SEAT-BELT INJURIES IN MEDICAL AND STATISTICAL PERSPECTIVES

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I. ABSTRACT

This paper reviews many findings from the medical literature regarding injuries to belt restrained adult occupants of motor vehicles. The review is limited to a subset of that literature in which restraint system contact forces were associated with the injury. Thus, injuries caused solely by internal loadings or by contacts with objects other than the lap or lap/shoulder restraint systems were generally excluded. Head and extremity injuries are therefore not discussed for either lap-only or lap-shoulder belt systems, nor are thoracic injuries considered for lap belt only systems. The injury rates seen in a recent decade of FARS (Fatality Analysis Reporting System) data for front outboard occupants of fatal frontal crashes are noted for comparison.

II. INTRODUCTION - HISTORICAL REVIEW OF OCCUPANT PROTECTION SYSTEMS

Motor vehicle accidents have grown to be a major cause of death and injury since the first known crash-related occupant fatality occurred in 1895. Fortunately, statistics indicate that the death rate in terms of fatalities per 100 million vehicle miles traveled has declined from a peak of 24.1 in 1921 to the present 1.7 (NHTSA, NCSA, 1997). The recent steady reduction in the fatality rate has been the result of a combination of a variety of factors including vehicle crash safety, engineering developments, and improved roadway design among others. Unquestionably, the most important motor vehicle crash safety innovation which contributed to that reduction has been the installation and proper use of seat belts.

The aircraft type lap belt was first incorporated into passenger car design by the Nash-Kelvinator Corporation in September 1949 with the introduction of the reclining front seat, but these belts were not widely used (Johannessen, 1984). The safety benefit afforded to users of these aircraft-type seat belts was confirmed by the Cornell Aeronautical Laboratories report issued in 1953 (Automotive Engineering, 1996). The American Medical Association was so convinced of the injury/death reduction potentials that in 1954 the Association voted to support the installation of lap belts in all automobiles (Consumer Reports, 1998). Ford Motor Company introduced the lifeguard safety package with its 1956 models which offered front and rear lap belts (Automotive Engineering, 1996). Chrysler Corporation also included lap belts as an option on some models in 1955 (Automotive Engineering, 1996; Chrysler Corporation, 1955). Chevrolet introduced the first lap/shoulder safety belts in 1957 (Automotive Engineering, 1996). Most U.S. automobile manufacturers provided lap belts as standard equipment at the front outboard seating positions in 1964 (Johannessen, 1984), and at the rear outboard seating positions for the 1968 model year (FHWA, 1967).

By 1/1/68, Federal Motor Vehicle Safety Standard 208 required lap and shoulder belts on all U. S. passenger cars. In 1974, a lap/shoulder seat belt (with non-detachable shoulder strap) in its basic form was required in all front outboard seating positions. Unfortunately, usage of belt systems remained quite low in the U. S. until the mid-1980's (NHTSA, 1998; Warner, 1997).

Passenger car restraint systems continued to evolve, with the phase-in of automatic occupant protection for front seat occupants in the form of either: (1) automatic seat belts, or (2) the combination of airbags and manual lap/shoulder belts beginning with the 1987 model year, and the installation of lap/shoulder belts for outboard rear seat occupants in cars manufactured on or after December 11, 1989 (NHTSA, 1984; 1989).

III. THE PERSPECTIVE ON THE MEDICAL LITERATURE OF BELT RELATED INJURIES.

Although few papers provide any reliable estimates of crash severity, many of the belt related injuries described in the medical literature surely have occurred in very severe crashes. They cannot be rationally related to any quantification of accident severity; neither can the information provided be used for inferences for overall injury rate or for estimates of belt effectiveness.

A useful source of information on belt effectiveness and injury rate in severe crashes in the United States is present in FARS, a census of almost every fatal crash in the United States since 1975, drawn from state police and death records. Although no quantitative severity information is presented, the FARS census is certainly representative of crashes within the upper levels of crash severity. The FARS census of front outboard occupants in severe fatal frontal crashes (initial force direction 11, 12 and 1 o'clock) was examined for the decade beginning in 1986, when U. S. mandatory belt use laws began to take effect and usage rates began to increase sharply in the U. S. (Warner, 1997).

During those ten years of FARS, over 270,000 occupants of fatal crashes were coded to have been unrestrained, lap-only or lap/shoulder belted, and restrained but type of "restraint unknown". The "restraint unknown", "child restraint" cases, and "unknown if restrained" cases are omitted from Table 1, which classifies the remaining cases as to fatal injury rates.

	Occupants	"K" Injury	"K" Injury Rate, %
"Unrestrained"	129,327	70,553	54.6%
"Lap/Only"	4,617	1,117	24.2%
"Lap/Shoulder"	81,461	20,561	25.2%
Total	215,405	92,231	42.8%

Table 1. Injury Rates vs. Coded Restraint Type FARS 1986-1995 Front Outboard Seat Occupants in Severe Frontal Crashes

Belt usage estimates for all occupants in the U. S. averaged about 40% over that decade. Fatal injury rates to belt users averaged about 25% in these severe crashes, regardless of the belt system used. The data leads to two important findings relating to these very severe frontal crashes. First, restraint usage is definitely helpful in prevention of fatalities and many severe injuries, even at the higher end of crash severity. Secondly, at these high severity levels lap-only and lap/shoulder belts appear to offer about the same level of injury reduction to front outboard occupants; distinctions in fatal injury rates between lap-only and lap/shoulder belts are not apparent at the severity levels represented by the FARS census data.

This finding of about the same injury rate to lap only and lap-shoulder belted outboard occupants of FARS frontal crashes has also been seen to be true for rear outboard seating positions (Warner, 1997; Padmanaban, 1998). This result is surprising when viewed against the background of conventional wisdom and many studies which have provided estimates of restraint system effectiveness. It should be kept in mind that like many of the severe injuries described in the following sections, the FARS data generally represent the higher end of the crash severity spectrum. The performance advantages of lap and lap-shoulder belts when used properly are unquestionable for low and moderate crash severities, and in many examples of severe crashes. Clearly, extreme impact distributions and structural intrusions are involved in many fatal frontal crashes, rendering any restraint system less effective.

The protective benefit afforded to users of all types of occupant restraint systems is well known and has been extensively documented. Several general injury reduction principles can be identified with restraint system design. Belt systems are expected to: (1) limit or mitigate to the extent practicable occupant interior contacts, (2) prevent occupant ejection, (3) extend the deceleration force distance of a collision by coupling the occupant with the crush characteristics of the vehicle (4) apply crash forces to the anatomically strongest portions of the human anatomy, and (5) be convenient and comfortable for the user.

Restraint system performance is often criticized by a perceived "failure" to prevent injuries under all accident circumstances and severities. As with any other form of technology, advancements or improvements are all too often prospectively lauded at the expense of earlier designs which were of value but were replaced by systems which held promise of greater benefit. Nowhere has this become more obvious than in the area of restraint system design. A recent example is demonstrative. In 1977, it was claimed that the implementation of driver airbag systems alone would save 96,000 lives per decade using a nominal projection (NHTSA, 1977). That estimate was incorrect by a large factor. In actuality, only approximately 1,700 lives have been saved in the decade 1986-1996 (NHTSA, 1997).

As belt system usage increased, terms like "seat-belt injuries" have come into wide circulation in the medical literature. This review examines many case reports which compare the types of injuries reduced by use of belt systems versus those injuries "caused" by the various belt systems used. The reader should be aware that, in general, the injuries in such studies arise from accidents in the higher severity range, and in some cases from improper seat belt use. The instances of no or minor injury consequences sustained by occupants using identical restraints systems in similar crashes are usually not reported. Further, the patients which comprise the majority of these "seat belt injury" reports in all probability, would have suffered serious or perhaps fatal injury if they had not been wearing seat belts. It is often forgotten that seat belts per se are not hazardous. Further, the issue of "causation" of certain types of injuries is the consequence of a variety of additional factors that can not be related to a specific type of restraint system to the exclusion of all others.

A proper engineering approach to injury analysis includes many physical and biomechanical factors influencing restraint system/occupant injury performance. It is difficult to assess the importance of these factors in the absence of an in-depth investigation of many crash factors not available to most medical authors. Among these are vehicle factors relating to crash severity and engineering factors such as seat design (geometry, structure, seat and interior trim). Other aspects of restraint performance include restraint design features such as anchorage geometry, webbing areas, webbing material elongation, force limiting energy absorbing devices, retractor behavior, and pretensioners. Also important are factors of occupant anatomy and crash tolerance such as stature, weight, age, gender, obesity and pre-existing health conditions. Further, usage variables can be pivotal to successful belt performance: anatomical positioning, pre-impact position, and belt slack being very important.

In contrast to a multi-disciplinary approach which could possibly discern many of these factors, most medical articles in this area simply contain assessments of the medical condition of patients seen in hospital emergency rooms with little or no information regarding the crash severity, the vehicle, and its restraint. While these reports are potentially of great value to a physician who may attempt to treat a similar injury in other cases, they offer little useful information to one who is interested in restraint effectiveness evaluation or design.

Seat belts (or any of many other injury reduction devices taken singly or together) do not constitute a panacea for all crash injuries. Used properly, they are a highly valuable and essential contribution to injury reduction. However, the fact that certain injuries are associated with each kind of restraint system in severe crashes must be kept in the context of the multiple injuries they help us to avoid.

IV. "INJURY TYPES" AND RESTRAINT SYSTEM DESIGNS

Since the first use of the term "seat belt syndrome" (Garrett, 1962), it has been employed extensively to describe those injuries associated with the restraining effect of both lap and lap/shoulder restraint systems (Asbun, 1990; Bibliography No. 62). Generally, those injuries are claimed to be the result of decelerative forces being directed through the restraint system webbing to the underlying anatomical structures (Pansky, 1984). The reviewed medical bibliography does not purport to be all-inclusive, comprising each and every publication on these injury types. Rather, it is meant, rather to provide a starting point from which more exhaustive research can commence for those interested in these injuries.

Injuries of various types are frequently associated with a particular type of restraint system. Lap belts have been variously reported as being the "cause" of lumbar spine fractures and various abdominal injuries. As will be seen, many of the cases reported as "lap belt injuries" come from medical case histories from the 1960's and 1970's.

Careful review of the papers indicates that similar injuries to these body regions have been documented in occupants using lap and occupants using lap/shoulder belt systems, again without controlling for accident severity. The literature reviewed is readily divided regarding injured skeletal and soft tissue systems as shown in figures 1 and 2 (Pansky, 1984; Pike, 1990):

- cervical spine/neck
- thoracic spine
- lumbar spine
- thorax and contents
- abdomen contents

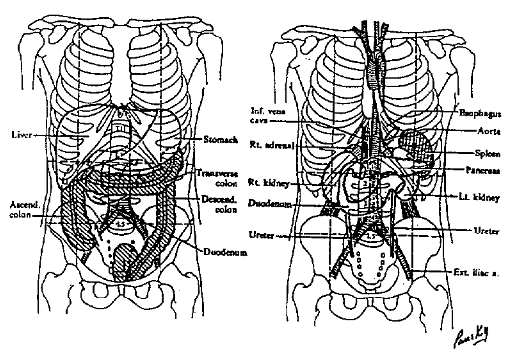

Figure 1. Topography of Abdomen and Thorax

(Pansky, 1984)

Table 2 identifies the specific citations for each region. Figure 3 (adapted from NHTSA, 1992) demonstrates the frequency distribution by region of numbers of citations reviewed. Table 3 gives a summary of reviewed citations regarding the 5 areas.

The authors were surprised to note that there were a greater number of citations relating to lap/shoulder belts than to lap belts in every anatomical region but one. Early citations were understandably linked predominantly to lap-belt-related injuries. These have been mistakenly cited out of context in some litigation situations as proof that addition of a shoulder belt would have prevented a specific injury. As is seen, this is not generally the case.

Some of the occupant injuries are reported as consequential injuries, resulting from contacts with the interior of the vehicle or other objects (Bibliography Nos. 18, 24, 33, 46, 52, 60,120, 128,129 refer to lap belt related cervical spine injuries among others). These are beyond the scope of this study.

V. DISCUSSION:

Perusal of the literature cited above provides a perspective on belt-related injuries in severe frontal crashes. The lumbar spinal and abdominal injuries often identified with lap belt forces applied above the bony pelvis are severe and often catastrophic. However, they are neither unique to the lap belt nor more severe than cervical spinal and carotid artery injuries which may result from lap/shoulder belt forces in other severe exposures.

It is clear that injuries will continue to occur in severe crashes, and that some of them will result from loadings which occur during contact with restraint systems which have been designed and proven to save lives and prevent injuries over the broad spectrum of crash severities.

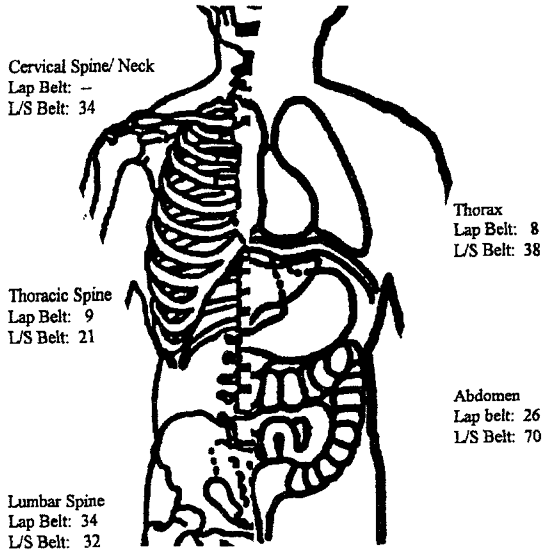

Figure 3 (NHTSA,1992). Frequency of Injury Citations by Type of Restraint

	Lap Belt	Lap/ Shoulder Belt	Not Specified or Other Belt
C-Spine/Neck	...	34	7
T-Spine	9	21	0
L-Spine	34	32	3
Thorax	8	38	4
Abdomen	26	70	17

Table 3. Summary of Injury Citations by Type of Restraint and Body Region

One is well advised to remember the overwhelming benefits of belt restraints in injury avoidance and mitigation while researching those relatively few cases in which injuries relating to restraint loadings, which result from the high forces generated in high-severity crashes.

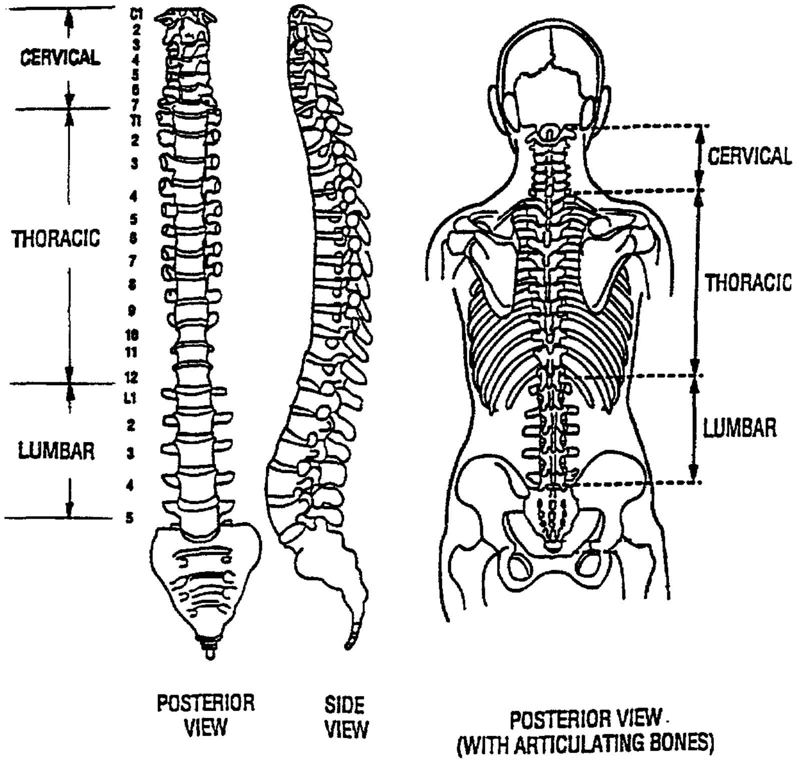

Figure 2. The Spine (Pike, 1990)

Body Region	Lap Belt Only	Lap/Shoulder Belt	Not Specified or Other Belt
C-Spine & Neck	0	12, 13, 18, 19, 24, 30, 32, 34, 35, 37, 39, 40, 41, 45, 46, 48, 52, 53, 60, 71, 86, 87, 89, 96, 116, 117, 118, 121-23, 126, 128, 129	34, 35, 46, 61, 85, 88, 127
T-Spine	18, 20, 24, 33, 38, 52, 120, 128, 129	6, 13, 18, 22, 24, 30, 39, 40, 48, 52, 63, 109, 116, 117, 118, 121-23, 126, 128, 129,	0
L-Spine	1, 3, 14, 18, 20, 22, 24, 29, 33, 38, 51, 52, 55, 69, 94, 96, 100, 101, 102, 103, 104, 105, 106, 107, 108, 110, 113, 114, 115, 119, 120, 124, 128, 129	1, 6, 14, 16, 17, 18, 20, 22, 24, 27, 29, 33, 38, 39, 40, 51, 52, 57, 63, 65, 69, 109, 116, 117, 118, 119, 121-23, 126, 128, 129	33, 125, 127
Thorax	24, 33, 52, 60, 100, 120, 128, 129	8, 11, 23, 24, 31, 32, 33, 39, 40, 44, 52, 54, 56, 57, 58, 60, 65, 69, 70, 71, 74, 78, 84, 90, 91, 96, 99, 111, 112, 116, 117, 118, 121-23, 126, 127, 132	9, 10, 33, 44
Abdomen	1, 3, 7, 14, 18, 20, 22, 24, 26, 29, 38, 47, 52, 55, 60, 69, 75, 97, 98, 114, 119, 120, 124, 128, 129	1, 2, 3, 4, 7, 8, 14, 15, 16, 17, 18, 20, 21, 22, 24, 25, 26, 27, 28, 29, 31, 33, 36, 37, 38, 39, 40, 42, 43, 44, 47, 48, 49, 50, 52, 55, 56, 57, 58, 59, 60, 62, 64-70, 72, 73, 75, 76, 81, 82, 91, 92, 111, 116, 117, 118, 119, 121-23, 127, 128, 129, 131	5, 9, 10, 33, 43, 44, 62, 73, 75, 77, 79, 80, 83, 92, 95, 125, 127

Table 2. Injury Citations by Type of Restraint and Body Region

REFERENCES

Asbun, 1990
H.J. Asbun, H. Irani, E.J. Roe, J.H. Bloch: "Intra-abdominal Seatbelt Injury." Journal of Trauma, Vol.30, No.2, 1990.

Automotive Engineering, 1996
Automotive Engineering: "The first 100 years of transportation safety: part 2." February, 1996.

Chrysler Corporation, 1955
Chrysler Corporation, Press Information Service #12755, April 26, 1955.

Consumer Reports, 1998
Consumer Reports: "Getting There Safely.", April, 1998.

FHWA, 1968
Federal Highway Administration, 49 CFR: 571,208; Standard No. 208; Occupant crash protection, 1968.

Garrett, 1962
J.W. Garrett, P.W. Braunstein: "The seat belt syndrome." Journal of Trauma, 2:220-238, 1962.

Johannessen, 1984
H.G. Johannessen: "Historical Perspective on Seat Belt Restraint Systems." SAE 840392, 1984.

NHTSA, 1977
National Highway Traffic Safety Administration, Federal Register; Docket No. 74-14, Notice 10. Vol. 42, No. 128, July 5, 1977.

NHTSA, 1984
National Highway Traffic Safety Administration, 49 CFR: 571.208; Docket No. 74-14; Notice No. 36; July, 1984.

NHTSA, 1989
National Highway Traffic Safety Administration, 49 CFR: 571.208; Docket No. 87-08; Notice No.5; November 2, 1989.

NHTSA, 1992
Adapted from: National Accident Sampling System-Crashworthiness Data System: Update Form; Form 433C. Revised January, 1992.

NHTSA, 1995
Fatal Accident Reporting System: Documentation data on CD-ROM. Transportation Data Center, The University of Michigan Transportation Research Institute.

NHTSA, 1997
National Highway Safety Administration, National Center for Statistics and Analysis, U.S. Department of Transportation. "Traffic Safety Facts 1996." DOT HS 808 649. December, 1997.

NHTSA, 1997
National Highway Traffic Safety Administration. "Air Bag Questions and Answers.", May, 1997.

NHTSA, 1998
National Highway Traffic Safety Administration. "Buckle Up America. First Report to Congress." January, 1998.

Padmanaban, 1998
J. Padmanaban, C.Y. Warner, U. Meissner, R. Bandstra: "Observations Relating to Rear Seat Belt Performance in Severe Frontal Collisions." 98SAF058. Proceedings of the 31st International Symposium on Automotive Technology and Automation. Duesseldorf, Germany. June 2-5, 1998.

Pansky, 1984
Adapted from: Pansky: "Review of Gross Anatomy." 5th edition, 1984.

Pike, 1990
Adapted from: J.A. Pike: "Automotive Safety." Society of Automotive Engineers, Warrendale, PA, 1990.

Warner, 1997
C.Y. Warner, U. Meissner, R. Bandstra, J. Padmanaban: "Usage and Effectiveness of Rear-Seat Belt Restraints in Severe Frontal Crashes." 97SAF063. Proceedings of the 30th International Symposium on Automotive Technology and Automation. Florence, Italy. June 16-19, 1997.

BIBLIOGRAPHY

1. Appleby, J, Nagy, AG,: "Abdominal Injuries Associated With the Use of Seatbelts". The American Journal of Surgery, Volume 157, May, 1989.

2. Gallup, BM, St-Laurent, AM, Newman, JA: "Abdominal Injuries to Restrained Front Seat Occupants in Frontal Collisions". 26th Annual Proceedings, American Association for Automotive Medicine, October 4-6, 1982.

3. Tso, EL, Beaver, BL, Haller, Jr., JA: "Abdominal Injuries in Restrained Pediatric Passengers". Journal of Pediatric Surgery, Vol. 28, No. 7, July, 1993.

4. Ryan, P, Ragazzon, R: "Abdominal Injuries in Survivors of Road Trauma Before and Since Seat Belt Legislation in Victoria". Aust. N.Z. J. Surg., Vol. 49 - No. 2, April, 1979.

5. Arajarvi, E, Santavirta, S, Tolonen, J: "Abdominal Injuries Sustained in Severe Traffic Accidents by Seatbelt Wearers". The Journal of Trauma, Vol. 27, No. 4, April, 1987.

6. Miniaci, A, McLaren, AC: "Anterolateral Compression Fracture of the Thoracolumbar Spine A Seat Belt Injury". Clinical Orthopaedics and Related Research, No. 240, March, 1989.

7. Snyder, C J: "Bowel Injuries from Automobile Seat Belts". The American Journal of Surgery, 1972.

8. Frydenberg, M, Royle, JP, Hoare, M: "Blunt Abdominal Aortic Trauma". Aust. N.Z. Surg. 1990.

9. Wisner, DH, Chun, Y, Blaisdell, FW: "Blunt Intestinal Injury".Arch Surg, Vol 125, October, 1990.

10. Hill, JR, Mackay, GM, Morris, AP, Smith, MT, Little, S: "Car Occupant Injury Patterns with Special Reference to Chest and Abdominal Injuries Caused by Seat Belt Loading". IRCOBI, 1992.

11. Hampson, S, Coombs, R, Hemingway, A: "Case Reports Fractures of the upper thoracic spine-an addition to the "seat-Belt" syndrome". The British Journal of Radiology, 57, November, 1984.

12. Johnson, DH: "A Case Report of cervical spine fracture with lap-shoulder belt restraints". Journal of the American College of Emergency Physicians, Jan/Feb. 1974.

13. Arndt, RD: "Cervical-Thoracic Transverse Process Fracture: Further Observations on the Seatbelt Syndrome". The Journal of Trauma, Vol. 15, No. 7, July, 1975.

14. Winton, TL, Girotti, MJ, Manley, PN, Sterns, EE: "Delayed Intestinal Perforation After Nonpenetrating Abdominal Trauma". The Canadian Journal of Surgery, Vol. 28, No. 5, September, 1985.

15. Wagner, AC: "Disruption of Abdominal Wall Musculature: Unusual Feature of Seat Belt Syndrome". AJR 133:753-754, October, 1979.

16. Dunlop, MG: "Distal arterial emboli following seat belt injury of the aorta". Injury: the British Journal of Accident Surgery, Vol. 17, 1986.

17. Hudson, I, Kavanagh, TG: "Duodenal transection and vertebral injury occurring in combination in a patient wearing a seat belt". Injury: the British Journal of Accident Surgery, Vol. 15, 1984.

18. Anderson, PA, Rivara, FP, Maier, RV, Drake, C: "The Epidemiology of Seatbelt-associated Injuries". The Journal of Trauma, Vol. 31, No.1, January, 1991.

19. Gogler, H, Athanasiadis, S: "Fatal cervical dislocation related to wearing a seat belt: a case report". Injury: the British Journal of Accident Surgery, Vol. 10, 1979.

20. LeGay, DA, Petrie, DP, Alexander, DI: "Flexion-distraction Injuries of the Lumbar Spine and Associated Abdominal Trauma". The Journal of Trauma, Vol. 30, No. 4, 1990.

21. Wright, JE: "Gallbladder Rupture, An Isolated Seat Belt Injury". The Medical Journal of Australia, May 22, 1976.

22. Williams, N, Ratliff, DA: "Gastrointestinal disruption and vertebral fracture associated with the use of seat belts". The Royal College of Surgeons of England, Vol. 75, 1993.

23. Fisher, P: "Injury Produced by Seat Belts". Journal of Occupational Medicine, Vol. 7, No. 5, May, 1965.

24. Agran, PF, Dunkle, DE, Winn, DG: "Injuries to a Sample of Seatbelted Children Evaluated and treated in a Hospital Emergency Room". The Journal of Trauma, Vol. 27, No. 1, 1987.

25. Huelke, DF, Mackay, GM, Morris, A: "Intraabdominal Injuries Associated with Lap-Shoulder Belt Usage". SAE 930639, 1993.

26. Asbun, HJ, Irani, H, Roe, EJ, Bloch, JH: "Intra-abdominal Seatbelt Injury". Journal of Trauma, Vol. 30, No. 2, February, 1990.

27. Rouse, T, Collin, J, Daar, A: "Isolated injury to the intestine from blunt abdominal injury". Injury: the British Journal of Accident Surgery, Vol. 16, No. 2, 1984.

28. Freeman, CP: "Isolated pancreatic damage following seat belt injury". Injury: the British Journal of Accident Surgery, Vol. 16., No. 7, 1985.

29. Newman, KD, Bowman, LM, Eichelberger, MR, Gotschall, CS, Taylor, GA, Johnson, DL, Thomas, M: "The Lap Belt Complex: Intestinal and Lumbar Spine Injury in Children". The Journal of Trauma, Vol. 30, No. 9, September, 1990.

30. Epstein, BS, Epstein, JA, Jones, MD: "Lap-Sash Three Point Seat Belt Fractures of the Cervical Spine". Spine, Vol. 3., No. 3, September, 1978.

31. Dryburgh, PR, White, JAM: "Late Obstruction of the Intrahepatic Common Bile Duct after Seat-Belt Injury". S A Medical Journal, September 27, 1980.

32. Benito, MC, Garcia, F, Fernandez-Quero, L, Lajara, ., Jardon, E., Frias, I, Manzanos, A: "Lesion of the Internal Carotid Artery Caused by a Car Safety Belt". The Journal of Trauma, Vol. 30, No. 1, 1990.

33. Williams, JS: " The Nature of Seat Belt Injuries". SAE 700896, 1970.

34. Bourbeau, R, Desjardins, D, Maag, U, Laberge-Nadeau, C: "Neck Injuries Among Belted and Unbelted Occupants of The Front Seat of Cars". The Journal of Trauma, Vol. 35, No. 5, November, 1993.

35. Galasko, CSB, Murray, PM, Pitcher, M, Chambers, H, Mansfield, S, Madden, M, Jordon, C, Kinsella, A, Hodson, M: "Neck sprains after road traffic accidents: a modern epidemic". Injury: the British Journal of Accident Surgery, Vol. 24, No.3, 1993.

36. Wang, SE, Tiu, CM, Chou, YH, Chang, T: "Obstructive intestinal herniation due to improper use of a seat belt: a case report". Pediatric Radiology, 1993 .

37. Ernst, A, Robertson, HJ, Bercier, ML, Kline, DG: "Occult Carotid Artery Injury Related to Automobile Seat Belts". Annals of Emergency Medicine, October, 1988.

38. Reid, AB, Letts, RM, Black, GB: "Pediatric Chance Fractures: Association with Intra-abdominal Injuries and Seatbelt Use". The Journal of Trauma, Vol. 30, No. 4, April, 1990.

39. Mackay, GM, Cheng, L, Smith, M, Parkin, S: "Restrained Front Seat Car Occupants Fatalities - The Nature and Circumstances of Their Injuries". Accident Analysis and Prevention, Vol. 24, No. 3, 1992.

40. Mackay, GM, Hill, J, Parkin, S, Mumms, J.A.R: "Restrained Occupants on The Nonstruck Side in Lateral Collisions". Accident Analysis and Prevention, Vol. 25, No.2, 1993.

41. Huelke, DF, Mackay, GM, Morris, A, Bradford, M: "A Review of Cervical Fractures and Fracture-Dislocations Without Head Impacts Sustained by Restrained Occupants". Accident Analysis and Prevention, Vol. 25, No. 6, 1993.

42. Bergqvist, D, Hedelin, H: "Roll Seat Belt Induced Injury of the Duodenum". The Journal of Trauma, Vol. 16, No. 5, 1976.

43. Vellar, ID, Vellar, DJ, Mullany, CJ: "Rupture of the Bowel Due to Road Trauma". The Medical Journal of Australia, May 8, 1976.

44. Bergqvist, D, Dahlgren, S, Hedelin, H: "Rupture of the Diaphragm in Patients Wearing Seatbelts". The Journal of Trauma, Vol. 18, No. 11, 1978.

45. Sumchai, A, Eliastam, M, Werner, P: "Seatbelt Cervical Injury in an Intersection Type Vehicular

Collision". The Journal of Trauma, Vol. 28, No. 9, 1988.

46. Taylor, TKF, Nade, S, Bannister, JH: "Seat Belt Fractures of the Cervical Spine". The Journal of Bone and Joint Surgery, Vol. 58, August, 1976.

47. Christophi, C, McDermott, FT, McVey, I, Hughes, ES: "Seat Belt-Induced Trauma to the Small Bowel". World Journal of Surgery, Vol. 9, No. 5, October, 1985.

48. Hamilton, JB: "Seat-belt Injuries". Britain Medical Journal, November, 1968.

49. Dempsey, EF: "Seat Belt Injury of the Colon". New Zealand Medical Journal, 1977.

50. Shennan, J: "Seat-Belt Injuries of the Left Colon". The British Journal of Surgery, Vol. 60, No. 9, September, 1973.

51. Yu, WY, Siu, CM: "Seat Belt Injuries of the Lumbar Spine-Stable or Unstable?" International Medical Society of Paraplegia, Paraplegia 27, 1989.

52. Banerjee, A: "Seat belts and injury patterns: evolution and present perspectives". Postgraduate Medical Journal, 1989.

53. Jeffery, RS, Cook, PL: "Seat belts and reclining seats". Injury: the British Journal of Accident Surgery, vol. 22, No. 5, 1991.

54. Nakamoto, SK, Taylor, Jr., A: "The Seat Belt Sign". Clinical Nuclear Medicine, 1981.

55. MacLeod, J H, Nicholson, DM: "Seat-Belt trauma to the Abdomen". The Canadian Journal of Surgery, Vol. 12 , April, 1969.

56. Woelfel, GF, Moore, EE, Cogbill, TH, Van Way, III, CW: "Severe Thoracic and Abdominal Injuries associated with Lap-harness Seatbelts". The Journal of Trauma, Vol. 24, No. 2, 1984.

57. Stevenson, JH: "Severe thoracic intra-abdominal and vertebral injury occurring in combination in a patient wearing a seat belt". Injury: the British Journal of Accident Surgery, Vol. 10, 1979.

58. Taylor, D, Magee F, Stordy, SN, Chan, N: "Small Bowel Injury Simulating Crohn's Disease After Blunt Abdominal Trauma". J Clin Gastroenterol, Vol. 9, No. 1, 1987.

59. Pohl, MJ, Cook, WJ: "Small-Bowel Stenosis After Seat Belt Injury". The Medical Journal of Australia, Vol. 2, No. 3, 1980.

60. Skold, G, Voigt, GE: "Spinal injuries in belt-wearing car occupants killed by head-on collisions". Injury: the British Journal of Accident Surgery, Vol. 9, No. 2, 1978.

61. Otremski, I, Marsh, JL, Wilde, BR, McLardy Smith, PD, Newman, RJ: "Soft tissue cervical spinal injuries in motor vehicle accidents". Injury: the British Journal of Accident Surgery, Vol. 20, No. 6, 1989.

62. Rutledge, R, Thomason, M, Oller, D, Meredity, W, Moylan, J, Clancy, T, Cunningham, P, Baker, C: "The Spectrum of Abdominal Injuries Associated with the Use of Seat Belts". The Journal of Trauma, Vol 31, No. 6, 1991.

63. Huelke, DF, Ostrom, M Mackay, GM, Morris, A: "Thoracic and Lumbar Spine Injuries and the Lap-Shoulder Belt". SAE 930640, 1993.

64. Spitz, L, Van Blerk, PJP: "Case Reports - Transection of the Common Bile Duct and Pelvi-Ureteric Junction due to Seat Belt". Journal of Trauma, 1971.

65. Johnstone, BR, Waxman, B P: "Transverse Disruption of the Abdominal Wall - A Tell-tale Sign of Seat belt Related Hollow Viscus Injury". Aust NZ J Surg., Vol. 57, No. 7, 1987.

66. Harris, JP, Storey, DW, Grassby, JM, May, J: "Traumatic Duodenal Transection at the Level of the Ampulla of Vater: Sphincteroplasty as a Technical Adjunct to Primary Repair". Aust NZ J. Surg., Vol. 56, No. 6, 1986.

67. Dinneen, MD, Wetter, LA, Orr, NW: "Traumatic indirect inguinal hernia: a seat belt injury". Injury: the British Journal of Accident Surgery, Vol. 20, No. 3, 1989.

68. Baker, AR, Perry, EP, Fossard, DP: "Traumatic rupture of the stomach due to a seat belt". Injury: the British Journal of Accident Surgery, Vol. 17, No. 1, 1986.

69. Howdieshell, TR, Delaurier, G,: "An Unusual Injury of the Sigmoid Colon Produced by Seat Belt Trauma". The American Surgeon, Vol. 59, No. 6, 1993.

70. Tang, OT, Mir, A, Delamore, IW: "Unusual Presentation of Seat-belt Syndrome". British Medical Journal, December, 1974.

71. Jefferiss, C: "An unusual seat-belt injury in a doctor". Injury: the British Journal of Accident Surgery, Vol. 7, No. 4, 1976.

72. Nitecki, S, Karmeli, R, Ben-Arieh, Y, Schramek, A, Torem, S: "Seatbelt Injury to the Common Iliac Artery: Report of Two Cases and Review of the Literature". The Journal of Trauma, Vol. 33, No. 6, 1992.

73. Coats, TJ: "Delayed presentation of perforation of the ileum following seat belt trauma". Archives of Emergency Medicine, Vol. 8, 1991.

74. Brownstein, EG: "Blunt Abdominal Trauma Simulating Crohn's Disease of the Terminal Ileum". Aust NZ J Surg., Vol. 54, No. 3, 1984.

75. Denis, R, Allard, M, Atlas, H, Farkough, E: "Changing Trends with Abdominal Injury in Seatbelt Wearers". The Journal of Trauma, Vol. 23, No. 11, 1983.

76, Taylor, PR, Rowe, PH, McColl, I: "Late presentation of a traumatic abdominal hernia associated with constipation ". Journal of the Royal Society of Medicine, Vol. 82, March, 1989.

77. Upadhyay, AK: "Seat belt injuries". Journal of the Royal Society of Medicine, Vol. 82, July, 1989.

78. Rutherford, WH: Letter, Journal of the Royal Society of Medicine, July, 1989.

79. Editorial: Seat Belt Injuries to the Colon British Medical Journal, January, 1974.

80. Dominguez, J, de Wardener, HE: "Stock-Car Kidney". Lancet, January, 1972.

81. Clyne, CAC, Ashbrooke, EA: "Seat-belt aorta: isolated abdominal aortic injury following blunt trauma". Br. J. Surg., Vol. 72, 1985.

82. Klurfeld, L, Klurfeld, DM: "Seat-Belt Neuropathy". Letter to the Editor, JAMA, Vol. 241, No. 8, 1979.

83. Huelke, DF: Letter to the Editor, Journal of Trauma, Vol. 25, No. 3, 1985.

84. Pennes, DR, Philips, WA: "Auto Seat Restraint Soft-Tissue Injury". AJR, February, 1987.

85. Saldeen, T: "Fatal Neck Injuries Caused by Use of Diagonal Safety Belts". The Journal of Trauma, Vol. 7, No. 6, 1967.

86. DeLorenzo, RA, Mayer, D, Gardner, GM: "Bilateral Vocal Cord Hematomas Associated with Shoulder Harness Use". American Journal of Emergency Medicine, Vol. 9, No. 2, March, 1991.

87. Chedid, MK, Deeb, ZL, Rothfus, WE, Abla, AA, Sherman, RL, Maroon, JC: "Major Cerebral Vessels Injury Caused by a Seatbelt Shoulder Strap: Case Report". The Journal of Trauma, Vol. 29, No. 11, 1989.

88. Holbrook, JL, Bennett, JB: "Brachial Plexus Injury Associated With Chest Restraint Seatbelt: Case Report". The Journal of Trauma, Vol. 30, No. 11, 1990.

89. Reddy, K, Furer, M, West, M, Hamonic, M: "Carotid Artery Dissection Secondary to Seatbelt Trauma: Case Report". The Journal of Trauma, Vol. 30, No. 5., 1990.

90. Martinez, R, Sharieff, G, Hooper, J: "Three-Point Restraints as a Risk Factor for Chest Injury in the Elderly". The Journal of Trauma, Vol. 37, No. 6, 1994.

91. Murerjea, SK, Nair, KK: "Seat-belt Injury Causing Pneumothorax with Rupture of Diaphragm, Stomach, and Spleen". The Lancet, November, 1978.

92. Reisman, JD, Morgan, AS: "Analysis of 46 Intra-Abdominal Aortic Injuries from Blunt Trauma: Case Reports and Literature Review". The Journal of Trauma, Vol. 30, No. 10, 1990.

93. Freeman, CP: "The seat-belt sign". Letter to the Editor, Arch Emerg Med, Vol. 4, No. 2, June, 1987.

94. Howland, WJ, Curry, JL, Buffington, CB: "Fulcrum Fractures of the Lumbar Spine". Trauma, 1965.

95. Myers, JW, Schmidt, C, Kraft, RO: "An Unusual Seat Belt Injury: Case Report". The Journal of Trauma, Vol. 12, No. 6, 2.

96. Ruskey, J, Lieberman, ME, Shaikh, KA, Talucci, C: " Unusual Subclavian Artery Lacerations Resulting from Lap-Shoulder Seatbelt Trauma: Case Reports". The Journal of Trauma, Vol. 29, No. 11, November, 1989.

97. Di Fiore, FR, Gin, O: "Injuries Due to Automobile Seat Belts". Trauma, April, 1970.

98. Backwinkel, KD: "Injuries From Seat Belts". Trauma, April, 1970.

99. Hamilton, JRL, Dearden, C, Rutherford, WH: " Myocardial contusion associated with fracture of the sternum: important features of the seat belt syndrome".Injury: the British Journal of Accident Surgery, Vol. 16, No. 3, 1984.

100. Fletcher, BD, Brogdon, BG: "Seat-Belt Fractures of the Spine and Sternum". Trauma, Vol. 11, No. 6, April, 1970.

101. Carroll, TB, Gruber, FH: "Seat Belt Fractures A Report of Two Cases". Trauma, Vol. 11, No. 6., April, 1970.

102. Steckler, RM, Epstein, JA, Epstein, BS: "Seat Belt Trauma to The Lumbar Spine". Trauma, Vol. 11, No. 6, April, 1970.

103. Smith, WS, Kaufer, H: "A New Pattern of Spine Injury Associated with Lap-Type Seat Belts: A Preliminary Report". The University of Michigan Medical Center Journal, Vol., 33, 1967.

104. Gunby: "Lap seat belts useful but can injure children". Journal of American Medical Association, Vol. 245, No. 22, 1981.

105. Gertzbein, MD, Court-Brown, CM: "Spine". Clinical Orthopaedics and Related Research, No. 227, February, 1988.

106. Huelke, DF, Kaufer, H: "Vertebral Column Injuries and Seat Belts". The Journal of Trauma, Vol. 15, No. 4, April, 1975.

107. Smith, WS, Kaufer, H: "Patterns and Mechanisms of Lumbar Injuries Associated with Lap Seat Belts". Trauma, Vol. 11, No. 6, 1970.

108. Kaufer, H, Hayes, JT: "Lumbar Fracture-Dislocation A Study of Twenty-One Cases". The Journal of Bone and Joint Surgery, Inc., Vol. 48-A, No. 4, 1966.

109. Huelke, DF, Mackay, GM, Morris, A: "Vertebral Column Injuries and Lap-Shoulder Belts". The Journal of Trauma Injury, Infection and Critical Care, Vol. 38, No. 4, April, 1995.

110. Dehner, JR: "Seatbelt Injuries of the Spine and Abdomen". American Journal of Roentgenology, Vol. 3, No. 4, 1971.

111. Arajarvi, E, Santavirta, S: "Chest Injuries Sustained in Severe Traffic Accidents by Seatbelt Wearers". The Journal of Trauma, Vol. 29, No. 1, 1989.

112. Evans, PD, Mackie, IG: "Fracture of the body of the sternum associated with the use of static seat belts". Injury: the British Journal of Accident Surgery, Vol. 16, No. 7, 1985.

113. Marsh, HO, Bailey, D: "Seat Belt Fractures Chance Fractures Caused by Seat Belts: Presentation of Three Cases". The Journal of the Kansas Medical Society, September, 1970.

114. Gumley, G, Taylor, TKF, Ryan, MD: "Distraction Fractures of The Lumbar Spine". The Journal of Bone and Joint Surgery, Vol. 64-B, No. 5, 1982.

115. Johnson, DL, Falci, S: "The Diagnosis and Treatment of Pediatric Lumbar Spine Injuries Caused by Rear Seat Lap Belts". Neurosurgery, Vol. 26, No. 3, March, 1990.

116. Murphy, MJ, Huelke, DF, Sherman, HW: "Case Descriptions of Lap-Shoulder Belted Occupants in Car Crashes". Society of Automotive Engineers # 770151, 1977.

117. Schmidt, G: "Injury Patterns of Fatally Impacted Car Front Passengers in Regard to The Three-Point Seat Belt and Related Occupant Injury Modes". SAE 870225, 1987.

118. Huelke, DF, Sherman, HW, Murphy, MJ: "Severe to Fatal Injuries to Lap-Shoulder Belted Car Occupants". SAE 770149, 1977.

119. Huelke, DF, Lawson, TE: "Lower Torso Injuries and Automobile Seat Belts". SAE 760370, 1976.

120. Nahum, AM, Siegel, AW, Hight, PV: "Injuries to Rear Seat Occupants in Automobile Collisions". SAE 670918, 1967.

121. Mackay, GM, Gloyns, PF, Nayes, HRM, Griffiths, DK, Rattenbury, SJ: "Serious Trauma to Car Occupants Wearing Seat Belts". IRCOBI, 2nd International conference Proceedings, 1975.

122. Dalmotas, DJ: "Mechanisms of Injury to Vehicle Occupants Restrained by Three-Point Seat Belts". Society of Automotive Engineers, Inc., No . 801311, 1980.

123. Nelson, WD: "Lap-Shoulder Restraint Effectiveness in the United States". SAE, # 710077, 1971.

124. Gallup, BM, Perry, RW, Pedder, JB, Dalmotas, DJ, Dance, M: "The Relationship Between Belt Fit and Abdominal Injuries to Rear Seat Occupants". Proceedings of the Canadian Multidisciplinary Road Safety Conference IV, May, 1985.

125. Dejeammes, M, Biard, R: "Avoiding Submarining with a Three Point Belt". IRCOBI Conference, 1983.

126. Rattenbury, SJ, Gloynes, PF, Hayes, HRN, Griffiths, DK: "The Biomechanical Limits of Seat Belt Protection". American Association for Automotive Medicine proceedings, Oct. 1979.

127. Huelke, DF, Lawson, TE: "The Rear Seat Automobile Passenger in Frontal Crashes". American Association for Automotive Medicine, 22nd Conference and the International Association for Accident and Traffic Medicine VII Conference, 1978.

128. Agran, PF: "Traumatic Injuries Among Children Using Lap Belts and Lap/Shoulder Belts in Motor Vehicle Collisions". AAAM, 31st Annual Proceedings, 1987.

129. Huelke, DF, Sherman, HW, Elliott, AF: "The Rear Seat Occupant from Data Analysis of Selected Clinical Case Studies". SAE, # 870487, 1987.

130. Huelke, DF: "The Rear Seat Occupant in Car Crashes". American Association for Automotive Medicine Journal, Vol. 9, No. 4, October, 1987.

131. Ramsey, E: "Seat belt injury to ileostomy". British Medical Journal, May 13, 1978.

132. Kendall, IG: "Seat Belt Injury". Letter to the editor, Archives of Emergency Medicine, June, 1992.

133. Steinberg, ML, Birnbaum, BA, Jacobs, JE, Schwab, CW: "Shoulder Harness Seatbelt Injury: CT Appearance of Hepatic Avulsion with Active Arterial Hemorrhage". Journal of Computer Assisted Tomography , Vol. 20, No. 6, 1996.