SEAT-BELT INJURIES OF THE SPINE IN YOUNG CHILDREN

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Seat-belt fractures of the lumbar spine in adolescents and adults are well recognised but there are few reports of these injuries in young children. We reviewed all seat-belt injuries in skeletally immature patients (Risser 0), seen at a tertiary referral centre between 1974 and 1991.

There were ten cases, eight girls and two boys, with an average age of 7.5 years (3 to 13). Four distinct patterns of injury were observed, most commonly at the L2 to L4 level. Paraplegia, which is thought to be uncommon, occurred in three of our ten cases. Four children had intra-abdominal injuries requiring laparotomy. There was a delay in diagnosis either of the spinal or of the intra-abdominal injury in five cases, although all had contusion of the abdominal wall, the 'seat-belt sign'. Treatment of the fractures was conservative, by bed rest and then hyperextension casts.

The incidence of this potentially devastating injury can be reduced by the optimal use of restraints, but there is often a delay in diagnosis. Our classification system may aid in the early detection and evaluation of this injury.

Traffic accidents are an important cause of death and disability in children (Baker 1987). The use of seat belts significantly reduces the risk of injury or death in a collision by preventing ejection from the car, decreasing the rate of deceleration, and modifying impact with the vehicle interior (Williams and Kirkpatrick 1971), but seat belts also change the distribution of forces and may be the cause of other injuries.

Seat-belt injuries have become more common in children and have raised concerns about the safety of lap belts in this age group. Fractures of the lumbar spine due to seat belts are well recognised in adolescents and adults, but there are few reports of such injuries in young children, for whom adult lap belts may fail to provide optimal protection (Agran, Dunkle and Winn 1987).

We have studied the characteristics and mechanisms of these injuries in skeletally immature patients.

PATIENTS AND METHODS

We reviewed all thoracic and lumbar spine fractures seen at the Children's Hospital of Eastern Ontario between 1974 and 1991, and identified 18 seat-belt injuries in patients between three and 17 years of age. We wished to investigate only skeletally immature children, and therefore excluded eight patients with radiographic evidence of ossification of their iliac apophyses.

The remaining ten cases, all with Risser O radiographs, are listed in Table 1; all had been using lap belts. In each case the fracture pattern was consistent with tension failure of the posterior and middle columns of the lumbar spine. All available records and images were evaluated in detail.

RESULTS

Most of the ten cases were seen in the last two years of the 17-year study period. There were eight girls and two boys with an average age of 7.5 years (3 to 13). All had been rear-seat passengers in motor vehicles, most of which had been involved in head-on collisions. They had been wearing lap belts but no specialised restraints. In 50% of the accidents other passengers had been killed.

All ten patients had also sustained other injuries; the average Injury Severity Scale (ISS) was 16 with a range of 10 to 26 (Committee on Injury Scaling 1985). They all had an abdominal-wall contusion or 'seat-belt sign', and four had intra-abdominal injuries requiring laparotomy. Three patients became paraplegic.

Eight of the spinal injuries were between L2 and L4, and we identified four distinct patterns of injury (Fig. 1): Type A. Bony disruption of the posterior column extending just into the middle column. Type B. Avulsion of the posterior elements with facet
joint disruption or fracture and extension into the 
apophysis of the vertebral body.
Type C. Posterior ligamentous disruption with a fracture 
line entering the vertebra close to the pars interarticularis 
and extending into the middle column.
Type D. Posterior ligamentous disruption, with a fracture 
line traversing the lamina and extending into the 
apophysis of the adjacent vertebral body.

In six cases there were compression fractures of the 
anterior column, sometimes at multiple levels, but usually 
producing less than 10% loss of height of the anterior 
vertebral column. Avulsion of spinous processes often 
extended over several vertebral levels.

There was delay in diagnosis of the spinal injury in 
three cases. Full radiographic evaluation of the spine was 
delayed for an average of nine days in two of them. In 
both of these a diagnosis of compression fracture had 
been made, but the full extent of posterior- and middle-
column injury had not been appreciated. In the third 
case, radiographs taken on admission were initially 
considered to be normal.

Two of the four significant abdominal injuries were 
difficult to diagnose, one patient requiring laparotomy 24 
hours after admission and the other developing a faecal 
fistula at 14 days.

Treatment of the spine. One child had an exploration and 
laminectomy at eight days for persisting paraplegia. She 
later developed a left lumbar scoliosis of 57° with a 6° 
kyphosis and required posterior instrumentation and 
fusion after five years. Seven patients were treated in an

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**Table I. Details of ten skeletally immature children who sustained seat-belt injuries of the spine**

<table>
<thead>
<tr>
<th>Age (yr)</th>
<th>Sex</th>
<th>Level of injury</th>
<th>Type*</th>
<th>Spinal cord injury</th>
<th>Intra-abdominal injury</th>
<th>Diagnostic delay (over 24 hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>F</td>
<td>L5</td>
<td>A</td>
<td>–</td>
<td>–</td>
<td>Spine</td>
</tr>
<tr>
<td>13</td>
<td>F</td>
<td>L4</td>
<td>A</td>
<td>–</td>
<td>Perforated jejunum</td>
<td>Abdomen</td>
</tr>
<tr>
<td>3</td>
<td>F</td>
<td>L2 to L3</td>
<td>B</td>
<td>Paraplegia</td>
<td>Perforated jejunum</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Sensory level T4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>M</td>
<td>L2 to L3</td>
<td>B†</td>
<td>Paraplegia</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Sensory level T6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>F</td>
<td>L3 to L4</td>
<td>B</td>
<td>–</td>
<td>–</td>
<td>Spine</td>
</tr>
<tr>
<td>7</td>
<td>F</td>
<td>L2 to L3</td>
<td>B†</td>
<td>–</td>
<td>–</td>
<td>Spine</td>
</tr>
<tr>
<td>8</td>
<td>F</td>
<td>L2 to L3</td>
<td>B†</td>
<td>–</td>
<td>Transection of ileum</td>
<td>–</td>
</tr>
<tr>
<td>10</td>
<td>F</td>
<td>L1 to L2</td>
<td>C</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>10</td>
<td>M</td>
<td>L3 to L4</td>
<td>C</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>9</td>
<td>F</td>
<td>L2 to L4</td>
<td>D</td>
<td>Paraplegia</td>
<td>Perforation of ileum</td>
<td>Abdomen</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Sensory level T10</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*see text and Figure 1    †associated facet fractures
extension body cast for a period of one to three months; the other two were treated by bed rest only.

Three patients remain paraplegic. Three were asymptomatic with a full range of motion at their last assessment and one patient is still under treatment. Three patients have been lost to follow-up.

DISCUSSION

The suitability of the lap belt for children is a subject of concern (National Transportation Safety Board 1986), although Canadian accident data do indicate a reduction in serious injury or death from the use of seat belts by this age group (Dalmotas et al 1985). It is recognised that specific injuries may result from the use and misuse of seat belts.

Seat-belt fractures of the lumbar spine in young children are considered to be uncommon (Moskowitz 1989), but our recent experience suggests that there may be an increase in the frequency of this injury. Twenty such injuries have been reported, most due to high-speed head-on collisions (Smith and Kaufer 1969; Ritchie et al 1970; Rogers 1971; Gumley, Taylor and Ryan 1982; Blasier and LaMont 1985; Vandersluis and O’Connor 1987; Moskowitz 1989; Gallagher and Heinrich 1990; Johnson and Falci 1990; Reid, Letts and Black 1990). The average age of these patients was eight years (3 to 12) with similar numbers of males and females. Almost all had seat-belt contusions; 15% had paraplegia and 55% had an intra-abdominal injury. Two patterns of injury have been described: ligamentous disruption with facet joint dislocation, and horizontal fracture of the spinous process and neural arch.

In adults, seat-belt injuries of the lumbar spine have been well described (Smith and Kaufer 1969; Gumley et al 1982; Denis 1983; Gertzbein and Court-Brown 1988), and the level of injury is commonly between L1 and L3. Neurological damage is uncommon and complete paraplegia was not reported.

Seat-belt fracture in children has several unique features, and we were able to identify four distinct patterns; type-B fractures were the most common. There is always a combination of bone and soft-tissue injury, and the anterior-column injury may involve several levels, probably because of the healthy state of the intervertebral discs in children (Hubbard 1976). For similar reasons, the middle-column injury is usually through the bone or the apophysis and not through the posterior disc. Posterior-column disruption also commonly involves several levels, probably due to the mobility of the child’s spine and the presence of a relatively weak spinous process apophysis. The level of injury in children is usually between L2 and L4, and was associated with complete paraplegia in three out of ten cases.

The mechanism of seat-belt injuries in children may be hyperflexion of the spine around the lap belt caused by the sudden deceleration. It has been suggested that the axis of flexion of the spine is probably the point of contact between the seat belt and the anterior abdominal wall (Smith and Kaufer 1969), but we frequently found compression fractures of the anterior column. If there is compression failure anteriorly, and tension failure posteriorly, then the axis of flexion is somewhere within the column (White and Panjabi 1978).

A child’s centre of gravity is relatively higher than that of an adult (Palmer 1928); this may result in an increased moment arm and probably greater distraction, contributing to the higher incidence of paraplegia in children.
In young children an ideal placement of the lap belt at the level of the hip is difficult to achieve, because of the lack of development of the iliac crest and the problem of maintaining an upright sitting posture. The lap belt tends to be placed over the abdomen (Agran et al 1987), confirmed in our series by clinical photographs of bruising. In some cases the child had slid under the belt (or 'submarined'), perhaps because it had been loosely applied (Dance et al 1981).

Failure to diagnose seat-belt injury is common (Asbun et al 1990; Reid et al 1990); this can increase both morbidity and mortality (Williams and Kirkpatrick 1971). In our series there were significant delays in the diagnosis of three spinal injuries and two bowel injuries. Vertebral injury can be detected by a complete physical examination, adequate radiography and an understanding of the common fracture patterns. CT scans may fail to detect the injury (Taylor and Dunne Eggli 1988). Lateral tomograms are the most useful additional investigation (see Fig. 2).

Abdominal signs are difficult to assess in a child with a fractured spine and a badly bruised abdomen: tenderness may be attributed to the bruising, and ileus to the fracture. Perforation of the bowel may have an insidious clinical course and spinal cord or head injury may further compromise assessment. Lateral decubitus radiographs may show free air. However, abdominal CT scans and peritoneal lavage should be considered when there is suspicion of such an injury (Asbun et al 1990).

The prevention of seat-belt injuries in children requires the optimal use of restraints (Ministry of Transportation 1990). Once a child has outgrown a fully strapped safety seat, a booster seat is needed to ensure a proper position for the lap belt, and properly adjusted shoulder straps are required to prevent hyperflexion. Further development of such harnesses may improve the protection provided (Dalmotas et al 1985). When extreme forces are involved, however, injuries may still occur (Sköld and Voigt 1977; Gögler, Athanasiadis and Adomeit 1979).

Conclusions. Seat-belt fracture in a child is a potentially devastating injury, frequently associated with the incorrect use of the belts. Our proposed classification system may help in the early evaluation of this injury and reduce delay in diagnosis. The optimal use of restraints and the development of specialised seat belts may improve the protection provided for young children.

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REFERENCES


Ministry of Transportation. What you should know about seat belts. Ontario, 1990.


