An Evaluation of Spinal Cord Injury (SCI) Associated with Motor Vehicle Crashes including Rollovers

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HARBORVIEW INJURY PREVENTION & RESEARCH CENTER
Traumatic Spinal Cord Injury

- 11,000 new cases annually in US
- 260,000 persons in US living with chronic SCI

Primary data source: National SCI Statistical Center
- non-random sample of US SCI cases treated at 14 SCI Model Systems
- Summary of data at: http://www.spinalcord.uab.edu/show.asp?durki=21446
Neurologic Classification

• Injury Level
  – Lowest cord level unaffected by SCI

• Completeness of injury
  – **Complete injury** (50% of all injuries): no motor or sensory signals pass through the injured segment
  – **Incomplete injury**: some signals pass
    • Some sensation below injury level
    • May have some motor below level

Greater impairment (higher level; complete injury) causes greater disability, more medical complications, and reduced life expectancy
Etiology: 2000-2005

Auto Crash: 36%
Violence: 14%
Falls: 24%
Sports: 9%
Other Vehicular: 10%
Other: 7%

% Vehicular Etiology

•source: National SCI Statistical Center
Vehicular Etiology: Level of Injury

- Complete Tetra
- Incomplete Tetra
- Complete Para
- Incomplete Para
- Other/Unk.

*source: National SCI Statistical Center*
Case with Most Common Attributes

- 19 y/o white male; auto collision
- C4-C5 vertebral fracture-dislocation
- C5 neurological level; complete injury (loss all movement and sensation below that level)
Level of Injury

- About 50% have tetraplegia (quadriplegia): impairment of upper and lower limbs

![Bar chart showing the percentage of patients with injuries in different spinal segments: C-Spine, T-Spine, L-Spine.](chart_image)
Age at Injury: Vehicular Etiology

Source: National SCI Statistical Center
Course of Care

• Acute care:
  – Operative treatment of spinal fracture (66%)
  – Medical complications (respiratory failure, pneumonia, DVT, pressure ulcers, UTI’s)
  – Mean LOS: 15 days

• Rehabilitation
  – Inpatient: Mean LOS: 40 days
  – Outpatient therapy

• Life-long care for secondary medical complications of SCI
Yearly Expenses and Lifetime Costs Per Patient (In 2006 US Dollars)

<table>
<thead>
<tr>
<th>Injury Severity</th>
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<tbody>
<tr>
<td>C1-C4</td>
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- Includes health care expenses and living expenses directly attributable to SCI.
- Excludes indirect costs such as lost wages, benefits, productivity ($59,212 per year).

Source: National SCI Statistical Center
Life Expectancy for Persons with SCI who Survive at Least One Year Post-injury

Source: National SCI Statistical Center
Life Expectancy for Persons with SCI who Survive at Least One Year Post-injury

Source: National SCI Statistical Center
Important Medical Complications of Chronic SCI

• Mortality
  – Pneumonia, sepsis

• Morbidity
  – Pressure ulcers, UTI’s

• QOL
  – Bladder, bowel, sexual dysfunction, pain
Seattle CIREN Research

“Spinal Cord Injury and Auto Crashes: Findings from Three United States Databases” – submitted ???…..

Stephen P. Burns, MD, Christopher D. Mack, MS, Robert P. Kaufman, BS, and Eileen Bulger, MD
# Databases with SCI

<table>
<thead>
<tr>
<th></th>
<th>NSCID (’93-05)</th>
<th>CDS –(’93-06) (unweighted)</th>
<th>CDS(’93-06)</th>
<th>CIREN (’96-06)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong># of Cases</strong></td>
<td>3014</td>
<td>843</td>
<td>46,539</td>
<td>163</td>
</tr>
<tr>
<td><strong>Annual # of Cases</strong></td>
<td>~3700</td>
<td></td>
<td>~3300</td>
<td></td>
</tr>
</tbody>
</table>
## Databases with SCI

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<th>CDS –(’93-06) (weighted)</th>
<th>CIREN (’96-06)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, mean (years)</td>
<td>35.1</td>
<td>39.1</td>
<td>41.3</td>
<td>39.7</td>
</tr>
<tr>
<td>Acute Care - LOS, mean (days)</td>
<td>18.1</td>
<td>7.8</td>
<td>6.5</td>
<td>8.8</td>
</tr>
<tr>
<td>Tetraplegia (%)</td>
<td>64.3</td>
<td>68.1</td>
<td>74.6</td>
<td>76.7</td>
</tr>
<tr>
<td>Paraplegia (%)</td>
<td>35.7</td>
<td>31.9</td>
<td>25.4</td>
<td>23.3</td>
</tr>
<tr>
<td>Complete (%)</td>
<td>50.0</td>
<td>59.3</td>
<td>47.1</td>
<td>44.2</td>
</tr>
<tr>
<td>Incomplete (%)</td>
<td>48.8</td>
<td>36.7</td>
<td>46.1</td>
<td>51.5</td>
</tr>
<tr>
<td>Transient Paralysis (%)</td>
<td>1.2</td>
<td>3.9</td>
<td>6.7</td>
<td>4.3</td>
</tr>
</tbody>
</table>
## PDOF and ASI-SCI

<table>
<thead>
<tr>
<th>PDOF Category</th>
<th>Occupants with ASI (%)</th>
<th>Occupants with SCI (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non Horizontal (rollover)</td>
<td>2.519</td>
<td>0.252</td>
</tr>
<tr>
<td>Near Side</td>
<td>0.962</td>
<td>0.116</td>
</tr>
<tr>
<td>Far Side</td>
<td>0.764</td>
<td>0.090</td>
</tr>
<tr>
<td>Front</td>
<td>0.621</td>
<td>0.051</td>
</tr>
<tr>
<td>Back</td>
<td>0.458</td>
<td>0.067</td>
</tr>
</tbody>
</table>

Source: NASS-CDS
SCI in Rollover Collisions
# Rollovers and Body Type

<table>
<thead>
<tr>
<th>Rollover Type</th>
<th>Car/Van/Other (%)</th>
<th>SUV/Pickup (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>95.03</td>
<td>81.60</td>
</tr>
<tr>
<td>1/4 turn</td>
<td>0.77</td>
<td>4.06</td>
</tr>
<tr>
<td>1/2 turn or greater</td>
<td>4.20</td>
<td>14.34</td>
</tr>
</tbody>
</table>

LTV body types were 3.7 times more likely to experience any degree of a rollover (1/4 turn or greater)

Source: NASS-CDS
## Rollover Types with ASI-SCI

<table>
<thead>
<tr>
<th>Rollover Type</th>
<th>ASI (%)</th>
<th>SCI (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>0.492</td>
<td>0.0494</td>
</tr>
<tr>
<td>1/4 turn</td>
<td>1.308</td>
<td>0.161</td>
</tr>
<tr>
<td>1/2 turn or greater</td>
<td>2.773</td>
<td>0.269</td>
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<table>
<thead>
<tr>
<th>Vehicle Body Type</th>
<th>ASI (%)</th>
<th>SCI (%)</th>
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<tbody>
<tr>
<td>Car/Van/Other</td>
<td>0.617</td>
<td>0.064</td>
</tr>
<tr>
<td>SUV/Pickup</td>
<td>0.862</td>
<td>0.086</td>
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Source: NASS-CDS includes those in multiple crash events
Roof Crush and ASI-SCI

Percentage of Occupants with ASI or SCI

Roof Crush

- None
- 3-8 cm
- 8-15 cm
- 15-30 cm
- 30-45 cm
- 45-60 cm
- >60 cm

ASI
SCI

Legend:
- ASI
- SCI
Other related research

• Outside of Arc, more severe injuries/death

• Roof was main contact points for severe head and neck injuries.
Roof Crush and SCI

Compression - Flexion

Compression - Extension

Compression – Lateral Bending
CIREN Case Reviews
with ASI & SCI
Rollover CIREN Case Reviews with ASI-SCI

2000 Sport Utility Vehicle
Front Right Passenger
Lap/shoulder restrained
20’s yrs. – Male

(A belt restrained driver, and two other belt restrained passengers in second row had minor injuries and did not qualify for CIREN criteria)
Injuries

AIS 2 – Head

AIS 4 – C-spine fractures and Spinal Cord Injury
Case Review

2006 Large Van

Driver - 50 yr. old, Male
Lap/Shoulder belt restrained

(Also front right restrained passenger with minor injury)
Roof Crush and Intrusion

40cm/16inches roof Intrusion into driver position
Contacts
Compression- Flexion
Injuries

AIS 1 – Head

AIS 3 – Multiple C-spine fractures
Case Review

2003 Compact Pickup Truck
Driver – 24 year old Male
Lap/shoulder restrained – Air bag deployed
(No other passengers in vehicle)
Driver Seat Position - Intrusion

Roof Intrusion over driver 23 cm / 9 inches
Injuries

AIS 1 – Head

AIS 5 – C-spine fractures and Spinal Cord Injury
Assessment of Costs due to SCI in Rollovers
Yearly Expenses and Lifetime Costs Matched to AIS coding

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Source: National SCI Statistical Center
Annual Costs of SCI for All Crashes

Billions of $


year

Everybody -- Unbelted, Ejected, No Rollover, etc.

Source: NASS-CDS – Nationally all crashes involving SCI
Percent SCI by Roof Crush Among Rollovers

![Bar graph showing the mean # of Qtr. Turns for different categories of roof crush.](image)

Source: NASS-CDS 1993-2006
Percent SCI by Roof Crush Among Rollovers by Body Type

Source: NASS-CDS 1993-2006
Percent SCI by Roof Crush Among Belted Occupants

Source: NASS-CDS 1993-2006
Mean Cost for SCI per Roof Crush for Belted Occupants

Source: NASS-CDS – Note: under count due to unknown restraint use for many
Minimize Roof Crush and Savings

• If roof crush were no higher than 30cm then total savings of $717,570,000 (1993-2006)

• Annual Savings $51,255,000

Note: For belted occupants and undercount due to unknown restraint use for many
Thank you