Abstract

Background: Occult pneumothoraces (OPTXs) are seen on abdominal computed tomographic (CT) scans but not on routine chest x-ray films. Optimal treatment for blunt trauma OPTXs has not been defined. We hypothesized that OPTXs could be safely observed without need for a chest tube (CT).

Methods: A prospective trial randomized blunt trauma patients with OPTXs to CT scan or observation. Patients were not excluded for positive pressure ventilation. Primary outcome measures were respiratory distress and pneumothoraces progression.

Results: Thirty-nine patients with 44 pneumothoraces were enrolled. Eighteen patients received a CT scan, and 21 patients were observed. Nine patients in each group received positive pressure ventilation. There was no difference in overall complication rate. No patient had respiratory distress related to the OPTX or required emergent CT scan.

Conclusions: Observation of OPTX is not associated with an increased incidence of pneumothorax progression or respiratory distress. These pneumothoraces can be safely observed in patients with blunt trauma injury regardless of the need for positive pressure ventilation.

The use of abdominal computed tomographic (CT) scan in the evaluation of blunt abdominal trauma led to the recognition of occult pneumothoraces, seen on CT scan but not on a supine AP chest radiograph. They occur in 2 to 12% of all patients with blunt trauma injury to the abdomen who undergo both chest x-ray film (CXR) and abdominal and/or thoracic CT scan. [1-5] As the number of patients undergoing nonoperative management of blunt solid organ injuries increases, the number of recognized or diagnosed occult pneumothoraces is also increasing. The necessity of tube thoracostomy for occult pneumothoraces is still debated. In a retrospective study, occult pneumothorax size was correlated with placement of a tube thoracostomy, and tube thoracostomy was suggested for all pneumothoraces 5 x 80 mm. [4] Enderson et al. prospectively documented that positive pressure ventilation was correlated with progression of occult pneumothoraces and recommended all occult pneumothoraces in patients requiring positive pressure ventilation be treated with tube thoracostomy. [6]
Tube thoracostomy is associated with several complications that are directly related to the tube, including pain, improper tube positioning, and postremoval complications. In addition, there are several other complications related to the underlying injury that may be exacerbated by tube placement, such as empyema, undrained hemothorax or pneumothorax, and length of stay. Some of these may also be present in an untreated hemothorax or pneumothorax. The overall complication rate related to tube thoracostomy may be as high as 21%. [7] With this potential for increased complications secondary to tube thoracostomy, we undertook a prospective, randomized trial to determine whether tube thoracostomy was necessary in patients with occult pneumothoraces regardless of size and requirement for positive pressure ventilation.

MATERIALS AND METHODS

All blunt trauma patients more than 18 years old admitted to St. Paul-Ramsey Medical Center, St. Paul, Minn, from January 1, 1995, to December 31, 1997 or to St. John's Regional Health Center, Springfield, Mo, from September 20, 1996, to December 31, 1997, having an occult pneumothorax were eligible for this study. An occult pneumothorax was defined as a pneumothorax seen on abdominal CT scan but not on an anteroposterior CXR as read by the trauma chief resident or attending staff member. The supine anteroposterior CXR was taken during the initial resuscitation of the trauma patient and the abdominal CT scan during the initial evaluation. Helical CT scans were performed on GE HiSpeed Advantage scanners. All abdominal CT scans obtained for trauma included 10-mm cuts through both the abdomen and pelvis with lung windows at the lung bases. A predose of intravenous contrast (Isovue, Optiray, or Renografin) was given before the scout film, and the remaining contrast given as a bolus immediately before axial imaging. Intravenous contrast was used for all; the use of oral contrast was variable. The abdominal CT scan was interpreted by the trauma chief or fellow with the in-house attending trauma staff. All chest tubes were 36 French, placed without the use of a trocar.

After consent was obtained from patient or relative, patients were randomized within 6 hours of admission to receive a chest tube (group 1) or observation (group 2). Patients with bilateral occult pneumothoraces were randomized by patient, with both pneumothoraces receiving the same treatment. Patients were not excluded for positive pressure ventilation or operative intervention. Patients in group 2 had labels placed on their chart identifying participation in the study and side of the pneumothorax and a sign placed above their bed. Chest tubes were placed in group 2 patients for progression of pneumothorax or respiratory distress. Once placed in either group, chest tubes were managed by the treating physician. Labels were not placed for patients not entered in the study.

All trauma patients with pneumothoraces from blunt trauma were identified by the trauma registries at both institutions. These charts were reviewed to identify all patients with occult pneumothoraces not entered in the study. These patients were compared with the study population, and reasons for exclusion were examined. CT scans of patients entered and not entered in the study were retrospectively reviewed, and pneumothorax size was measured according to Garramone et al. [4]

Primary outcome measures were respiratory distress and pneumothorax (PTX) progression. Pneumonia, retained hemothorax, and placement of CT(s) in group 2 were also tracked. Age, Glasgow Coma Scale score, Injury Severity Score, mechanism of injury, pneumothorax size, length of stay, and ventilator days were compared. Power calculations were based on overall complication rate and length of stay.

Data were analyzed with Student's t test and z test for proportions. The protocol was approved by the Institutional Review Boards at both institutions.

RESULTS
During the study period, 5,126 adult patients with blunt trauma were admitted to the two institutions. Abdominal CT scans were obtained in 1,669 patients. Eighty-six patients with 98 occult pneumothoraces were identified for an incidence of 5.9%. Thirty-nine patients with 44 PTXs were enrolled in this study. Eighteen patients received 20 CT scans for PTXs in group 1, and 21 patients with 24 PTXs were observed in group 2. Four patients (two in each group) had occult pneumothoraces read by the trauma service, but the official radiology report revealed a pneumothorax on the initial CXR. Increased anxiety on the part of nursing staff, physician staff, patient, or family as a result of chart and bedside labeling was not noticed during the study.

Fifty-three pneumothoraces in 47 patients were found on retrospective review. Reasons for exclusion from the study were clear in 31 patients, and included physician judgment, patient or next of kin refusal, diagnosis not made until more than or equal to 6 hours after admission, patient enrolled but not randomized, and participation in another study. For 16 patients, the reason for exclusion was not obvious.

Age, Glasgow Coma Scale score, Injury Severity Score, mechanism of injury, and pneumothorax size were not statistically different (Table 1). Nine patients in each treatment group required positive pressure ventilation. Three in each group required ventilation only for an operative procedure, and six required ventilation for more than or equal to 1 day. There was no difference in the number of ventilator days between groups (Table 2).

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Group 1</th>
<th>Group 2</th>
<th>Nonentered</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patients</td>
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<td>47</td>
</tr>
<tr>
<td>Pneumothoraces</td>
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<td>24</td>
<td>53</td>
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<tr>
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<td>0</td>
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<tr>
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<td>&lt;5 × 80 mm</td>
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<td>7</td>
<td>15</td>
</tr>
<tr>
<td>5 × 80 mm</td>
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<tr>
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<td>1</td>
<td>4</td>
<td>6</td>
</tr>
</tbody>
</table>

* Group 1, chest tube placed; group 2, observation; nonentered, patients with occult pneumothoraces not enrolled in study.

Table 1. Demographic comparison of study groups*
Table 2. Ventilator days and lengths of stay

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Group 1</th>
<th>Group 2</th>
<th>Nonentered</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of patients</td>
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<td>47</td>
</tr>
<tr>
<td>Any positive pressure ventilation</td>
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<td>9</td>
<td>17</td>
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<tr>
<td>(n)</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Ventilator only for operating room</td>
<td>3</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>(n)</td>
<td></td>
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</tr>
<tr>
<td>Ventilator days (median, range)b</td>
<td>1 (1–19)</td>
<td>2 (1–4)</td>
<td>1 (1–29)</td>
</tr>
<tr>
<td>Length of stay (median, range)</td>
<td>8 (3–23)</td>
<td>5 (1–30)</td>
<td>6 (1–55)</td>
</tr>
<tr>
<td>ICU length of stay (median, range)c</td>
<td>1 (0–19)</td>
<td>1 (0–9)</td>
<td>2 (0–32)</td>
</tr>
</tbody>
</table>

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*a* Group 1, chest tube placed; group 2, observation; nonentered, patients with occult pneumothoraces not enrolled in study.

*b* For patients receiving positive pressure ventilation postoperatively in the intensive care unit.

*c* Median reported only for patients with ICU stay.

One patient in group 1 developed stridor and required intubation. Three patients in group 2 developed respiratory distress without PTX progression. Two patients were treated with pulmonary toilet and supplemental oxygen with subsequent improvement, and one patient undergoing nonoperative management of a splenic injury was taken to the operating room for splenectomy. No patient had respiratory distress related to the occult pneumothorax or required emergent tube thoracostomy. Four patients with PTX progression in group 1 had thoracostomy tubes returned to suction. Three of these patients were on positive pressure ventilation. Three patients in group 2 had PTX progression, two on positive pressure ventilation. One patient with progression in group 2 not on positive pressure ventilation was treated with continued observation. Both patients on positive pressure ventilation with pneumothorax progression received chest tubes. Nonprotocol tube thoracostomies were placed in group 2 patients for retained hemothorax, increasing pleural effusion, after a transpleural spinal approach, and asymptomatic PTX progression. [2] Pneumothorax progression was found in 10 patients not entered in the study. Half were treated with chest tubes; three of these cases were for asymptomatic progression. One chest tube was placed for pneumothorax progression associated with increased peak pressures and decreased tidal volumes that developed over 24 to 36 hours. One patient developed increasing respiratory distress despite previous placement of a chest tube.

Chest tubes remained in place for a median of 3 days (range, 1-12 days). The only complications directly referable to chest tube placement were pneumothorax progression with chest tube in place.

There was no difference between groups in length of stay, intensive care unit length of stay, or overall complication rate (Table 2 and Table 3). Two patients in group 1 developed pneumonia; one patient in group 2 developed a retained hemothorax, which required a tube thoracostomy for drainage. Other complications included respiratory distress and pneumothorax progression discussed above.
The majority of patients with pneumothorax progression had larger pneumothoraces (Table 4). However, the likelihood of progression for these occult pneumothoraces 5 × 80 mm is not statistically different than for small pneumothoraces. Similarly, the likelihood of progression for patients on positive pressure ventilation is not statistically different than for those not on positive pressure ventilation.

### DISCUSSION

The majority of patients with pneumothorax progression had larger pneumothoraces (Table 4). However, the likelihood of progression for these occult pneumothoraces 5 × 80 mm is not statistically different than for small pneumothoraces. Similarly, the likelihood of progression for patients on positive pressure ventilation is not statistically different than for those not on positive pressure ventilation.
The 5.9% incidence of occult pneumothorax encompasses both prospectively enrolled patients and those identified by retrospective review, so it is likely that this value represents a true incidence in this patient population. This incidence is within the range of 2 to 12% reported by others. [1-5] There is no question that increased use of abdominal CT scan in the nonoperative management of solid organ injury will identify more thoracic injuries not visualized on initial chest radiograph, of which occult pneumothoraces represent only one injury. Rhea et al. found 24% of all patients with blunt trauma injuries evaluated with abdominal CT scan had an unsuspected thoracic injury. Twenty percent of these injuries were pneumothoraces. [2] Appropriate treatment for these incidentally found injuries remains in question.

Placement of chest tubes for all occult pneumothoraces due to concern over potential pneumothorax progression with positive pressure ventilation was initially recommended based on two retrospective series. [1,2] Garramone et al. established size criteria for occult pneumothoraces, suggesting those less than 5 x 80 mm can be safely observed regardless of the need for positive pressure ventilation, whereas those 5 x 80 all required chest tube placement. [4] The conclusions of these retrospective series were echoed in the conclusions of a prospective trial conducted by Enderson et al. Eight of 15 patients receiving positive pressure ventilation randomized to observation in his study had progression of their pneumothoraces, with three clinically significant pneumothoraces. One of these pneumothoraces was less than 5 x 80 mm. The duration of positive pressure ventilation was not stated, and all patients that received positive pressure ventilation in this study underwent operative intervention. [6]

Collins et al. have reported safe treatment of occult pneumothoraces with careful observation regardless of the need for positive pressure ventilation. Two of 10 patients on positive pressure ventilation required placement of tube thoracostomy in their series. [8]

Chest tubes were placed in four patients randomized to observation in the current series, none for clinically significant pneumothorax progression. Nine patients in each group received positive pressure ventilation, six patients in each group for longer than 1 day. The majority of patients treated by observation that received positive pressure ventilation did not have progression of their pneumothorax or require chest tube placement. Importantly, respiratory distress was not seen in any of the patients treated with observation requiring positive pressure ventilation. It is possible that differences in ventilator management contributed to lack of clinically significant occult pneumothorax progression in this study compared with Enderson et al. Although specific data regarding ventilatory mechanics were not collected, the ventilatory strategies generally used during the study included tidal volumes of 8 to 10 mL/kg, limited positive end-expiratory pressure, and peak pressure limits of 40 to 50 cm H₂O. Ventilator management during the study was not altered by the presence of an occult pneumothorax.

Insertion of a chest tube can be associated with significant morbidity. Complications include technical misadventures during placement (1%), empyema (2-10%), pneumothorax after thoracostomy tube removal, lung laceration, and patient dislodgment occur in up to 21% of patients with tube thoracostomies. [7,9,10] We found the incidence of complications with chest tube placement to be equal to that with observation, with no difference in major or clinically significant complications. Likely because of overall injury severity, chest tube placement did not statistically lengthen hospital stay in this study.

Approximately 20% of patients in this series treated with observation required chest tube placement. Our data suggest that it is possible to safely observe patients regardless of the need for positive pressure ventilation or pneumothorax size, because no patient had clinically significant pneumothorax progression or respiratory distress related to the occult pneumothorax. Heightened awareness of the presence of an occult pneumothorax is needed by all care providers. Close communication with the anesthesiologist, should the patient require operation, is mandatory. With close observation, chest tubes can be placed only if necessary, and the majority of patients can be spared the potential morbidities of chest tube
Acknowledgments

The authors thank Dorina Weigelt and Tracy Wendland for help with data collection.

DISCUSSION

Dr. James G. Hinsdale (San Jose, California): This study from Dr. Brasel and Dr. Weigelt's group from Minnesota has taken a well-designed look at the current management of occult pneumothorax. The objective and methodology of the work is sound, and I appreciate the authors forwarding me the manuscript well in advance of the meeting.

From the manuscript and the slides, less than half of the eligible patients were entered into the study, and exclusions were made for physician judgment and other factors, possibly giving concern to an element of preselection. That factor aside, however, this study is well randomized and well matched.

A key conclusion is that patients on positive pressure ventilation can be safely observed for occult pneumothorax. This conclusion appears justifiable, given the data, although 20% of patients being observed ultimately required a chest tube.

Dr. Enderson of Knoxville presented the only other randomized prospective study of this issue to this society's meeting in Louisville in 1992. Study design was very similar to this for the most part, although the Enderson study recommended a chest tube insertion for patients on positive pressure ventilation.

In that study, three patients under observation progressed to tension pneumothorax, one of whom was not under positive pressure ventilation. This particular event alarmed Dr. Jacobs, who commented at the meeting, and I suspect he will comment today, too. This study had no patients progress to respiratory distress due to increasing pneumothorax.

In addition, this study, like Dr. Enderson's, focused on the original size of the occult pneumothorax as first described by Drs. Garramone and Jacobs.

Other key measurement of outcomes are pneumothorax progression and respiratory distress. Neither was different between the two groups. All three of the observed patients having pneumothorax progression had original size exceeding 5 x 80 mm, and despite the lack of significance, I do wonder if this factor alone is important in predicting the need for a chest tube and would ask the authors to comment. It is supported by Drs. Garramone and Jacobs data but not Dr. Enderson's.

The authors suggest in their manuscript that different methods of ventilation management revolving on minimizing barotrauma may explain the differences in their outcomes versus Dr. Enderson's. This observer is in general agreement and would note that all of Dr. Enderson's positive pressure patients were ventilated through surgical procedures, while Dr. Brasel's study had only three patients in each group ventilated through surgeries. Perhaps there are differences in the ventilator management of patients undergoing anesthesia versus patients being observed in the ICU, and I would ask the authors to comment.

Many observers do feel that chest tube insertion in the hands of experienced house staff or attendings is a procedure of minimum morbidity, perhaps in the 5% range for that group.

Finally, I think this paper does help settle the issue that a small occult pneumothorax in a patient not
needing positive pressure ventilation can certainly be managed with observation. The conclusion that observation is safe in patients undergoing positive pressure ventilation should be remembered as valid only in a setting where continuing awareness is made to all personnel caring for the patient. A lapse in this vigilance could be disastrous in a center not rigorously employing it.

I enjoyed the presentation. I feel that this is an honest paper that has taken a new look at an important clinical issue and applied methodology that helps advance the field in caring for patients with occult pneumothorax. I commend the authors and thank the Association for asking me to discuss it.

Dr. Sheldon Brotman (Atlantic City, New Jersey): I have a problem with one of your cases: a patient being watched with major splenic injury. If that patient's splenic injury progressed and he became unstable, the treating surgeon would be hard pressed to know whether to place a chest tube or perform a laparotomy. I would probably have treated this patient with a chest tube.

Dr. Michael L. Hawkins (Augusta, Georgia): I want to ask about supplemental oxygen. If you looked at that, if there was any difference in these two groups, since potentially at least this would change the PO2 in the pleural space and maybe help the pneumothorax resolve?

Dr. Homer M. Smathers (Detroit, Michigan): The author mentioned that about 20% had to have a chest tube, and these were small pneumothoraces. Dr. Morris Blau, a member of this organization since 1950, developed a little S-tube, the lumen about the size of an 18 needle with a blunt end, and would insert this in these small pneumothoraces perhaps up to 20% at Detroit Receiving Hospital, put a little finger cot on the end, punch a hole in it, and it would let out such air.

I wonder if the author might consider such a thing. We have used it many times, and you do not have to put a chest tube in these small pneumothoraces.

Dr. Kathleen M. Kelly (Morristown, New Jersey): I would like to know if there was any standard ventilatory management for the protocol. Standard practice has changed over the last 5 to 7 years, towards decreased airway pressures and tidal volumes. Did a change in ventilatory management affect the results of the study?

Dr. M. Gage Ochsner (Savannah, Georgia): I have some concerns about this concept, and I guess my question to the authors would be, since half your patients you treated for the most significant complication, which would be a tension pneumothorax -they had a chest tube in, you are really looking at half of your patient population that made criteria -do you routinely now at your institution, anybody that comes in with any occult pneumothorax, regardless of whether they're going to surgery and positive pressure ventilation, observe them all now? Is that your standard?

Dr. Gerald B. Demarest (Albuquerque, New Mexico): I notice that you said there was no difference in length of stay, but if you converted length of stay into hospital cost, was there a significant difference in the two groups or in the groups in terms of cost of hospital stay?

Dr. Janice A. Mendelson (San Antonio, Texas): Was there a close relationship between the sites of the disruption and the location of the observed pneumothoraces? Thank you.

Dr. Reuven Rabinovici (New Haven, Connecticut): In these 20% of patients who did require insertion of a chest tube, were you able to identify any predisposing factors, such as duration of pneumothorax, the presence of air leak, or degree of positive airway ventilation?

Dr. K. J. Brasel (closing): To answer Dr. Hinsdale's question, our rate of exclusion was about 50%. In
looking at many clinical trials, you are lucky to enroll around 20%. It was hard to tell in patients that were excluded for physician judgment whether it was because they were unstable, and that would lead to one particular bias, or whether the occult pneumothorax was their only injury and the treating physician did not want to place a chest tube in that patient that would probably go home the next day, where the chest tube might significantly lengthen their hospital stay.

In terms of looking at size as a risk factor, our post-hoc analysis did not identify this as a significant risk factor for progression of the pneumothorax or for respiratory distress. However, the numbers are very small, and I would say that this study does not have the power specifically to comment on size.

And I agree that positive pressure ventilation strategies may explain some of the differences in this paper versus Dr. Enderson's.

And that also speaks to Dr. Kelly's question. We did not have a particular ventilatory strategy standard of care. Over the course of the study period, our ventilatory strategy certainly did change. We ventilate with lower volumes and lower peak pressures now than we did at the beginning of the study.

Dr. Hawkins, we did not look at supplemental oxygen.

And Dr. Smathers, we would say that these pneumothoraces do not need any treatment at all, neither the trauma chest tube that we placed, the 36 French or 40 French, or a small catheter aspiration.

And yes, Dr. Ochsner, we now do observe all of these patients, regardless of the need for operative intervention or positive pressure ventilation.

We did not look at cost.

And I cannot comment on the geography of the pneumothorax for Dr. Mendelson.

There were no particular predisposing factors for the 20 percent of patients that did require chest tube placement. One was postoperatively; two were for asymptomatic progression. But there were no specific risk factors that we could identify.

Again, I would like to thank the Association.

REFERENCES

1. Tocino IM, Miller MH, Frederick PR, et al. CT detection of occult pneumothorax in head trauma. AJR. 1984;143:987-990. [Context Link]


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