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Seat Belts and Human Rights: An Appraisal

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ABSTRACT: Mandatory seat belt legislation has been passed in 15 states. Accompanying this action has been a deluge of information concerning the lives saved and the injuries prevented by the wearing of seat belts by the front seat passengers in automobiles. This study presents data relating to the injuries and deaths attributable to their usage. There is virtually no major area of the adult body that has escaped such involvement. Mechanisms by which seat belt injury is effected are described in relation to the restraint systems currently available in the United States and abroad.

KEYWORDS: pathology and biology, automobile seat belts, injuries, pathology of seat belt injury, mechanisms of seat belt injury

Perhaps the earliest report of human injury resulting from the use of seat belts was that of Teare, who in 1951 described several cases of rupture of the thoracic and abdominal aorta sustained by individuals who were involved in a Comet aircraft accident in England [*1,2*]. The information derived from autopsies on these victims yielded the conclusion that these injuries resulted from the seat belt causing extreme lateral flexion forces to be placed on the body as it was stretched over the arm of the seat occupied by the subject at the time of the accident. Five years later, Kulowski and Rost [*3*] reported a case of delayed ileal obstruction by fibrous adhesions following abdominal injury from a seat belt.

In 1960, the seat belt was introduced into the automotive world. This device was patterned after the internal restraint systems already used in aircraft. Its rationale was the prevention of body ejection in the event of rapid deceleration of the vehicle. In these early years of seat belt usage, however, there was some speculation that seat belt injuries might arise from defects within the restraining system itself, expressed as failure of the belt material or of its installation [*4*].

The pioneer study of automobile seat belt injuries made by Garrett and Braunstein in 1962 [*5*] generated data on 2778 automobile accidents in which at least 1 front seat occupant was wearing a seat belt. These cars contained 3673 occupants: 3325 occupants wore belts; 348 did not. In these cars, there were 1000 belt users and 181 nonbelt users; injury was sustained by 944 seat belt users. In their study, Garrett and Braunstein introduced the term "seat belt syndrome" to describe the injuries directly attributable to the use of automotive restraining systems.

The automobile seat belt failed to gain initial public acceptance, perhaps a result of its

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relatively poor construction, inadequate frame anchoring, complicated buckling system, and its inconvenience. But the seat belt, at first optional, became a standard automotive accessory item by the mid-1960s.

Lagging public usage encouraged the government to pressure the automotive industry into doing something to prevent the many accidents attributed to the absence of a restraint system. Alternatives to seat belts were developed, such as a complicated air bag apparatus that would become operable only in the event of a front-end crash. This device has proven costly and impracticable.

In an attempt to arouse favorable public opinion for the usage of restraints in cars, many state governments encouraged statisticians and experts in the field of public safety to report only positive findings regarding the use of these devices. Such data would free the automotive industry from having to install the more costly air bag systems because of governmental influence, ultimately pricing their products beyond the reach of many potential customers.

Predictions were made by many safety experts, among them some physicians, of many thousands of additional traffic deaths that would result each year in the absence of seat belt usage. Eventually some states began to move toward mandatory seat belt legislation. New York, New Jersey, and Illinois were the first states to adopt laws requiring the use of front seat belts by both the driver and passenger, under penalty of monetary fines. By July of 1985, eleven additional states had adopted mandatory seat belt legislation; four others, namely, Ohio, Pennsylvania, Wisconsin, and Washington, DC, are considering such action.

The material to be discussed is not intended to project any moral judgments, nor is it intended to infer a rate of incidence beyond about 2% of all vehicular injuries; its sole purpose is to relate that aspect of the "seat belt story" that is left untold.

There are two principle types of automotive restraint systems in common usage in recent years. One is the air bag system which thus far has proven to be of value only in head-on collisions; its expense and general impracticability have severely limited its development. The other is the seat belt, or lap restraint system.

This latter system has three principal components (Fig. 1). The first is the lap belt, often used synonymously with the term "seat belt." The second component is the two-point diagonal system, a combination of the lap belt and a shoulder strap or belt attached to it. The third is the three-point system which combines the lap belt with two shoulder belts that cross in the center of the chest, usually over the sternum, to be attached to the lap belt. The belts in these various systems, if properly installed, are anchored to the automobile frame at some point. The basic design of these is aimed at achieving an arrest of the forward and lateral motion of the human body in the event of sudden vehicular deceleration. In such a situation, the body, its motion arrested, may form a fulcrum at some point of its contact with the

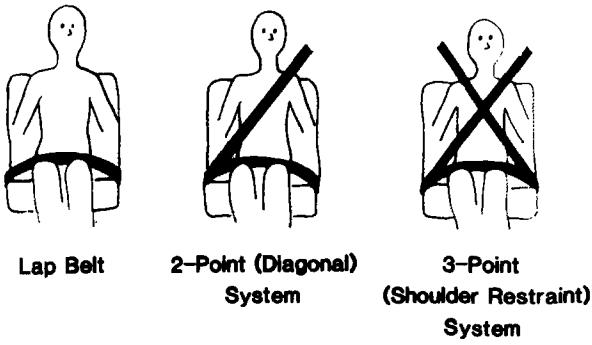

FIG. 1—*Forms of automobile restraint systems in current use.*

restraining system; physical energy is transmitted to the interior of the body, adversely affecting soft tissues, ligaments, and bone (Fig. 2).

An in-depth study by Williams and Kirkpatrick [*6*] has defined the nature of these injuries in both sexes from the first to the seventh decade of life. Most frequently the age was under 35, men being affected about twice as commonly as women. When only the lap belt was employed, the area of injury was often confined to the abdominal wall, with occasional deeper visceral injury. Another area affected by the lap belt injury is the lumbar vertebral column. Injuries here included ligamental rupture, anteriorly displaced vertebral dislocation and fracture, and disk extrusion. In addition, fractures of the vertebral laminae and articular processes also occurred. Splenic rupture, omental detachment, and ruptures of the liver and diaphragm have also occurred. Tears in the mesentery occurred more often in the jejunal and ileal area than in the colon. A summary of these injuries appears in Table 1.

Damages associated with the two-point system are related to fractures of the ribs, sternum [*7*], cervical, thoracic, and lumbar vertebrae. Upper thoracic soft tissue injuries are associated with contusions, abrasions, and lacerations of the skin in contact with the belt (Figs. 3 and 4). If the belt twists (Fig. 5), the edge is capable of exerting an incising action upon the cervical integument and deeper structures.

Injuries related to the three-point shoulder restraint system are represented by fractures of the cervical and upper thoracic vertebrae, ribs, sternum, and clavicles. Dermal contusions may also appear over the chest, shoulder, neck, and back. Slippage over the lap belt is thought to be the cause of the perforation of the small intestine noted by Williams [*6*].

The use of seat (lap) belts by pregnant women has resulted in several types of injury. Among these are retroperitoneal hemorrhage which had a higher incidence than in nonpregnant women. Retroperitoneal hemorrhage is encouraged by the myriad of small vessels within the broad ligament and the general increase in vascularity that accompanies pregnancy. It has been estimated that a quantity approaching 4 L of blood escaping from engorged pelvic veins can be contained within the retroperitoneal area [*8*]. Elliot has reported that ruptures of the spleen, liver or mesenteric lacerations can elicit severe hemorrhage, prompting fetal death [*9*].

The uterus itself appears to suffer minimal injury during the first trimester of pregnancy since it is well protected by the bony pelvis. Injury at this stage of pregnancy is most often due to pelvic fractures with direct penetration by the bony fragments. Such pelvic injury is rarely attributable to the seat belt.

The uterus, rising out of the pelvis during the last trimester of pregnancy, is subject to seat belt injury at that time. The organ, however, is protected by the anterior abdominal wall, the urinary bladder, and coils of intestine. The fluid content of the gravid uterus also affords a measure of security for the fetus. Rupture of the uterus has been reported as a result of the compressive effect of severe antero-flexion of the body against the fixed point created by the

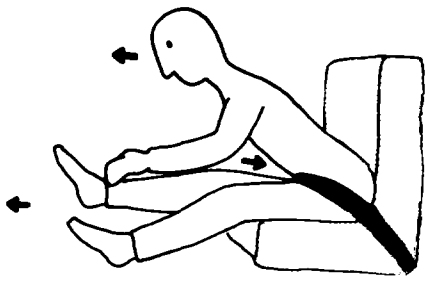

FIG. 2—*Mechanism of abdominal belt injury in the event of rapid deceleration.*

TABLE 1—*Primary areas of seat belt injury.*

Cervical area	cervical vertebral and ligaments
Thoracic area	ribs, sternum, clavicle, and thoracic vertebral bodies
	abrasions of skin
Abdominal area	lacerations and/or rupture of liver, spleen, pancreas, and small and large intestines
	injuries to the biliary system
	injuries to lumbar vertebral bodies, ligaments, and disks
Pelvic area	fractures of the ilium, pubic rami, and ischium
	injuries to the urinary bladder
	injuries to the uterus in the latter months of pregnancy
	disruption of the placenta
	fetal deaths
Lower extremities	fractures of the ankles
	injuries to the lateral femoral-cutaneous nerves by direct trauma, causing hematoma of soft tissues in the region of the anterior superior iliac spine
	nerve expression or interference with blood supply

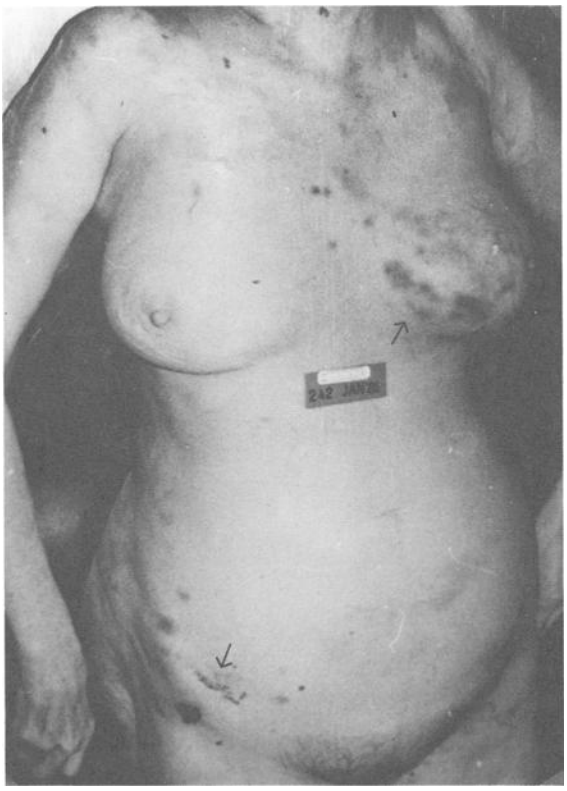

FIG. 3—*Skin abrasions resulting from contact with the shoulder and lap components of the two-point restraint system incurred during a fatal automobile collision.*

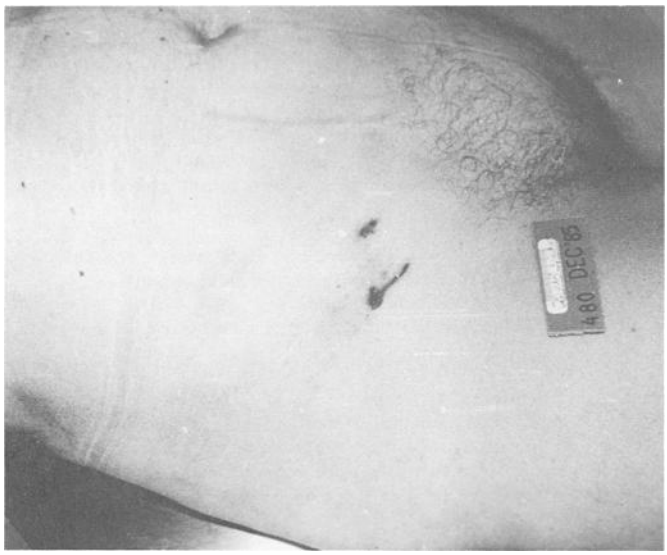

FIG. 4—*Abdominal abrasion resulting from lap belt injury during rapid deceleration in a fatal collision.*

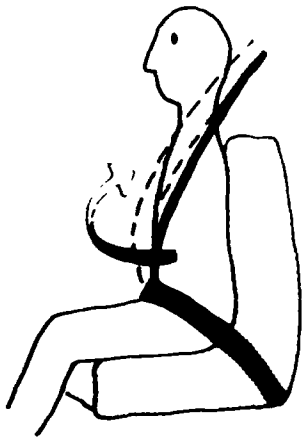

FIG. 5—*Twisting effect of the shoulder component of the two-point system.*

lap belt, but more often, as reported by Crosby and Costiloe [*10*], the uterus and its contents remain intact in such situations.

The violent movements associated with vehicular collisions often lead to the disruption of the placental attachments. Because the placenta does not contain elastic fibers, changes in its configuration, by stretching or contracting, to adapt to sudden increases or decreases in the area of its attachment to the uterine wall, may eventuate in detachment. Rupture of the uterus, however, is not common. The villi, which anchor the placenta, may be sheared off by the violent motion. Placental separation, infarction, and hematoma formation can accompany such injuries.

It has been reported that if 10 to 25% of the placenta surface is affected, labor will frequently be induced. If 50% is affected, fetal death is inevitable [*11*]. This represents the most significant effect of seat belt injury upon the fetus itself. Although fetal injury can result from the penetration of the uterus, fetal injury from seat belt usage is uncommon. The only exception to this is the crushing of the fetal head by the seat belt buckle during the flexion of the mother's body over the belt, reported by Crosby [*12*]. Fractures of the pubic rami have induced fractures of the fetal skull, but this is not a common occurrence in belted subjects. Other fetal injuries include rupture of the spleen and liver.

The automobile restraining systems currently used are designed to have three beneficial effects during a collision: they allow the occupant to decelerate within the car in the initial milliseconds when energy-absorbing structural deformation of the vehicle occurs [*13–15*]; they may prevent a second collision between the victim and the interior structures of his vehicle; and they may deter ejection of the victim during or immediately after impact.

Mechanisms of Seat Belt Injury

The current automotive restraining system, best exemplified by the single lap belt, is capable of inflicting a variety of injuries. The trapping of the victim in a car, either submerged in a body of water or set aflame in an accident or explosion, is associated with the restraint system. Because the subject cannot free himself from the belting system, either because of a defective buckle or because he rapidly loses consciousness, death will follow by drowning or conflagration. This represents about 0.5% of all seat belt injuries [*16*].

In general, the abdominal area bears the brunt of injury in conditions of rapid and unexpected deceleration [*15, 16*]. In such a situation, several possibilities for injury exist. First is direct trauma, in which the skin of the abdominal wall is subjected to abrasions and contusions by the overlying belt (Fig. 6). Second, the rapid deceleration of a vehicle may generate sufficient force applied directly through the lap belt to injure the abdominal viscera, depending upon the position of the belt.

Injuries to the small intestine and its mesenteric attachments have also been noted. The mechanism for this type of injury results from direct trauma to the bowel wall, causing the

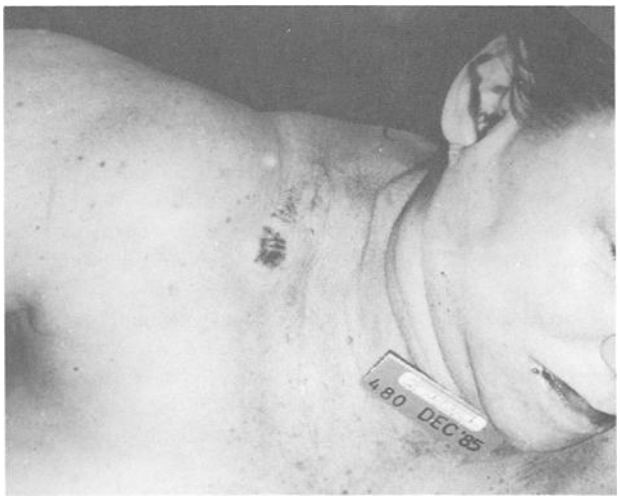

FIG. 6—*Skin and subcutaneous injury induced by twisting of the shoulder component of the two-point system.*

laceration of the small vessels in the mesentery and hematoma formation; the blood supply to the affected intestinal segment will be compromised and gangrene may result. In more extensive lacerations, the mesentery may be torn in a direction at right angles to the bowel axis [*17*].

The fourth type of small intestinal injury observed with seat belt usage is what has been termed by Williams as "entrapment" [*18*]. Here, a segment of the small bowel is forced by the unyielding lap belt against the posterior body wall; the result is the bursting of the intestine. Although this may occur from direct violence, it is more likely to occur in the latter circumstance.

The pancreas, liver, and spleen may suffer lacerations through this same mechanism of entrapment against the posterior body wall. The biliary ducts may also be ruptured by the force of blunt trauma [*19*], and the aorta may be disrupted [*20*].

The nonpregnant uterus and the uterus in the first trimester of pregnancy are well protected by the pelvic brim and rarely suffer injury in seat belt trauma. Even the enlarged uterus in late pregnancy, rising well above the pelvic brim, is often able to dissipate traumatic force in an efficient manner. Occasionally, rupture of the gravid uterus may occur when the force of deceleration is absorbed through the lower uterine segment, inducing a laceration of the myometrium [*21,22*].

In most circumstances, the urinary bladder, by its anatomic situation in the true pelvis, is well protected from these same forces. If the organ, however, is distended with urine, it is conceivable that pressure from the seat belt applied to the abdominal wall could be transmitted through the fluid content, inducing rupture of the detrussor muscle.

Vertebral Injuries

Injury to the vertebral column is reflected by fractures of the vertebral bodies, articular processes, and laminae, by rupture of the associated ligaments and disc extrusion, or by various combinations of these.

The three regions affected by seat belt injuries are the cervical, thoracic, and lumbar regions. The cervical vertebral bodies endure crushing injuries primarily from the use of the two- and three-point shoulder belt systems. The abdomen and thorax are firmly fixed against the seat, but in the event of a collision, the neck is hyperextended, and the head is thrown violently backward, producing fractures of the lower cervical vertebral bodies and rupture of the interspinous ligaments, an effect not unlike that induced by the hangman's noose (Figs. 7 and 8) [*23,24*]. Crushing injuries of the cervical and upper thoracic vertebral bodies have been reported from the same source and mechanism [*25,26*].

Injuries to the lumbar vertebral area result from a complex mechanism of compression, shear, and torsion acting either singly or in combination. The most common lumbar vertebral fracture is the simple compressive fracture at the thoracolumbar junction caused by a combination of hyperflexion around the lap belt fulcrum with an excessive vertical load from the upper portion of the body [*27,28*]. Although hyperflexion of the vertebral column is a critical factor in such injuries, Roaf has shown that this alone is not capable of producing either fracture or dislocation of the vertebral bodies [*29*]. Instead, it is a combination of hyperextension and increased vertical load with torsional (rotation) force that is responsible for the rupture of the interspinous ligaments and posterior disk extrusion.

The automobile seat belt in our modern day society is much like a two-edged sword. One edge may be equated with the prevention of deceleration injuries in vehicular accidents through its restraining action; the other edge, the one not usually exposed to public scrutiny, is associated with the data herein described.

The determination of which edge bears the most significance to human welfare may be controversial. Clearly evident, however, is the fact that only when full information becomes available can legislation be tailored to best serve the interests of the driving public.

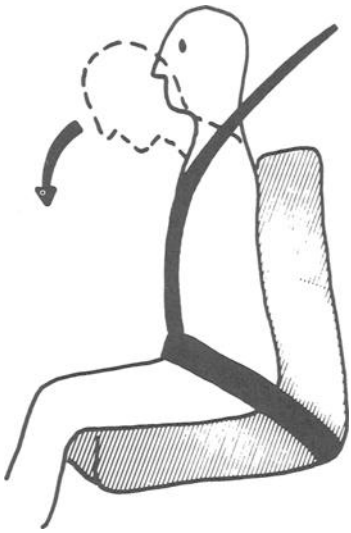

FIG. 7—*"Flopping action" of the head during the course of rapid deceleration when the chest and abdomen are firmly fixed by the three-point restraint system.*

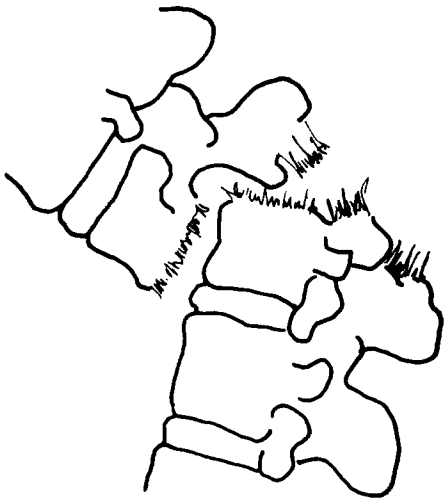

FIG. 8—*Vertebral and ligamental disruption incurred in the situation described in Fig. 7.*

Acknowledgment

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