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ON-SITE ADULT AIR BAG-RELATED FATALITY INVESTIGATION

CASE NUMBER - IN-03-033
LOCATION - MISSOURI
VEHICLE - 1997 FORD EXPLORER XL
CRASH DATE - July 2003

Submitted:

August 23, 2007



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The crash investigation process is an inexact science which requires that physical evidence such as skid marks, vehicular damage measurements, and occupant contact points be coupled with the investigator's expert knowledge and experience of vehicle dynamics and occupant kinematics in order to determine the pre-crash, crash, and post-crash movements of involved vehicles and occupants.

Because each crash is a unique sequence of events, generalized conclusions cannot be made concerning the crashworthiness performance of the involved vehicle(s) or their safety systems.

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15. <i>Supplementary Notes</i> On-site air bag deployment investigation involving a 1997 Ford Explorer XL, four-door sport utility, with manual safety belts and dual front air bags, which ran-off-road and impacted a wooden utility pole					
16. <i>Abstract</i> This report covers an on-site investigation of an air bag deployment crash that involved a 1997 Ford Explorer XL (case vehicle) which ran-off-road and impacted a wooden utility pole. This crash is of special interest because the case vehicle's unrestrained driver (35-year-old, female) sustained critical brain injuries from her deploying driver air bag, resulting in her death. The trafficway on which the case vehicle was traveling was a five-lane, divided, state highway, traversing in a north-south direction. On the southern leg of the intersection, both the north and southbound roadways had two through lanes while the northbound roadway had a left-hand turn lane. The case vehicle was traveling north in the outside northbound through lane and entered a four-leg intersection. The case vehicle departed the northeast corner of the intersection and traveled essentially northward on the right (eastern) shoulder. The crash occurred off road on the eastern roadside. The front right of the case vehicle impacted a large wooden utility pole, causing the case vehicle's driver and front right passenger supplemental restraints (air bags) to deploy. The case vehicle's driver was seated with her seat track located between its middle and rearmost positions, but the position of the tilt steering column could not be determined because of the loading that occurred to the steering wheel and column. She was not using her available, active, three-point, lap-and-shoulder, safety belt system and sustained, according to her medical records, critical brain injuries that included: a critical nonanatomic brain injury, small left subdural hematoma, severe brain swelling, diffuse left subarachnoid hemorrhage, and a developing pneumocephalus. Furthermore, the driver's torso sustained bilateral lung contusions with pneumothoraces, a right adrenal gland injury, a liver contusion, and a retroperitoneal hematoma. In addition, she sustained a 7 centimeter (2.8 inch) laceration under her chin and contusions to her neck, chest, shoulder tops, and to her right thigh. This occupant's primary brain and chest injuries were most likely caused by her contact with the case vehicle's driver air bag and her loading of the steering wheel and column, respectively.					
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This investigation was brought to NHTSA's attention on July 22, 2003 by an officer with the applicable police department. This crash involved a 1997 Ford Explorer XL (case vehicle) which ran-off-road and impacted a wooden utility pole. The crash occurred in July 2003 at 7:21 a.m., in Missouri and was investigated by the applicable city police department. This crash is of special interest because the case vehicle's driver (35-year-old, Asian or Pacific Islander female) sustained critical injuries from her deploying driver air bag, resulting in her death. This contractor inspected the scene and vehicles on 25 July, 2003. This report is based on the Police Crash Report, a conversation with the investigating police officer, scene and vehicle inspections, occupant kinematic principles, and this contractor's evaluation of the evidence.

SUMMARY

Crash Environment:

The trafficway on which the case vehicle was traveling was a five-lane, divided, state highway, traversing in a north-south direction, and the case vehicle was approaching a four-leg intersection. On the southern leg of the intersection, both the north and southbound roadways had two through lanes while the northbound roadway had a left-hand turn lane. At the time of the crash the light condition was daylight, the atmospheric condition was clear, and the roadway pavement was dry; see **CRASH DIAGRAM** at end.

Pre-Crash:

The case vehicle was traveling north in the outside northbound through lane and entered a four-leg intersection, intending to continue straight ahead. According to an eyewitnesses, the case vehicle just ran-off-road. The case vehicle departed the northeast corner of the intersection and traveled essentially northward on the right (eastern) shoulder. One witness indicated that they heard the sound of a vehicle skidding, indicating that the case vehicle's driver most likely braked, attempting to avoid the crash. The crash occurred off road on the eastern roadside.

Crash:

The front right of the case vehicle impacted a large wooden utility pole, causing the case vehicle's driver and front right passenger supplemental restraints (air bags) to deploy.

Post-Crash:

The case vehicle rebounded straight back from the pole, a very short distance. At final rest the case vehicle was on the eastern shoulder, straddling the eastern curb, heading north-northeastward. The case vehicle was towed due to damage.

Case Vehicle:

The 1997 Ford Explorer XL was a four wheel drive (4x4), four-door sport utility vehicle (VIN: 1FMDU34E4VZ-----). The case vehicle was equipped with four wheel, anti-lock brakes and driver and front right passenger supplemental restraint systems (air bags) which deployed as a result of the frontal impact with the wooden utility pole.

Vehicle Exterior:

Based on the vehicle inspection, the CDC for the case vehicle was determined to be: **12-FREN-1 (0 degrees)**. The WinSMASH reconstruction program, barrier algorithm, was used on the case vehicle's highest severity impact. The preliminary Total, Longitudinal, and Lateral Delta Vs are, respectively: 20.0 km.p.h. (12.4 m.p.h.), -20.0 km.p.h. (-12.4 m.p.h.), and 0.0 km.p.h. (0.0 m.p.h.).

Case Vehicle's Driver :

The case vehicle's driver (35-year-old, female) was seated with her seat track located between its middle and rearmost positions, but the exact position of the tilt steering column could not be determined because of the loading that occurred to the column. She was not using her available, active, three-point, lap-and-shoulder, safety belt system and sustained, according to her medical records, critical brain injuries that included: a critical nonanatomic brain injury, small left subdural hematoma, severe brain swelling, diffuse left subarachnoid hemorrhage, and a developing pneumocephalus. Furthermore, the driver's torso sustained bilateral lung contusions with pneumothoraces, an injury to her right adrenal gland, a liver contusion, and a retroperitoneal hematoma. In addition, she sustained a 7 centimeter (2.8 inch) laceration under her chin and contusions to her neck, chest, shoulder tops, and to her right thigh. This occupant's primary brain and chest injuries were most likely caused by her contact with the case vehicle's driver air bag and her loading of the steering wheel and column, respectively.

CRASH CIRCUMSTANCES

Crash Environment: The trafficway on which the case vehicle was traveling was a five-lane, divided, state highway, traversing in a north-south direction, and the case vehicle was approaching a four-leg intersection (**Figure 1**). On the southern leg of the intersection (**Figure 2**), both the north and southbound roadways had two through lanes while the northbound roadway had a left-hand turn lane. The state highway was straight and level at the area of impact. The pavement was bituminous, and the width of the outside northbound lane on the southern leg of the intersection was 7.5 meters (24.6 feet); however, the width of the same, outside, northbound lane on the northern leg of the intersection was only 9.2 meters (20.3 feet). There is no evidence that indicates the case vehicle's exact position within the outside through lane as it passed from the



Figure 1: Case vehicle's northward travel path in outside northbound lane toward impact location with utility pole on east roadside (case photo #04)



Figure 2: Southward view of case vehicle's northern travel path from northeast corner of intersection, just southwest of impact location (case photo #09)

southern leg, through the intersection, toward the northern leg (**Figure 2** above). As a result, it cannot be determined whether the narrowing of the outside lane played a role in this crash.

The shoulders were improved (i.e., concrete rain gutter) but their width was not measured. The trafficway was bordered by barrier curbs. The northern and southern roadways were separated on both the northern and southern legs of the intersection by unprotected, raised, concrete medians (**Figures 1** and **2** above). On the southern leg of the intersection, pavement markings consisted of a solid white lane line and the left-hand turn lane was separated from the through lanes by a solid white lane line. Furthermore, the median curb and the raised, paved median was painted yellow. In addition, no edge lines were present for the northern roadway (**Figure 3**); although, a curving white edge line was present for the westward intersecting roadway (**Figure 2** above and **Figure 3**). The coefficient of friction was not estimated.

Traffic controls consisted of multiple on-colors, pre-timed, vertically mounted traffic control signals located on the northern leg of the intersection, hanging from the arm of a pole mounted in the median (**Figure 1** above). In addition, there was a regulatory **LEFT TURN YIELD ON GREEN** sign (Manual on Uniform Traffic Control Devices, R10-12) fastened on the median signal pole (**Figure 1** above). The statutory speed limit was 48 km.p.h. (30 m.p.h.). No regulatory speed limit sign was posted near the crash site. At the time of the crash the light condition was daylight, the atmospheric condition was clear, and the roadway pavement was dry. Given the time of day and the proximity of the crash scene to an interstate entrance/exit, the Traffic density was most likely heavy, and the site of the crash was urban commercial; see **CRASH DIAGRAM** at end.



Figure 3: Case vehicle's travel path off roadway toward wooden utility pole (case photo #05)

Pre-Crash: The case vehicle was traveling north in the outside northbound through lane and entered a four-leg intersection, intending to continue straight ahead. According to an eyewitnesses, the case vehicle just ran-off-road. The case vehicle departed the northeast corner of the intersection and traveled essentially northward on the right (eastern) shoulder (**Figure 3**). One witness indicated that they heard the sound of a vehicle skidding, indicating that the case vehicle's driver most likely braked, attempting to avoid the crash. The crash occurred off road on the eastern roadside.



Figure 4: Case vehicle's frontal damage with contour gauge set at bumper level; Note: yellow tape (arrows) shows location and direct damage width of pole impact (case photo #10)

Crash: The front right (**Figure 4**) of the case vehicle impacted a large wooden utility pole

(Figure 5), causing the case vehicle's driver and front right passenger supplemental restraints (air bags) to deploy.

Post-Crash: The case vehicle rebounded straight back from the pole, a very short distance. At final rest the case vehicle was on the eastern shoulder, straddling the eastern curb, heading north-northeastward.

CASE VEHICLE

The 1997 Ford Explorer XL was a four wheel drive (4x4), five-passenger, four-door sport utility vehicle (VIN: 1FMDU34E4VZ-----) equipped with a 4.0L, V-6 engine and a four-speed automatic transmission. Braking was achieved by a power-assisted, front and rear disc, four-wheel, anti-lock system. The case vehicle's wheelbase was 283 centimeters (111.5 inches), and the odometer reading at inspection was 165,136 kilometers (102,611 miles).

Inspection of the vehicle's interior revealed adjustable front bucket seats with integral head restraints; a non-adjustable back bench seat with adjustable head restraints for the back outboard seating positions; continuous loop, three-point, lap-and-shoulder, safety belt systems at the front and back outboard positions; and a two-point, lap belt system at the back center position. The exact position adjustment for either of the two back outboard adjustable head restraints was not determined. The driver's upper anchorage adjuster was located in the upmost position, but the adjuster was located in down-most position for the front right seating position. The vehicle was equipped with knee bolsters for both the driver and front right seating positions, neither of which showed evidence of occupant contact or deformation. Automatic restraint was provided by a Supplemental Restraint System (SRS) that consisted of a frontal air bag for the driver and front right passenger seating positions. Both frontal air bags deployed as a result of the case vehicle's frontal impact with the wooden utility pole.

CASE VEHICLE DAMAGE

Exterior Damage: The case vehicle's contact with the wooden utility pole involved the front with the



Figure 5: Case vehicle's travel path on east shoulder toward point of impact with wooden utility pole; Note: arrow indicates location of damage on pole (case photo #06)

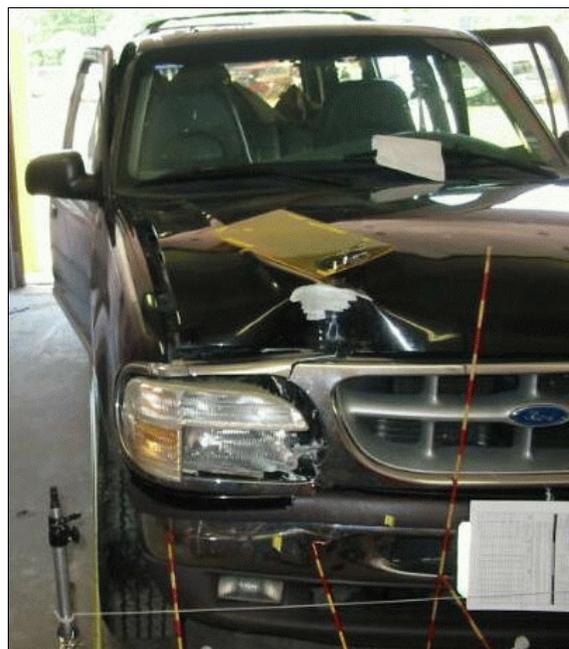


Figure 6: Case vehicle's front right damage from impact with utility pole viewed along right side (case photo #21)

damage distributed on approximately the front right portion (Figure 6 above). Direct damage began 24 centimeters (9.4 inches) inward from the front right bumper corner and extended 21 centimeters (8.3 inches) to the left along the front bumper. Residual maximum crush was measured as 17 centimeters (6.7 inches) at C₆ (Figure 7). The table below shows the case vehicle’s crush profile.



Figure 7: Overhead view of case vehicle’s frontal damage with contour gauge present at bumper level; arrow indicates location of pole impact (case photo #22)

The wheelbase on the case vehicle’s left side was extended at most 1 centimeter (0.4 inches) while the right side was shortened approximately 3 centimeters (1.2 inches). The case vehicle’s front bumper fascia, grille, hood, and right head lamp assembly were directly damaged and crushed rearward. The right headlight and turn signal assemblies sustained induced damage as well as both the right and left fenders. No obvious induced damage or remote buckling was noted to the remainder of the case vehicle’s exterior.

Units	Event	Direct Damage		Field L	C ₁	C ₂	C ₃	C ₄	C ₅	C ₆	Direct	Field L
		Width CDC	Max Crush								±D	±D
cm	1	21	17	152	7	6	7	12	16	17	39	0
in		8.3	6.7	59.8	2.8	2.4	2.8	4.7	6.3	6.7	15.4	0.0

The vehicle manufacturer’s recommended tire size was: P225/70R15, but tire sizes P235/75R15 and P255/70R16 were optional; the case vehicle was equipped with optional tire size: P235/75R15. None of the case vehicle’s tires were damaged, deflated, or physically restricted. The maximum tire pressure for each of the case vehicle’s four tires was 241 kPa (35 psi) which means that the case vehicle’s tires were grossly overinflated.

Tire	Measured Pressure		Recommend Pressure		Tread Depth		Damage	Restricted	Deflated
	kPa	psi	kPa	psi	milli-meters	32 nd of an inch			
LF	303	44	179	26	7	9	None	No	No
RF	296	43	179	26	7	9	None	No	No
LR	283	41	179	26	7	9	None	No	No
RR	296	43	179	26	7	9	None	No	No

Interior Damage: Inspection of the case vehicle's interior revealed loading to the steering column and approximately 1 centimeter (0.4 inches) of deformation to the top half of the steering wheel rim. Furthermore, the column was driven forward, approximately 5 centimeters (2.0 inches), into the left instrument panel (**Figure 8**). The windshield-mounted rearview mirror was cracked and broken off the windshield, and there were stress fractures to the right windshield's glazing from the collision (**Figure 9**). There was no other evidence of occupant contact on the interior surfaces of the case vehicle (**Figure 10** and **Figure 11** below). Finally, there was no evidence of intrusion to the case vehicle's interior, and it could not be determined if there was compression to the energy absorbing steering column device.



Figure 8: Case vehicle's slightly deformed steering wheel rim and loaded steering column; Note: steering column driven forward against left instrument panel (case photo #38)



Figure 9: Case vehicle's center and right instrument panel and greenhouse areas showing no obvious evidence of occupant contact and crack to right windshield's glazing (case photo #40)

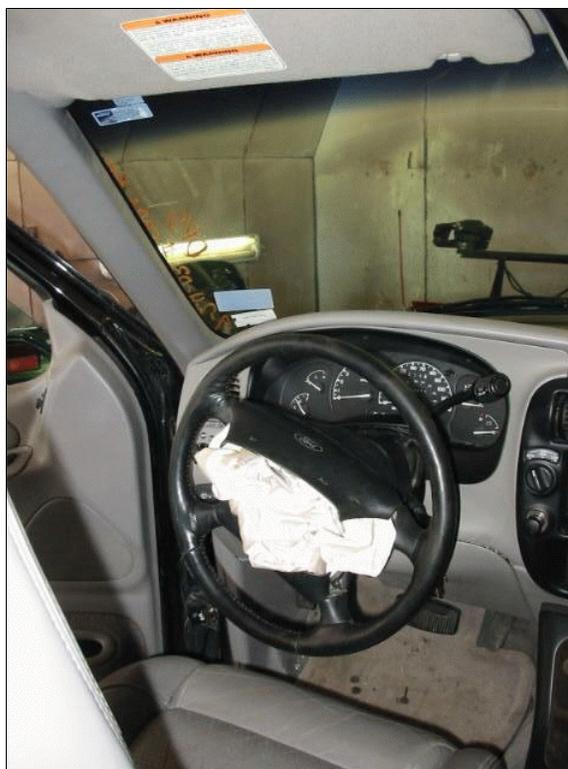


Figure 10: Case vehicle's driver seating area showing deployed driver air bag and no obvious contact evidence to greenhouse area or right side of driver's knee bolster (case photo #25)

Damage Classification: Based on the vehicle inspection, the CDC for the case vehicle was determined to be: **12-FREN-1 (0 degrees)**. The WinSMASH reconstruction program, barrier algorithm, was used on the case vehicle's highest severity impact. The preliminary Total,

Longitudinal, and Lateral Delta Vs are, respectively: 20.0 km.p.h. (12.4 m.p.h.), -20.0 km.p.h. (-12.4 m.p.h.), and 0.0 km.p.h. (0.0 m.p.h.). The case vehicle was towed due to damage.

AUTOMATIC RESTRAINT SYSTEM

The case vehicle was equipped with a Supplemental Restraint System (SRS) that contained frontal air bags at the driver and front right passenger positions. Both frontal air bags deployed as a result of the frontal impact with the wooden utility pole. The case vehicle's driver air bag was located in the steering wheel hub. The module cover consisted of asymmetrical "H"-configuration cover flaps made of a medium thickness vinyl with overall dimensions of 18.5 centimeters (7.3 inches) at the top horizontal seam, 17.5 centimeters (6.9 inches) at the bottom horizontal seam, 9 centimeters (3.5 inches) vertically for the upper flap and 6 centimeters (2.4 inches) vertically for the lower flap. An inspection of the air bag module's cover flaps and the air bag's fabric revealed that the cover flaps opened at the designated tear points. Furthermore, there were vertically oriented scuffs on the driver air bag module's top cover flap (Figure 12) which most likely occurred as a result of contacting the chest, neck, and/or chin of the case vehicle's driver. There was no evidence of damage to the air bag during the deployment. The driver's air bag was designed with two tethers, each approximately 14 centimeters (5.5 inches) in width. The driver's air bag had two vent ports, approximately 1.5 centimeters (0.6 inches) in diameter, located at the 11 and 1 o'clock positions. The deployed driver's air bag was round with a diameter of 61 centimeters (24.0 inches). The distance between the mid-center of the driver's seat back, as positioned at the time of the vehicle inspection, and the front surface of the air bag's fabric at full excursion was 19 centimeters (7.5 inches). An inspection of the driver's air bag fabric revealed no obvious contact



Figure 11: Case vehicle's driver seating area showing deployed frontal air bags, driver's toe pan area, and left instrument panel; Note: no obvious contact evidence present (case photo #26)



Figure 12: Vertically oriented scuffs on case vehicle driver air bag module's top cover flap (case photo #34)



Figure 13: Case vehicle's deployed driver air bag showing (i.e., yellow tape) blood spots near 3 o'clock position and between center and 9 o'clock position (case photo #27)

evidence on the air bag's fabric; although, there were a couple of very small blood spots on the front surface of the air bag (**Figure 13** above) and one spot on the back surface (**Figure 14**).

The front right passenger's air bag was located in the middle of the instrument panel. There was a single, essentially rectangular, modular cover flap. The cover flap was made of a medium thickness vinyl but thicker than the vinyl on the driver's module. The flap's dimensions were 37 centimeters (14.6 inches) at the lower horizontal seam and 17.5 centimeters (6.9 inches) along both vertical seams. The profile of the case vehicle's instrument panel was flush with the leading edge of the cover flap. An inspection of the front right air bag module's cover flap and the air bag's fabric revealed that the cover flap opened at the designated tear points, and there was no evidence of damage during the deployment to the air bag or the cover flap. The front right passenger's air bag was designed without any tethers. The front right air bag had two vent ports, approximately 5 centimeters (2.0 inches) in diameter, located at the 9:30 and 2:30 clock positions. The deployed front right air bag was rectangular with a height of approximately 62 centimeters (24.4 inches) and a width of approximately 85 centimeters (33.5 inches). An inspection of the front right passenger's air bag fabric revealed two small blood stains on the front surface of the front right air bag's fabric, just to the right of the bag's center (**Figure 15**).



Figure 14: Blood spot on back surface of case vehicle's deployed driver air bag (case photo #31)



Figure 15: Front surface of case vehicle's deployed front right passenger air bag showing blood spots near bag's center (case photo #44)

CASE VEHICLE DRIVER KINEMATICS

The exact posture of the case vehicle's driver [35-year-old, Asian or Pacific Islander female; 165 centimeters and 54 kilograms (65 inches, 120 pounds)] immediately prior to the crash is unknown but, based on witness observations, she was presumably seated with her back against the seat back her left foot was on the floor, her right foot on the brake (i.e., tire squealing was heard), and at least one of her hands on the steering wheel. Her seat track was located between its middle and rearmost positions, and it should be noted that the front edge of the driver's seat was 58 centimeters (22.8 inches) forward of the left "B"-pillar. As a result the amount of space measured between the fully extended air bag and the center of the front seat back (bag excursion) was only 19 centimeters (7.5 inches). The seat back was in an upright position, but the exact position of the tilt steering column could not be determined because of the loading that occurred to the column.

The case vehicle's driver was not using her available, active, three-point, lap-and-shoulder, safety belt system. Furthermore, there was no medical evidence of belt pattern bruising and/or abrasions to the driver's torso, and the inspection of the driver's seat belt webbing, "D"-ring, and latch plate showed no evidence of loading. Furthermore, the witnesses (i.e., first on scene) and the investigating officer found the driver without her safety belt engaged.

Based on the available evidence, the case vehicle's driver braked, attempting to avoid the crash. As a result of this attempted avoidance maneuver and the nonuse of her available safety belts, she most likely moved forward just prior to impact. The case vehicle's impact with the utility pole enabled the case vehicle's driver to continue forward along a path opposite the case vehicle's 0 degree Direction of Principal Force as the case vehicle decelerated. The driver air bag module's top cover flap impacted the driver's chest and/or neck, resulting in a transverse cut under her chin. As the air bag continued to expand, the air bag's fabric contacted the driver in her chest. According to the responding police officer, the deploying air bag and/or cover flap produced two vertical tears to the driver's clothing, exposing both of her breasts. The interaction between the driver and the air bag module also produced loading on the steering column that caused the steering wheel to be moved forward. The driver was redirected backwards as a result of the air bag's expansion and the vehicle's backward rebound from the utility pole. According to the witnesses on the scene and the responding police officer, at final rest the driver was located behind the steering wheel, leaning back in her seat. She was unconscious and not able to exit the case vehicle.

CASE VEHICLE DRIVER INJURIES

The driver was transported first by ambulance to the hospital, and then by helicopter to an urban trauma center. According to her medical records, she sustained critical injuries, was hospitalized, and pronounced dead two days post-crash. According to her medical records, the brain injuries sustained by the case vehicle's driver included: a critical nonanatomic brain injury, small left subdural hematoma, severe brain swelling, diffuse left subarachnoid hemorrhage, and a developing pneumocephalus. Furthermore, the driver's torso sustained bilateral lung contusions with pneumothoraces, an injury to her right adrenal gland, a liver contusion, and a retroperitoneal hematoma. In addition, she sustained a 7 centimeter (2.8 inch) laceration under her chin and contusions to her neck, chest, shoulder tops, and to her right thigh. This occupant's primary brain and chest injuries were most likely caused by her contact with the case vehicle's driver air bag and her loading of the steering wheel and column, respectively.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
1	Nonanatomic brain injury with loss of consciousness; pupils initially unequal, then fixed and dilated; eventually no response to painful stimuli, GCS = 3; gag, corneal, cough, and cold caloric reflexes were negative; failed two apnea tests and declared brain dead	critical 160824.5,0	Air bag, driver's	Probable	Hospitalization records
2	Hematoma, subdural, small, left frontoparietal with midline shift out of proportion to size of hematoma	severe 140652.4,2	Air bag, driver's	Probable	Hospitalization records
3	Brain swelling/edema cerebrum, severe, with effaced brainstem cisterns and attempted herniation through left craniectomy	critical 140666.5,2 ¹	Air bag, driver's	Probable	Hospitalization records
4	Hemorrhage, subarachnoid, diffuse; observe during craniectomy following subdural evacuation	serious 140684.3,2	Air bag, driver's	Probable	Hospitalization records
5	Pneumocephalus, developing, not further specified	serious 140682.3,9	Air bag, driver's	Probable	Hospitalization records
6	Contusions lungs, bilaterally with bilateral pneumothoraces	severe 441410.4,3	Steering wheel hub and/or spokes and rim	Probable	Hospitalization records
7	Injury {hemorrhage} right adrenal gland, not further specified	minor 540299.1,1	Steering wheel hub and/or spokes and rim	Probable	Hospitalization records
8	Contusion {hematoma} liver, subcapsular, anterolateral	moderate 541812.2,1	Steering wheel hub and/or spokes and rim	Probable	Hospitalization records
9	Hematoma, retroperitoneum, on right, not further specified	serious 543800.3,8	Steering wheel hub and/or spokes and rim	Probable	Hospitalization records
10	Laceration, linear, 7 cm (2.8 in), to chin in submandibular position	minor 290602.1,8	Driver module's cover flap	Certain	Emergency room records

¹ The brain swelling/edema is known to have occurred in the left cerebrum; it is not known whether there was swelling/edema in the right cerebrum.

Case Vehicle Driver Injuries (Continued)

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Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
11	Contusion {bruises} to neck, not further specified	minor 390402.1,9	Driver module's cover flap	Probable	Emergency room records
12	Contusion {bruises} to chest, not further specified	minor 490402.1,9	Steering wheel hub and/or spokes and rim	Probable	Emergency room records
13	Contusions {bruising} top of shoulders, bilaterally	minor 790402.1,3	Air bag, driver's	Probable	Emergency room records
14	Contusion right thigh, not further specified	minor 890402.1,1	Steering wheel rim	Probable	Emergency room records

