

# Seat-belt injuries in children involved in motor vehicle crashes

Miriam Santschi, MD;\* Vincent Echavé, MD;† Sophie Laflamme, MD;\* Nathalie McFadden, MD;†  
Claude Cyr, MD\*

**Background:** The efficacy of seat belts in reducing deaths from motor vehicle crashes is well documented. A unique association of injuries has emerged in adults and children with the use of seat belts. The “seat-belt syndrome” refers to the spectrum of injuries associated with lap-belt restraints, particularly flexion-distraction injuries to the spine (Chance fractures). **Methods:** We describe the injuries sustained by 8 children, including 2 sets of twins, in 3 different motor vehicle crashes. **Results:** All children were rear seat passengers wearing lap or 3-point restraints. All had abdominal lap-belt ecchymosis and multiple abdominal injuries due to the common mechanism of seat-belt compression with hyperflexion and distraction during deceleration. Five of the children had lumbar spine fractures and 4 remained permanently paraplegic. **Conclusions:** These incidents illustrate the need for acute awareness of the complete spectrum of intra-abdominal and spinal injuries in restrained pediatric passengers in motor vehicle crashes and for rear seat restraints that include shoulder belts with the ability to adjust them to fit smaller passengers, including older children.

**Contexte :** L’efficacité des ceintures de sécurité pour réduire le nombre des décès causés par les collisions de véhicules à moteur est bien documentée. On a toutefois relevé une association particulière entre certains traumatismes et le port de la ceinture de sécurité chez les adultes et les enfants. Le «syndrome de la ceinture de la sécurité» désigne l’éventail des traumatismes associés aux ceintures ventrales, et en particulier les traumatismes de flexion-distraction de la colonne (fractures de Chance). **Méthodes :** Nous décrivons les traumatismes subis par huit enfants, dont deux paires de jumeaux, dans trois accidents de véhicules à moteur. **Résultats :** Tous les enfants prenaient place à l’arrière et portaient une ceinture ventrale ou à trois points. Tous ont subi une ecchymose causée par la ceinture ventrale et de multiples traumatismes abdominaux à cause du mécanisme usuel de compression par la ceinture de sécurité avec hyperflexion et distraction au cours de la décélération. Cinq des enfants ont subi une fracture à la colonne lombaire et quatre sont demeurés paraplégiques en permanence. **Conclusions :** Ces incidents démontrent qu’il faut être vivement conscient du spectre complet des traumatismes intra-abdominaux et rachidiens, à la suite de collisions de véhicules à moteur, chez les enfants passagers attachés, ainsi que de la présence des ceintures arrières à baudrier et de la possibilité de les ajuster pour des passagers plus petits, y compris des enfants plus âgés.

School-aged children are a special group with respect to occupant restraint systems in motor vehicles. Four- to 9-year-old children outgrow the child safety seats designed for younger children and are frequently restrained in seat belts designed for adults.<sup>1</sup> Compared with

infants and younger children, school-aged children have a lower centre of gravity, and their body habitus differs from that of adults in 2 ways: the intra-abdominal organs are less protected by the bony thorax and pelvis, and the iliac crests are not adequately developed to serve as anchor points

for the belt, allowing the belt to ride up over the abdomen.<sup>2</sup>

The efficiency of seat belts in reducing deaths from motor vehicle crashes is well documented.<sup>3</sup> A unique association of injuries, however, has emerged in adults and children with the use of seat belts.<sup>4-7</sup> The

From the Departments of \*Pediatrics and †Surgery, Faculty of Medicine, Université de Sherbrooke, Sherbrooke, Que.

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**Correspondence to:** Dr. Miriam Santschi, Département des Soins Intensifs, Hôpital Ste-Justine, 3175, ch. Côte Ste-Catherine, Montréal QC H3T 1C5; fax 514 345-7731; miriamsantschi@yahoo.com

“seat-belt syndrome,” first described by Garrett and Braunstein<sup>8</sup> in 1962, referred to the spectrum of injuries associated with lap-belt restraints. These injuries include partial- and full-thickness intestinal injuries, mesenteric disruption, lumbar spine dislocation and fractures. The entire class of seat-belt-related flexion-distraction injuries to the spine are commonly referred to as Chance fractures. These fractures are most likely caused by hyperflexion around a lap belt, with the belt acting as a fulcrum, subjecting the vertebrae to tension and distraction.<sup>9</sup> This mechanism of hyperflexion and distraction would explain not only these fractures but also the frequent association of intra-abdominal injuries as viscera are crushed between the lap belt and the spine. The spinal fractures are different in the pediatric population from those in adults. Children frequently have a combination of bone and soft-tissue injury. Their spinal injuries

commonly involve several levels, and paraplegia is seen more frequently. Several specific characteristics make children especially vulnerable to this kind of injury. They have a higher centre of gravity than adults, creating a greater distraction. Furthermore, because the iliac crests have not developed, the lap belt tends to be placed over the abdomen, contributing to the abdominal and spinal injuries during rapid deceleration.<sup>10</sup> In this case series we describe the different injuries sustained by 8 children including 2 sets of twins in 3 different motor vehicle crashes.

### Case analysis

Eight children (4 girls, 4 boys, ranging in age from 8–12 yr) involved in multiple-victim motor vehicle crashes were seen at the Centre Hospitalier Universitaire de Sherbrooke between September 2000 and May 2001 (Table 1<sup>11</sup>).

The first accident (crash 1 in Table 1) included 3 siblings (1 girl and twin boys). The minivan in which they were passengers collided head-on with a light truck at high speed (100 km/h). The front seat passenger was killed on impact. The second accident (crash 2) involved twin girls riding in the rear seat of a passenger car. The vehicle collided head-on with another passenger car at high speed. The third accident (crash 3) involved 3 children. The driver lost control of a minivan at high speed, and the van rolled over.

### Case example

This 12-year-old girl was restrained in the back seat of a minivan at the time of a head-on collision. She had lost consciousness when emergency personnel arrived. On admission, her Glasgow Coma Scale score was 5. She was tachycardic (heart rate 150 beats/min) and hypotensive (blood

**Table 1**

**Type of restraint and injuries sustained by 8 children involved in multiple-victim motor vehicle crashes**

Age, yr	Sex	Type of restraint	Location of injury	Extent of injury	Follow-up
<b>Crash 1</b>					
12	F	3-point	Abdomen, thorax, brain, spine	Hepatic laceration (grade III),* shattered kidney, small-bowel laceration (grade IV),* transection of small bowel, segmental duodenal tissue loss (D3), diaphragmatic laceration, multiple mesenteric tears, right hemothorax, pulmonary contusion, subarachnoid hemorrhage, small subdural hematoma, hemorrhagic contusion, T12–L1 Chance fracture with paraplegia	Rehabilitation Paraplegic
9	(Twin) M	Lap belt	Abdomen, spine	Mesenteric laceration, jejunal laceration, L1–L2 Chance fracture with paraplegia	Rehabilitation Paraplegic
9	(Twin) M	Lap belt	Abdomen, spine	Small-bowel laceration (grade II),* mesenteric tear, L1–L2 Chance fracture with paraplegia	Rehabilitation Paraplegic
<b>Crash 2</b>					
8	(Twin) F	Lap belt	Abdomen, spine	Multiple jejunoileal lacerations, devascularization of jejunum, avulsion of colic serosa, avulsion of abdominal muscles, L3 Chance fracture without spinal cord injury	Normal
8	(Twin) F	Lap belt	Abdomen, spine	Transection and devascularization of jejunum, devascularization of transverse colon, mesenteric tears, L1 Chance fracture with paraplegia	Paraplegic
<b>Crash 3</b>					
9	M	3-point	Abdomen, thorax, brain, extremity	Iliac fracture, psoas hematoma, pulmonary contusion, occipital and parietal hemorrhagic contusion, Salter II fracture of radius, transverse cubital fracture	Normal
9	F	Lap belt	Abdomen	Mesenteric tears and colon serosal tears	Normal
9	M	3-point	Abdomen, thorax, brain, extremity	Avulsion of abdominal muscles, pulmonary contusion and respiratory failure, concussion, fracture of right femur	Post-traumatic headache

Note: all children were rear seat passengers, and all had abdominal wall ecchymosis.  
\*Organ injury scales according to Moore EE et al.<sup>11</sup>

pressure 70/palpable mm Hg). Her condition improved after 1-litre bolus of crystalloid.

Pertinent physical findings included an area of ecchymosis just above the umbilicus, abdominal distension and guarding. Rectal sphincter tone was absent. The lower extremities were flaccid, and deep tendon reflexes were absent bilaterally.

Because of her hemodynamic instability, she was taken rapidly to the operating room, and a damage control approach was used. An incision was made from the xiphisternum to the pubis. Immediate bleeding control was necessary, and this was initially achieved with 4-quadrant packing with multiple large abdominal packs. Renal injury with an expanding hematoma was dealt with by right nephrectomy. Bleeding liver injuries were treated with large hemostatic sutures and packing. A large right diaphragmatic laceration was closed. Bleeding mesenteric and mesocolon lacerations were sutured. Aortic control was necessary at this stage and was achieved at the diaphragmatic hiatus by aortic cross-clamping. The duodenum was found to be transected 1 cm distal to the papilla of Vater with a 5-cm duodenal gap distal to the injured area. The proximal duodenum was closed temporarily, carefully preserving the papilla, with adequate external drainage. The distal duodenum was closed proximal to the ligament of Treitz. Packing to control nonarterial hemorrhage allowed the girl to be transferred to the intensive care unit to continue resuscitation and correct her coagulopathy and hypothermia. Abdominal closure was rapid and temporary. Only the skin was closed with multiple towel clips.

The patient was actively warmed. Perfusion was restored by intravenous infusion of warmed crystalloid, administration of blood and inotropic support. Coagulopathy was treated by giving fresh frozen plasma, cryoprecipitate and platelets, and correcting hypothermia and acidosis.

The spine was visualized by plain film radiography, which showed a Chance fracture at T12-L1 (Fig. 1). Open reduction and posterior stabilization of the spine were done. There was no neurologic recovery.

Twenty-four hours later, the remaining small intestine was completely viable. Cholecystectomy, gastrostomy and pyloric exclusion were performed with adequate drainage of the duodenal stump, and a feeding jejunostomy was established. After full recovery of nutritional status, 4 months after injury, a gastrojejunostomy and a Roux-en-Y jejunoduodenostomy were performed to reestablish duodenal continuity. Her general condition improved and no major abdominal complication was noted at follow-up. The patient returned home after undergoing treatment in a rehabilitation centre.

## Discussion

The children in this series demonstrate that, with the common mechanism of seat-belt compression with hyperflexion and distraction during deceleration in a motor vehicle crash, the physician should consider the complete spectrum of spinal and intra-abdominal injuries when a school-aged child has been restrained by a seat belt and been involved in such a motor vehicle crash. The impact of a relatively high-riding restraint compresses the fixed duodenum against the lumbar spine, leading to a high rate of injury.

Crash 1 resulted in a family disruption; 1 of the parents died and the 3 surviving children were paraplegic. The prevalence of this syndrome may be rare (0.4%), but the burden of injuries is of great importance.<sup>2</sup>

The hallmark indicator of the seat-belt syndrome is abdominal wall ecchymosis, suggesting the pattern of a lap belt.<sup>12</sup> Many children with abdominal injury caused by blunt trauma have equivocal or absent physical findings. Peritoneal signs may be missed in presence of the as-

sociated tender rectus muscle hematomas or contusions. All of the children in our series had abdominal wall ecchymosis, and 6 of the 8 had hollow-viscus injuries. Repeated physical examinations of the abdomen are mandatory as the signs of peritoneal irritation can be missed when the child arrives at the hospital. Furthermore, diagnosis of hollow-viscus injury in children is difficult even with CT and only a close clinical follow-up can help identify children with these injuries.<sup>12-14</sup>



FIG. 1. Plain film of the lumbar spine shows a Chance fracture at T12-L1.

In contrast to abdominal wall ecchymosis, Chance fractures are more readily catalogued because the radiologist often acts as a second screen in identifying such fractures.

In our patients, all 5 children with a Chance fracture had hollow-viscus injury. Albanese and associates<sup>15</sup> reported a 17% incidence of Chance fractures with a hollow-viscus lesion in children but did not include the frequency of Chance fractures for all blunt trauma patients during the study period. Examining the epidemiologic characteristics of seat-belt-associated injuries, Anderson and associates<sup>2</sup> found that 10 of 16 patients (62%) with Chance fractures had hollow-viscus injury.

To our knowledge, this is the first case series that reports on twins with seat-belt syndrome. It is also one of few reports of multiple pediatric victims with seat-belt syndrome.<sup>16</sup> These incidents illustrate the need for back-seat restraints that include shoulder belts and the ability to adjust them to fit small people, including older children. Most of the children described here were properly restrained in the back seat with lap belts only or 3-point belts. None of them was restrained in a booster seat. Adult seat belts do not provide protection equivalent to child safety or booster seats. In examining the relationship between type of restraint used (lap belt v. lap belt with shoulder harness) and injury pattern,

Anderson and associates<sup>2</sup> showed that lap belts were associated with an increased risk of hollow-viscus injury as well as Chance fractures. The proper fitting of lap belts and the addition of shoulder harnesses, or use of booster seats when appropriate, may affect this injury pattern and reduce the injuries described here.

**Competing interests:** None declared.

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