NECK INJURIES IN REAR END COLLISIONS AMONG FRONT AND REAR SEAT OCCUPANTS

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BACKGROUND

Neck injuries occurring in traffic accidents, which are sometimes called whip-lash injuries and then classified as AIS 1, are often regarded as minor injuries. Related to the mortality risk, this is a true assessment, but it has been shown by Nygren (1) that there is a considerable risk that such injuries will lead to permanent medical disability. One-third of all injuries with permanent disability are neck injuries. This risk has been found to exist for both children and adults (2). It is therefore important that the occurrence of neck injuries be thoroughly analysed.

Neck injuries classified as AIS 1 often occur in rear end collisions (1) and it has been shown that the most common injury in rear end collisions is a neck injury.

The only known passive safety measure aimed at reducing the risk of neck injuries in rear end collisions is the head rest. Such devices have been found to reduce injuries to a definite but small extent, which varies between different car models and designs. One factor that has been proved important is the height of the head rest (3).

The aim of this study was to compare front and rear seat occupants with respect to the incidence of neck injuries (AIS 1) in rear end collisions and to relate any differences to some simple characteristics of the occupants and the vehicles.

MATERIAL AND METHODS

A prospective study was conducted on car accidents in which at least one occupant was travelling in the rear seat. The study was carried out between June 1, 1983 and December 31, 1984. All car accidents, reported to the Folksam Insurance Company, both those causing car damage alone and those producing personal injuries were recorded and a questionnaire was sent to the driver, if possible, in all cases (approximately 80,000). The questionnaire was sent out in connection with the initial contact between the claim adjuster and the policyholder, within a few days after the accident. The questionnaire was to be returned if at least one child (0-14 years) or an adult rear seat occupant had been present in the car in question during the accident. The questionnaire concerned the travel occasion, the accident, car damage, the age, sex and size of all occupants, available restraints, used restraints, and injuries. If any of the occupants had been injured, medical data such as hospital records and doctors' certificates were collected from the insurance files.

From the registration number of the car, the car make and model were identified and information was thereby obtained about the interior dimensions, head rests and so on.

Personal injuries were coded according to the Abbreviated Injury Scale (AIS) (4).

The height of the rear seat back was measured from drawings made by Autograph Hb, from a dummy h-point to the highest position of the seat back.

The quality of the data has been assessed previously (2) in a study based on the same material, in which the response rate was found to be 78 %.

The number of children in the study material was 2,899, and the number of adults was 7,169.

RESULTS

Table 1 shows the numbers of children and adults in different seating positions and the absolute and percentage numbers injured (inj).

Table 1. Number of involved and injured (inj) children (0-14 years) and adults in different seating positions.

	Front seat			Rear seat			All		
	Total	No. inj	% inj	Total	No. inj	%inj	Total	No. inj	% inj
Children	461	43	9.3	2,428	300	12.4	2,899	344	11.9
Adults	4,819	721	15.0	2,350	389	16.6	7,169	1,110	15.5

As seen in the table, the proportion of injured car occupants varied with both age and seating position. The use of restraints was not, however, considered to explain the higher proportion of injured persons among rear seat occupants compared with those in the front seat. In the front seat restraints were used by 97.7 % of the children and 94.5 % of the adults. The corresponding figures for the rear seat were 47.7 % and 28.9 % respectively.

In Table 2a the number of neck injuries classified as AIS 1 is shown for different ages and seating positions. It is seen that such injuries were relatively fewer in the rear seat among both children and adults, than in the front seat.

Table 2b gives the number of neck injuries in rear end collisions and other collision modes. It was calculated that more than one-fourth of the adult occupants had been involved in a rear end collision, but only about one-seventh of the children. More than half of the neck injuries sustained by adults occurred in rear end collisions.

Table 2a. The number of neck injuries (inj) related to all injuries among children (0-14 years) and adults occupying front and rear seats.

	Front seat			Rear seat		
	No. with neck inj.	No. with inj.	% neck injuries of total	No. with neck inj.	No. with inj.	% neck injurise of total
children	8	43	18.6	37	300	12.3
adults	252	721	35.0	83	389	21.3

Table 2b. The number of neck injuries in rear end collisions and in all accidents.

	all occupants	rear end collisions	all neck injuries	neck injuries in rear end collisions
children	2,889	387	45	20
adults	7,169	1,908	335	179

Table 3. The number of neck injuries (inj.) in rear end collisions with respect to head rest fitting.

		No head rest			Head rest	
	Total occupants	No. with neck inj.	% with neck inj.	No. of occupants	No. with neck inj.	% with neck inj.
children *	344	16	4.7	43	4	9.3
unknown	431	5	1.2	133	1	0.8
adults						
15-45 yr	445	47	10.6	590	74	12.5
46- yr	131	22	16.8	178	20	11.2
Total	1,351	90	6.7	944	99	10.5

*) excl children in child restraints

The numbers of neck injuries among occupants seated in a position with and without a head rest are given in Table 3. It was calculated that there was an overall head rest effectiveness of 36.6 %, but that this effectiveness was mainly attributable to differences in age distributions in different seating positions. There was no consistent difference in the incidence of neck injuries between the two adult age groups.

Table 4. The percentage numbers of neck injuries among front seat occupants of ages ≥ 15 years involved in rear end collisions, by body height and sex.

	Male			Female		
Body height cm	Total occupants	No. with neck inj.	% with neck inj.	Total occupants	No. with neck inj.	% with neck inj.
155-65	32	5	15.6	247	32	13.0
166-75	247	26	10.5	96	14	14.6
176-85	265	18	6.8	5	1	
186-	23	1				
Total	567	50	8.8	348	47	13.5

In Table 4 the occupants with neck injuries are divided according to sex and body height. The risk of neck injury was considerably higher among females, by about 50 % (53.4 %, significant). The body height, at least in the front seat, and no consistent influence on the incidence of neck injuries.

Table 5. The percentages of neck injuries among adult occupants (occ) of front and rear seats with and without a head rest, in rear end collisions.

	No head rest		Head rest		% of injuries male pop.
Front seat					
injured	22		75		
all occ.	156		759		62.0
% injured	14.1		9.9		
Rear seat					
injured	32		6		
all occ.	344		31		35.7
% injured	9.3	(6.5)	19.4	(18.0)	

In Table 5 the numbers of occupants with neck injuries in the front and the rear seat are shown in relation to the presence of a head rest. The table refers only to adults. If the calculations for the front and the rear seat had both been based on a male to female ratio of 62 to 38 per cent, the proportion of neck injuries in the rear seat would have been 6.5 %, compared with 14.1 % in the front seat. The reduction would then have been 53.9 % instead of 34.0 %. Both reductions were significant. There was no reduction due to a head rest in the rear seat, while the effectiveness in the front seat was 29.8 % (significant*).

Table 6. The number of neck injuries among rear seat occupants in cars with low and high seat backs in rear end collisions.

	Total occupants	No. with neck injuries	% with neck injuries
Seat back less than 48 cm	194	13	6.7
Seat back 48 cm or more	426	24	5.6

In Table 6 the number of rear seat occupants with neck injuries are divided into those sitting in a car with a low seat back and those with a high seat back. There was no significant difference.

DISCUSSION

It has been shown earlier that neck injuries can entail a considerable risk of permanent medical disability (1). In an injury rating system called the rating system for serious consequences (RSC), the proportion of persons medically disabled from a neck injury classified as AIS 1 has been found to be 10 % if the injury has occurred in a rear end collision (5). Among injuries classified as AIS 1, neck injuries are by far the most hazardous when related to long-term consequences. The low severity as measured by AIS indicates a low mortality risk. It seems that the AIS score, if used directly and used for other purposes than the mortality risk, can be misleading.

Among injuries to car occupants, neck injuries are very common. In rear end collisions neck injuries classified as AIS 1 are by far the most common injury. The overall incidence of neck injuries in rear end collisions is therefore high. In this study more than 10% of those car occupants involved in a rear end collision sustained a neck injury. Considering that the accident severity in rear end collisions is low, such a high incidence would not be expected. In wiew of the high incidence of injury and the high severity of the injuries associated with rear end collisions, prevention of such collisions should be given higher priority in the future. In this study children were less exposed to rear end collisions than were adults.

In the present material there was no consistent relationship between body height and neck injury. Such a relationship has been found by Norin et al (6) in Volvo cars. In our study the height is considered in 10 cm intervals, which may be too broad. The difference between male and female occupants was clear, however. As the proportion of female rear seat passengers was higher than that of male and differed from the proportion of female front seat passengers, it was considered important to include sex in the comparison between the front and rear seat incidence of neck injuries. When the rear seat incidence was recalculated using the same proportion of male/-female occupants as in the front seat, it was reduced substantially and to a level approximately 50% lower than that in the front seat. The effectiveness of the head rest in the front seat was estimated to be about 30%, compared with the figure of about 20% obtained by Nygren in 1984 (1). The effect of moving from the front to the rear seat is thereby greater than that of fitting a head rest to the front seat. This fact may be utilised in attempts to better understand the mechanism of neck injuries in rear end collisions and the possible increase in safety. The rear seat back is more rigid and

behaves differently from the front seat back, which is pliable in its movement (5). The high effectiveness of rear seat positioning may provide information on the factors that influence neck injury measurement for further research on real life accidents. One approach could be to investigate the occurrence of neck injuries in relation to different front seat characteristics.

The effectiveness of head rest fitting in the rear seat could not be calculated, but as neck injuries still occur in the rear seat, this effectiveness should be investigated in order to permit adequate decisions on future head rest fitting. In the meantime, it would seem advisable to install head rests in the rear as well as the front seat.

The findings in this study may be summarized as follows:

- Injuries to the neck were common, especially in rear end collisions, in which almost 10% of the occupants involved sustained such an injury (AIS 1).

- Children were less prone to neck injuries than adults, but otherwise age had no influence on the incidence of such injuries.

- Sex, but not body height, had a significant influence on the occurrence of neck injuries.

- The relative incidence of neck injuries in the rear seat was significantly lower than in the front seat. When sex was taken into account, the risk was approximately 50% lower.

- The effectiveness of head rest fitting in the front seat was approximately 30%, while in the rear seat this factor could not be calculated.

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