PATTERNS OF INJURY IN FRONTAL COLLISIONS WITH AND WITHOUT AIRBAGS

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ABSTRACT

To assess the effect of airbags on patterns of injuries sustained in vehicular crashes, records were reviewed for the 1,369 seatbelt-restrained drivers admitted to Maryland hospitals in 1993 and 1994. The airbag group had a lower incidence of spinal, thoracic, abdominal and serious facial injuries; however, that group also had a higher incidence of brain injuries and upper and lower extremity fractures. This study of a relatively small sample suggests that airbags are associated with changing patterns of injury. Additional studies involving larger study groups and crash reconstructions are warranted to further elucidate injury patterns associated with airbag deployment.

WITH THE INCREASING AVAILABILITY OF AIRBAG-EQUIPPED VEHICLES, it is possible to begin to assess the real-world performance of these safety devices. Airbag-associated reduction in fatalities has been noted by Lund and Ferguson (1995), and Zador (1993). While the overall decrease in mortality effected by airbags has been estimated, there is still little information about the association between airbag use and specific types of injuries (Huelke, 1992). Most reports to date have been anecdotal in nature, based on small case series, since there have not yet been large numbers of crashes in airbag-equipped vehicles (Blacksin, 1993; Gault, 1995; Burgess, 1995; Smock, 1995; Huelke, 1995; Freedman et al., 1995). The purpose of this study was to use available sources of data, linking motor vehicle crash reports and hospital discharge records, to assess the prevalence of airbag associated crashes and the nature and severity of the injuries sustained among all drivers hospitalized in the state of Maryland.

METHODS

For the years 1993-1994, all restrained drivers injured in non-rollover frontal motor vehicle collisions occurring in the state of Maryland were identified. Those with at least a minor injury (based on the police injury severity assessment) were eligible for study. This scale, which is used throughout the U.S., categorizes injuries on a scale of 1-5: 1 (no injury), 2 (minor injury), 3 (non-minor injury), 3 (non-incapacitating injury), 4 (incapacitating injury), and 5 (fatality). For this same time period, all persons admitted to hospitals throughout the state of Maryland for an injury (those with ICD-9 codes between 800 and 959.9) were selected from hospital discharge records.

Using probablistic linkage techniques, the two databases were linked based on the following variables: date of birth, gender, and date of injury. A selection of "frontal" crashes was based on data from the police reports; crashes selected included those involving a point of impact to the front left and left corners and front right and right corners of vehicles. In addition, police reports include a variable which indicates the extent of damage to the vehicle defined as superficial, functional, disabled, or destroyed. In an attempt to control somewhat for crash severity, after examining the total group of restrained drivers, further analyses were based on a subset of drivers of disabled/destroyed vehicles.

Once the linked database was created, analyses of injury types were conducted to determine whether there were differences for those drivers in collisions with and without airbags. Injury severity scores were computed using an ICD-9 to AIS conversion program (MacKenzie et al., 1989). Chi square tests or t-tests, where appropriate, were used to test for statistical differences.

RESULTS

From 1993-1994, there were 57,274 car drivers involved in non-rollover collisions in Maryland. During this same period, there were 73,224 individuals admitted to Maryland hospitals as a result of an injury. Based on a linkage of these two databases, 3,175 drivers injured in motor vehicle collisions and admitted to hospitals were identified (Figure 1). Thus, approximately 5.5 percent of drivers for whom there was any indication of injury on the police report were admitted to hospitals.

Using the vehicle diagram from the police report, only frontal collisions were selected (1,2,3,16 of Figure 2), as those are obviously the ones for which airbags would be most effective. This resulted in a final study population of 1,369 belted car drivers, who were admitted to hospitals after being injured in non-rollover frontal collisions. Among this group, 81 were involved in airbag crashes.

Furthermore, the vast majority (88.3%) were involved in crashes in which the vehicle was disabled or destroyed.

Fig. 1 - Linkage of Police Report (MAARS) and Hospital Discharge Data

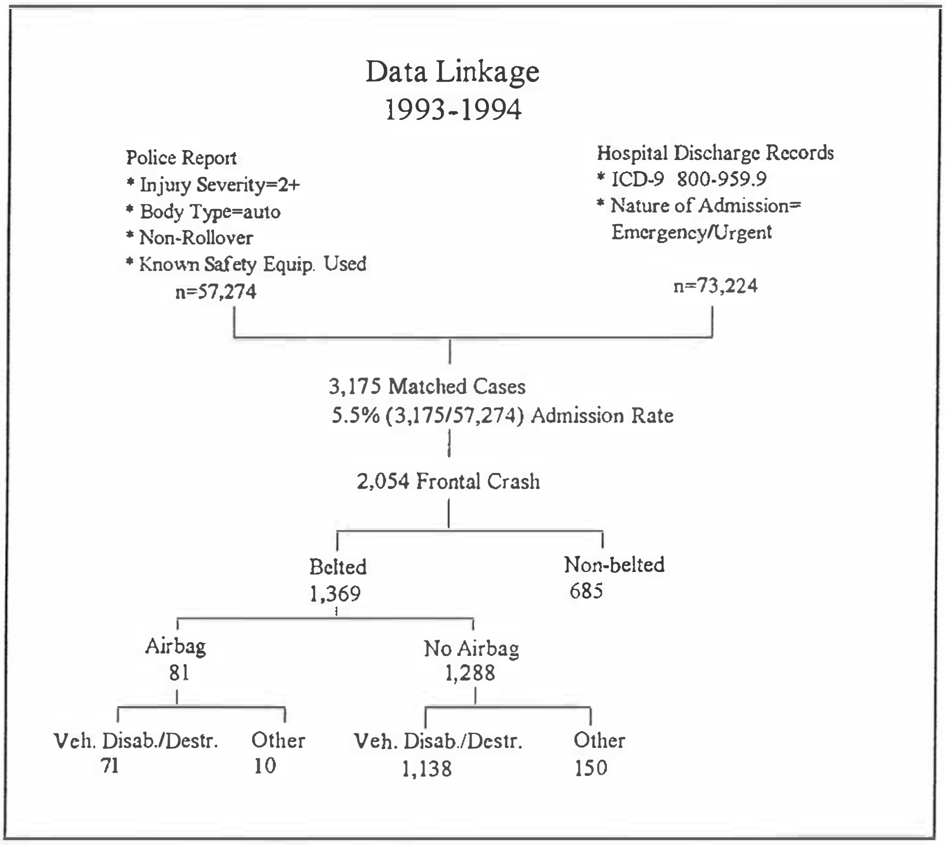

Fig. 2 - Police Report Car Schematic

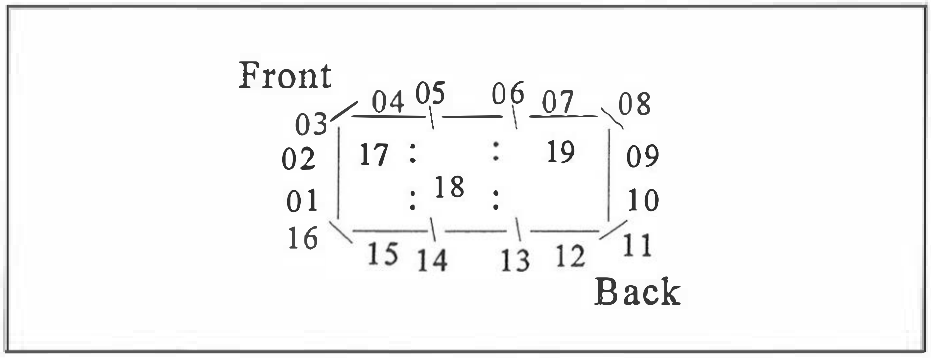

Figure 3 shows the distribution of injuries by ISS (injury severity score) and airbag use. It is apparent that, with the exception of those in the highest (25+) ISS group, drivers with airbags had a distribution of ISS scores which was shifted towards a lower severity. However, due to relatively small numbers, these differences were not statistically significant.

Fig. 3 - Distribution of Injuries by ISS and Airbag Use

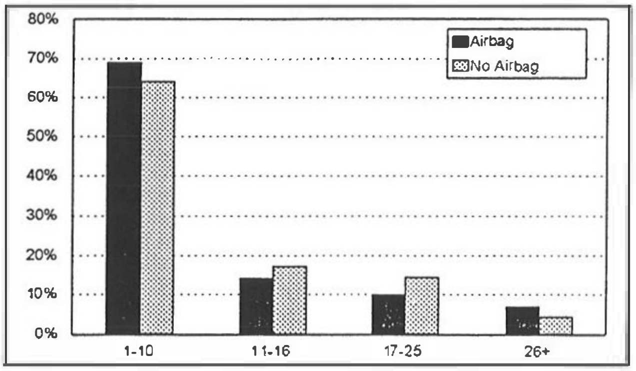

Table 1 shows the overall incidence of specific injuries, with and without airbags, for belted drivers in frontal collisions. For drivers with airbags there was a significant reduction in facial injuries as a whole, while there was an increase in superficial injury to the tissues around the eye (ocular adnexa).

Table 1 - Comparison of Selected Injuries With and Without Airbags
(Belted Drivers, N = 1,369)

	Airbag (%) (n=81)	No Airbag (%) (n=1,288)	p	Total (%) (n=1,369)
Head/Neck	30.9	38.6	NS	38.1
Brain	21.0	15.5	NS	15.9
Skull	6.2	9.9	NS	9.6
Spine	3.7	5.8	NS	5.6
Face	6.2	14.1	<0.05	13.6
Facial Fracture	4.9	8.9	NS	8.6
Ocular Adnexa*	3.7	0.2	<0.05	0.5
Thorax	21.0	27.0	NS	26.7
Abdomen	8.6	9.5	NS	9.5
Liver	2.5	3.1	NS	3.1
Kidney	2.5	0.9	NS	1.0
External	55.6	56.4	NS	56.3
Lower Extremity	30.9	19.7	<0.05	20.4
Femur	12.4	4.7	<0.05	5.1
Tibia/Fibula	8.6	4.2	<0.06	4.5
Tarsal	12.4	4.6	<0.05	5.0
Upper Extremity	21.0	12.3	<0.05	12.9
Scapula	2.5	0.2	<0.05	0.4
Humerus	1.2	1.9	NS	1.8
Radius/Ulna	13.6	5.7	<0.05	6.2

*Superficial

Overall, there was a decline in head/neck injuries, including skull fractures. The incidence of brain injury, however, was higher among those with airbags (21.0%) as contrasted to those without (15.5%). Injuries to the spine, thorax, and abdomen also declined. The incidence of both upper and lower extremity injuries was significantly higher in crashes with airbags. Specifically, there was an increase in femur, tibia/fibula and tarsal fractures as well as fractures of the scapula and radius/ulna.

In Table 2, a similar comparison is made, but for those drivers in collisions in which the vehicle was disabled or destroyed; that is, the cases in Table 2 represent a subset of the cases in Table 1. Although the trends remain the same, the incidence of most injuries was slightly higher in this severe crash subset. For drivers in destroyed/disabled vehicles, the incidence of brain injury was higher than previously noted in the total group of restrained drivers, with a rate of 23.9% in those with airbags, as contrasted with 15.4% in those without airbags (p=.06).

Table 2 - Comparison of Selected Injuries With and Without Airbags
(Belted Drivers in Disabled / Destroyed Vehicles, N = 1,209)

	Airbag (%) (n=71)	No Airbag (%) (n=1,138)	p	Total (%) (n=1,209)
Head/Neck	33.8	38.8	NS	38.5
Brain	23.9	15.4	0.06	15.9
Skull	7.0	10.2	NS	10.0
Spine	2.8	5.7	NS	5.5
Face	7.0	14.5	0.08	14.1
Facial Fracture	9.2	5.6	NS	9.0
Ocular Adnexa*	4.2	0.3	<0.05	0.5
Thorax	19.7	27.6	NS	27.1
Abdomen	8.5	9.2	NS	9.2
Liver	2.8	3.2	NS	3.1
Kidney	2.8	0.9	NS	1.0
External	54.9	57.0	NS	56.9
Lower Extremity	31.0	20.4	0.05	21.0
Femur	12.7	4.8	<0.05	5.3
Tibia/Fibula	8.5	4.4	NS	4.6
Tarsal	11.3	4.8	<0.05	5.1
Upper Extremity	19.7	12.7	0.09	13.1
Scapula	1.4	0.3	NS	0.3
Humerus	1.4	1.9	NS	1.9
Radius/Ulna	12.7	5.9	<0.05	6.3

*Superficial

Table 3 shows the mean injury severity scores (ISS), hospital costs, and length of stay (LOS) for all restrained drivers in crashes with and without airbags. It is apparent that, in this small population, there were no significant differences between the airbag and non-airbag groups as a whole. This is at least partly due to the fact that lower extremity injuries, which are very costly, are actually more prevalent among the airbag cases. As shown in Table 3, the average hospital costs and mean length of stay were significantly less for drivers with airbags and without lower extremity injuries, whereas for drivers with these injuries there was no difference.

Table 3 - ISS Length of Stay and Cost By Airbag Use

	Lower Ext Fx			No Lower Ext Fx			Total (n=1209)		
	Airbag (n=22)	No Airbag (n=232)	p	Airbag (n=49)	No Airbag (n=906)	p	Airbag (n=71)	No Airbag (n=1138)	p
Mean ISS	11.3	12.2	NS	9.8	9.1	NS	10.3	9.8	NS
Mean LOS (Days)	11.2	7.9	NS	2.1	3.4	<0.001	4.3	4.9	NS
Mean Hosp Charge	$16,115	$15,379	NS	$3,967	$6,036	<0.003	$7,731	$7,940	NS

DISCUSSION/CONCLUSIONS

A definitive estimate of the impact of airbags on injury requires a comprehensive surveillance of all airbag crashes in a given population, including those drivers with and without injuries. From the police reports, it is possible to ascertain the number of drivers involved in crashes with and without airbags, and to examine the police-estimated incidence of injury in these drivers. However, in order to examine details of the actual nature and severity of injuries, data must be obtained from hospital discharge records. This analysis is based on a comprehensive study of all drivers admitted to hospitals within the state of Maryland following a motor vehicle crash.

It is apparent that there are differences in the patterns of injury among drivers with and without airbags. A shift in the overall distribution of injuries towards lesser severity was noted. Similar findings, based on trauma center cases with crash reconstruction, were noted by Loo et al. In an analysis of 60 restrained patients involved in frontal collisions (23 with airbag, 37 with no airbag), a decrease in overall injury severity scores was noted. In the current study, declines have been noted for spine, thorax, abdominal and serious facial injuries. However, increases are noted for brain injuries and upper and lower extremity fractures.

There are basically three categories of injury associated with airbag crashes. First, it is apparent that some of the injuries associated with airbag use are due to *indirect association*: that is, they may be attributable to the higher change in velocity or other factors associated with crashes in which airbags are deployed. In other words, crashes that activate airbags may be more serious than crashes in which airbags do not deploy. This is probably the case for the drivers with lower extremity injuries. This possibility is further evidenced by the fact that the mean ISS scores for those drivers with lower extremity injuries was higher than for those without. The second category includes injuries such as facial injuries, which may actually be *prevented* by the airbag. Still a third group of injuries (such as radius and ulna fractures) may actually be *caused* by contact with the airbag.

The increase in brain injury is somewhat surprising. This could be due to an indirect association with crash severity, i.e., those with airbags are involved in higher energy crashes more likely to produce brain injuries, or to injury actually caused by contact with the airbag, or both. Loo, et al., showed that there was no difference in the incidence of brain contusions for trauma patients with and without airbags, but that the severity of the brain injury was decreased; unfortunately, this level of detail (i.e. Glascow Coma Scores) is not available for the current analysis. This question will have to be pursued in greater detail as larger numbers of cases become available. However, it must be kept in mind that there is no documentation of the brain injuries *prevented* by airbags.

Data on costs and length of hospital stay reveal that, at least in this population of drivers, there are no significant differences between those with and without airbags as a whole. Since lower extremity injuries have been identified as major contributors to cost (MacKenzie, 1988; Siegel, 1993; Siegel,1994), the data were then examined for those drivers with and without such injuries. From this analysis it is apparent that, despite the small numbers, there is a significantly decreased length of stay for drivers without lower extremity injuries who had airbags. However, for the group with lower extremity injuries, there was no such difference between drivers with and without airbags. If the mean cost for all drivers with airbags and no extremity injuries is applied to the group without airbags and with no lower extremity injuries, the estimated cost savings for that group of 906 drivers alone is estimated to be $1,874,514.

Although the numbers of airbag cases are still small, it is possible, using available sources of data, to begin to assess the epidemiology of injuries associated with airbag crashes. It is anticipated that the number of crashes involving airbags will increase exponentially within the next few years, as newer cars enter the vehicle fleet. Once larger numbers of cases are available it will be possible to study injury and driver characteristics in much greater detail. Actual information on the mechanism of injury and the forces involved in the collisions will obviously have to be obtained from more in-depth crash reconstruction studies. However, by combining data from clinical, epidemiologic, and engineering/experimental sources, a better understanding of injuries prevented by, caused by, or merely associated with airbag use will emerge.

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