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## ON-SITE OFFICE OF DEFECTS INVESTIGATION AIR BAG NON-DEPLOYMENT INVESTIGATION

CASE NUMBER - IN10041  
LOCATION - MARYLAND  
VEHICLE - 2007 FORD ESCAPE XLT  
CRASH DATE - October 2010

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 on-site investigation focused on the non-deployment of the driver's frontal air bag of a 2007 Ford Escape XLT. The restrained 82-year-old male driver was traveling southeast on a parking lot access roadway to a strip mall when he experienced a medical episode. A witness observed the driver slumped over the steering wheel as the vehicle accelerated through the parking lot in a northeast direction and impacted a concrete curb (events 1 and 2). The front plane then impacted a brick building (event 3). The vehicle rotated counterclockwise and the right quarter panel impacted a trash can and a brick support column for the roof of the building (events 4 and 5). The impact with the building did not deploy the driver's frontal air bag. The impact partially displaced the brick wall producing a small hole in the wall. The displacement of the wall may have been a factor in the non-deployment of the driver's frontal air bag. The driver was transported by air ambulance to a hospital where he was admitted. He succumbed to his injuries 14 days following the crash.					
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This on-site investigation focused on the non-deployment of the driver's frontal air bag of a 2007 Ford Escape XLT (**Figure 1**). This crash was brought to our attention by the National Highway Traffic Safety Administration (NHTSA) on December 15, 2010 through the Office of Defects Investigation (ODI) in Washington D.C. ODI was notified of the crash on November 13, 2010 through a Vehicle Owner's Questionnaire, which was submitted by the driver's son via the Auto Safety Hotline. This investigation was assigned on December 20, 2010. The crash involved only the Ford, which departed a parking lot and impacted a curb, a building, a trash can, and a brick support column. The crash occurred in October, 2010, at 1116 hours, in Maryland and was investigated by a municipal police department. The Ford and crash scene were inspected and three witnesses interviewed on January 4-5, 2011. The driver's son was interviewed on January 3, 2011. This report is based on the police crash report, vehicle inspection, crash scene inspection, exemplar vehicle inspection, Event Data Recorder (EDR) report, interview information, driver medical records, occupant kinematic principles, and evaluation of the evidence.



**Figure 1:** The damaged 2007 Ford Escape XLT

## CRASH CIRCUMSTANCES

**Crash Environment:** This crash occurred within an urban strip mall parking lot during daylight hours and clear weather conditions. The Ford was traveling on a 2-lane, undivided, parking lot access roadway. The access roadway traversed in a southeast-northwest direction and had one bituminous travel lane in each direction. The southeast-bound lane was 3 m (9.8 ft) in width, while the northwest-bound lane was 4 m (13.2 ft) in width. The roadway provided access to the strip mall parking lot. The strip mall buildings were located on the northeast side of the parking lot. The access roadway had no posted speed limit. The Crash Diagram is on page 10 of this report.

**Pre-Crash:** The restrained 82-year-old male driver was traveling southeast on the parking lot access roadway (**Figure 2**) when he experienced a medical episode. A witness observed the driver slumped over the steering wheel. The vehicle departed the roadway in a northeast direction and entered a parking lot. Multiple witnesses reported hearing squealing tires as the vehicle accelerated through the parking lot and approached a building located at the northeast corner of the parking lot.



**Figure 2:** View southeast of approach of the Ford on the parking lot access roadway; arrow shows entrance where the Ford entered the parking lot

**Crash:** The Ford traversed approximately 65 m (213 ft) through the parking lot (**Figure 3**) and traveled over a 15 cm (5.9 in) high curbed landscape strip, which separated the parking lot from an access roadway. The vehicle continued in a northeast direction an additional 54 m (177 ft) and impacted a 17 cm (6.9 in) high concrete curb (**Figure 4**), which damaged the rims of the right front and left rear wheels (events 1 and 2). The vehicle traveled across a 3.7 m (12.1 ft) wide sidewalk and the front plane (**Figure 5**) impacted the corner of a brick building (**Figure 4**, event 3). The front left corner of the vehicle engaged the building, which caused the vehicle to rotate counterclockwise and the right quarter panel (**Figure 6**) impacted a trash can and a brick support column for the roof of the building (**Figure 4**, events 4 and 5). The impact damaged and displaced the bricks on the corner of the building and shattered the plate glass windows. The driver's frontal air bag did not deploy.

**Post-Crash:** Police, emergency medical personnel, and rescue personnel responded to the crash scene. The driver was transported by air ambulance to a trauma center and admitted. The vehicle was towed due to damage.

#### CASE VEHICLE

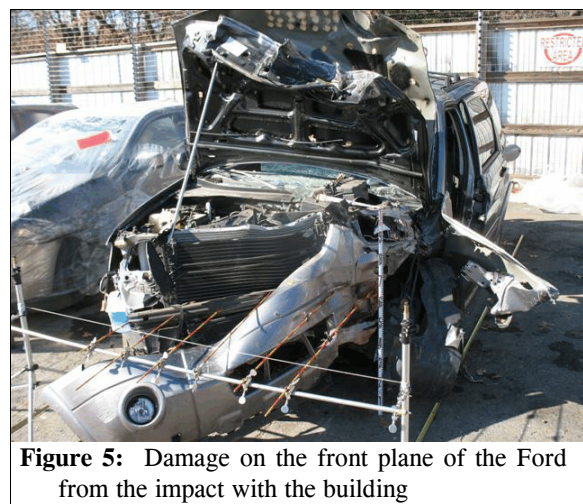
The 2007 Ford Escape XLT was an all wheel drive, 5-passenger, 4-door sport utility vehicle (VIN: 1FMYU93157K-----) equipped with a 3.0-liter, V6 engine, automatic transmission, 4-wheel anti-lock brakes with electronic brake force distribution, traction control, and electronic stability control. The front row was equipped with bucket seats, adjustable head restraints, lap-and-shoulder safety belts, and dual stage driver and front right passenger frontal air bags. The second row was equipped with a split bench seat with folding backs, lap-and-shoulder seat safety belts, adjustable head restraints, and Lower Anchors and Tethers for Children (LATCH) in outboard seating positions. During the SCI interview, the driver's son estimated the



**Figure 3:** Approach through the parking lot to the impact with the building; arrow shows the impacted building (view northeast)



**Figure 4:** Approach northeast to the impacts with the curb, building, trash can, and brick support column



**Figure 5:** Damage on the front plane of the Ford from the impact with the building

vehicle's mileage was less than 32,186 kilometers (20,000 miles). The vehicle's specified wheelbase was 262 cm (103.1 in).

### CASE VEHICLE DAMAGE

**Exterior Damage Events 1 and 2:** The Ford sustained damage to the right front and left rear wheels during the impacts with the curb. A portion of the right front rim was fractured and the left rear rim was dented.

**Damage Classification Events 1 and 2:** The Collision Deformation Classifications (CDC) for the right front wheel damage was 12FRWN3. The CDC for the left rear wheel damage was 12FLWN9. The WinSMASH program could not be used to calculate Delta V for either wheel impact since such impacts are out of scope for the program. The severity of the damage for each wheel was minor.

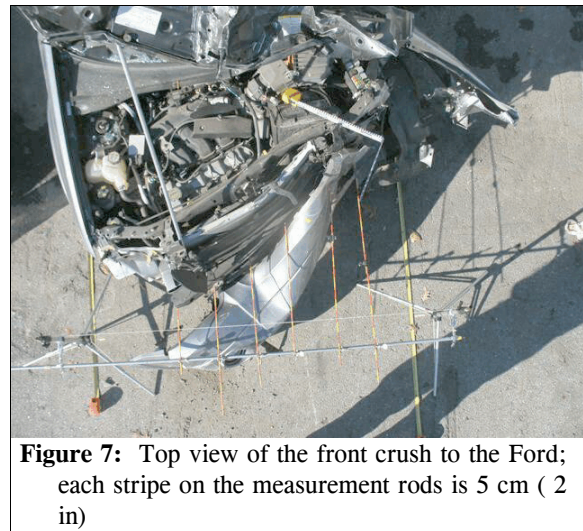
**Exterior Damage Event 3:** The Ford sustained front plane damage during the impact with the building. The left portion of the front bumper, the left headlamp/turn signal, left front fender, and the hood were directly damaged. The direct damage began at the front left bumper corner and extended 50 cm (19.7 in) across the bumper. The crush measurements were taken at the bumper level and the maximum residual crush was 66 cm (26 in) occurring at  $C_1$  (**Figure 7**). The left wheelbase was reduced 42 cm (16.9 in). The right wheelbase was extended 5 cm (2 in). The induced damaged involved the left A-pillar, roof, left roof side rail, left front door, and the right front door.

**Damage Classification Event 3:** The CDC was 12FLEW3 (0 degrees). The WinSMASH program could not be used to calculate Delta V since the brick wall was displaced. However, the Barrier algorithm of WinSMASH was used to calculate an Barrier Equivalent Speed (BES) based on the front crush. The calculated BES was 57 km/h (35.4 mph).

**Exterior Damage Event 4:** The right quarter panel was damaged during the impact with the trash can. The direct damage from this impact was masked by the damage from the impact with the brick support column. No crush measurements could be determined.



**Figure 6:** Damage on the right quarter panel from the impacts with the trash can and brick support column



**Figure 7:** Top view of the front crush to the Ford; each stripe on the measurement rods is 5 cm ( 2 in)

**Damage Classification Event 4:** The CDC was 03RBE999 (90 degrees). Since there was overlapping damage, columns 6 and 7 of the CDC were coded unknown. The severity of the damage was minor.

**Exterior Damage Event 5:** The Ford sustained damage on the right quarter panel during the impact with the brick support column. The quarter panel and right rear corner of the back bumper fascia were directly damaged. The direct damage began 38 cm (15 in) rear of the right rear axle and extended 40 cm (15.7 in) rearward on the right plane. The crush measurements were taken at the mid-quarter panel level and the maximum residual crush was 7 cm (2.8 in) occurring at C<sub>2</sub>. The induced damage involved the quarter panel and the back bumper fascia.

**Damage Classification Event 5:** The CDC was 03RBEE1 (90 degrees). Since the support column was displaced by the impact, the Barrier algorithm of the WinSMASH program was used to calculate and Barrier Equivalent Speed (BES) based on the right plane crush. The calculated BES was 5 km/h (3.1 mph).

The vehicle manufacturer's recommended tire size was P235/70R16. The vehicle was equipped with tires of the recommended size. The Ford's tire data are shown in the table below.

Tire	Measured Pressure		Vehicle Manufacturer's Recommended Cold Tire Pressure		Tread Depth		Damage	Restricted	Deflated
	kPa	psi	kPa	psi	milli-meters	32 <sup>nd</sup> of an inch			
LF	Flat	Flat	207	30	7	9	Sidewall cut	Yes	Yes
LR	Flat	Flat	207	30	8	10	None	No	Yes
RR	Flat	Flat	207	30	9	11	None	No	Yes
RF	Flat	Flat	207	30	7	9	Sidewall cut	No	Yes

**Vehicle Interior:** The inspection of the interior of the Ford revealed a scuff on the lower left instrument panel from contact by the driver's left knee. The lower instrument panel on the right side of the steering wheel was broken from contact by the driver's right knee. The energy absorbing steering column was compressed 2 cm (0.8 in) from contact by the driver's chest. The steering wheel was not deformed.

The left front and right rear doors were jammed closed. The right front door, left rear door, and back hatch remained closed and operational. Prior to the crash, the glazing for the adjustable windows was closed and the remaining glazing was fixed. The windshield was in place and cracked from impact forces and had been partially cut, probably during rescue activities. The left front glazing was disintegrated from impact forces.



The vehicle sustained four intrusions of the passenger compartment. The most severe intrusions into the driver's space involved the toe pan, left A-pillar, and left instrument panel, which intruded longitudinally 7 cm (2.8 in), 7 cm (2.8 in), and 3 cm (1.2 in), respectively.

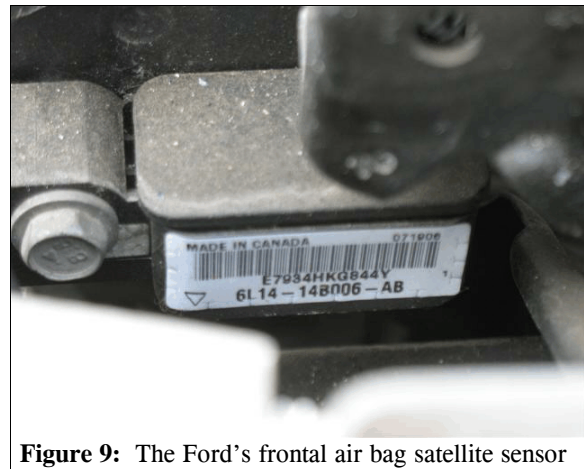
#### AUTOMATIC RESTRAINT SYSTEM

The Ford was equipped with a Certified Advanced 208-Compliant (CAC) frontal air bag system that consisted of dual stage driver and front right passenger frontal air bags, a front right passenger weight sensor, driver seat track sensor, safety belt switch sensors, retractor-mounted and buckle-mounted pretensioners. The manufacturer has certified that the vehicle is compliant to the Advanced Air Bag portion of the Federal Motor Vehicle Safety Standard (FMVSS) No. 208. Neither frontal air bags deployed in this crash.

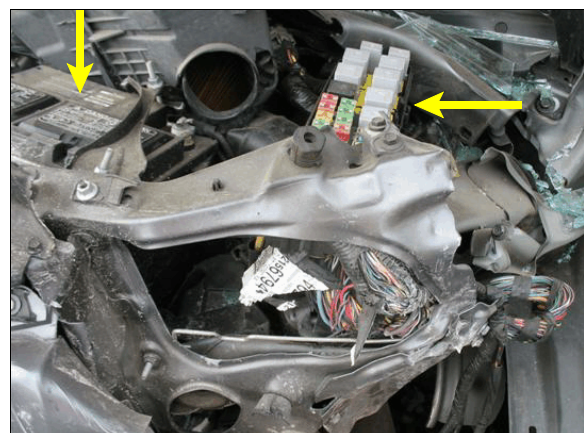
**Air Bag Related Components:** The Ford's Restraint Control Module (RCM), which contains the EDR was harvested from the vehicle and sent to NHTSA headquarters for imaging by the manufacturer. The RCM and the electrical connections (**Figure 8**) were examined prior to removal. There was no damage to the RCM and the electrical wires and connectors that were visible were intact and undamaged. The frontal air bag satellite sensor (**Figure 9**) was also examined. The component numbers on the sensor were E7934HKG844Y and 61-14-14B006-AB. The sensor was located on the upper center radiator support. Its location placed it inboard of the area of the direct frontal damage. There was no visible damage to the sensor. The electrical connections and wires that were visible were intact and undamaged. The Ford's battery and power distribution box (**Figure 10**) were located within the engine compartment on the driver's side front corner. The power distribution box contains the high current fuses for the vehicle's main electrical systems. The battery and power distribution box were in the area of the direct frontal damage. The



**Figure 8:** The condition of the Ford's ACM prior to removal from the vehicle



**Figure 9:** The Ford's frontal air bag satellite sensor



**Figure 10:** The battery and power distribution box were located in the front left corner of the Ford's engine compartment in the area of the direct damage

battery was displaced but it was not fractured. The power distribution box and electrical wiring were damaged.

**Driver's Frontal Air Bag Non-Deployment Discussion:** Photographs of the damaged building (Figures 11 and 12) showed that the brick wall was partially displaced producing a small hole in the wall. There was a steel support column at the corner of the building behind the brick wall, which was indirectly engaged by the vehicle as the brick wall was displaced. It is possible that the yielding of the brick wall was a factor in the non-deployment of the driver's frontal air bag. It is this contractor's understanding that the RCM must make the decision to deploy the frontal air bags within approximately 40-50 ms following Algorithm Enable (AE). It's possible that due to the yielding of the brick wall the vehicle's acceleration did not reach the deployment threshold within this time frame. Additional factors were that the driver's seat was in the forward track position and the driver was restrained by the lap-and-shoulder belt.



**Figure 11:** View northeast to final rest position of the Ford and the damage to the building from the impact



**Figure 12:** On-scene photo of the interior damage to the building from the impact by the Ford; view to southeast

### EVENT DATA RECORDER

The EDR report provided by the manufacturer contained an RCM analysis block, acceleration charts, and Delta V charts for both the Frontal Crash Sensor (FCS) and the RCM. No pre-crash data addressing accelerator pedal position, vehicle speed, engine RPM, or brake status were reported. The RCM analysis section reported the following: The driver's safety belt was buckled and the driver's seat track position was "Forward." The RCM did not command restraint deployment. The velocity crash recording threshold was met 82 ms after frontal AE. There were between 0 and 1 minute from "key-on" until AE. The front safing criteria was met 35 ms after AE. The following values were extrapolated from the acceleration and Delta V charts: The maximum velocity change reported by the FCS was approximately -31.4 km/h (-19.5 mph) at 104 ms following AE. The maximum FCS-reported acceleration was approximately -154 g at 82 ms following AE. The maximum RCM-reported velocity change was approximately -24.6 km/h (-15.3 mph) at 110 ms following AE. The maximum RCM-reported acceleration was approximately -38.5 g at 110 ms following AE. The maximum FCS-reported velocity change prior to 50 ms was approximately 3.2 km/h (2 mph), which occurred at 40 ms following AE. The maximum FCS-reported acceleration prior to 50 ms was approximately 10 g, which occurred at 38 ms following AE. The maximum ACM-reported velocity change prior to 50 ms was approximately 1.6 km/h (-1 mph), which occurred at 38 ms following AE. The maximum ACM-

reported acceleration prior to 50 ms was approximately -10 g, which occurred at 38 ms following AE. There were no diagnostic codes detected between key-on and the onset of the event. The FCS's communication was interrupted 175 ms after AE. This was probably the result of a loss of power due to the crash damage.

## **MANUAL RESTRAINT SYSTEM**

The Ford was equipped with lap-and-shoulder safety belts in the front and second rows. The driver's safety belt was equipped with continuous loop belt webbing, an adjustable upper anchor that was in the full-up position, a sliding latch plate, an Emergency Locking Retractor (ELR), a retractor-mounted pretensioner, and a buckle-mounted pretensioner. Neither pretensioner actuated in this crash. The front right safety belt was similarly equipped, but had a switchable ELR/Automatic Locking Retractor (ALR). The second row safety belts were similar to the front right safety belt, but had fixed upper anchors and were not equipped with pretensioners.

The inspection of the driver's safety belt assembly revealed load marks on the belt webbing 6 cm (2.4 in) in length that were located 39 cm (15.4 in) above the stop button. There were also load marks on the latch plate belt guide and the D-ring. This evidence indicated that the driver was restrained at the time of the crash. The other seats were unoccupied.

## **CASE VEHICLE DRIVER KINEMATICS**

The restrained driver of the Ford [82-year-old male, 127 cm (50 in) and 59 kg (130 lbs)] was seen by a witness slumped over the steering wheel just prior to the crash. The seat track was adjusted to the forward position and the seat back was slightly reclined. The head restraint was adjusted to the full-up position and the distance from the top of the seat back to the top of the head restraint was 32 cm (12.6 in). The tilt steering column was located in the full up position. The driver was wearing glasses at the time of the crash.

The driver was displaced forward by the curb impacts (events 1 and 2) and probably rebounded. He was again displaced forward by the building impact (event 3) and loaded the safety belt and contacted the steering wheel. The steering wheel contact fractured the driver's sternum, multiple ribs, teeth, cervical and thoracic vertebrae, and contused both lungs causing pneumothorax. The driver rebounded and he sustained multiple lumbar vertebrae fractures from contacting the seat cushion. He also contacted the back of his head on the metal vertical support of the head restraint sustaining a laceration on the back of the head. The vehicle rotated counterclockwise from the building impact and the driver was redirected to the right within the safety belt when the vehicle impacted the brick support column. He remained restrained in his seat position throughout the crash. Rescue personnel mechanically removed the left front door and extricated the driver from the vehicle.

The driver was transported by air ambulance to a trauma center where he was admitted for treatment of his injuries. He was subsequently admitted to a rehabilitation facility where he developed an atrial flutter, fever, hypotension, and a rapid heart beat. He was readmitted to a hospital where he expired 14 days following the crash. The table below presents the driver's injuries and injury sources.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 2005	Injury Source	Source Confidence	Source of Injury Data
1	Fractured ribs: left 1 <sup>st</sup> -2 <sup>nd</sup> , posteriorly with displacement; left 3 <sup>rd</sup> , laterally; right 3 <sup>rd</sup> - 5 <sup>th</sup> , anteriorly	serious 450203.3,3	Steering wheel hub and/or spokes and rim	Certain	Hospitalization records
2	Contusion right and left lungs, underlying right and left rib fractures, respectively	serious 441411.3,3	Steering wheel hub and/or spokes and rim	Certain	Hospitalization records
3	Pneumothorax, tiny, left lung, not further specified; resolved prior to initial hospital discharge	moderate 442202.2,2	Steering wheel hub and/or spokes and rim	Certain	Hospitalization records
4	Fractured sternum: body and manubrium, non-displaced with trace retrosternal hematoma	moderate 450804.2,4	Steering wheel hub and/or spokes	Certain	Hospitalization records
5	Fractured teeth, not further specified	minor 251404.1,8	Steering wheel hub and/or spokes	Certain	Hospitalization records
6 7	Fracture C <sub>4</sub> and C <sub>5</sub> spinous processes	moderate 650218.2,6 650218.2,6	Steering wheel rim (indirect injury)	Possible	Hospitalization records
8 9 10	Fracture T <sub>2</sub> body, anterior, inferior endplate and left transverse processes of T <sub>1</sub> , T <sub>2</sub> , and T <sub>3</sub>	moderate 650420.2,7 650417.2,7 650420.2,7	Steering wheel rim (indirect injury)	Possible	Hospitalization records
11	Fracture, compression, comminuted, L <sub>4</sub> -2 column, inferior and superior endplates	serious 650634.3,8	Seat cushion, driver's (indirect injury)	Possible	Hospitalization records
12	Fracture L <sub>3</sub> superior endplate	moderate 650632.2,8	Seat cushion, driver's (indirect injury)	Possible	Hospitalization records
13	Laceration posterior scalp, not further specified with staples intact in posterior scalp	minor 110600.1,6	Head restraint, driver's seat	Possible	Interviewee (relative-son) Hospitalization records
14	Contusion left forehead, not further specified	minor 210402.1,7	Steering wheel rim	Probable	Hospitalization records

*Case Vehicle Driver Injuries (Continued)*

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Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 2005	Injury Source	Source Confidence	Source of Injury Data
15	Laceration left eyebrow, not further specified, sutured, with foreign body removal	minor 210600.1,7	Steering wheel rim	Probable	Hospitalization records
16	Contusion (hematoma) left eye, periorbital, not further specified	210402.1,2	Steering wheel rim	Probable	Hospitalization records
17	Contusions, obvious, about face, not further specified	minor 210402.1,0	Steering wheel hub and/or spokes	Certain	Hospitalization records
18	Contusion (hematoma, ecchymoses) extrapleural over left proximal lung (chest wall)	minor 410402.1,2	Steering wheel hub and/or spokes	Certain	Hospitalization records
19	Contusion over left shoulder/clavicle, not further specified	minor 710402.1,2	Torso portion of safety belt system	Probable	Hospitalization records
20	Contusions (bruising) bilateral arms, not further specified	minor 710402.1,3	Steering wheel rim	Possible	Hospitalization records
21	Abrasion, small, proximal left forearm, not further specified	minor 710202.1,2	Noncontact injury: flying glass, unknown source	Possible	Hospitalization records
22	Contusion (hematoma) over left wrist with significant swelling posterolateral distal forearm	minor 710402.1,2	Left instrument panel	Probable	Hospitalization records
23	Contusions (bruising) anterior, bilateral lower extremities including right shin	minor 810402.1,3	Left lower instrument panel (includes knee bolster)	Probable	Hospitalization records

