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# ON-SITE AIR BAG INVESTIGATION

CASE NUMBER - IN98-021
LOCATION - TEXAS
VEHICLE - 1991 FORD TAURUS GL
CRASH DATE - August, 1997

Submitted:

December 4, 2002

Contract Number: DTNH22-94-D-17058

Prepared for:

U.S. Department of Transportation
National Highway Traffic Safety Administration
National Center for Statistics and Analysis
Washington, D.C. 20590-0003

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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.

**Technical Report Documentation Page**

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| 16. *Abstract*<br>This report covers an on-site investigation of an air bag deployment crash that involved a 1991 Ford Taurus GL (case vehicle) and a concrete culvert. This crash is of special interest because the case vehicle's driver (18-year-old female) sustained critical brain injuries from her deploying driver air bag, resulting in her death. The case vehicle was traveling south in the southbound lane of a two-lane, undivided, city roadway. After missing the city street she intended to turn onto, the distracted driver attempted to turn right at the next street but steered toward the southwest corner of the three-leg intersection. The crash occurred just past (i.e., south of) the Tee intersection when the case vehicle departed the road and impacted a concrete culvert. The front bumper and front undercarriage of the case vehicle impacted the concrete culvert, causing the case vehicle's driver supplemental restraint (air bag) to deploy. The case vehicle came to rest at impact against the culvert. The case vehicle's driver was seated with her seat track located between its middle and forward-most positions or closer, and the tilt steering wheel was located between its middle and down-most positions. She was restrained by her available, active, three-point, lap-and-shoulder, safety belt system and sustained, according to her medical records, critical brain injuries which included: a diffuse axonal injury, a nonanatomic brain injury, a brain stem contusion, a subdural hemorrhage, subarachnoid hemorrhage, and bilateral atlanto-axial dislocations. In addition, she sustained a hemothorax, a subgaleal hematoma in the left parietal-occipital region, a periorbital contusion, tongue contusion, a lower lip laceration, face and neck abrasions, and abrasions and contusions to her chest. The front right passenger (i.e., mother; 30-year-old female) was seated with her seat track located in its forward-most position and was restrained by her available, active, three-point, lap-and-shoulder, safety belt system. She sustained minor injuries but the specific injuries she sustained are unknown. | | | |
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## BACKGROUND

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This on-site investigation was brought to NHTSA's attention on September 21, 1998 by an attorney representing the family of the deceased driver in this crash. This crash involved a 1991 Ford Taurus GL (case vehicle), and a concrete culvert. The crash occurred in August, 1997, at 2:15 p.m., in Texas and was investigated by the applicable city police department. This crash is of special interest because the case vehicle's driver [18-year-old, White (Hispanic) female] sustained critical brain injuries from her deploying driver air bag, resulting in her death. This contractor inspected the scene and case vehicle on 1-2 October, 1998. This contractor was unable to interview the front right passenger. This report is based on the Police Crash Report, scene and vehicle inspections, occupant kinematic principles, occupant medical records, and this contractor's evaluation of the evidence.

## SUMMARY

The case vehicle was traveling south in the southbound lane of a two-lane, undivided, city roadway on the cap of a Tee intersection and intended to turn right at the intersecting street (i.e., stem of Tee intersection). The case vehicle's driver was apparently distracted and overshot the city street she intended to turn onto. The case vehicle's driver steered toward the right, and as a result, the case vehicle headed toward the west edge of the southbound roadway. The case vehicle's driver presumably braked, attempting to avoid departing the road. The crash occurred just past (i.e., south of) the Tee intersection when the case vehicle departed the road and impacted a concrete culvert. The case vehicle came to rest against the concrete culvert heading in a southwesterly direction; see **CRASH DIAGRAM** below. It should be noted that the case vehicle's driver was in the process of learning to drive at the time of the crash.

The front bumper and front undercarriage of the case vehicle impacted the concrete culvert, causing the case vehicle's driver supplemental restraint (air bag) to deploy. The case vehicle came to rest at impact.

The case vehicle was a front wheel drive 1991 Ford Taurus, four-door station wagon (VIN: 1FACP57U8MA------). The case vehicle was not equipped with anti-lock brakes. Based on the vehicle inspection, the CDC for the case vehicle was determined to be: **12-FDLW-1 (0)**. The WinSMASH reconstruction program, barrier algorithm, was used on the case vehicle's highest severity impact. The Total, Longitudinal, and Lateral Delta Vs are, respectively: 18.8 km.p.h. (11.7 m.p.h.), -18.8 km.p.h. (-11.7 m.p.h.), and 0 km.p.h. (0 m.p.h.). According to the attorney representing the family of the deceased driver, the vehicle was originally towed from the scene and then driven from the tow yard to their residence prior to being towed to the holding facility.

The case vehicle's contact with the culvert involved the front end. Direct damage began at the front right bumper corner and extended laterally cross the entire front end and vertically involved the bumper and undercarriage only. Residual maximum crush was 19 centimeters (7.5 inches) between $C_2$ and $C_3$. The case vehicle's wheelbase was unaltered from the crash. The vehicle's impact with the concrete culvert crushed the bumper and bumper fascia rearward and downward. The downward movement was minimal compared to the rearward deformation. The left frame rail was deformed upwards 7.6 centimeters (3 inches). None of the case vehicle's tires

were damaged, deflated, or physically restricted. Both the right and left fenders sustained induced damage as well.

The case vehicle's driver air bag was located in the steering wheel hub. An inspection of the air bag module's cover flaps and air bag revealed that the cover flaps opened at the designated tear points, and there was no evidence of damage during the deployment to the air bag or the cover flaps. The driver's air bag was designed with two tethers, each 2 centimeters (0.8 inches) in width. The driver's air bag had two vent ports, approximately 2 centimeters (0.8 inches) in diameter, located at the 9 and 3 o'clock positions. The deployed driver's air bag was round with a diameter of 65 centimeters (25.6 inches). An inspection of the driver's air bag fabric revealed evidence of skin and blood readily apparent on the driver's air bag. The case vehicle was not equipped with a front right passenger air bag.

Immediately prior to the crash the case vehicle's driver [157 centimeters and 56 kilograms (62 inches, 123 pounds)] was seated upright with her back against the seat back, her left foot on the floor, her right foot on the brake, and both hands on the steering wheel. The exact location of the driver's seat track is unknown, but based on her short stature, her seat track was located between the middle and forward-most positions or closer. The seat back was upright, and the tilt steering wheel was located between its middle and down-most positions.

The case vehicle's driver was restrained by her available, active, three-point, lap-and-shoulder, safety belt system. In addition, there was mention of belt pattern bruising and/or abrasions to the driver's chest on the autopsy. The inspection of the driver's seat belt webbing, "D"-ring, and latch plate showed evidence of loading (i.e., heat abrasion to latch plate, dried blood on webbing, and plastic transfer to webbing from "D"-ring).

Presumably, the case vehicle's driver braked, attempting to avoid the crash. As a result of this attempted avoidance maneuver and the use of her available safety belts, she most likely moved forward and slightly to her left just prior to impact. The case vehicle's impact with the concrete culvert enabled the case vehicle's driver to continue forward and upward toward the **0** degree Direction of Principal Force and into the deploying air bag. The air bag contacted the driver on the chin and left side of her face lifting her upwards and to the left. The driver rebounded back down and to the right into her seat coming to rest in her seat slumped forward.

The driver was transported by ambulance to the hospital. She sustained critical brain injuries and was pronounced dead 41 minutes post-crash (i.e., 6 minutes after arriving at the hospital's emergency department). Based on the autopsy, the brain and spinal cord injuries sustained by the case vehicle's driver included: a diffuse axonal injury, a nonanatomic brain injury, a brain stem contusion, a subdural hemorrhage, subarachnoid hemorrhage, and bilateral atlanto-axial dislocations. In addition, she sustained a hemothorax, a subgaleal hematoma in the left parietal-occipital region, a periorbital contusion, tongue contusion, a lower lip laceration, face and neck abrasions, and abrasions and contusions to her chest.

Presumably, the case vehicle's front right passenger [30-year-old, White (Hispanic) female; of unknown height and weight] was seated upright with her back against the seat back, both feet

on the floor, and both her right hands on her lap. Her seat track was located in its forward-most position, and the seat back was upright. The case vehicle's front right passenger was restrained by her available, active, three-point, lap-and-shoulder, safety belt system. The front right passenger was transported by ambulance to the hospital. She sustained minor injuries and was treated and released. The specific injuries sustained by the front right passenger are unknown.

## CRASH CIRCUMSTANCES

The case vehicle was traveling south in the southbound lane of a two-lane, undivided, city roadway on the cap of a Tee intersection and intended to turn right at the intersecting street (i.e., stem of Tee intersection). The case vehicle's driver was apparently distracted and overshot the city street she intended to turn onto. As a result the case vehicle's driver proceed further south to turn on the following street (**Figure 1**). The case vehicle's driver steered toward the right, and for unknown reasons failed to complete the right turn. The case vehicle headed toward the west edge of the southbound roadway. The case vehicle's driver presumably braked, attempting to avoid departing the road. The crash occurred just past (i.e., south of) the Tee intersection when the case vehicle departed the road and impacted a concrete culvert (**Figure 2**). The case vehicle came to rest against the concrete culvert heading in a southwesterly direction; see **CRASH DIAGRAM** below. It should be noted that the case vehicle's driver was in the process of learning to drive at the time of the crash.

**Figure 1:** Case vehicle's southward travel path in southbound lane; Note: arrow indicates location of impact with culvert (case photo #01)


**Figure 2:** South-southwest view from southbound lane showing case vehicle's path of travel to impact with culvert on southwest corner of "Tee" intersection; Note: front right tire track in mud (case photo #03)

The roadway was bituminous, straight, and level at the point the case vehicle departed the roadway. There were no lane or edge line markings on the roadway. The west side of the roadway was bordered by a 1.4 meter (4.6 feet) wide gravel and grass shoulder parallel to the culvert. The east side was bordered by a 15 centimeter (6 inches) mountable curb. There was a posted DEAD END sign and a NO PARKING sign just south of the point of impact on the west edge of the roadway. There was also a SCHOOL SPEED LIMIT 20 m.p.h. sign a few meters (6.6 feet) south of the other previously mentioned signs on the west edge of the roadway (**Figure 2** above). The speed limit is 48 km.p.h. (30 m.p.h.). Based on photographs taken days following the crash and photographs taken during this contractor's on-scene investigation, the roadway had

a few areas within the junction of the Tee-intersection that had been resurfaced. The drainage ditch was 1.3 meters (4.3 feet) wide and 51 centimeters (20 inches) deep. The concrete culvert was approximately 15 centimeters (6 inches) wide and appears to have been cracked and separated from the impact by the case vehicle's front end and undercarriage. It also appears that it has been partially repaired prior to this contractor's scene inspection. At the time of the crash the light condition was daylight, the atmospheric condition was clear/cloudy, and the road pavement was dry. Traffic density is unknown, and the site of the crash was urban and a combination of residential on the west side of the roadway and manufacturing plants on the east side.

**Figure 3:** Case vehicle's frontal damage at bumper level and below with contour gauge present; Note: front edge of bumper has been rotated downward and the right side of bumper has been pushed down relative to the left side (case photo #07)

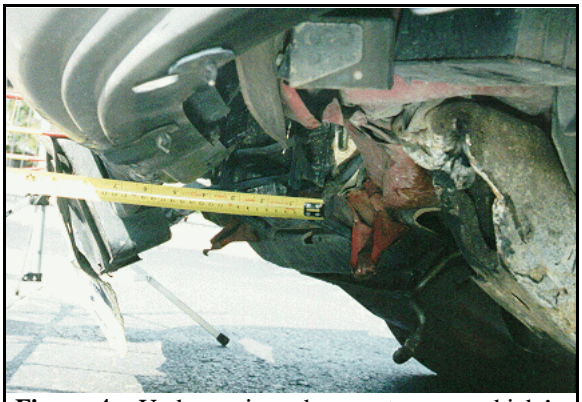

**Figure 4:** Undercarriage damage to case vehicle's front supports viewed from left side (case photo #10)

The front bumper (**Figure 3**) and front undercarriage (**Figure 4**) of the case vehicle impacted the concrete culvert, causing the case vehicle's driver supplemental restraint (air bag) to deploy. The case vehicle came to rest at impact.

## CASE VEHICLE

The 1991 Ford Taurus GL was a front wheel drive, eight-passenger, four-door station wagon (VIN: 1FACP57U8MA------) equipped with a 3.0L, V-6 engine and a four-speed automatic transmission. Braking was achieved by a power-assisted, front disc and rear drum system. The case vehicle was not equipped with anti-lock brakes. The case vehicle's wheelbase was 269 centimeters (106 inches), and the odometer reading at inspection was 119,627 kilometers (74,335 miles).

The interior of the case vehicle was equipped with a 60/40 split bench with separate backs and adjustable head restraints, the back seat was a 60/40 split folding bench seat without head restraints for the back outboard seating positions, three-point lap-and-shoulder belts in the four outboard seating positions, and a lap belt only in the front and back center seat positions. The driver and front right passenger seat backs had a center arm rest that when folded up formed the seat back for a front center passenger. In addition, there was a fold away, two passenger bench seat in the rear cargo area. The vehicle was equipped with a knee bolster for the driver only. The driver's knee bolster was scuffed. The front belt systems were not equipped with manually operated height adjusters for the "D"-rings. Automatic restraint was provided by a Supplemental Restraint System (SRS) that consisted of a frontal air bag for only the driver seat position.

**Figure 5:** Damage to case vehicle's front bumper and undercarriage from culvert impact viewed from right of front (case photo #13)

**Figure 6:** Close-up of damage to case vehicle's front right bumper and undercarriage area from impact with culvert (case photo #14)

**Figure 7:** Case vehicle's steering wheel rim viewed from left showing slight deformation to rim (case photo #22)

The case vehicle's contact with the culvert involved the front end. Direct damage began at the front right bumper corner and extended laterally cross the entire front end, a distance of 147 centimeters (57.9 inches), and vertically involved the bumper and undercarriage only (**Figure 3** above and **Figure 5**). Residual maximum crush was 19 centimeters (7.5 inches) between $C_2$ and $C_3$. The case vehicle's wheelbase was unaltered from the crash. The vehicle's impact with the concrete culvert crushed the bumper and bumper fascia rearward and downward (**Figure 6**). The downward movement was minimal compared to the rearward deformation. The left frame rail was deformed upwards 7.6 centimeters (3 inches–**Figure 4** above). None of the case vehicle's tires were damaged, deflated, or physically restricted. Both the right and left fenders sustained induced damage as well.

An examination of the case vehicle's interior revealed very little contact evidence. The attorney would not allow the contractor to take apart the driver's knee bolster; therefore, movement of the energy absorbing steering column could not be assessed. There was a rectangular piece of plastic that appeared to be broken off immediately below the steering column but still not enough room for an assessment. The upper half of the steering wheel rim was bent toward the left instrument panel, 1.5 centimeters (0.6 inches), as a result of the driver loading the air bag, momentarily blocking the air bag's forward expansion, and causing the air bag to expand against and bend the steering wheel rim (**Figure 7**). There were

blood smears to the driver's seat belt webbing (**Figure 8**), air bag, as well as to the door sill on the front right passenger side. The toe pan in driver and front right passenger foot wells showed no evidence of intrusion.

**Figure 8:** Case vehicle driver's seat belt webbing showing blood evidence and plastic transfer on webbing from "D"-ring (case photo #28)

Based on the vehicle inspection, the CDC for the case vehicle was determined to be: **12-FDLW-1 (0)**. The WinSMASH reconstruction program, barrier algorithm, was used on the case vehicle's highest severity impact. The Total, Longitudinal, and Lateral Delta Vs are, respectively: 18.8 km.p.h. (11.7 m.p.h.), -18.8 km.p.h. (-11.7 m.p.h.), and 0 km.p.h. (0 m.p.h.). According to the attorney representing the family of the deceased driver, the vehicle was originally towed from the scene and then driven from the tow yard to their residence prior to being towed to the holding facility.

## AUTOMATIC RESTRAINT SYSTEM

The case vehicle was equipped with a Supplemental Restraint System (SRS) that contained frontal air bags at only the driver position. The driver air bag deployed as a result of the frontal impact with the concrete culvert. 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 thick vinyl with overall dimensions of 20.5 centimeters (8.1 inches) at the horizontal seam and 14 centimeters (5.5 inches) vertically for the upper flap and 4 centimeters (1.6 inches) vertically for the lower flap. An inspection of the air bag module's cover flaps and air bag revealed that the cover flaps opened at the designated tear points revealed that the cover flaps opened at the designated tear points, and there was no evidence of damage during the deployment to the air bag or the cover flaps. The driver's air bag was designed with two tethers, each 2 centimeters (0.8 inches) in width. The driver's air bag had two vent ports, approximately 2 centimeters (0.8 inches) in diameter, located at the 9 and 3 o'clock positions. The deployed driver's air bag was round with a diameter of 65 centimeters (25.6 inches). An inspection of the driver's air bag fabric revealed what appeared to be two areas of skin and oil transfers to the left and right sides of the air bag in the 9-3 o'clock area (**Figure 9** below). The one contact mark extended inwards from the right outside edge 12 centimeters (4.7 inches) and was approximately 6 x 7 centimeters (2.4 x 2.8 inches) in area and was located approximately 34 centimeters (13.4 inches) from the top edge. The other mark started 10 centimeters (3.9 inches) in from the left edge and was 6 x 10 centimeters (2.4 x 3.9 inches) in area and was located approximately 33 centimeters (13.0 inches) from the top edge (**Figure 10** below). Furthermore, there was a blood spot in the upper right quadrant of the air bag, 9 centimeters (3.5 inches) down from the top edge

and was 19 centimeters (7.5 inches) in from right side. There was another small spot of blood in the stitched center of the air bag. In addition, there was a final small area of blood on the back of the air bag near the 12 o'clock position. Finally, there burgundy colored transfers to the front and rear panels of the air bag.

**Figure 9:** Vertical view of case vehicle's driver seating area showing deployed air bag and green-house area; Note: tape indicates skin transfers (case photo #21)

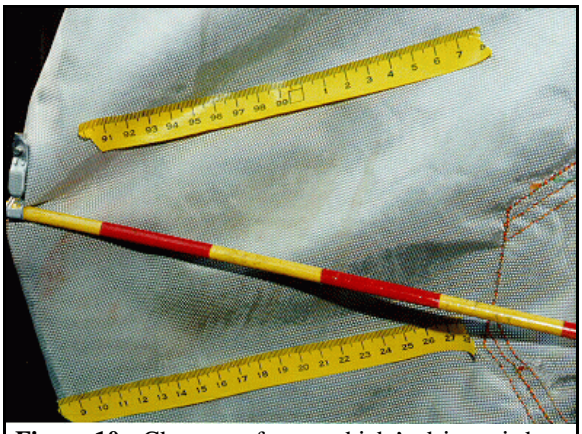

**Figure 10:** Close-up of case vehicle's driver air bag showing skin transfer on left side (case photo #24)

## CASE VEHICLE DRIVER KINEMATICS

Immediately prior to the crash the case vehicle's driver was seated upright with her back against the seat back, her left foot on the floor, her right foot on the brake, and both hands on the steering wheel. The exact location of the driver's seat track is unknown, but based on her short stature, her seat track was located between the middle and forward-most positions or closer. The seat back was upright, and the tilt steering wheel was located between its middle and down-most positions.

The case vehicle's driver [18-year-old, White (Hispanic) female; 157 centimeters and 56 kilograms (62 inches, 123 pounds)] was restrained by her available, active, three-point, lap-and-shoulder, safety belt system. In addition, there was mention of belt pattern bruising and/or abrasions to the driver's chest on the autopsy. The inspection of the driver's seat belt webbing, "D"-ring, and latch plate showed evidence of loading (i.e., heat abrasion to latch plate, dried blood on webbing, and plastic transfer to webbing from "D"-ring–**Figure 8** above).

Presumably, the case vehicle's driver braked, attempting to avoid the crash. As a result of this attempted avoidance maneuver and the use of her available safety belts, she most likely moved forward and slightly to her left just prior to impact. The case vehicle's driver may have braced her arms against the steering wheel just prior to impact. Because of the driver's short stature [i.e., 157 centimeters (62 inches)] she was presumably sitting up close to the steering wheel, unavoidably close to the air bag module. The case vehicle's impact with the concrete culvert enabled the case vehicle's driver to continue forward and upward toward the **0** degree Direction of Principal Force and into the deploying air

bag. The air bag contacted the driver on the chin and left side of her face (**Figures 9** and **10** above) lifting her upwards and to the left. The driver's inertia sensitive seat belt system locked up preventing the driver from contacting the left roof, the left roof side rail, the left "A"-pillar, and/or the windshield's glazing. Although no direct contact evidence was found, based on occupant kinematics principles and injury information, the driver most likely contacted the left front window frame. The driver rebounded back down and to the right into her seat, coming to rest in her seat slumped forward still restrained by her seat belt.

## CASE VEHICLE DRIVER INJURIES

The driver was transported by ambulance to the hospital. She sustained critical brain injuries and was pronounced dead 41 minutes post-crash (i.e., 6 minutes after arriving at the hospital's emergency department). Based on the autopsy, the brain and spinal cord injuries sustained by the case vehicle's driver included: a diffuse axonal injury, a nonanatomic brain injury, a brain stem contusion, a subdural hemorrhage, subarachnoid hemorrhage, and bilateral atlanto-axial dislocations. In addition, she sustained a hemothorax, a subgaleal hematoma in the left parietal-occipital region, a periorbital contusion, tongue contusion, a lower lip laceration, face and neck abrasions, and abrasions and contusions to her chest.

| Injury Number | Injury Description (including Aspect) | NASS Injury Code & AIS 90 | Injury Source (Mechanism) | Source Confidence | Source of Injury Data |
|---|---|---|---|---|---|
| 1 | Diffuse axonal injury[1] (white matter shearing) | 140628.5 critical | Air bag, driver's | Certain | Autopsy |
| 2 | Nonanatomic brain injury–unconscious, unresponsive[2], pupils fixed and dilated, GCS=3 | 160824.5 critical | Air bag, driver's | Certain | Emergency room records |
| 3 | Contusion, 5 ml in diameter, in medulla oblongata and hemorrhage to midbrain, pons, and medulla | 142004.5 critical | Air bag, driver's | Certain | Autopsy |
| 4 | Hemorrhage, subdural[3]–approximately 15 ml | 140652.4 severe | Air bag, driver's | Probable | Autopsy |
| 5 | Hemorrhage, subarachnoid, diffuse [i.e., location(s) not specified] | 140684.3 serious | Air bag, driver's | Probable | Autopsy |

[1] The autopsy noted small/minute (i.e., petechial) hemorrhages in the parenchymal white matter and in the cerebral hemispheres. Small focal hemorrhages were also noted in the midbrain, pons, and medulla oblongata. Since the exact location of the diffuse axonal injury was not specified, this lesion was coded to the cerebrum; however, it may have involved the brain stem as well. The section below entitled: **CRANIOCEREBRAL IMPACT INJURIES**, discusses acceleration/deceleration injuries and compares subdural hematoma and diffuse axonal injury.

[2] This occupant was declared dead six minutes after arrival in the emergency department.

[3] The exact location of the subdural hemorrhage was not specified.

| Injury Number | Injury Description (including Aspect) | NASS Injury Code & AIS 90 | Injury Source (Mechanism) | Source Confidence | Source of Injury Data |
|---|---|---|---|---|---|
| 6 | Dislocation, atlantoaxial, bilaterally | 650206.3 serious | Air bag, driver's | Certain | Autopsy |
| 7 | Hemothorax[4], approximately 75 ml, bilaterally | 442202.3 serious | Air bag, driver's | Probable | Autopsy |
| 8 | Contusion, 1 cm (0.4 in), right anterior tongue[5] consistent with biting trauma | 243099.1 minor | Air bag, driver's | Certain | Autopsy |
| 9 | Hematoma, subgaleal, 11.4 x 2.5 cm (4.5 x 1.0 in) over left parietal occipital region | 190402.1 minor | Left side window frame | Probable | Autopsy |
| 10 | Contusion {ecchymosis} periorbital, aspect not specified | 297402.1 minor | Air bag, driver's | Certain | Emergency room records |
| 11 | Laceration, 2.5 cm (1.0 in), lower right lip[5]–full thickness | 290602.1 minor | Air bag, driver's | Certain | Autopsy |
| 12 | Abrasion, rectangular, 15.2 x 4.4 cm (6.0 x 1.75) in) from right chin to left lateral cheek | 290202.1minor | Air bag, driver's | Certain | Autopsy |
| 13 | Abrasion, 5.1 x 1.3 cm (2.0 x 0.5 in), left lateral neck | 390202.1 minor | Air bag, driver's | Probable | Autopsy |
| 14 | Abrasion, 2.5 x 0.6 cm (1.0 x 0.25 in), left upper chest approximately over sternoclavicular angle | 490202.1 minor | Torso portion of safety belt system | Certain | Autopsy |
| 15 | Contusion, 3.8 x 1.9 cm (1.5 x 0.75 in), middle chest just below nipple line | 490402.1 minor | Torso portion of safety belt system | Certain | Autopsy |

[4] The exact description was 75 milliliters of serosanguineous fluid in each pleural cavity. In addition, the peritoneal cavity contained 350 milliliters of ascitic fluid.
The following terms are defined in DORLAND'S ILLUSTRATED MEDICAL DICTIONARY as follows:
***ascites (a-si′tez)***: effusion and accumulation of serous fluid in the abdominal cavity; called also *abdominal* or *peritoneal dropsy*, *hydroperitonia*, and *hydrops abdominis*.
***ascitic (a-sit′ik)***: pertaining to or characterized by ascites.
***serosanguineous (ser"o-sang-gwin′e-as)***: pertaining to or containing both serum and blood.
***serum (ser′em)***: 1. the clear portion of any body fluid; the clear fluid moistening serous membranes. 2. blood serum; the clear liquid that separates from blood on clotting.

[5] This passenger's head was turned slightly to her right at the moment of deployment. The deploying air bag abraded this occupant's face from her left cheek to her right chin, causing her to bite and contuse the anterior right side of her tongue and lacerate her right lower lip.

Presumably, the case vehicle's front right passenger [30-year-old, White (Hispanic) female; of unknown height and weight] was seated upright with her back against the seat back, both feet on the floor, and both her right hands on her lap. Alternatively, her back may have been leaning forward with her arms outstretched in front against the right instrument panel, bracing for the crash. Her seat track was located in its forward-most position, and the seat back was upright.

The case vehicle's front right passenger was restrained by her available, active, three-point, lap-and-shoulder, safety belt system. Furthermore, the inspection of the front right passenger's seat belt webbing, "D"-ring, and latch plate showed evidence of loading during this crash.

The case vehicle's driver braked, attempting to avoid the crash. As a result of this attempted avoidance maneuver and the use of her available safety belts, the front right passenger most likely moved forward and slightly to her left just prior to impact. The case vehicle's impact with the concrete culvert enabled the front right passenger to continue forward and upward toward the **0** degree Direction of Principal Force and into contact with the right instrument panel. Her forward movement was restricted because her seat belt system locked up, preventing her from completely loading the instrument panel and contacting windshield's glazing. The front right passenger rebounded backwards and to the right into her seat. At final rest the right front passenger remained in her seated and conscious. The passenger removed her seat belt and tried to help the driver, but the case vehicle's driver did not respond. She then went for help.

## CASE VEHICLE FRONT RIGHT PASSENGER INJURIES

The front right passenger was transported by ambulance to the hospital. She sustained minor injuries and was treated and released. The specific injuries sustained by the front right passenger are unknown.

The following material is taken from the book: FORENSIC PATHOLOGY, 2ND EDITION by Vincent J. DiMaio, M.D., and Dominick J. DiMaio, M.D., CRC Press, Boca Raton, Florida, 2001; Chapter Six: Trauma to the Skull and Brain: Craniocerebral Injuries, ***Impact Injuries***, pages 147, 166-168, and 169-172.

**Acceleration or deceleration** injuries are due to sudden movement of the head the instant after injury, with resultant production of intracranial pressure gradients and the subjecting of the brain to both shearing and tensile forces. Two types of injuries are typically produced: (1) **Subdural hematomas** and (2) **Diffuse axonal injury**.

Subdural hematomas are secondary to tearing of the subdural bridging veins; diffuse axonal injury is secondary to injury to the axons. While acceleration or deceleration injuries are associated with impact, theoretically, impact is not necessary for the production of these injuries, just sudden angular rotation of the head. In situations encountered by forensic pathologists, however, acceleration or deceleration injuries of the brain involve impact.

***Subdural Hematomas***

The subdural hematoma is the most common lethal injury associated with head trauma. The high mortality associated with subdural hematomas is due in part to associated brain damage. Since a large number of the subdural hematomas are caused by falls, it is not uncommon to find contrecoup contusions in association with subdural hematomas. Unlike epidural hematomas, subdural hematomas are often not associated with a fracture of the skull and can occur in the absence of cerebral contusions or any other visible brain injury….

Subdural hematomas can be acute, subacute, or chronic. Acute subdural hematomas manifest themselves clinically within 72 hours of injury, subacute between 3 days and 2-3 weeks, and chronic more than 3 weeks after injury. Subdural hematomas are caused by the stretching and tearing of the parasagittal bridging veins that drain the surface of the cerebral hemispheres into the dural venous sinuses. These injuries occur after the head impacts a hard surface and the brain is accelerated. This rapid acceleration causes the tearing of the bridging veins. The more rapid the acceleration or deceleration, and the shorter the time of acceleration or deceleration, the more likely one will have a subdural hematoma rather than diffuse axonal injury. The reason that subdural hematomas are less common in motor vehicle accidents, in contrast to diffuse axonal injury, is that in a motor vehicle accident, the head typically strikes a yield or energy-absorbing surface, thus extending the time interval in which the acceleration or deceleration occurs. This reduces the probability of a subdural hematoma's occurring, because it requires a large acceleration or deceleration over a short time. It does, however, predispose the brain to diffuse axonal injury.

Part of the lethality associated with subdural hematomas is because of injury to the cerebral parenchyma by the same acceleration/deceleration force that produces the acute subdural hematoma. This acceleration or deceleration force may also induce brain injury of the diffuse axonal injury type. The severity of this injury would vary

from totally recoverable to such that, regardless of the subdural hematoma, death would occur.

There is no consistent relation between the presence or location of skull fractures and the presence of subdural hematomas. A fracture might be either on the same or contralateral side to the hematoma or may not even be present (which is more common in elderly individuals). Subdural hematomas may be on the same side or contralateral side as the point of impact or bilateral. Subdural hematomas can occur without apparent head injury or with very minor injury in the elderly and in individuals on anticoagulants or who have bleeding dyscrasias. Occasionally, a cerebral aneurysm or intracerebral hemorrhage will rupture into the subdural space, producing a subdural hematoma.

In subdural hematomas, the onset of symptoms is usually rapid. In elderly individuals, however, symptoms may develop over days. There may be a relapse of symptoms secondary to recurrent hemorrhage. In an adult, a rapidly developing (acute) subdural hematoma becomes life threatening when it reaches approximately 50 milliliters in size. With slow bleeding, a considerable larger subdural hematoma can be tolerated without symptoms or serious side effects. In infants, a smaller volume is life threatening. Renewed bleeding into an old subdural hematoma can occur. It can be either "spontaneous" or the result of new trauma to the head. It originates from the sinusoidal vessels in the outer neo-membrane formed during the organization of the initial hematoma. Rapid development of a subdural hematoma with mass displacement of the brain with or without generalized cerebral edema may result in compression of the brain stem and development of secondary (Duret's) hemorrhage. These may develop in as little as 30 minutes after trauma....

In subdural hematomas, the blood presses on both the crests and depths of the gyri so that the cerebral convolutions retain their normal contours. The hematoma, however, causes displacement of the cerebral hemisphere with flattening of the convolutions of the opposite hemisphere as they are pressed against the dura and bone. If rebleeding occurs within the sac formed by an organized subdural hematoma, the convolutions on the side of bleeding will become flattened as the fibrous membrane presses on the crests of the gyri.

If a person does not immediately die from a subdural hematoma, the hematoma will gradually become encapsulated by cells from the dura. The arachnoid does not participate in this encapsulation. Therefore, the capsule is attached to the dura and not the arachnoid. When formed, this sac of blood will press on the underlying gyri, flattening them, deforming the surface of the brain immediately underneath this sac. There is, however, no shifting of the hemisphere toward the other side, which is seen in the acute non-organized subdural hematoma....

***Diffuse Axonal Injury***

Immediate prolonged coma unaccompanied by an intracranial mass lesion occurs in almost half of patients with severe head injuries. The etiology of this coma and the cause of death in fatal cases is diffuse axonal injury (DAI). Diffuse axonal injury results from the effects of head motion on the brain. It is caused by sudden acceleration or

deceleration of the head. While, theoretically, impaction of the head against a hard object is not necessary, in reality, brain injury in humans requires contact, not just acceleration or deceleration. For all practical purposes, it is the impact that starts the acceleration or deceleration injury to the brain.

Diffuse axonal injury is a continuum, varying from mild brain injury and dysfunction to severe irreversible dysfunction and injury, and even death. The severity of injury is determined by the amount of acceleration or deceleration of the brain, the time span over which it occurs, and the direction of movement. Experiments have shown that only motion in the coronal[6] plane causes severe injuries. Sagittal[7] head movement produces diffuse axonal injury of mild, or at most, moderate type.

At low levels of acceleration or deceleration, there is no anatomical disruption of the axons, only physiological dysfunction. This may lead to either complete recovery of an axon or its degeneration. As the physical force increases, there will be a progressive increase in the extent of irreversible physiological injury to axons (thus making it more likely that they will subsequently undergo degeneration) plus an increase in the amount of immediate structural disruption of axons (transaction) with immediate cessation of all activities.

**Concussion** is defined by Kelly et al. as "a trauma-induced alteration in mental status that may or may not involve loss of consciousness." In **mild concussion**, there is confusion and disorientation, but no loss of consciousness. Retrograde amnesia may or may not develop. If it does, it develops 5 or 10 minutes after the trauma and, while it might subsequently decrease, there will always be some residue. In **cerebral concussion**, there is immediate loss of consciousness, which usually returns within minutes but can persist for hours (<6 hours) as confusion and retrograde, or posttraumatic, amnesia. What is clinically called concussion is thought to be a manifestation of diffuse brain injury, with no or insignificant irreparable physical injury to the brain....

The term **diffuse axonal injury** (DAI) is used clinically to characterize a condition of diffuse injury of the axons of the brain associated with immediate unconsciousness and coma longer than 6 hours of duration. In mild DAI, there is coma of 6-24 hours; in moderate DAI, coma of more than 24 hours without prominent clinical signs of brain stem dysfunction; and, in severe DAI, coma of more than 24 hours with brain stem signs. Severe DAI usually results in severe disability or death. Axonal injury of a greater or lesser degree is the pathological lesion common to all three forms of DAI.

With mild DAI, the injury is predominately physiological. Some axons, however, may show immediate physical disruption with cessation of functions. In other axons, the physiological disruption will eventually lead to degeneration. As the acceleration or deceleration force increases, the proportion in each category changes, until, with severe DAI, the predominant injury is shearing of axons and immediate cessation of functioning. In severe DAI, there is mechanical disruption of the axons in the white

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[6] Motion that is along the coronal plane [i.e., side-to-side (e.g., right-to-left, left-to-right)].

[7] Motion that is along the midsagittal (median) plane [i.e., anterior to posterior (front-to-back), posterior to anterior (back-to-front)].

matter of the cerebral hemispheres, the corpus callosum, and upper brain stem. Focal hemorrhages are usually grossly visible in the corpus callosum and dorsolateral quadrant of the rostral brain stem. Occasionally, laceration or even transection of the corpus callosum can occur. Gliding contusions of the gray matter of the cerebral hemispheres and hippocampi may be present.

The histologic hallmark of DAI is axonal swelling or "retraction balls" (see below). ... As time passes, the extent and degree of axonal injury increase.

In DAI, the axons first appear dilated, like sausage links; then club shaped, and finally (in 18-24 hours) as round balls know as "retraction balls." Retraction balls represent axons that are transected. They are seen in the cerebral white matter, corpus callosum, and upper brain stem....

In diffuse axonal injury, experiments have revealed that it is not only the magnitude of acceleration that produces the injury, but the time over which the acceleration occurs. Severe angular accelerations over a short period result in subdural hematomas; acceleration over a long period, diffuse axonal injury. This agrees with the observation that diffuse axonal injury is more common in vehicular accidents, where the time of impact may be prolonged due to absorbing materials, but rare in falls, where there is no absorption of impact....

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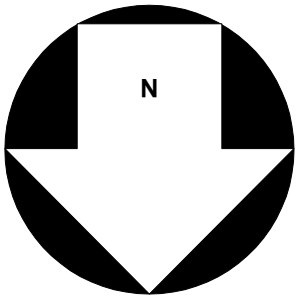


Scale: 1 cm = 2.5 m

Straight and Level;
Daylight, Clear, and Dry
Bituminous surface

CV = 1991 Ford Taurus GL,
four-door stationwagon