel Safety) is an effective strategy for draining the pleural space with reduced morbidity and offers the potential for a significant cost savings over more traditional methods. The needle-catheter design offers safety features that minimize the potential for pneumothorax in comparison with single-needle thoracocentesis. A large prospective trial that compares this needle-catheter system to standard needle thoracocentesis is required to confirm our pilot observations. As the practice of medicine becomes more outpatient based, this method of pleural fluid management offers a potential for reduced cost and increased patient comfort compared to repeated thoracocentesis procedures or closed tube thoracostomy. Direct comparisons of these two strategies is not possible from these data. A questionnaire concerning patient tolerance of the
indwelling pleural catheter was not included in this study. However, patients were not rendered immobile, had fewer complaints of pain, did not have long-lasting discomfort or a scar, and had minimal pleural irritation. We believe that the procedure described in this study has potential advantages over serial needle thoracentesis procedures and closed tube thoracostomy and is likely to have reduced morbidity, increased patient comfort, and reduced cost.

REFERENCES
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