Analysis of Brain Trauma Coded as a Diffuse Axonal Injury

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Methods

- CIREN 1997 – 2006
- Coded phrase: DAI
- NASS / AIS coding
- AIS 1990+ scheme
- All restraint systems
- All impact modalities
- All occupant positions
- No ejections, rollovers
- Synthesize individual cases
Results

• 2,823 crash cases
• 3,178 medical cases
• 67 occupants (2.4%)
• One to 85 years of age
• 53 survivors, 14 fatalities
• 41 drivers, 26 passengers
• 15 pediatric, 52 adult occupants
Adult Age Distribution (years)

- All
- Frontal
- Nearside
- Farside
Adult Weight Distribution (kg)
Delta-V Distribution (km/h)
Body Mass Index (kg/m²)

<table>
<thead>
<tr>
<th>Category</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td></td>
</tr>
<tr>
<td>Frontal</td>
<td></td>
</tr>
<tr>
<td>Nearside</td>
<td></td>
</tr>
<tr>
<td>Farside</td>
<td></td>
</tr>
<tr>
<td>Rearend</td>
<td></td>
</tr>
</tbody>
</table>
## Injury Details

<table>
<thead>
<tr>
<th>Coded as:</th>
<th>Brainstem DAI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cerebellum DAI</td>
</tr>
<tr>
<td></td>
<td>Cerebrum DAI</td>
</tr>
<tr>
<td>Cerebrum contusion</td>
<td></td>
</tr>
<tr>
<td>Cerebrum hematoma/laceration</td>
<td></td>
</tr>
<tr>
<td>Brainstem hemorrhage or swelling</td>
<td></td>
</tr>
<tr>
<td>Subarachnoid or subdural hematoma</td>
<td></td>
</tr>
<tr>
<td>Cranial vault fracture</td>
<td></td>
</tr>
<tr>
<td>Basilar skull fracture</td>
<td></td>
</tr>
<tr>
<td>Facial fracture (orbit, zygoma, mandible, …)</td>
<td></td>
</tr>
<tr>
<td>Cervical spine trauma (fracture, dislocation, …)</td>
<td></td>
</tr>
<tr>
<td>Scalp or facial laceration, abrasion, contusion</td>
<td></td>
</tr>
<tr>
<td>LOC ??</td>
<td></td>
</tr>
</tbody>
</table>
Impact Type

- Nearside: 38
- Frontal: 15
- Far-side: 10
- Rearend: 3
- Other: 1

Legend:
- Nearside
- Far-side
- Frontal
- Rearend
- Other
Associated Injuries
Quasistatic Loading Human Zygoma

Yoganandan, Pintar et al, Stapp 1988
Dynamic Loading
Human Facial Fracture Probability

Yoganandan, Pintar et al, J Biomech 1996
Injuries
Dynamic Axial Loading to the Head

Yoganandan, Pintar et al, Spine 1991
Compressive Force-Induced Trauma

- Sample size = 30
- Force : 3.5 ± 1.5 kN
- Deflection: 19 ± 3 mm
- 29 to 95 years of age

Pintar, Yoganandan et al, Stapp 1995
Effect of Loading Rate (Female)

Injury Analyses: Frontal Impact

# of cases

<table>
<thead>
<tr>
<th>Category</th>
<th># of Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coded as DAI</td>
<td>15</td>
</tr>
<tr>
<td>Skull fx</td>
<td>9</td>
</tr>
<tr>
<td>Facial fx</td>
<td>9</td>
</tr>
<tr>
<td>Scalp / face</td>
<td>6</td>
</tr>
<tr>
<td>Contact</td>
<td>15</td>
</tr>
</tbody>
</table>
Cumulative Frequency Distribution

Delta-V (km/h)
Side Impact Type

Farside

Nearside

38 cases
Only Brain Injuries
Associated Injuries
Injury Analyses: Nearside Impact

# of cases

- **Coded as DAI**: 35
- **Skull fx**: 10
- **Facial fx**: 20
- **Scalp / face**: 15
- **Contact**: 25

Medical College of Wisconsin CIREN Center, Milwaukee, WI
Side Impact Type

Farside
9 cases

Nearside

38 cases
Injury Analyses: Far-side Impact

# of cases

Coded as DAI | Skull fx | Facial fx | Scalp / face | Contact
--- | --- | --- | --- | ---
9 | 3 | 6 | 9 | 9
Comparison by Mode

- Contusion
- SAH
- Skull fx
- Facial fx
- Scalp / face
- Contact

<table>
<thead>
<tr>
<th>Condition</th>
<th>Frontal</th>
<th>Nearsdie</th>
<th>Farside</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contusion</td>
<td>50%</td>
<td>20%</td>
<td>30%</td>
</tr>
<tr>
<td>SAH</td>
<td>40%</td>
<td>10%</td>
<td>50%</td>
</tr>
<tr>
<td>Skull fx</td>
<td>20%</td>
<td>50%</td>
<td>30%</td>
</tr>
<tr>
<td>Facial fx</td>
<td>30%</td>
<td>40%</td>
<td>30%</td>
</tr>
<tr>
<td>Scalp / face</td>
<td>60%</td>
<td>80%</td>
<td>20%</td>
</tr>
<tr>
<td>Contact</td>
<td>70%</td>
<td>90%</td>
<td>10%</td>
</tr>
</tbody>
</table>
Focal injuries

Motion injuries

Rotation
Noncontact Loading

Delta-V (kmph)

rad/sec/sec

DAI

Side

Frontal

of Wisconsin

Wisconsin Center, Milwaukee, WI
LINCAP Tests
Linear Acceleration (g)

No Head Contact

Head Contact

HIC < 1000

HIC: 712, 3986
LINCAP Tests
Angular Acceleration (rad/s/s)

No Head Contact

Head Contact
Summary

• Used CIREN 1997-2006 database
• 66 cases coded-DAI, AIS 1990/98
• Side impacts predominate, >70%
• Pediatric to geriatric age groups
• Skull/face involved > 90% cases
• Head contact association exists
  ⇒ Images, clinical reports, & other BR (face, neck)
• NCAP tests & laboratory studies
  ⇒ contact-induced metrics
Acknowledgment

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