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## ON-SITE AIR BAG INVESTIGATION

CASE NUMBER - IN97-030

LOCATION - MISSISSIPPI

VEHICLE - 1997 DODGE NEON LE

CRASH DATE - September, 1997

Submitted:

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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. <i>Abstract</i> This report covers an on-site investigation of an air bag deployment crash that involved a 1997 Dodge Neon LE (case vehicle) and a wooden utility pole. This crash is of special interest because the case vehicle's front right passenger (4-year-old female), who was seated on her mother's lap, sustained critical brain injuries as a result of contacting the deploying front right passenger air bag, resulting in her death. The case vehicle was traveling west in the westbound lane on a two-lane, undivided, city street and was approaching an offset, four leg intersection. A noncontact vehicle had backed out of a private driveway on the north side of the street, heading westward and was just beginning to make a left-hand turn at the intersection. The case vehicle's driver steered to the left and successfully avoided the noncontact vehicle, but it subsequently veered off the southwest corner of the intersection and the crash occurred. The case vehicle's left front tire impacted a raised curb, causing the driver and front right passenger supplemental restraints (air bags) to deploy. Almost simultaneously the front bumper impacted a wooden utility pole. The case vehicle's "on-lap" front right passenger was seated on her mother's lap between her legs. The adult front right passenger (24-year-old female) was seated with her seat track located between its middle and rearmost positions. Neither front right occupant was using the available, active, three-point, lap-and-shoulder, safety belt system. Based on her available medical records, the injuries sustained by the case vehicle's "on-lap" front right passenger included: a critical nonanatomic brain injury, massive cerebral edema, posterior subarachnoid hemorrhage, a right tension pneumothorax, pneumomediastinum, a right occipital scalp laceration, a small anterior neck avulsion, and abrasions to the dorsal surface of her left wrist. The front right passenger indicated that she did not sustain any injuries as a result of this crash. The case vehicle's driver (20-year-old male) was seated with his seat track located between its middle and rearmost positions, and the vehicle was not equipped with a tilt steering wheel. He was not using his available, active, three-point, lap-and-shoulder, safety belt system and sustained, according to his interview, abrasions (rug burns) to his right forearm.					
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This on-site investigation was brought to NHTSA's attention on September 17, 1997 by a police officer with the applicable police department. This crash involved a 1997 Dodge Neon LE (case vehicle) that impacted a curb and wooden utility pole. The crash occurred in September, 1997, at 4:06 p.m., in Mississippi and was investigated by the applicable city police department. This crash is of special interest because the case vehicle's front right passenger [4-year-old, Black (non-Hispanic) female], who was seated on her mother's lap, sustained critical brain injuries as a result of contacting the deploying front right passenger air bag, resulting in her death. This contractor inspected the scene and the case vehicle on September 19, 1997. This contractor interviewed the front right passenger on September 19, 1997. This report is based on the Police Crash Report, an interview with the case vehicle's front right passenger, scene and vehicle inspections, occupant kinematic principles, occupant medical records, and this contractor's evaluation of the evidence.

## SUMMARY

The case vehicle was traveling west in the westbound lane on a two-lane, undivided, city street and was approaching an offset, four leg intersection, intending to continue traveling westbound. A noncontact vehicle had backed out of a private driveway on the north side of the street, entering into the same two-lane, undivided, roadway, heading essentially westward and was just beginning to make a left-hand turn at the intersection, intending to travel southward. The case vehicle's driver steered to the left and successfully avoided the noncontact vehicle, but it subsequently veered off the southwest corner of the intersection. The case vehicle's driver braked, depositing approximately 4 meters (13.1 feet) of front tire skid marks, attempting to avoid the crash. The crash occurred off the southwest corner of the intersection; see **CRASH DIAGRAM** below.

The case vehicle's left front tire impacted a raised curb [20 centimeters (7.9 inches)], damaging the rim and shortening the wheelbase on the driver's side 15 centimeters (5.9 inches) and causing the case vehicle's driver and front right passenger supplemental restraints (air bags) to deploy. Almost simultaneously the front bumper impacted a wooden utility pole. The case vehicle rotated approximately 20 degrees counterclockwise and moved slightly backward before coming to rest near the point of impact.

The case vehicle's front right passenger (i.e., mother of "on-lap" passenger) indicated that her daughter, the "on-lap" front right passenger [91 centimeters and 19 kilograms (36 inches, 42 pounds)], was not using the available, active, three-point, lap-and-shoulder, safety belt system and that she was holding her daughter on her lap. The child was facing forward. In addition, there was no evidence of belt pattern bruising and/or abrasions to the "on-lap" front right passenger's body, and the inspection of the right front seat belt webbing, "D"-ring, and latch plate showed no evidence of loading or blood transfers.

The case vehicle's driver had most likely steered leftward at least partially into the opposing lane of travel in order to pass the noncontact vehicle which had backed into the westbound lane. When the noncontact vehicle began to move forward and begin its left-hand turn, the case vehicle's driver swerved to the left and avoided the turning noncontact vehicle. However, when the driver noticed the impending impact with the curb and pole, he braked attempting to avoid the crash. As a result of these attempted

avoidance maneuvers and the nonuse of either a child safety seat or the available front right safety belts, the "on-lap" front right passenger moved first to her right and then forward (i.e., in a head first posture) and slightly upward just prior to impact. The case vehicle's impact with the raised curb enabled the "on-lap" front right passenger to continue forward and slightly upward toward the 360 degree Direction of Principal Force as the case vehicle decelerated. The "on-lap" front right passenger was most likely just in front of (i.e., toward the front right seat back) and above the front right passenger's air bag module when it deployed. The top right (as one views it) of the deploying air bag caught this passenger in the anterior neck area as she continued to move forward and redirected her upwards into the top right portion of the windshield's glazing and the front right windshield header, causing a spider web-type impact and depositing hair, oil smears, and skin. Sometime during the "on-lap" front right passenger's air bag-related deflection toward the windshield, the case vehicle struck the wooden utility pole, causing the case vehicle to rotate counterclockwise to final rest. The second impact enabled the "on-lap" front right passenger to continue forward because the Direction of Principal Force was also 360 degrees; however, the second impact may have contributed, along with the deploying front right air bag, to this passenger's upward movement. Also contributing to this passenger's upward movement was the forward movement of the case vehicle's adult front right passenger. In this contractor's opinion, the deploying front right passenger air bag lifted (alternatively, propelled, yanked, etc.) the "on-lap" passenger out of the front right passenger's grasp enabling the child to move upward independently of her mother's kinematics. However, the front right passenger (discussed below) was also moving forward as a result of the crash forces and the nonuse of her available restraints. As a result, the adult front right passenger most likely loaded, to some extent, the back of the child, further pushing her upward into the top of the windshield. The counterclockwise rotation of the vehicle (i.e., a result of maximum engagement and the offset location of the impact) enabled the "on-lap" passenger to move slightly to the right because this occupant was most likely still in contact with the windshield's glazing and header when the rotation began. As the vehicle rotated to final rest, the "on-lap" passenger moved backwards and to her right. At final rest, according to the child's mother, the "on-lap" front right passenger's pelvis and lower extremities were back in her mother's lap. The child's upper torso was leaning against the right front door panel, and her head was ejected out the disintegrated right front door glazing. Specifically, her neck was laying over the door sill and she was facing down.

The "on-lap" front right passenger was transported by ambulance to the hospital. She sustained critical brain injuries and was hospitalized prior to being pronounced brain dead four days post-crash. Based on her available medical records, the injuries sustained by the case vehicle's "on-lap" front right passenger included: a critical nonanatomic brain injury, massive cerebral edema, posterior subarachnoid hemorrhage, a right tension pneumothorax, pneumomediastinum, a right occipital scalp laceration, a small anterior neck avulsion, and abrasions to the dorsal surface of her left wrist. This occupant's brain injuries were caused by contact with the upper right windshield's glazing and the windshield's header. This occupant made contact with the windshield and header primarily as a result of her being redirected upward by the front right passenger's air bag and to a lesser extent by loading from the adult front right passenger. Had the vehicle in which she was riding not been equipped with air bags, she almost certainly would have been injured; however, the severity of her injuries is difficult to quantify.

The 1997 Dodge Neon LE was a front wheel drive, four-door sedan (VIN: 1B3ES47Y3VD-----). The case vehicle was not equipped with anti-lock brakes. The case vehicle was towed due to damage

from the scene. Based on the vehicle inspection, the CDCs for the case vehicle were determined to be: **12-FLWN-3 (360)** for the curb impact and **12-FYEN-1 (360)** for the utility pole impact [maximum crush at the front bumper was 17 centimeters (6.7 inches)]. The WinSMASH reconstruction program, barrier algorithm, was used on the case vehicle's second highest (i.e., front bumper) impact. The Total, Longitudinal, and Lateral Delta V's are, respectively: 14.5 kmph (9.0 m.p.h.), -14.5 kmph (-9.0 m.p.h.), and 0.0 kmph (0.0 m.p.h). This contractor believes that had the case vehicle's left front tire not impacted the raised curb, which shortened the wheelbase by 15 centimeters (5.9 inches), the resultant Delta V would have been higher [e.g., visually estimated as between 19 kmph (12 m.p.h.) and 26 kmph (16 m.p.h.)].

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 four tethers, each 7 centimeters (2.8 inches) in width. The driver's air bag had two vent ports, approximately 2 centimeters (0.8 inches) in diameter, located at the 11 and 1 o'clock positions. The deployed driver's air bag was round with a diameter of 63 centimeters (24.8 inches). There was no contact evidence readily apparent on the driver's air bag; however, there was an excessive amount of black cover flap transfers on the air bag's fabric that occurred during the deployment.

The front right passenger's air bag was located in the top of the instrument panel. An inspection of the front right air bag module's cover flaps and air bag 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 flaps. The front right passenger's air bag was designed with two tethers, each 30 centimeters (11.8 inches) in width. The front right air bag had one vent port, approximately 6 centimeters (2.4 inches) in diameter, located at the 12 o'clock position. The deployed front right air bag was rectangular with a height of approximately 63 centimeters (24.8 inches) and a width of approximately 47 centimeters (18.5 inches). There was contact evidence readily apparent (e.g., an area of skin transfer) on the right side and top right portions of the front right air bag.

Inspection of the case vehicle's interior revealed that: the rearview mirror had been tilted askew from contact by the deploying front right air bag; there was a spider web-type contact on the lower right windshield's glazing from impact by the front right air bag's fabric (i.e., the Police Crash Report indicated that there were white fibers in the glazing that did not appear to be hair), which most likely occurred when the top portion of the air bag's fabric was pushed backwards from loading by the "on-lap" front right passenger; there were blood splatters on the front right air bag module's cover flap, left side of the passenger's sun visor, right side of the driver's seat back support, and on the right front window sill; the air vent on the right instrument panel near the front right passenger air bag module was broken out; and there was a scuff on interior surface of the right front door near the door handle. In addition, the driver's sun visor showed a dark skin and oil transfer from impact by the driver.

Immediately prior to the crash the case vehicle's "on-lap" front right passenger was seated in a reclined posture between her mother's legs but on her mother's lap with her back leaning against her mother's chest, her feet hanging down, dangling over the front edge of her mother's legs and the seat's cushion, and both of her arms in her lap. The adult front right passenger [i.e., mother; 24-year-old, Black,



(non-Hispanic) female] was seated in a upright posture with her back against the seat back, both feet on the floor, and both hands around her daughter. The seat track was located between its middle and rearmost positions, and the seat back was upright.

The case vehicle's front right passenger [168 centimeters and 86 kilograms (66 inches, 190 pounds)] was not using her available, active, three-point, lap-and-shoulder, safety belt system. The front right passenger was transported by ambulance to the hospital so that she could accompany her daughter. She declined treatment and, according to her interview, indicated that she did not sustain any injuries as a result of this crash.

The case vehicle's driver [nephew of front right passenger; 20-year-old, Black (non-Hispanic) male] was seated in a slightly reclined posture, with his back against the seat back, both feet on the brake, and both hands on the steering wheel bracing for the crash. His seat track was between its middle and rearmost positions, the seat back was slightly reclined, and the vehicle was not equipped with a tilt steering wheel. The case vehicle's driver [170 centimeters and 59 kilograms (67 inches, 130 pounds)] was not using his available, active, three-point, lap-and-shoulder, safety belt system. The driver was neither transported by ambulance to a medical facility nor did he indicate that he sought medical treatment. According to his interview, he sustained abrasions (rug burns) to his right forearm.

**CRASH CIRCUMSTANCES**



**Figure 1:** Case vehicle's westward travel path on residential, city street; Note: driveway (arrow on right), from which noncontact vehicle came, and utility pole (arrow on left), which was impacted (case photo #02)



**Figure 2:** Utility pole located off southwest corner of offset, four-leg intersection that was impacted by case vehicle when driver swerved to miss a noncontact vehicle that had back from a driveway in northeast quadrant of intersection and was attempting to turn left and go southward on the intersecting roadway (case photo #03)

The case vehicle was traveling west in the westbound lane on a two-lane, undivided, city street and was approaching an offset, four leg intersection (**Figure 1** above), intending to continue traveling westbound. A noncontact vehicle had backed out of a private driveway on the north side of the street, entering into the same two-lane, undivided, roadway, heading essentially westward and was just beginning to make a left-hand turn at the intersection, intending to travel southward. The case vehicle's driver steered to the left and successfully avoided the noncontact vehicle, but it subsequently veered off the southwest corner of the intersection (**Figure 2** above). The case vehicle's driver braked, depositing approximately 4 meters (13.1 feet) of front tire skid marks (**Figure 3**), attempting to avoid the crash. The crash occurred off the southwest corner of the intersection; see **CRASH DIAGRAM** below. Based on the scene evidence and the pre-impact braking, the case vehicle was traveling approximately 47 km.p.h. (29.3 m.p.h.) prior to striking the curb and utility pole.



**Figure 3:** On-scene view showing police marked front tire skids of case vehicle at final rest; Note: curb impacted by left front wheel and vehicle's counterclockwise rotation to final rest position (case photo #47)



**Figure 4:** East-northeastward view from beyond case vehicle's final rest position showing case vehicle's pre-crash travel path (case photo #09)

The city roadway was straight and level (i.e., actual slope was 1.6%, negative to the west) in the case vehicle's direction of travel near the area of impact. The pavement was bituminous, but traveled and worn, and the width of the roadway was 9.1 meters (30 feet). The north side of the road had no shoulder and the south side had a 0.6 meter (2 foot) concrete shoulder. The roadway was bordered by barrier curbs. No pavement markings were present. The estimated coefficient of friction was 0.71. There were no visible traffic controls for westbound traffic in the immediate area of the crash. No regulatory speed limit sign was posted near the crash site (**Figure 4**). At the time of the crash the light condition was daylight, the atmospheric condition was clear, and the road



**Figure 5:** Damage to case vehicle's left front tire and wheel assembly from impacting curb (case photo #16)

pavement was dry. Traffic density was light, and the site of the crash was urban residential. In addition, the driveway from which the noncontact vehicle emerged was located 14.5 meters (47.5 feet) west of the east edge north leg of the intersection and “in-line” with the east edge of the south leg of the four-leg, offset intersection.

The case vehicle’s left front tire (**Figure 5** above) impacted a raised curb [20 centimeters (7.9 inches)], damaging the rim and shortening the wheelbase on the driver’s side 15 centimeters (5.9 inches) and causing the case vehicle’s driver and front right passenger supplemental restraints (air bags) to deploy. Almost simultaneously the front bumper (**Figure 6**) impacted a wooden utility pole. The case vehicle rotated approximately 20 degrees counterclockwise and moved slightly backward before coming to rest near the point of impact (**Figure 7**).

**CASE VEHICLE**

The 1997 Dodge Neon LE was a front wheel drive, five-passenger, four-door sedan (VIN: 1B3ES47Y3VD-----). equipped with power-assisted steering, a 2.0L, SOHC- SMPFI, I-4 engine, and a three-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 264 centimeters (104.0 inches), and the odometer reading at inspection was 11,904 kilometers (7,397 miles).

Inspection of the vehicle’s interior revealed adjustable front bucket seats with adjustable head restraints; a non-adjustable back bench seat with integral 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 front seat belt systems were equipped with manually operated height adjusters for the “D”-rings. The vehicle was equipped with knee bolsters for both the driver and front right passenger, neither of which were deformed. 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 barrier curb.



**Figure 6:** Overhead left view of case vehicle’s direct and induced frontal damage from pole impact; Note: windshield glazing on passenger side near header damaged from contact by “On-Lap” front right passenger’s head (case photo #13)



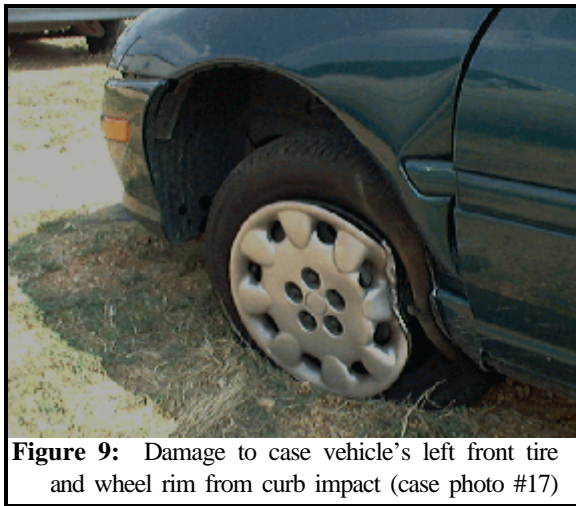
**Figure 7:** On-scene view of case vehicle at final rest; Note: case vehicle struck curb with the left front tire and wooden utility pole with front left (case photo #44)



The case vehicle's initial contact with the barrier curb involved direct damage to the left front tire and wheel rim. The direct contact with the wooden utility pole involved the Neon's front bumper and hood, left of center. Direct damage along the front bumper was located 15 centimeters (5.9 inches) left of center and 31 centimeters (12.2 inches) inward from the front left bumper corner and extended, a measured distance of 21 centimeters (8.3 inches), along the front bumper. The field L was 134 centimeters (52.8 inches). Maximum crush was measured as 17 centimeters (6.7 inches) between C<sub>2</sub> and C<sub>3</sub> (**Figure 8**). The wheelbase on the case vehicle's left side was shortened 15 centimeters (5.9 inches) from the curb impact, while the right side was not shortened. The case vehicle's left front wheel rim was severely deformed and the tire deflated (**Figure 9**) from the curb impact. The case vehicle's front bumper, bumper fascia, grille, and hood were directly damaged and crushed rearward from the utility pole impact. The left fender sustained induced damage and the right front door's glazing was disintegrated as a result of the crash (**Figure 8**).



**Figure 8:** Overhead right view of case vehicle's front left damage with contour gauge present and tape indicating width of direct damage; Note: disintegrated right front door glazing and spider web type impacts to windshield (case photo #20)



**Figure 9:** Damage to case vehicle's left front tire and wheel rim from curb impact (case photo #17)



**Figure 10:** Case vehicle's cracked right windshield glazing showing two distinct impacts to glazing (case photo #22)

Inspection of the case vehicle's interior revealed that the rearview mirror had been tilted askew from contact by the deploying front right air bag. The windshield glazing showed two distinct contacts (**Figure 10** and **Figure 11** below). There was a spider web-type contact on the lower right windshield's glazing (**Figure 11** below) from impact by the front right air bag's fabric (i.e., the Police Crash Report indicated that there were white fibers in the glazing that did not appear to be hair), which most likely occurred when the top portion of the air bag's fabric was pushed backwards from loading by the "on-lap" front right

passenger. Above this contact was another spider web-type contact with skin, curly black hair, an oil smear, and blood transfers to the windshield, header, and forward edge of the sun visor on the front right side from impact by the “on-lap” front right passenger’s anterior and posterior head (**Figure 11** and **Figure 12**).



**Figure 11:** Close-up of spider web-type damage to case vehicle’s right upper windshield (upper dot) from impact by “On-Lap” front right passenger; Note: lower dot most likely represents contact by air bag’s fabric during deployment (case photo #31)



**Figure 12:** Close-up of head contact to case vehicle’s right upper windshield and header, near right “A”-pillar (i.e., hair and skin stuck in crease) from back of “On-Lap” front right passenger’s head (case photo #32)



**Figure 13:** Case vehicle’s center and front right instrument panel, right knee bolster, and glove box door showing no evidence of occupant contact; Note: right air vent knocked out (case photo #30)



**Figure 14:** Vertical view of case vehicle’s driver seating area showing no visible contact evidence on driver’s air bag and a head contact (highlighted) to the left side of driver’s sun visor (case photo #25)

There were blood splatters on the front right air bag module’s cover flap, left side of the passenger’s sun visor, right side of the driver’s seat back support, and on the right front window sill. The air vent on the right instrument panel near the front right passenger air



bag module was broken out (Figure 13), and there was a scuff on interior surface of the right front door near the door handle, either from the child passenger's torso or from the adult front right passenger. In addition, the driver's sun visor showed a dark skin and oil transfer from impact by the driver (Figure 14 above and Figure 15).

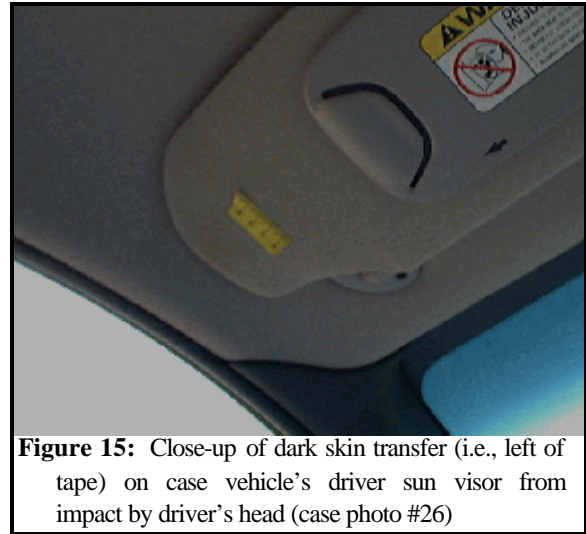


Figure 15: Close-up of dark skin transfer (i.e., left of tape) on case vehicle's driver sun visor from impact by driver's head (case photo #26)

Based on the vehicle inspection, the CDCs for the case vehicle were determined to be: **12-FLWN-3 (360)** for the curb impact and **12-FYEN-1 (360)** for the utility pole impact. The WinSMASH reconstruction program, barrier algorithm, was used on the case vehicle's second highest (i.e., front bumper) impact. The Total, Longitudinal, and Lateral Delta V's are, respectively: 14.5 kmph (9.0 m.p.h.), -14.5 kmph (-9.0 m.p.h.), and 0.0 kmph (0.0 m.p.h.). This contractor believes that had the case vehicle's left front tire not impacted the raised curb, which shortened the wheelbase by 15 centimeters (5.9 inches), the resultant Delta V would have been higher [e.g., visually estimated as between 19 kmph (12 m.p.h.) and 26 kmph (16 m.p.h.)]. The case vehicle was towed due to damage from the scene.

#### 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 air bags deployed as a result of the tire/wheel impact with the curb. The case vehicle's driver air bag was located in the steering wheel hub. The module cover consisted of a single quasi-rectangular cover flap made of thick vinyl with overall dimensions of 23 centimeters (9.1 inches) at the top horizontal seam and 15 centimeters (5.9 inches) vertically. 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 (Figure 16). The driver's air bag was designed with four tethers, each 7 centimeters (2.8 inches) in width, sewn internally to the circular stitching in the center of the air bag at the 12, 3, 6, and 9 o'clock positions. The driver's air bag had two vent ports, approximately 2 centimeters (0.8 inches) in diameter, located at the 11 and 1 o'clock positions. The deployed driver's air bag was round with a diameter of 63 centimeters (24.8 inches). There was no contact evidence readily apparent on the driver's air bag (Figure 15); however, there was a significant

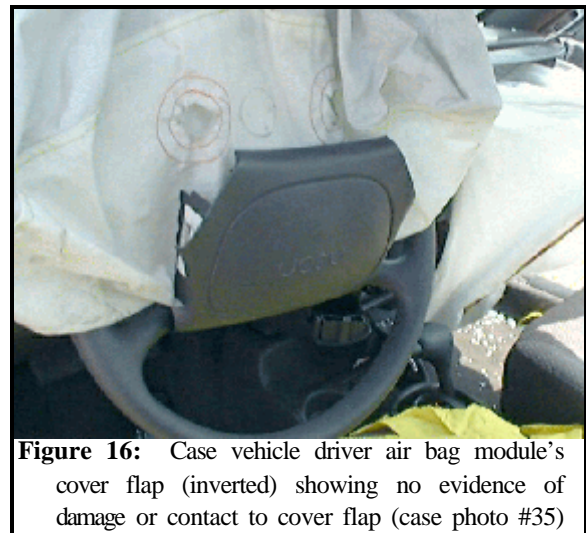
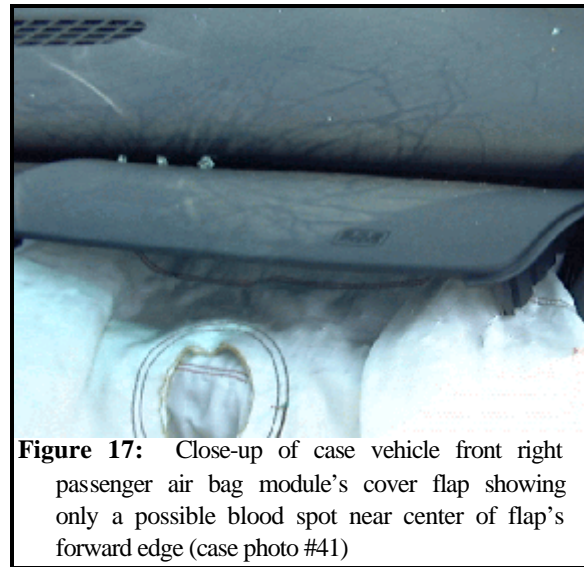


Figure 16: Case vehicle driver air bag module's cover flap (inverted) showing no evidence of damage or contact to cover flap (case photo #35)

amount of black cover flap transfers on the air bag's fabric that occurred during the deployment.

The front right passenger's air bag was located in the top of the instrument panel. There was a single, essentially rectangular, modular cover flap. The cover flap was made of a thick vinyl over a sheet metal frame/liner which acted as the hinge point for the deploying flap. The flap's dimensions were 33 centimeters (13.0 inches) at the lower horizontal seam and 16 centimeters (6.3 inches) along both vertical seams. The profile of the vehicle's instrument panel resulted in a 2.5 centimeter (1.0 inch) setback of the leading edge of the cover flap relative to the protruding right instrument panel. The hinged flap was not

capable, due to its height and placement, of contacting the windshield. An inspection of the front right air bag module's cover flaps and air bag 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 flaps (**Figure 17**).



**Figure 17:** Close-up of case vehicle front right passenger air bag module's cover flap showing only a possible blood spot near center of flap's forward edge (case photo #41)



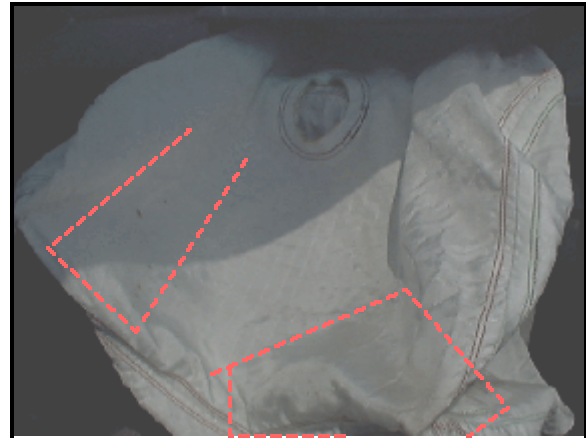
**Figure 18:** Frontal view of case vehicle's front right passenger air bag showing no visible evidence of contact (case photo #37)

The front right passenger's air bag was designed with two tethers, each 30 centimeters (11.8 inches) in width. The top tether was aligned with the top edge of the air bag. The bottom tether was positioned 36 centimeters (14.2 inches) down from the top tether. Both tethers started approximately 9 centimeters (3.5 inches) inward from the left edge. The front right air bag had one vent port, approximately 6 centimeters (2.4 inches) in diameter, located at the 12 o'clock



**Figure 19:** Vertical view of case vehicle's front right passenger seating area; Note: highlighted contacts to top of front right air bag, windshield, and right header (case photo #40)

position (**Figure 17**). The deployed front right air bag was rectangular (**Figure 18**) with a height of approximately 63 centimeters (24.8 inches) and a width of approximately 47 centimeters (18.5 inches). Examination of the front right passenger air bag revealed one area of dark skin transfer to the top right portion and blood splatter to the top left portion which extended onto the front surface (**Figure 19** above). In addition there was a dark skin transfer to the right side of the air bag towards the top. The skin evidence to the top right portion of the air bag was approximately 6 x 6 centimeters (2.4 x 2.4 inches) square and was located along the top right corner and top forward edge (**Figure 20**). The skin evidence on the right side extended downwards 17 centimeters (6.7 inches) from the top edge, approximately, and angled back from the front surface approximately 5 centimeters (2.0 inches) at its beginning and 7 centimeters (2.8 inches) at its end (**Figure 21**). The area of blood spots on the top surface began 11 centimeters (4.3 inches) back from the leading edge and continued down onto the front surface a measured distance of 8 centimeters (3.1 inches). This area of blood spots were located approximately 7-8 centimeters (2.8-3.1 inches) inward from the left edge.



**Figure 20:** Close-up view of top portion of case vehicle's front right passenger air bag showing blood splatter to left side and barely visible dark skin transfer to top right corner towards front portion (case photo #38)

### CASE VEHICLE "ON-LAP" FRONT RIGHT PASSENGER KINEMATICS

Immediately prior to the crash the case vehicle's "on-lap" front right passenger [4-year-old, Black (non-Hispanic) female] was seated in a reclined posture between her mother's legs but on her mother's lap with her back leaning against her mother's chest, her feet hanging down, dangling over the front edge of her mother's legs and the seat's cushion, and both of her arms in her lap. The seat track was located between its middle and rearmost positions, and the seat back was upright.

The case vehicle's "on-lap" front right passenger [91 centimeters and 19 kilograms (36 inches, 42 pounds)], was not using the available, active, three-point, lap-and-shoulder, safety belt system. The child was facing forward. In addition, there was no evidence of belt pattern bruising and/or abrasions to the "on-lap" front right passenger's body, and the inspection of the right front seat belt webbing, "D"-ring, and latch plate showed no evidence of loading or blood transfers. The seat belt's upper anchorage was adjusted to the full-up position.



**Figure 21:** Dark skin transfer on right side near top front corner of case vehicle's front right passenger air bag (case photo #40)



The case vehicle's driver had most likely steered leftward at least partially into the opposing lane of travel in order to pass the noncontact vehicle which had backed into the westbound lane. When the noncontact vehicle began to move forward and begin its left-hand turn, the case vehicle's driver swerved to the left and avoided the turning noncontact vehicle. However, when the driver noticed the impending impact with the curb and pole, he braked attempting to avoid the crash. As a result of this attempted avoidance maneuver and the nonuse of either a child safety seat or the available front right safety belts, the "on-lap" front right passenger moved first to her right and then forward (i.e., in a head first posture) and slightly upward just prior to impact. The case vehicle's impact with the raised curb enabled the "on-lap" front right passenger to continue forward and slightly upward toward the 360 degree Direction of Principal Force as the case vehicle decelerated. The "on-lap" front right passenger was most likely just in front of (i.e., toward the front right seat back) and above the front right passenger's air bag module when it deployed. The top right (as one views it) of the deploying air bag caught this passenger in the anterior neck area as she continued to move forward and redirected her upwards into the top right portion of the windshield's glazing and the front right windshield header (**Figures 11, 12, and 19** above) causing a spider web-type impact and depositing hair, oil smears, and skin.

Sometime during the "on-lap" front right passenger's air bag-related deflection toward the windshield, the case vehicle struck the wooden utility pole, causing the case vehicle to rotate counterclockwise to final rest (**Figure 7** above). The second impact enabled the "on-lap" front right passenger to continue forward because the Direction of Principal Force was also 360 degrees; however, the second impact may have contributed, along with the deploying front right air bag, to this passenger's upward movement. Also contributing to this passenger's upward movement was the forward movement of the case vehicle's adult front right passenger. In this contractor's opinion, the deploying front right passenger air bag lifted (alternatively, propelled, yanked, etc.) the "on-lap" passenger out of the front right passenger's grasp enabling the child to move upward independently of her mother's kinematics. However, the front right passenger (discussed below) was also moving forward as a result of the crash forces and the nonuse of her available restraints. As a result, the adult front right passenger most likely loaded, to some extent, the back of the child, further pushing her upward into the top of the windshield. The "on-lap" front right passenger most likely struck the top of the windshield with the anterior portion of her scalp; although, there are no identified lesions to this occupant's forehead and/or anterior scalp. As she continued to move forward, her neck flexed causing the top posterior portion of her scalp to come into contact with the uppermost part of the windshield's glazing and the lower portion of the front right windshield header. As a result her posterior scalp was lacerated and hair, skin, and smudges were deposited. The counterclockwise rotation of the vehicle (i.e., a result of maximum engagement and the offset location of the impact) enabled the "on-lap" passenger to move slightly to the right because this occupant was most likely still in contact with the windshield's glazing and header when the rotation began. As the vehicle rotated to final rest, the "on-lap" passenger moved backwards and to her right. At final rest, according to the child's mother, the "on-lap" front right passenger's pelvis and lower extremities were back in her mother's lap. The child's upper torso was leaning against the right front door panel, and her head was ejected out the disintegrated right front door glazing. Specifically, her neck was laying over the door sill and she was facing down.

The "on-lap" front right passenger was transported by ambulance to the hospital. She sustained critical brain injuries and was hospitalized prior to being pronounced brain dead four days post-crash. Based on her available medical records, the injuries sustained by the case vehicle's "on-lap" front right passenger included: a critical nonanatomic brain injury, massive cerebral edema, posterior subarachnoid hemorrhage, a right tension pneumothorax, pneumomediastinum, a right occipital scalp laceration, a small anterior neck avulsion, and abrasions to the dorsal surface of her left wrist. This occupant's brain injuries were caused by contact with the upper right windshield's glazing and the windshield's header. This occupant made contact with the windshield and header primarily as a result of her being redirected upward by the front right passenger's air bag and to a lesser extent by loading from the adult front right passenger. Had the vehicle in which she was riding not been equipped with air bags, she almost certainly would have been injured; however, the severity of her injuries is difficult to quantify.

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 minimal flexion to painful stim-uli and neurologic deficit (i.e., vomiting, seizure activity, unequal pupils); GCS = 5 to 3; and multiple complicating conditions <sup>1</sup> including: diabetes insipidus, disseminated intravascular coagulation, hypocapnia, hypernatremia, hypovolemic	160822.5 critical	Windshield and front right header	Certain	Hospitalization records

<sup>1</sup> The following terms are defined in DORLAND'S ILLUSTRATED MEDICAL DICTIONARY as follows:

**anoxic (a-nok'sik):** pertaining to or characterized by anoxia.

**anoxia (a-nok'se-a):** a total lack of oxygen; often used interchangeably with *hypoxia* to mean a reduced supply of oxygen to the tissues.

**coagulation (ko-ag'u-la'shen):** the process of clot formation.

**diffuse intravascular c., disseminated intravascular c. (DIC):** a disorder characterized by reduction in the elements involved in blood coagulation due to their utilization in widespread blood clotting within the vessels; the activation of the clotting mechanism may arise from any number of disorders. In the late stages, it is marked by profuse hemorrhaging. Called also *consumption coagulopathy* and *defibrination syndrome*.

**diabetes (di'c-be'z):** a general term referring to disorders characterized by excessive urine excretion (polyuria), as in diabetes mellitus and diabetes insipidus. When used alone, the term refers to diabetes mellitus.

**d. insipidus, central:** a metabolic disorder due to injury of the neurohypophyseal system, which results in a deficient quantity of antidiuretic hormone being released or produced, and thus in failure of tubular reabsorption of water in the kidney. As a result, a large amount of urine of low specific gravity is excreted, followed by voracious appetite, loss of strength, and emaciation. It may be inherited, acquired, or idiopathic.

**d. insipidus, pituitary:** central d. insipidus.

**hypernatremia (hi'per-ne-tre'me-c):** excessive amount of sodium in the blood.

**hypocapnia (hi'po-kap'ne-c):** deficiency of carbon dioxide in the blood, resulting from hyperventilation and eventually leading to alkalosis.

**hypovolemic shock:** shock resulting from insufficient blood volume for the maintenance of adequate cardiac output, blood pressure and tissue perfusion. Without modification the term refers to absolute hypovolemic shock caused by acute hemorrhage or excessive fluid loss. Relative hypovolemic shock refers to a situation in which the blood volume is normal but insufficient because of widespread vasodilation as in neurogenic shock or septic shock.

**hypoxia (hi-pok'se-a):** reduction of oxygen supply to tissue below physiological levels despite adequate perfusion of the tissue by blood. Compare with *anoxia*.

**idiopathic (id'e-o-path'ik):** of the nature of an idiopathy; self-originated; of unknown causation.

**idiopathy (id'e-op'le-the):** a morbid state of spontaneous origin; one neither sympathetic or traumatic.

**insult (in'slt):** injury or trauma; attack.

**neurohypophyseal (noor'o-hi'po-fiz'le-cl):** neurohypophysial

**neurohypophysial (noor'o-hi'po-fiz'le-cl):** pertaining to the neurohypophysis.

**neurohypophysis (noor'o-hi'po-pof'le-sis):** the posterior lobe of the pituitary gland, making up the neural portion. ... It serves as a reservoir for the hypothalamic neurohormones vasopressin, oxytocin, and the neurophysins, releasing them as needed.... Called also *posterior pituitary*, *posterior lobe of pituitary gland*.

**shock (shok):** 1. a sudden disturbance of mental equilibrium. 2. a condition of profound hemodynamic and metabolic disturbance characterized by failure of the circulatory system to maintain adequate perfusion of vital organs. It may result from inadequate blood volume (hypovolemic shock); inadequate cardiac function (cardiogenic shock); or inadequate vasomotor tone (neurogenic shock, septic shock).

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
2	Edema, severe {massive}, with complete effacement of cisterns, ablation of sulci <sup>2</sup> , and small or effaced ventricles <i>and</i> diffuse cerebral swelling {see <b>SWELLING</b> below} [Aspect = Unknown]	140674.5 critical	Windshield and front right header	Certain	Hospitalization records
3	Hemorrhage, subarachnoid, over tentorium <sup>3</sup> [Aspect = Unknown]	140684.3 serious	Header, front right windshield	Certain	Hospitalization records
4	Pneumothorax <sup>4</sup> with moderate tension <sup>5</sup> on right	442210.5 critical	Air bag, front right passenger's	Probable	Hospitalization records

<sup>2</sup> The following terms are defined in DORLAND'S ILLUSTRATED MEDICAL DICTIONARY as follows:  
**ablation** (*ab-la~~h~~cn*): 1. separation or detachment; extirpation; eradication. 2. removal or destruction of a part, especially by cutting.  
**cistern** (*sis~~h~~tern*): a closed space serving as a reservoir for fluid; see also *cisterna*.  
**cisterna** (*sis-ter~~h~~na*) pl. **cister~~h~~nae**: a cistern -- a closed space serving as a reservoir for lymph or other body fluid, especially one of the enlarged subarachnoid spaces containing cerebrospinal fluid.  
**extirpation** (*ek~~h~~'ster-pa~~h~~cn*): complete removal or eradication of an organ or tissue.  
**fissure** (*fish~~h~~ur*): any cleft or groove, normal or otherwise; especially a deep fold in the cerebral cortex which involves the entire thickness of the brain wall. Compare *sulcus*.  
**gyrus** (*ji~~h~~ras*) pl. **gyri** (*ji~~h~~ri*): one of the convolutions of the surface of the brain caused by infolding of the cortex; see *gyri cerebri*.  
**g. cerebel~~h~~li**: folia cerebelli.  
**g. cerebra~~h~~les**: cerebral gyri; the tortuous convolutions of the surface of the cerebral hemisphere, caused by infolding of the cortex and separated by the fissures or sulci. Many are constant enough that they have been given special names. Called also *gyri cerebri* and *gyri of cerebrum*.  
**g. ce~~h~~rebri, gyri of cerebrum**: gyri cerebrales.  
**sulcus** (*sul~~h~~kas*) pl. **sul~~h~~ci** (*sul~~h~~ki*): a groove, trench, or furrow; a general term for such a depression, especially one of those on the surface of the brain, separating the gyri. Compare *fissure*.

<sup>3</sup> The following terms are defined in DORLAND'S ILLUSTRATED MEDICAL DICTIONARY as follows:  
**tentorial** (*ten-tor~~h~~e-al*): pertaining to the tentorium of the cerebellum.  
**tentorium** (*ten-tor~~h~~e-am*): an anatomical part resembling a tent or a covering.  
**t. cerebel~~h~~li, t. of cerebellum**: the process of dura mater that supports the occipital lobes and covers the cerebellum. Its internal border is free and bounds the tentorial notch; its external border is attached to the skull and encloses the transverse sinus behind.

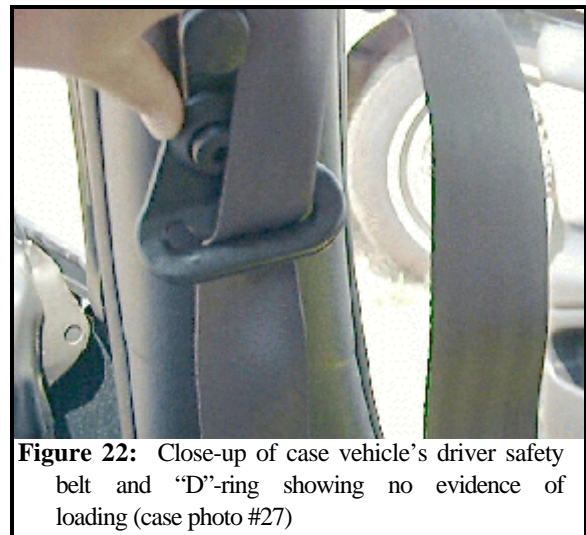
<sup>4</sup> These lesions were detected by chest X-ray on the fourth and final day of hospitalization--the day that this patient was declared brain dead.

<sup>5</sup> The following term is defined in DORLAND'S ILLUSTRATED MEDICAL DICTIONARY as follows:  
**tension pneumothorax** (*noo~~h~~'mo-thor~~h~~aks*): closed pneumothorax in which the tissues surrounding the opening into the pleural cavity act as valves, allowing air to enter but not to escape. The resultant positive pressure in the cavity displaces the mediastinum to the opposite side, with consequent embarrassment of respiration. Called also *pressure pneumothorax*.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
5	Pneumomediastinum <sup>4</sup>	442204.3 serious	Air bag, front right passenger’s	Probable	Hospitalization records
6	Laceration, 3 cm (1.2 in), right occipital scalp	190602.1 minor	Header, front right windshield	Certain	Hospitalization records
7	Avulsion, small, anterior neck from chin to thyroid cartilage	390802.1 minor	Air bag, front right passenger’s	Certain	Hospitalization records
8	Abrasions, multiple, small, dorsal left wrist	790202.1 minor	Air bag, front right passenger’s	Probable	Emergency room records

**CASE VEHICLE DRIVER KINEMATICS**

The case vehicle's driver [nephew of front right passenger; 20-year-old, Black (non-Hispanic) male] was seated in a slightly reclined posture, with his back against the seat back, both feet on the brake, and both hands on the steering wheel, presumably at the 10 and 2 o’clock positions, bracing for the crash. His seat track was between its middle and rearmost positions, the seat back was slightly reclined, and the vehicle was not equipped with a tilt steering wheel. Although the case vehicle's driver [170 centimeters and 59 kilograms (67 inches, 130 pounds)] indicated that he was restrained by his available, active, three-point, lap-and-shoulder, safety belt system and an inspection of the driver’s seat belt did show some evidence of loading (**Figure 22**) to the “D”-ring (i.e., heat abrasion), the alleged restraint usage was discounted because of the head contact to the driver’s sun visor. Furthermore, the case vehicle was a rental vehicle and the observed indications of restraint system usage could have occurred prior this crash. The driver’s shoulder belt upper anchorage was adjusted to the full down position. The shear capsules on the steering column were most likely unchanged, although it was not documented during the inspection.



**Figure 22:** Close-up of case vehicle’s driver safety belt and “D”-ring showing no evidence of loading (case photo #27)

The case vehicle's driver swerved to the left and avoided the turning noncontact vehicle. However, when the driver noticed the impending impact with the curb and pole, he braked attempting to avoid the crash. As a result of this attempted avoidance maneuver and nonuse of his available safety belts, the driver moved first slightly to his right and then forward, still bracing with his arms, just prior to impact. The case vehicle's impact with the raised curb enabled the driver to continue forward and slightly upward towards the steering wheel and the 360 degree Direction of Principal Force as the case vehicle decelerated. When the driver’s air bag deployed it struck him in the chest. Sometime during the driver’s forward movement, the case vehicle struck the wooden utility pole.

The second impact enabled the driver to continue forward and upward because the Direction of Principal Force was also 360 degrees. The second impact in conjunction with the deploying front right air bag lifted the driver upwards. Meanwhile the case vehicle’s pole impact also caused the vehicle to rotate counterclockwise to final rest (Figure 7 above). This counterclockwise rotation (i.e., as a result of maximum engagement) enabled the driver to move slightly to his left as the vehicle rotated underneath him. Given the driver’s upward movement from the impacts and the deploying air bag and the slight leftward movement from the rotation, the case vehicle’s driver contacted the sun visor with his head (Figures 14 and 15 above). It was also at this point that the driver sustained the abrasion to his right forearm from the deploying air bag. As the vehicle came to final rest, the driver rebounded back into his seat. At final rest he remained in his seat. The driver was conscious following the crash and was able to exit the vehicle without any assistance.

**CASE VEHICLE DRIVER INJURIES**

The driver was neither transported by ambulance to a medical facility nor did he indicate that he sought medical treatment. According to his interview, he sustained abrasions (rug burns) to his right forearm.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
1	Abrasion {rug burn} right forearm, not further specified	790202.1 minor	Air bag, driver’s	Certain	Interviewee (same person)

**CASE VEHICLE FRONT RIGHT PASSENGER KINEMATICS**

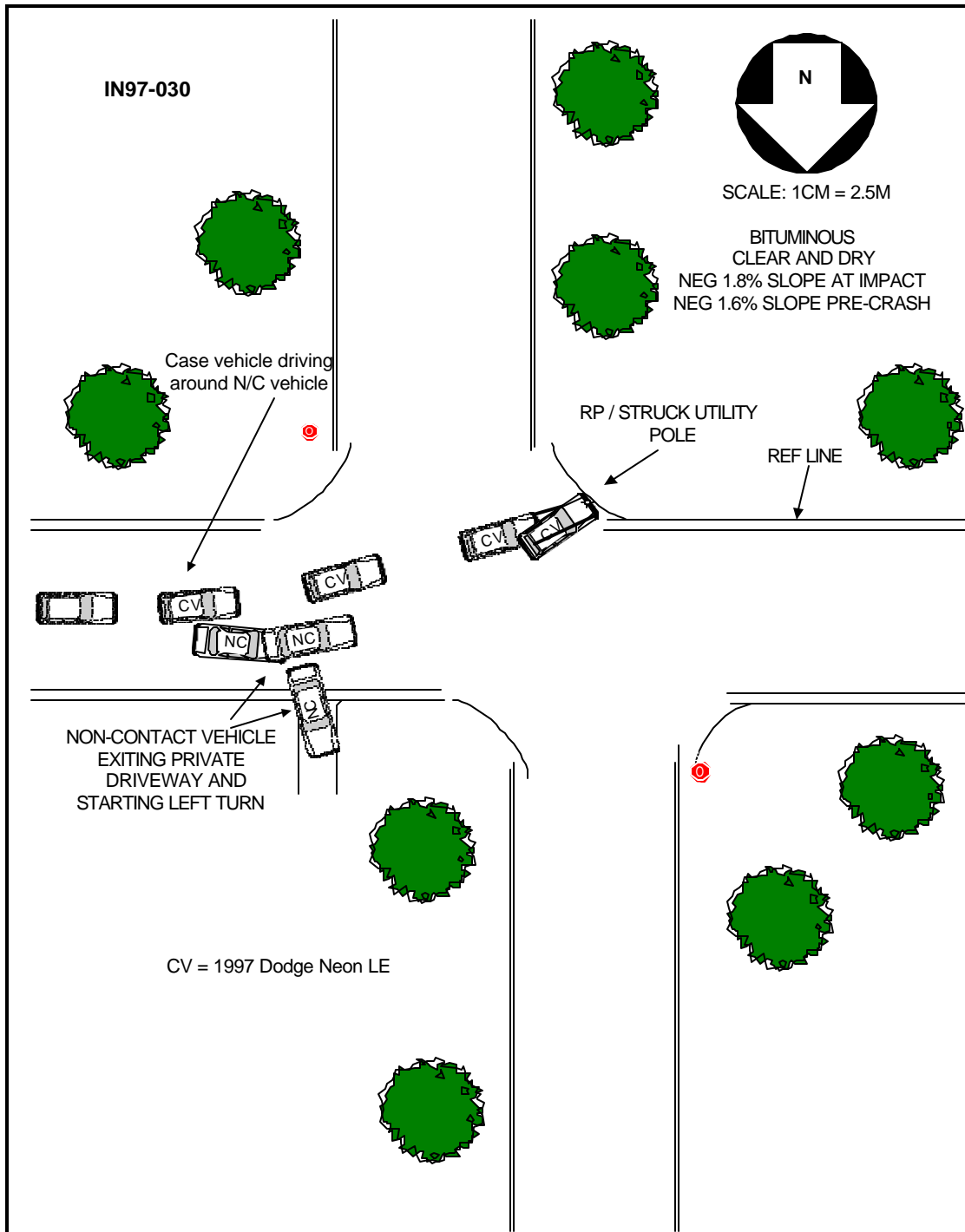
The adult front right passenger [i.e., mother; 24-year-old, Black, (non-Hispanic) female] was seated in an upright posture with her back against the seat back, both feet on the floor, and both hands around her daughter’s waist. The seat track was located between its middle and rearmost positions, and the seat back was upright. The case vehicle’s front right passenger [168 centimeters and 86 kilograms (66 inches, 190 pounds)] was not using her available, active, three-point, lap-and-shoulder, safety belt system. The inspection of the front right passenger’s seat belt webbing, “D-ring” and latch plate showed no evidence of usage during the crash. The upper anchorage for the passenger’s shoulder belt was adjusted in the full-up position.

The case vehicle's driver swerved to the left and avoided the turning noncontact vehicle. However, when the driver noticed the impending impact with the curb and pole, he braked attempting to avoid the crash. As a result of this attempted avoidance maneuver and nonuse of the available front right safety belts, the front right passenger moved first to her right and then forward with her daughter on her lap just prior to impact. The case vehicle's impact with the raised curb enabled the front right passenger to continue forward and slightly upward toward the 360 degree Direction of Principal Force as the case vehicle decelerated. The deploying air bag lifted the “on-lap” front right passenger off this passenger’s lap and out

of her grasp. According to this passenger's interview, she had no interaction with the deploying front right air bag. Sometime during the front right passenger's forward movement, the case vehicle struck the wooden utility pole, causing the case vehicle to rotate counterclockwise to final rest (**Figure 7** above). The second impact enable the front right passenger to continue forward because the Direction of Principal Force was also 360 degrees. The second impact may have contributed, along with the deploying front right air bag, to enable this passenger to propel her "on-lap" daughter upward and into the windshield's glazing and header. The counterclockwise rotation of the vehicle (i.e., a result of maximum engagement and the offset location of the impact) enabled this passenger to move slightly to the left as the vehicle rotated underneath her. As the vehicle came to final rest, the front right passenger moved backwards into her seat back and then to her right toward the right front door. At final rest the front right passenger was essentially in her seat with her "on-lap" daughter on her lap. Following the crash she exited the vehicle without any assistance and, according to witnesses, was extremely concerned about her daughter's condition.

#### **CASE VEHICLE FRONT RIGHT PASSENGER INJURIES**

The front right passenger was transported by ambulance to the hospital so that she could accompany her daughter. She declined treatment and, according to her interview, indicated that she did not sustain any injuries as a result of this crash.





The following material is taken from the book: FORENSIC PATHOLOGY by Dominick J. DiMaio and Vincent J.M. DiMaio, CRC Press, Ann Arbor, 1993; Chapter Six: Trauma to the Skull and Brain: Craniocerebral Injuries, *Traumatic Brain Swelling and Edema*, pages 165-167.

Following significant head injury, whether clinically mild or severe, swelling of the brain may occur. Brain swelling may be focal, adjacent to an area of brain injury; be diffuse, involving both cerebral hemispheres; or involved only a single hemisphere. This latter condition is seen most commonly following evacuation of an acute subdural hematoma and involves the ipsilateral<sup>6</sup> hemisphere. The secondary swelling may, in fact, cause a more serious mass effect than the original hematoma.

**BRAIN SWELLING** can be due to either **an increase in intravascular cerebral blood volume secondary to vasodilation** or **an absolute increase in the water content of the brain tissue**. This latter condition is called **CEREBRAL EDEMA** and is often incorrectly considered synonymously with brain swelling. If continued long enough, brain swelling due to an increase in the intravascular cerebral blood volume progresses to cerebral edema, presumably due to increased vascular permeability. The magnitude of the brain swelling does not necessarily correspond to the severity of the injury.

With severe brain injury, diffuse brain swelling of a severe degree may occur immediately without the individual regaining consciousness. Brain swelling, however, may not occur immediately after an injury, but rather develop minutes to hours later. Delayed brain swelling of a significant degree is rare. It is usually diffuse and more often associated with the less severe forms of brain injury. Typically, the patient receives a concussion {*nonanatomic brain injury*}, regains consciousness, only to become stuporous and lapse into coma minutes to hours later. The most severe form of delayed brain swelling is more common in children between the ages of 4 and 10 years of age.

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<sup>6</sup> The following term is defined in DORLAND'S ILLUSTRATED MEDICAL DICTIONARY as follows:  
*ipsilateral* (*ip''sī-lat-ur-al*): situated on, pertaining to, or affecting the same side, as opposed to contralateral.