Wide vs. Narrow Frontal Crashes: Do Injury Patterns Differ?

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Presentation Objectives

- Discuss differences between wide and narrow impacts
- Present examples of wide and narrow impacts investigated by San Diego CIREN
- Compare injury experience of occupants in wide vs. narrow impacts using CIREN database
- Discuss implications for injury prevention comparing wide vs. narrow impacts
Why Study Wide vs. Narrow Impacts Using CIREN Data?

- NHTSA frontal crash test: “head on” into fixed barrier to assess safety system effectiveness
  - Not tested on narrow impacts
- Delta T differs for wide and narrow impacts
- Real world experience provides information on safety system effectiveness during narrow impacts
Definitions

◆ Narrow impact
  - 6th column of CDC=“N”
  - Damage distribution across frontal plane < 41 cm

◆ Wide impact
  - 6th column of CDC=“W” and 4th column of CDC=“D”
  - Wide damage distribution across 66% of frontal plane
Deceleration pulses

Wide vs. Narrow Impacts (Delta V / Delta T)

Wide impact (evenly distributed force)
- Significant speed change begins immediately

Narrow impact (focalized force)
- Significant speed change is delayed until enough resistance is built up

Delta V (velocity change)

@ 50ms

35 mph
This case involves a belted, male driver responding to a frontal (this vehicle) collision with the back of a slow moving, heavy truck.
Driver – sole occupant

21yo male, 6’2”, 205 lbs

Pretensioner equipped belt used, frontal impact air bag(s) deployment. Bucket seat between mid & rear, slightly reclined. Cushion twisted to right, seat back twisted to left due to remote buckling

- Mesenteric arterial avulsion
- Small bowel avulsion
- Sigmoid colon “degloving” injury
- Left testicular artery and vein laceration
- Right rectus muscle partial transection

12:00 PDOF
Crash: 1 event

- Frontal to Vehicle – Back plane full end plane impact

- Case vehicle
  
  **2003 Mitsubishi Lancer**
  4-door sedan, 2697 lbs.
  **12:00 PDOF (Zero-degrees)**
  54 kmph BES **DV (34 mph)**

- Opposing vehicle (V2)
  
  **2003 Peterbilt 3-axle “cement truck”** nfs.
  Heavy Truck, full load, > 10,000 lbs GVWR

- 6:40 am, Saturday, cloudy, dry, daylight
2002 Mitsubishi Lancer / 54 cm Max. crush / 34 mph DV / 12:00 PDOF
Direction of travel

POI
Transfer on bag (skin?)

Sheared completely
Contact: lower dash/bolster, belt, air bag, steering assembly
Wide Impact CIREN Case

Right lower abdominal abrasion  Left lower abdominal abrasion
Toe pan intrusion 5 cm
Wide Impact CIREN Case

- 21 year old male, 6’2”, 205 lbs
- MAIS 4, ISS 17
- Ground transport to ED with complaint of pain
- US and DPL positive → OR ½ hour after arrival
- Multiple operative procedures
  - Exploratory laparotomy, repair of partial transection of right rectus muscle
  - Ligation of mesenteric arterial bleeds, left testicular artery, and left testicular vein
  - Small bowel resection with primary anastomosis
  - Sigmoid colon resection with primary anastomosis
Wide Impact Case: Injury Sources

- Abdomen
  - AIS 3-4 Major lac of arteries and veins (safety belt)
  - AIS 4 Massive (OIS Grade IV/V) jejunum-ileum lac (safety belt)
  - AIS 4 Massive (OIS Grade IV/V) colon laceration (safety belt)
  - AIS 1 Contusions and abrasions
This case involves a belted driver responding to a narrow frontal impact into a rigid object with frontal impact air bag deployment.

Subject – Driver
1996 Nissan Sentra
Crash: 1 event

- Narrow front to rigid object
  30cm steel, non-breakaway utility pole, not damaged
- Case vehicle
  1996 Nissan Sentra
  4-door sedan, 2315 lbs., 100” wheelbase
  12 o’clock PDOF
  WinSmash dV = 66 mph
- 1:54 am, Saturday, clear, dry dark-street lights
Subject – Driver (sole occupant)

30-year-old male, 5’10”, 200 lbs. Belt used, frontal impact air bag(s) deployed.

- R - internal pudenal artery laceration
- R - acetabulum fracture
- R - posterior tibial artery and vein transection
- R - fibula mid shaft fracture, nondisplaced, minimal angulation
- Multiple R - foot fractures and soft tissue injury
- Concussion w/ LOC < 1 hour (CT negative)
- L - extensive diastasis sacroiliac joint and pubic symphysis w/ retroperitoneal hematoma
- L - iliolumbar artery laceration
- L - distal tibia/fibula
- L - medial malleolus
- L - calcaneous fracture
- L - hand laceration w/ extensor tendon lacerations
1996 Nissan Sentra / Max. crush = 135 cm / 12:00
PDOF / 66mph dV (stvz 45mph)
Left: dash (32), toe pan (86), steering assembly (31), A-pillar, floor pan (15) intrusion.
Contacts:
knee bolster (L & R),
steering assembly,
belt, floorboard
(pedals)
Right Foot
Left medial malleolus fracture
Right Calcaneous Fracture
L - Sacroiliac Joint Diastasis
Narrow Impact CIREN Case

- 30 year old male, 5’11”, 201 lb, MAIS 4, ISS 34
- 45 minute extrication ⇒ helicopter transportation
- Multiple operative procedures
  - Pelvic angioembolization: gelfoam embolism R-internal pudenal artery, coil embolism L-iliolumbar branches
  - Exploratory laparotomy
  - ORIF symphysis pubis
  - Irrigation & debridement w/splinting open heel injury
  - Vascular grafting  L-tibial artery transection
  - External fixation R-foot and ankle
  - Irrigation & debridement L-hand w/repair of 3rd & 4th digit extensor tendons
  - Closed reduction  L-pilon fracture w/ internal and external fixation
  - Closed reduction, percutaneous screw fixation L-sacroiliac joint dislocation
- Hospital length of stay 24 days, discharged to extended care facility
Narrow Impact Case: Injury Sources

◆ Head
  ➢ AIS 2  LOC < 1 hour (Air bag)

◆ Upper extremity
  ➢ AIS 1  Multiple hand tendon lacerations (IP)

◆ Abdomen
  ➢ AIS 4  Major laceration iliac artery (Steering wheel)
  ➢ AIS 3  Minor laceration other named arteries (IP)

◆ Lower extremities
  ➢ AIS 3  Skin laceration w/ blood loss >20% volume (IP)
  ➢ AIS 3  Symphysis pubis diastasis (Floor/toe pan)
  ➢ AIS 3  Open, displaced, comminuted tibia shaft fx (Floor/toe pan)
  ➢ AIS 3  Laceration arteries/veins (IP)
  ➢ AIS 2  Closed pelvic fractures (Floor/toe pan)
  ➢ AIS 2  Calcaneal fracture (Floor/toe pan)
  ➢ AIS 2  Talus, Metatarsal/Tarsal fracture and traumatic arthrotomy (Floor/toe pan)
  ➢ AIS 2  Fibula fracture (head/neck/shaft) (Floor/toe pan)
  ➢ AIS 2  Medial malleolus tibia fracture (IP)
CIREN Database

Used to compare injury patterns for wide vs. narrow impacts

- Regions injured
- Within regions, compare severity and sources
- Specific injuries for selected regions
Study Criteria

- Frontal impact
  - PDOF=12 o’clock and GAD=F
  - Ranked #1 impact by Crash Investigator
  - Wide: damage distribution $\geq 66\%$ of frontal plane
  - Narrow: damage distribution $< 41$ cm
Study Criteria

◆ Inclusion criteria
  ➢ Safety belt use
  ➢ Frontal air bag deployment during impact
  ➢ AIS ≥ 2 injury severity

◆ Exclusions criteria
  ➢ Children (<13 yrs)
  ➢ Passengers
  ➢ Open cases
CIREN Cases

- **Wide Impacts**: $N = 141$
  - Mean age = 43, Median age = 41 (range: 16-80 yrs)
  - Mean ISS = 19, Median ISS = 14 (range: 5-75)
  - Mean delta V = 49, Median = 47 (range: 14-92 kmph)

- **Narrow Impacts**: $N = 35$
  - Mean age = 46, Median age = 47 (range: 17-86 yrs)
  - Mean ISS = 17, Median = 14 (range: 5-43)
  - Mean Delta V = 52, Median = 47 (range: 22-113 kmph)
WIDE vs. NARROW FRONTAL CRASHES

Injury Severity by Body Region

![Chart showing injury severity by body region for wide and narrow crashes.]

- **Head**
  - AIS 6: 0%
  - AIS 5: 10%
  - AIS 4: 20%
  - AIS 3: 30%
  - AIS 2: 50%

- **Spine**
  - AIS 6: 0%
  - AIS 5: 20%
  - AIS 4: 30%
  - AIS 3: 50%
  - AIS 2: 60%

- **Thorax**
  - AIS 6: 0%
  - AIS 5: 20%
  - AIS 4: 30%
  - AIS 3: 50%
  - AIS 2: 60%

- **Abdomen**
  - AIS 6: 0%
  - AIS 5: 20%
  - AIS 4: 30%
  - AIS 3: 50%
  - AIS 2: 60%
WIDE vs. NARROW FRONTAL CRASHES

Injury Sources

Body Region

- Head
- Spine
- Thorax
- Abdomen

Percentage of Injuries

- Other
- Non-contact
- Interior
- Inst Panel
- Air Bag
- Steering Wheel
- Safety Belt
WIDE vs. NARROW FRONTAL CRASHES

Injury Patterns

◆ Head
◆ Thorax
◆ Abdomen*
  ➢ Wide impact ➔ Solid organ injury
  ➢ Narrow impact ➔ Hollow viscus injury
Source of Injuries

Wide Impact Injury Sources

Narrow Impact Injury Sources
# WIDE vs. NARROW FRONTAL CRASHES

## Differences in Abdominal Injury

<table>
<thead>
<tr>
<th></th>
<th>Wide</th>
<th>Narrow</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abdominal injury</td>
<td>Solid organ</td>
<td>Hollow viscus</td>
</tr>
<tr>
<td>Seatbelt use &amp; air bags</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>Age (years)</td>
<td>Mean 43, Median 41</td>
<td>Mean 46, Median 37</td>
</tr>
<tr>
<td>ISS</td>
<td>Mean 19, Median 14</td>
<td>Mean 17, Median 14</td>
</tr>
<tr>
<td>Death</td>
<td>11%</td>
<td>3%</td>
</tr>
<tr>
<td>Type of Auto = Car</td>
<td>77%</td>
<td>74%</td>
</tr>
<tr>
<td>Object hit</td>
<td>78% moving auto</td>
<td>89% pole or tree</td>
</tr>
<tr>
<td>Delta T</td>
<td>Evenly distributed</td>
<td>Focalized</td>
</tr>
</tbody>
</table>
Summary

- Different injury patterns observed for some regions
  - Wide impacts have more head and upper extremity injuries
  - Narrow impacts have more abdomen and thoracic injuries
  - Wide impacts have more solid organ abdominal injuries compared to narrow impacts with more hollow viscus injuries

- Wide impacts result in greater injury severity for each region except the abdomen

- Different patterns of injury sources observed for some regions comparing wide vs. narrow impacts
  - Implications for vehicle and safety system design to prevent injury

- Needs further study as more CIREN cases become available
San Diego CIREN Team

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