

DRIVER STATURE INJURIES AND AIRBAG DEPLOYMENT CRASHES? -- ANALYSIS OF UMTRI CRASH INVESTIGATIONS--

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ABSTRACT

At the University of Michigan Transportation Research Institute (UMTRI), 776 crashes involving steering wheel airbag deployments have been investigated in detail (as of 1/1/98). A subset of only the frontal crashes, in which the steering wheel airbag deployed, and driver stature was known, was formed (646 drivers). The vast majority of all drivers were lap-shoulder belted. Of these drivers, 70% sustained no injuries or an AIS-1 level injury. In these 646 crashes there were 203 "short" stature drivers, 165 cm or less in height (32% of all drivers). Of the shorter drivers there were 40 MAIS-2 level injuries and 15 who survived with an MAIS injury level of 3, 4, or 5. These higher level injuries were usually found in only one body area. Details of the injury locations and contacts are presented. Data on the taller drivers (443) were similarly tabulated. Of the taller drivers (≥ 168 cm), 74% had a MAIS-0 or 1 level injury. Of taller drivers with the MAIS-3, 4 or 5 injuries, the majority (70%) had such injuries unrelated to the deployment of the airbag. Of all the MAIS-2+ injured drivers, short or tall, 57% had such injuries unrelated to airbag deployments. The lower extremity was the body area most often involved, followed by the brain and upper extremity injuries.

INTRODUCTION

Recently concern has been raised about the short driver exposed to steering wheel airbag deployments. NHTSA has reported that there are about 40 drivers who sustained fatal or serious injuries in airbag deployment crashes. These were mostly females, 65 inches in stature (164 cm), or less and were in minor to moderate severity airbag deployment crashes. A review of the UMTRI crash investigations, wherein the steering wheel airbag deployed, was conducted in order to determine the frequency of injury and injury severity in the short driver population, and to compare these findings with the "taller" drivers in the UMTRI series.

MATERIALS AND METHODS

As of 1/1/98 UMTRI personnel have investigated 776 crashes in which the steering wheel airbag deployed. In this series there were 130 non-frontal crashes, or cases with unknown driver stature. These were omitted, leaving 646 crashes for review. Of these 646 drivers, 203 (31%) are the shorter drivers whose stature was 165 cm or less. All of these drivers were females, except one, and the majority were belt restrained (86%). These cases were individually reviewed to determine the location of the body areas of AIS-2 or greater

injury severity, and to identify the object(s) contacted to cause these injuries. The data on each driver set were divided into two groups, those drivers with their highest injury level of MAIS-2, and those with an MAIS-3, 4, or 5 level injury who survived. The same review was carried out for the drivers who were 168 cm or taller.

RESULTS

The Shorter Drivers

Of the 203 drivers exposed to airbag deployments, most (70%) had an MAIS-0 or 1 level injury severity (Table 1). These injuries were noted to the face, upper extremity, thorax and abdomen. They include abrasions, contusions, and muscle strains to one or more body areas. In general, most were due to the lower instrument panel, floor, toepan (lower extremity injuries), restraint webbing (torso injuries) or airbag (face and forearms).

Of the 40 drivers who had an MAIS-2 injury, 20% of all the short drivers, the injuries were primarily located in one of three body regions--the lower or upper extremity, or the brain (Table 2). There were three drivers with two body areas involved, each with an AIS-2 level injury, and one driver with three AIS-2 level body areas involved. Half of the short drivers did not have the MAIS-2 injury from airbag contact or due to airbag deployment. These injuries were primarily located in the lower extremity (Table 2). Injuries of AIS-2 in short drivers, related to airbag deployments, were primarily located in the forearm (fractures), or the brain (unconscious less than one hour).

Of the 203 short drivers, 7% (15 drivers) survived with MAIS-3, 4 or 5 level injury (Table 3). Six drivers had these injuries in the lower extremity. Of the 15 drivers, 13 had AIS-3+ injuries from sources unrelated to airbag deployment.

A subset of the short drivers was created, using those drivers 160 cm or less (Table 1). Of these 91 drivers (all females), 21 (23%) had an MAIS-2 level injury and nine (10%) had MAIS-3, 4 or 5 level injuries. Two-thirds (64%) had only AIS-0 or 1 level injuries (Table 1). In Tables 2 and 5 these drivers are separately presented in parentheses.

The shortest of drivers fair well in airbag deployments. Of the shortest drivers stature is not related to injury severity (Table 3) Note that of the very short drivers (≤ 154 cm), AIS-2 or 3 level injuries are infrequent. Of the 20 shortest drivers (≤ 160 cm) with an MAIS-2 level injury, 10 had these AIS-2 level injuries unrelated to airbag deployment. (Table 4) There were 25 body regions injured at the MAIS-2 level in these 20 drivers. The majority of these were unrelated to the airbag deployment (16). Of the AIS-2 injuries in this group of 21 drivers that were related to the airbag deployment, four were to the upper extremity, and five to the brain.

Of the 91 shortest drivers there were only nine at the MAIS-3 or 4 level involving one of three body regions--the lower extremity (5), chest (3) and the upper extremity (1) (Table 6). Five were due to contact with the floor, pedals, or with the instrument panel. Two others were injured by steering wheel contact. Only two of the nine drivers had airbag related injuries.

There were six short drivers who were killed (Table 7). Five sustained a cervico-cranial dislocation or upper cervical fracture-dislocation with spinal cord or the spinal cord/brainstem junction disruption. Four of the six were in

severe crashes and had significant injuries other than in the cervical area. One died in a relatively minor crash.

Table 1
The MAIS of Drivers in Frontal Airbag Crashes

<u>MAIS</u>	≤160 cm		161-165 cm		All ≤ 165 cm		≥ 168 cm	
	No	%	No	%	No	%	No	%
0-1	59	64	83	75	142	70	326	74
2	20	23	20	17	40	20	68	14
3+	9	10	6	5	15	7	42	9
<u>Died</u>	<u>3</u>	<u>3</u>	<u>3</u>	<u>3</u>	<u>6</u>	<u>3</u>	<u>7</u>	<u>2</u>
Total	91	100	112	100	203	100	443	100

Table 2
MAIS-2 Level Injuries of Drivers ≤ 165 cm in Stature [⊖]

Source of Injury	Body Regions								
	Lower Extrem	Upper Extrem	Brain	Neck	Abd	Brain/LX	Brain/UX/LX	UX/Neck	UX/LX
Floor/Pedals	10* (5)								
Instrument Panel	2* (1)	(2)							
Door Interior	1*								
3-Point Restraint		1*			(1)*				
Airbag		(1)	6 (5)	1			1	1	
Side Glass		(1)							
Wshd/Sunvisor/Roof		4	4* (1)						
Steering Wheel		(1)*							
Door Int/Inst. Panel						(1)			(1)*
Total	13* (6)	10 (5)	11 (6)	1	(1)	(1)	1	1	(1)

BODY REGION:
Abd=Abdomen
LX=Lower Extremity
UX=Upper Extremity

[⊖]In parentheses () are drivers ≤ 160 cm in stature
*Injuries unrelated to airbag deployments

Table 3
The Shortest Drivers (≤ 160 cm)
Stature & Injury Severity
MAIS

Stature (cm)	0-1	2	3 or 4	Died	Total
160	20	9	2	1	32
158	2				2
157	18	6	3	1	28
155	8	3	3	1	14
154	1				1
153	1				1
152	7	1	1		10
151	1				1
150	1	1			2
Total	59	20	9	3	91

Table 4
The Shortest Drivers (≤ 160 cm)
MAIS-2 Body Regions & Sources of Injury by Stature

Body Regions						
Source of Injury	Lower Extremity	Upper Extremity	Brain	Abd	Brain/LX	UX/LX
Floor/Pedals	160, 160, 157, 155, 155					
Instrument Panel	160	157, 157				
3-Point Restraint				150		
Airbag		160	160, 160, 160, 157, 157			
Side Glass		160				
Wshd/Sunvisor/Roof			160			
Steering Wheel		152				
Door Int/Inst. Panel					157	155

Bold italics=related to airbag deployment

Table 5
MAIS- 3, or 4 Injuries of Drivers Who Survived (≤ 165 cm in Stature) [⊖]

Body Regions						
Source of Injury	Lower Extremity	Brain	Chest	UX	Chest/Abd	LX/LX
Floor/Pedals	2* (2)					
Instrument Panel	3* (3)	1*		(1)		
Airbag			1 (1)			
Roof		1, 1*				
Steering Wheel			3* (2)			
Instrument Panel/Side Panel						1*
<u>3 Point Restraint</u>					1*	
Total	5* (5)	3	4 (3)	(1)	1	1

[⊖]In parentheses () are drivers ≤ 160 cm in stature

*Injuries unrelated to airbag deployments

There were only 3 AIS-4 injuries in this group. All were 162 or 163 cm in height.

Table 6
The Shortest Drivers (≤ 160 cm)
MAIS- 3, or 4 Body Regions & Sources of Injury by Stature

Body Regions			
Source of Injury	Lower Extremity	Chest	UX
Floor/Pedals	157, 157		
Instrument Panel	157, 157, 152		
Airbag		157	160
Steering Wheel		157, 160	

Bold italics=related to airbag deployment

The Taller Drivers

In the series of 646 drivers exposed to airbag deployment, there were 443 taller drivers (≥ 168 cm). Of these, 74% sustained injuries of an MAIS-0 or 1 (Table 1). Of the tall drivers, 14% had an MAIS-2 level injury. As with the shorter drivers, there were more lower extremity injuries that are unrelated to airbag deployment (Table 5). Additionally, there were a number of these tall drivers, 15 of 68, with an AIS-2 upper extremity injury as their most severe injury. Also, the brain ranked in the top three body areas with an AIS-2 injury in these taller drivers. These three body areas, lower and upper extremity and brain accounted for the majority of the body areas with an AIS-2 level injury. In the taller drivers there were 11 individuals who had multiple body areas (two or more) that were involved, each with an AIS-2 level injury.

Table 7

Short Drivers Who Died

<u>Body Areas</u>	<u>No.</u>
Brain	1 (1)
Neck	5 (2)
Total*	6 (3) ϕ

*All airbag related

ϕ In parenthesis () are drivers ≤ 160 cm in stature

Table 8
MAIS-2 Level Injuries of Tall Drivers*

Source of Injury	Body Regions						
	Lower Extremity	Upper Extremity	Brain	Chest	Eye	Face	Lumbar Spine
Floor/Pedals	8*						
Instrument Panel	7*	2 1*					
Door	4*	1*					
3-Point Restraint				6*			
A-Pillar			1				
Airbag		6	3	1	2	1	
Side Glass			1				
Sunvisor/Header			2				
Steering Wheel		2*					
Seat Back			1*				
Console	2*	1*					
Exterior to Car				1*			
Unknown		1*					
Miscellaneous		1*				1*	
Induced							1
Total	21*	15	8	8	2	2	1

*Injuries unrelated to airbag deployment

Additionally 11 drivers had two or more body areas injured at the AIS-2 level:

- | | | | |
|--------------------|----------------------------------|------------------------|-----------------------|
| *Neck/Lumbar Spine | rear passenger | *Brain/Chest | header/steering wheel |
| *LX/LX(x2) | inst panel/floor | *UX/LXinst panel/floor | |
| *Chest/LX | 3-point restraint/inst panel | Brain/Face/LX | airbag/airbag/floor |
| *Skull/Face/Chest | steering wheel | UX/Abdomen | airbag/steering wheel |
| *UX/Chest | steering wheel/3-point restraint | Brain/LX | airbag/inst panel |

In Table 8, the sources of these AIS-2 level injuries of the 68 tall drivers are shown. Those injuries, unrelated to the airbag deployment, are shown with an asterisk. There are 21 lower extremity injured drivers whose injuries were unrelated to airbag deployment. Of the upper extremity AIS-2 injuries, seven contacted structures within the car, contacts unrelated to the deploying airbag. This is also true for one of the individuals with an AIS-2 brain injury. In addition, seven of the drivers with multiple body areas injured at the AIS-2 level had their injuries unrelated to airbag deployment. Thus,

of the 68 tall drivers with a AIS-2 level injury, 45 (66%) had AIS-2 injuries unrelated to the airbag deployments.

The taller drivers with more serious injuries of AIS-3, 4, or 5 (42 drivers) had a distribution fairly widely through the different body areas (Table 9). The lower extremity and chest are the areas that predominate, with the chest being more frequently severely injured than, for example, the upper extremity. At these higher levels of injury severity, there are but few combinations of body areas at the AIS-3 level, only four of the 42 drivers. In Table 9 the sources of the injury of

the various body areas of the tall drivers who survived at the MAIS-3, 4, 5 level are indicated. Again, many of the injuries are unrelated to the airbag deployment. Of these 42 drivers, 29 (69%) had these more severe injuries from impacts unrelated to airbag deployments.

Of the seven tall drivers who died, all were in severe crashes, (car, tree, semi-trailers) or were over 70 years of age. One driver was lying on the steering wheel at impact having passed out due to drugs and alcohol (Table 10).

Table 9

MAIS-3, 4 or 5 Level Injuries of Tall Drivers Who Survived*

Source of Injury	Body Regions										
	LX	Chest	Brain	UX	Abd.	Neck	Face	Brain/ Chest	UX/ LX	Chest/ LX	LX/ LX
Instrument Panel	10*			3			1			1*	
Airbag		1		3		1		1			
Header, A-pillar			1			1					
Steering Wheel		2*									
3-Point Restraint		5*			2*						
Roof, Roof Side Rail			5*	1							
Console	1*										
Door/IP									1*		
Floor-Pedals	1*										
IP/Floor											1*
Total	12*	8	6	7	2*	2	1	1	1*	1	1*

*Injuries unrelated to airbag deployments. In this table there are 9 drivers with AIS-4 or 5.

Table 10
Tall Drivers Who Died

Body Areas	No
Brain	2
Chest	4
Brain & Chest	1
Total*	7

*one chest and the brain/chest fatalities were airbag related

tall driver group were not airbag related. The majority of the more severe injuries (MAIS-3+) to short drivers were not related to the airbag as was found in the tall driver group. The shortest of drivers (≤ 160 cm) do not appear to be at a higher risk in frontal airbag crashes than those 161 cm or taller, except possibly in the lower extremity. One-third of the shortest drivers had an MAIS-3 or greater injury level in the lower extremity. Most of the shortest driver's MAIS-2 level injuries were unrelated to airbag deployment. Short drivers of 161-165 cm in height have an injury severity distribution nearly identical to the tall drivers (≥ 168 cm).

Brain injury accounts for about 30-35% of the AIS-2 injuries to all drivers in this study. As described in the AIS dictionary, any loss of consciousness for less than an hour, amnesia or lethargic, stuporous or obtunded on admission to the hospital, or on initial observation at the scene, places the patient at the AIS-2 level.² However, the majority of these drivers studied are concussed for much less than one hour and did not have any long-term cerebral dysfunction.

In all drivers, the lower extremity is the body area most commonly involved in AIS-2+ injuries and these are sustained on the lower instrument panel, on the floor or foot pedals. The leading cause of the upper extremity fractures is the flinging of the extremity onto interior structures by the deploying airbag.

An interesting finding is the lack of AIS-2+ injuries, to the abdomen and thoraco-lumbar spine, body regions which are noted to be injured in lap-shoulder belted drivers without airbags in frontal crashes.

In the tall driver series the lower extremity, brain and upper extremity injuries predominate, as was noted in the short driver group. Chest injuries were also noted in the taller

DISCUSSION

Airbags are reducing fatalities, moderate and serious injuries. In frontal impacts (12 o'clock) the fatality reduction is 31%¹. Moderate head injuries, with a combination of the 3-point restraint and airbag, are reduced by 83% and serious head injuries are reduced by 75% with the belt/airbag combination. Belts and bags reduce moderate chest injury by 59% and serious chest injuries by 66%.

Malliaris, et al reviewed the 1988-92 NASS/CDS file and identified 350 drivers with lap-shoulder belts and airbag deployments¹. Their analysis indicated a higher frequency of AIS-1 level injury than in our data (83% vs. 72%) and had the same frequency of AIS-2 level injuries. However, data were not presented on driver stature and injury severity.

The majority of all drivers, tall and short, have but minor injuries. Short drivers have a higher frequency of AIS-2 level injuries than do the taller drivers, but about the same frequency of MAIS-3, 4 or 5 level injuries. Half of the MAIS-2 level injuries of short drivers are unrelated to airbag deployments whereas two-thirds of the MAIS-2 injuries in the

driver group. Of the 22 upper extremity injuries of AIS-2 or 3 in the tall drivers, 15 were related to the airbag deployment.

Taller drivers have slightly higher frequency of the more severe injuries (MAIS-3+) and are more prone to having two or even three body regions injured, at the AIS-2 level, than noted in the short drivers.

REFERENCES

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