SEATBELT SAFETY: NHTSA OVERSIGHT

HEARING

BEFORE A

SUBCOMMITTEE OF THE

COMMITTEE ON GOVERNMENT OPERATIONS HOUSE OF REPRESENTATIVES

ONE HUNDREDTH CONGRESS

SECOND SESSION

JUNE 23, 1988

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SEATBELT SAFETY: NHTSA OVERSIGHT

THURSDAY, JUNE 23, 1988

HOUSE OF REPRESENTATIVES,
GOVERNMENT ACTIVITIES AND
TRANSPORTATION SUBCOMMITTEE
OF THE COMMITTEE ON GOVERNMENT OPERATIONS,
Washington, DC.

The subcommittee met, pursuant to notice, at 10:05 a.m., in room 2203, Rayburn House Office Building, Hon. Cardiss Collins (chairwoman of the subcommittee) presiding.

Present: Representatives Cardiss Collins, Gerald D. Kleczka, and Howard C. Nielson.

Also present: John Galloway, staff director; Michael Skrak, professional staff member; Cecelia Morton, clerk; and Ken Salaets, minority professional staff, Committee on Government Operations.

OPENING STATEMENT OF CHAIRWOMAN COLLINS

Mrs. COLLINS. Good morning. This hearing of the Government Activities and Transportation Subcommittee will come to order. Although most consumers are not aware of it, all cars manufactured since 1973 are equipped with anchor points to permit the installation of rear seat shoulder belts.

Also, unknown to most consumers, shoulder belts in combination with lapbelts offer twice the protection of lapbelts alone. Annually almost 2,000 rear seat automobile passengers are killed and 200,000 are injured in this country. Many of those deaths and injuries could have been prevented through the use of rear seat lap and shoulder belts.

Federal regulations on rear seat safety are ambiguous. They do not require manufacturers to install shoulder belts. Simple lapbelts in both new and old cars are sufficient. On the other hand, fittings are required on all cars manufactured since 1973 to permit the installation of rear seat shoulder straps to supplement federally required lapbelts.

Those regulations do not, however, require manufacturers to provide nor install such shoulder straps. That, in turn, has rendered it all but impossible for consumers in many cases to purchase and have installed that life-saving feature. To further compound matters, the shoulder strap fittings are frequently placed behind the car's molding and trim which contributes to the high cost of installing rear seat shoulder straps, assuming their availability. On the brighter side, during the past year, most car companies have announced that they will voluntarily install rear seat shoulder belts in new cars.

Clearly, the superiority of shoulder straps over lap-only type belts is no longer at issue. Our hearing today has been called to consider means to encourage the greater availability of rear seat shoulder belts for cars already on the road. In particular, we will consider: (1) The failure of car companies to educate consumers on the need for rear seat shoulder belts; (2) the failure of certain car companies, such as Volkswagen and Ford, to provide rear seat shoulder straps for certain models; and (3) the refusal of new car dealers throughout the country to install back seat shoulder belts when available.

To help assess these issues we will receive testimony from the Center for Automobile Safety, the Institute for Injury Reduction and Mr. Harold Sakayan, an attorney familiar with the rear seat, lapbelt injury cases.

Following that testimony, we will hear from the Motor Vehicle Manufacturer Association and DOT's National Highway Traffic Safety Administration.

Mr. Nielson.

Mr. NIELSON. Thank you, Madam Chairwoman. Good morning. After reviewing the materials for this hearing, I am concerned that we may unintentionally be sending out the wrong message regarding seatbelt use. I have a little scar right here on my forehead which I sustained during an accident when not wearing a seatbelt. So I for one want to go on record in support of seatbelt usage. Back seat lapbelts may not be ideal and may even present problems of their own, as we will hear, but in the majority of cases, they're certainly better than nothing and are very effective in preventing a passenger from being thrown from a car during a collision.

No one can question the potential severity of injuries a person could sustain if thrown through a windshield. With that said, I welcome our witnesses and thank them for coming. I'm very interested in hearing your testimony.

Mrs. COLLINS. Thank you, Mr. Nielson. Our first panel this morning will be Mr. A. Benjamin Kelley, Mr. Larry Coben, and Mr. Harold A. Sakayan, all from the Institute for Injury Reduction and Mr. Robert Dewey who is from the Center for Automobile Safety. Why don't we begin with you, Mr. Kelley?

STATEMENT OF A. BENJAMIN KELLEY, PRESIDENT, INSTITUTE FOR INJURY REDUCTION

Mr. KELLEY. Thank you, Madame Chairwoman. I'm Albert Benjamin Kelley, president of the Institute for Injury Reduction. As you said, with me today is Larry Coben, our chairman, and Harold Sakayan, a founding member of the Institute. Mr. Coben will make an opening remark and then I will describe for you the test and research results we wish to present today to the subcommittee.

STATEMENT OF LARRY COBEN, CHAIRMAN, INSTITUTE FOR INJURY REDUCTION

Mr. COBEN. Good morning, Madam Chairman, members. I am Larry Coben. I'm a trial attorney from Philadelphia and the chairman of the Institute for Injury Reduction. I'm appearing here today at your invitation to discuss the issue of rear seatbelt sys-

tems in American automobiles, an issue which presently involves needless exposure to harm for millions of American consumers.

The Institute for Injury Reduction was organized to carry out research, investigation and public education involving the product design, performance and use which contributes needlessly to deaths and injuries. Product related injuries including those sustained in highway crashes are a wide, leading cause of death and serious injury. Unfortunately though, most consumers and most folks that ride in cars are unaware of those risks.

It is the job of the Government regulatory agencies such as the National Highway Traffic Safety Administration which you are oversighting today, to promulgate and enforce vehicle performance regulations which will assist in developing minimum basic performance standards to assure a minimum level of safety in all motor vehicles.

The institute is committed to reducing the mayhem on the highways that may be indirectly caused by product design. It is our thought that better product design can reduce injury and lessen the need for the costs imposed upon society by these injuries and deaths.

In a moment, Mr. Kelley will describe to you our work involving rear seat lap-only performance as compared to shoulder harness performance in the rear seat of automobiles. Also today we will present to you the testimony of Mr. Sakayan dealing with some very real incidents to demonstrate the effectiveness or lack of effectiveness of the safety systems provided in automobiles in America.

The immediate need to take steps to rectify a very serious safety design flaw in vehicles manufactured and sold in this country was highlighted by the report of the NTSB in 1986 which accounted for a number of lapbelt-only serious injuries and deaths in cars being used in this country.

A review of the history of automobile safety technology and regulation clearly shows that Americans are exposed to an unnecessary risk which we all take when we buckle up for safety with only lapbelts.

While it is true, as Mr. Nielson mentioned, that wearing a lapbelt is better than none at all in most occasions, and it is clearly a correct statement in the front seats of automobiles to prevent running into the windshield in a crash, the dynamics of what occurs in the rear seat of automobiles is different and the injuries that we're seeing are not a result of being ejected and not a result of striking a windshield, but are a result of people in those cars wearing lapbelts and being injured by the lapbelt system that they're wearing.

From the outset of its regulatory activity in the late sixties, NHTSA intended that its standards would require lap/shoulder belt protection for rear seat outboard occupants as well as front seat outboard occupants. This initial thought had its foundation in research that goes back to at least 1964. In some attachments that I've included with the statement today, there is a report from Dr. Horace Campbell who was associated with the Cornell Institute in which he pleaded in 1964 that manufacturers include lap and shoulder harness belt systems in all automobiles, in the front as well as the back of those vehicles.

Not surprisingly, the manufacturers have known about the value of those systems at least since the midsixties. Also attached to the material are some internal documents from some Ford engineers responsible for studying injury in crashes and their conclusion, obvious as it is to us sitting here today, is that wearing a lap and shoulder harness system provides superior protection to lap only, and it was recommended by the Ford engineers that lap and shoulder harness systems be included in all outboard positions.

In the late sixties in Europe, Governments passed regulations requiring that manufacturers install lap and shoulder harness systems in the rear as well as the front seats of automobiles. Attached to the material are regulations from the Swedish Government from 1968 dealing with that very issue. Also attached and interestingly, are the design standards of the Ford Motor Co. which manufactured and sold automobiles in Europe with lap and shoulder harness systems because the Government required those systems.

For those reasons, the institute recommends the following: That initially and immediately, a statement be made to the public dealing with the danger imposed upon the users of lap-only systems in the rear of automobiles. Second, that automobile manufacturers specifically send to their consumers warnings dealing with the risk of harm resulting from wearing lap-only systems in the rear of automobiles. Third, that manufacturers immediately notify all consumers directly that retrofit kits will be made available, and are available, and will be installed in vehicles at no cost to the consumer.

Fourth, that NHTSA immediately issue a regulation requiring retrofit kits be made readily available, and I emphasize "readily available." Fifth, that a three-point rear seatbelt system regulation be immediately imposed upon manufacturers for the rear seats of automobiles. While automobile manufacturers have said they will voluntarily install these systems, they are slow to do so. As of this year, perhaps four or five model cars out of perhaps 200 sold in the United States have rear lap and shoulder systems.

We implore the committee to make these recommendations to NHTSA to in turn make these recommendations and these regulations to the industry immediately.

Mr. COBEN. Thank you.

Mr. KLECZKA [presiding]. Thank you, Mr. Coben, for your testimony.

[The prepared statement of Mr. Coben follows:]

TESTIMONY OF LARRY E. COBEN
CHAIRMAN, INSTITUTE FOR INJURY REDUCTION
BEFORE A HEARING OF THE
GOVERNMENT ACTIVITIES AND TRANSPORTATION SUBCOMMITTEE,
HOUSE GOVERNMENT OPERATIONS COMMITTEE
INTO
'SEAT BELT SAFETY: NHTSA OVERSIGHT'
JUNE 23, 1988

Madam Chairwoman, Members:

I am Larry E. Coben, a trial attorney from Philadelphia, Pennsylvania, and the chairman of the Institute for Injury Reduction. I am appearing today at your invitation to discuss the issue of rear-seat belt systems in American automobiles -- an issue which presently involves needless exposure to harm for millions of Americans.

The Institute for Injury Reduction was formed early this year to carry out research, investigation and public education involving product design, performance and use which may contribute needlessly to deaths and injuries.

Product-related injuries, including those sustained in highway crashes, are a leading cause of death in the United States -- a fact which is not widely understood by the public. It is the job of government regulatory agencies, such as the National Highway Traffic Safety Administration, which you are oversighting today, to promulgate and enforce vehicle performance standards which will, at least, provide minimum basic protection for vehicle users, and thereby effectively reduce the high number of injuries and deaths on our highways.

IIR seeks to build an improved base of knowledge and public awareness of product failures and needed improvements in support of this safety mission. Our founders are trial attorneys who through their practices have learned the extent to which defective products, inadequate user instructions and lack of warnings hurt and kill people. They are committed to seeing the mayhem reduced. The integrity of our common law products liability system must be preserved, because it constitutes one of the few remaining individual liberties in this complex society, and allows for the fair compensation of persons injured by product design. Our common law system and the federal regulation of product safety have complemented each other when each has functioned as intended. However, we at the Institute realize that a more aggressive approach to safety can reduce this national epidemic. In reality, therefore, the IIR was created with the thought that better product design can reduce injury and lessen the need for product liability claims. IIR membership is open to everyone -- attorneys, engineers, students, and the general public -- who supports our public-health objective. Our information and research results are available to any organization or person who requests them. (Attachment "A" to my testimony is a detailed description of IIR's structure and mission.)

In a moment Mr. Kelley will describe in detail our work involving rear-seat, lap-only belt performance -- work that reflects our concern at the extent to which these belt systems, unlike properly designed lap-shoulder belt systems, present a potential for serious or fatal injury to their wearers in crashes. Since the vast majority of American cars on the roads and in the dealer showrooms today do not have rear-seat lap shoulder belts, that potential already has become a grim reality for many rear-seat occupants -- including children wearing

lap-only belts. Several tragic examples of injury and death to our children will be described by Mr. Sakayan this morning.

The initial research project undertaken by the Institute was borne out of frustration emanating from the failure of the American Automobile Industry to voluntarily design and sell their products with necessary rear seat 3 Point seat belt systems. This frustration has been compounded by the National Highway Traffic Safety Administration's refusal to promulgate regulations making 3 Point seat belt systems mandatory in the rear seats of motor vehicles sold in the United States. The immediate need to take steps to rectify a very serious safety design flaw was highlighted by the July 28, 1986 report of the National Transportation Safety Board, in which it reviewed the dilemma motorists face today because all American-made vehicles include lap belts without shoulder harnesses in the rear seats.

A review of the history of automobile safety belt technology and regulation makes clear a number of basic points that bear directly on the concern of this hearing, and which are covered in detail in Attachment "B":

-- Automotive engineers and physicians have long recognized the hazards associated with lap-belt-only systems and the superior protection afforded by lap-shoulder belt systems. As early as the mid-1960's the car companies were being put on notice of the need for lap-shoulder belt systems in all outboard seating positions, both front and rear.

-- From the outset of its regulatory activity in the late 1960's, NHTSA intended that its standards would require lap-shoulder belt protection for rear-seat outboard occupants, as well as front-seat outboard occupants.

In July, 1969, a position paper prepared by the agency stressed that even if air bags were introduced to protect front-seat occupants, "both lap and shoulder belts will be required in rear seat positions for the foreseeable future." Proposed rulemaking of the period reflected the same intention. Yet, because of manufacturer resistance, agency indifference, or a combination of the two, the final rule was never put into place. The resistance offered by the industry is difficult to understand in light of certain internal documents which prove that the manufacturers were well aware of the need for 3 Point belt systems. As Attachment "C" reveals, as early as 1967, Ford Motor Company's top engineers recommended properly designed 3 Point seat belt systems to replace lap belts.

In 1968, the National Swedish Road Safety Board announced safety belt regulations which required the installation of 3 Point belts in all positions except the middle seat position. [An example of the Ford Motor Company's compliance with this regulation, along with the regulation itself is appended as Attachment "D".]

American manufacturers have told NHTSA that in the future they will voluntarily provide standard-equipment rear lap-shoulder belts in an increasing share of their new-car production, and some already have begun to do so in a few cars. Yet the agency, despite decades of research showing the hazards of lap-only belt systems and despite the demonstrated ability of the companies to install them, still has not proceeded to set a Federal Motor Vehicle Safety Standard requiring rear-seat lap-shoulder belt systems. Its only move in that direction has been noncommittal "advance notice of proposed rulemaking" issued more than a year ago. (Attachment "E")

Until NHTSA puts a standard in place, of course, Americans will have to rely solely on the good faith of the car companies for adequate rear-seat restraint protection in crashes. If the companies decide to discontinue plans for putting rear-seat lap-shoulder belts in new cars tomorrow morning, they will be entirely free to do so -- just as General Motors and Ford discontinued their promised air bag programs in the 1970's because NHTSA had not put a "passive restraint" standard in place.

Thus the industry, not the regulatory agency, has effectively taken control of providing or denying adequate crash protection to rear-seat occupants. This defies the intent of the National Traffic and Motor Vehicle Safety Act of 1966 since in effect it turns the regulatory reins over to the manufacturer.

The only recourse available to people injured in crashes due to hazardous rear-seat lap-only belts is common-law action against the derelict manufacturer. But, here too, the manufacturers have made legal manuevers to thwart these claims on the basis that their only obligation is to meet the minimum standard set by NHTSA -- in this instance, the rear-seat lap-belt-only standard. This ignores the Act's crystal-clear injunction that compliance with a minimum standard does not protect a manufacturer from common-law action when the manufacturer could have prevented or lessened the severity of a crash injury by providing a better alternative safety system. In fact, a central purpose of the Act and the standards is to encourage manufacturers to exceed the minimums with improved technologies whenever possible. (See Attachment "F" for a full discussion of this issue.)

There is no excuse for NHTSA's continued failure to set a Federal Motor Vehicle Safety Standard requiring that at a minimum, rear-seat outboard occupants of future new cars be given lap-shoulder belt systems to protect them in crashes. Anything less makes a mockery of the Act's intentions and NHTSA's mission.

The NHTSA should issue regulations regarding the manufacture and sale of retrofit 3 Point rear seat belt systems, and the installation of factory-built, 3 Point belt systems in all new vehicles.

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Attachment A

3/20/88

QUESTIONS AND ANSWERS ABOUT
THE INSTITUTE FOR INJURY REDUCTION

The Institute for Injury Reduction was established in March, 1988 to carry out and support research and educational programs dealing with product-related injuries.

Its underlying premise is that if Americans are better informed about the nature of deaths and injuries involving product hazards, they will be better able to make judgments and decisions that lead to reducing or eliminating those hazards.

The following "questions and answers" about IIR are to assist prospective members and supporters in understanding the organization's purposes, programs and structure.

* * *

Why Is IIR Needed?

Accidents involving products account for the vast majority of deaths and seriously disabling injuries to Americans from birth to retirement age. The design, manufacture and use of products play a pervasive role in generating severe and fatal damage to human health - a role larger than illnesses for most age groups.

Yet the public is largely uneducated about that role, and unaware that product-related trauma would be much less frequent and much less severe if product design and manufacturing defects were reduced and adequate instructions and warnings were provided to product users.

IIR's mission is to design and carry out programs of information, education, research and notification that will improve society's knowledge of product-injury interactions and countermeasures. Its goal is to help reduce product-related trauma in America; its premise is that better, more widely available information about such injuries and their causes will contribute to achieving that goal.

Aren't Other Groups Doing This Already?

No. A number of organizations in government and the private sector are involved in aspects of injury reduction, but none works to carry out or support programs of education and research specifically involving product-related injuries.

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Attachment A

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No. A number of organizations in government and the private sector are involved in aspects of injury reduction, but none works to carry out or support programs of education and research specifically involving product-related injuries.

IIR will make the results of its programs available to all agencies and groups whose activities involve injury causation and control, and is prepared to collaborate with such organizations on specific projects where appropriate.

Who Started IIR?

IIR has been formed by a group of leading plaintiff's attorneys experienced in litigation involving injuries stemming from the design, manufacture and use of products.

Their concern is that not enough has been done to inform the public, government policymakers, manufacturers, and the research community as to the nature, causes, extent and severity of deaths and injuries involving or generated by products of all kinds, or to promote research in those areas.

Their commitment is to encourage attorneys, research scientists, engineers, health professionals, and injured people themselves to become active in contributing both information and support toward that end.

Is Membership Confined to Attorneys?

Not at all. Membership is open to all individuals and organizations committed to IIR's goals, whether professionals, laypeople or students.

How May I Join?

Applications for membership are approved by the Board of Directors. Anyone may apply simply by writing to: IIR, P.O. Box 375, Dunkirk, Maryland, 20754. A brief letter or postcard or the completed form below is all that is needed.

How Much Does Membership Cost?

Annual dues vary by class of membership, as follows:

--Founding Member, $5,000.

--Organizational Member, $5,000

--Sustaining Member, $1,000

--Regular Member, $100

--Associate (Students and Retired) Member, $25

All members receive IIR's quarterly newsletter summarizing its activities and research results. In addition, Founding, Sustaining and Organizational members receive copies of all reports, studies and films published by IIR without separate charge.

How Is IIR Run?

IIR's policymaking body is its Board of Directors. Board members are elected annually by members with voting rights, which include all Founding, Sustaining and Regular members, on an annual basis. Current board chairman is Larry E. Coben. Other members include Wayne Fisher, Bertram M. Goldstein, John R. Overchuck and David L. Perry.

The day-to-day management of IIR is carried out under the direction of its president, A. Benjamin Kelley, a leading authority on motor vehicle-related injury causation and prevention. Mr. Kelley, formerly senior vice president of the Insurance Institute for Highway Safety and an official of the U.S. Department of Transportation, has been active in the injury control field for more than two decades.

Describe IIR's Program.

In general, IIR's concern extends to products in the automotive, aviation, medical, occupational, farm, home and all other categories in which product-injury relationships are found. Its developing emphasis in each of these is in the following areas of work:

--Collecting, analyzing and distributing data concerning the nature, severity, and frequency of product-related injuries, and relating them to design, manufacture and use causation.

Sources for such information will include research published by government, private-sector and academic groups; completed product-injury litigation; regulatory and legislative proceedings concerned with product injury issues, and special research and fact-finding projects undertaken or sponsored by IIR.

--Providing notice to manufacturers, the medical community, government regulatory agencies and the general public of product hazard and injury-causation information.

--Conducting or sponsoring special research, testing, demonstration and analytical projects to examine specific types and patterns of injury generated by the design, manufacture and use of products.

--Supporting outside research to increase knowledge of product hazard-injury relationships.

Who Determines The Direction Of IIR Research?

A Technical Advisory Committee, appointed by the Board of Directors, evaluates and approves proposals for IIR research, testing and data analysis. Members must be accredited experts in scientific or engineering fields related to injury causation and control.

How Can I Advance IIR's Work?

By applying for membership or contribing now!

If you are able, apply to become a Founding, Organizational or Sustaining member. Your dues will go far toward helping IIR to bring about important improvements in the public's awareness of product-related injuries, as well as in the breadth and quality of research, analysis and notification concerned with product hazards that result in injuries.

Or, you may wish to make a substantial one-time contribution toward IIR's start-up effort while joining at a lower dues level.

Whether you are interested in Founding, Organizational, Sustaining, Regular or Associate membership, with or without a separate contribution, it takes only a moment to apply using the attached form or a letter or card to: IIR, P.O. Box 375, Dunkirk, Md. You'll receive a prompt response and be billed for your first-year dues at that time.

* * *

(The Institute for Injury Reduction is a non-profit organization incorporated in the State of Maryland to meet the objectives described above. IIR is in the process of applying for an advance determination of its compliance with provisions of the Internal Revenue code and regulations that permit "charitable" tax deductions for membership dues and contributions to the organization. That determination, if favorable, will apply to all membership dues and contributions received from the time of the organization's

incorporation. However, until it is received, prospective members and contributors are cautioned that no guarantee may be made as to the deductibility of dues and contributions received at this time.)

TO: Institute for Injury Reduction
Post Office Box 375
Dunkirk, Maryland 20754

1. This is my/our application to become a (Founding) (Organizational) (Sustaining) (Regular) (Associate) member of the Institute for Injury Reduction. Please notify me of approval of this application and bill me for my first-year dues.

2. I wish to make a contribution to IIR's start-up effort in the amount of $_____. (It is enclosed.) (Bill me, please.)

Name_____

Address_____

_____

Phone_____

_____ Date:_____
(signature)

Attachment B Excerpted From: National Transportation Safety Board, "Performance of Lapbelts in 26 Frontal Crashes", July 26, 1986.

REPERENCES

1. Adomeit, Dieter. Seat Design -- A Significant Factor for Safety Belt Effectiveness (SAE 791004).
2. _____ and Appel, H. Influence of Seat Design on the Kinematics and Loadings of the Belted Dummy. IRCOBI (1979).
3. Aiken, D.W. Intestinal perforation and facial fractures in an automobile accident victim wearing a seat belt. J. Louisiana State Med. Soc. 115:235, 1963.
4. Aldman, Bertil. The Value of the Automobile Safety Belt. International Road Safety and Traffic Review, Vol. IX, No. 2, Spring 1961.
5. Almqvist, Rune et al. Frontal Crash Protection in a Modern Car Concept. IXth Experimental Safety Vehicle Conference, Kyoto (1982).
6. American Academy of Pediatrics. Lap belts for youngsters: implications for counseling and legislation. Safe Ride News, Vol. II, No. 1 (October 1982).
7. Arkoino, F.L. Dynamics of the Belted Occupant, Implications for Protection. In, Aldman, B. and Chapon, A. (eds): The Biomechanics of Impact Trauma. International Center for Transportation Studies (Elsevier Science Publishers, Amsterdam: 1984).
8. Avery, J.G. Seat belt success: where next? Br. Med. J. 288:662, 1984.
9. Backwinkel, K.D. Injuries from seat belts. J. Am. Med. Assn. (JAMA) 205:305, 1968.
10. Baker, Susan et al. Traffic Deaths Due to Blunt Abdominal Trauma. Proceedings, 14th Annual Conference of the American Association for Automotive Medicine (AAAM), Ann Arbor (1970).
11. Barancik, Jerome I. and Fife, Daniel. Discrepancies in Vehicular Crash Injury Reporting: Northeastern Ohio Trauma Study IV (1984).
12. Birrell, J.H.W. Med. J. Aust. Vol 1, No. 3.
13. Blumenberg, R.M. The seat belt syndrome: sigmoid colon perforation. Ann. Surg. 165:637, 1967.
14. Bohlin, Nils I. A Statistical Analysis of 28,000 Accident Cases with Emphasis on Occupant Restraint Value. Proceedings, 11th Stapp Car Crash Conference, Society for Automotive Engineering (SAE), New York (1967).
15. _____. Refinements of Restraint System Design -- A Primary Contribution to Seat Belt *Effectiveness* in Sweden. International Symposium on Occupant Restraints, Toronto (AAAM, 1981).
16. Bondy, Nancy. Abdominal Injuries in the National Crash Severity Study. In, Collected Technical Studies, Vol. II: Accident Data Analysis of Occupant Injuries and Crash Characteristics — Eight Papers, National Center for Statistics and Analysis, U.S. DOT (1981).
17. Brink, D.C. Spinal cord injuries and seat belts. Med. J. Aust. 2:801 (1973).
18. Cameron, H.M. and Nelson, P.G. Injury Patterns With or Without Seat Belts. Proceedings, 6th International Conference of the Association for Accident and Traffic Medicine (1977).
19. Campbell, B.J. Seat Belt Effectiveness. International Symposium on Seat Belts, Tokyo (1979).
20. _____. The automotive crash injury research program of Cornell University. J. Iowa Med. Soc. 51:760 (1961).

21. _____ and Kihlberg, Jaakko K. Seat Belt Effectiveness in the Non-Ejection Situation. Proceedings, 7th Stapp Car Crash Conference (1965).
22. Campbell, H.E. Role of the safety belt in nineteen auto crashes. Bull. Am. Coll. Surg. 40: 155 (1955).
23. _____. The automobile seat belt and abdominal injury. Surg. Gynec. Obstet. 119:591 (1964).
24. Christian, M.S. Non-fatal injuries sustained by seat belt wearers: a comparative study. Br. Med. J. 2:1310 (1976).
25. Cocke, W.M., Jr., and Meyer, K.K. Splenic rupture due to improper placement of automobile safety belt. JAMA 183:693 (1963).
26. Dajee, H. and MacDonald, A.C. Gastric rupture due to seat belt injury, Br. J. Surg. 69:436 (1982).
27. _____ et al. Seat belt aorta: acute dissection and thrombosis of the abdominal aorta. Surgery 85:263 (1979).
28. Dalmotas, D.J. et al. Current Activities in Canada Relating to the Protection of Children in Automobile Accidents (SAE 840529). In, Advances in Belt Restraint Systems: Design, Performance and Usage, Detroit (1984).
29. Dance, M. et al. An In-Depth Analysis of a Multiple-Fatal, Head-On Motor-Vehicle Collision. Proceedings, 25th AAAM conference, San Francisco (1981).
30. DeRosa, D. and Larsonneur, J.F. Seat Belt Improvements (SAE 840400). In, Advances in Belt Restraint Systems: Design, Performance and Usage, Detroit (1984).
31. Desjeammes, Maryvonne et al. Exploration of Biomechanical Data Towards a Better Evaluation of Tolerance for Children Involved in Automotive Accidents (SAE 840530). In, Advances in Belt Restraint Systems: Design, Performance and Usage, Detroit (1984).
32. Doersch, K.B. and Dozier, W.E. The seat belt syndrome: the seat belt sign, intestinal and mesenteric injuries. Amer. J. Surg. 116:831 (1968).
33. DuBois, E.F. Safety belts are not dangerous. Br. Med. J. 2:685 (1952).
34. Finch, D.M. and Palmer, J.D. Dynamic Testing of Seat Belts. Preprint No. 48, for presentation at SAE Summer Meeting, Atlantic City (1956).
35. Fish, J. and Wright, R.H. The seat belt syndrome — does it exist? J. Trauma 5:746 (1965).
36. Fisher, P. Injury produced by seat belts: report of two cases. J. Occupat. Med. 7:211 (1965).
37. Flamboe, Eugene E. A Comparison of Injuries Between Lap-Belted and Non-Restrained Automobile Occupants According to Seated Position and Vehicle Size (DOT-HS-801-350), January 1975.
38. Fletcher, B.D. and Brogdon, B.G. Seat-belt fractures of the spine and sternum. JAMA 200:177 (1967).
39. Frazier, R.G. Effectiveness of seat belts in preventing motor vehicle injuries. N. Eng. J. Med. 264:1254 (1961).
40. Fulton, J.L. Seat Belts Versus Shoulder Harness (SAE 660536).
41. Gallup, B.M. et al. Abdominal Injuries to Restrained Front Seat Occupants in Frontal Collisions. Proceedings, 26th AAAM conference, Ottawa (1982).
42. _____ et al. The Development of Two Prototype Seat Belt Systems for Improved Lap Belt Fit. Proceedings, 28th AAAM conference, Denver (1984).

43. _____ et al. The Relationship Between Belt Fit and Abdominal Injuries to Rear Seat Occupants. Proceedings, 4th Canadian Multidisciplinary Highway Safety Conference, Montreal (1985).
44. _____ et al. Untitled. "Preprint" for 1985 SAE Conference.
45. Garrett, J.W. and Braunstein, P.W. The seat belt syndrome. J. Trauma 2:220 (1962).
46. Garvin, G. Children in Injury Level Accidents. Proceedings, 20th AAAM conference, Atlanta (1976).
47. Gerritsen, R. et al. Unusual abdominal injuries due to seat belts. J. Albert Einstein Med. Ctr. 14:63 (1966).
48. Grattan, E. and Hobbs, J.A. Some Patterns and Causes of Injury in Car Occupants. Proceedings, 5th International Technical Conference on Experimental Safety Vehicles (1974).
49. Green, R.N. et al. Investigation of Injury Mechanisms Associated with Fully Restrained Passenger Vehicle Occupants in London, Ontario. Proceedings, 21st AAAM conference (1977).
50. Grime, G. Information on Injuries Obtained from Reports of Accidents to Car Occupants Wearing Safety Belts. Proceedings, Conference on Road Safety, Foundation for Road Safety Research, Brussels (1968).
51. Haddad, G.H. and Zickel, R.E. Intestinal perforation and fracture of lumbar vertebra caused by lap-type seat belt. N.Y. State J. Med. 67:930 (1967).
52. Hartemann, F. and Tarriere, C. How to Further Improve the Protection of Occupants Wearing Seat Belts. Proceedings, 19th AAAM conference (1975).
53. Henderson, J.M. and Freedman, K. The Effect of Mandatory Seat Belt Use in New South Wales, Australia. Proceedings, 17th AAAM conference, Oklahoma City (1973).
54. _____ et al. Performance of Child Restraints in Crashes and in Laboratory Tests. Proceedings, Seat Belt Seminar, Melbourne (1976).
55. _____ et al. The Effect of Seat Belt Design and Anchorage Geometry on Injury Patterns. Proceedings, 6th International Conference of IAATM, Melbourne (1977).
56. Herbert, D.C. Injury reduction by diagonal and other vehicle safety belts. Med. J. Aust. 1:61 (1964).
57. _____ and Cutting, D. Crash Protection for Children After Their Third Birthday. Dept. of Motor Transport, New South Wales (1978).
58. Hobbs, C.A. Car Occupant Injury Patterns and Mechanisms. Proceedings, 8th International Technical Conference on Experimental Safety Vehicles. Wolfsburg (1980).
59. Howland, W.J. et al. Fulcrum fractures of the lumbar spine. JAMA 193:240 (1965).
60. Huelke, D.F. Effectiveness of Occupant Restraints in Reducing Serious Injuries and Fatalities. International Symposium on Occupant Restraint, Toronto (AAAM, 1981).
61. _____. Study of 139 Accidents Involving 177 Fatalities. Highway Safety Research Institute, University of Michigan (1961).
62. _____. The Effectiveness of Belt Systems in Frontal and Rollover Crashes (SAE 770143).
63. _____. The Rear Seat Automobile Passenger in Frontal Crashes. Proceedings, 22d AAAM conference (1978).
64. _____ and Chewning, W.A. Comparison of Occupant Injuries With and Without Seat Belts (SAE 690244).

65. _____ et al. Injury Causation in Rollover Accidents. Proceedings, 17th AAAM conference, Oklahoma City (1973).
66. _____ and Lawson, Thomas E. Injuries to Rear-Seat Passengers in Frontal Automotive Crashes. The HSRI Research Review, Vol. 9, No. 1 (1978).
67. _____. Lower Torso Injuries and Automobile Seat Belts (SAE 760370). SAE Automotive Engineering Congress and Exposition, Detroit (1976).
68. _____. The Rear Seat Automobile Passenger in Frontal Crashes. Proceedings (Vol. 1), 22d AAAM conference (1978).
69. Hurwitt, E.S. and Silver, C.E. Seat belt hernia: a ventral hernia following an automobile crash. JAMA 194:829 (1965).
70. Johannessen, H. George. Historical Perspective on Seat Belt Restraint Systems (SAE 840392). In, Advances in Belt Restraint Systems: Design, Performance and Usage, Detroit (1984).
71. _____ and Pilarski, Regis V. Rear Seat Occupant Protection (SAE 810797).
72. _____ and Vos, Thomas H. The Changing Shape of Seat Belt Systems (SAE 820796).
73. Kahane, Charles. Remarks at meeting sponsored by U.S. Department of Transportation and OECD, The Effectiveness of Safety Belt Use Laws: A Multi-National Examination, Washington, D.C. (1985).
74. Kihlberg, J.K. Efficacy of Seat Belts in Injury and Non-Injury Crashes in Rural Utah. Report VJ-2721-R3, Calspan Corporation, Buffalo (1969).
75. Knoop, J.C. et al. Statistical Evaluation of the Effectiveness of Child Restraints (DOT-HS-805-660), September 1980.
76. Kulowski, J. and Rost, W.B. Intra-abdominal injury from safety belt in auto accident: report of a case. Arch. Surg. 73:970 (1956).
77. Lane, J.M. et al. Evaluation of the 1981-82 Rear Seat Belt Campaign. Road Safety and Traffic Authority (ROSTA) Report No. 4, Victoria (1983).
78. "Lap seat belt useful but can injure children," JAMA 245:2281 (1981). See also, "Lumbar injuries seen as possible result of auto seat belt use," Orthopedics Today 1:1 (1981).
79. Lawson, J.J. and Dalmotas, D.J. An Assessment of the Potential Cost-Effectiveness of a Regulation Requiring Three-Point Rear Seat Belts in Passenger Cars. Proceedings, 3d Canadian Multidisciplinary Highway Safety Conference, London, Ontario (1984).
80. LeMire et al. Intra-abdominal injuries caused by automobile seat belts. JAMA 201:109 (1967).
81. Leung, Y.C. et al. Submarining Injuries of Three-Point Belted Occupants in Frontal Collisions — Description, Mechanisms, and Protection. Proceedings, 26th Stapp Car Crash Conference, Ann Arbor (1982).
82. Levine, Donald N. and Campbell, B.J. Effectiveness of Lap Seat Belts and the Energy-Absorbing Steering System in the Reduction of Injuries. Highway Safety Research Center, University of North Carolina (1971).
83. Lhotka, Donald C. Motor Vehicle Occupant Protection — A Historical Perspective. Proceedings, 19th AAAM conference (1975).
84. Lindgren, S. and Warg, E. Seat belts and accident prevention. Practitioner 188:467 (1962).
85. Lister, R.D. and Milson, B.M. Car seat belts: an analysis of the injuries sustained by car occupants. Practitioner, 191:332 (1963).

86. Louton, J.C. and Ruster, T.W. Restraint Systems, Design and Performance Parameters. Proceedings, GMC Automotive Safety Seminar (1968).

87. Lowne, R. et al. The Effect of the UK Seat Belt Legislation on Restraint Usage by Children. In, Advances in Belt Restraint Systems: Design, Performance and Usage, Detroit (1984).

88. Lundell, B. et al. Safety Performance of a Rear Seat Belt System with Optimized Seat Cushion Design (SAE 810796). SAE Passenger Car Meeting (1981).

89. Mackay, G.M. Belted Occupants in Frontal Crashes. Proceedings, 6th International Conference of the IAATM, Melbourne (1977).

90. _____. Seat Belts in Europe -- Their Use and Performance in Collisions. International Symposium on Occupant Restraint, Toronto (AAAM, 1981).

91. _____. Two Years' Experience with the Seat Belt Law in Britain (SAE 851234).

92. _____ et al. Serious Trauma to Car Occupants Wearing Seat Belts. SAE International Automotive Engineering Congress, Detroit (1973). (Also presented at IRCOBI conference, Birmingham, England, 1975.)

93. MacLeod, J.H. and Nicholson, D.M. Seat belt trauma of the abdomen. Canad. J. Surg. 12:202 (1969).

94. Marsh, Joseph C. et al. Injury Patterns by Restraint Usage in 1973 and 1974 Passenger Cars. Proceedings, 19th Stapp Car Crash Conference, San Diego (1975).

95. McPherson, D. and Oversby, M. Investigations of Injury Mechanisms in Fully Restrained Vehicle Occupants. Proceedings, 6th International Conference of the IAATM, Melbourne (1977).

96. McRoberts, J.R. Seat belt injuries and legal aspects. Industrial Med. Surg. 34:866 (1965).

97. Mellbring, G. et al. The hospital experience of seat belt legislation in the County of Skaraborg, Sweden. Injury 12(6):506 (1981).

98. Mills, P.J. and Hobbs, C.A. The Probability of Injury to Car Occupants in Frontal and Side Impacts (SAE 841652). Proceedings, 18th Stapp Car Crash Conference (1985).

99. Milne, Peter W. Fitting and Wearing of Seat Belts in Australia: The History of a Successful Countermeasure. Australian Dept. of Transport, Office of Road Safety (1979).

100 Moffatt, Charles A. et al. Diagnosis of Seat Belt Usage in Accidents (SAE 840396). In, Advances in Belt Restraint Systems: Design, Performance and Usage, Detroit (1984).

101 Mukerjea, S.K. and Nair, K.K. Seat belt injury causing pneumothorax with rupture of diaphragm, stomach and spleen. Lancet 2:1044 (1978).

102 Najjar, Daniel. Restraint Usage and Effectiveness for Rear Seat Occupants. In, Collected Technical Studies, Vol II: Accident Data Analysis of Occupant Injuries and Crash Characteristics -- Eight Papers, National Center for Statistics and Analysis, U.S. DOT (1981).

103 Nelson, P.G. Aspects of injury patterns in automobile accidents. Aust. N.Z. J. Surg. 47:162 (1977).

104 Newman, James A. et al. Development of a Belt Configuration Test Device (SAE 840402).

105 Niederer, P. et al. Adverse Effects of Seat Belts and Causes of Belt Failures in Severe Car Accidents in Switzerland (SAE 770916). Proceedings, 21st Stapp Car Crash Conference, New York (1977).

106 Norin, Hans and Andersson, Britta. The Adult Belt--A Hazard to the Child? Proceedings, 6th International Association for Automotive and Traffic Medicine (IAATM) International Conference, Melbourne (1977).
107 _____ et al. Children in Cars. (Internal survey performed by Volvo; no date, but not later than 1979).
108 _____ et al. Child Restraints in Cars -- An Approach to Safe Family Transportation (SAE 790320).
109 _____ et al. Seat Belt Usage in Sweden and its Injury Reducing Effect. In, Advances in Belt Restraint Systems: Design, Performance and Usage, Detroit (1984).
110 O'Day, James and Kaplan, Richard. Fatal Injuries to Restrained Passenger Car Occupants. The HSRI Research Review, Vol. 9, No. 1, University of Michigan (1978).
111 O'Neill, Brian. Presentation, SAE Panel on the Political and Technical Considerations of Inflatable Restraints, Detroit (1984).
112 Patrick, L.M. et al. Impact Dynamics of Unrestrained, Lap Belted and Lap and Diagonal Chest Belted Vehicle Occupants (SAE 660788). Proceedings, 10th Stapp Car Crash Conference (1966).
113 Physicians for Automotive Safety. Shoulder belts in rear seats. PAS News (Summer/Fall 1981).
114 Porter, S.E. and Green, E.W. Seat belt injuries. Arch. Surg. 96:242 (1968).
115 Prentice, H.A.J. Seat Belt Effectiveness: Possible Benefits and Advertising. International Symposium on Seat Belts, Tokyo (1979).
116 Preston, Fred. A Comparison of Contacts for Unrestrained and Lap Belted Occupants in Automobile Accidents. Proceedings, 17th AAAM conference, Oklahoma City (1973).
117 Quinn, F.R., Jr. Are seat belts enough? Gen. Pract. 26:101 (1962).
118 Rattenbury, S.J. et al. The Biomechanical Limits of Seat Belt Protection. Proceedings, 23d AAAM conference (1979).
119 Reinfurt, D.W. et al. A Statistical Analysis of Seat Belt Effectiveness in 1973-75 Model Cars Involved in Towaway Crashes. National Highway Traffic Safety Administration, U.S. DOT (1976).
120 Ritchie, W.P., Jr. et al. Combined visceral and vertebral injuries from lap seat belts. Surg. Gynecol. Obstet. 131:431 (1970).
121 Roberts, A.K. The Effects of Rear Seat Passengers on Front Seat Occupants in Front Impacts, TRRL Report LR 1979, Dept. of Transport (UK), London (1983).
122 Roberts, Verne L. et al. Biomechanics of Seat Belt Design. Proceedings, 16th Stapp Car Crash Conference, Detroit (1972).
123 Root, H.D. et al. Peritoneal trauma: experimental and clinical studies. Arch. Surg. 95:531 (1967).
124 Ryan, P. and Ragazzon, R. Abdominal injuries in survivors of road trauma before and since seat belt legislation in Victoria. Aust. N.Z. J. Surg. 49:200 (1979).
125 Scherz, R.G. Fatal motor vehicle accidents of children passengers from birth through 4 years of age in Washington State. Pediatrics, Vol. 68, No. 4 (1981).
126 Schneider, R.C. et al. Lap seat belt injuries: the treatment of the fortunate survivor. Mich. Med. 67:171 (year not legible).
127 Scott, R.E. et al. An Evaluation of the 1974 and 1975 Restraint Systems. Highway Safety Research Institute, University of Michigan (1976).

128 Severy, D.M. et al. Passenger Protection from Front-End Impacts. International Automotive Engineering Congress, Detroit (1969).
129 Sharp, J.E. et al. Analysis of Lap Shoulder Belt Effectiveness in Accidents. Proceedings, 9th Stapp Car Crash Conference (1965).
130 Shortridge, Ray M. A Comparison of Injury Severity Patterns for Unrestrained, Lap Belted, and Torso Restrained Occupants in Automobile Accidents. Proceedings, 17th AAAM conference, Oklahoma City (1973).
131 Smith, W.S. and Kaufer, H. Patterns and mechanisms of lumbar injuries associated with lap seat belts. J. Bone Jt. Surg. 51A:239 (1969).
132 Snyder, R.G. Survey of Automotive Occupant Restraint Systems: Where We've Been, Where We Are, and Our Current Problems (SAE 690243).
133 _____ et al. A new pattern of spine injuries associated with lap type seat belts. U. Mich. Med. Ctr. J. 33 (May-June, 1967).
134 _____ et al. Pathology of trauma attributed to restraint systems in crash impacts. Aerospace Med. 39:812 (1968).
135 _____ et al. Seat Belt Injuries in Impact. Highway Safety Research Institute, University of Michigan (1967).
136 Stapp, Col. John P. and Enfield, Lieut. D.L. Evaluation of the Lap-Type Automobile Safety Belt with Reference to Human Tolerance. Presented at SAE Summer Meeting, Atlantic City (1958).
137 States, J.D. et al. The Medical Aspects of Driver Protection Systems and Devices Developed Through Automobile Racing (SAE 700660).
138 Steckler, R.M. et al. Seat belt trauma to the lumbar spine: an unusual manifestation of the seat belt syndrome. J. Trauma 9:508 (1969).
139 Stevenson, J.H. Severe thoracic, intra-abdominal and vertebral injury occurring in combination in a patient wearing a seat belt. Injury 10: 321 (1979).
140 Straith, C.L. Guest passenger injuries. JAMA 137:348 (1937).
141 Sube, J. et al. Seat belt trauma to the abdomen. Amer. J. Surg. 113:346 (1967).
142 Tarriere, C.H. Proposal for a Protection Criterion as Regards Abdominal Internal Organs. Proceedings, 17th AAAM conference, Oklahoma City (1973).
143 Taylor, T.F.K. et al. Seat belt fractures of the cervical spine. J. Bone Jt. Surg. 58:328 (1976).
144 Thomas, C. et al. The Main Causes of Risk Differences for Restrained Drivers and their Restrained Front Passenger in Frontal Collisions. Proceedings, 9th International Technical Conference on Experimental Safety Vehicles, Kyoto (1982).
145 Tolins, S.H. An unusual injury due to the seat belt. J. Trauma 4:397 (1964).
146 Transport Canada, unpublished data (1985).
147 Trinca, Gordon W. Medical Aspects of Seat Belt Usage. International Symposium on Seat Belts. Tokyo (1979).
148 _____. the Medical Significance of Occupant Restraint on Road Crash Victims and Those Who Treat Them. International Symposium on Occupant Restraint. Toronto (AAAM, 1981).
149 U.S. Department of Transportation. Denial of Petition for Rulemaking (49 F.R. 15241, April 18, 1984).
150 _____. Docket No. 74-14; Notice 17 (44 F.R. 77210, December 31, 1979).
151 _____. Docket No. 74-14 (44 F.R. 2060, December 1980).

152 _____. Docket No. 74-14; Notice 19 (46 F.R. 2064, January 8, 1981).

153 _____. Docket No. 74-14; Notice 37 (50 F.R. 14580, April 12, 1985).

154 _____. Docket No. 74-14; Notice 38 (50 F.R. 14589, April 12, 1985).

155 _____. Docket No. 74-14; Notice 39 (50 F.R. 14602, April 12, 1985).

156 _____. Docket No. 74-14 (50 F.R. 34152, August 23, 1985).

157 _____. Docket No. 74-14; Notice 42 (50 F.R. 46056, November 6, 1985).

158 _____. Final Regulatory Impact Analysis of the amendment to FMVSS 208: Passenger Car Front Seat Occupant Protection, July 11, 1984.

159 Vellar, I.D. et al. Rupture of the bowel due to road trauma: the emergence of the seat belt syndrome. Med. J. Aust. 1:694 (1976).

160 Volvo Car Corporation and Swedish Road Safety Office. Injury-Reducing Effect of Seatbelts on Rear Seat Passengers (1979).

161 Wagenaar, Alex. Remarks at meeting sponsored by U.S. DOT and the OECD, The Effectiveness of Safety Belt Use Laws: A Multi-National Examination. Washington, D.C. (1985).

162 Walpole, Bryan. Motor vehicle accident — multiple trauma. Australian Family Physician, Vol. 13, No. 4, (1984).

163 Walz, Felix H. et al. Severely and Fatally Injured Rear Seat Car Passengers (OAIS >/= 2) in Switzerland During 1976. Proceedings, 22d AAAM conference (1978).

164 Warner, Charles Y. Belt Occupant Restraint Effectiveness. Proceedings, 17th AAAM conference, Oklahoma City (1973).

165 Wexler, L. and Silverman, J. Traumatic rupture of the innominate artery — a seat belt injury. N. Eng. J. Med. 21:1186 (1970).

166 Wild, B.R. et al. Effect of seat belts on injuries to front and rear seat passengers. Br. Med. J. 290:1621 (1985).

167 Williams, Allan F. and Zador, Paul. Injuries to children in automobiles in relation to seating location and restraint use. Accident Analysis and Prevention, Vol. 9, No. 1 (1977).

168 _____ et al. Occupant Protection in Interior Impacts: An Analysis of FMVSS No. 201. Proceedings, 23d AAAM, Louisville (1979).

169 Williams, James S. and Kirkpatrick, John R. The nature of seat belt injuries. J. Trauma 11:207 (1971). (Also published as SAE 700896 in, Proceedings, 14th Stapp Car Crash Conference, Detroit (1970); also presented at 28th Annual Convention of the American Association for Surgery of Trauma, Montreal (1971).

170 _____ et al. The automotive safety belt: in saving a life may produce intra-abdominal injuries. J. Trauma 6:303 (1966).

171 Witte, C.L. Mesentery and bowel injury from automotive seat belts. Ann. Surg. 167:486 (1968).

172 Woelfel, G.F. et al. Severe Thoracic and Abdominal Injuries Associated with Lap-Harness Seatbelts. J. Trauma, Vol. 24, No. 2 (1984).

173 Yajko, R.D. et al. Rupture of the stomach from blunt abdominal trauma. J. Trauma 15:177 (1975).

SELECTED CASES FROM MEDICAL LITERATURE ON LAP BELT INDUCED INJURIES

Aiken, D.W. (1963). Lap belt-induced jejunal perforation of the small intestine. Undetected for 6 days after crash. Injury probably caused by sudden compression between belt buckle and spinal column. Only external indication of belt injury was welt across lower abdomen, below umbilicus. Probable correct belt use, no submarining.

Beckwinkel, K.D. (1968). Reports 2 cases. Case 1: A 61-year woman in rear with lap belt; frontal impact, followed by right lateral. Belt bruising across abdomen seen initially, accompanied by complaints of abdominal pain, but condition seemed stable until next morning, when severe pain developed and woman went into shock. At laparotomy, a tear in the mesentery of the small bowel was found, with about 12" of gangrenous bowel. Generalized peritonitis was present and the woman died on the operating table. Case 2: A 19-year man in "high speed" frontal hit, wearing lap belt in right front seat. Driver ejected, fractured nose. Lap belt wearer had extensive multiple laceration of scalp, upper/lower lips, requiring emergency surgency. 20" x 20" area of abrasion and ecchymosis corresponding to seat belt dimensions across lower abdomen, right across left and right iliac crests (indicates correct belt placement). Fracture of third lumbar vertebra. Abdominal distention, no blood at 4-quadrant tap. At laparatomy, however, 750 cc of old blood found, along with perforation of ileum, large tear in mesentery of small bowel, which extended down to inferior mesenteric vein. Also, incomplete tear of ileocolic artery. A 15-cm length of sigmoid colon was "completely stripped of its external coat of serosa, muscularis propria, submucosa, and muscularis mucosae."

Blumenberg, R.M. (1967). Reports 20 cases of "intra-abdominal visceral and mesenteric trauma due to the seat belt syndrome" in the literature at that time. Reports a new case: 25-year lap belted man involved in an approximate 35 mph lateral skid into pole. Received facial lacerations, contusions of the lower abdominal wall at the iliac crests (indicates proper belt placement). Discharged from hospital. 3 days later, abdominal distention and cramping appeared. Internal inspection found a linear tear of the mesosigmoid "extending to its root, and avulsion of the mesentery of a 4-inch segment of redundant sigmoid." Also, a 2-cm performation on the mesenteric aspect of sigmoid. Required 6 weeks in hospital.

Cocke, W.M., J. and Meyer, K.K. (1963). Reports case involving frontal crash into side of another vehicle at estimated 35 mph. Unbelted driver said to have received no injury. A 62-year woman at right front, lap belted (overweight), showed a reddened band on the upper abdomen but no other symptoms noted. 5 hours later, went into shock. The spleen was "severely ruptured," required removal. Also fractured ribs.

Dajee, H. and MacDonald, A.C. (1982). Discusses 27-year woman admitted to hospital with "noticeable seat belt abrasion across the abdomen." Complained of "severe abdominal pain," was pale, with heart rate 120, blood pressure of 70/40 mm Hg. Abdominal distention with tenseness and rebound tenderness. No bowel sounds. At laparatomy, the peritoneal cavity found "filled with food fragments and blood." Transection of stomach, avulsion of the left colonic mesentery and several small bowel serosal lacerations with areas of contusion of the peritoneum and mesentery. She had lost considerable blood.

Doersch, K.B. and Dozier, W.E. (1968). Reports 3 cases of lap belt-induced injury, all in "head-on" collisions. Case 1: 45-year man. Fractured ankle, multiple facial and head injuries. Lower abdominal contusions, abrasions, and ecchymoses. Audible peristalsis, no rebound tenderness of abdomen. Abdominal bleeding noted after catheter had been in place for 8 hours. Laparotomy undertaken 12 hours after accident. Found "large mesenteric laceration beneath a 15-inch segment of infarcted ileum." Case 2: 20-year man sustained compression fracture of 4th lumbar vertebra, multiple facial fractures and lacerations. Abdominal tap was negative, no bowel sounds. Laparatomy undertaken 10 days after accident. Found 2 perforations of cecum with surrounding abscesses. Mesenteric tears and hemoperitoneum. Victim required a "very prolonged convalescence." Case 3: 23-year woman sustained facial fractures and lacerations, fractured right ankle and fracture of the fifth lumbar vertebra. Multiple abdominal contusions and abrasions, "severe 'seat belt sign.'" No abdominal spasm or rebound tenderness. Peristalsis. Hunger. Left femoral pulse moderately diminished. Abdominal taps negative twice. Began deteriorating on day 2. At surgery, found "both rectus muscles, including their sheaths, as well as their adjacent oblique musculature, were completely transected." Peritoneum torn, one continuous abscess cavity from peritoneal space into the muscles and subcutaneous tissues on each side lower abdomen. Small bowel almost completely transected. Two large mesenteric lacerations and traumatic thrombosis of left iliac artery with dissection of intima. Patient died one week later of "overwhelming sepsis."

DuBois, E.F. (1952). Reports 23 cases of intra-abdominal injuries sustained by lap belted aircraft occupants, along with 32 cases of contusions along the belt line.

Fish, J. and Wright, R.H. (1965). Presents 4 cases of lap belt-induced injuries from air crash. Case 1: Arrived hospital in shock. Bruises across lower abdomen and pelvis. Abdomen tense, tender. Paracentesis in 3 quarters was negative. found 2-foot segment of ileum avulsed from its mesentery; small seromuscular tear midportion of the intestine. Avulsed end of mesenteric artery actively bleeding. Hematoma in left transverse mesocolon; spleed had capsular tear near inferior pole. Case 2: Shortly after crash, noted pain in right flank and lower abdomen. Examination found lower abdominal wall and right flank contusions corresponding to areas of pain. Paracentesis in 4 quadrants all negative. In hospital, complained of abdominal discomfort, ate little, had low grade fever to the 13th post-injury day. Exploratory operation found proximal ileum partially transected, adjacent bowel markedly contused; the injured bowel was adherent to the left side. Case 3: This man "extracted himself without difficulty from the wreckage." Only complaint at hospital was lower abdominal and flank pain corresponding to contusions from belt. Able to eat, had normal bowel movement following day. During next 3 days, developed abdominal distention and nausea. Abdominal X-rays showed dilated loops of small intestine. Abdominal exploration on 9th post-injury day found lacerated proximal ileum adjacent to urinary bladder, with considerable surrounding inflammatory reaction. Also, large tear in mesentery. Case 4: Arrived hospital in shock, died within 1 hours. Autopsy showed "wide band of contusions across the lower abdominal wall corresponding to the seat belt. Peritoneal cavity and retroperitoneal space filled with blood. Large segment of small intestine and segment of sigmoid colon avulsed from mesentery. Hemorrhage secondary to laceration of mesentery determined to be cause of death."

Fletcher, B.D. and Brogdon, B.G. (1967). 21-year driver of "small, foreign sports car" struck rear of semitrailer "at a high rate of speed." She "flexed acutely over the seat belt and struck her face against the dashboard." Multiple hematomas of lower limbs, laceration and fracture of nose. "No abdominal contusions, hematomas, or abrasions were noted." Transverse fracture of third lumbar vertebra; also small compression fracture of anterosuperior margin of vertebra body."

Gerritsen, R. et al (1966). Reports 2 cases, both "obese" women in "head-on" collisions, said to be wearing lap belt "loosely." Case 1: Passenger in left rear. At surgery, revealed laceration of jejunum, multiple lacerations of mesentery, traumatic amputation of lower half of omentum. Case 2: Passenger in right rear. At surgery, found to have 3,000 cc of blood in abdominal cavity with lacerations of mesenteric attachment of small bowel, laceration of ileum and cecum, division of ileocecal artery, and tear in serosa of sigmoid colon.

Howland, W.J. et al (1965). 19-year male driver (5'9", 150 lb.) in estimated "80 mph, head-on" collision with steel pole. Said to be wearing belt "loosened." Remained conscious. Low back, neck, left hand pain. Facial lacerations. Numerous upper chest contusions, neck contusions and abrasions. Large hematoma in muscles both sides of midlumbar. Transverse fracture of third lumbar vertebra. Attributed injuries to "seat belt's acting as fulcrum, over which vertebral body was split transversely into two parts; the mechanism was similar to breaking a stick over one's knee."

Hurwitt, E.S. and Silver, C.E. (1965). Young woman, right front passenger, involved in ran-off-road crash into abutment at high speed. Received facial injuries, fractured vertebrae, subluxation of fourth lumbar over fifth lumbar vertebra. White striae over both iliac crests "which conformed to the region of distribution of the seat belt over this area at the time of injury." 16 months after crash, a large hernia, containing colon, small bowel, and stomach, developed in the left upper quadrant of abdomen. (Cf. Case 1 in LeMire et al.)

Kulowski, J. and Rost, W.B. (1956). Said to be first report of a case in which crash injury was attributed to a lap belt. Belt-induced trauma to segment of ileum; later, fibrous adhesion of the terminal ileum to the right iliac crest developed, causing obstruction of the distal part of the small bowel.

"Lap seat belt useful but can injure children," AMA 245:2281 (1981). Reports findings by orthopedic surgeon in 7 cases of serious lap belt-induced injuries among children 9 to 15 in Ontario auto crashes 1977-79 (after Ontario's mandatory belt use law in effect). All riding in rear seat, in frontal collisions. Three sustained torn posterior ligaments, lumbar spine dislocations; two of these remain paraplegic. Four sustained "Chance" fractures of lumbar spine; two of these were immobilized for 6 months in body casts and braces. One had "extensive intra-abdominal injury requiring laparotomy." All had seat belt bruises on their abdomen, facial contusions, the latter resulting from head strikes during hyperflexion over belt.

LeMire, J.R. et al (1967). Reports 2 cases. Case 1: 26-year woman at right front in rear end impact. Lap belt said to be "loose" and "high." Only sign of intra-abdominal injury was "ecchymosis and contusion of lower part of abdominal wall corresponding to site of seat belt." Five months post-crash, victim re-entered hospital. Exam found large hernia in right side of abdominal wall, containing colon and small intestine. (Cf. case described in Hurwitt and Silver.) Case 2: 24-year man in "head-on" crash. Lap belt "broke." On admission, general condition seemed good, but complained of pain, tenderness in lower abdomen. Observed for 7 hours, released. Ten hours later, returned to hospital with greatly increased abdominal pain, vomiting. Blood pressure was low, pulse elevated, weak. Abdomen rigid, with rebound tenderness. No bowel sounds. At surgery, 4-cm perforation found in proximal end of jejunum.

Ritchie, W.P. et al (1970). Reports four cases. Case 1: 35-year male driver involved in "head-on" collision "while passing at 50 mph." Car destroyed. Lap belt was in "proper position," but says that "buckle was arranged to ride across the lower part of the abdomen between the iliac crests." Lacerations to chin and knees. 12 hours after admission, abdominal distention, vomiting. 36 hours later, transferred in "moderate distress." Blood pressure 116/70, pulse 104. Abdomen "slightly distended, tense, diffusely tender." Rebound tenderness, most severe over right lower quadrant. No bowel sounds. No evidence of fractured lumbar vertebrae. At surgery, 1000 cc bloody fluid in peritoneal cavity. Terminal portion of ileum transected in 2 adjacent areas. Subjacent mesentery also interrupted, intervening tissue "clearly non-viable." 2 weeks in hospital. Case 2: Woman at right front in same crash. Severe back pain at admission. Fracture of 2d lumbar vertebra. 7 hours later, still severe pain, plus abdominal pain. Blood pressure 130/80, pulse 110, low fever. Transverse contusion over the lower part of abdominal wall corresponded to site of seat belt. Below contusion was palpable defect in tissues of anterior abdominal wall. Abdomen rigid, tender, with rebound tenderness over lower quadrants. No bowel sounds. At laparotomy, found circumferential serosal tear at midjejunal level, 1-cm punctate laceration of antemesenteric border of proximal protion of ileum, longitudinal serosal tear of hepatic flexure of colon. 2 months in hospital. Case 3: 11-year girl in same crash (seated rear). "Pale and agitated" at admission. Blood pressure 100/60, pulse 130 and "thready." Abdomen tense, moderately distended, extensive ecchymosis over lower quadrants. Diffuse rebound tenderness. No bowel sounds. Transverse fracture of body of 3d lumbar vertebra. At laparotomy, showed "circumferential transection of proximal protion of ileum. Serosal tear along antemesenteric border of ileum, just proximal to area of transection, rent in mesentery of ascending colon. 2 months hospital. Case 4: 7-year girl in same crash (rear seat). No signs of acute distress at admission. Blood pressure 104/60, pulse 100. Abdomen "soft and flat but not tender." Bowel sounds present. Tender contusions over anterior superior iliac spines bilaterally, no contusions on abdominal wall. Soft tissue swelling, tenderness, over lumbar spine were prominent. Fracture of 3d lumbar vertebra. Fracture of right transverse process. 5 weeks hospital.

Snyder, R.G. et al (1967). Reports 2 cases with correct lap belt use. Case 1: Right front female passenger in VW struck by oncoming car. Wearing a "snug" lap belt. Concussion, nose fracture, lacerations to cheek and left elbow. Numerous contusions and faintly visible marks from belt on lower abdomen and anterior superior iliac spines. 12 hours later, surgery found tear of jejunum about 8 inches below ligament of Treitz, which nearly severed the bowel. Case 2: 61-year woman in right front, "wearing a snug lap belt," in frontal crash at "about 30 mph." Compression fracture to body of first lumbar vertebra. Cites to "personal communication" with Nahum and Siegel, indicating in "their unpublished study of over 150 accidents in the L.A. area," more than 30 cases of seat belt injuries.

Tolins, S.H. (1964). Reports on man in right front wearing lap belt when car hit tree. Driver and three rear seat passengers unrestrained. They were all uninjured. Lap belted passenger suffered severe midabdominal wall contusion and perforation of upper jejunum. Admitted to hospital 28 hours post-injury, not operated on until 4th post-injury day.

Walpole, Bryan (1984). 45-year woman admitted to hospital after crash. "External signs of seat belt contusion" on abdomen. Swelling, generalized tenderness, marked guarding and rebound tenderness. Bowel sounds audible. "Extremely pale, very confused and gasping for air but responding to commands. Pulse 140, blood pressure 90/50, respiration 45/minute (shallow)." X-ray found left ruptured diaphragm, protrusion of abdominal contents into left chest. At emergency laparotomy, ruptured spleen removed, left 12th rib excised; diaphragmatic deficit repaired; several segments torn small bowel and mesentery removed; end-to-end anastomosis and relieving colostomy performed.

Williams, James S. and Kirkpatrick, John R. (1971). Discusses findings from 80 crash victims wearing lap belts. Intra-abdominal injuries in 42; 39 sustained intestinal or mesenteric injuries, or both. 51 had lumbar spine injuries: 32 fractures, 7 subluxations, 2 ruptured disks, 2 complete anterior dislocatoins. (6 spinal injuries were unknown). 7 patients had intra-abdominal injuries as well. 35 additional injuries due to belt: 22 to abdominal organs or other soft tissue, 4 fractured pelvis, 9 fractures of extremities or facial bones.

Williams, James S. et al (1966). Reports 4 cases, all involving correctly placed lap belts. Case 1: 42-year man in "severe" impact. Sustained perforation of mid-ileum. Case 2: 33-year woman in "severe" impact. Sustained transection of rectus muscle, blood in peritoneal cavity, mid-portion of omentum amputated from attachment to transverse colon (found "hanging by only one thin, vascular stalk"), multiple hematomas and lacerations along small bowel, contusion of right colon, serosal tear in right colon. 2 months in hospital. Case 3: 16-year girl in side impact into fire hydrant (side opposite victim). Transverse tear of duodenum around two-thirds of circumference. 3 months in hospital. Case 4: 20-year man in "severe" impact. 6-cm tear in mesentery of mid-ileum, 6-cm tear in mesosigmoid, contused sigmoid with subserosal hemorrhage, sigmoid questionably viable, blood in peritoneal cavity. 3-1/2 weeks in hospital.

PARTIAL CHRONOLOGY OF SEAT BELT RELATED EVENTS

This chronology of events related to the development and use of motor vehicle seat belts may provide some perspective for those unfamiliar with these topics. The Board was unable to locate a single, complete history of seat belts and their use; the following has been pieced together from a number of sources (14, 33, 52, 69, 71, 78, 82, 89, 110, 131, and correspondence of Thomas Turbell, Chief Biomechanics Researcher, Swedish Road and Traffic Research Institute, to Safety Board, October 11, 1985).

1930's

Several U.S. physicians equip their own cars with lap belts and begin urging manufacturers to provide them in all new cars

1953

Colorado State Medical Society publishes policy supporting installation of lap belts in all automotibles

1954

Sports Car Club of America requires competing drivers to wear lap belts

American Medical Association House of Delegates votes to support installation of lap belts in all automobiles

1955

California Vehicle Code is amended to require State approval of seat belts before their sale or use

National Safety Council, American College of Surgeons, International Association of Chiefs of Police vote to support installation of lap belts in all automobiles

Society of Automotive Engineers (SAE) appoints Motor Vehicle Seat Belt Committee

1956

Volvo markets 2-point cross-chest diagonal belt as accessory

Ford and Chrysler offer lap belts in front as option on some models

Ford begins 2-year ad campaign based on safety, focusing heavily on belts

1957

Volvo provides anchors for 2-point diagonal belts in front

Special Subcommittee on Traffic Safety, U.S. House of Representatives, opens hearings on effectiveness of seat belts in automobiles

1958

Volvo provides anchors for 2-point diagonal belts in rear

1959

Volvo introdues 3-point belt in front as standard, in Sweden

New York considers and rejects bill to require seat belts in new cars sold in State.

1960

New York again considers and again rejects seat belt bill

1961

SAE issues standard for U.S. seat belts (J4)

New York requires seat belt anchors at front outboard seat positions (effective January 1, 1962)

Wisconsin requires seat belts in front outboard seat positions

Standards Association of Australia issues standard for "safety belts and harness assemblies"

1962

Association for Aid to Crippled Children and Consumers Union sponsor landmark conference on "Passenger Car Design and Highway Safety" with occupant protection the sole theme

Six U.S. States require front outboard seat belt anchors

U.S. manufacturers provide seat belt anchors in front outboard as standard

1963

Volvo introduces 3-point belt in front as standard, in USA

Some U.S. manufacturers provide lap belts in front outboard positions (23 States have laws to require belts in front, most effective 1/64)

SAE issues revised standard (J4a)

U.S. Congress passes P.L. 88-201 to allow Commerce Department to issue mandatory standards for seat belts sold in interstate commerce

1964

About half the U.S. States require seat belt anchorages at front outboard

Most U.S. manufacturers provide lap belts at front outboard seat positions

Victoria and South Australia require seat belt anchorages at front outboard positions in new cars (either 2- or 3-point permitted)

1965

U.S. Commerce Dept. issues first seat belt standard (adopted SAE standard)

SAE issues revised standard (J4c)

All U.S. manufacturers providing lap belts in front outboard positions by this time

Some U.S. manufacturers provide automatic locking retractors (ALRs) in front seat belts

1966

Swedish regulations prohibit 2-point cross-chest diagonal belt at seats next to a door, and Y-type of 3-point belt altogether

U.S. Commerce Dept. issues revised seat belt standard (SAE J4c)

U.S. Congress passes P.L. 89-593, establishing National Highway Safety Bureau (now NHTSA)

Sports Car Club of America requires competing drivers to wear a shoulder harness as well as a lap belt (perhaps 1967, according to ref. 131)

1967

U.S. manufacturers provide lap belts at rear outboard positions (MY 1967)

NHSB issues initial Federal Motor Vehicle Safety Standards 208, 209, setting standards for lap and shoulder belts in front outboard positions, lap belts in all other positions (to take effect 1/1/68 and 3/67, respectively)

Volvo introduces 3-point belt in rear as standard, certain markets

Great Britain requires 3-points in front outboard positions

Australian standard for belt anchorages issued

South Australia requires seat belts (lap belts OK) at front outboard positions

1968

Volvo provides emergency locking retractors (ELRs) as standard in front, in Sweden

Great Britain requires retrofit of 3-point belts in front in MY 65 and newer cars

Many U.S. cars this MY provide ALRs.

1969

Sweden requires 3-point belts of approved type in front

Volvo provides 3-point belt in rear as standard, all markets

Mercedes-Benz adds 3-point belt in rear outboard seats as standard, all markets

Japan requires seat belts, front and rear

Australia requires 3-point belts, front outboard seats, all cars registered since 1965

1970

Sweden requires belts in rear (diagonal and static allowed; lap-only not approved)

Victoria, Australia requires 3-point belts, front and rear and mandates use, front and rear

1971

Volvo provides ELRs as standard in rear, all markets

NHTSA amends FMVSS 208 to require passive restraints in front, to be effective 1973

New South Wales requires use of seat belts

1972

Volvo introduces adjustable B-post anchor point (not standard) to permit better fitting of shoulder portion of front lap/shoulder belts

Last Australian state law requiring belt use, front and rear, goes into effect 1/1

New Zealand requires belt use, front and rear

W. Germany requires 3-point belts, front and rear

NHTSA requires anchorages for (detachable) shoulder straps for rear outboard (FMVSS 210)

VW displays 3-point belt system with webbing pre-tensioner (Transport 72, Washington, D.C.)

1973

Mercedes-Benz provides ELR on 3-point belts in large ("S" class) cars

1974

Mercedes-Benz provides ELR on 3-point belts in midsize (300 Series) cars

Sweden requires ELR on belts in front seats

NHTSA requires 3-point belts (i.e., non-detachable shoulder straps) in front outboard positions

U.S. cars provide "vehicle-sensitive" ELRs in front outboard shoulder belts (lap belt portion has ALR)

First production tension relief device on U.S. vehicle.

1975

Sweden requires 3-point, ELR belts in rear; mandates front use by persons 15 and older

1979

France mandates seat belts in rear: either 3 lap belts or 3-points at outboard positions and lap belt at center (most manufacturers choose latter option)

New Zealand requires 3-point belts, front and rear outboard positions

1980

Mercedes-Benz provides driver side airbag and knee bolster, and pre-tensioner on all 3-point belts

1981

NHTSA rescinds requirements for eventual installation of passive restraint systems

1983

New Brunswick and Ontario make belt use mandatory, front and rear (front seat use mandatory in Ontario since 1/76)

Saab introduces 3-point in rear in all models sold in U.S. (had provided "for years" in Scandinavia and Europe)

1984

Austria makes belt use mandatory in rear for cars with vehicle approval after 1/84 (front seat use mandatory since 7/76)

W. Germany makes rear seat belt use mandatory in cars manufactured since 5/79 (mandatory use in front since 1/76)

Seven of Canada's 10 provinces by this time require occupants of moving vehicles to use whatever seat belt system is available to them

1985

Nova Scotia makes belt use mandatory, front and rear

Norway makes rear seat belt use mandatory in vehicles registered after 1/84 (front seat use mandatory since 9/75)

New York makes belt use mandatory, front and rear (in rear for persons 10 years or older)

Mercedes-Benz introduces driver side air bag with knee bolster (in addition to pre-tensioned 3-point belts) in U.S. market

Excerpted From: Evans, L., Occupant Protection Device Effectiveness in Preventing Fatalities, General Motors Research Laboratories, April 14, 1987.

Table 9. Empirically determined effectiveness of three occupant protection devices. In all cases effectiveness means the reduction in fatalities which would occur if a population not using the protection device were to change to universal use. The uncertainty indicated is plus or minus one standard error.

Vehicle	Occupant	Protection device	Effectiveness in preventing fatalities	
Car	Driver	Lap/shoulder belt	(42 ± 4)%	(41 ± 4)%
	Right front passenger	Lap/shoulder belt	(39 ± 4)%	
Car	Left rear passenger	Lap belt	(19 ± 10)%	(18 ± 9)%
	Right rear passenger	Lap belt	(17 ± 9)%	
Motor-cycle	Driver	Helmet	(25 ± 9)%	(27 ± 9)%
	Passenger	Helmet	(29 ± 9)%	

Table 10. Summary of the effectiveness of the three devices in preventing fatalities.

Occupant protection device	Effect-iveness
Lap/shoulder belts in outboard front seats of cars	(41 ± 4)%
Lap only belts in outboard rear seats of cars	(18 ± 9)%
Motorcycle helmets	(27 ± 9)%

ROCKY MOUNTAIN MEDICAL JOURNAL, VOL. 61, no. 8, August 1964

Thirty-three fatal crashes with seat belts

Horace E. Campbell, MD, Denver*

DUE TO THE GENEROUS CO-OPERATION of the Department of Highways, the Motor Vehicle Division, and the Colorado State Patrol, it has been possible to study all fatal crashes in Colorado in the last two years in which at least one person was wearing a seat belt. At the outset, it should be understood that this study does not attempt to ascertain the protection afforded by a seat belt. A study of 232 matched pairs of crashes with and without seat belts, by the Cornell group,[1] to be published soon, proves that the seat belt is not enough.[2] Although this investigation confirms this observation, the purpose of the study is to learn why belts must frequently fail to protect—motorcars being constructed the way they are.

In Colorado during 1962 and 1963, there were 51 persons fatally injured in 33 automobile accidents, in which at least one person was wearing a seat belt. There were 129 persons and 59 automobiles involved in these 33 fatal crashes. Twenty-three of those fatally injured were wearing seat belts. Data of these fatal accidents are summarized in Table 1. On analysis, the fatalities were from steering shaft displacement, roll-over, or crushing of car interior except for one belted passenger who died because of head injuries incurred by striking the instrument panel—a death preventable by adequately padded panel or shoulder strap.

Steering shaft displacement

Five drivers, one-third of the belted ones fatally injured, were killed because the solid steel steering shaft was displaced back into the drivers' seating space for a distance of one and a half to two and a half feet. These were severe crashes, but the drivers' seating space was not otherwise severely encroached upon. One of these deaths was in a compact in which the steering shaft starts from a point some two inches in front of the leading surface of the front tires. In almost any crash involving the left front corner, the shaft is routinely displaced backwards. In the fatal crash, the shaft was displaced as measured two

TABLE 1

33 FATAL CRASHES IN COLORADO IN 1962 AND 1963 IN WHICH AT LEAST ONE PERSON WAS WEARING A SEAT BELT

	Fatally Injured	Survived
With Seat Belts	23	26
Drivers	15	18
Passengers	8	8
Without Belts	28	32
Drivers	8	14
Passengers	20	34
Total	51	78

* Dr. Campbell is Chairman of the Automotive Safety Committee, Colorado Medical Society.

feet, and broke the driver's neck. He had no other injuries of consequence.

That severe crashes with steering shaft displacement can be survived with a seat belt is illustrated by a case in a previous series[1] where the driver was fortunate to be thrown to the left, so that the steering shaft passed over his right shoulder, and the steering wheel came to rest behind the front seat back. It must be pointed out that a shoulder strap in this case would have prevented this survival, although for maximum protection we must add upper torso restraints to the current lap belt. The Liberty Mutual Survival Car has eliminated the solid steel steering shaft.

Roll-overs

There were eight roll-overs in this series: all the drivers had belts fastened; three survived, and five were fatally injured. There were three right front seat passengers, all with seat belts fastened; one survived with scarcely any injury, and two were fatally injured. In one of the latter, a right side impact preceded the roll-over and was the probable cause of the fatality.

Door opening was the definitive factor in four of the five driver fatalities in roll-overs. Three of the four deaths were in European compacts, and one in a late-model American car. These recall the accident of Dr. John Waugh, distinguished surgeon, who was wearing a seat belt when his car rolled, the door opening, and death resulting from multiple skull fractures.

Although door locks have been improved beginning with the 1956 models, doors continue to pop open in roll-overs. It is in this type of accident that upper torso control is needed to keep the head inside the car under any circumstances. For the shoulder strap to come into general use, we must have built-in attachment points in forthcoming cars, because shoulder straps are more difficult to attach than were seat belts before built-in attachment points for these were provided. New York State is the first to introduce legislation requiring built-in shoulder strap attachment points, and other States should quickly follow. Although the small foreign cars have shortcomings as regards protection, it must be pointed out that both the Volvo and the Volkswagen have ten built-in strap attachment points, three for each of two front seat passengers, and two for each of two rear seat passengers. We plead for twelve such points in all cars, so that upper torso control may be provided for at least four car occupants.

Crushing of car interior

Five drivers were killed by the destruction of, or severe encroachment upon, their seating space. In perhaps two of these, upper torso control by means of a shoulder strap might have allowed survival since there was marked bending forward of the steering column by body impact. Five of the eight passenger fatalities were crashes from the side with penetration of the passenger seating space. Seat belts can be expected to provide little or no added protection in this type of crash.

There would appear to be several improvements which might be made to reduce injuries in blows from the side. We have noted that liver injuries are a prominent feature of crashes from the right side, and in non-fatal accidents without liver injuries, the arm rest seems to be the cause of very disabling bruises. We suggest the use of one of the plastic foams for the molding of broad based armrests. These plastic foam armrests might well be an integral part of a two-inch sheet of this padding material applied over all the lateral surfaces of the car interior. This is protection which will not need the consent or decision of the occupants for use, but will be built-in and inconspicuous, but ever-present for the time of need.

Aluminum honey-comb material has widespread use in airplane construction. Other metals and alloys can be thus formed, and when electrically welded to the "skin" material provide the lightest and strongest type of construction yet devised. Undoubtedly side panels of these materials would save many lives.

However, perhaps an even more important and immediately available remedy is reversion to the old-style wide and concave bumper. The bumpers for the last three years are narrow and convex and are bound to override. In fact, a former automobile engineer states that "... many auto designers are now shaping front bumpers in an attempt to ride over the bumper of the car ahead."[2] In end-to-end crashes this can be very expensive, but perhaps not too dangerous to the car occupants. However, in lateral crashes, the modern bumper over-rides the side rails (if any) and penetrates the impacted car more deeply than formerly. In those cars without frame side rails, fatalities are significantly greater in lateral crashes. A wide concave bumper, on the other hand, like those in cars of the mid-40's, would engage and remain in contact with the side rails and inflict less damage to occupants of the laterally impacted car, and also would produce very much less property damage in any end-to-end crash. Inter-

ance underwriters are aware of the destructive qualities of the modern bumper and call it "that decorative bauble."

Conclusions

All motorists, in both front and rear seats, should wear seat belts whenever the car is in motion. We beg the carmakers to provide built-in seat belt attachment points for the rear seat, just as they have for the front seat since the 1962 models.

Twenty-three crash fatalities to seat belt wearers are reported and analyzed. An extremely wide range of motion, and potential injury, is still available to the head of the belted motorist. Upper torso control and restraints, in addition to the seat belt, are needed. We beg the carmakers to provide built-in shoulder strap attachment points for all belt positions, front and rear. Two popular foreign cars have done this for the last two years.

Side impact fatalities are increasing and the carmakers must give the motorist more protection in crashes of this nature. Current bumpers provide almost no protection for car or occupants, and actually increase property damage and occupant injury. The most serious design defect of the current automobile is the steering assembly, against which the driver is hurled to his death, or which is displaced backwards on impact to kill the driver wise enough to wear a seat belt and shoulder strap.

REFERENCES

1. Campbell, B. J., and Kihlberg, J.: Seat Belt Effectiveness in the Nonpedestrian Situation, Cornell Aeronautical Laboratory, in the publishing.
2. Campbell, K. E.: Role of the Safety Belt in Minimum Auto Crashes, Bull. Amer. Coll. Surgeons 48:138-139 (May-June) 1963. Case 3.
3. Wakeland, R. H.: Unnecessary Designed-In Hazards of Today's Automobiles, Bulletin, Public Information and Education Committee, The National Association of Chiefs of Police, 3:1-4 (Jan.) 1964.

Attachment C

Ford Motor Company — ENGINEERING STAFF

Intra-Company Communication — 19 September 1967

Mr. John Versace

cc P. C. Bertelson

From: R. G. Snyder

Subject: Protection Offered by Shoulder Belt (3-Point System)

In response to the request for more complete documentation pertaining to the protection, pro and con, offered by the 3-point shoulder restraint system proposed for 1968, the following clinical and experimental data should be combined with Impact Dynamics' findings for consideration. These are essentially contained in my memo of 29 August to Mr. Briggs. We have noted all published data, and some unpublished data, known to us relative to clinical cases found to date in automotive accidents. This is very sparse to date and certainly inconclusive. It seems important to note that members of the Biomechanics Department have participated in the only experimental studies with living subjects accomplished to date with an objective of assessing injury potential which may be attributed to various restraint systems. Our position based upon the evidence we have found experimentally is as follows:

I. ADVANTAGES

1. When properly worn, the 3-point, diagonal shoulder belt system has been demonstrated to offer much greater protection to the vehicle occupant than does a single lap belt alone, since it prevents injuries from jackknifing. (Attachment B)

2. The few injuries reported to date for auto accidents (Fisher, '65; Fletcher and Bragdon, '67; Ebbetts, '62; Snyder, et al, '67) involving 3-point systems would all have probably been much worse had the individuals been wearing no belt, European-type diagonal belt only, or a lap belt only. (Attachment A)

II. DISADVANTAGES

1. When snugged properly, the diagonal belt may not allow the occupant to reach all controls adequately, without the addition of an inertia reel.

2. Improper location of the upper belt anchorage can critically affect the usefulness of the system. Since the lower and upper anchor

points in current installations are fixed, movement of the seat, combined with a wide range of occupant body sizes, increases the likelihood of improper positioning.

a) If the upper anchorage is too far forward relative to the seated occupant, the belt angle will be such that it is too low on the shoulder, and this can allow the individual not only to flex over it and slip out, but may be torqued forward and rotated sideward during the deceleration, which could be particularly injurious.

b) On the other hand, if the anchorage location is too far to the rear relative to the seated occupants' position, the diagonal belt will impinge upon the neck, causing discomfort even during normal driving (Figs. 1 - 5 attached). Such a situation can, by creating pressures upon the blood vessels of the neck, and particularly upon the carotid artery, have a subtle but disastrous effect. In an impact or rapid deceleration, severe neck injury could occur.

3. Improper positioning in vehicles sold to the public may also affect occupant acceptance and future use if, upon first experience, it is uncomfortable, rubs against the neck, or will not allow proper freedom to reach controls. (See photos, 1968 Mercury, attached)

4. In side impact at higher impact velocities (30G), there is some evidence that serious and fatal injury attributable to impingement of the neck upon the diagonal belt may result. (See attached test results.)

Our conclusion, based upon review of the available epidemiological and clinical studies of accidents, reinforced by our experimental data, is that a properly worn, 3-point system clearly protects the occupant better than a lap-belt-only system. However, in practice, it must be noted that effectiveness is greatly dependent upon the installation of the shoulder belt anchorages allowing proper positioning for the occupant. Although injuries may occur that are attributed to this system, the increased protection provided the occupant by the shoulder belt far outweighs, in our opinion, any argument for non-installation based upon such potential injury.

While this communication pertains only to the question of the relative value of the 3-point system, it should also be noted that there are several restraint systems which are considerable improvements, from a protection point-of-view, over the 3-point, including the double-torso harness, the Ford inverted-Y yoke with inertia reel (either roof or seat mounted), and potentially, the experimental air bag system.

Richard G. Snyder, Manager
Biomechanics Department

/gds

A. Clinical Studies of Injuries to Automotive Occupants Attributed to the 3-Point Belt

A comprehensive review of the published and unpublished clinical findings relating to seat belt injuries is provided in reference 8. These may be summarized as follows:

Since the 3-point restraint configuration has not yet been used extensively, being offered only as options in 1967 vehicles, accident experience is still limited and injuries attributed to this system have been infrequently reported to date. Fisher in 1965 described the first case of a splenic rupture from use of a 3-point combination lap and diagonal belt. Ironically, the impact forces involved were unusually small, a Volkswagen striking a Renault broadside at 5-10 mph from a full stop. Both the 42-year-old woman driver and the 67-year-old woman passenger were wearing snugly fitted 3-point restraints. The driver received a fractured sternum; the passenger fractures of the left fifth, sixth, seventh, eighth and ninth ribs and a severely lacerated spleen. Since this woman had been taking Coumadin^{R} daily for two years prior to this accident for anticoagulation, the hemorrhaging of the spleen required unusual treatment.(5) In another case, Fletcher and Bragdon reported fractures of the left 6-9th ribs and rupture of the spleen.(6)

A second case, involving a hyper-extension, hyper-flexion cervical injury, was attributed by Ebbetts to a 3-point belt. In his opinion trauma occurred "in a low-velocity impact in which there was little danger of serious injury to the patient had she not worn a seat belt. Conversely, it was an injury which was definitely aggravated by the use of a seat belt."(4)

Two cases of injury to pregnant occupants wearing 3-point restraints have been reported by Snyder, et al(8) In one instance, the woman was a right-front seat passenger in a small foreign car which had a head-on collision with a larger one. Impingement of the diagonal seat belt caused fractures

of every rib on her left side, and ruptured her spleen with massive intra-abdominal hemorrhage. Post-impact, an outline of the belt (in ecchymoses) was visible extending from right shoulder to left thigh. The fetus was stillborn 48 hours post-impact. The diagonal belt did not prevent both her head and knees from impacting the panel. Injuries to the chest and head of a pregnant woman also occurred in a second case, occurring under almost identical conditions; however, the outcome of trauma to the fetus is still unknown.

Swedish studies have reported few injuries due to this system[1] and similar studies have been made in England[7] and Australia.[3] In a Dutch study "three times as many chest and leg injuries" were found for diagonal and 3-point users as for lap belt users.[2] (In the American 3-point system, both ends of the diagonal and lap belt are attached, while in the European 3-point system, there are only three points, one end of the lap belt swiveling up to form the continuous diagonal attachment.) Unfortunately, these European studies do not provide specific injury breakdowns. The major advantage of the 3-point system over either the single diagonal or the lap belt is that it offers additional protection by preventing flexion of the upper torso. Disadvantages appear to be that it must fit the occupant correctly to be effective, can allow the occupant to slip out in side impact if impacted on the same side as the shoulder harness. There may also be some possibility of cervical injury through impingement on the belt if impacted from the other side, nevertheless, a properly worn 3-point restraint system offers greater protection than the lap belt.[9, 10]

REFERENCES CITED

1. BACKSTROM, C.: 1963 Traffic Injuries in South Sweden with Special Reference to Medico-Legal Autopsies of Car Occupants and Value of Seat Belts. Chirurgica Scandinavica, Suppl. 308.

2. BASTIAANSE, J. C. and A. A. BOIROMON: 1966 Statistical Study. Effectiveness (of) Seat Belts. Rapport. RAI-TNO, Institunt Voor WegtransportMiddelen. Netherlands.

3. BIRRELL, J. E.: 1964 "Safety Belts for Motor Vehicles in Victoria" Med. J. Australia 1:67

4. EBBETTS, J.: 1962 "Seat Belts and Cervical Spondylosis" Practitioner 188:802.

5. FISHER, P.: 1965 "Injury Produced by Seat Belts: Report of 2 Cases" J. Occupational Medicine 7:211-212.

6. FLETCHER, E. D. and B. G. HRAGDON: 1967 "Seat Belt Fractures of the Spine and Sternum" JAMA 200(2):177-178, 10 April

7. LISTER, R. D. and B. M. MILSON: 1963 "Car Seat Belts: An Analysis of the Injuries Sustained by Car Occupants" Practitioner 191:332-340

8. SNYDER, R. G., W. M. CROSBY, C. C. SNOW, J. W. YOUNG P. HANSON: 1967 "Seat Belt Injuries in Impact" (In press) Proceedings, The Prevention of Highway Injury Symposium, The University of Michigan Medical School. (Preprint attached).

9. YOUNG, J. W.: 1967 "A Functional Comparison of Basic Restraint Systems" CAM Report (in press) Federal Aviation Administration.

B. Experimental Studies of Restraint Protection with the 3-Point Harness

Eight tests have been conducted with baboon subjects utilizing the Holloman AFB Daisy Decelerator. Three were impacted in the forward-facing body orientation, two rearward facing, one at 50° side facing, and two at 90° side facing. To our knowledge, these represent the only experimental study of the injury protection represented by the 3-point restraint system. The results of these tests are summarized in the attached Table. Complete discussion and conclusions are found in reference 1.

In two forward-facing impacts at 20 and 22G, no injury was found in one case and slight injury (pancreatic petechial hemorrhage, adrenal pericapsular hemorrhage, uterus broad ligament hematoma) in the other. A third test a 30G (20° seat pitch, 74.2 ft/sec velocity, 3000 g/sec onset rate for 0.095 secs duration) also resulted in minor trauma (belt contusions, dural congestion) only. This appears to offer much better injury protection, for example, to the same level of impact than with a lap belt only which appears to offer marginal survivability at 30G.

Two rear-facing tests were run in this configuration. At 20G, no injury was found. At 40G, injury was not severe (subdural hemorrhage, subcapsular kidney hemorrhage, and petechial hemorrhages), and only the kidney and rib petechial hemorrhages attributed to the belt (in rebound).

After one 50° left, side impact at 22G moderate intra-dural hemorrhage was found upon gross examination, and myocardial myomalacia upon microscopic histological study.

Two 90° sideward-facing impacts at 22 and 30G were run. At the lower level, severe dural and urinary bladder hemorrhage occurred, in marked contrast to the 22G forward run where no trauma was found. At 30G

trauma was instantly fatal, due primarily to dislocation of the occipital-atlantoid joint as the neck impinged upon the diagonal belt.

REFERENCE

1. SNYDER, R. G., C. C. SNOW, J. W. YOUNG, W. M. CROSBY and G. T. PRICE: 1967 Pathology of Trauma Attributed to Restraint Systems in Crash Impacts. Presented Sixth Scientific Session, Joint Committee on Aviation Pathology, Ottawa. 12 September.

THE 3-POINT RESTRAINT SYSTEM

TABLE III
3-POINT (DIAGONAL AND LAP BELT) TESTS

Test	Dairy Test No.	Wgt. (lbs.)	Pathology: Gross	Pathology: Microscopic	Sled: Peak G	Sled: End Pitch	Sled: Lo. Vel. (ft/sec)	Sled: Onset Rate (g/sec)	Time Duration (secs): Plateau	Time Duration (secs): Total	Peak Belt Force (LBS): Lap Right	Peak Belt Force (LBS): Lap Left	Peak Belt Force (LBS): Diagonal Top Right	Peak Belt Force (LBS): Diagonal Bottom Left
A. FORWARD FACING BODY ORIENTATION (−Gx)														
41	3316[1]	21.3	None	None	31.3	30°	51.8	1900	0.012	0.156			470	104
42	3318	30.5	Petechial Hemorrhage, Head of Pancreas; Broad Ligament Hematoma; Subchorionic Hemorrhage Insertion of Cord	Adrenal Pericapsular Hemorrhage, slight	90.5	10°	66.4	2250	1.073	.113	450	450	750	150
43	3370	26.0	Transverse Contusion (lap belt); Dural Congestion, moderate, bilateral	Arachnoid Hemorrhage of Pons, slight	30	20°	74.8	3400	0.031	0.065	561	215	310	400
B. REARWARD FACING BODY ORIENTATION (+Gx)														
44	3361[2]		None	None	34.3	30°	60	3600	0.076	.106	0	0	15	15
45	3364[3]	33	Subpleural Hemorrhages either side T-7 to T-11; Bilateral Adrenal Hemorrhages; Petechial Hemorrhage over Ribs, Extensive; Subcapsular Hemorrhage Anterior Left Kidney	No Report	40.4	20°	66.4	5400	0.032	0.077	10	0	25	50
C. 90° SIDEWARD FACING BODY ORIENTATION (−Gy)														
46	3347	90	Marked Subserosal Congestion; Med. Intestinal Hemorrhage; Intraluminal Hemorrhage	Myocardial Myomalacia	33	12°	48.1	3300	0.063	.143	400	510	430	119
D. 90° SIDEWARD FACING BODY ORIENTATION (+Gy)														
47	3400	34.5	Subpleural Hemorrhage, L. Lung; Right Intracapsular Hemorrhage L. Kidney; Right Intracapsular Petechial R. Kidney; Retroperitoneal Hemorrhage, Severe; Marked Hemorrhage Bladder [illegible] (Fetus, Dural Hemorrhage)	Subpleural Hemorrhage; Urinary Bladder Hemorrhage; Severe Brain Hemorrhage	33.1	10°	56.0	1900	0.063	.104	140	—	—	900
48	3367	34.0	Total Dislocation, Occipital-Atlantoid Joint; Med. Bilateral Intradural Hemorrhage; Contusion, left side Neck; Transverse Heart Contusion (lap belt); Subcutaneous Hemorrhage Right Shoulder; Subpleural; Subpleural Ecchymotic Hemorrhages Left, 3-4 ribs; Right 3-4 ribs; Uterine Hemorrhage; Sternocleidomastoid Muscle Hemorrhage; Extensive right intramuscular Hemorrhage (Right shoulder), Left Thoracic Wall 3 Fract. 11-12 ribs	Intra-alveolar Hemorrhage; Leptomeningeal Hemorrhage; Perivascular Hemorrhage; Cerebral vessels Hemorrhage; Ventricular Hemorrhage; Subarachnoid Hemorrhage	39	90°	14.0	3000	0.034	0.009	300	370	600	940

(1) 130 days pregnant. Terminated post-impact. Fetal death 10 hr. post Caesarian Section
(2) 120 days pregnant. Fetus died 1-1/2 hrs. post-impact, placental separation.
(3) 133 days pregnant.

(Source: Snyder, R.G., C.C. Snow, J.W. Young, W.H. Crosby, and G.T. Price 1967 "Pathology of Trauma Attributed to Restraint Systems in Crash Impacts". Paper presented 12 October, *Sixth Scientific Session*, Joint Committee on Aviation Pathology, Ottawa.)

Attachment D

THE NATIONAL SWEDISH ROAD SAFETY BOARD
(Statens trafiksäkerhetsverk)

27.3.1968 F 9 1968

REGULATIONS RE SAFETY BELTS (Translation from the Swedish origi: l)

1. Application

1.1 These regulations apply to passenger cars.

2. Definitions

2.1 "Safety belt" means a device consisting of straps with fastening and adjustable buckles, attachment fittings and, occasionally a retractor device, which, firmly secured to the structure of a car, is designed to reduce the risk of injury to the wearer by limiting his mobility in the event of collision or other violent retardation of the vehicle.

2.2 "Three point belt" is a safety belt with a diagonal strap and a lap strap and with one upper and two lower anchorage points.

2.3 "Two point belt" is a safety belt with a diagonal strap with one upper and one lower anchorage point.

2.4 "Lap belt" is a safety belt with a lap strap with two lower anchorage points.

2.5 "Anchorage point" means a point where a safety belt is connected to the car body or equivalent part of the constructio

3. Scope

3.1 With the exceptions stated in point 3.2, a safety belt shall be installed in each seat position.

3.2 The requirement of point 3.1 does not apply to side-facing seats, folding auxiliary jump seats and rear-facing seats.

4. Requirements

4.1 For the use of different types of safety belts the followin- shall apply :

4.1.1 Three point belts may be used for all seat positions.

4.1.2 Two point belts must not be used for the seat position by the

4.1.3 Lap belts may be used only for a middle seat position and for other seat positions in convertible cars where an upper anchorage point cannot be arranged.

4.2 Safety belts shall be of a type approved by the National Road Safety Board according to special regulations.

4.3 The anchorage points for safety belts shall be located in accordance with the Swedish Standard SMS 2470 "Seat Belts Anchorages". If the construction of the vehicle does not make this possible, other suitable locations may be used.

4.4.1 Pins and holes in anchorages shall conform to the above-mentioned standard.

4.4.2 The regulation of point 4.4.1 need not be applied to a car which has been equipped with safety belts of an approved type by the manufacturer, provided that the requirements for sufficient strength are fulfilled.

4.5 The vehicle body structural strength at the anchorage points shall be satisfactory for the type of safety belt to be used.

5. Control that the requirements are fulfilled

5.1 At type inspection, or the first registration inspection, the applicant shall present a certificate from the manufacturer stating that the vehicle with the chassis number as stated in the certificate fulfils the requirements of point 4.5 and when necessary of point 4.4.2. As for the rest, the inspector shall control that the requirements are fulfilled.

6. Coming into operation

6.1 The regulations shall, concerning safety belts for seat positions in front seats, be applied to vehicles which are considered as 1969 or later models, or which are otherwise included in type certificate or presented for registration inspection after January 1, 1969 for the first time, with the exception of second-hand imported vehicles which were manufactured before this date, and for other seat positions one year later.

6.2 The regulations of point 4.5 are meant to be replaced by more detailed ones when present work on international regulations has been completed.

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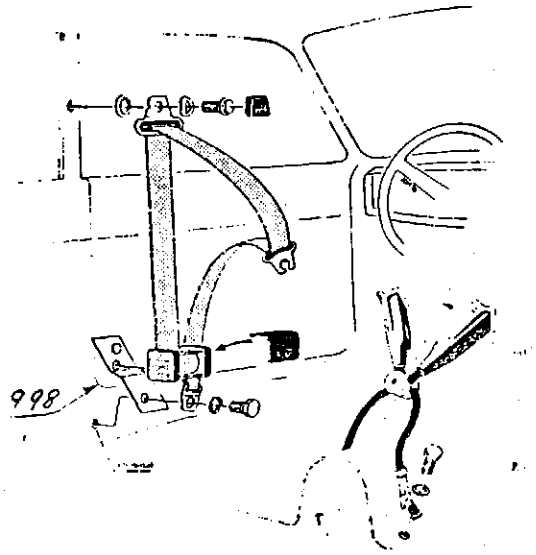

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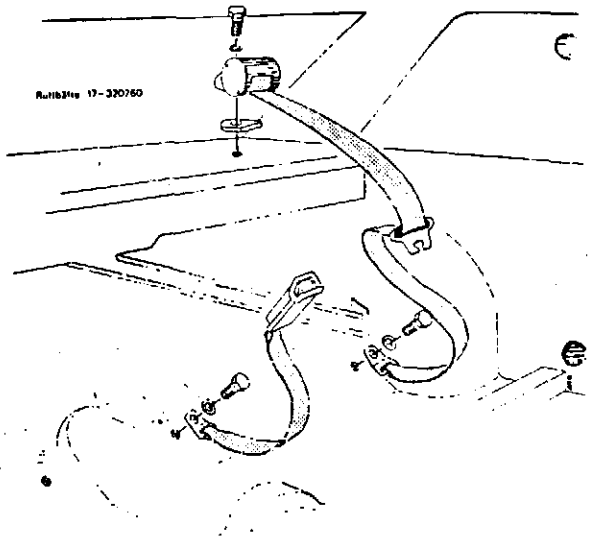

EXHIBIT

B

Attachment F

870483

A Three-Point Belt in the Rear Center Seating Position as Accessories

Leif Karlbrink and Hugo Mellander
Volvo Car Corp.

ABSTRACT

This paper describes some of the engineering situations encountered during the development of a three point belt for the rear center seating position in a sedan car. The belt will be sold as an accessory for the after market.

The reinforcement of the parcel shelf to achieve a sufficiently strong anchorage for the retractor and the geometrical locations of the belt anchorages are presented.

The conflict between the geometrical requirements, the design and the visibility will be focussed. The need for updated requirements for belt installations in the rear center seating position will be pointed out.

Data from the performed tests show that all demands from regulations and "in-house" requirements are fulfilled.

BACKGROUND

THE 1ST OF JULY, 1986, Sweden introduced a compulsory belt law for the rear seat in passenger cars. Countries as West-Germany, Norway, New Zeeland and Australia have already enforced similar laws. This will increase the use of seat belts in the rear and also increase the demand on comfort of seat belt installations.

Today most European car manufacturers have three point belts on the rear outboard positions and a lap belt in the center as standard equipment.

It is, even for the front seat occupant, important that rear seat occupants use their safety belts [1]*. In the center seating position today we have a very low usage rate, mainly because it is uncomfortable and difficult to put on and wear a non-retractor lap belt.

Children may prefer to sit in the rear center position where they can have a clear view out on the road. Families with three children may want to have all their children use the same type of three point belt.

Taking all this into account it was decided to develop a three point belt for this seating position as an accessory. The main advantages of a three point belt in the rear center position are:

- Higher safety level in frontal impacts
- Increased comfort and convenience
- Better design, compared to a non-retractor lap belt
- Children prefer this place

* Numbers in parentheses designate references at end of paper.

ENGINEERING

The requirements governing the development of this belt system came from "in-house" requirements and from regulations. The regulations were static strength testing of belt anchorages according to ECE R14 and ADR 5B, belt system testing as in FMVSS and geometrical locations of anchorage points.

The "in-house" requirements were frontal barrier crash tests in 30 and 35 mph, design and comfort requirements, such as easy handling, minimizing of the webbing pressure on the shoulder and easy installation in the car of the accessory belt.

During the development phase it became clear that the parcel shelf had to be reinforced. Special parts had to be engineered to make the parcel shelf anchorage meet the existing strength requirements.

In the engineering of the special parts (see figures 1 and 2) the following points had to be considered:

- As low weight as possible
- Low manufacturing cost
- No interference with the luggage area
- No interference with existing parts like loudspeakers, window shade and head restraints

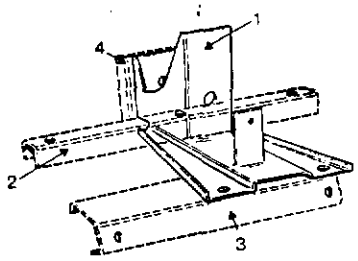

Fig. 1. Reinforcement brackets supplied in the accessory kit

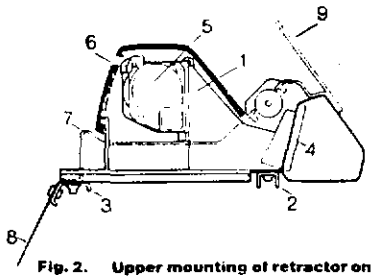

Fig. 2. Upper mounting of retractor on the parcel shelf

1. A bracket holding and keeping the retractor at the decided position
2. Profile distributing the load
3-4. Profiles preventing the tipping of the retractor due to the bending moment
5. Retractor
6. Plastic cover
7. Parcel shelf trim
8. Parcel shelf sheet-metal
9. Rear window

It was also a problem to find a retractor that was capable of withstanding a load of 15 kN directly into the reel. In this beltsystem there is no D-ring and the load comes from a different angle than in a normal loading case, as in a B-post installation (see figure 3).

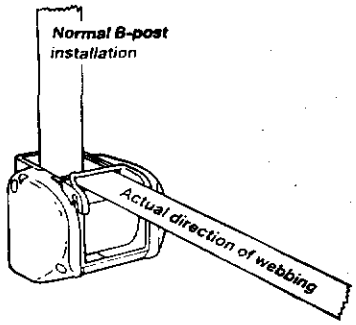

Fig. 3. Difference in loading directions for the retractor