INJURY PATTERNS CAUSED BY SEAT BELTS

S. Behrens, Dr. med. Department of Surgery-Trauma
E.G. Suren, Dr. med. Unit - Medical University
L. Gotzen, Dr. med. Hannover

G. Stürtz, Dipl.-Ing. Institute of Automotive Engineering
Technical University, Berlin

SURVEY

The effectivity in the use of passive restraint within the whole combine of safety devices, such as deformation areas, passenger compartments, seat construction, head-rest and steering unit has been determined in several investigations (8)(6)(10). During the last years, however, together with an increasing use of safety belts, a frequency of injuries was apparent, which - for the first time - was described in 1956, and to which in 1962 the description "Seat-belt-Syndrom" became attached (3). Ever since a steadily increasing tendency of specific publications could be observed, with a definite predomination of spectacular single-case presentations in medical journals (2)(4)(5)(2).

Rather a large number of detailed single case analyses is required for the definition of injury mechanism as well as injury model and injury cause, in order to make clear statements. In 1975, Mackay (8) reported about 82 passenger-car accidents, involving a total of 108 car occupants wearing seat belts. He worked out further aspects concerning type and frequency of heavy injuries caused by safety belts (13).

The task of this investigation is the collection of typical injury models, without as well as with disfunction of the systems passenger compartment/seat/restraint/occupant.

+) numbers in parentheses designate references at end of paper

METHOD OF INVESTIGATION

Since February, 1973 the Medical University of Hanover is - within the framework of a Traffic Accident Research Program [+]) collecting data of real traffic accidents, in which people have been injured. At the scene of the accident, the documentation starts on average about 13 minutes after the accident happened. It includes mainly the medical, technical and psychological data of the pre-crash, crash and post-crash phase.

The technical documentation contains mainly a photogrammetric survey of accident traces, vehicle damage as well as technical particulars of the vehicle and condition of safety device (the latter for instance, in order to clarify the usage of safety belts).

Details about traffic area and its surrounding as well as weather conditions were also collected. The medical documentation contains personal data of the accident victim, such as the type and severity of injuries received, the steps taken for accident rescue, such as voluntary help from the public or perhaps, medical emergency treatment. The documentation is completed by supplementation of out-patient respectively hospital care, the course, including epicrisis or, if need be, the post mortem report.

DATA

Basing on a number of 843 documented traffic accidents until April, 1977, 122 accidents involving a total of 161 adult occupants of passenger cars wearing safety belts, have been included in this report. In order to eliminate the influence of varying impact directions of trauma, only cases with frontal directions (10.00 am to 2.00 pm) with solid

[+]) A research program financed by the Federal Authorities of Road Systems, Cologne, FRG.

obstructions, such as motor cars, were considered.

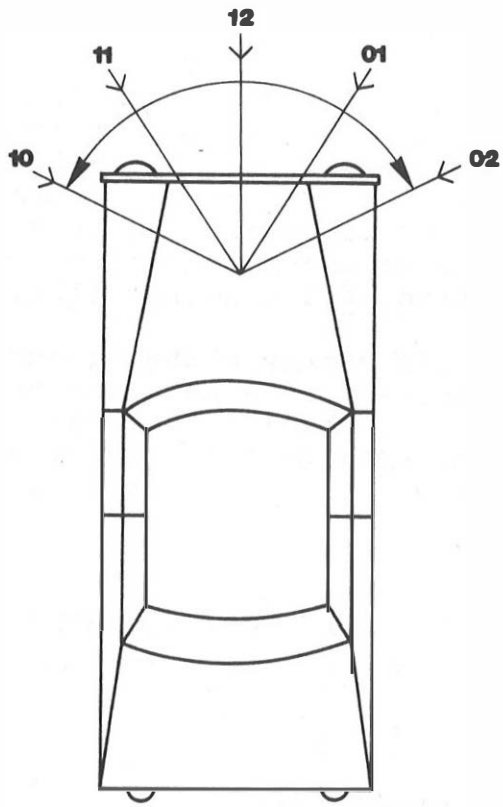

Fig.:1

Fig. 1 Impact Types in Sample

The investigation material consists of 81 head-on impacts, involving 110 adult drivers, respectively co-drivers wearing safety belts. Safety belt wearing adult passengers occupying the back seat, have up to now not been observed.

METHOD OF ANALYSING

The car occupants were by assessment of each single case divided into the groups I (without system disfunction) and II (with system disfunction). It was rated as a disfunction if one or several elements within the joint combine of

vehicle compartment, seat, belt and car occupant visibly lead to an intensification of the trauma. Those can be for example intrusion, weak seat anchorage, slack belts as well as wrong use of belt, respectively seating position. The trauma was estimated by its severity and frequency. The injury severity was determined by the "Abbreviated Injury Scale" (14) for every body region (AIS) as well as for the body as a whole by the "Overall Injury Severity Degree" (OAIS).

With the objective of a quantitative and qualitative valuation of the trauma, the "Absolute traumatic degree " (13) of single body regions, as the result of injury frequency and medium severity, was made. The average injury severity was calculated with reference to costs arising from injury sequence of single degrees of injury severity, with the help of an average valuation of 5th degree (12).

As a measure for the kinetic energy changing during the crash phase to deformation, and as a measurement for the degree of deformation of the vehicle, the "Vehicle Deformation Index" (VDI) was estimated for every crash vehicle. Its degree of valuation results from depth of deformation - vehicle length areas .

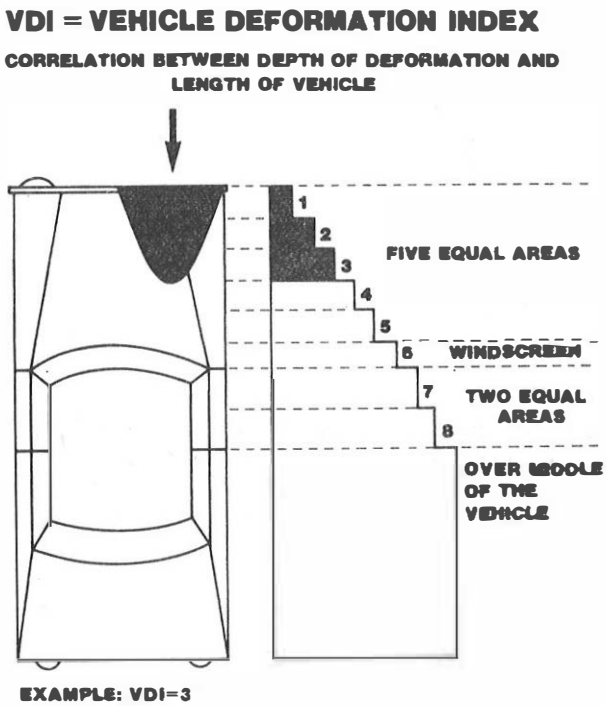

Fig. 2 Vehicle Deformation Index

RESTRAINT WITH OR WITHOUT DISFUNCTIONS

A division of car occupants lead to 77 persons in group I (without disfunction) and 33 people in group II (with disfunction). As cause of disfunction

1.	Incorrect wearing of belts	16
2.	Intrusion into passengers compartment	8
3.	Seat yielding or torn out	7
4.	Combination between 2 and 3	1
5.	Slipped loading	1
	total	33

Fig. 3 Cause of misfunction in safety-belt-system

the wrong belt fastening is predominating, followed by intrusion of the occupant department and seat security. Up to now only the predominating disfunction for each case was mentioned.
A division of all safety belt accidents by the type of belt systems

1.	Three-point automatic belt	59
2.	Three-point static belt (running through)	38
3.	Three-point static belt (single adjustment)	11
4.	Diagonal static belt	2
	Total	110

Fig. 4 Types of Seat-belt-systems

shows clearly the predomination of the three-point-automatic belt, in each case with pass-through hardware.

A division of all injured belt users by injury severity of body regions and various seating positions is shown in

	1	2	3	4	5	6	AIS	6	5	4	3	2	1	
Driver	25	11	1	1	1	-	Head	1	-	1	1	2	8	Co-driver
	6	4					Neck					1	1	
	18	11	5	1			Chest				2	2	9	
	4	3	2	1	4	-	Abdomen		1	4		2	2	
	3						Spine							
	3	1		1			Pelvis						3	
	10	3	1				Arm				1	2	4	
	24	8	4	1			Leg				3	3	12	
Total	93	41	13	5	5	-	222	1	1	5	7	12	39	

Fig. 5 Summary of injuries of different severities by body areas, separation between driver and co-driver

Dominating - after injury frequency - with the driver as well as the co-driver - are the head injuries, followed by the trauma of the lower extremities and the thorax. Concerning the injury severity, the position, however, is changing. The most endangered body regions are first and foremost the abdominal and the thorax region. Every passenger received on an average 3 injuries.

Subdivided into the groups I and II, it is evident

OAIS	Group I	Group II
0	37	-
1 + 2	39	17
3 + 4	1	9
5 + 6	-	7

Fig. 6 Correlation between Overall Injury Scale and both Groups Wearing Seat-belts

that the car occupants in group I were not at all, or only slightly injured. Those in group II were all injured, 9 of them fatally.

A comparison between both groups, as far as the Absolute Traumatic Degree is concerned, underlines the difference in the endangering degree. This applies also to injury frequency and injury severity

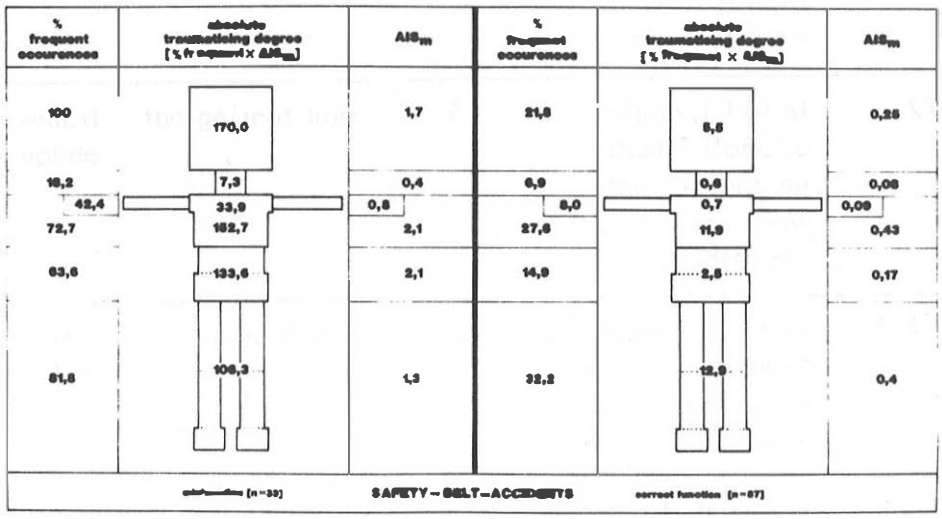

Fig. 7 The Absolute Traumatising Degree

All 33 occupants in group II received head injuries. The head, next to the Absolute Traumatic Degree, appears to be the most endangered region, followed by the thorax and abdominal region.

Group I, however, shows substantially lower Absolute Traumatic Degrees. Owing to the derivation of inertial force of the passenger over the belt system, the thorax injuries are consequently predominating.

A subdivision of the fatal belt accidents

UFO (Hannover)	Diagnosis	OAIS	VDI	Misfunction of Safety Belts	Cause of Death
No. 724/2	Lung rupture, serious rip fract. flail chest, upper armfract., brain contusion, tibial fract.	5	4	slipped loading	chest trauma
No. 61/2	severe brain injury, forearm wounds	6	2	belts worn slack	brain injury
No. 572	le fort I, ruptur of small intestine, radial fract., wound of knee, both tibia	5	5	seat tearing out	trauma of the abdomen
No. 519/2	rupture of small intestine, hemorrhage from art. mesent.	5	5	seat broken	trauma of the abdomen
No. 511/1	le fort II, disloc. of hip joint, fem. fract., tibial head fract., patel. fract., clavic. fract., contusion of small intestine, rupture mesent.	5	5	intrusion into the passengers compartment	trauma of the abdomen, shock
No. 505	serious rip fract., splen and liver rupture, wounds of both knees	5	5	reel broke up	trauma of the abdomen, chest trauma
No. 348	severe brain injury, wound of the face, serious rip fract., splen-liver-kidney rupture, fem. neck fract.	5	6	intrusion into the passengers compartment	trauma of the abdomen, brain injury

Fig. 8 Fatal Traffic Accidents Passengers Wearing Seat Belts

all of which belong to group II, leads with regard to the medical cause of death to the predominating factor of severe trauma of the abdomen, to be followed by trauma of the thorax.

The important part the degree of vehicle damage is playing concerning the trauma of belt-wearing occupants, is to be seen in figures 9 - 12.

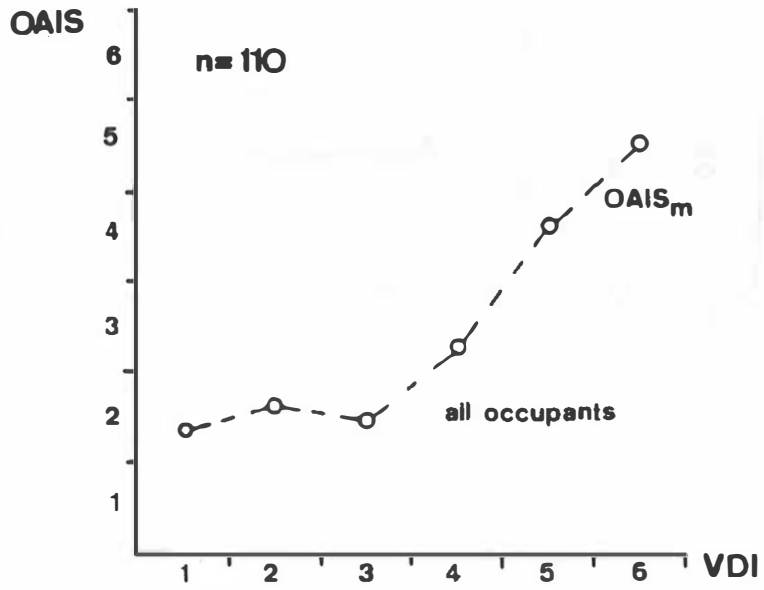

Fig. 9 Correlation between OAIS$_m$ and Vehicle Deformation Index for all occupants

According to figure 9 a comparison between Vehicle Deformation Index (VDI) and Overall Injury Severity Degree (OAIS) shows an increase of injury severity, with a rising VDI for all 110 occupants.

The increase in injury severity for group I is evidently less than the one in group II, with an upward trend in

vehicle deformation

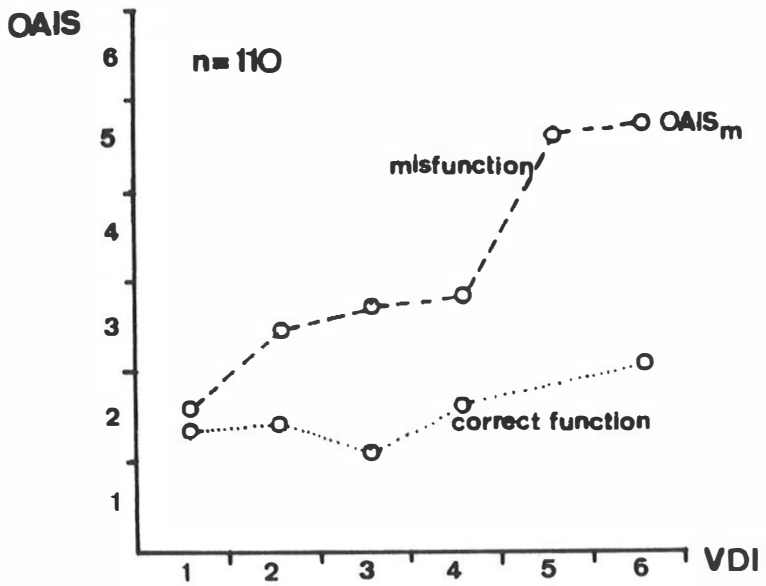

Fig. 10 Correlation between OAIS and VDI for the different Groups

The comparison of injury severity for different occupant positions shows for driver and co-driver an increase with rising VDI, with more peril to group II for drivers

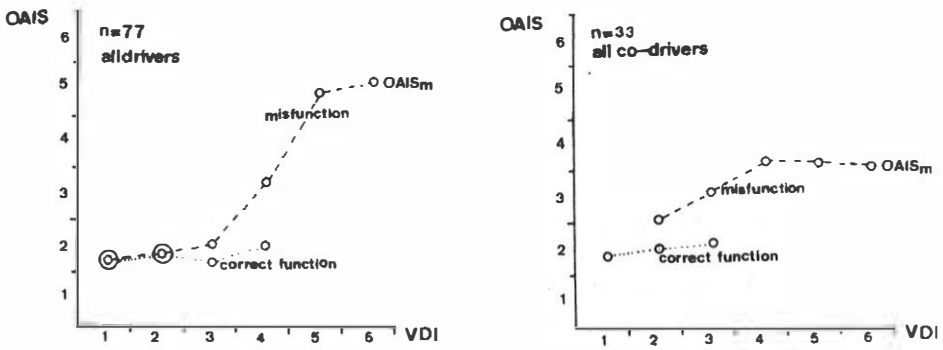

Fig. 11 + 12 The Difference between Driver and Co-Driver in the two groups

SUMMARY

The analysis of accidents in which 110 car occupants were injured, clearly stresses the urgency for action, in order to reduce injury risks, not only as far as the safety belt itself is concerned but also in view of the injury model with safety belt usage.

The following facts are evident:

1. The crucial point for injury severity - after the Absolute Traumatic Degree through system disfunction - is the head region, followed by the thorax and pelvis/abdomen.

2. Typical injuries owing to disfunction are ruptures of the intestines, the liver and spleen, as well as thorax lesions.

3. The severe trauma of the abdomen is predominating with lethal injuries.

4. Together with increasing vehicle deformation the injury severity for drivers as well as co-drivers, especially in connection with system disfunctions, is rising.

5. Severe injuries specific for belts and without system disfunction only are inflicted in connection with a High Vehicle Deformation Index.

6. Wrong usage of safety belt, weak seating anchorage respectively rigidness, and intrusion of the passenger compartment are causing an increase of injury severity.

   Here injuries already occur with low vehicle deformation degrees (VDI).

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