Patterns of Skeletal and Internal Thoracic Injuries from CIREN Crash Investigations of Frontal and Near-Side Impacts

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The University of Michigan

CIREN Session
SAE Government/Industry Meeting

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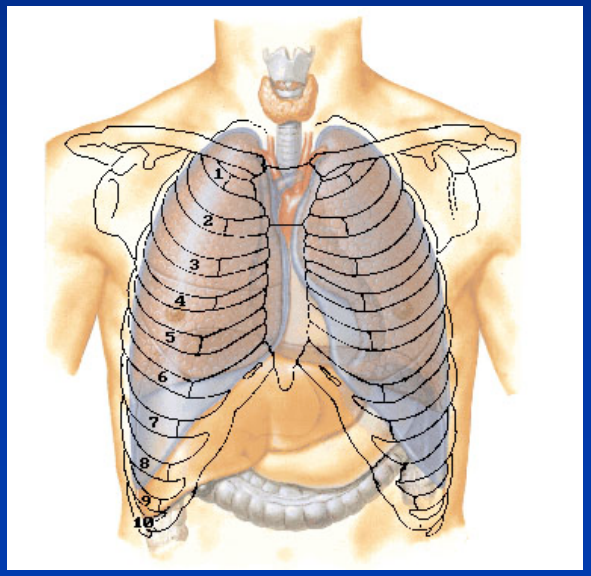
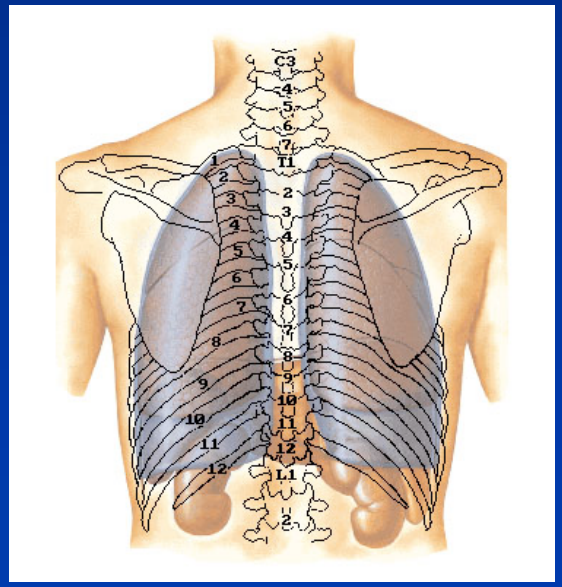




Using the CIREN Crash/Injury Database for Injury Biomechanics Research

1) CIREN crash investigations are trauma-patient based and are highly biased toward more severe injuries and more severe crashes.

2) CIREN investigations include detailed injury data not available in NASS and other crash investigations.

3) CIREN investigations involve a multidisciplinary analysis of crash and injury data.

As a result, the CIREN database provides an excellent resource for validating and interpreting results of biomechanical testing with human surrogates (i.e., cadavers) for the purpose of determining injury tolerance, injury mechanisms, and injury criteria.

Initial Analysis Used the UM CIREN Database

- 168 FRONTAL Crashes
  - 138 drivers; 30 adult RFP
  - 80 men; 88 women

- 66 NEAR-SIDE Impacts to Adults
  - 44 drivers; 22 adult RFP
  - 27 men; 29 women

Initial Analysis Used the UM CIREN Database

- 168 FRONTAL Crashes
  - 138 drivers; 30 adult RFP
  - 80 men; 88 women
  - 54 (32%) with AIS 3+ thorax injury

- 66 NEAR-SIDE Impacts to Adults
  - 44 drivers; 22 adult RFP
  - 27 men; 29 women
  - 44 (67%) with AIS 3+ thorax injury

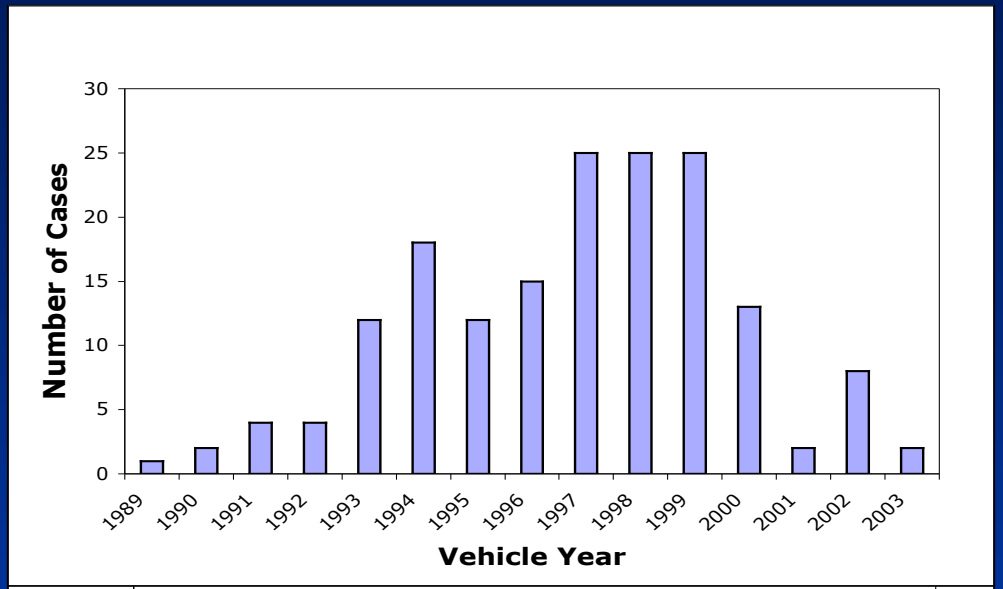
Initial Analysis Used the UM CIREN Database

- 168 Front-Seat Occupant in FRONTAL Crashes
  - 138 drivers; 30 adult RFP
  - 80 men; 88 women
  - 54 (32%) with AIS 3+ thorax injury
  - 5 fatals - none from thoracic injuries

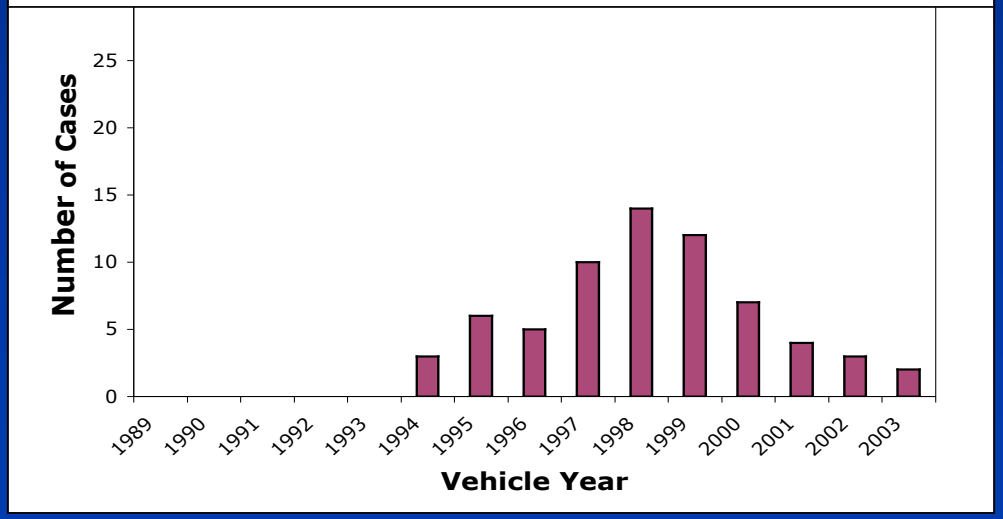
- 66 NEAR-SIDE Impacts to Adults
  - 44 drivers; 22 adult RFP
  - 27 men; 29 women
  - 44 (67%) with AIS 3+ thorax injury
  - 12 fatals - 8 from thoracic injuries

Distributions of Vehicle Model Year in UM CIREN Cases

Frontal Impacts
n = 168

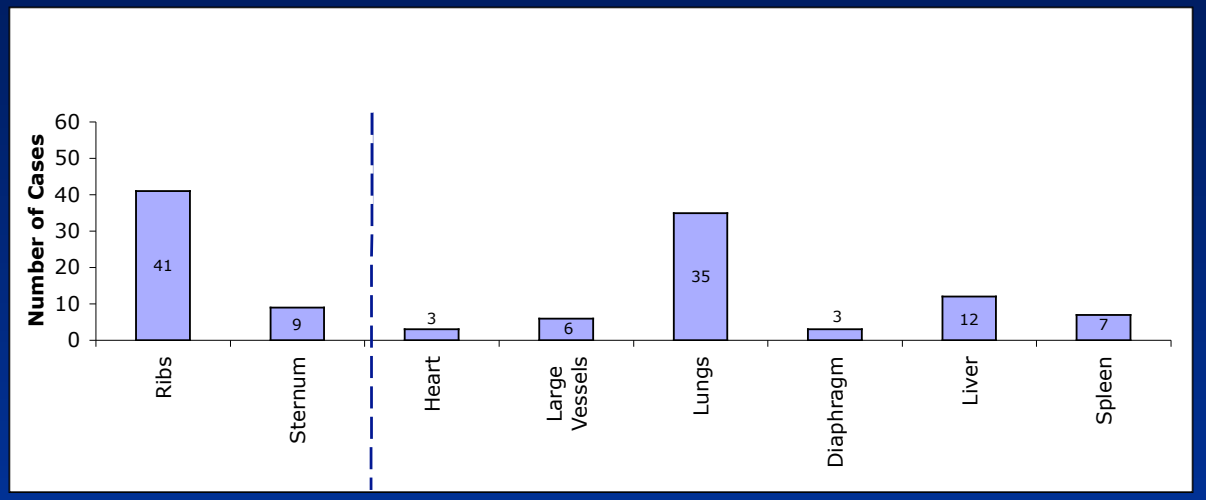


Lateral Impacts with Near-Side Adult Occupant
n == 66

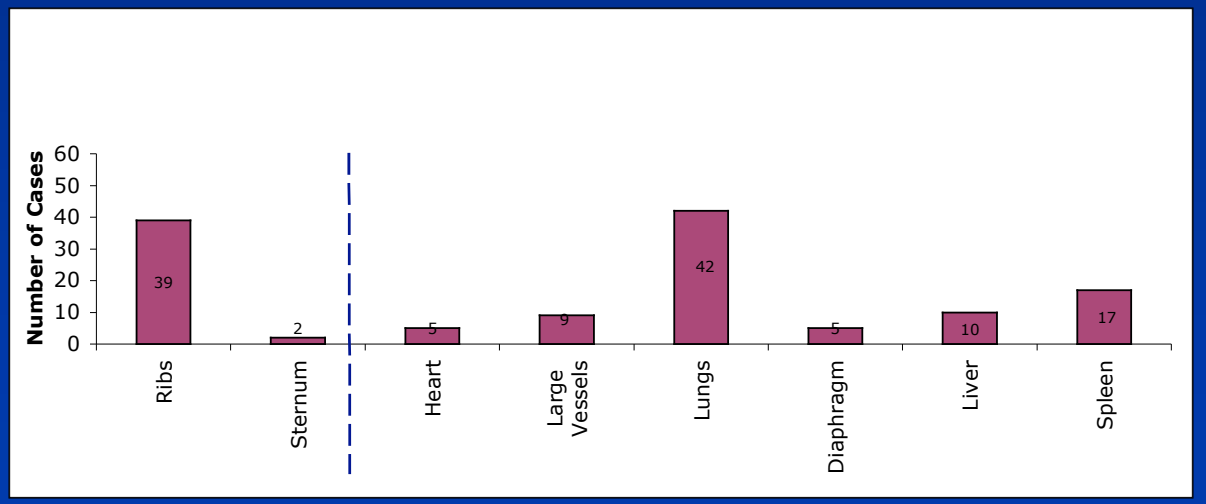


Patterns of Skeletal and Internal Thoracic Injuries in Frontal and Near-Side Impacts

Frontal Impacts
54 occupants with 116 thorax injuries



Near-Side Impacts
44 occupants with 129 thorax injuries



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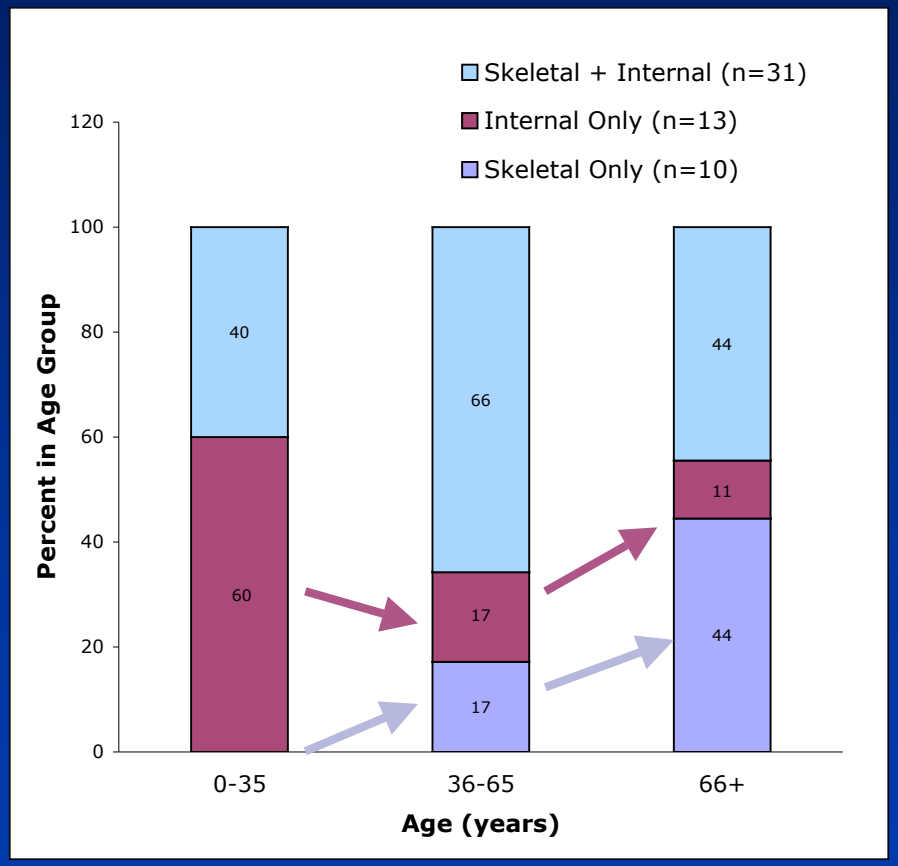
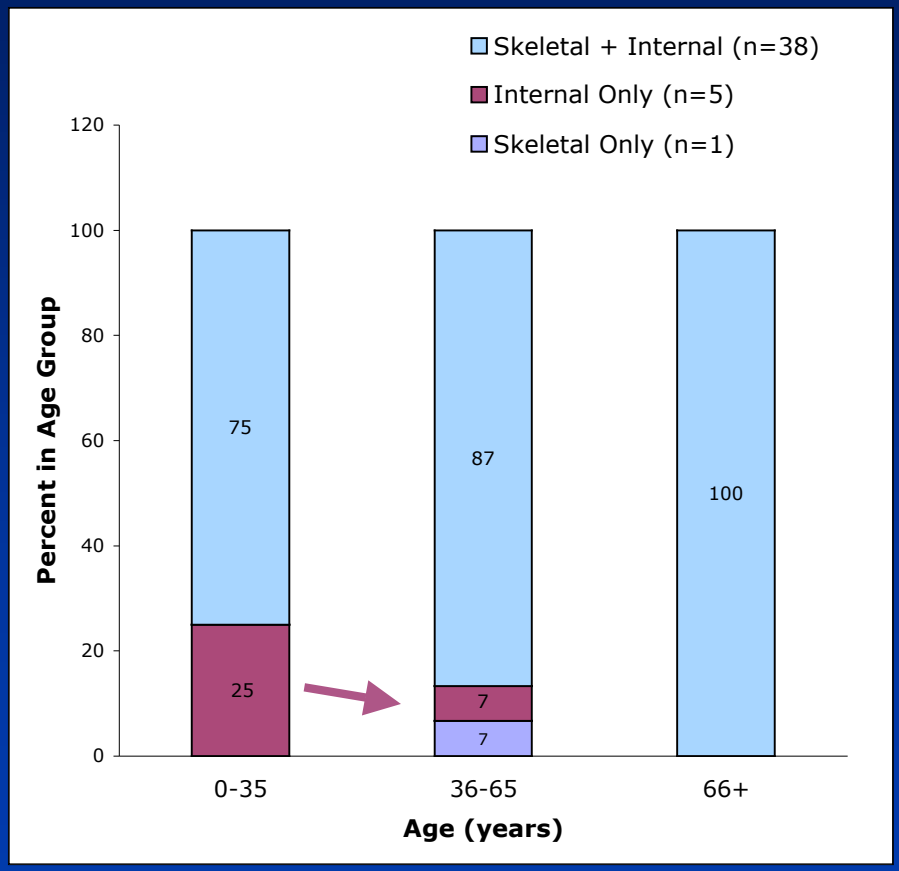
Patterns of Skeletal and Internal Thoracic Injuries with Occupant Age

Frontal Impacts (n=54)



Near-Side Impacts (n=44)



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Multivariate Logistic Regression Analysis of Crash, Occupant, and Restraint Factors to AIS 3+ Thoracic Injuries

Predictors of Thoracic Injury in FRONTAL Impacts (n=168)

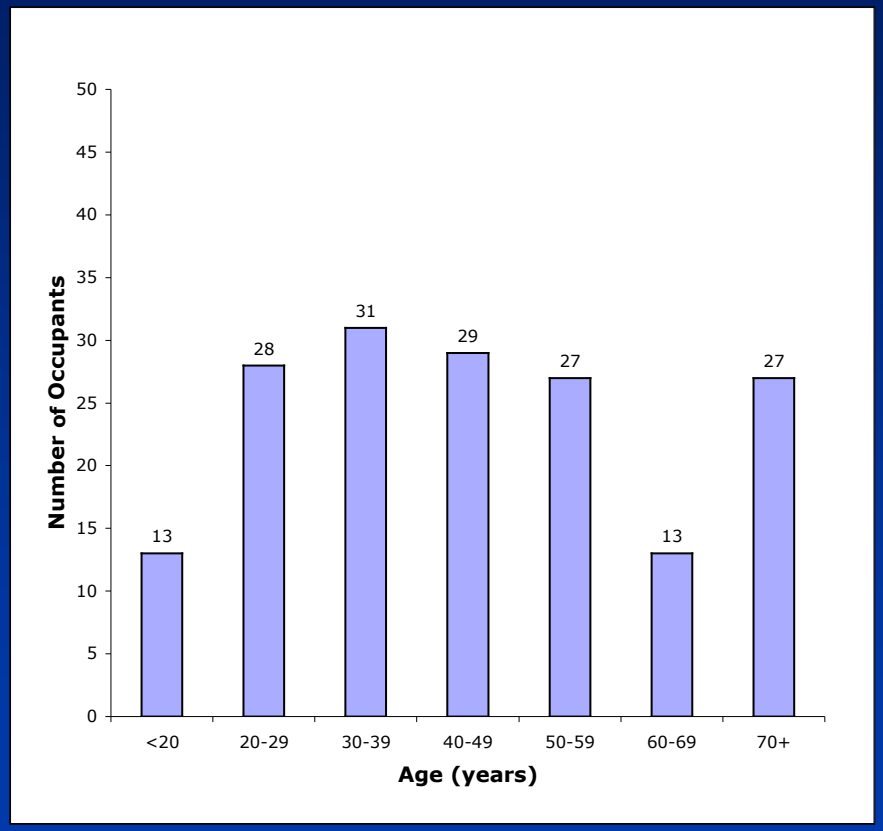
Crash Severity
Occupant Age
Occupant Stature

Predictors of Thoracic Injury in NEAR-SIDE Impacts (n=66)

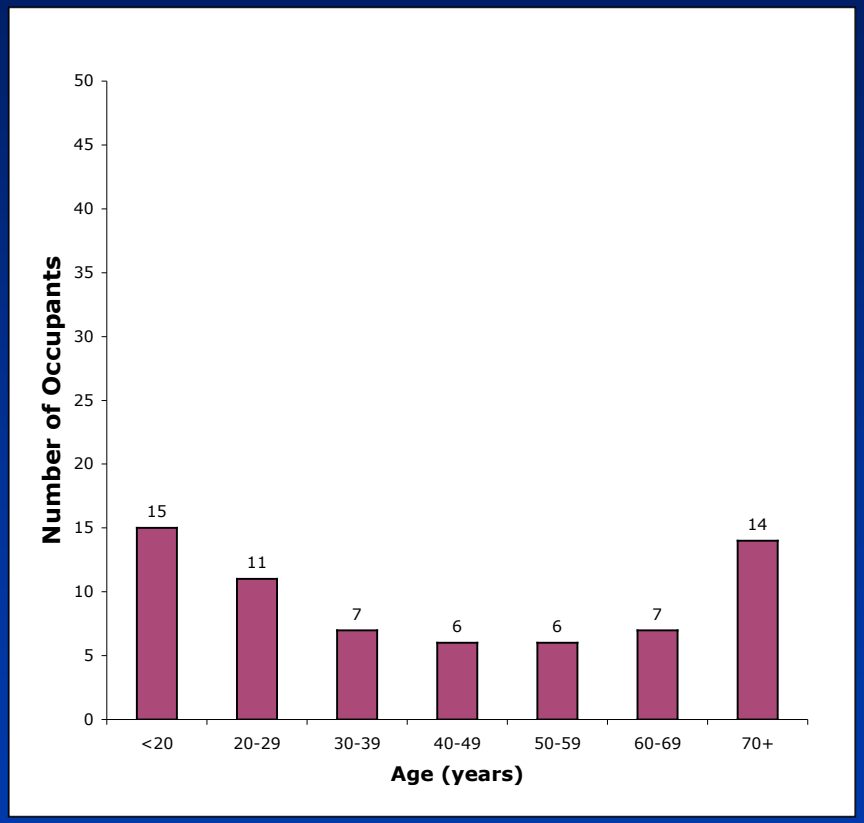
Occupant Age

Distributions of Occupant Age

Frontal Impacts (n=168)



Near-Side Impacts (n=66)



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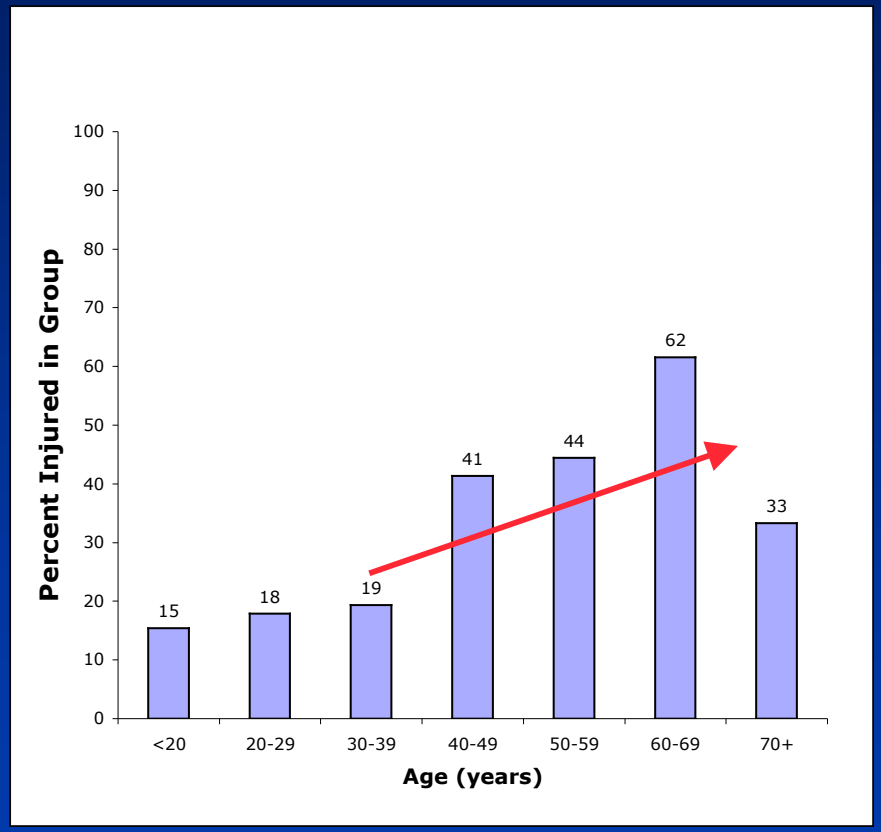
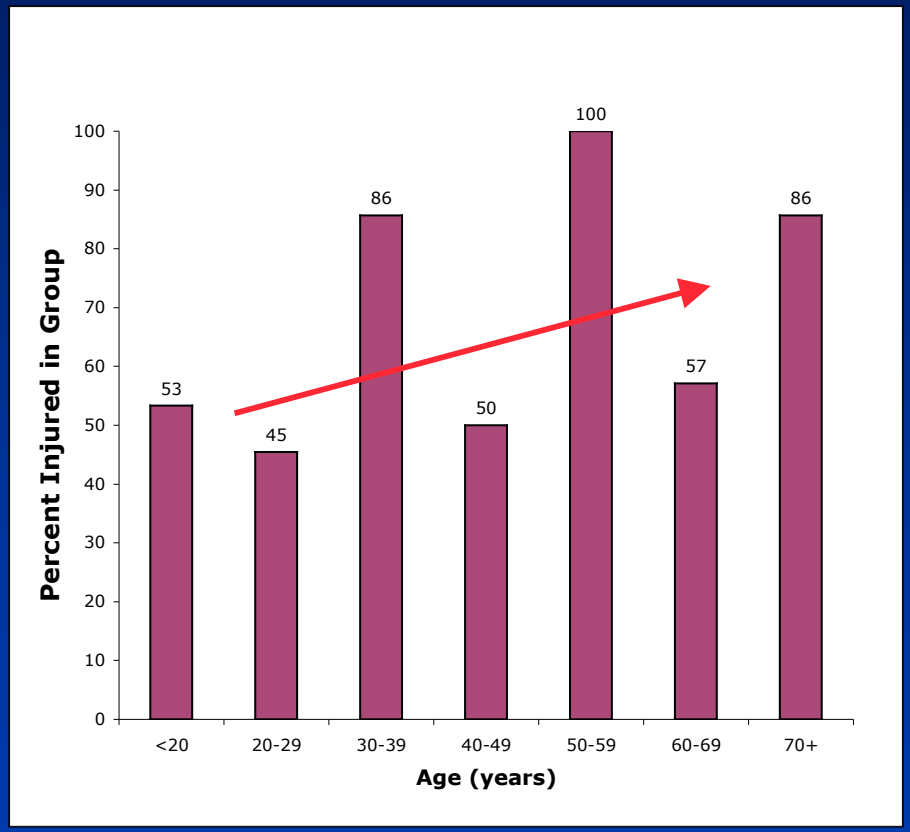
Percent of Occupants with AIS 3+ Thoracic Injury by Age Group

Frontal Impacts (n=168)



Near-Side Impacts (n=66)



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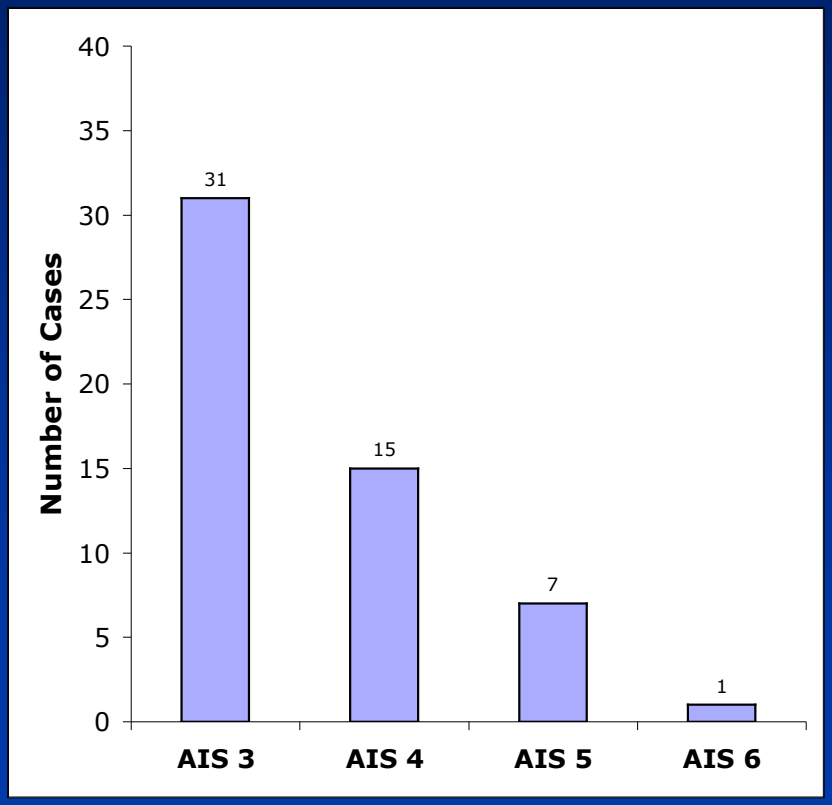
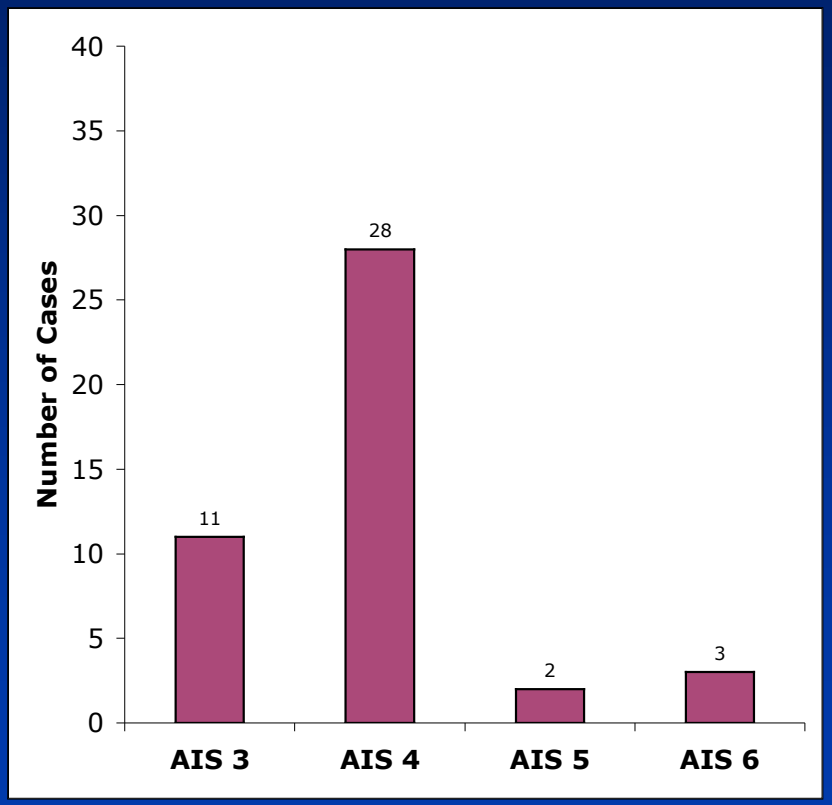
Distributions of Thoracic MAIS for Occupants with Thoracic AIS 3+ Injuries

Frontal Impacts (n=54)



Near-Side Impacts (n=44)



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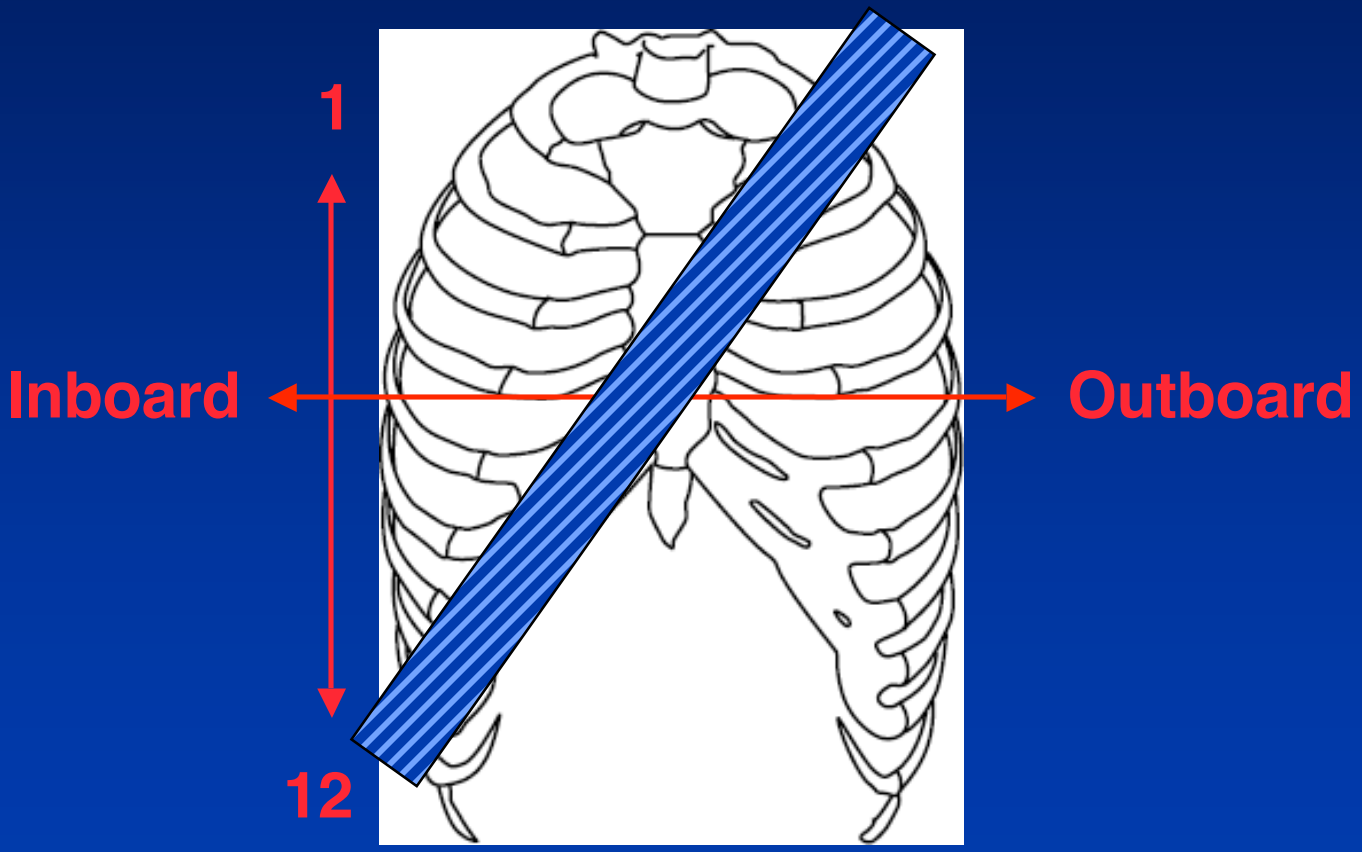
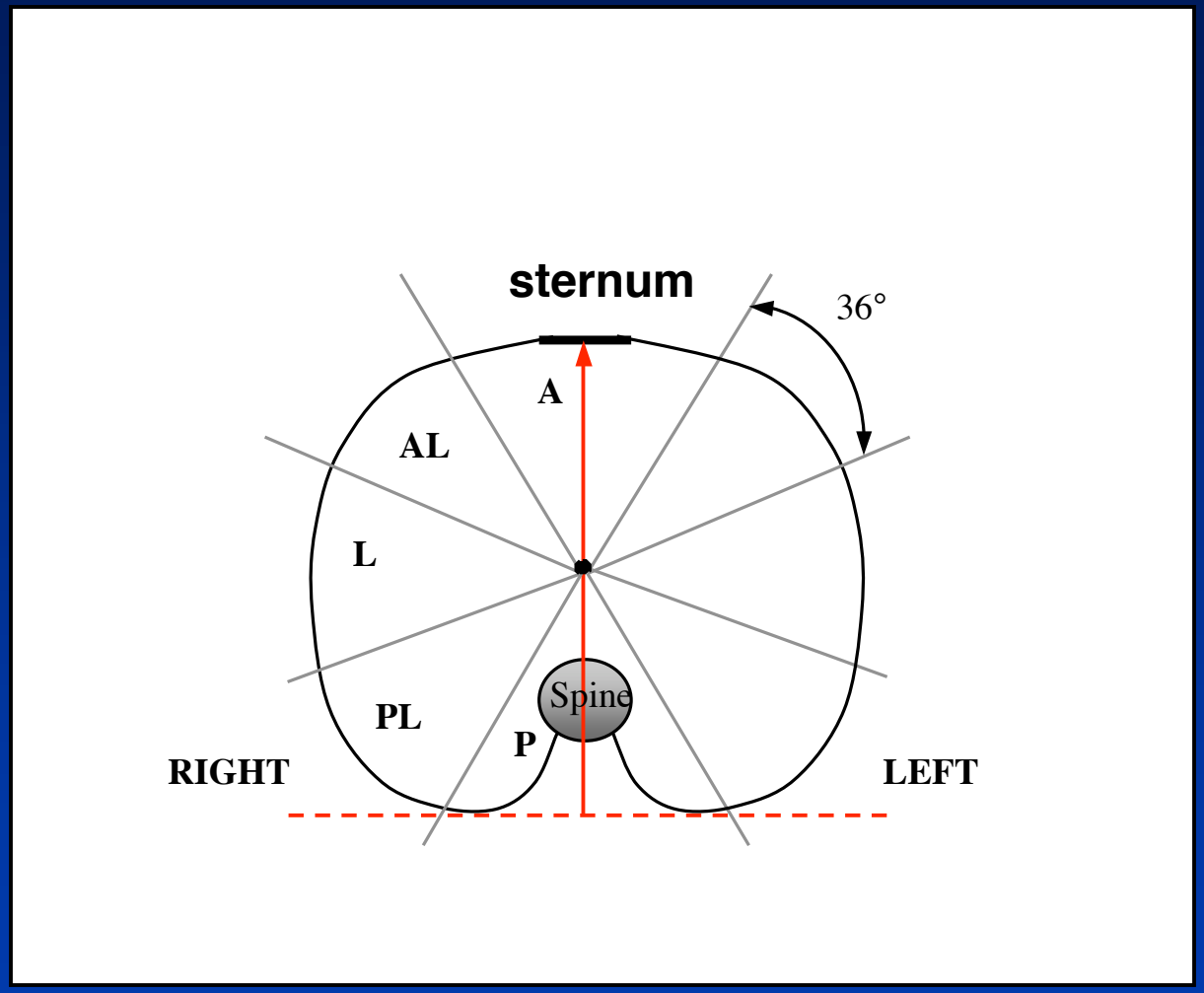
Patterns of Rib Fracture Locations

- Rib # and Side
- Circumferencial

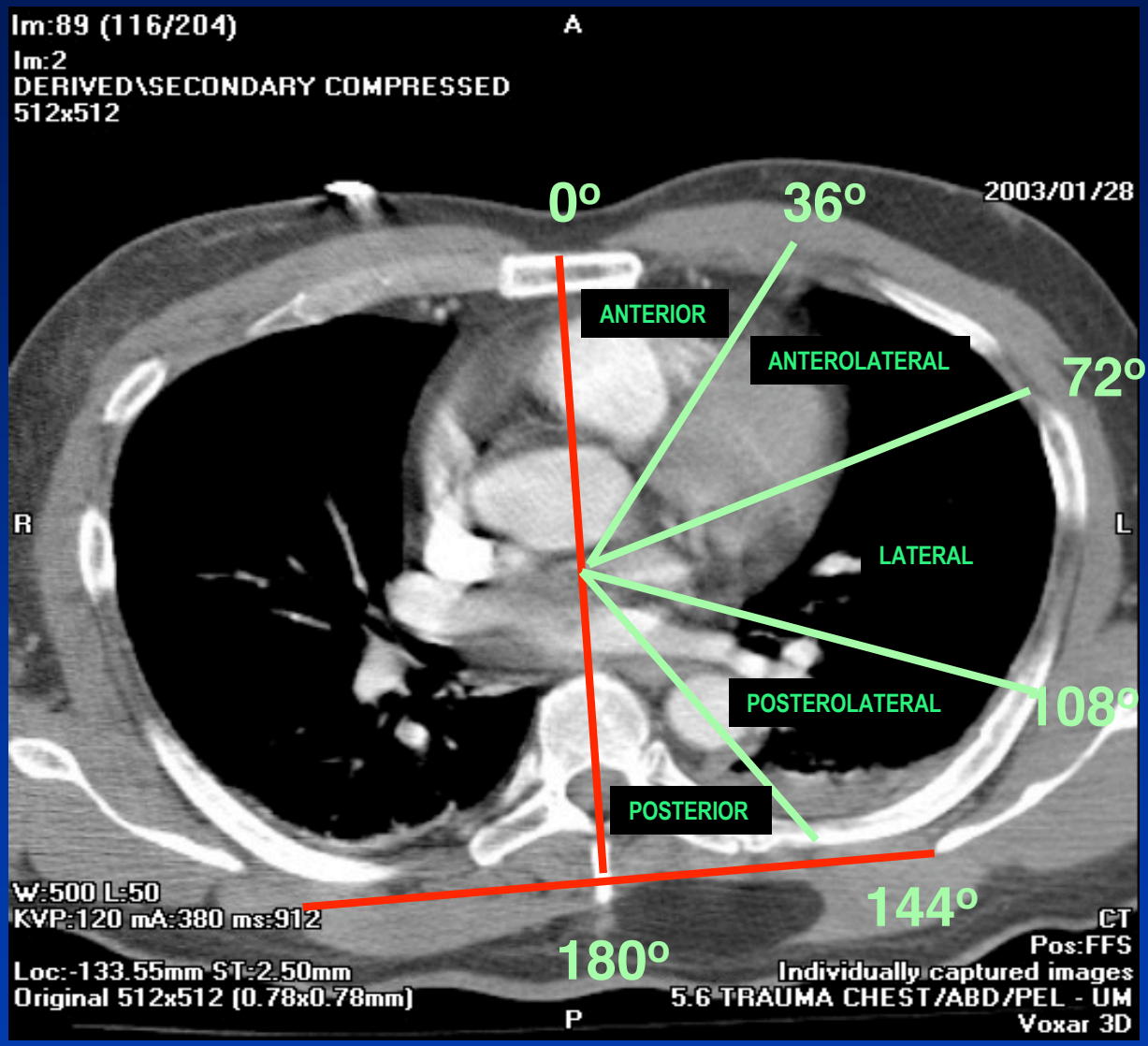
Locations of Fractures by Rib # and Side



Circumferential Locations of Rib Fractures



Circumferential Locations of Rib Fractures



Planar CT looking up from feet

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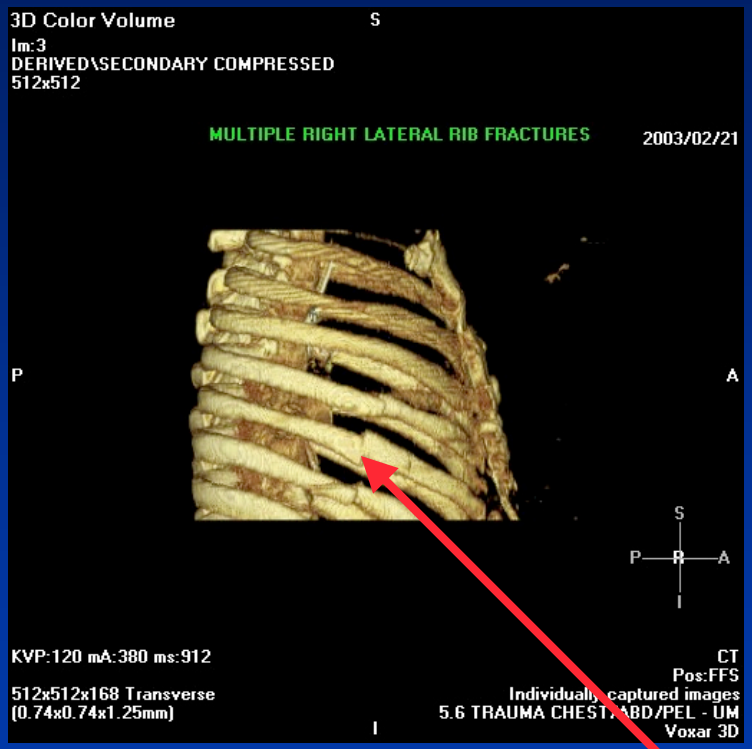
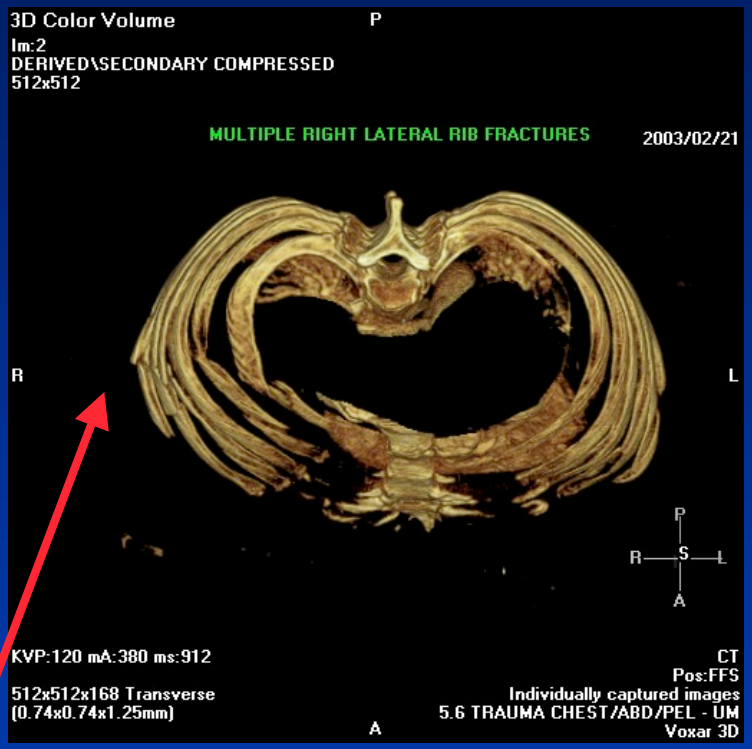
Example of Right Lateral Rib Fracture

3D CT Scan - side view



3D CT Scan - top view



rib fractures

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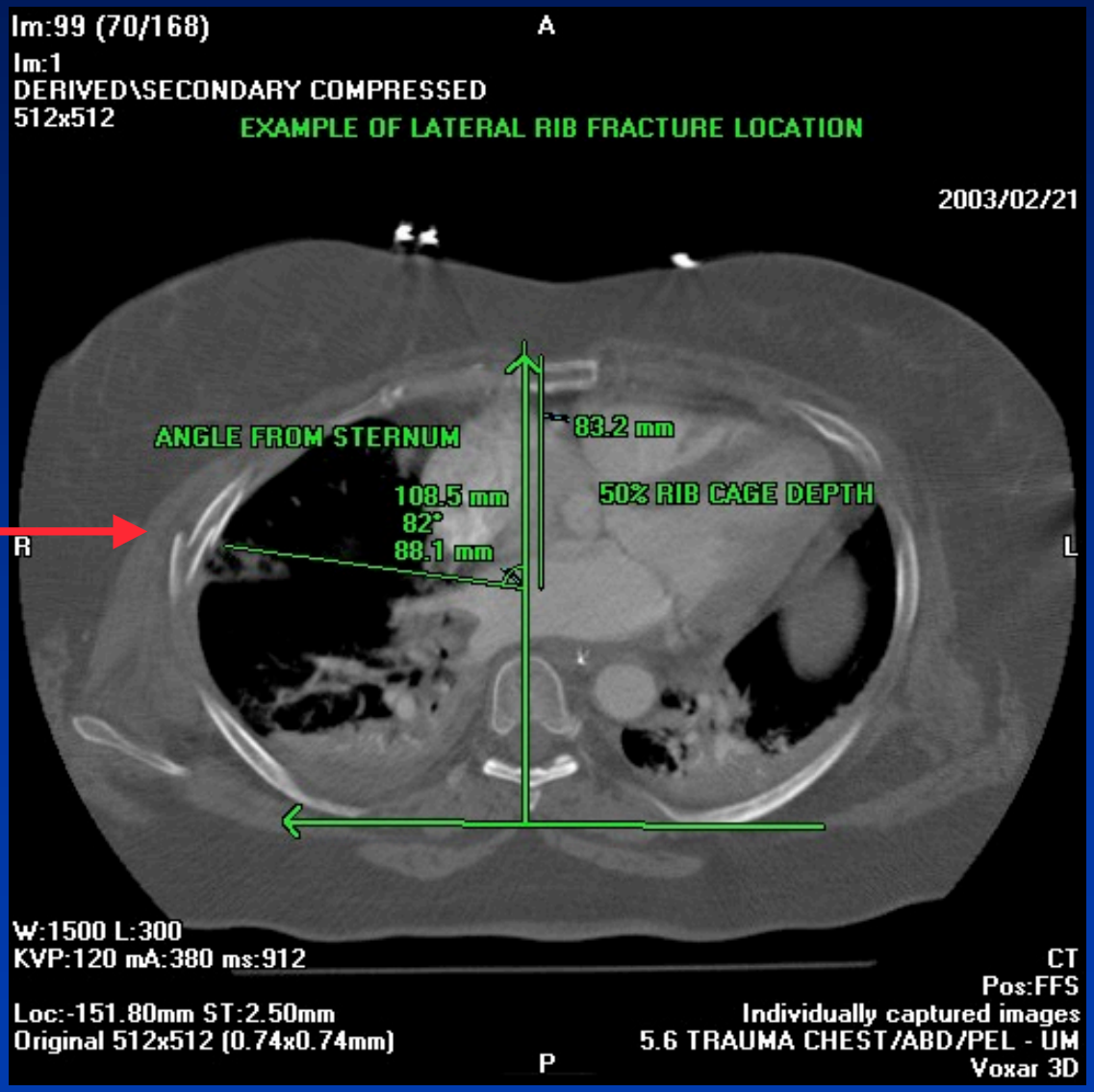
Example of Right Lateral Rib Fracture

Lateral
rib fractures



Planar CT looking up from feet

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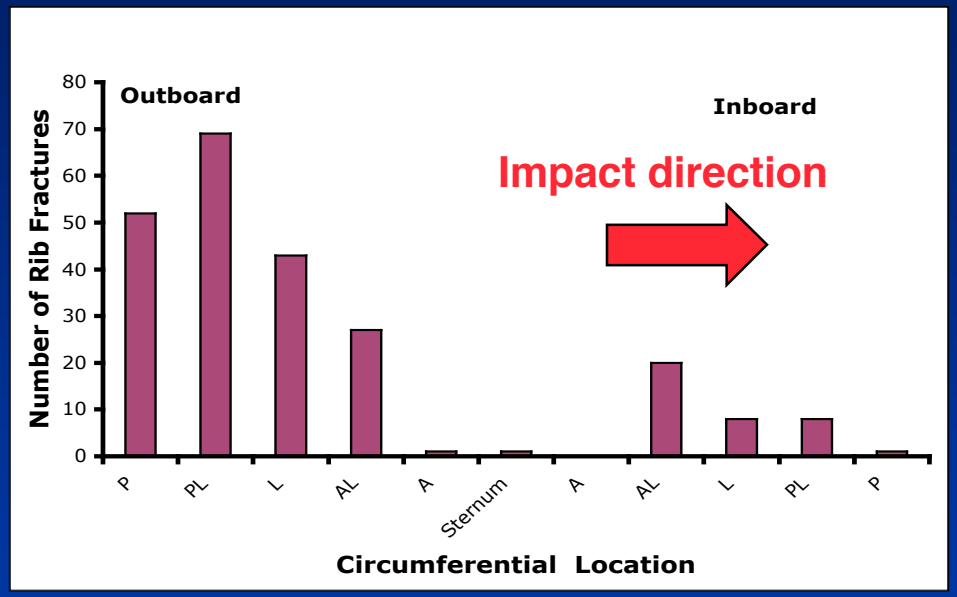
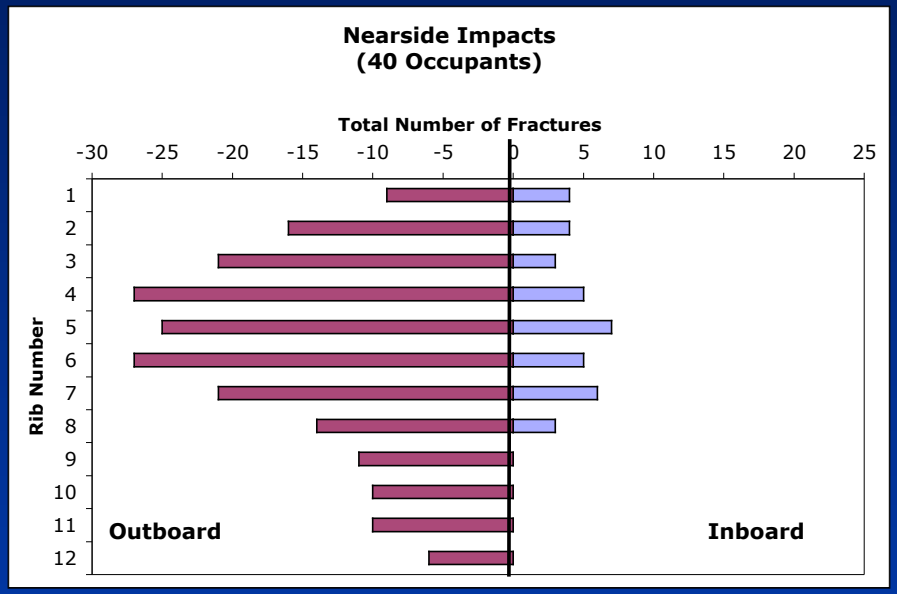
Locations of Rib Fractures in Near-Side Impacts

Circumferencial



Side and Rib



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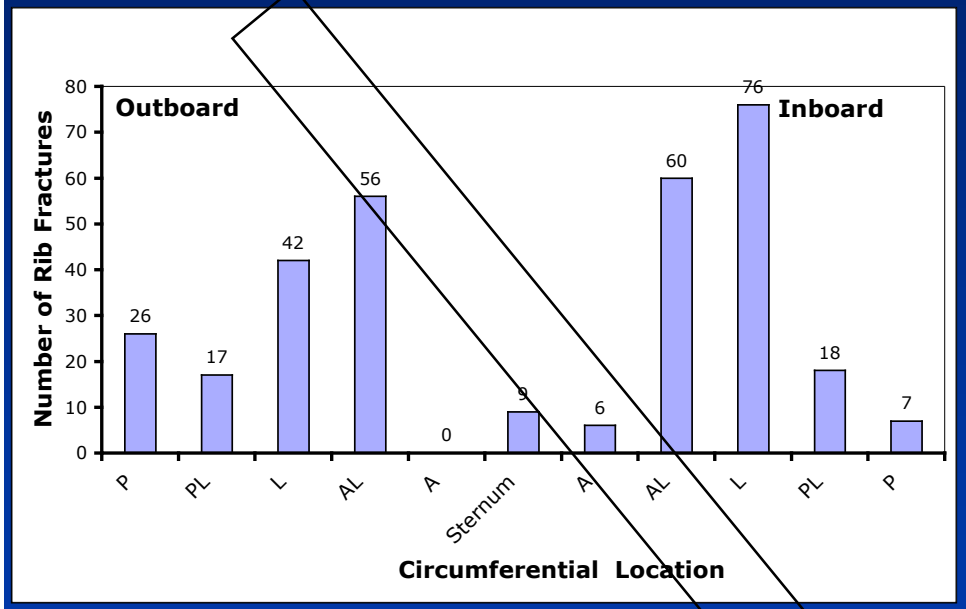
Locations of Rib Fractures in Frontal Impacts

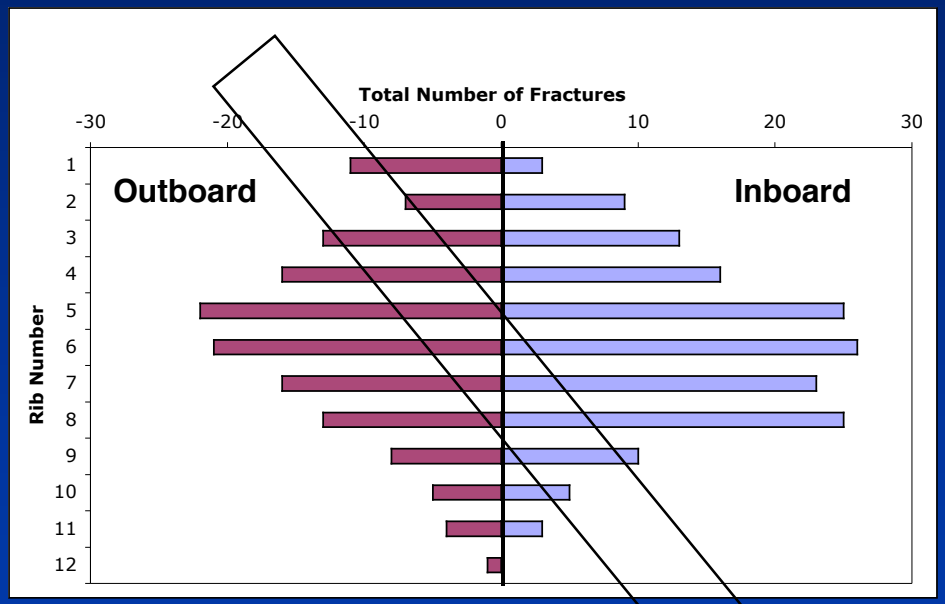
(Total n = 63)

(belt only =11, airbag only = 20, belt+ airbag = 32)

Circumferencial



Side and Rib



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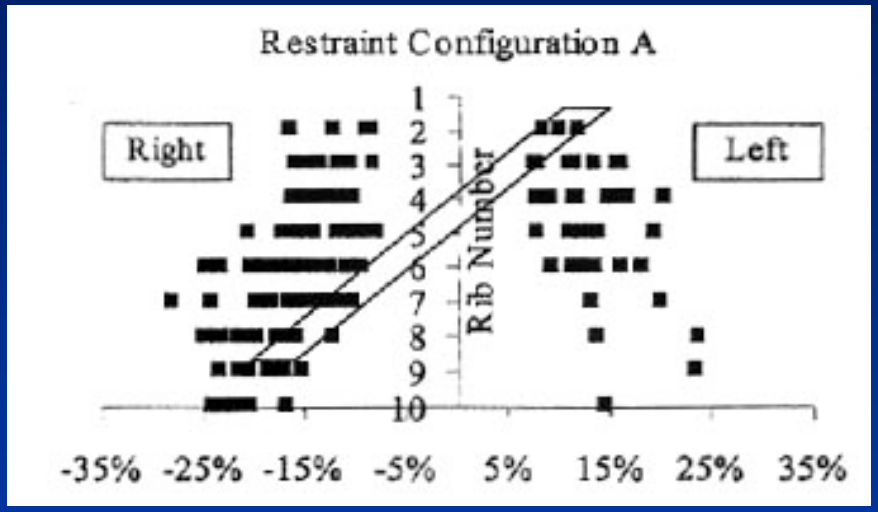
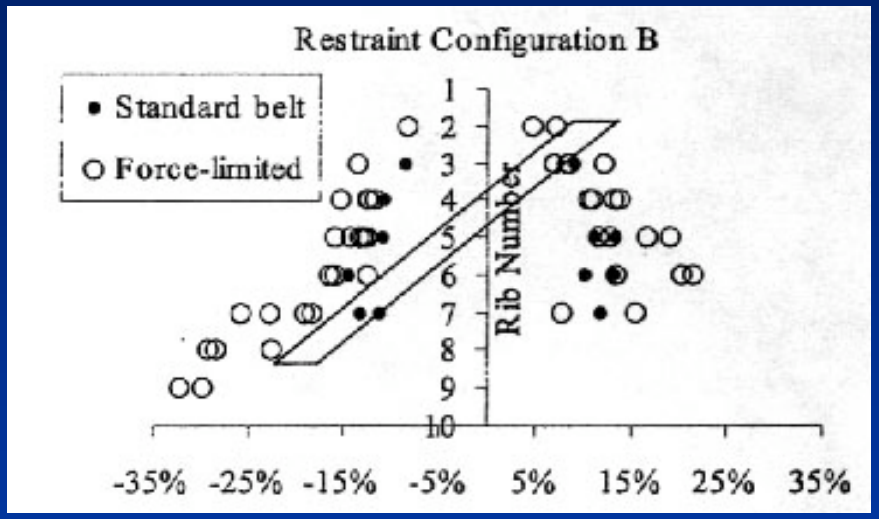
Rib Fracture Locations from Frontal Impact Tests of Cadaver Subjects from Crandall et al. 2000

Standard 3-Pt Belt (n = 14)



3-Pt Belt w load limiter+ AB (n = 15)



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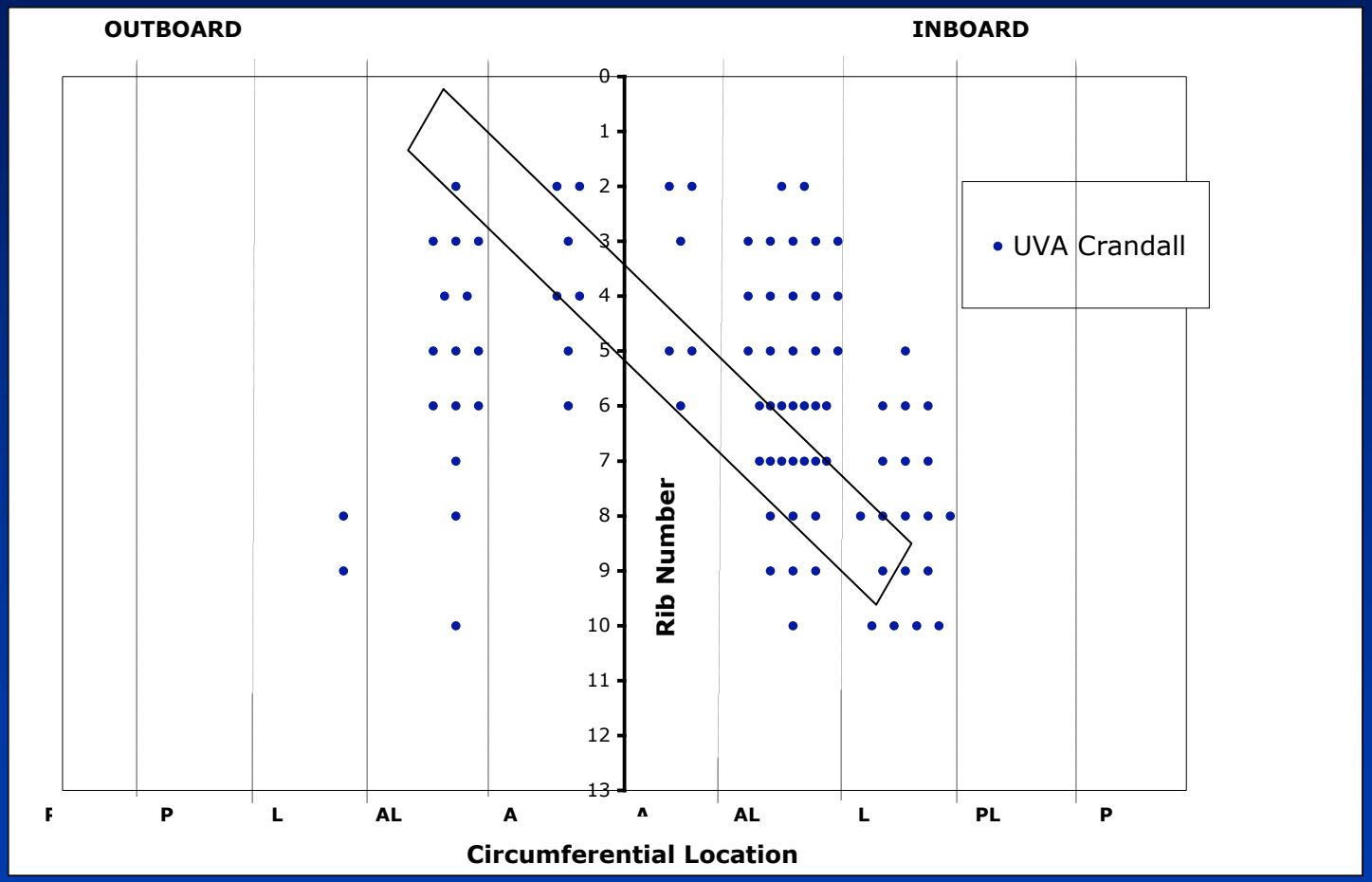
Rib Fracture Locations from Frontal Impact Tests of Cadaver Subjects Restrained by Standard 3-Point Belt from Crandall et al. 2000 (n = 14)



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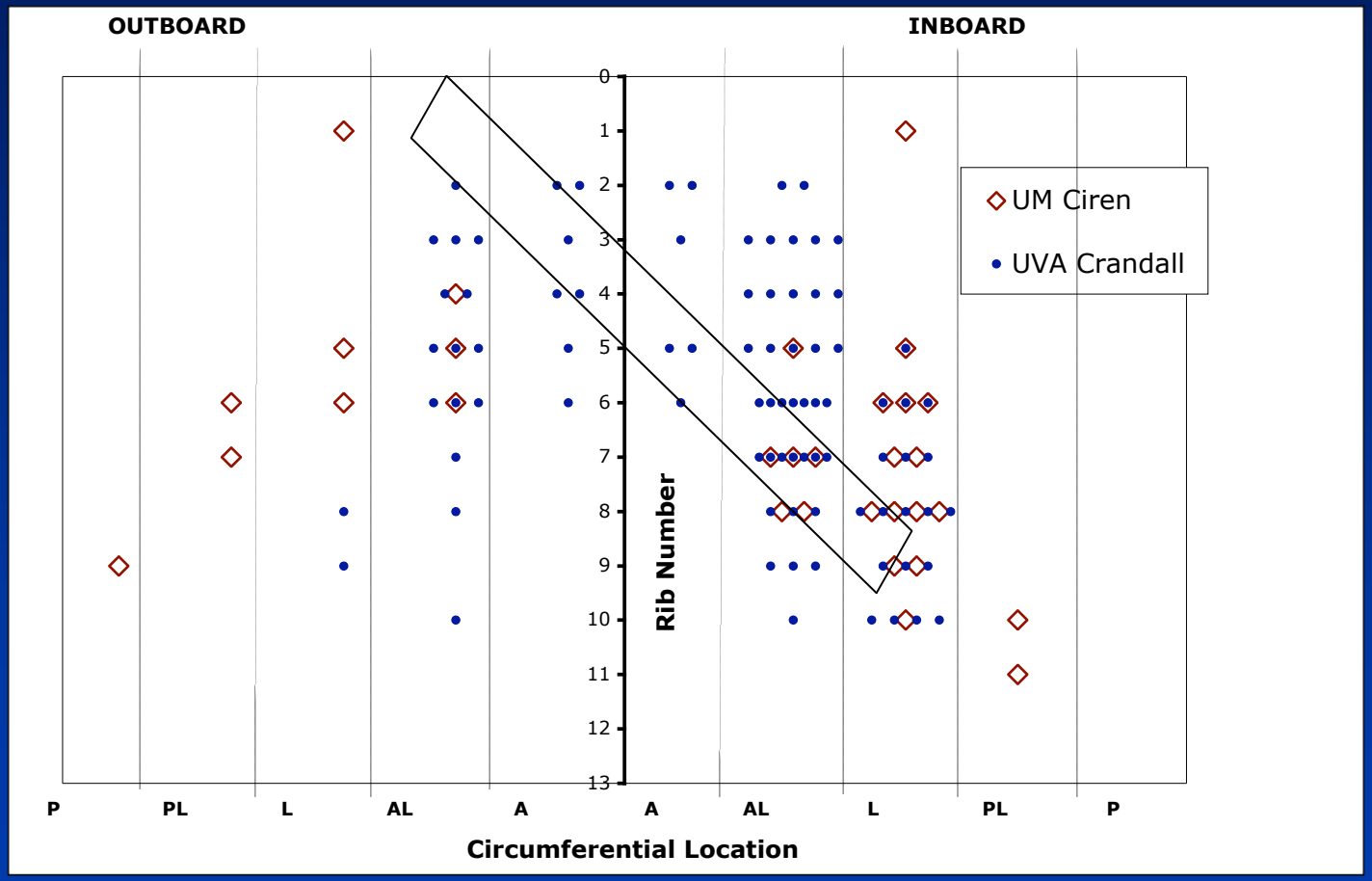
Rib Fracture Locations from UM CIREN Subjects Restrained by 3-Point Belt (n=11) in Frontal Crashes Versus Locations in Cadaver Subjects from Crandall et al. 2000 (n=14)



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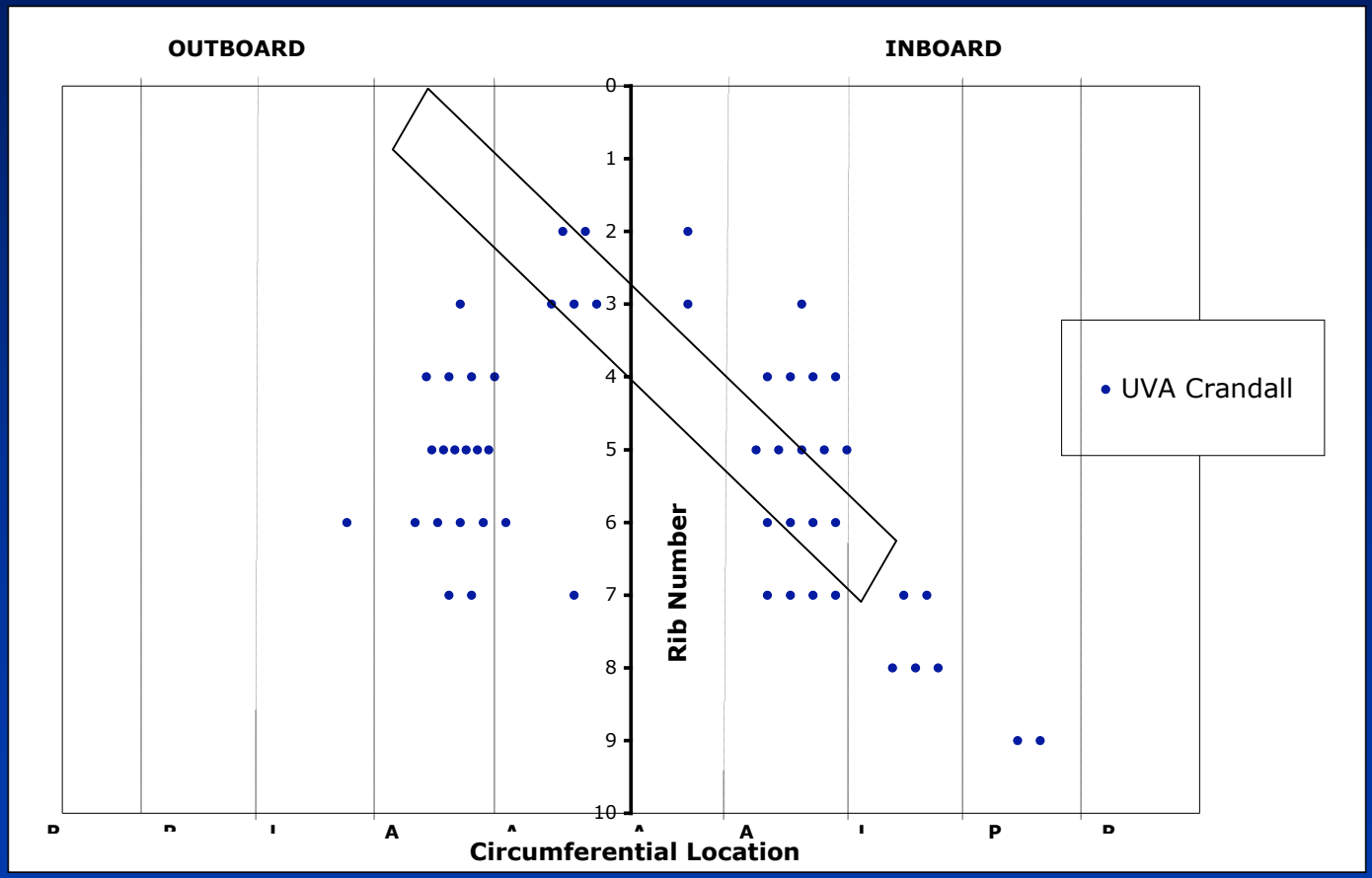
Rib Fracture Locations from Frontal Impact Tests of Cadaver Subjects Restrained by 3-Point Belt With Load Limiter+Airbag from Crandall et al. 2000 (n = 15)



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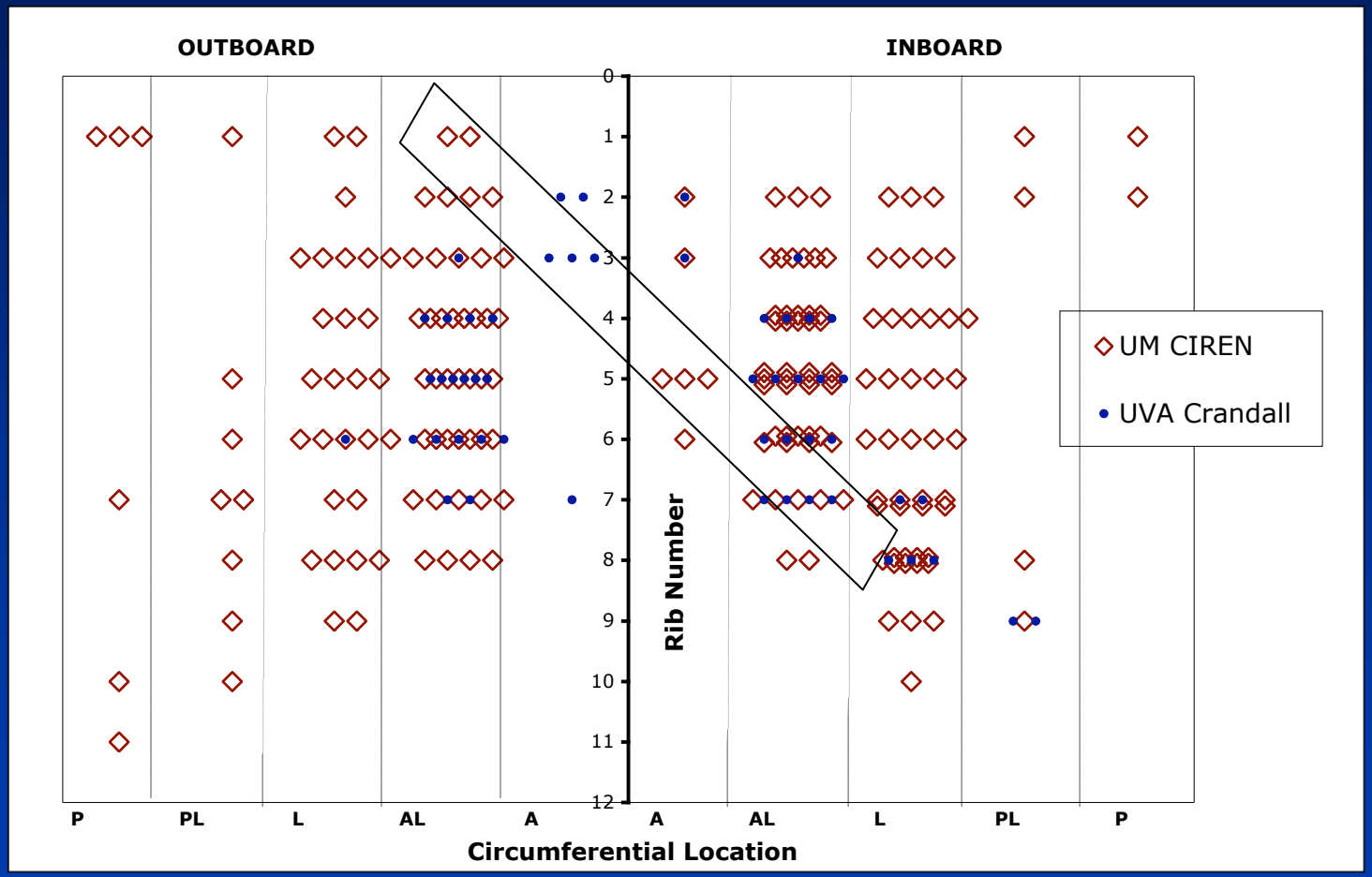
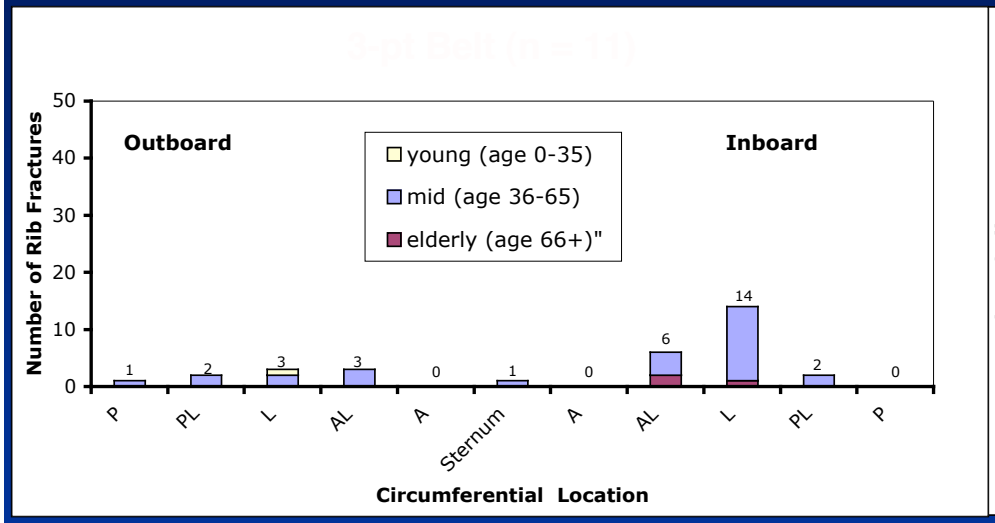
Rib Fracture Locations from UM CIREN Subjects Restrained by Belt+Airbag (n=32) in Frontal Crashes Versus Locations in Cadaver Subjects from Crandall et al. 2000 (n = 15)

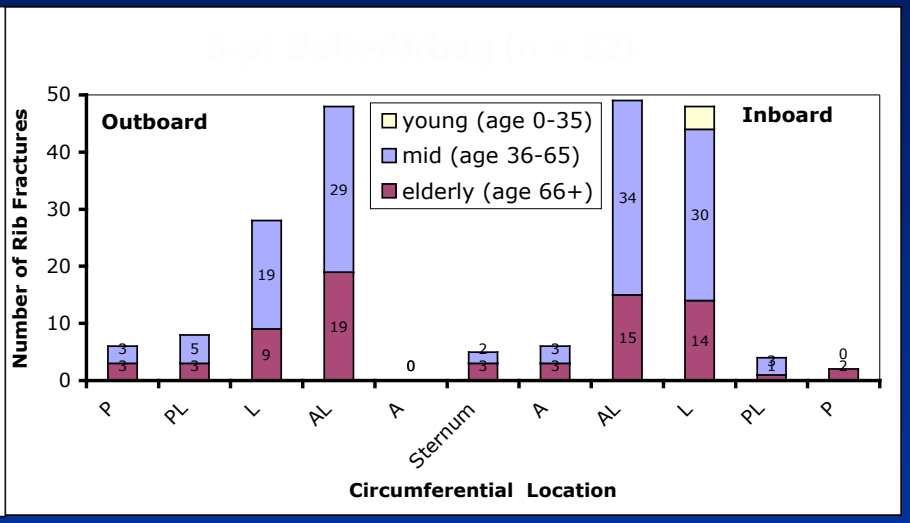


Circumferencial Locations of Rib Fractures for Occupants in UM CIREN Frontal Crashes

3-pt Belt (n = 11)



3-pt Belt+Airbag (n = 32)



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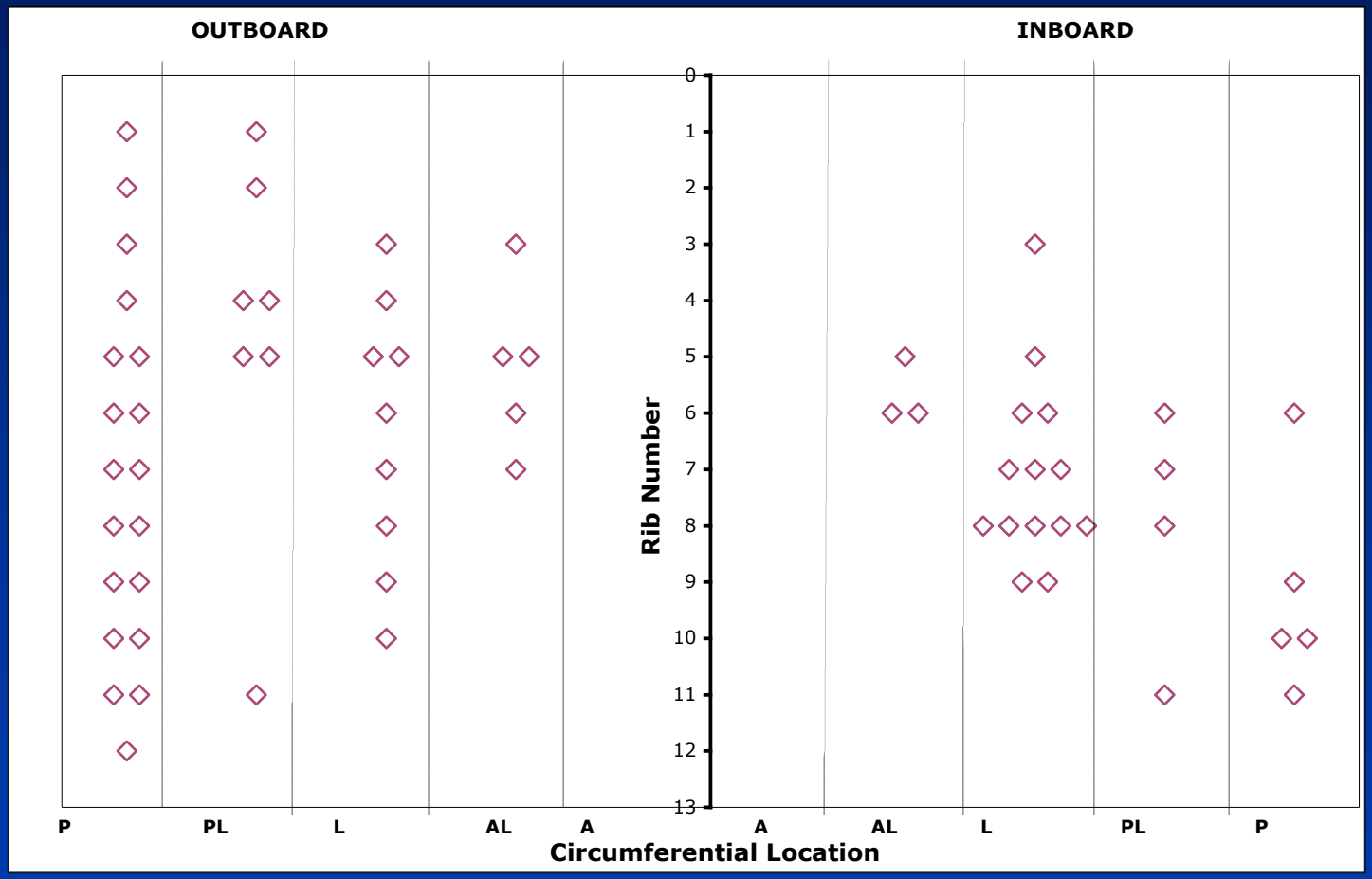
Rib Fracture Locations for Occupants in Frontal Crashes with Airbag-Only Restraint (n=20)



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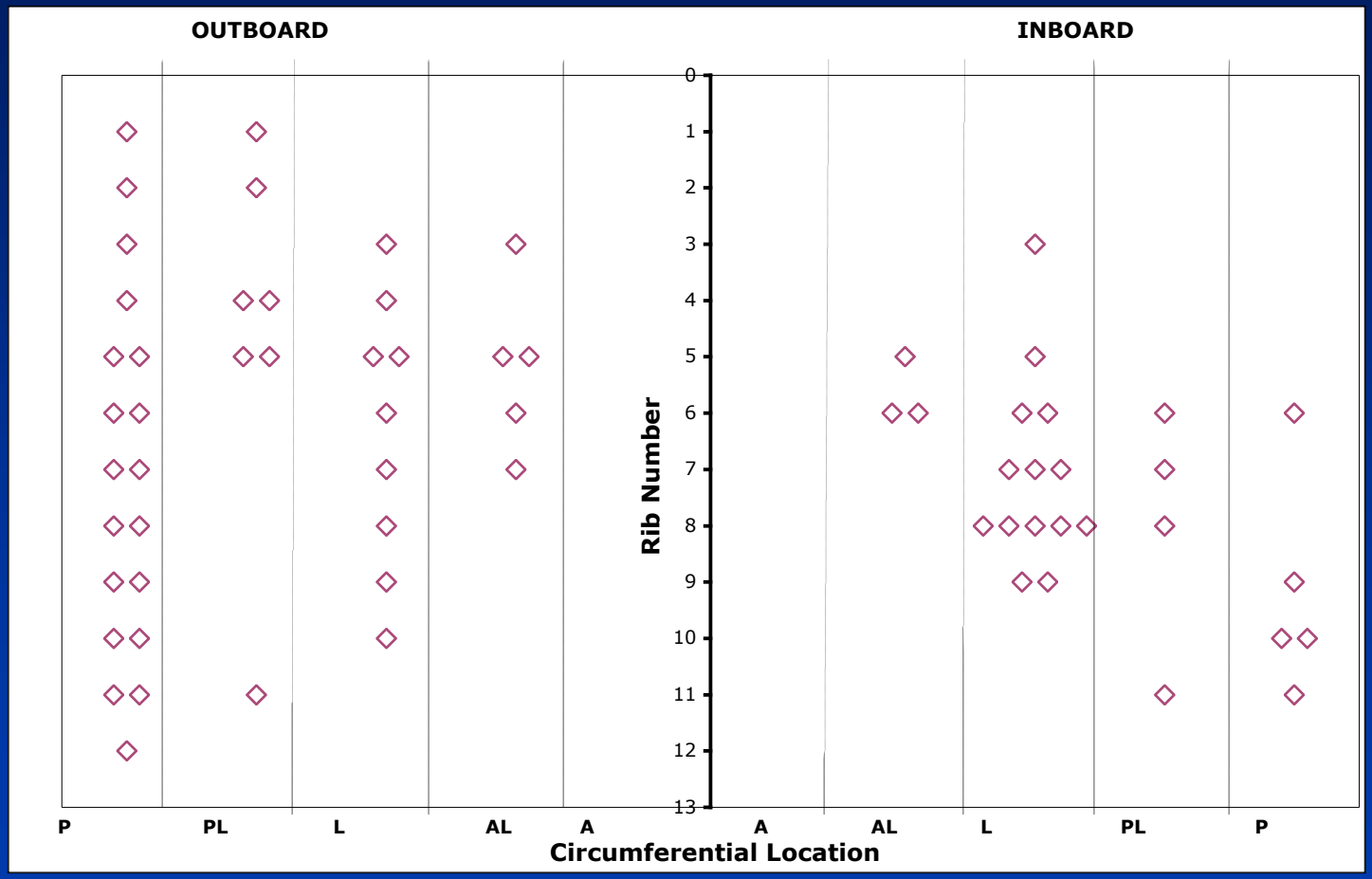
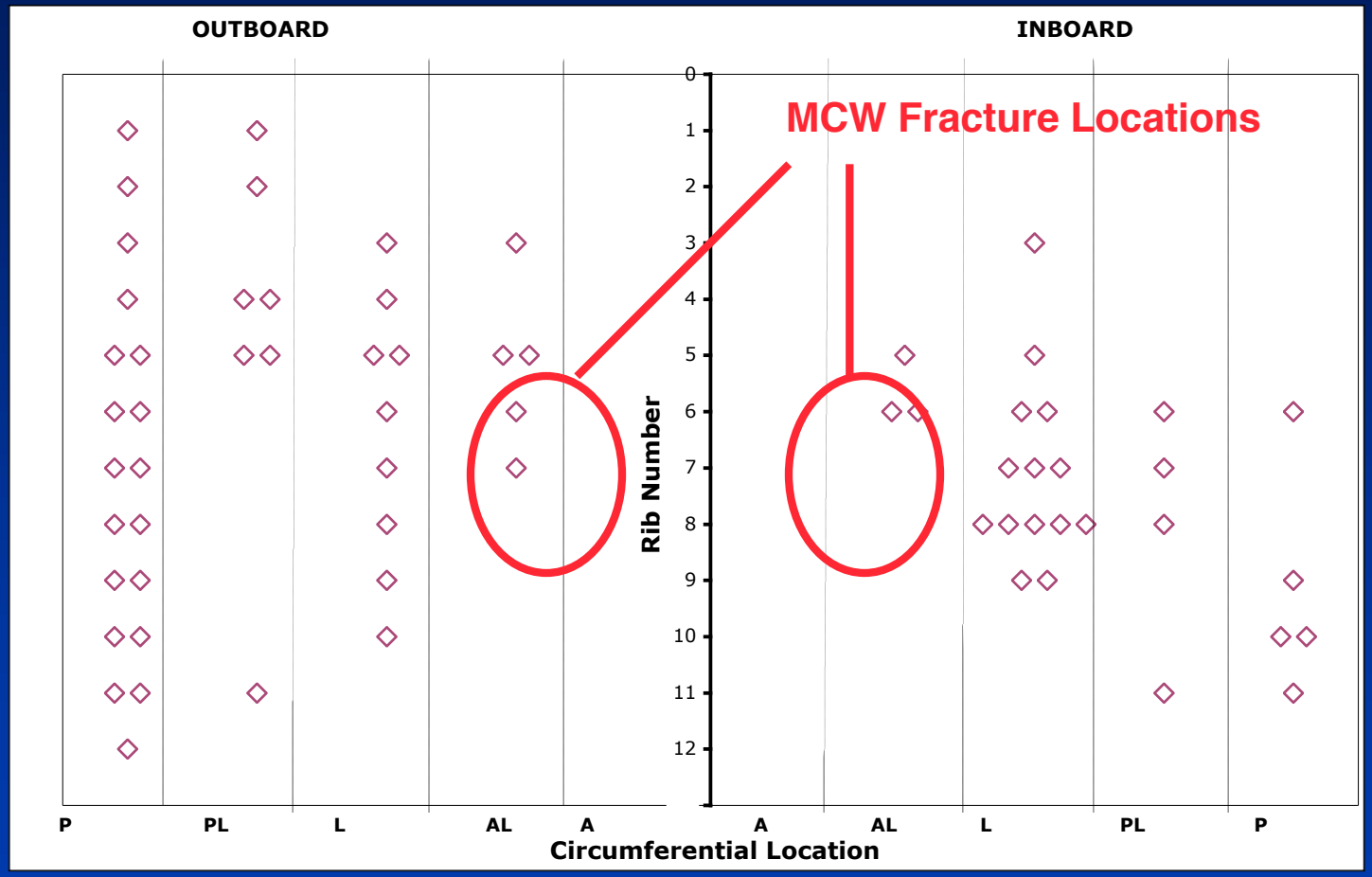
Rib Fracture Locations for Occupants in Frontal Crashes with Airbag-Only Restraint (n=20)

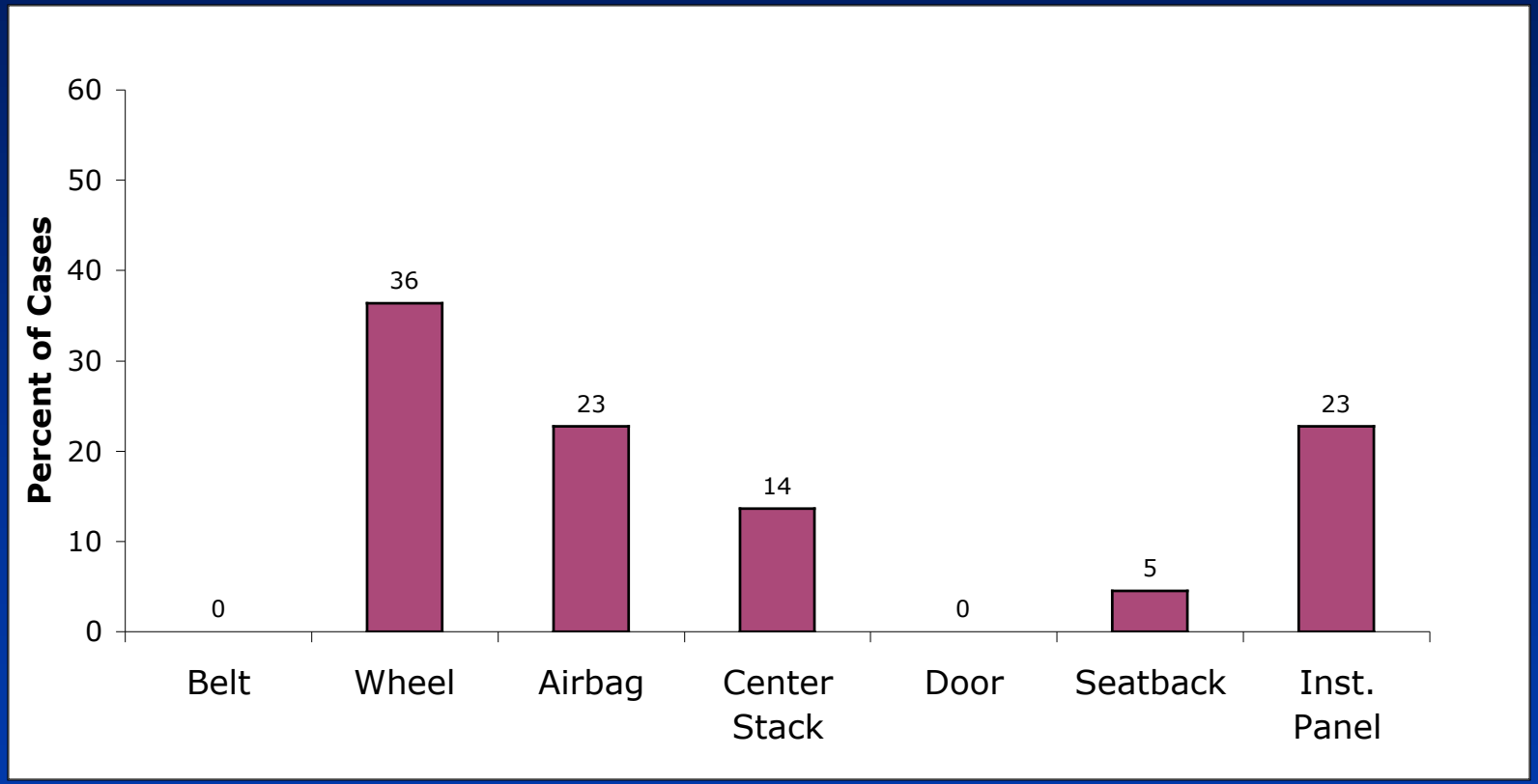


UM CIREN

Rib Fracture Locations for Occupants in Frontal Crashes with Airbag-Only Restraint (n=20)



Attributed Sources of Rib Fractures in UM CIREN Frontal Crashes with Airbag-Only Restrained Occupants (n = 20)



Future Work

1) Document specific locations of internal relative to skeletal injuries
2) Expand documentation and analysis of locations of skeletal and internal thoracic injuries to full CIREN database
3) Examine changes in skeletal and internal injury patterns with advanced restraint features such as belt pretensioners and belt load limiters
4) Examine differences in skeletal and internal thoracic injuries for near-side occupants by striking vehicle types and with and without side-impact airbags
5) Make data available to biomechanical researchers for experimental validation and interpretation of injury results

Acknowledgements

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Aaron Lange
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