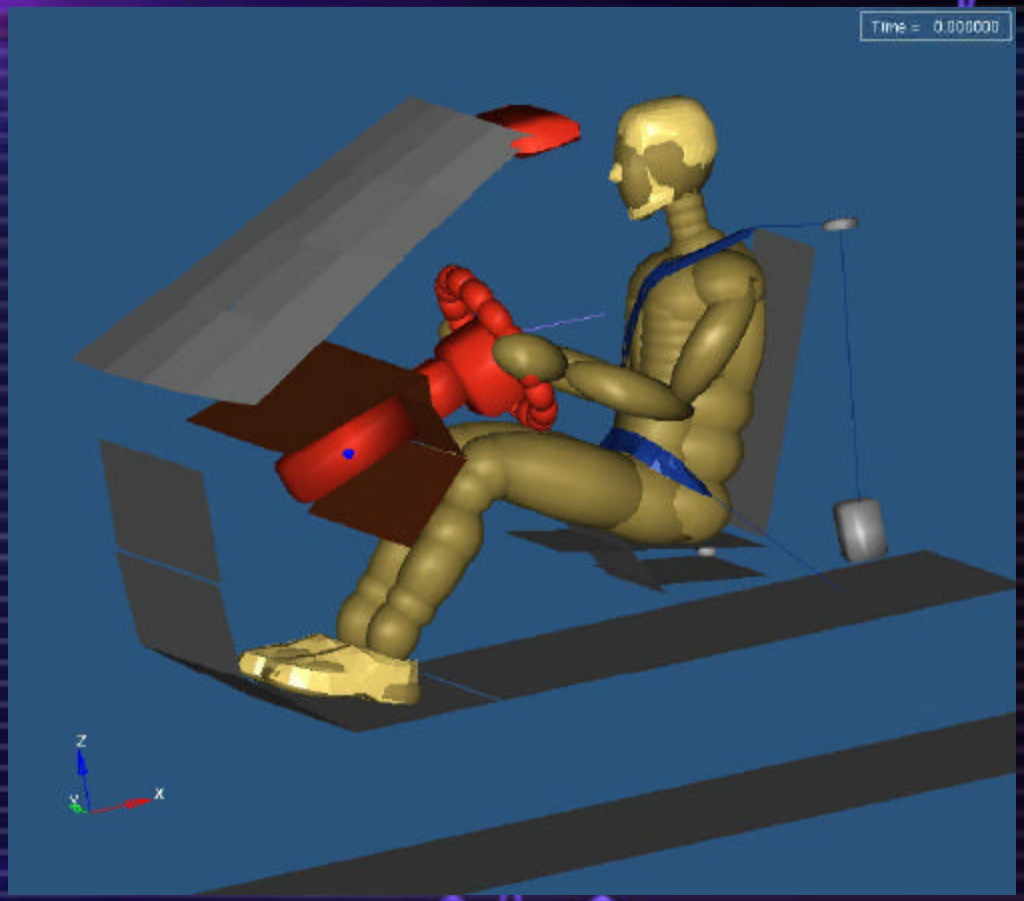
Crash, Vehicle and Restraint Factors and Their Influence on Thoracic Injury Patterns

Jeffrey S. Augenstein, Elana Perdeck, James Stratton, Jerry Phillips, Luis Labiste, Jeff MacKinnon
William Lehman Injury Research Center
University of Miami

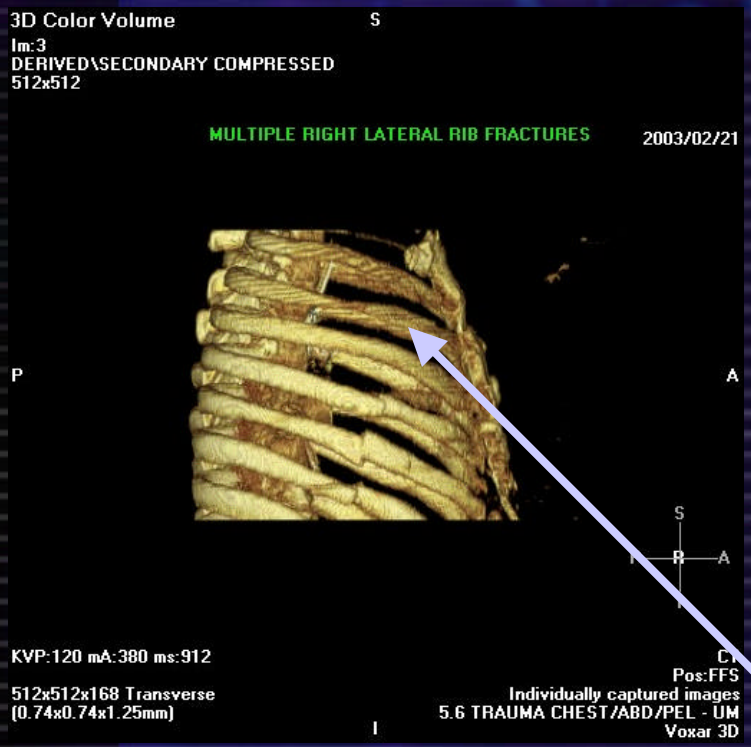
Kennerly Digges, George Bahouth, Khaled Mostafa
FHWA/NHTSA National Crash Analysis Center
The George Washington University

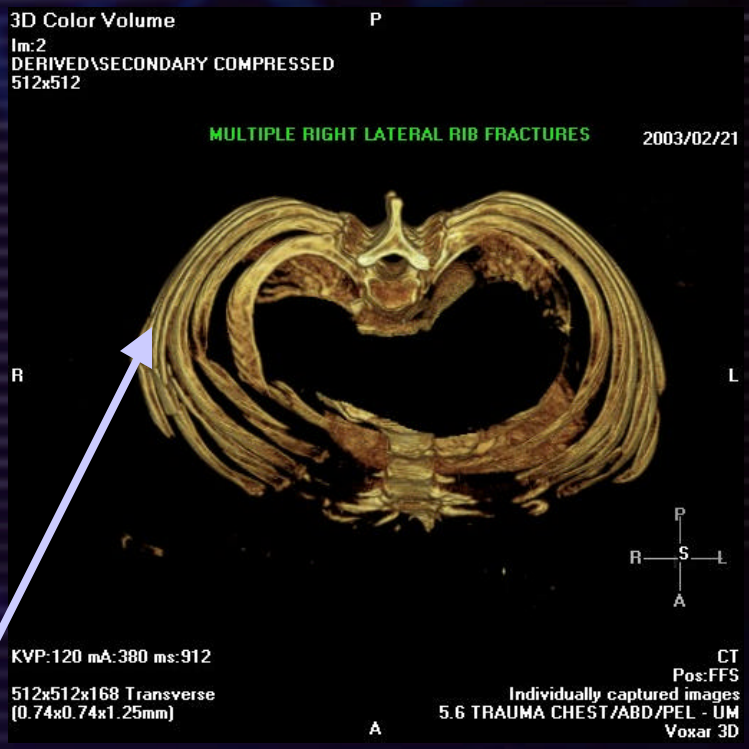
Stewart Wang, Larry Schneider, Mark Sochor, Paul Weber
University of Michigan Transportation Research Institute

Model of Driver in a Crash



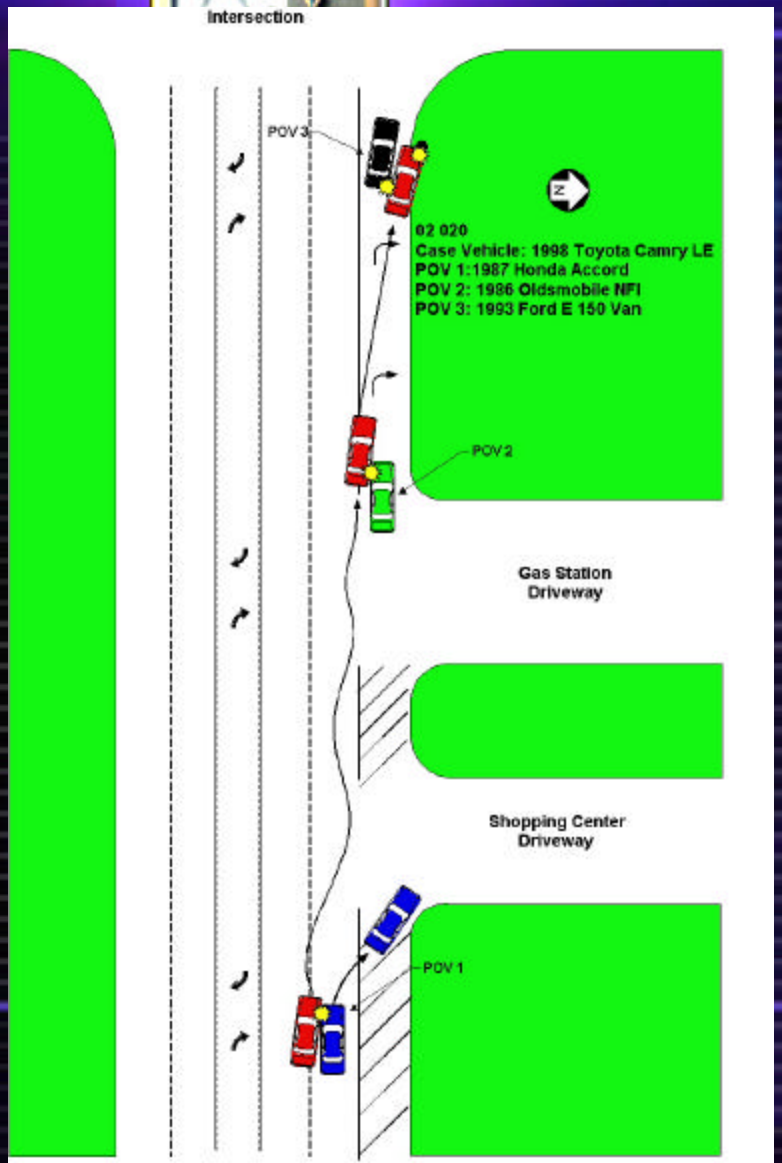
3-D CAT Scan





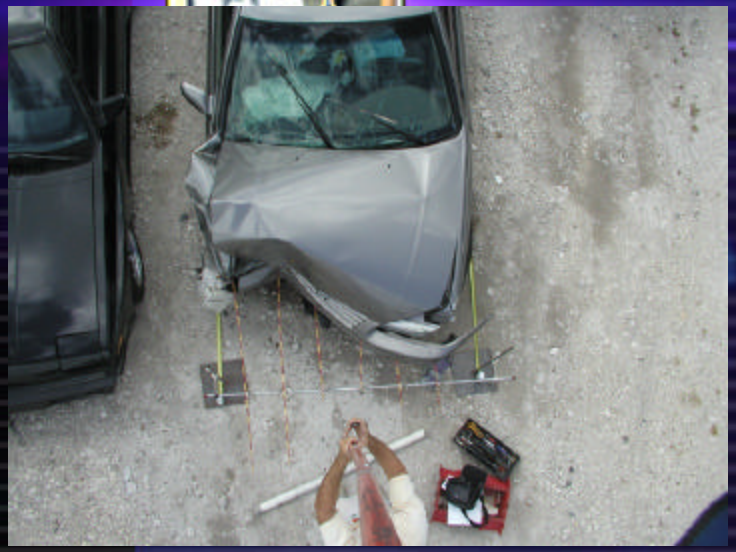
Rib Fractures

Example Case- Elderly Occupant



- 60 YO, Female Occupant
- 3-point Belt Used
- Right Rear Seat Occupant
- 1998 Toyota Camry

Example Case- 60 YO Occupant



- 21.1 MPH Frontal DV
- Semi- Narrow Object Impact
- 24” Max Crush

- (2) Low Severity Lateral Crashes followed by significant frontal
- Offset Frontal Crash into Concrete Pole

Example Case- Elderly Occupant

- Injuries Sustained
  - AIS 5 Rib Fx. (belt)
  - AIS 4 Splenic Lac. (belt)
  - AIS 3 Diaphragm Lac. (belt)
  - AIS 2 Sternum Fx. (belt)
- Possible Poor Belt Placement
- 4 days hospitalization
- Fatally Injured Occupant

Example Case- Case Significance

- Decreased injury tolerance for elderly female leads to rib fracture and fatality
- Injuries sustained by elderly introduce increased risk of fatality and prolonged recovery period
- Lung contusions/lacerations introduce respiratory complications

Basis for Injury Tolerance Criteria for Dummies

- Chest injury tolerance is based largely on cadaver tests
- Rib fractures are the most consistent injury measurements
- Resulting regulatory criteria for 50% male:
  - 60g on chest for longer than 3 ms.
  - 50 mm of chest deflection at chest center
- New generation dummies (Thor and EuroThor) can measure chest deflection in multiple locations –
- Predict soft tissue injuries?

Purpose

- Application of CIREN data to understand real world injury patterns for young and elderly
- Are cadaver rib fracture patterns like crash victims?
- Do cadaver rib fractures correlate to chest soft tissue injuries?
- How do injury patterns change with age and type of restraint?

Outline of Presentation

- Cadaver test results
- NASS data for elderly chest injuries
- CIREN data for elderly chest injuries
- CIREN rib fracture patterns vs. cadavers
- Summary & Conclusions

Injury Tolerance for Elderly, Based on Cadaver Tests

- Zhou, Rouhana et. al. 1996 proposed that tolerance to thoracic injury decreases with age in 3 categories (15-30, 30-65, 65+ yrs)
- Injury risks based on cadaver test results
- Study concluded that injury tolerance decreases by 20% for blunt loading and up to 70% for concentrated belt-loading for elderly population (65+)

NHTSA Cadaver Tests

- NHTSA has sponsored numerous cadaver tests with belts, air bags, and belts+air bags.
- UVa (Crandall) 14 belt only; 15 belt + bag
- MCW (Yoganandan) belt & air bag only
- Uva and MCW tests will be the basis for comparisons to be made later

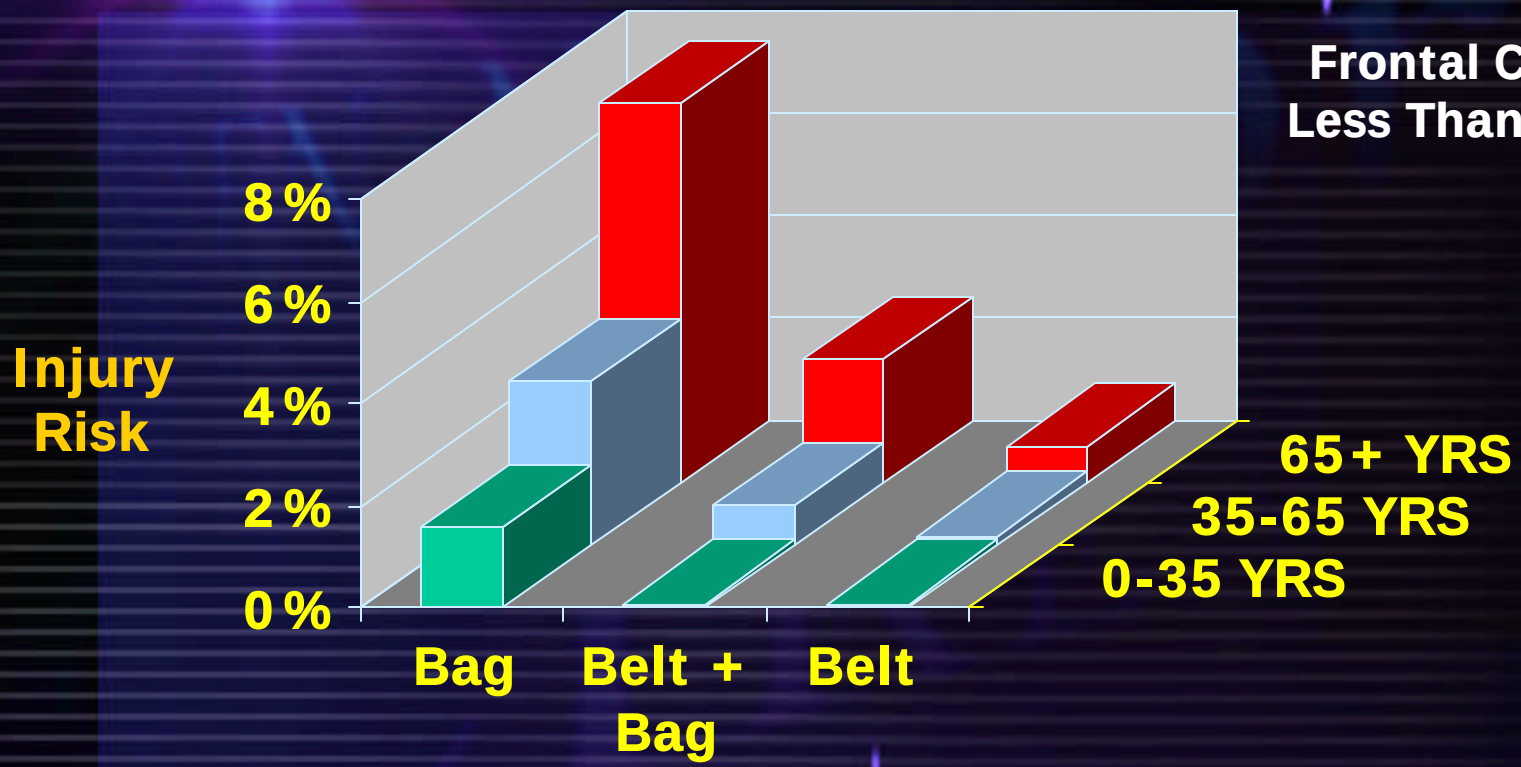
Outline of Presentation

- Cadaver test results
- NASS data for elderly chest injuries
- CIREN data for elderly chest injuries
- CIREN rib fracture patterns vs. cadavers
- Summary & Conclusions

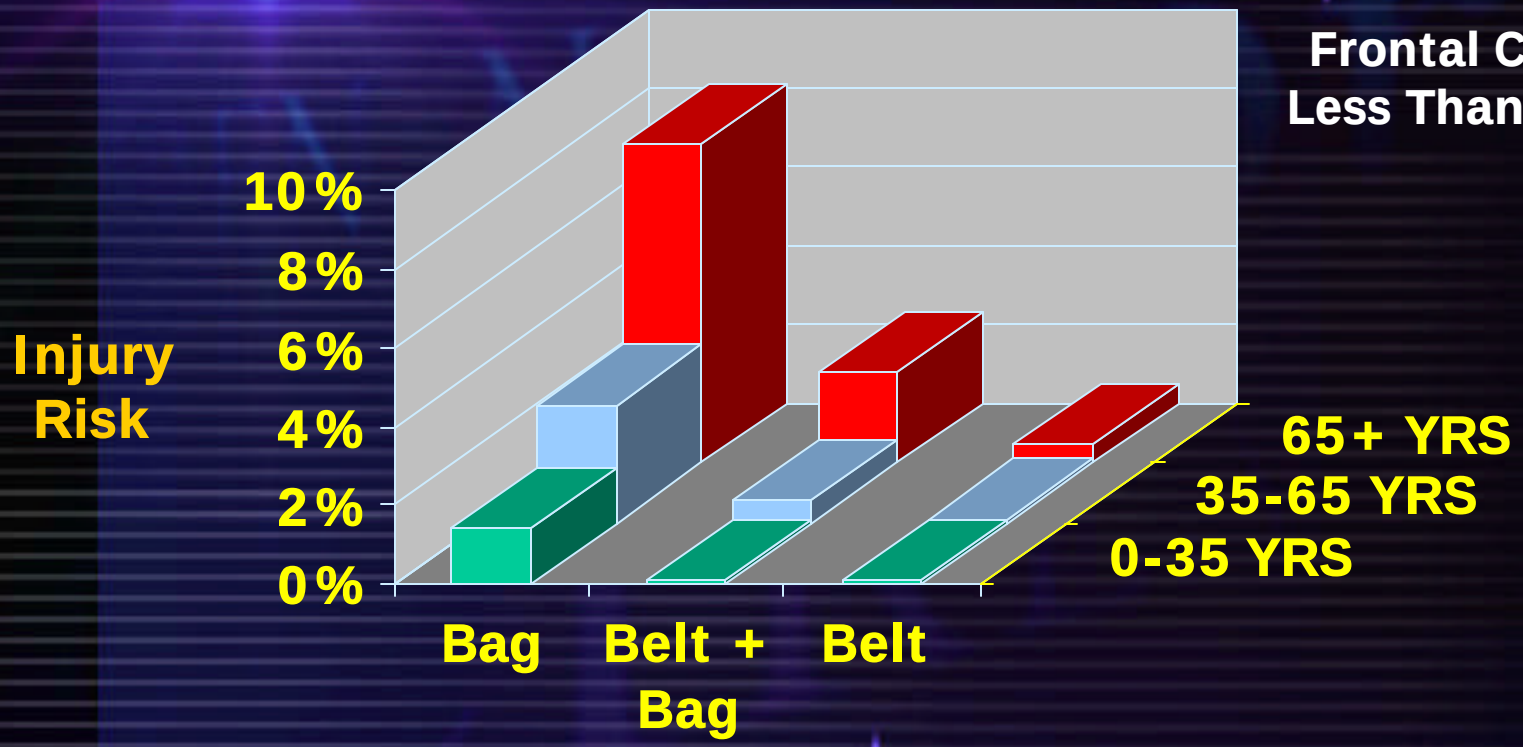
Data Utilized

- NASS/CDS 1990-2002
- Frontal Crashes (11,12,1 o'clock or 10,2 w/frontal damage)
- Front Seat Occupants Reviewed (driver, right front passenger)
- Filtered by:
  - Restraint usage (3-point belt)
  - Occupant age category (15-65, 65+ YRS)
  - Airbag deployment at seating position

Chest Injury Risk by Restraint and Age



Chest Injury Risk by Restraint and Age



Outline of Presentation

- Cadaver test results
- NASS data for elderly chest injuries
- CIREN data for elderly chest injuries
- CIREN rib fracture patterns vs. cadavers
- Summary & Conclusions

Driver Chest Injuries WLIRC Data

- Frontal Crashes with No Rollover
- WLIRC Cases + All Fatal Cases

- Trauma Center Patients + Fatals = Census of Severely Injured in South Florida

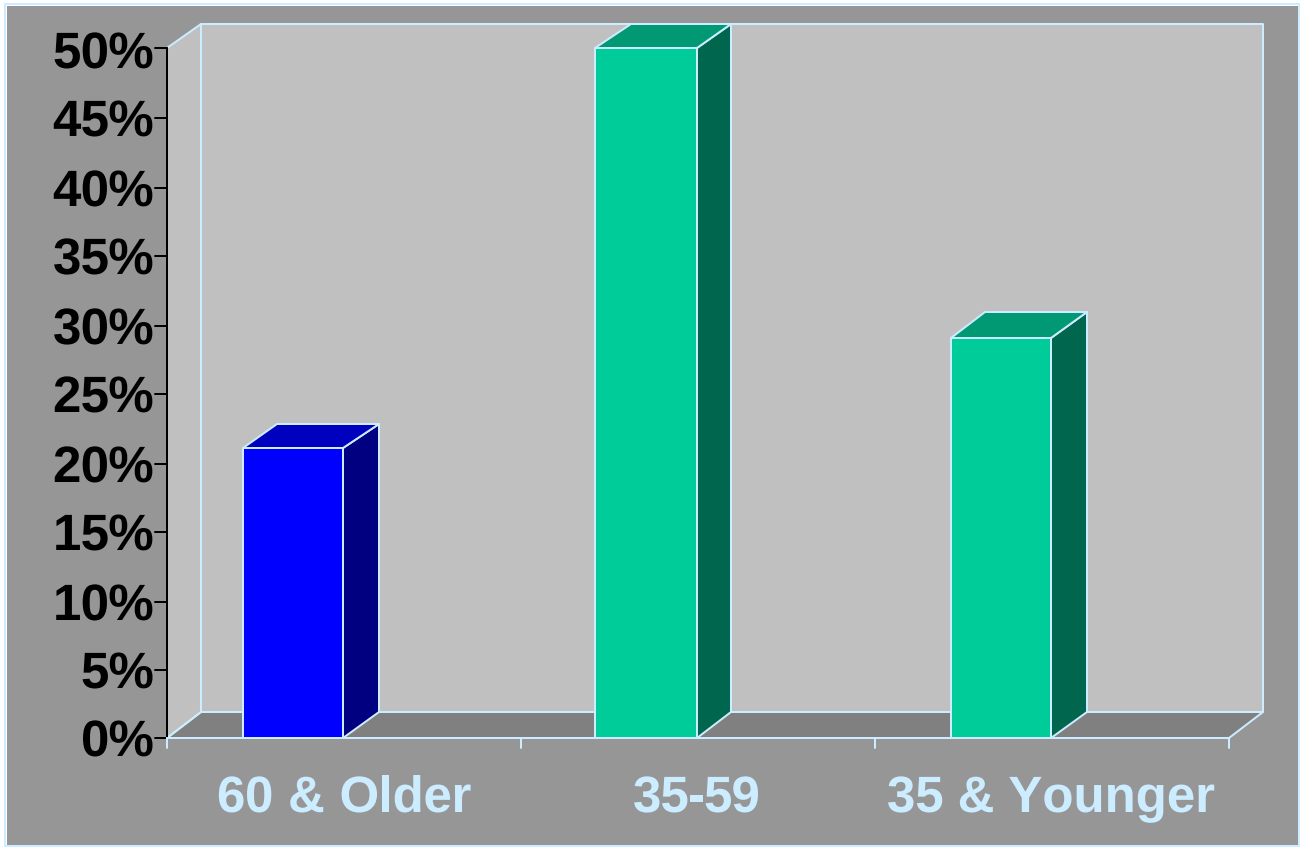
Examination of Chest/Abdominal Injuries at WLIRC

- Belted Drivers in Frontal Crashes with AIS 3+ Chest/Abdominal Injuries - WLIRC Data

- Number in Population - 86

Age Distribution of Belted Drivers in Frontal Crashes with AIS 3+ Chest Injuries

% Drivers with AIS 3+ Chest Injuries



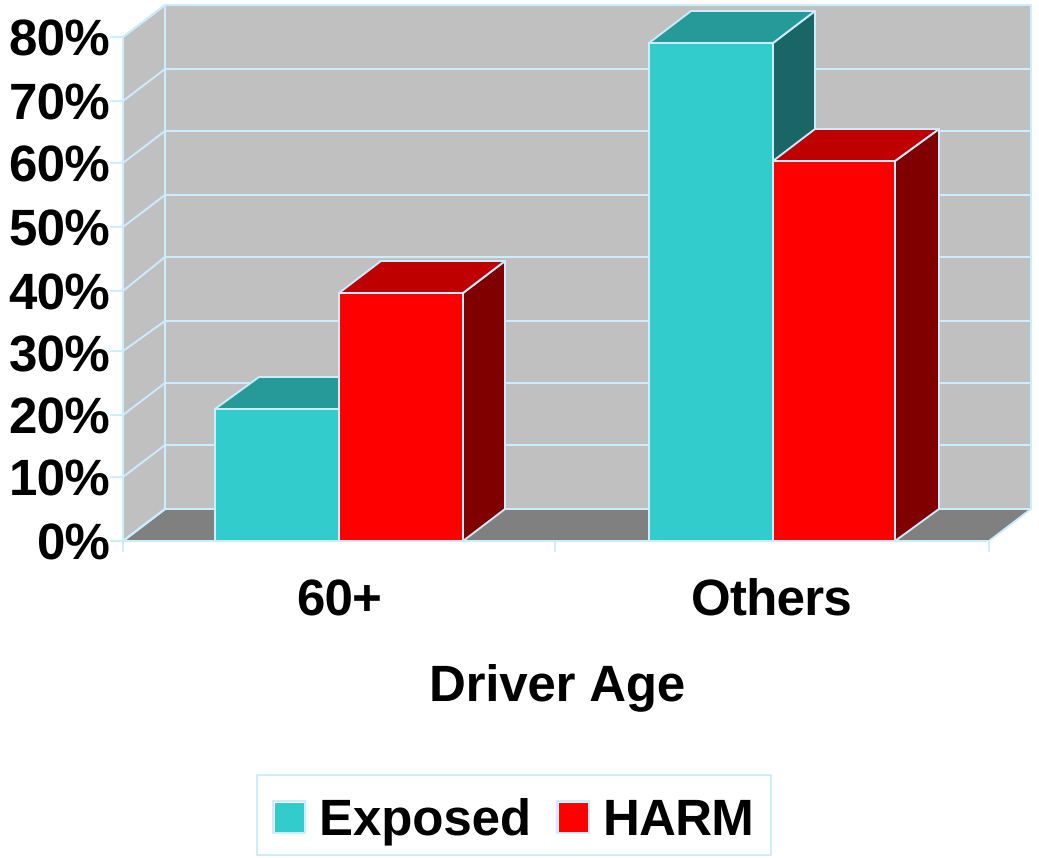
HARM Factors

Injury Severity	Harm Factor
AIS 2	0.038
AIS 3	0.119
AIS 4	0.269
AIS 5	0.848
AIS 6	1.000

Belted Drivers in Frontal Crashes with AIS 3+ Chest Injuries

WLIRC Data

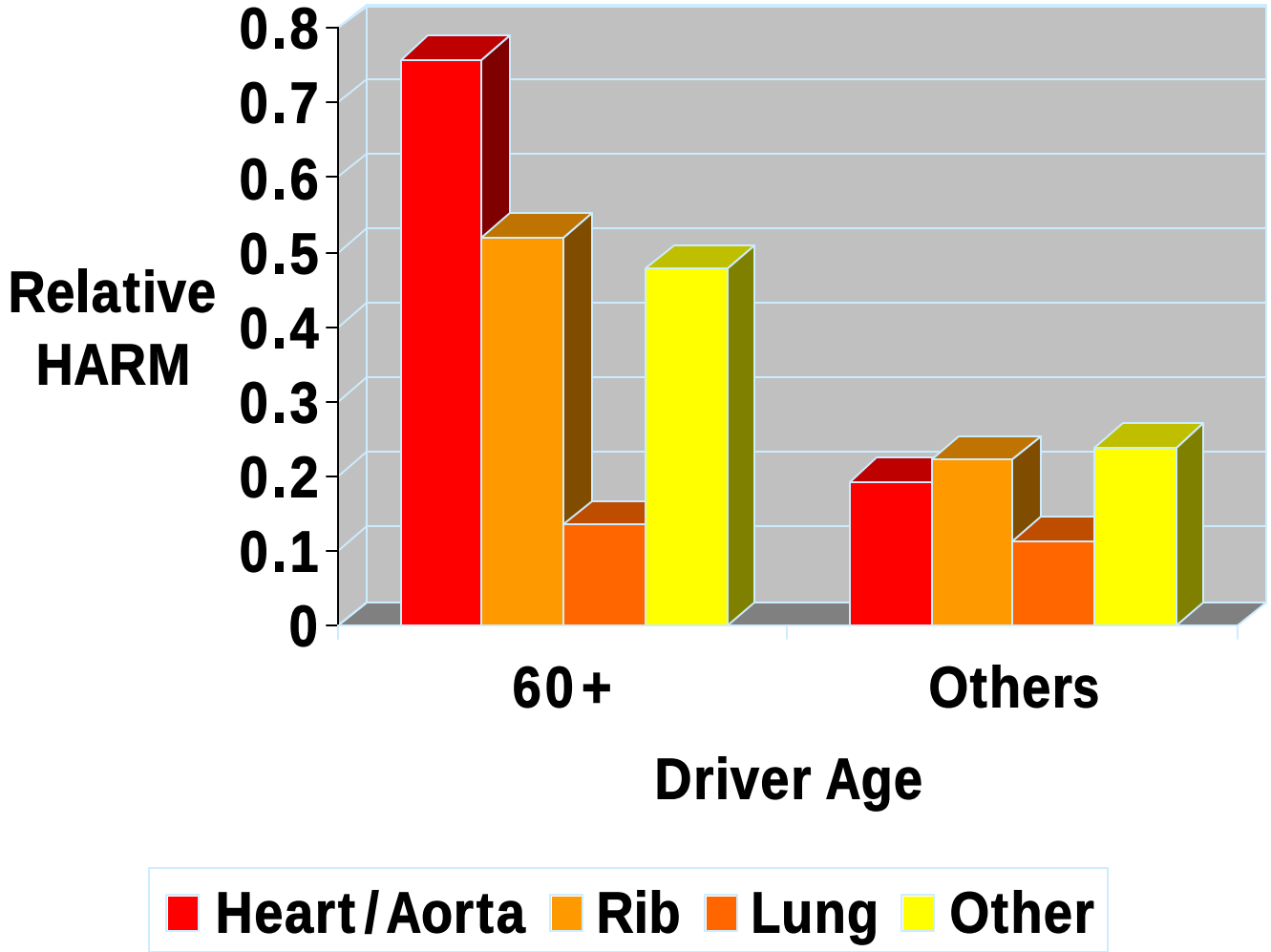
Distribution of MAIS 3+ Chest Injuries & HARM



Distribution of HARM in Population by Injured Organ

Injured Organ	60+	All Others
Heart/Aorta	40.2%	25.2%
Lung	7.1%	14.7%
Rib	27.5%	28.9%
Liver	9.8%	22.4%
Spleen	3.8%	4.8%
Kidney	4.8%	0.3%
Bowel	6.8%	3.6%

Relative HARM by Driver Age (WLIRC Data)



Observations- Chest Injuries & the Elderly

- 60+ age group are:
  - 21% of injured and
  - 40% of HARM
- Elderly have more extensive chest injuries
  - Multiple organ injuries
  - More severe individual injuries
- Heart/aortic injuries are much more common among elderly

Outline of Presentation

- Cadaver test results
- NASS data for elderly chest injuries
- CIREN data for elderly chest injuries
- CIREN rib fracture patterns vs. cadavers
- Summary & Conclusions

UMTIR ANALYSIS

Outline of Presentation

- Cadaver test results
- NASS data for elderly chest injuries
- CIREN data for elderly chest injuries
- CIREN rib fracture patterns vs. cadavers
- Summary & Conclusions

Summary & Conclusions

- NASS elderly–
  - Chest injury risk more that 2 times other ages
- CIREN elderly–
  - 21% of AIS 3+ and 40% of HARM
  - Soft tissue injuries differ with age
- Fracture patterns –
  - Cadavers in 3pt belts have more bilateral fractures & higher rib fractures
  - Other differences noted

Summary & Conclusions

- CIREN data offers the possibility to refine injury criteria