Seat Belt Syndrome: A global issue

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Abstract

Background: The seat belt does not alter the amount of force sustained in an accident, but it does alter the distribution of that force, in attempting to place it across the less vulnerable pelvic area. Its greatest usefulness is in the rollover type accidents and in preventing ejection from the vehicle.
The aim of the present study was to review the literature about the sea-belt.
Methods: An extensive literature search was performed aiming to identify and review research studies that investigate the causes and the consequences of the seat belt syndrome during the last 25 years. The databases that were searched were: the Cochrane Library, Medline and PubMed.
Results: There are a number of significant risk factors associated with seat-belt nonuse in the general public: male gender, young age, passenger status, risk-taking rural living, low level of education, black or hispanic ethnicity, having few dependents or children, smoking, speeding, alcohol consumption before driving and travelling on secondary roads late in the day. The seat belt syndrome is most commonly associated with using a lap belt, but has also been reported in occupants using three-point restraints. In these cases the patient often has cutaneous signs of injury with a lap belt mark. The seatbelt syndrome itself is characterized by injuries in the plane of the lap portion of the belt particularly with laceration of the colon, small bowel and occasionally the stomach, laceration of the liver and spleen, occasional injury of the pancreas, major vascular injuries. Some spinal injuries, such as lumbar spine or spinal cord injury are included in the 'seat-belt syndrome', but it is not clear whether or not these injuries are caused directly by the belt.
Conclusions: Seat belts are effective in reducing the incidence of major and fatal injuries in automobile accidents.

Key words: seat belt syndrome, injuries, abdominal, spinal

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Introduction

The belt does not alter the amount of force sustained in an accident, but it does alter the distribution of that force, in attempting to place it across the less vulnerable pelvic area. Its greatest usefulness is in the rollover type accidents and in preventing ejection from the vehicle[1]. The Automotive Crash Injury Research of Cornell University has shown that seat belts are effective in reducing the incidence of major and fatal injuries in automobile accidents [2]. Three-point lap and shoulder belts are designed to restrain the adult body frame. When properly worn the diagonal shoulder strap limits the forward motion of the occupant's upper torso and dissipates crash forces across the clavicles, sternum and thorax. The lap belt is designed to fit snuggly over the anterior superior iliac spines of the pelvis just above the femur. This placement prevents the forward motion of the lower body and absorbs the deceleration energy forces into the strong bony structures of the pelvis rather than the unprotected abdomen [3].

A study of the injury-effects of lap-type safety belt in light-plane accidents, completed by De Haven, Tourin and Macri in 1953, led to the following conclusions: 1) Safety belts are a very infrequent cause of injury and are not dangerous. 2) Safety belts provide protection for the body in crashes. 3) Injuries which may have seemed directly related to safety belts actually are determined by other factors such as failure of safety belt installations and vertically acting crash forces [4].

Materials and Methods

We searched MEDLINE, the Cochrane Library, and government, legal and other road-safety-related websites to extract information on road traffic accidents, policy, types and incidence of injuries, and knowledge and use of restraints by drivers and occupants. MEDLINE was searched via Ovid. We found 489 titles using the search terms "seat belt AND injuries" (limits: English language) and 213 titles using "lap belt". Our search focused on injuries associated with seatbelt and/or seating position for passengers travelling in motor vehicles. Of 702 abstracts identified, 79 articles were relevant for this review. Randomised controlled trials of restraints as intervention are not ethical and none were identified. We found one literature review and one Cochrane systematic review of the effectiveness of interventions to increase optimal restraint use. We excluded articles if there was no focus on type of restraint used or misuse of restraint; there was a lack of description of the types of injuries sustained; or it was a case report only.

We conducted an Internet search using the terms: seat belt legislation/law, safety belt, road fatalities, crash statistics, passenger deaths, and passenger injuries.

Results

The first report of the ACIR's study of road accidents was published in 1960[5]. After studying injuries to 933 front-seat occupants with seatbelts and 8784 without, Tourin and Garrett concluded that seat-belt users sustained 35% fewer major or fatal injuries than did non-users, although the overall number of injuries was comparable in the two groups. The seat-belts seemed to be most effective in rollover accidents, and this was probably owing to the prevention of ejection, which had been shown to be a major cause of death in road accidents [6].

The first most detailed statistical analysis was carried out by Kihlberg and Robinson [7] using the ACIR computer. From 50,000 tabulated accidents they matched 651 pairs for car make and year, direction of impact and severity of crash. They concluded that the relative risk taken by an occupant without a seat-belt was 70% higher than that for a belted occupant.

Use of seat belts reduces injury and saves lives in motor vehicle collisions (MVCs) [8]. Unbelted occupants involved in an MVC sustain significantly more trauma to the head, face, chest, abdomen and extremities [9]. Unbelted motorists also have a greater

hospitalization rate [10], are costly to the health care system [11], account for many lost years of productive life [12] and have a higher death rate when involved in MVC trauma[12]. These issues are particularly frustrating since MVC injuries are preventable. Despite the clear effectiveness of seat belts and the knowledge that MVCs are a major cause of injury and hospital admission [12], noncompliance with seat-belt laws in trauma patients involved in MVCs is very high. The reported rate of seat-belt use in this population is only 41%–43% [13], a rate that is markedly lower than the overall Canadian national rate of 88% [13]. The underlying reasons for this remain unclear. There are a number of significant risk factors associated with seat-belt nonuse in the general public: male gender [14-17], young age [14, 15], passenger status [14,15], risk-taking [16] rural living [15,16], low level of education [16], black or hispanic ethnicity [14], having few dependents or children, smoking, speeding, alcohol consumption before driving [16] and travelling on secondary roads late in the day[17]. However, there is a lack of comparable information pertaining specifically to the MVC trauma patient. Male sex, youth, nonwhite ethnicity and low annual income were each associated with seat-belt nonuse in these patients in one recent study[18]. Because of the lack of data, seat-belt compliance intervention programs have been forced to broadly target the population as a whole, rather the group most commonly injured during a collision.

Lerner and associates 18 reported independent associations between older age, female sex and driver status with seat-belt use in the injured adult population, others have reported younger age [14,15,18], male sex [19], passenger status [14,15,16], living in a rural community [16], low level of education21 and having a limited number of children or dependents [16] as risk factors predictive of seat-belt nonuse in the general public only.

The National Highway Traffic Safety Administration (NHTSA) estimates that lap and shoulder belts reduce the risk of fatal or critical injuries to front seat occupants (age 5 years and older) by 50 percent. Among passenger vehicle occupants over the age of four, safety belts saved an estimated 12.144 lives in 2001 [20]. Federal Motor Vehicle Safety Standards and Regulations have mandated lap-shoulder assemblies for each designated seating position in a vehicle since 1998. These regulations establish the industry standard for all automobiles produced or sold in the U.S.A.[21]

Injuries caused by seat-belts

Despite the series of reports stressing the protection afforded by the seat-belt there has been an increasing volume of literature suggesting that at the same time the seat-belts may produce injury. This has been reported mainly from the U.S.A., where lap-belts are the type almost universally used, and the injuries reported have been confined chiefly to the abdomen and lumbar spine.

As early as 1962, Garrett and Braunstein in the journal of Trauma reported on the "seatbelt syndrome", injuries occurring in those patients wearing lap belts [22]. They reported on 3.325 belted motor vehicle crash victims. Of these, 150 sustained injury to the lower torso, with only 26 serious injuries. The frequency of lower torso injuries among seatbelt users was essentially the same as injury to nonbelted crash victims. Since Garrett and Braunnstein`s first presentation, a number of reports have described injuries associated with the use of seat belts[23]. These injuries are believed to be caused by the force of deceleration directed through the seatbelt to the abdomen.

The seat belt syndrome is most commonly associated with using a lap belt but also has been reported in occupants using three-point restraints [24]. The seatbelt syndrome itself is characterized by injuries in the plane of the lap portion of the belt particularly with laceration of the colon, small bowel and occasionally the stomach, laceration of the liver and spleen, occasional injury of the pancreas, major vascular injuries and also lumbar spine or spinal cord injury.

The patient often has cutaneous signs of injury with a lap belt mark. There may be bruising, laceration, avulsion or other signs of direct trauma to the skin in the area of the lap portion of the seatbelt. These signs can aid the physician by increasing the suspicion that the patient may have suffered an abdominal injury.

Sato noted that proper positioning of the belt is over the pelvis at the level of the anterior superior iliac spines. He attributes intra-abdominal injuries to belts worn too loosely or improperly positioned higher on the abdomen. Most reports have implicated lap belts in these injuries. Fracture dislocations of the lumbar spine (Chance fractures) are seen with lap belts because of hyperflexion jackknifing of the upper and lower portions of the body against the seatbelt[25]. Occupants wearing shoulder lap, three point restraints sometimes sustained cervical and upper thoracic spine fractures induced by severe hyperflexion or extension of the neck. Occasional carotid and abdominal aortic injuries as well as chest wall trauma and hepatic injuries caused by seatbelt transmission of direct force into the body have been reported [36].

The seat belt syndrome includes injuries to the lumbar spine as well as intra-abdominal organs. The mechanism of injury is apparently hyperflexion over the fulcrum of the seatbelt, usually resulting in a transverse fracture of the lumbar vertebrae. LeGay noted the importance of recognizing this pattern of associated injury involving the use of seat belts with flexion distraction injury to the spine and intra-abdominal hollow viscous injury [27].

The entire class of seat-belt-related flexion-distraction injuries to the spine is 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. This mechanism of hyperflexion and distraction would explain not only these fractures but also the frequent association of intraabdominal 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 [28].

Before the use of seat belts, the majority of fatal automobile accident injuries involved striking the head against the windshield, impacting the face and chest against the steering wheel and dashboard, hitting the unrestrained body against roof and doors, or ejection of the victim from the car. The usual intra-abdominal injuries sustained involved primarily solid viscera. Jordan and Beall [29] reported that liver and spleen were injured with much greater frequency (61%) than were hollow viscera (28%).

The spectrum of injuries included in the seat belt syndrome is: abdominal contusions, intra-abdominal injuries and distraction-type lumbar–spine injuries [30]. The mechanism of such injuries is that the rapid deceleration caused by the seat belt results in the compression of the abdomen and in the flexion of the upper body [30]. Since its original appearance [29], safer versions of seat belts (three-point restrains) have been introduced. If, a three-point restrain seat belt is ill-fitting (loose), a young patient can 'submarine' beneath it so that the seat belt acts as a lap belt, with the axis of rotation located near the umbilicus [31]. Children have a higher centre of gravity than adults, which increases the lever-arm movement around the axis of rotation, thus causing greater destruction and making them especially susceptible to seat belt injuries of the spine. Four distinct types of seat belt injuries of the spine have been described [32].

The type of restraints and mainly their positioning contribute to the pattern of injuries. With lap belt, injuries include liver and spleen contusions, lumbar spine fracture (Chance fracture) with frequent neurological deficits, and digestive tract perforations, resulting from direct seat belt related abdominal compression, with distraction and hyperflexion to the dorsal spine during deceleration[33]. With lap shoulder harness, thoraco-abdominal injuries could include rib, clavicle, and sternum fractures; extensive pulmonary contusions; and liver and spleen lacerations[34]. Traumatic diaphragmatic

rupture, although rare, has also been reported in improperly restrained children and should be ruled out systematically [35]. Common carotid artery injury in blunt trauma is rarewith 0.08% to 0.33% incidence [36]. In a prospective study in patients with cervical seat-belt sign, a carotid artery injury was found in only 3% of the cases associated with ipsilateral thoracic fractures [37]. The most frequent lesions were acute CCA dissection, thrombosis, or pseudoaneurysm, but no case was reported in children. In high-speed motor vehicle accident, these injuries result from hyperextension/rotation forces and, less commonly, from direct blow to the neck.

The abdominal SBS is a term used to describe superficial abdominal wall injury caused by seat belt use. The term seat belt syndrome has been used by some authors to describe a particular pattern of injury sustained secondary to seat belt use that is associated with the presence of a SBS. The spectrum of injuries that comprises the seat belt syndrome includes fracture dislocations of the lumbar spine (chance fractures), mesenteric tears, hollow visceral blow-outs, and injury to solid intra-abdominal organs[38]. The risk of abdominal injury in the presence of SBS has been reported to be as high as 232 times more likely as in children without SBS [39].

Seat belts are designed to secure the occupant in the car seat by limiting forward excursion, thereby precluding collision with the steering wheel, dashboard, and windshield, and by preventing ejection. As the kinetic energy transfer during a collision is halted by the restraint device, it applies forces to the occupant that can potentially give rise to injury. During a collision, energy transfer from the shoulder component has been shown to impact the occupant's neck, cervical spine, supra-aortic vascular structures, thoracic spine, chest wall, and intrathoracic structures. The lap component has been shown to affect the lumbar spine, abdominal wall, pelvis, and intra- and retroperitoneal structures. These types of injuries occur when the restraints were worn properly and by occupants appropriate in size for their use. Typically observed combinations of these injuries were identified that led to the introduction of the "seat belt syndrome."[40]

Abdominal injuries

Kulowski and Rost described an adhesion between the mesentery of the ileum and the pelvic brim causing partial small bowel obstruction, and claimed that this was produced by pressure from a seat-belt in a car accident three months earlier. In Sweden, diagonal seat-belts were implicated in the production of upper abdominal injuries, such as ruptured spleen, liver and kidney. This problem was investigated by Garrett and Braunstein of the ACIR, who studied 2778 ears with 3673 occupants, at least one of whom in each car was wearing a seat-belt. They found seven cases of "internal injury". Unfortunately, no statistical comparison was made with similar injuries in non-users of seat-belts. All of the serious injuries were produced in high-speed crashes, and the authors felt that the belts prevented more injuries than they caused [2,13,34]. Since the publication of that report there have been numerous papers describing abdominal injuries attributable to seat-belts. These include rupture of the stomach, small and large bowel and omentum, spleen and the pregnant uterus and production of a ventral hernia. The statistical analyses of Kihlberg and Robinson tend to confirm that these injuries are indeed caused by seat-belts, rather than being coincidental, as the incidence of abdominal trauma was consistently higher in belted than in unbelted occupants, although other injuries were reduced. Of the 651 belted occupants, 30 had abdominal injuries which could be ascribed to seat-belts, but 27 of these were minor (bruises, abrasions), so that the incidence of severe trauma caused by seat-belts is 0.5%, which can favourably be set against an overall reduction of 59% in serious and fatal injuries. From a practical point of view, it was noted that seatbelt injuries were more common in front-seat passengers and in frontal impacts. It can therefore be assumed that seat-belts can be held

responsible for a variety of intra-abdominal injuries, but that these injuries are considerably less common and less serious that those which the seatbelt prevents [25,27,39].

Spinal injuries

Garrett and Braunstein included some spinal injuries in their study of the 'seat-belt syndrome', but it is not clear whether or not these injuries were caused directly by the belt. In most of the other cases reported the fractures were of the dompression type, and were thought to have been caused by hyper flexion over the belt. In some cases there were fractures of the pelvis, the articular processes of the vertebrae and the transverse processes: Many of these fractures can have a cause other than the seat-belt[13,25,33]. However, a unique pattern of fracture has been reported by Smith and Kaufer which they describe as follows: disruption of the posterior elements of the lumbar spineosseous, ligamentous or both; longitudinal separation of the disrupted elements; no (or minimal) compression of the vertebral body; no (or minimal) forward displacement of the superior vertebra or fragment; no (or minimal) lateral displacement; usually located between LI and L3, and a seatbelt contusion is usually visible. A particularly interesting variant of this fracture is one first described by Chance, in which there is a horizontal fracture of the vertebral body, spine and transverse processes. This has now been described again in seatbelt injuries by Smith and Kaufer, and also by Fletcher and Brogdon [24,34,38].

Conclusion

Seat belts are effective in reducing the incidence of major and fatal injuries in automobile accidents. Their greatest usefulness is in the rollover type accidents and in preventing ejection from the vehicle. The relative risk taken by an occupant without a seat-belt is 70% higher than that for a belted occupant. Injuries which may have seemed directly related to safety belts actually are determined by other factors such as failure of safety belt installations and vertically acting crash forces. The seat belt syndrome is most commonly associated with using a lap belt but has also been reported in occupants using three-point restraints. Injuries, such as abdominal contusions, intra-abdominal injuries and distraction-type lumbar–spine injuries are associated with the use of seat belts.

Bibliography

1. Campbell B.J. The automotive crash injury research program of Cornell University. J Iowa State Med Soc. 1961 Dec;51:760-2.
2. Cocke W.M., Meyer K.K. Splenic rupture due to improper placement of automobile safety belt. JAMA. 1963 Feb 23;183:693..
3. McSwain NE. Kinematics of teauma. In Mattox KL, Feliciano DV, Moore EE, eds. Trauma. New York: McGraw Hill; 2000: 127-151.
4. DeHaven, H., Tourin, B., Macri, S. Aircraft safety belts: their injury effect on the human body. Published by Crash Injury Research of Cornell Univ. Med. College, New York, 1953.
5. Tourin B., Garrett J. W.: Safety belt effectiveness in rural California automobile accidenla; a comparison of injuries to users and non-users of safety belts. Automotive Crash Injury Research of Cornell University, New York, 1960.
6. Backstrom CG. Traffic injuries in south Sweden; with special reference to medico-legal autopsies of car occupants and value of safety belts. Acta Chir Scand Suppl. 1963;Suppl 308:1-104.
7. Kihlbero J. K., Robinson S.: In: Automotive Crash Injury Research Report no. VJ-1823-R30, Cornell University, New York, 1967.
8. U.S. Department of Transportation National Highway Traffic Safety Administration National Centre for Statistics and Analysis. Traffic safety facts. Washington: Department of Transportation; 1997.

9. Orsay E., Dunne M., Turnbull T. Prospective study of the effect of seatbelts in motor vehicle crashes. Ann Emerg Med 1990;19:258-61.
10. Peterson T. Trauma prevention from the use of seatbelts. Iowa Med 1987;77:233-6.
11. Runge J. The cost of injury. Emerg Med Clin North Am 1993;11:241-53.
12. Centers for Disease Control and Prevention (CDC). Systematic review of strategies to prevent motor vehicle injuries. Atlanta: CDC; 1999.
13. Porter R., Zhao N. Patterns of injury in belted and unbelted individuals presenting to a trauma center after a motor vehicle crash: seat belt syndrome revisited. Ann Emerg Med 1998;32:418-24.
14. Transport Canada. Seat belt use in Canada survey results. November 21, 2002. Available: www.tc.gc.ca/mediaroom/releases/nat/2004/04-h107e.htm (accessed 2004 Nov 25).
15. Eby DW., Vivoda JM., Fordyce TA. The effects of standard enforcement on Michigan safety belt use. Accid Anal Prev 2002;34:815-23.
16. Sahai V., Pitblado R., Bota G., Rowe B. Factors associated with seat belt use: an evaluation from the Ontario Health Survey. Can J Public Health 1998;89:320.
17. Baker DR., Clarke SR., Brandt EN. An analysis of factors associated with seatbelt use: prevention opportunities for the medical community. J Okla State Med Assoc 2000;93:496-500.
18. Lerner EB., Jehle DV., Billittier AJ., Moscat RM., Connery CM., Stiller G. The influence of demographic factors on seatbelt use by adults injured in motor vehicle crashes. Accid Anal Prev 2001;33:659-62.
19. Petridou M. Person, time and place predictors of seat belt use in Athens, Greece. J Epidemiol Community Health 1998;52:534-5.
20. National Highway traffic Safety Administration. Traffic safety facts 2001: Occupant protection (DOT HS 809 474). Available at http://www.nhtsa.dot.gov. Accessed January 17, 2003.
21. National Highway traffic Safety Administration. Federal motor vehicle safety standards and regulations (1998). Available at http://www.dot.gov/cars/rules/standards/safstan2.htm. Accessed January 17, 2003.
22. Garrett JW., Braunstein PW: The seat belt syndrome. J Trauma. 1962 May;2:220-38.
23. Reid AB., Letts RM., Black GB: Pediatric chance fractures: Association with intra-abdominal injuries and seatbelt use. J Trauma. 1990 Apr;30(4):384-91.
24. Yu WY., Siu CM.: Seat belt injuries of the lumbar spine-stable or unstable? Paraplegia. 1989 Dec;27(6):450-6
25. Sato TB.: Effects of seat belts and injuries resulting from improper use. J Trauma. 1987 Jul;27(7):754-8.
26. Gumley G., Taylor T., Ryan MD.: Distraction fractures of the lumbar spine. J Bone Joint Surg Br. 1982;64(5):520-5.
27. Asbun HJ., Irani H., Roe EJ., Bloch JH.: Intra-abdominal seatbelt injury. J Trauma. 1990 Feb;30(2):189-93.
28. Smith WS., Kaufer H. Patterns and mechanisms of lumbar injuries associated with lap seat belt. J Bone Joint Surg Am 1969; 51:239-54.
29. Howland WJ., Curry JL., Buffington CB. Fulcrum fractures of the lumbar spine. Transverse fracture induced by improperly placed seat belt. JAMA 1965; 193:240–241.
30. Prince JS., LoSasso BE., Senac MO Jr. Unusual seat-belt injuries in children. J Trauma 2004; 56:420–427.
31. Smith WS., Kaufer H. Patterns and mechanisms of lumbar injuries associated with lap seat belts. J Bone Joint Surg Am 1969;51:239–254.
32. Agran PF., Dunkle DE., Winn DG. Injuries to a sample of seat-belted children evaluated and treated in a hospital emergency room. J Trauma 1987;27:58–64.

33. Rumball K., Jarvis J. Seat-belt injuries of the spine in young children. J Bone Joint Surg Br 1992;74:571–574.
34. Anderson PA., Rivara FP., Maier RV., Drake C. The epidemiology of seatbelt associated injuries. J Trauma. 1991;31:60Y67.
35. National Highway traffic Safety Administration. Traffic safety facts 2001: Occupant protection (DOT HS 809 474). Available at http://www.nhtsa.dot.gov. Accessed January 17, 2003.
36. Shehata SM., Shabaan BS. Diaphragmatic injuries in children after blunt abdominal trauma. J Pediatr Surg. 2006;41:1727Y1731.
37. Lew SM., Frumiento C., Wald SL. Paediatric blunt carotid injury: a review of the national paediatric trauma registry. Pediatr Neurosurg. 1999;30:239Y244.
38. Achildi O., Betz RR., Grewal H. Lapbelt injuries and the seatbelt syndrome in pediatric spinal cord injury. J Spinal Cord Med. 2007; 30(suppl 1):S21–S24.
39. Lutz N., Nance ML., Kallan MJ., Arbogast KB., Durbin DR., Winston FK. Incidence and clinical significance of abdominal wall bruising in restrained children involved in motor vehicle crashes. J Pediatr Surg. 2004;39:972–975.
40. Richter M., Otte D., Pohlemann T., Krettek C., Blauth M. Whiplash-type neck distortion in restrained car drivers: frequency, causes and long-term results. Eur Spine J. 2000 Apr;9(2):109-17.