LESIONS IN BELTED CAR RIDERS FROM OBLIQUE AND LATERAL IMPACTS.

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ABSTRACT.

44 belted car riders, admitted to the Odense University Hospital after oblique and side impacts, have been the subject of closer examination in as much their lesions have been correlated to car damage and restraint systems. Near-side impacts appeared to result in the most serious lesions, even with moderate car damage. Drivers suffered heavier lesions than front seat passengers in the head, chest and abdomen. Inertia reel belts seemed to exert more protection against cabin contact lesions than static belts - as worn. Of those using static belts only 15 out of 32 had adjusted the belt for fitting. No serious side effects of the belt were seen in these impact directions.There were no technical failures in the inertia reel belts and there were no broken belts. A better protection and a more flexible steering system is proposed in order to reduce the most common lesions in belt users.

INTRODUCTION.

The law of compulsory use of seat belt was introduced in Denmark on January the 1st, 1976 at a time, where the voluntary degree of usage was about 20 per cent. From April, 1st 1976 the penalty for not wearing the belt was a fine, and from that date on the degree of usage has been around 70 per cent.
Surely a change in the pattern of lesions might be expected in the accident involved car riders following the increased use of belts.

In an earlier paper (1) we have shown that the number of lesions fell by 18 per cent after the seat belt law was introduced. This also applied to the length of inability days following light and moderate injuries, which fell by 30 per cent.
Ahead of the passage of the law the Society of Traffic Medicine had gone some way to exert an influence on the politicians. because of this we have also felt a certain obligation to follow up the law with a registration of any side effects of the existing restraint systems.
The present investigation has been carried out as a part of the above mentioned registration of the belt side effects. From the basic material, which registered all belt users admitted to the Odense University Hospital in the period 1.2.76. - 1.4.77, we have selected those users who were admitted to the hospital after oblique and side impacts for this material.
As a routine the Odense University Hospital, from the 1st of February 1971, has EDP registered all persons injured in the traffic (2).
There are 230.000 inhabitants in an area of mixed urban and rural environment. As of now the material comprises approximately 18.000 persons and each year about 2.800 is added.
This investigation has been carried out in co-operation with the Odense Division af the Danish Department of Vehicle Control.
From medical side the greatest importance has been attached to the description of lesions, and from car inspection side to the description and size of impact.
Together we have tried to correlate the lesions inflicted to cabin contact in correct application of the belt or an eventual belt failure.

METHODOLOGY.

The period of investigation ran from February 1st, 1976 to April 1st, 1977, and in this time 89 in-patient belt users were registered. After admission the patients were examined according to a

special formula by one of the authors. The examination aimed at registration of the lesions inflicted, particularly lesions which might be due to use of seat-belt.
The patients were questioned as to whether they had adjusted the belt to fit within a reasonable amount of time before the accident. When the lesions were registered the car inspection was contacted and consequently a car inspector (co-author) examined the cars according to a special form.
The car inspector payed particular attention to the direction of the impact, the degree of deformation to the car, the kind of restraint system, its function and fitting.
From his knowledge of the place of injury in the involved person the car inspector also examined eventual cabin contacts. The car was photographed from the outside and inside, whenever this was possible.

MATERIAL.

The material comprises 26 men with an average age of 33.6 years (range 19-75 years) and 18 women with an average age of 39.9 years, (range 17-80 years).
With one exception (one driver in a H-belt) all belts used were three-point belts. The relation between static and inertia reel belts is demonstrated in table 1.

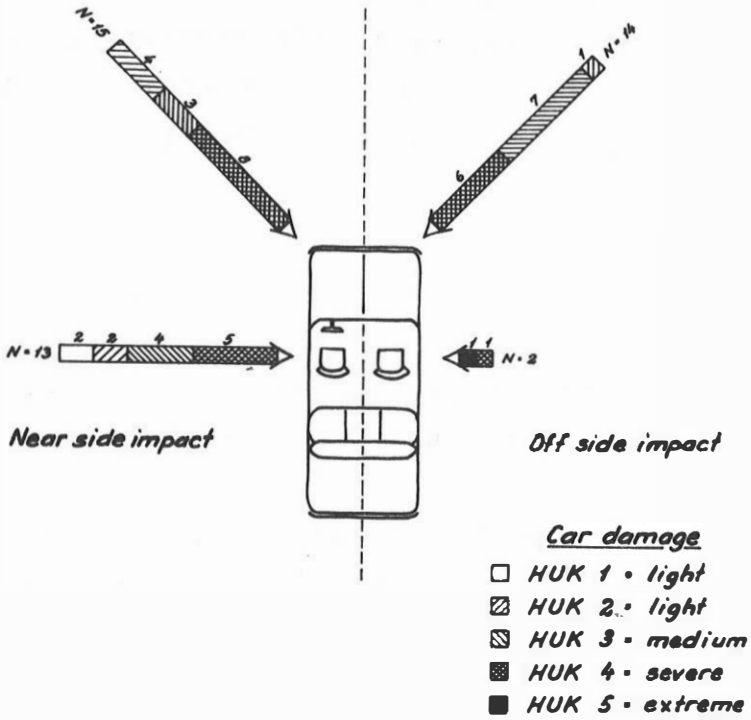
Tab. 1

Belt type / Position	Static	Inertia reel	Total
Driver	23	10	33
Frontseat passenger	9	2	11
Total	32	12	44

In this analysis we have not seen any broken belts.
The direction of impact in relation to the patient's position in the car appears in figure 1.

FIG.1

Direction of Impact
in relation to
Degree of Car Damage. (HUK Grading).
44 belted frontseat occupants in 33 cars.



VN/WE, Odense University Hospital, 1977.
Fronto-lateral impacts.

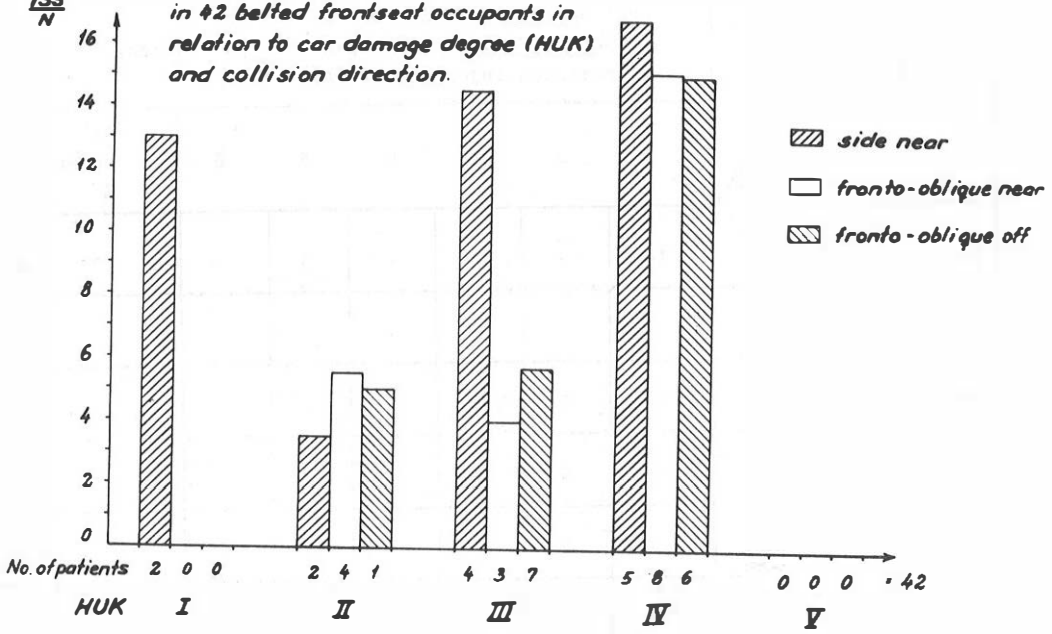
We have defined side impact as a clean side impact without involving the front or rear end. Fronto-oblique impact is defined as an impact, which mostly includes the one side of the car and part of the front but which leaves the opposite side of the front undamaged.
Thus this analysis excludes clean frontal impacts, rear impacts, and roll over accidents.
From the figure it appears that we have registered 13 side impacts on the side of the front seat occupant (called near-side) and two impacts on the opposite side of the frontseat occupant's place (called off-side).

15 fronto-oblique near-side impacts and 14 fronto-oblique off-side impacts were registered.
The degree of deformation of the car is stated in the HUK-graduation (3).

SEVERITY OF LESIONS CORRELATED TO THE IMPACT.

Figure 2 illustrates the degree of car damage according to HUK, correlated to average Injury Severity Score - ISS (4) with regard to the different impact directions.
Here average ISS is used to be able to make a graphic demonstration of the difference in severity of lesions with regard to position in the car and impact direction.

FIG.2 *Average Injury Severity Score (ISS) in 42 belted frontseat occupants in relation to car damage degree (HUK) and collision direction.*



VN/WE, Odense University Hospital, 1977.
Fronto-lateral impacts.

The high average ISS in HUK grade 1 is due to a 75-year old patient who died after suffering a subdural hematoma following a moderate side impact. His head had been in contact with the inside of the roof above the driver's seat, and this blow caused a contre coup intracranial bleeding.
In HUK grade 2 no difference appears between side and fronto-oblique impacts.
In HUK grade 3 a considerably increased degree of severity in the lesions appear in near-side accidents, up to a level, which is only reached in HUK grade 4 what the other impact directions are concerned.

In HUK grade 4 the severity of lesions is the same for the three directions.

REGIONAL DISTRIBUTION OF TOTAL LESIONS.

Table 2 demonstrates the regional distribution of the total number of lesions in Abbreviated Injury Scale (AIS) rating (5).

TAB.2 AIS / Body area	Regional distribution of 103 lesions in 44 belted frontseat occupants in percentage. Abbreviated injury scale (AIS) rating.						
	1	2	3	4	5	6	All severities %
Head	10	52	7	-	9	-	78
Neck	7	2	-	-	-	-	9
Chest	41	5	14	2	-	-	62
Abdomen	14	5	2	2	2	-	25
Pelvis	2	2	2	-	-	-	6
Upper extremities	14	7	5	-	-	-	26
Lower extremities	21	5	7	-	-	-	33

VN/WE Odense University Hospital, 1977.
Fronto-lateral impacts

78 per cent had lesions in the head region, of which 16 per cent were AIS grade 3-5 lesions. This is a higher rate of serious head lesions than found by other authors in frontal and rollover accidents (6).

Second highest lesion frequency was found in the chest region where 62 per cent of the patients had a lesion.

In the lower extremiteties, the upper extremities and the abdomen the distribution was about equal.

Lesions to the neck rarely appeared and only low AIS grades were registered.

REGIONAL DISTRIBUTION OF AVERAGE AIS RELATED TO IMPACT DIRECTION

Table 3 gives the regional distribution of average AIS correlated to direction of impact.

TAB.3
REGIONAL DISTRIBUTION OF LESIONS COMPARED TO DIRECTION OF IMPACT
AVERAGE AIS

44 belted front seat occupants

Region / Impact	head	neck	chest	abdomen	pelvis	upper extrem.	lower extrem.	No. of patients
fronto-oblique near	1.9	1.0	2.0	2.0	1.0	2.0	2.0	15
fronto-oblique off	2.4	2.0	1.2	3.5	0	1.5	1.0	14
side near	3.1	0	2.0	1.7	2.0	1.5	1.0	13
side off	2.5	0	2.0	0	0	0	0	2
total average AIS	9.9	3.0	7.2	7.2	3.0	5.0	4.0	44

VN/WE Odense University Hospital 1977

The patterns of average AIS in the various regions are rather uniform. Exceptions are the high AIS in near-side head lesions and the high AIS in the abdomen in the fronto-oblique off situation.

REGIONAL DISTRIBUTION AND SEVERITY OF LESIONS IN RELATION TO POSITION IN FRONTSEATS.

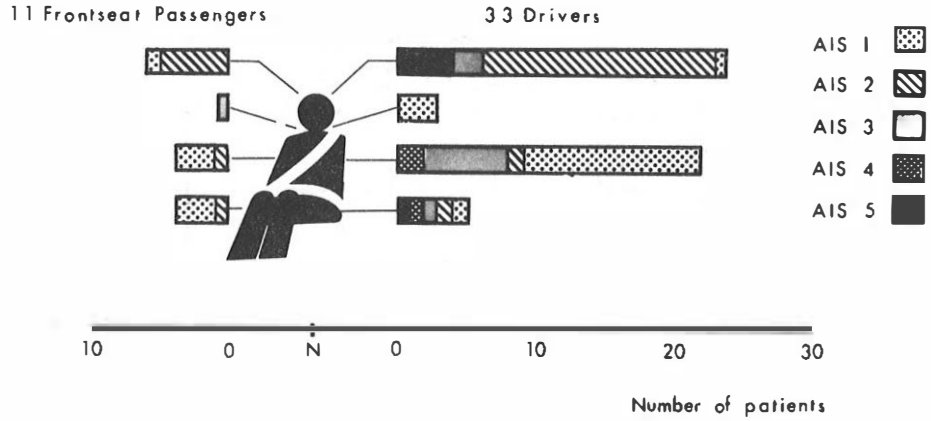
Figure 3 gives the regional distribution of lesions in drivers and frontseat passengers respectively in the regions which are of most interest what seat belt problems are concerned, namely head, neck, chest, and abdomen. Here the expected heavier pattern of lesions to head, chest, and abdomen in the driver than in the frontseat passenger is found. All grades of lesions in AIS 3 and above are found solely in the drivers's group.

In the region of the neck only four lesions were found. Out of these only one was serious, AIS grade 3, and this was in an elderly frontseat passenger who's static belt was inappropriately placed and fitted in combination with an overload from an unrestrained backseat passenger.

FIG.3

REGIONAL DISTRIBUTION AND SEVERITY OF LESIONS
IN BELTED FRONTSEAT-PASSENGERS
AND DRIVERS

ABBREVIATED INJURY SCALE RATING



VN/WE ODENSE UNIVERSITY HOSPITAL 1977
fronto lateral impact

Registration of the more severe degree of lesions in the regions of the head, chest, and abdomen in drivers' indicates a cabin contact due to the position of the steering wheel.

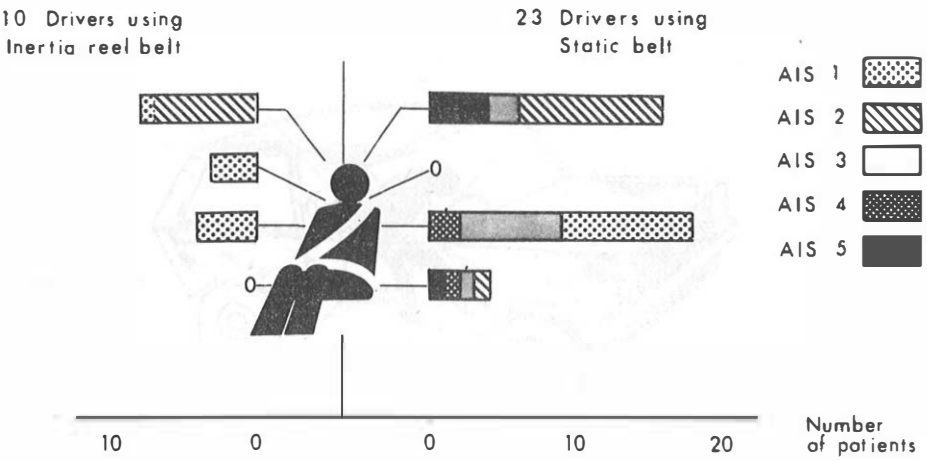
TYPE OF SEAT BELT COMPARED TO REGIONAL DISTRIBUTION OF LESIONS.

We have tried to evaluate differences in lesions dependant of the belt system in use.
23 drivers used static belts, whereas 10 used inertia reel belts. The lesions are shown in figure 4.
The registered heaviest lesions according to AIS grades are found in the group who used static belts. The group of drivers who used inertia reel belts mostly acquired lesions of grade 2 in the region of the head, whereas lesions in the regions of neck and chest

only came to AIS grade 1, which corresponds to seatbelt bruises. No abdominal lesions at all were registered in the group who used inertia reel belts, and certainly this speaks against steering wheel contact in this group.

FIG.4

TYPE OF SEAT BELT COMPARED TO
REGIONAL DISTRIBUTION AND SEVERITY OF LESIONS
ABBREVIATED INJURY SCALE RATING



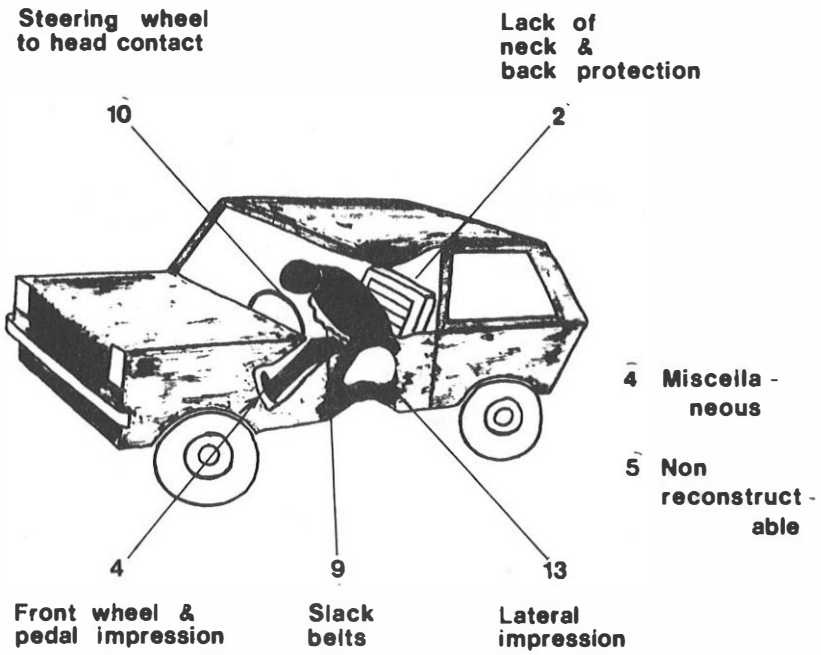
VN. WE Odense University Hospital 1977

PROBABLE LESIONAL FACTORS.

Figure 5 demonstrates the probable lesional factors concerning 47 lesions registered in 38 of the patients.
A large number of lesional factors recur in frontal impact materials as well, but a few of them are of special interest in the impact situations which are analyzed in the present material. That is particularly the case with the most frequently registered lesional factor in the present material, namely side intrusion into the front seats which was registered in 13 patients.
Head to steering wheel contact was seen in 10 patients, 7 of whom were wearing static belts and the last 3 in inertia reel belts.
Slack belts as main lesional factor was found in 9 patients of whom 7 were placed in static belts. Of these 7, 5 had made no attempts to adjust the belt to fit themselves. Two patients had been

sitting in inertia reel belts, and the function of these belts was found to be perfect at the following technical examinations of the belts.

FIG.5 **PROBABLE LESIONAL FACTORS (N-38)**



Odense University Hospital, Denmark 1977
VN/WE Fronto-lateral Impacts.

4 patients were found to have lesions as a result of intrusion of the front wheel and/ or pedals into the cabin floor.
In two cases only the lesions were probably due to lack of back and head protection to a satisfactory extend, and in both cases it was a question of overload from unrestrained backseat passengers.
In 9 patients the cause of lesions could not be reconstructed or it was a matter of complex reasons.
The last 6 patients only had minor contusions owing to the restraint system, but no cabin contacts.

DISCUSSION.

At the moment the predominant sorts of restraint systems are mostly constructed to protect in frontal collisions, and they do have their strongest effect in this particular situation (3).

Far the most cars, at the same time, have the main stress in collision protection laid on frontal collision situations, corresponding with the dominant statistical incidense of this impact direction. A more severe degree of lesions might be expected in the side collision type because of sideways forces on the passenger, but also because of the direct contact between the passenger and the intruding cabin. This is also found in our material.
In the cars with medium damage (= HUK 3) we find lesions on a high ISS level which first recurs again in the group with severely damaged cars (HUK 4) in both side- and fronto-oblique situations.
In the highest damage degrees (= HUK 4 and 5) a certain intrusion of the cabin will often be seen, which results in cabin contact. This may occur without any relation to direction of impact or correctly applied restraint system.

REGIONAL DISTRIBUTION OF LESIONS.

We have found the same patterns of regional distribution of lesions as other authors.
In the head region we find an AIS which is higher on an average in near-side collisions, due to direct head contact with intruding door/door frame.
Strikingly high is the average AIS in the abdominal region in fronto-oblique off collision situations.
We have not found any explanation of this high value. It might be a question of a statistical coincidence.

RESTRAINT SYSTEMS.

In our analysis we have not, like other authors (7) been able to prove that inertia reel belts are inferior to static belts.
The many high AIS grades in the group with static belts point towards a higher frequency of cabin/steering wheel contact than in the group who uses inertia reel belt systems.
There is a strong presumption that these serious lesions most often are a result of non-adjusted or inappropriately used static belts. The same question has been elucidated by Henderson (8).
An interview investigation among the users of static belts in our material showed, that only 15 of the 32 patients had adjusted the belt to fit themselves within a reasonable time before the accident, while 13 had done nothing at all to adjust the belt. In 4 cases there was no such information available.
Looking at the average AIS values in the group with adjusted belt as opposed to the group with non-adjusted belt, within the regions of the head, neck, chest, and abdomen it appears, that there is an increase in the AIS value of 0.5 (on the level 2 to 2.5) per patient, when not using the seat belt.

SPECIAL SIDE IMPACT PROBLEMS.

In our material we have not been able to find any negative side effects from belt use in this type of collision.
The off-side accidents have profitted from use of seat belts, in as much as the belt has retained the occupant in the part of the cabin which was relatively undamaged.
The well known problem of weak side constructions is found in this material as well. In clean side collisions higher AIS lesions were registered within lower HUK grades than is the case in other types of collisions.

FRONTO-OBLIQUE IMPACT PROBLEMS.

In this type of collisions there are,just as it is found in clean frontal collisions,many head/steering wheel contacts in spite of the use of belt systems.This indicates that an effort should be made to extend protective measures in prevention of this lesional factor.Reidelbach (9) mentioned air-bags in the steering wheel. Other possibilities would be to make the whole steering wheel, brim and column more flexible.A longer distance to the steering wheel would be an advantage in many cars.

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