# Side Air Bags

## *Protection in Near Side Impacts*

Mercedes-Benz CIREN Center
Center for Injury Sciences
University of Alabama at Birmingham

# Side Air Bags

- CIREN Case
- Published Research
- Injury Kinematics & Modeling

# Side Impact Bar


Side
Impact
Bar

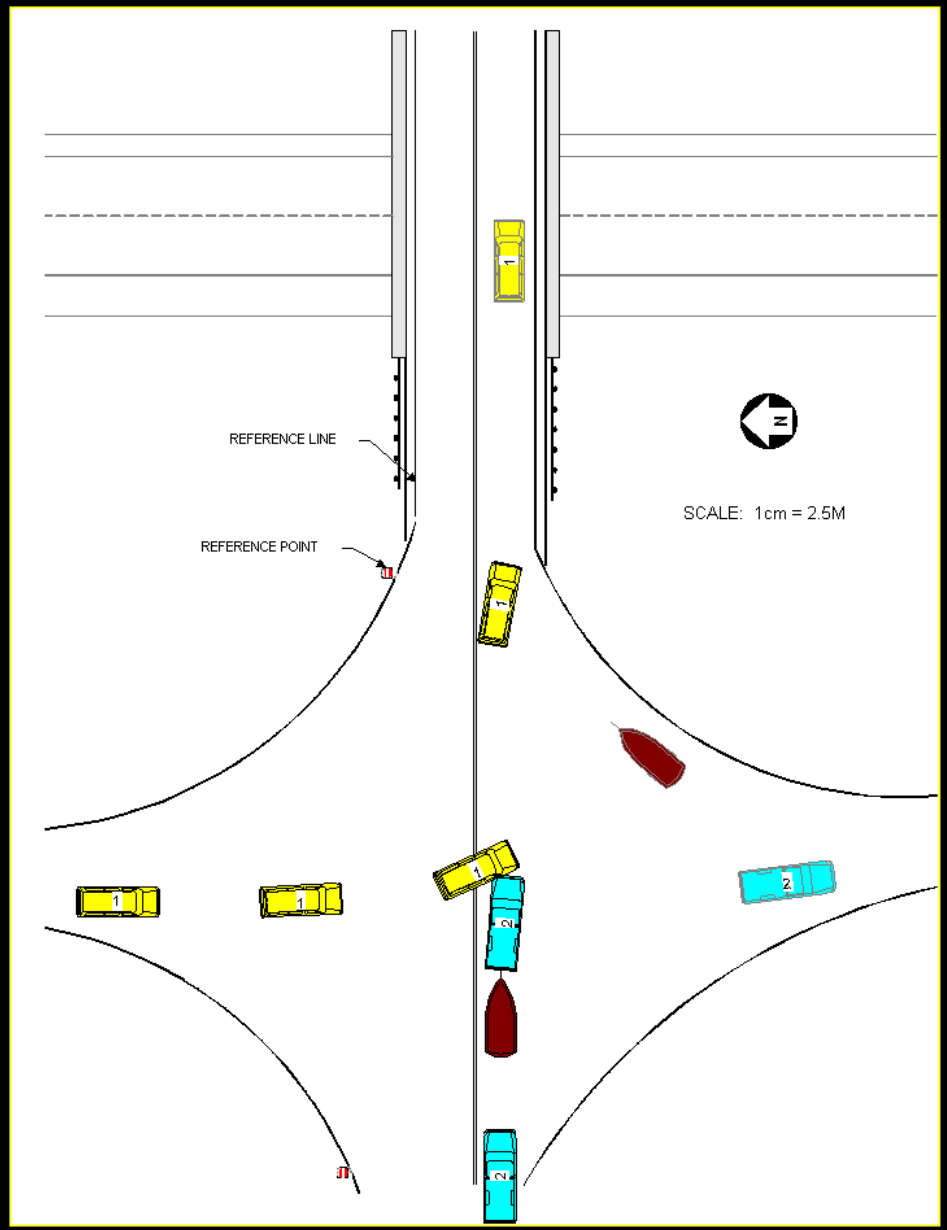
# Case 01

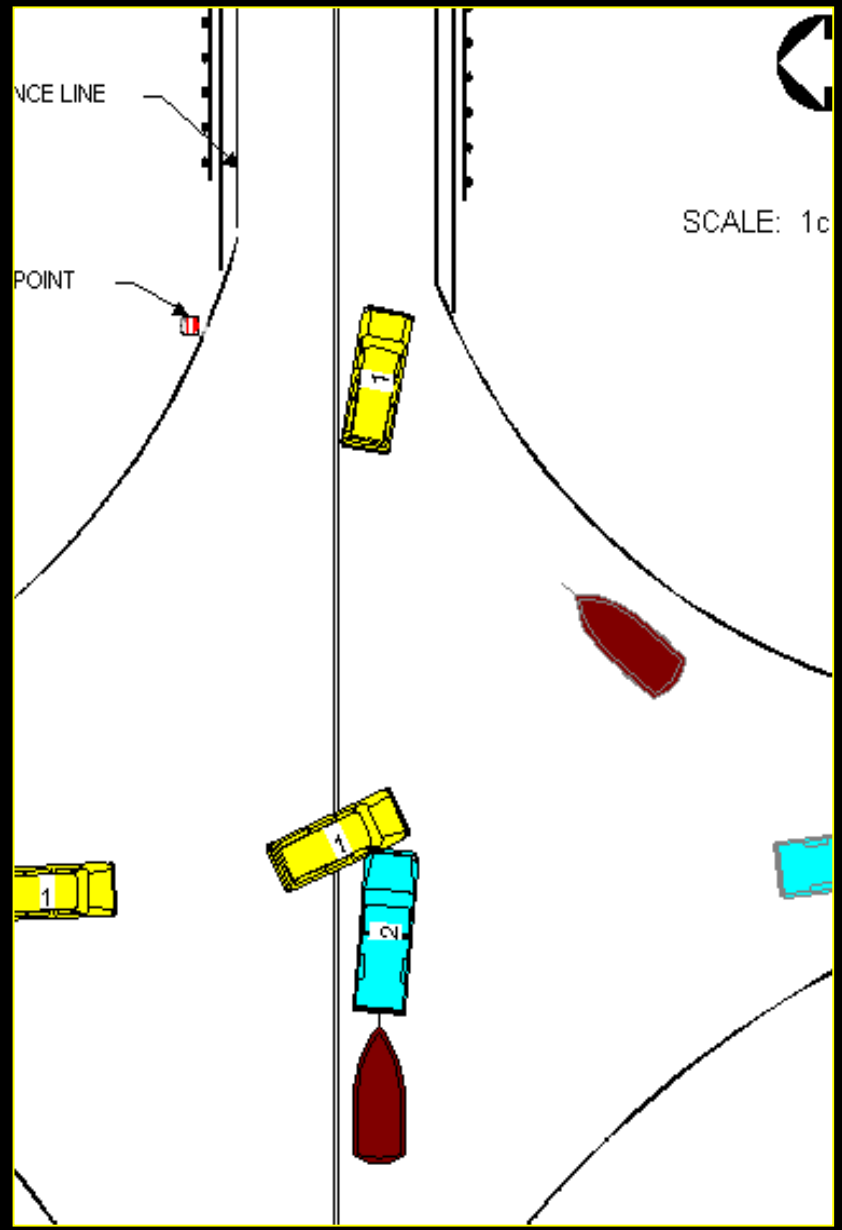
- 77 yr old female restrained passenger in a 2001 Chevrolet Venture struck in the passenger side door by a 1994 Chevrolet full size pick up truck
- Side airbag deployed

# CRASH DATA

| | |
|---|---|
| CASE VEHICLE | 2001 Chevrolet Venture |
| CASE SUBJECT | Front Right Passenger |
| OPPOSING VEHICLE | 1994 Chevy full size pickup pulling a boat & trailer |
| TIME OF CRASH | 3:24 p.m. / Daylight |
| ROAD CONDITIONS | Dry Asphalt |
| SPEED | 35 mph / 45 mph |
| AVOIDANCE | None |
| RESTRAINTS | Lap / Shoulder Belt<br>Side Airbag |

# Scene Diagram



# Approach Path of 2001 Chevrolet Venture

# Point of Impact

# Approach Path of 1994 Chevrolet Pick Up

# Point of Impact

# VEHICLE SPECIFICATIONS

*2001 Chevrolet Venture van*

| | |
|---|---|
| WHEELBASE | 284 cm. (112 in.) |
| LENGTH | 475 cm. (187 in.) |
| WIDTH | 183 cm. (72 in.) |
| CURB WT. | 1723 kg. (3799 lb.) |
| OCC. WT. | 127 kg. (280 lb.) |
| CARGO WT. | 45 kg. (100 lb.) |
| PDOF | 70 degrees |
| CDC | 02RPAW3 |
| BE | 18 km/h (11 mph) |

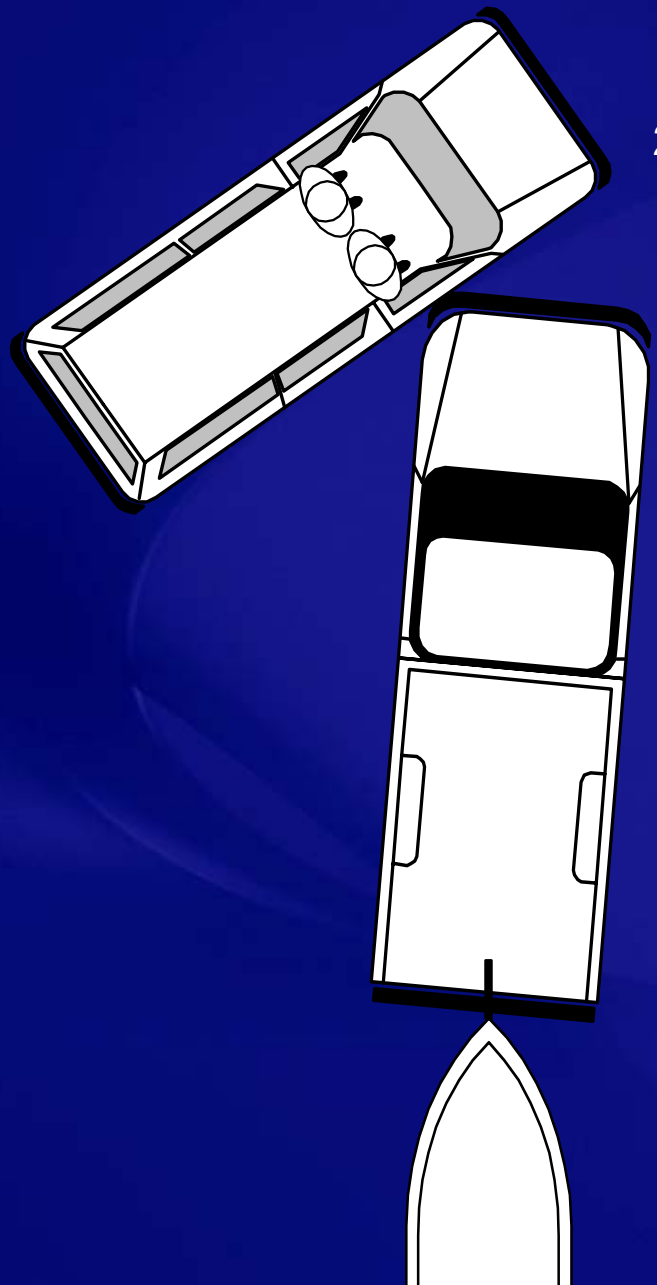
*1994 Chevrolet full size pickup*

| | |
|---|---|
| WHEELBASE | 334 cm. (131 in.) |
| LENGTH | 540 cm. (213 in.) |
| WIDTH | 195 cm. (77 in.) |
| CURB WT. | 1867 kg. (4117 lb.) |
| OCC. WT. | Unknown |
| CARGO WT. | Unknown (boat) |
| PDOF | Unknown |
| CDC | Unknown |

IMPACT ANGLE

**Driver**
**78 year old male**
**5'8"  160 lb**

**Right Front Passenger**
**78 year old female**
**5'2"  120 lb.**



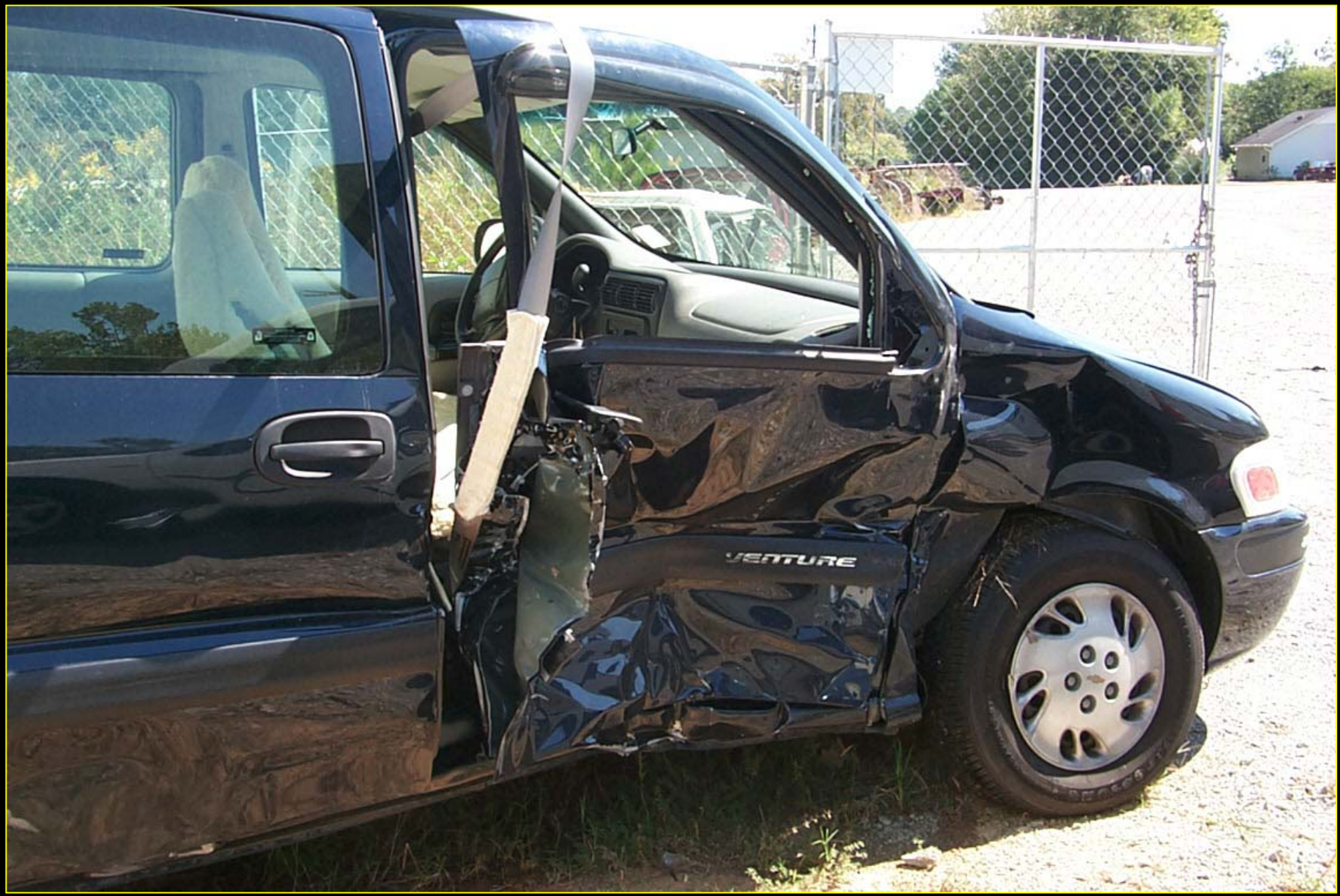
2001 Chevrolet Venture Van

1994 Chevrolet Pickup with Boat

# *2001 Chevrolet Venture Van - Front*

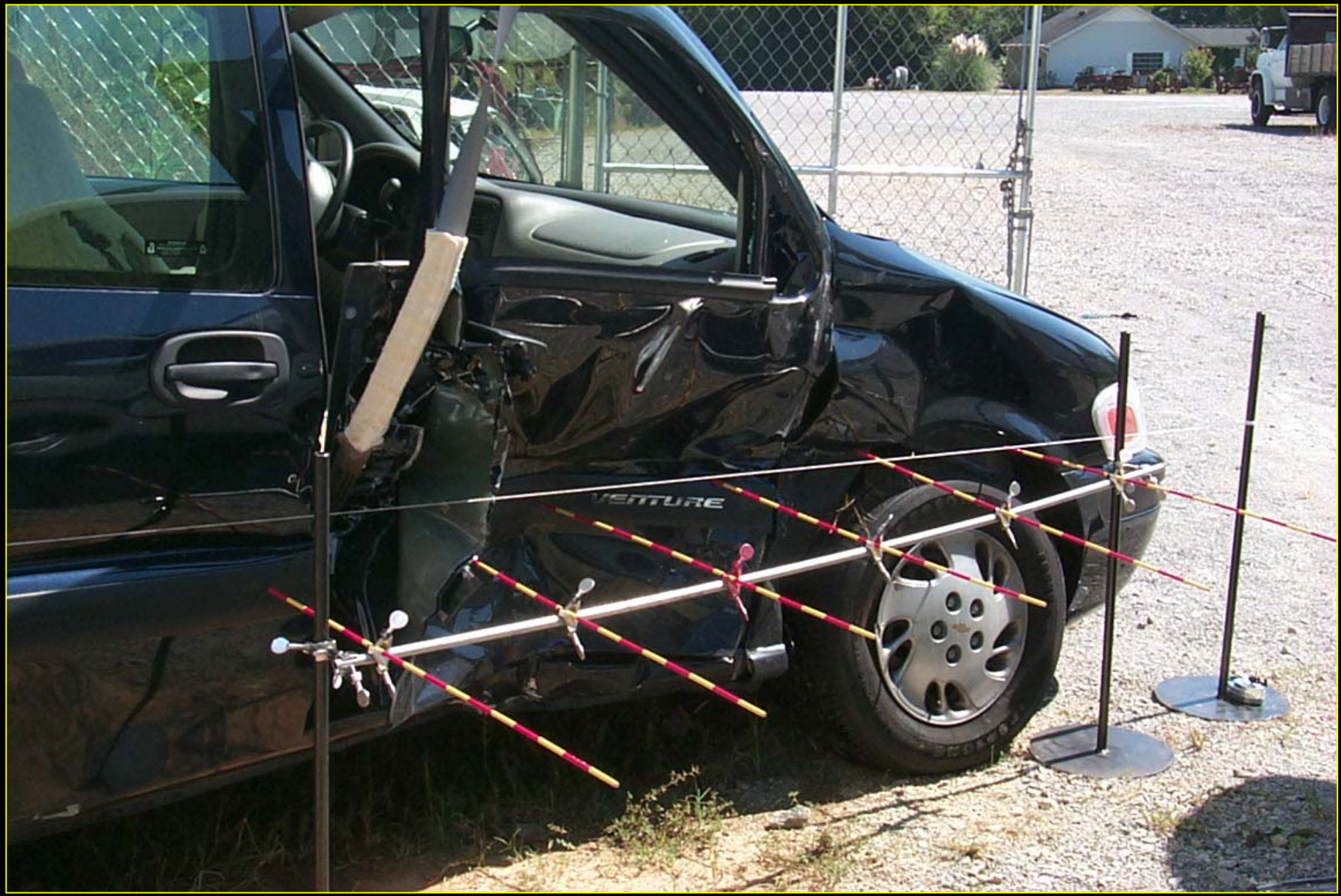
# 2001 Chevrolet Venture Van - Side

# 2001 Chevrolet Venture Van

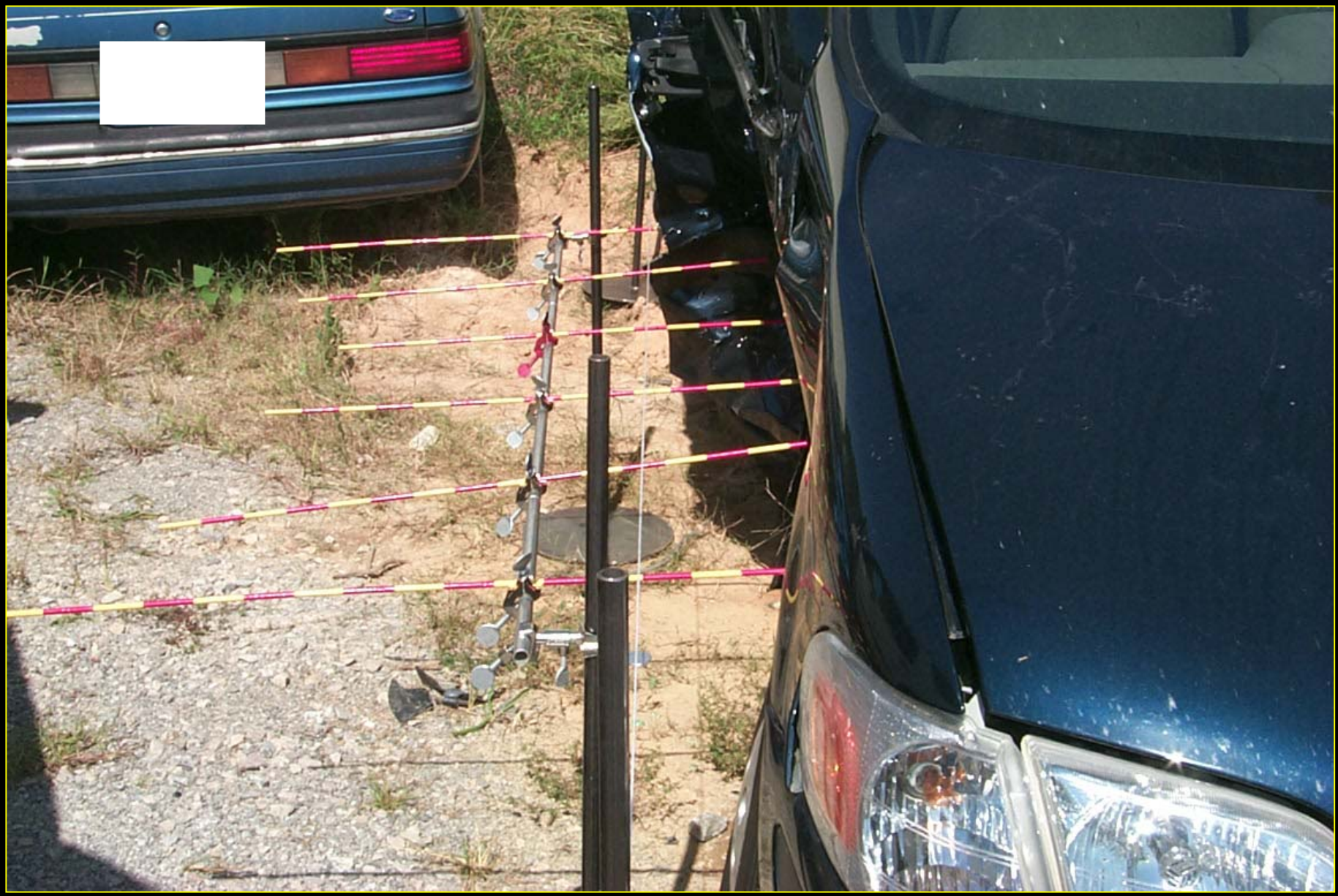


# 2001 Chevrolet Venture Van - Front

# *2001 Chevrolet Venture Van – Side Crush Measurement*



# *2001 Chevrolet Venture Van – Side Crush Measurement*



# INTRUSIONS

| | | |
|---|---|---|
| RIGHT FRONT DOOR PANEL | 10 cm. (4 in.) | Lateral |
| RIGHT FRONT SILL | 19 cm. (7 in.) | Lateral |
| RIGHT 'B' PILLAR | 19 cm. (7 in.) | Lateral |
| RIGHT FRONT SEATBACK | 17 cm. (7 in.) | Lateral |

# OCCUPANT CONTACTS

| | |
|---|---|
| RIGHT FRONT DOOR PANEL | Scuffed |
| RIGHT ‘B’ PILLAR | Scuffed |
| RIGHT FRONT SEATBELT | Blood |

# *2001 Chevrolet Venture Van – Interior*

# ***2001 Chevrolet Venture Van – Interior***

# 2001 Chevrolet Venture Van – Interior

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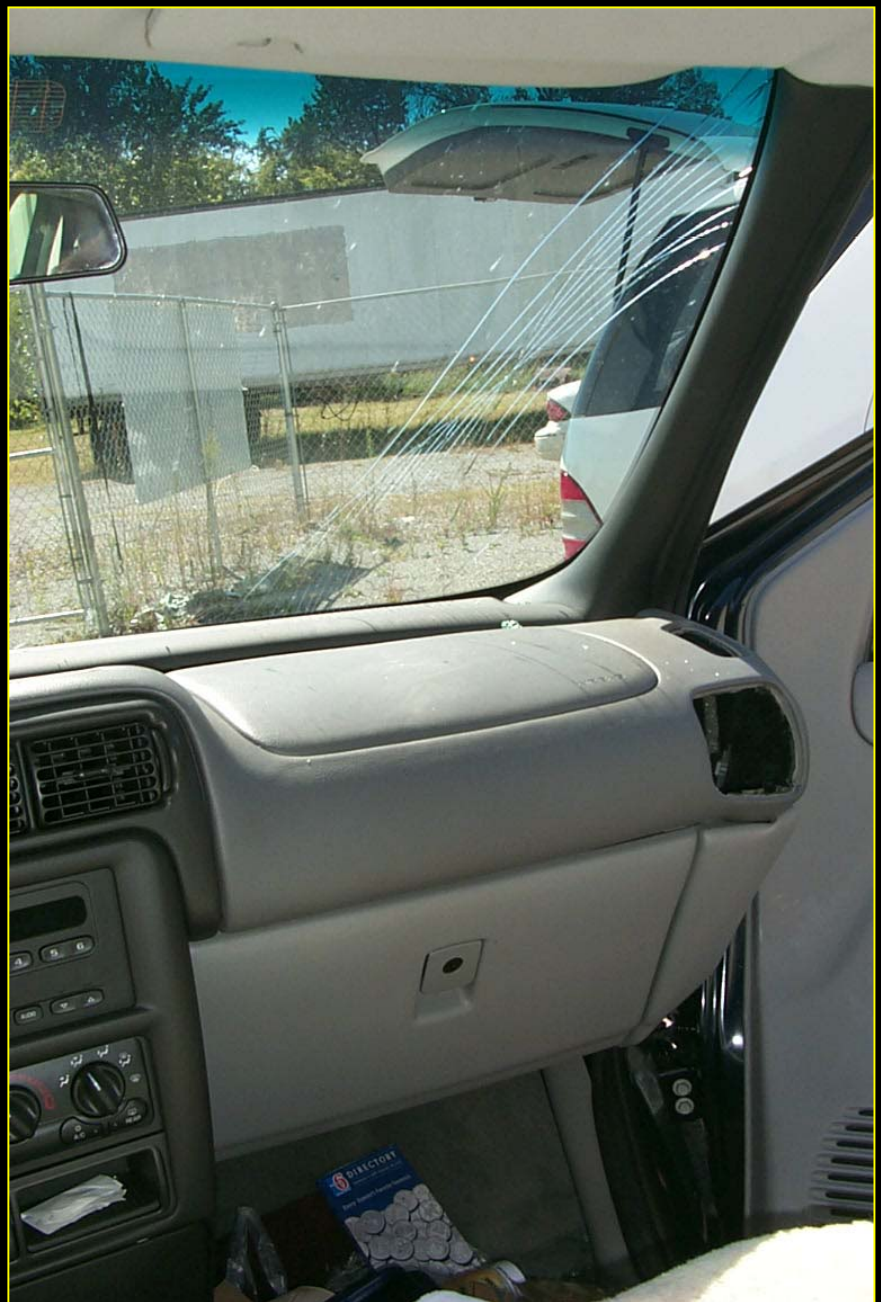
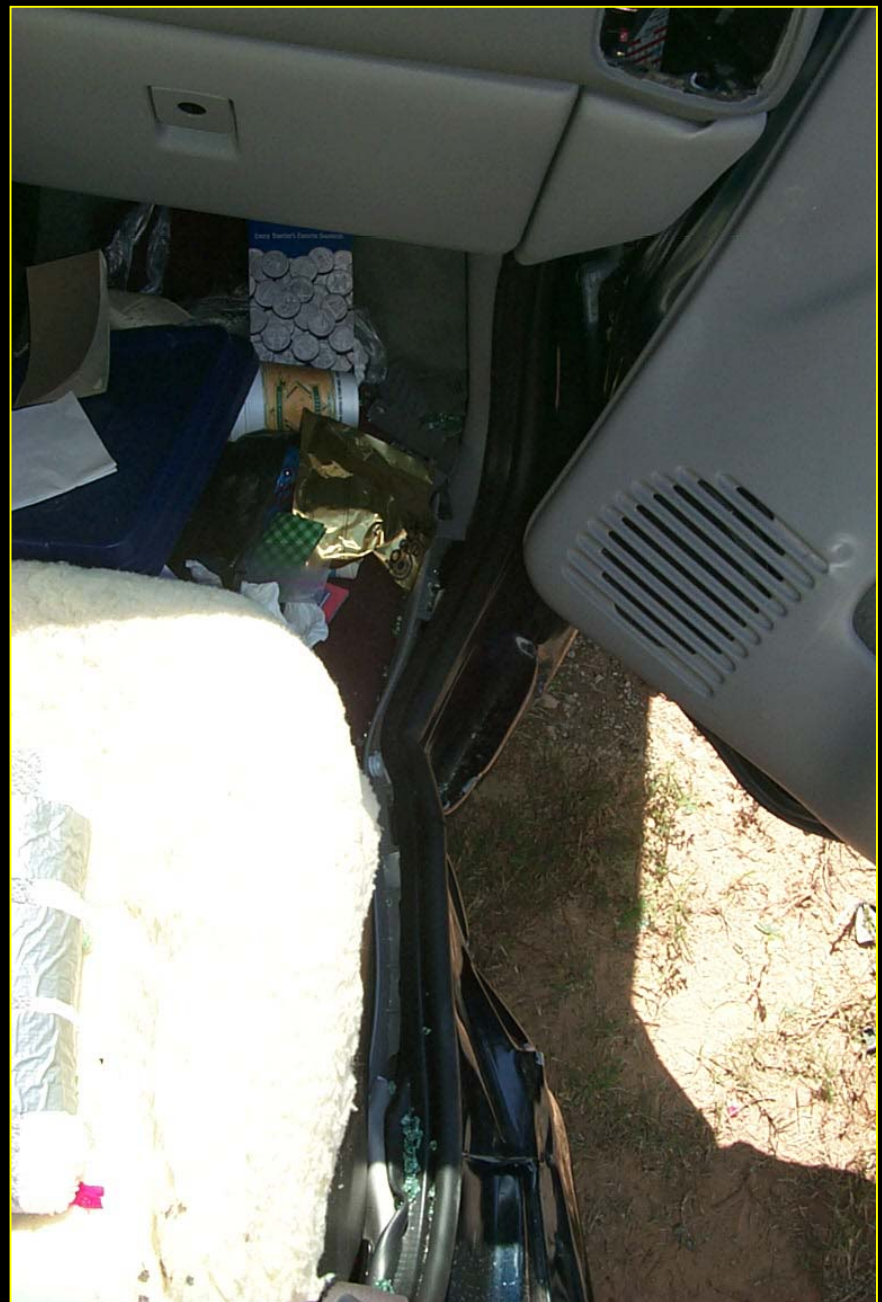
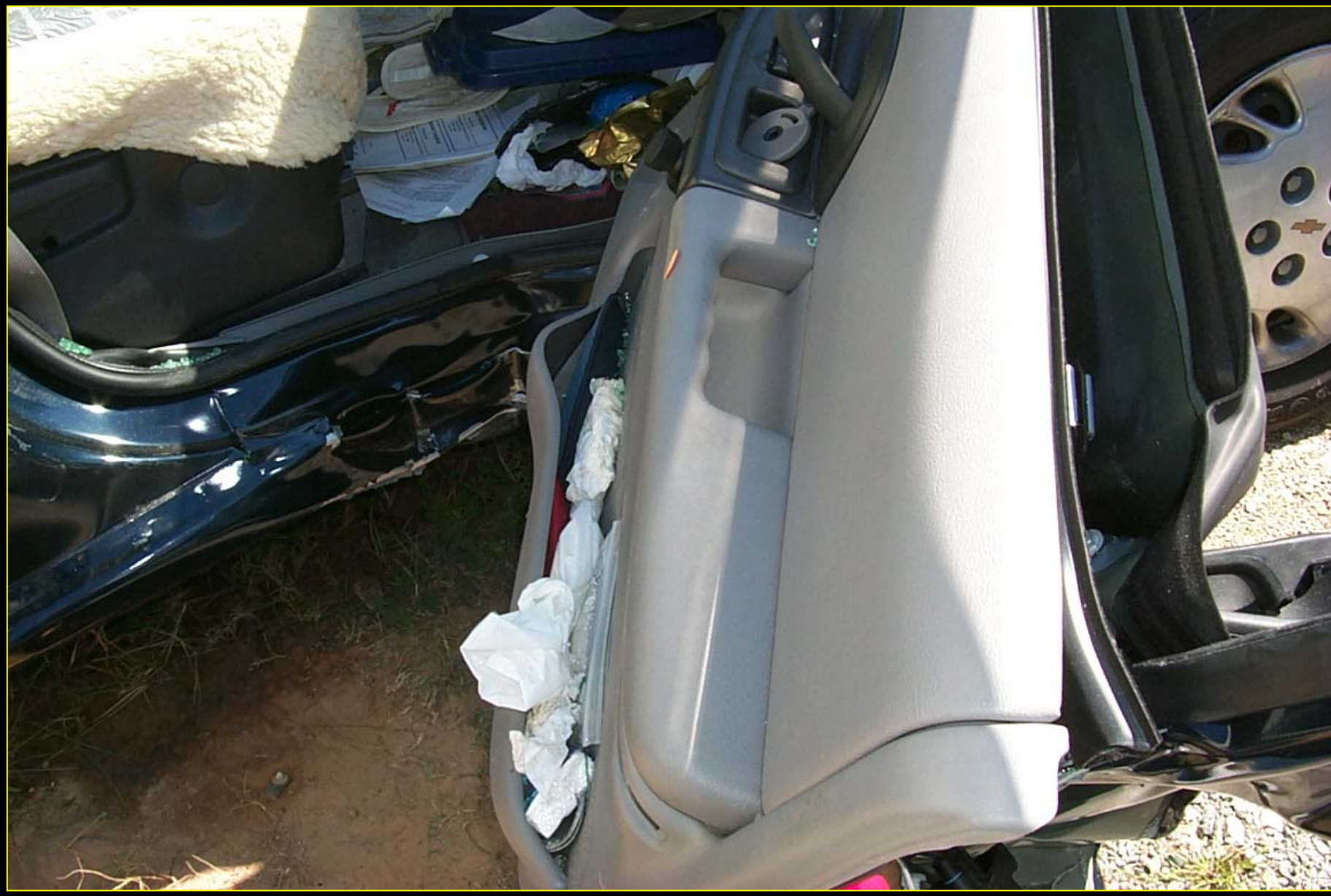
# 2001 Chevrolet Venture Van – Interior





# *2001 Chevrolet Venture Van – Interior*

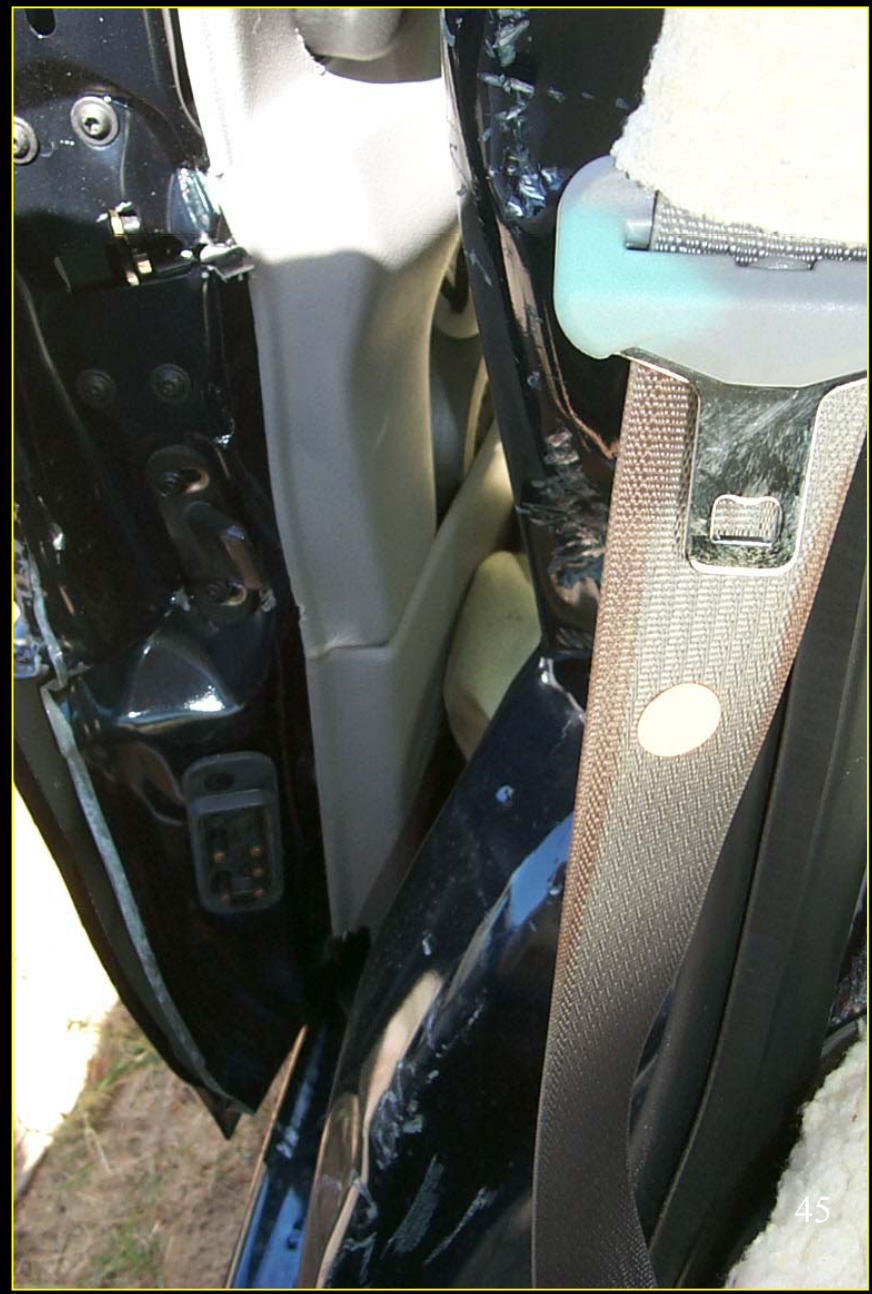


# 2001 Chevrolet Venture Van – Right Front Passenger Door

# *2001 Chevrolet Venture Van – Door Contact Point*

# 2001 Chevrolet Venture Van – Interior

# 2001 Chevrolet Venture Van – Interior



# RIGHT FRONT SIDE AIRBAG

## DRIVER'S SIDE

# Case 01Injuries

- Right comminuted distal clavicle fracture
- Right rib fracture, 2-6
- Right pulmonary contusion
- Right Pneumothorax
- Lt Zone I sacral fracture
- Right Acetabular fracture
- Bilateral superior/inferior pubic rami fracture

Right clavicle fracture
Right rib fractures, 2-6
Right pulmonary contusion

Direct contact with
right ‘B’ pillar

Confidence level:
Certain

Zone 1 sacral fracture right acetabular fracture, Bilateral superior/inferior pubic rami fracture

Direct contact with right door

Confidence level: Certain

Right pneumothorax

Non-contact
Result of rib fractures

Confidence level:
Certain

# The Association Between Side Air Bags and Risk of Injury in Near-Side Impact Motor Vehicle Collisions

Gerald McGwin, Jr., Jesse Metzger,
John R. Porterfield, Stephan G. Moran, Loring W. Rue, III

Center for Injury Sciences
University of Alabama at Birmingham

# Background

- Frontal impacts are the most common type of motor vehicle collision (MVC)
- Near-side are collisions associated with a higher risk of injury and death than other types of collisions
- Occupants are likely to contact interior and exterior structures of the vehicle
- Less opportunity for energy dissipation as compared to a frontal collision

# Background

- In the mid-1990's, side air bags (SABs) became available on a limited basis
- Since 1998, the proportion of new vehicles with SABs increased; the proportion of vehicles on the road with SABs is low
- SAB systems differ in terms of location and area(s) of protection offered

**Seat-Mounted Head and Thorax**

**Seat-Mounted Thorax**

# Roof-Mounted Curtain

# Roof-Mounted Curtain

# Background

- SABs function as an energy-absorbing barrier between the occupant and potentially injury-producing structures
- Simulated MVCs document that SABs have the potential to reduce forces on the occupant in near-side impact MVCs
- No population-based studies evaluating SAB effectiveness in reducing injury risk

# Objective

The objective of this study is to assess the effectiveness of SABs in reducing the risk of injury or death in near-side impact MVCs

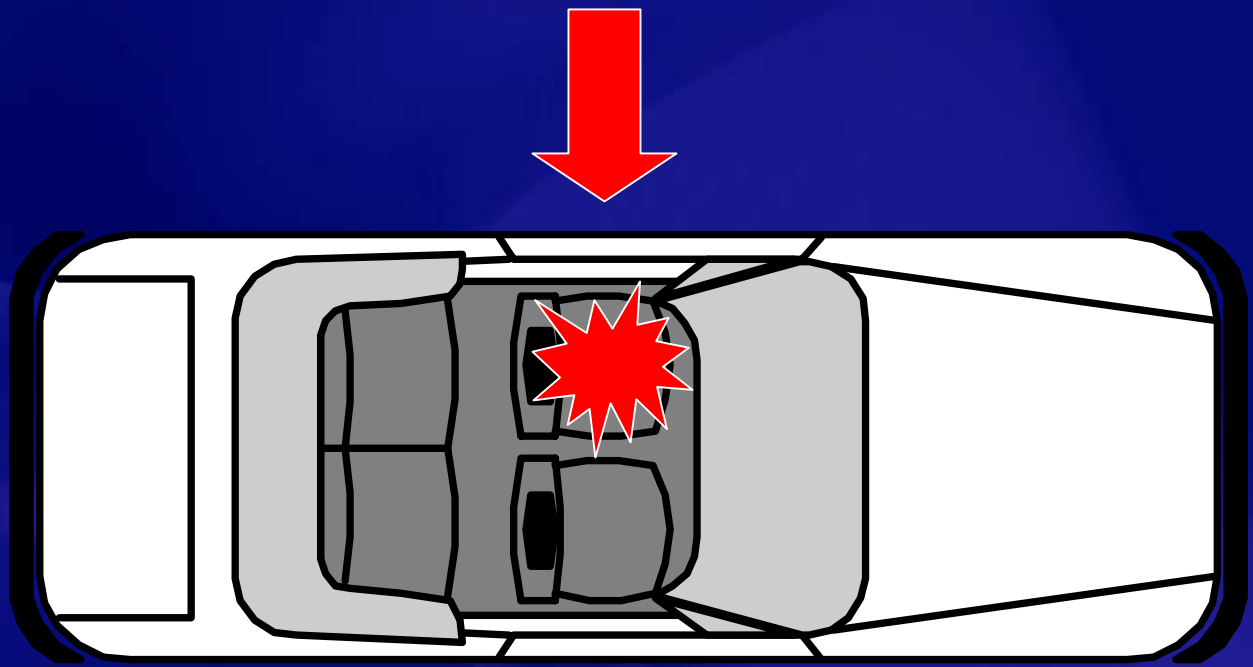
# Data Source

- National Highway Traffic Safety Admini-stration, General Estimates System (GES), 1997-2000
- Nationally representative probability sample selected from all police-reported MVCs which occur annually
- Information from approximately 48,000 police crash reports from 400 police jurisdictions is abstracted annually

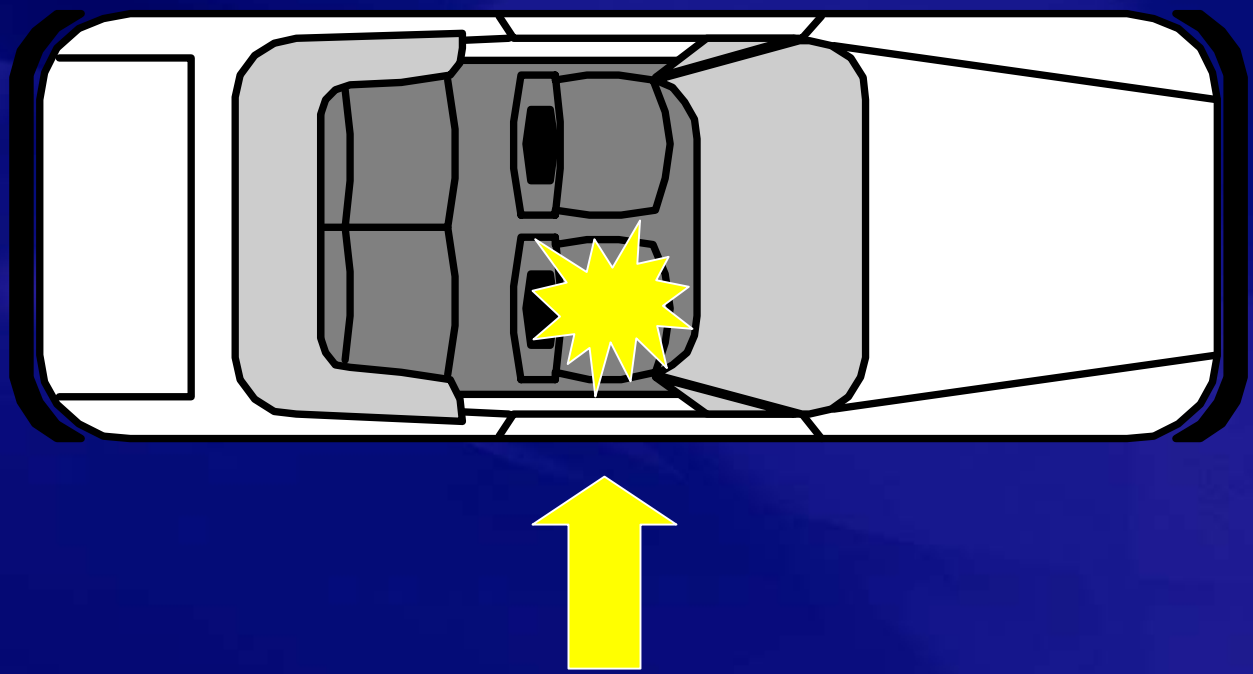
# Study Cohort

- Vehicles – *1998 and later model year passenger vehicles*
- Occupants – *Front seated drivers and passengers*
- Collisions – *Near-side impact collisions*

# Study Cohort



# Study Cohort



# Variable Selection

- Occupant Characteristics
  - Age, gender, seat belt use, injury severity
- Vehicle Characteristics
  - Body type, make, model, damage location
- SAB availability was identified by cross-referencing the make, model and year vehicles with information from vehicle manufacturers

# Variable Definitions

- Primary Outcome of Interest
  - An MVC-related injury according to the police crash report.
- Secondary Outcomes of Interest
  - Minor injury: *possible or non-incapacitating evident injury*
  - Major injury: *incapacitating evident injury or fatal injury*

# Statistical Analysis

- SUDAAN (version. 8.0.0) was used for statistical comparisons to account for multistage sampling of the GES
- Crude and adjusted risk ratios (RRs) and 95% confidence intervals (CIs) were calculated comparing the risk of injury among occupants in vehicles with and without SABs

# Statistical Analysis

$$\text{Relative Risk (RR)} = \frac{\text{Injury Risk Among } \textit{SAB Occupants}}{\text{Injury Risk Among } \textit{non-SAB Occupants}}$$

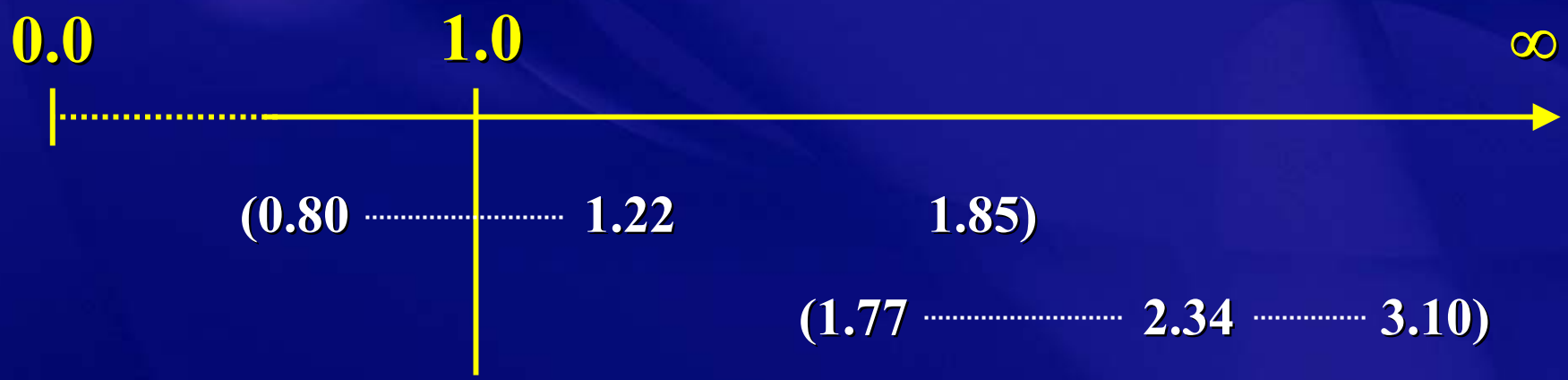
RR > 1 SABs associated with *increased* risk of injury

RR = 1 SABs *not* associated with risk of injury

RR < 1 SABs associated with *reduced* risk of injury

# Statistical Analysis

- 95% CIs indicate precision of RR estimates
- 95% CIs that do include the null value (i.e., 1.0) are generally consistent with non-statistically significant associations



## GES Occupant Population, 1997-2000

| Unweighted | Weighted |
|---|---|
| 572,039 | 66,108,394 |

**Exclusions**

- Vehicle Model Year Prior to 1998
- Vehicles Other than Cars, Minivans or SUVs
- Non Near-Side Collision to Front Seat Occupants
- Missing Information on Vehicle Model

## Final Study Population

| Unweighted | Weighted |
|---|---|
| 6,223 | 757,852 |

TABLE 1. Occupant Characteristics According to Side Air Bag Availability.

| | Side Air Bag Availability | | |
|---|---|---|---|
| | No<br>N = 655,777 | Yes<br>N = 102,075 | p-value |
| Age, mean | 36.9 | 41.4 | <0.001 |
| Gender, % | | | 0.160 |
| Male | 46.5 | 42.7 | |
| Female | 53.5 | 57.3 | |
| Seat belt use, % | | | 0.165 |
| No | 12.3 | 8.9 | |
| Yes | 87.7 | 91.1 | |
| Seating position, % | | | 0.057 |
| Driver | 80.2 | 84.0 | |
| Passenger | 19.8 | 16.0 | |

TABLE 2. Vehicle Characteristics According to Side Air Bag Availability.

| | Side Air Bag Availability | | |
|---|---|---|---|
| | No<br>N = 655,777 | Yes<br>N = 102,075 | p-value |
| Vehicle body type, % | | | 0.967 |
| Passenger car | 76.0 | 76.1 | |
| Sport utility vehicle | 17.0 | 17.2 | |
| Minivan | 7.0 | 6.7 | |
| Damage severity, % | | | 0.153 |
| None or minor | 42.7 | 37.8 | |
| Moderate or severe | 57.3 | 62.2 | |
| Model year | | | <0.001 |
| 1998 | 54.7 | 16.6 | |
| 1999 | 32.6 | 45.6 | |
| 2000 | 12.0 | 34.1 | |
| 2001 | 0.8 | 3.7 | |

TABLE 3. Risk Ratios (RRs) and 95% Confidence Intervals (CIs) for the Association Between Side Air Bag Availability and Injury.

| | Side Air Bag Available | | Unadjusted | Adjusted* |
|---|---|---|---|---|
| | No | Yes | RR (95% CI) | RR (95% CI) |
| | % | % | | |
| Injured | | | | |
| No | 81.7 | 82.5 | | |
| Yes | 18.3 | 17.5 | 0.96 (0.79-1.15) | 0.90 (0.76-1.08) |
| Minor | 15.8 | 14.7 | 0.93 (0.75-1.16) | 0.88 (0.71-1.09) |
| Major | 2.2 | 2.7 | 1.23 (0.82-1.85) | 1.15 (0.78-1.72) |

* Adjusted for age, gender, seat belt use, seating position, damage severity, damage location and vehicle body type.

# Study Limitations

- Information on actual SAB presence was not available in GES data files
- Information on specific type of SAB could not be associated with specific injuries
- SAB availability used as a surrogate for SAB deployment
- Only front seat occupants were studied

# Conclusions

- In near-side impact MVCs, front seat drivers and passengers in vehicles with SABs have the same risk of injury as occupants in vehicles without SABs
- Future research is needed to determine if SABs reduce the risk of specific injuries (e.g., head and chest injury)

# The Influence of Side Air Bags on the Risk of Head and Thoracic Injury Following Motor Vehicle Collisions

**Gerald McGwin, Jr., Jesse Metzger, Loring W. Rue, III**

**Center for Injury Sciences at the University of Alabama at Birmingham**

# Objective

To evaluate whether vehicles equipped head and thorax protection SABs reduce injury risk in these body regions

# Data Source

- National Highway Traffic Safety Administration, Crashworthiness Data System (CDS), 1995-2001
- Probability sample of all police-reported tow-away MVCs in the United States
- Scene, vehicle, collision, occupant, & medical characteristics collected

# Study Cohort

- Vehicles – *1998 and later model year passenger vehicles*
- Occupants – *Front seated drivers and passengers*
- Collisions – *Near-side impact collisions*

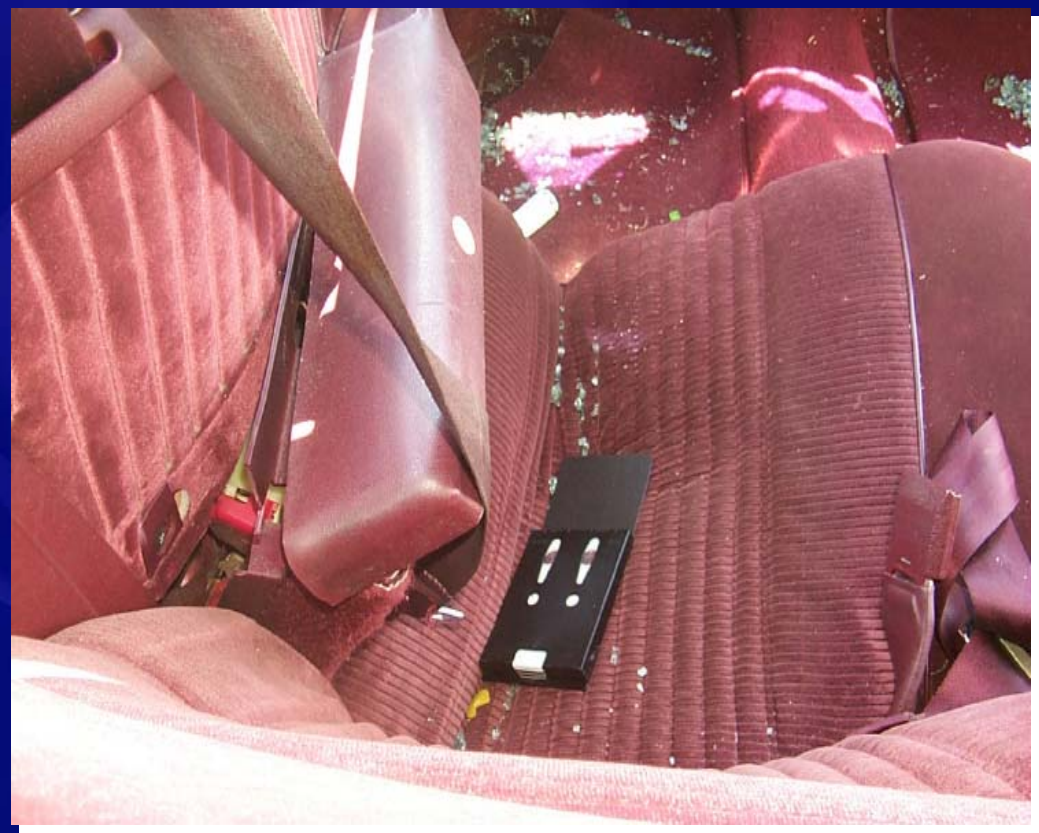
# Variable Selection

- Occupant Characteristics
  - *age, gender, seat belt use*
- Vehicle Characteristics
  - *curb weight, body type*
- Collision Characteristics
  - *ΔV (change in velocity), crush, intrusion*

# Variable Selection

## Crush *versus* Compartment Intrusion

Crush



Intrusion

# Variable Selection

- SAB availability was identified by cross-referencing the make, model and year vehicles with information from vehicle manufacturers
- SABs subclassified as to whether they provided head and/or thoracic protection

# Variable Selection

*Primary Outcomes of Interest*

*Head Injury – Any injury (AIS≥1) to AIS head, face, neck body regions*

*Thoracic Injury – Any injury (AIS≥1) to AIS thoracic body region*

# Statistical Analysis

- SUDAAN used for statistical comparisons to account for multistage sampling of the CDS
- Risk ratios (RRs) and 95% confidence intervals (CIs) were calculated comparing the risk of injury among occupants in vehicles with and without SABs

## CDS Occupant Population, 1995-2001

**35,747,517**

**Exclusions**

- Vehicle Model Year Prior to 1998
- Vehicles Other than Cars, Minivans or SUVs
- Non Near-Side Collision to Front Seat Occupants

## Final Study Population

**431,889**

**TABLE 1. Occupant and Collision Characteristics Among Occupants in Vehicles With and Without Side Air Bags.**

| | Side Air Bag Availability | | |
|---|---|---|---|
| | Yes<br>N = 99,810 | No<br>N = 332,079 | P-value |
| *Occupant* | | | |
| Age (in years), mean | 36.7 | 36.0 | 0.72 |
| Seat belt use, % yes | 89.0 | 81.2 | 0.04 |
| Ejection, % yes | 1.2 | 3.3 | 0.40 |
| Occupant type, % driver | 78.5 | 78.3 | 0.98 |
| *Collision* | | | |
| $\Delta V$ (in kmph), mean | 17.6 | 20.7 | 0.38 |
| Maximum crush (in cm), mean | 21.3 | 22.7 | 0.45 |

**TABLE 2. Vehicle Characteristics Among Occupants in Vehicles With and Without Side Air Bags.**

| | Side Air Bag Availability | | |
|---|---|---|---|
| | Yes<br>N = 99,810 | No<br>N = 332,079 | P-value |
| **Model year, %** | | | 0.03 |
| 1998 | 9.2 | 46.3 | |
| 1999 | 17.0 | 31.8 | |
| 2000 | 44.0 | 18.0 | |
| 2001 | 29.0 | 3.4 | |
| 2002 | 0.8 | 0.5 | |
| **Vehicle body type, %** | | | 0.43 |
| Passenger car | 74.6 | 73.5 | |
| Sport utility vehicle | 11.7 | 17.0 | |
| Minivan | 13.7 | 9.5 | |
| **Intrusion† (in cm.), %** | | | 0.85 |
| None | 83.9 | 85.3 | |
| 3 – 14 | 8.9 | 8.8 | |
| >14 | 7.2 | 5.9 | |

† Intrusion to the lateral aspect of the occupant's seating position.

**TABLE 3. Risk Ratios (RRs) and 95% Confidence Intervals (CIs) for the Association Between Side Air Bag Availability and Head and Thorax Injury.**

| | Injury Risk per 100 Occupants | | Unadjusted RR (95% CI) | Adjusted* RR (95% CI) |
|---|---|---|---|---|
| | Side Air Bag Availability | | | |
| | No | Yes | | |
| Head | 17.4 | 5.8 | 0.33 (0.14-0.79) | 0.25 (0.08-0.79) |

* Adjusted for age, gender, seat belt use, ejection, occupant type, model year, body type, intrusion, delta-V, and maximum crush.

**TABLE 3. Risk Ratios (RRs) and 95% Confidence Intervals (CIs) for the Association Between Side Air Bag Availability and Head and Thorax Injury.**

| | Injury Risk per 100 Occupants | | Unadjusted RR (95% CI) | Adjusted* RR (95% CI) |
|---|---|---|---|---|
| | Side Air Bag Availability | | | |
| | No | Yes | | |
| Thorax | 4.7 | 1.1 | 0.24 (0.08-0.69) | 0.32 (0.11-0.91) |

* Adjusted for age, gender, seat belt use, ejection, occupant type, model year, body type, intrusion, delta-V, and maximum crush.

# Study Limitations

- Information on actual SAB deployment not reliably available in CDS data files
- Thus, SAB availability used as a surrogate for SAB deployment
- SABs as standard versus optional equipment
- Only front seat occupants were studied

# Conclusions

- In near-side impact MVCs, front seat drivers and passengers in vehicles with SABs have lower risk of head & thoracic injury than those in vehicles without SABs
- Risk reduction is equivalent to seat belt effectiveness in frontal MVCs; much greater than frontal AB effectiveness

# IIHS Status Report

- Nearside Impacts
  - Drivers only, passenger cars
  - FARS/GES  RR dying
- Head SAB
  - 45% reduction risk of death
- Chest SAB
  - 11% reduction risk of death

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