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ORIGINAL ARTICLE

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Management and outcomes of traumatic hemothorax in children

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Abstract

Background: Adult guidelines for the management of traumatic hemothorax are well established; however, there have been no similar studies conducted in the pediatric population. The purpose of our study was to assess the management and outcomes of children with traumatic hemothorax. **Materials and Methods:** Following Institutional Review Board approval, we conducted a retrospective cross-sectional study of all trauma patients diagnosed with a hemothorax at a Level-1 pediatric trauma center from 2007 to 2012. **Results:** Forty-six children with hemothorax were identified, 23 from blunt mechanism and 23 from penetrating mechanism. The majority of children injured by penetrating mechanisms were treated with tube thoracostomy while the majority of blunt injury patients were observed (91.3% vs. 30.4% tube thoracostomy, penetrating vs. blunt, $P = 0.00002$). Among patients suffering from blunt mechanism, children who were managed with chest tubes had a greater volume of hemothorax than those who were observed. All children who were observed underwent serial chest radiographs demonstrating no progression and required no delayed procedures. Children with a hemothorax identified only by computed tomography, after negative plain radiograph, did not require intervention. No child developed a delayed empyema or fibrothorax. **Conclusion:** The data suggest that a small-volume hemothorax resulting from blunt mechanism may be safely observed without mandatory tube thoracostomy and with overall low complication rates.

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Full Text

Introduction

Thoracic trauma is relatively uncommon in children but remains a significant cause of morbidity and mortality. [1],[2] Because of anatomic differences from increased chest wall ligamentous laxity and incomplete bony ossification, children have a more compliant thoracic cage than their adult counterparts. Upon traumatic impact, kinetic energy is then dissipated to the underlying lungs and thoracic contents, increasing the overall risk for significant internal injury without associated external findings. [3],[4] Children also have less soft tissue mass, which offers less cushioning and also increases the risk of thoracic injury.

Hemothorax is one of the more common thoracic injuries, exceeded only by pulmonary contusions, rib fractures and pneumothorax in children. Hemothoraces are caused by injury to the intrathoracic vessels or the lung parenchyma and have a reported incidence of 7-29% in registry data analysis of pediatric thoracic trauma. [3],[5] Delayed complications from traumatic hemothorax remain a significant concern as the presence of blood within the pleural space can initiate a fibrotic reaction that prevents adequate lung expansion resulting in atelectasis, ventilation/perfusion mismatch due to trapped lung and pneumonia. This compartmentalized blood may also serve as a nidus for infection and lead to empyemas.

To prevent these potential complications, the adult trauma literature supports aggressive early and complete evacuation of all pleural blood with tube thoracostomy. [3] Additionally, blood that is incompletely drained by tube thoracotomy (retained hemothorax) requires early operative intervention with thoracoscopy in adult patients. However, due to the relative infrequency of this injury observed in children, pediatric guidelines for the management of traumatic hemothorax are limited and remain based on studies of adult patient populations. [6] As such, outcomes for hemothorax specific to pediatric trauma patients are less well defined and may not be appropriate. While establishment of guidelines requires a large prospective study, the purpose of our study was to first assess trends in management and outcomes of children with traumatic hemothorax at our own institution.

Materials and Methods

Following Institutional Review Board (IRB) approval from our Human Research Protection Office, we conducted a retrospective cross-sectional study of all children (aged 0-18 years) sustaining a traumatic hemothorax. All patients underwent screening plain chest radiographs (CXR) in the Emergency Department (ED) per Advanced Trauma Life Support® (ATLS) guidelines. Abdominal/pelvic computed tomography (CT) and full chest CT were obtained at the discretion of the trauma surgeon. Hemothorax was identified in all children by CXR or CT scan and was defined as pleural fluid on immediate post-injury imaging.

All children received treatment at a Level-1 pediatric trauma center between January 2007 and December 2012. ED activation status (STAT, Minor, Consult) was institutionally based per protocol and determined by reported pre-hospital physiology and injury mechanism. Children who had non-survivable injuries, including those who had died from non-thoracic injuries or who received an ED thoracotomy and had died within 24 h of admission, were excluded.

Data extracted included age, gender, injury severity score (ISS), abbreviated injury score (AIS), level of trauma activation, mechanism of injury, imaging results, associated injuries, ED admission vital signs, treatment of hemothorax (tube thoracostomy vs. observation), ED disposition, intensive care unit (ICU) and hospital length of stay (LOS), ventilator days, duration of tube thoracostomy drainage and hemothorax-related complications. Because of the varying sizes of children's chest cavities by age, the size of the hemothorax was determined by a Board Certified Pediatric Radiologist and calculated as a volume percentage by dividing the calculated volume of the hemothorax by the volume of the child's hemithorax. Analysis included means and SD for continuous data and numbers and percentages for categorical data. Chi-square was used to compare categorical data and t-test was used to compare continuous data. A P-value of <0.05 was considered significant.

Results

During the 5-year study period, 7667 children were treated at our institution for traumatic injuries and entered into the hospital trauma registry. From this database, we identified a total of 46 children (0.6%) with radiographically documented hemothoraces. Demographics for the cohort are listed in [Table 1]. The mean patient age was 12.7 ± 0.8 years, and the majority of patients were male (36, 78%). Most children presented to our ED as Trauma STATs, the highest level of trauma activation at our institution (28, 60.7%) based on physical exam (shock, traumatic brain injury) or mechanism (penetrating torso injury). The overall mean ISS for the entire cohort was 17.0 ± 1.5 , with a mean ICU and total hospital length of stay of 3.2 ± 0.8 and 11.1 ± 2.6 days, respectively. [Table 1]

Of the 46 injured children, half were the result of blunt mechanism while the other half resulted from penetrating trauma. There were no differences in age or ISS between patients with blunt and penetrating mechanisms [Table 2]. Significantly more patients who sustained penetrating injury came to the ED as Trauma STATs (91.3% of penetrating vs. 30.4% of blunt, $P = 0.00002$) and went to the Operating Room (OR) directly from the ED (30.4% of penetrating vs. 4.3% of blunt, $P = 0.02$). Additionally, the vast majority of patients with hemothoraces from penetrating injury underwent tube thoracostomy (91.3%). In contrast, we found that significantly more children who suffered a hemothorax from a blunt mechanism were observed without chest tube (69.6%). However, there was no difference in the presence of concomitant pneumothorax between the groups. [Table 2]

There were no differences in ventilator days or ICU and hospital length of stay between patients with blunt and penetrating mechanisms, with or without tube thoracostomy. In those patients with chest tubes, there was also no difference in the duration before tube removal between blunt and penetrating mechanisms (3.9 ± 0.7 vs. 5.1 ± 0.5 days, respectively).

To better define factors contributing to management decisions, the subgroup of children with hemothoraces secondary to blunt mechanism was analyzed separately. We identified no differences in age or ISS between those children who received a tube thoracostomy from those who were observed [Table 3]. There were also no differences in the number of patients on positive-pressure ventilation or with concomitant pneumothoraces between groups. Chest AIS, however, was higher in the group who received a tube thoracostomy compared with those who were observed (3.3 ± 0.2 vs. 2.68 ± 0.2 , $P = 0.03$). Additionally, the percent volume of the hemothorax relative to chest cavity was significantly greater in the intervention group ($21.5\% \pm 10.2$ vs. $3.4\% \pm 0.8$, $P = 0.04$). All hemothoraces that were treated with tube thoracostomy were found on CXR during ED resuscitation, as opposed to only 20% of patients who were observed ($P = 0.0003$). The remaining 80% of these observed patients had a negative CXR and had occult hemothorax diagnosed from the lower chest images on their abdominal CT scan. [Table 3]

In an attempt to further distinguish patients who underwent tube thoracostomy from those who were observed as well as to explain differences in observed AIS, the associated injuries were analyzed [Table 4]. In both groups, rib fractures, pulmonary contusions and pneumothoraces were the most common associated injuries. However, there were no differences in the type of associated injuries or their severity between groups, indicating that blood volume alone was the likely source of AIS variation. [Table 4]

The initial ED vital signs were also analyzed to determine their potential impact on management [Table 5]. No differences in systolic blood pressure, heart rate or oxygen saturation were found between the observation and intervention groups. [Table 5]

ICU and hospital length of stay as well as ventilator days were similar between observation and tube thoracostomy groups [Table 6]. There were no instances of empyema or fibrothorax reported as a complication in either group. All children underwent serial CXRs during their hospitalization. No child treated conservatively demonstrated any progression of their hemothorax; therefore, there were no delayed procedures. Only one child went to the OR for Video Assisted Thoracoscopic Surgery (VATS) within -24 h of tube placement due to a retained hemothorax based on persistent plain CXR abnormality despite no change in clinical status. All children were seen in the trauma clinic follow-up 2-4 weeks after discharge, with improved CXRs. [Table 6]

Discussion

This study represents the largest review of children with traumatic hemothoraces to date. Based on our experience, traumatic hemothoraces in pediatrics are a relatively uncommon occurrence with an even distribution from penetrating and blunt injuries. Based on the literature and findings from our trauma registry, the vast majority of thoracic injuries (80-85%) are the result of blunt trauma. Thus, these results confirm an expected higher incidence of hemothorax in penetrating injuries. [3],[5],[7]

Following the ATLS® guidelines, hemothoraces resulting from penetrating injuries were more likely to be treated with tube thoracostomy at our institution. Although there were no differences in ISS or length of stay, penetrating torso trauma is perceived as more severe and treated with a higher proportion of Trauma STAT activations. Associated pneumothorax is also more likely following penetrating mechanisms, and treatment often precedes radiographic confirmation of injury. As such, the mechanism and trauma activation level may have influenced practitioners to place chest tubes in our series. This was expected as penetrating mechanisms have a significantly increased risk of mortality from the thoracic injury itself than blunt mechanisms. [5]

However, in patients who were injured as a result of blunt trauma, we found more hemothoraces observed without tube thoracostomy. This occurred despite the fact that there were no differences in associated injuries or admission vital signs. In addition, children with a small volume hemothorax identified only by CT but not on initial screening CXR were more likely to be observed with serial imaging. We suspect this may have contributed to the discrepancy in chest AIS noted between the intervention and observation groups despite no differences in associated injuries or severities. Chest AIS is reported retrospectively; therefore, chest AIS in the observation group may be less than the tube thoracostomy group due to the smaller size of the collection on imaging. It is also possible that the presence of a tube thoracostomy itself may have biased one to increase the value.

For the entire cohort of children, the overall complications rate was very low in contrast to the adult series. Additionally, unlike in adult patients, we found no negative sequelae to hemothoraces that were observed [Table 6]. The incidence of retained hemothorax in adult trauma has been reported to be as high as 20%, while in our series we found only one patient who underwent a VATS for a retained hemothorax, and this patient did not experience any clinical deterioration before or after the procedure. [8],[9] The complications of retained hemothorax have been well documented in adults. The incidence of empyemas has been found to be 12-30% in patients with retained hemothorax after traumatic injury, while 19.5% develop pneumonia. [10],[11],[12],[13] These complications subsequently lead to longer lengths of ICU and hospital stay. [10] These results have driven recommendations of aggressive treatment of retained hemothorax in adults with VATS to prevent these complications. [6]

The greatest limitation of our study is that it is a single-center retrospective review. Traumatic hemothorax in children is a low-frequency event and our study alone is not powered to demonstrate any differences in outcomes or complications. We believe that our data, however, does suggest that small volume hemothoraces resulting from blunt trauma that are not identified on screening CXR may be safely observed without tube thoracostomy. This management approach appears similar to small pneumothoraces identified only as an incidental finding on CT as reported in the adult literature. [14] Guidelines for management of post-traumatic hemothoraces in children (tube thoracostomy vs. observation) would require a prospective, multi-center study.

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