Critical Care of Chest Trauma in Children

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Summary

Chest injuries greatly influence the outcome of the trauma victims in adults. Eighty one children with chest trauma treated at our institution during the past 3 years and 6 months period were reviewed and the critical care of pediatric chest trauma was discussed. All of 81 children sustained thoracic injuries by blunt forces and a road traffic accident in the form of automobile vs pedestrian was the major cause of injury in 65 (80.2 %) children. Pulmonary contusion was the most frequent injury of the chest (34.6 %). Pneumothorax or hemothorax was noted in 8 (9.9 %) children and fractures of the ribs were accompanied in 5 (6.1 %) children. The elasticity of a child's thorax may account for the presence of these intrathoracic lesions without rib fractures. Twenty three (28.3 %) children were polytraumatized and 3 deaths occurred in this group of patients. All deaths were attributable to the associated neurological or abdominal damage. It became clear that significant chest injuries are frequently a component of multisystem injuries in children. Thus, a proper sequence must be followed in the management of the poly-traumatized children with chest trauma. A well organized system of evaluation and resuscitation is mandatory for the best care of children with major blunt injuries.

Chest trauma caused by blunt force occurs frequently in children, but overt injuries are not commonly manifested. Penetrating chest trauma is rare in the pediatric population. It seems likely that caring for infants and children with thoracic injuries poses a number of problems in diagnosis and treatment.

The purpose of this paper is to review our experience in dealing with pediatric chest trauma with particular regard to cause and type of injury, diagnosis and critical care, and any difference from similar injuries in adults.

Clinical material

Eighty one infants and children were treated during the period from October 1979 through February 1983 (Table 1). The children were all under 15 years of age. Nonaccidental and iatrogenic injuries were excluded from this study. Seventy six (93.8 %) children had no fractures of the ribs or the sternum. However, 27 of the 76 (35.5 %) children without rib fractures were accompanied by intrathoracic injuries. There were only 5 children with rib fractures and all of these 5 had intrathoracic injuries.

Age and Sex Distribution

The age ranged from 9 months to 15 years and injuries occurred in all age groups except 12 year age range (Fig. 1). The peak incidence occurred in the 5-to 7-yr age range. Sinclair and Moore1, in a series of 199 children and adolescents with abdominal and thoracic trauma, also found the first peak in

Key Words: Pediatric chest trauma, Pulmonary contusion, Multiple injuries, Critical care
Table 1  Chest Trauma in 81 Children.

<table>
<thead>
<tr>
<th>Trauma</th>
<th>Number of Patients (Incidence)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chest wall contusion only</td>
<td>49 (60.5%)</td>
</tr>
<tr>
<td>Chest wall contusion with Intrathoracic injuries</td>
<td>27 (33.3%)</td>
</tr>
<tr>
<td>Rib fractures with Intrathoracic injuries</td>
<td>5 (6.2%)</td>
</tr>
</tbody>
</table>

In 77 auto accidents, 65 children were pedestrians and other causes of blunt chest trauma were relatively infrequent.

Types of Chest Injuries

Pulmonary contusion occurred in 28 (34.6%) children and was the most frequent injury (Table 2). The incidence of pulmonary contusion in pediatric chest trauma was reported to be from 39.7 to 61.7%\(^2,\)\(^3\). In 2 children with pulmonary contusion, one was associated with intrapulmonary hematoma and the other with air cyst of the lung. There were only 5 children with rib fractures and none with paradoxical respiration (Flail chest). Smyth\(^4\) found rib fractures in 45 of 94 (47.8%) children. Flail chest is uncommon in children\(^2\). Eight (9.9%) children had pneumothorax, hemothorax, or both. The elasticity of the thorax in children accounts for the presence of pneumo-or hemothorax in the absence of rib fractures. The incidence of pneumo-or hemothorax in children was reported to be 16 to 51%\(^2,\)\(^3\). Traumatic asphyxia was observed in 4 children. Three children were run over by a car and one had compression of the chest by a steel rope. One child had traumatic rupture of the left diaphragm.

Associated Extrathoracic Injuries

Thirteen children manifested the signs of shock on admission or shortly thereafter. Table 3 indicates the frequency of the extrathoracic injuries. Injuries to the head and
Table 3
Associated Injuries in 81 Children with Chest Trauma.

<table>
<thead>
<tr>
<th>Injury</th>
<th>Number of Patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head injuries</td>
<td>68</td>
</tr>
<tr>
<td>(brain concussion, 44;</td>
<td></td>
</tr>
<tr>
<td>brain contusion, 25; skull</td>
<td></td>
</tr>
<tr>
<td>fractures, 20; intracranial</td>
<td></td>
</tr>
<tr>
<td>hematoma, 8)</td>
<td></td>
</tr>
<tr>
<td>Abdominal injuries</td>
<td>14</td>
</tr>
<tr>
<td>(contusion/laceration liver, 7; perforation intestine, 1; Hematoma omentum, 1; contusion/laceration kidney, 7)</td>
<td></td>
</tr>
<tr>
<td>Major fractures</td>
<td>23</td>
</tr>
<tr>
<td>Fractured pelvis</td>
<td>2</td>
</tr>
<tr>
<td>Urinary tract injuries</td>
<td>2</td>
</tr>
</tbody>
</table>

Long bones were frequent. Abdomen was the least commonly injured area. Nine children showed evidence of urinary tract injuries by exhibiting hematuria. Four children had craniotomy for removal of intracranial hematomas and another 4 children underwent exploratory laparotomy for acute abdominal signs. Early operative procedures of fractures of major bones were done for 10 children. Nine had closed thoracotomy and 3 had tracheostomy for prolonged respiratory care.

Table 4
Mortality in Relation to Number of Systems Injured in 81 Children.

<table>
<thead>
<tr>
<th>Injury</th>
<th>Number of Patients</th>
<th>Number of Death</th>
<th>Mortality (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chest trauma alone</td>
<td>7</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Chest trauma and other major system</td>
<td>50</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Chest and 2 other major system</td>
<td>22</td>
<td>2</td>
<td>9.1</td>
</tr>
<tr>
<td>Chest and 3 other major system</td>
<td>2</td>
<td>1</td>
<td>50.0</td>
</tr>
</tbody>
</table>

Mortality

There were 3 deaths out of 81 children—an overall mortality of 3.7%. All 3 deaths were caused by vehicle-pedestrian accidents; 2 were boys and 1 was a girl. Their ages were 3, 4 and 5 years, respectively. Reports by several authors indicated a mortality of 4.1 to 13.8%. Two deaths occurred within 2 days after trauma and one on the 12th day. In all 3 children, death was mainly due to nonthoracic trauma (e.g., injury to brain or abdominal organs). If the chest plus 2 other major systems are involved, the mortality increases to 9.1% while with 4 systems it increases to 50% (Table 4). There are many reports indicating that the mortality related to chest trauma in adults is most often due to associated extrathoracic injuries, especially due to head or abdominal injuries. This is also true in the children in our series.

Modified Injury Severity Scale (MISS)

Mayer and colleagues advocated this scale (MISS) to clarify the effect of multiple trauma on pediatric patients. MISS was applied to score injuries in our 81 children with chest trauma (Table 5). MISS scores ranged from 5 to 50, with a mean score of 16.1. Among the children with MISS scores greater than 31, 37.5% died. No mortality was seen in the children with scores less than 30. All children with MISS scores greater than 40 died. MISS is considered to be an accurate, simple, and reproducible method for classifying pediatric patients with multiple trauma. In our

Table 5
Mortality Figures compared to Modified Injury Severity Scale (MISS) Scores in 81 Children.

<table>
<thead>
<tr>
<th>MISS Scores</th>
<th>Number of Patients</th>
<th>Number of Deaths</th>
<th>Mortality (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0–10</td>
<td>22</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>11–20</td>
<td>35</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>21–30</td>
<td>16</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>31–40</td>
<td>6</td>
<td>1</td>
<td>16.7</td>
</tr>
<tr>
<td>40&lt;</td>
<td>2</td>
<td>2</td>
<td>100.0</td>
</tr>
</tbody>
</table>
experience, MISS scores greater than 31 and the severity of neurologic injury were the most accurate predictors of mortality.

**Critical care of the specific chest injuries**

Crushing chest injuries are much more common in children, so immediate correction of functional deficits are often required. Therefore, physicians, nurses, and paramedical personnel who are responsible for the immediate care of an injured child with a potential chest injury must be prepared to act according to some preconceived plan of evaluation and triage. The management of chest injuries should be the first priority in emergency care of poly-traumatized child. In the majority of the pediatric patients sustaining major chest trauma, securing an adequate airway and insertion of a thoracostomy tube are the essential methods of management. A physician who takes care of a trauma victim should have an adequate knowledge and skill of inserting a chest drainage tube for evacuation of air and blood from the intrapleural space and also for monitoring. Thoracotomy is not usually needed but when judged essential it can be life saving.

**Chest Wall Injuries**

Chest wall contusion and fractures of ribs or the sternum are best treated by rest and analgesia or intercostal nerve block when pain is severe. Also attention should be paid to clearing airway and deep breathing to prevent atelectasis of the lungs. Oxygen and nebulization by a head box or ultrasonic nebulizer may also be needed. If flail chest with paradoxical respiration, though rare in children, is observed, more aggressive respiratory care as described below is instituted.

**Pulmonary Contusion**

In pulmonary contusion, there is an outpouring of blood and edema fluid into the alveoli and interstitial space. This interferes with effective gas exchange across the alveolar-capillary membrane. A contusion may not be shown up on an initial chest radiograph, but the extent of the lesion often increases during the first 24 hours after injury. The region of the lung affected is usually localized (Fig. 3), but bilateral contusion can occur in cases of severe crush injury. Pulmonary contusion may easily be overlooked when there is no severe trauma to the chest wall and, again when multiple injuries, especially those of the head or abdomen, demand urgent attention. Evaluation of the arterial blood gases is most important in documenting the underlying pulmonary contusion. Children with pulmonary contusion show a diminution in the PaO₂ and PaCO₂ (Fig. 4). Occasionally, children with pulmonary contusion do not manifest significant respiratory embarrassment even if alteration in blood gases is marked and chest radiograph demonstrates contused area in the lung. Thus, in children with lung contusion, serial evaluation of the blood gases is mandatory to document an increasing intrapulmonary shunt and progressive respiratory insufficiency. For mild degree of pulmonary contusion oxygen and nebulization are utilized by a head box for infants and small children, or by ultrasonic nebulizer and intermittent positive pressure breathing (IPPB) with a pressure-cycled ventilator for older children. Severe pulmonary contusion is treated by endotracheal intubation and a volume-cycled ventilator with or without positive end-expiratory pressure (PEEP). If continued mechanical assistance is required beyond 2 to 3 weeks, a tracheostomy should be considered. We usually prefer
Fig. 3 Chest X-P and CT Scan: Pulmonary Contusion.

prolonged nasal intubation to a tracheostomy in children. Fluid restriction and diuretics are applied to reduce the excess pulmonary interstitial fluid.

Pneumothorax

Pneumothorax results from air leaking into the pleural space from a disruption of the lung parenchyma, a tear in the tracheobronchial trees, an esophageal perforation, or penetration of the chest wall (Fig. 5). The elasticity of the thorax in children accounts for the presence of pneumothorax in the absence of rib fractures. Pneumothorax should always be considered during the evaluation of an injured child. Definitive treatment consists of prompt insertion of a chest tube. A patient with pneumothorax who requires general anesthesia or a mechanical ventilation is best treated by initial insertion of a chest tube to prevent the occurrence of tension pneumothorax. Tension pneumothorax occurs because of progressive entry of air into the pleural space that cannot escape. Tension pneumothorax rapidly embarrasses cardiorespiratory function. If a chest tube is not immediately available, a large bore needle should be in,
Hemorrhage in the brain tissue if the glottis closed at the time of injury.

The patient is usually disoriented with evidence of respiratory compromise. The face and neck are cyanotic with petechiae on the head, neck and chest. Subconjunctival and retinal hemorrhages are frequently present. As soon as the chest compression is relieved, there is a slow but continuous subsidence of the petechial hemorrhages with complete resolution commonly in 5 to 7 days.

Traumatic Rupture of the Diaphragm

The rupture of diaphragm, which is most common on the left side, allows the abdominal contents to enter the thoracic cavity with subsequent respiratory compromise (Fig. 6). The diaphragmatic tear is easily missed as symptoms and signs of a diaphragmatic hernia may be absent. Surgical repair should be done as soon as the diagnosis is made. The

Fig. 5 Chest X-P: Pneumohemothorax of the right pleural cavity. A thoracostomy tube was inserted.
repair is accomplished either by the transthoracic or by the transabdominal approach.

**Comment**

The commonest cause of chest trauma in children is a road traffic accident, but a penetrating injury is rare. Blunt chest injuries are more serious than penetrating chest injuries and are often associated with extensive trauma elsewhere.

The difference between adults and children suffering from chest trauma should be borne in mind. Children are more likely to be injured as pedestrians. The relative elasticity of the child’s thorax accounts for the severe intrathoracic injuries without evidence of rib fractures. In children, respiratory distress may not be recognized even with pulmonary confusion and hemothorax until blood gas measurements are made. Proper respiratory care should be instituted according to the status of an individual child. Knowledge and skill in inserting a thoracostomy tube are minimum requirements for those who are responsible for the care of an injured child.

Our experience with major blunt chest trauma in children has shown that significant thoracic injuries are frequently a component of multisystem injuries as in adults. Therefore, a proper sequence must be followed in the management of the whole spectrum of multi-organ injuries. Whatever therapy is rendered, it must be aimed toward maintaining an adequate airway and satisfactory ventilation and optimal tissue perfusion throughout the course of evaluation and resuscitation. The total evaluation of the child with major blunt trauma is diagnostic challenge requiring the greatest experience and skill in judgement. A well organized system of evaluation and resuscitation is necessary for the best care of children with major blunt trauma including thoracic injuries.

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References


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小児胸部外傷患者の集中治療

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成人外傷患者の予後は合併する胸壁損傷により大きく左右される。胸壁損傷が小児外傷患者に及ぼす影響について81症例で検討し、かつ胸部損傷の集中治療に言及した。81症例は純的外力で受傷したが、最も多くは交通事故、これに対自動車事故であった（約80％）。胸壁損傷の中では肺挫傷が最も頻度が高かった（34.6％）。肋骨骨折例は3例と少ないのが特徴であった。肋骨骨折が少ないことおよび肋骨骨折非合併例でも肺挫傷や血気胸合併が多いことは小児の胸郭の柔軟性が大きいに関与する。なお、重篤な胸壁損傷を合併する症例で体幹部損傷の重症損傷を伴う例は23例であった。成人と同様に小児胸部損傷を含む外傷の一部を症例とみなし、適切な患者管理を行うことが重要である。