Injury Mechanisms in Seat Belt-restrained Occupants in Side Impact Crashes

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Background

– Much attention on frontal crashes and tremendous success

– Recent attention on side impacts
  • Extensive focus on adults
  • Focus on children: limited to CRS

42% of fatalities of rear seat occupants age 0-8 were in side impacts (FARS)
Background
Previous Research Findings

• Know general information about injury risk in side impact
  – Fatality risk
    • Nearside vs. center, rear, all restraints 2.5 [Howard, 2004]
  – Injury risk
    • Nearside: front vs. rear, all restraints 2.6 [Durbin, 2001]
    • Nearside vs. farside, belted rear 1.8 [Maltese, 2005]
    • Belt vs. Booster, side impact rear 1.7 [Arbogast, 2005]
  – Injured Body Region, belt restrained
    • Head injuries the most frequent, rear
    • Abdominal injury increase suspected in center/non-struck

→ Limited injury mechanism information.
Project Goal

Delineate injury mechanisms for belt-restrained children involved in side impact crashes.
Methods
Retrospective Case Review

• CIREN-like Interdisciplinary Team
  – Met ~3x per month
  – Reviewed 2-3 cases per meeting
  – For 8 months

• CIREN, PCPS Databases

• Case Review
  – CIREN-type presentation
  – BIOTab AIS 2+
  – Contact Points
Methods

Dataset Inclusion Criteria

- Side impact
- Belt-only restrained
- Rear row
- 4 to 15 years old
- AIS 2+

63 cases met criteria

17 cases eliminated after quality control

46 total cases
Dataset Characteristics
Vehicle

Case Vehicle
- Passenger Car: 82%
- Minivan: 9%
- SUV: 9%

Other Vehicle/Object
- Car: 32%
- SUV: 24%
- Pickup truck: 17%
- Narrow Object: 11%
- Large truck: 9%
- Minivan: 7%
- Other Vehicle/Object: 11%
Dataset Characteristics

Crash

PDOF

CDC Damage

Delta V (kmph)

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td><strong>Average</strong></td>
<td>26.5</td>
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<tr>
<td><strong>Standard Dev.</strong></td>
<td>12.4</td>
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</tbody>
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Dataset Characteristics

**Occupant**

**Occupyant Age**

- 4-8 yrs: 54%
- 9-12 yrs: 26%
- 13-15 yrs: 20%

**Injury Severity**

- 2+ AIS: 100%
- 3+ AIS: 60%
- 4+ AIS: 20%
Injured Body Regions

Body Region

- Head (All)
- Face
- Thorax
- Abdomen
- Spine
- Upper Ext
- Pelvis
- Lower Ext

Injured Body Regions

- Nearside
- Center
- Farside

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Head Injury* Contact Points

**Nearside**
- Door
- Window
- Intruding Object
- Pillar

**Farside**
- Front Seat
- Other Occupant

**Center**
- Other Occupant
- Window
- Door
- Pillar

*no concussion*
Head Injury Case

- 9 year old female
- 127 cm (50 in.): 16%
- 34 kg (75 lb.): 78%
- Second row right
- 3 pt. lap and shoulder belt
- Maximum AIS: 4
Injuries

**Head**
- Right Small Subdural Cerebrum Hematoma/Hemorrhage, AIS 4, Right side window frame
- Lower Base (basilar) Skull Fracture NFS, AIS 3, Right side window frame
- Right Posterior Minor Scalp Laceration, AIS 1, Right side window frame

**Other Injuries**
- Thorax - AIS 2
- Abdomen - AIS 2
- Upper Extremity - AIS 1
- Lower Extremity – AIS 2
Interior Contacts
On the left, you see an artist’s rendering of the interior of a motor vehicle. On the right is a photograph of the interior of the vehicle that was involved in a crash, with one or more numbers in the picture. The numbers signify the location inside the vehicle where an occupant contacted the vehicle interior. Your task is to estimate the position of the numbers relative to the position of the seatback, locate the corresponding cell in the image on the left, and type the number in the cell.
Injured Body Regions

- Head (All)
- Face
- Thorax
- Abdomen
- Spine
- Upper Ext
- Pelvis
- Lower Ext

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Farside Abdominal Injury Case

Case Occupant

- 13 year old male
- 168 cm (66 in), 93%
- 66 kg (145 lbs), 95%
- Second seat right seating position
- 3 pt. manual lap and shoulder belt
- Maximum AIS: 3
Summary of Vehicles

- Case Vehicle: 1997 Plymouth Neon 4-door sedan
- Vehicle 2: 1991 Ford Aerostar minivan
Other Occupants

17 year old male
178 cm, 72 kg
Left front seating position (driver)
Manual lap/shoulder belt
Injuries:
  - Contusions to anterior chest
  - Contusions to left shoulder
  - Contusions to abdominal wall

16 year old male
173 cm, 68 kg
Right front seating position
Manual lap/shoulder belt
Injuries:
  - Contusions to right hip
  - Contusions to left hip
Injuries

Head
• Right anterior cerebrum contusion, AIS 3, Unknown source

Abdomen
• Lacerated small intestine, AIS 3, Lap belt webbing
• Lacerated/ruptured spleen, AIS 2, Shoulder belt webbing
• Contusions to right hip, AIS 1, Lap belt webbing
• Contusions to left hip, AIS 1, Lap belt webbing

Upper Extremity
• Contusions to right arm, AIS 1, Right rear inside door panel
• Abrasions to right arm, AIS 1, Right rear inside door panel
Conclusions

• Application of CIREN-model to retrospective case review
  – Retrospective BioTab
• Method developed for occupant contact localization from photographs
• Head injuries most common
  – Most frequent contact point is rear 1/3 of door, on the window sill and lower ½ of window (preliminary)
• Farside injuries in minor crashes
  – 4-point belts
  – Load limiters
Future Work

- Compare Crash Investigation dataset with PCPS Surveillance
- Compare farside child with adult
- Head injury protection
  - Headform
  - Curtain Airbag
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Crash Injury Research & Engineering Network

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