The Relationship of Pleural Pressure to Symptom Development During Therapeutic Thoracentesis*

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Study objective: **To describe the relationship of patients' symptoms during therapeutic thoracentesis to pleural pressure (Ppl).**
Design: **Review of prospectively collected data during 169 therapeutic thoracentesis procedures.**
Setting: **University Hospital in Boston, MA.**
Patients and methods: **One hundred sixty-nine patients who had Ppl measured during therapeutic thoracentesis were included in this study. End-expiratory pressures were measured after the withdrawal of 5 mL of fluid and every 240 mL thereafter until the pressure was lower than −20 cm H_2O, chest discomfort developed in the patient, or no more fluid could be removed. Patients' symptoms, including chest pain, chest discomfort, and cough were recorded simultaneously.**
Results: **There was no correlation between the amount of pleural fluid removed and the development of symptoms. The closing pressures and the total change in Ppl (see the "Materials and Methods" section for definitions), however, were significantly lower in the group of patients who experienced chest discomfort compared to patients who developed cough or were asymptomatic. There was also a trend toward a significantly lower pleural elastance in patients who developed cough compared to that in the other two groups. Additionally, only 22% of patients in whom chest discomfort developed, and 8.6% of patients in whom symptoms did not develop, had potentially dangerous Ppl values (*ie*, lower than −20 cm H_2O).**
Conclusions: **The development of chest discomfort is associated with a potentially unsafe drop in Ppl values and should be a sign to terminate thoracentesis. It is not necessary to terminate thoracentesis solely because of the development of cough. Without attention to pleural manometry, a significant percentage of patients may develop potentially dangerous Ppl. Although we recommend pleural manometry with all thoracenteses, when it is not used attention to symptoms remains a valuable surrogate.** ***(CHEST 2006; 129:1556–1560)***

Key words: manometry; physiology; pleural; pleural effusion; pressure; symptoms; thoracentesis

Abbreviations: Pel = pleural space elastance; Ppl = pleural pressure

The monitoring of pleural pressure (Ppl) during thoracentesis not only provides a better understanding of the real-time physiology of the pleural space, but also helps to prevent pressure-related complications such as reexpansion pulmonary edema,[1,2] to predict improvement in FVC,[3] and to predict the success of pleurodesis.[4] Despite this evidence, most thoracenteses are still performed at the bedside without attention to the Ppl. Thoracenteses are often terminated prior to the removal of maximal volumes of pleural fluid due to a concern for removing large volumes and inducing reexpansion edema, or for the development of symptoms such as cough or chest pain. The termination of thoracentesis prior to the removal of maximal volumes of fluid may result in incomplete symptom improvement,[3] multiple procedures, or inadequate

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postprocedural imaging. Most studies of pleural manometry have stopped thoracentesis for Ppl values lower than −20 cm H_2O or for symptoms such as cough or chest pain.[1–3] The value of −20 cm H_2O was arbitrarily chosen by Light et al[1] based on prior animal studies[5,6] demonstrating minimal pulmonary edema with Ppl values of −20 mm Hg (approximately 27 cm H_2O) but significant pulmonary edema with pressures of −40 mm Hg (approximately 54 cm H_2O). Light et al[1] have noted that, at times, significant changes in Ppl were associated with "chest tightness," although this relationship was not quantified. It is unknown whether the development of symptoms during thoracentesis correlate with Ppl values and represent a meaningful signal to stop the procedure.

The purpose of this study was to determine whether symptoms that are recorded during thoracentesis relate to changes in Ppl. We hypothesize that the symptom of cough is not related to "unsafe" changes in Ppl values (*ie*, −20 cm H_2O or lower) and likely represents a benign resolution of atelectasis during the removal of pleural fluid. Furthermore, we hypothesize, as Light et al[1] have observed, that chest tightness correlates with the development of lung entrapment or trapped lung and should be used as a signal to terminate thoracentesis.

Materials and Methods

Data were collected prospectively during thoracenteses performed by the Division of Interventional Pulmonology at Beth Israel Deaconess Medical Center from September 9, 2002, to December 2004. The 169 patients who underwent pleural manometry were included in this study. The study protocol was approved by our internal review board.

Thoracentesis was performed using a kit (Pleura-Seal thoracentesis kit; Arrow-Clark; Reading, PA), and Ppl values were recorded as previously described.[7] Ppl measurements were made with both a simple water manometer, as well as an electronic transducer system (Biobench; National Instruments; Austin, TX). Doelken et al[7] have found a strong correlation between these two methods ($r = 0.97$; $p < 0.0001$).

End-expiratory Ppl values were recorded after the withdrawal of 5 mL of fluid (opening pressure), and every 240 mL thereafter until there was no more fluid present, chest discomfort developed in the patient, or the Ppl was lower than −20 cm H_2O (closing pressure). If drainage ceased, an attempt at obtaining a final closing Ppl was made. This requires the presence of a fluid column, and if there is actually no more pleural fluid and this final pressure could not be recorded, the last recorded pressure was used as the closing pressure. If lung entrapment or trapped lung were suspected, serial pressure measurements were made after the removal of 50 to 100 mL of fluid. We differentiated between two distinct descriptors of chest discomfort. One, described as "sharp" and occurring over the ipsilateral shoulder/scapula, and the other, a more vague and typically anterior discomfort. As we postulated that the sharp pain could be due to diaphragmatic irritation from the catheter, and the more vague anterior discomfort from lung entrapment or trapped lung, if the patient developed the sharp pain, an attempt at repositioning the catheter was made and additional fluid was removed. If the pain continued, the procedure was terminated. For patients with the vague chest discomfort, a closing Ppl was recorded and the procedure was terminated.

Pleural elastance (Pel) was calculated as the change in pressure (opening to closing) divided by the volume of fluid removed. All procedures were performed using ultrasound guidance (SonoSite 180 plus; SonoSite Inc; Bothell, WA). Statistical analysis was performed using a statistical software package (JMP, version 3.1.5; SAS Institute; Cary, NC). Differences between multiple groups were calculated using analysis of variance and subsequent Tukey-Kramer honestly significant differences for unequal groups ($p < 0.05$).

Results

The baseline characteristics of the patients included in the study can be seen in Table 1. No significant differences were present for age, gender, or side of the effusion for patients in whom symptoms developed compared to those in whom they did not develop. The diagnoses made by thoracentesis are seen in Table 2, and, again, there were no differences between the patients in whom symptoms developed and those in whom they did not.

Symptoms

Symptoms developed in 29 of the 169 patients (17%) during thoracentesis (cough, 11 patients [6%]; chest tightness, 18 patients [11%]). The total volume of fluid removed and the opening Ppl values were not significantly different among the asymptomatic patients, the patients with cough, and the patients with chest discomfort (Table 3).

Closing Ppl values, however, were significantly lower in the group of patients who experienced chest discomfort compared to the group of patients who did not have symptoms. There was no difference in closing pressures in the patients in whom cough developed compared to those who had chest tightness or in whom symptoms did not develop (Table 3).

The total change in Ppl during thoracentesis was significantly different between the patients who developed chest discomfort and both the patients who

Table 1—*Baseline Characteristics of Patients

Characteristics	Values
Male gender	83/169 (49%)
Mean age, yr	66 ± 17
Left side	82/158 (52%)
Housestaff-operator	46%
Mean volume removed	1.3 ± 0.88 L
Range of fluid volume removed	50 mL to 6.5 L

*No significance differences between symptom groups existed for the data.