Riding in a car continues to be the most dangerous thing you do on a daily basis
MOTOR VEHICLE SAFETY

- CRASHES ARE NOT “ACCIDENTS”
- EVERYDAY 93 PEOPLE DIE IN MOTOR VEHICLE CRASHES, 33,808 PEOPLE IN 2009
- ONE PERSON DIES EVERY 16 MINUTES
- LEADING CAUSE OF DEATH FOR PERSONS 3-33 YEARS OF AGE

Persons Killed and Injured in Crashes

<table>
<thead>
<tr>
<th>Year</th>
<th>Persons Killed</th>
<th>Persons Injured</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005</td>
<td>43,443</td>
<td>2,699,000</td>
</tr>
<tr>
<td>2006</td>
<td>42,708</td>
<td>2,575,000</td>
</tr>
<tr>
<td>2007</td>
<td>41,059</td>
<td>2,491,000</td>
</tr>
<tr>
<td>2008</td>
<td>37,261</td>
<td>2,367,000</td>
</tr>
<tr>
<td>2009</td>
<td>33,808</td>
<td>2,217,000</td>
</tr>
</tbody>
</table>

Sources: FARS, NASS Ges
Motor Vehicle Fatalities: Lowest Rate In Recorded History

Sources: 2003 NCSA, FARS, FHWA

Physics and Medicine

Injuries occur when the energy released exceeds the body's ability to absorb it, which results in tissue destruction and organ damage.
KINETIC ENERGY

\[ E = \frac{1}{2} \cdot M \cdot V^2 \]

This is the energy an object has by virtue of its motion.
GRAVITATIONAL FORCES

\[ g = \frac{\Delta v_{mph}^2}{30 \cdot dist_{stopping, ft}} \]

Human Tolerance = 30-45 g’s

Three Phases of Deceleration

- Automobile
- Occupant
- Internal Organs
OCCUPANT KINEMATICS

- The branch of mechanics concerned with the effects of external forces on the motion of a body.
- Driven by Newton's Laws of motion and the principals of physics

BIOMECHANICS

- The study of the mechanics of a living body
- The science concerned with forces exerted on the anatomical structure of a body and the resultant stresses and strains within that structure
### BIOMECHANICAL FORCES

- **SHEAR**: oppositely directed non-aligned forces (scissors)
- **COMPRESSION**: caused by opposing aligned forces (squeeze)
- **TENSION**: caused by opposing aligned forces (stretch)
- **BENDING**: outer surface in tension, inner surface in compression
- **TORSION**: twisting forces that are opposing and non-aligned

### Haddon Matrix

<table>
<thead>
<tr>
<th>Human</th>
<th>Vehicle</th>
<th>Environment</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Human" /></td>
<td><img src="image2.png" alt="Vehicle" /></td>
<td><img src="image3.png" alt="Environment" /></td>
</tr>
</tbody>
</table>

*Post-Event Event*
Contributing Factors

- Human
- Vehicle
- Environment

YOUTH

Young people 16-19 years of age are 4x as likely to die in a motor vehicle crash compared to those 25-69 years of age.
Older Drivers

The fatality rate for older drivers is 9 times higher than the rate for drivers 25 to 69 years old.

ALCOHOL

- 10,839 Deaths in 2009
- 32.0% of the total motor vehicle deaths
- There is one alcohol related fatality every 48 minutes
ALCOHOL

- Impairs your driving skills
- Drunks drive faster
- Drunks use their seatbelts less
- Drunks have decreased response time

Contributing Factors

- Host
- Agent (vehicle)
- Environment
SAFETY BELTS

SAFETY BELT FACTS

- ABOUT 84% USE NATIONWIDE
- 45% EFFECTIVE
- SINCE 1975- 267,890 LIVES SAVED AS OF 2009
- 12,713 IN 2009 (COULD HAVE BEEN 16,401)
Primary vs. Secondary Laws

- **Primary law**
  - Motorist can be cited for failing to use the safety belt

- **Secondary law**
  - Motorist can only be cited for failure to use belt IF stopped for another offense first

PRETENSIONERS
AIRBAG DEATHS SINCE 1990

- 260 total deaths - mostly in older vehicles
- 86 Drivers
- 11 Passengers
- 130 Children
- 23 infants
### AIRBAG DEATHS SINCE 1990

<table>
<thead>
<tr>
<th>Drivers</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>86</td>
<td></td>
</tr>
<tr>
<td>- 54 unbelted</td>
<td></td>
</tr>
<tr>
<td>- 25 belted</td>
<td></td>
</tr>
<tr>
<td>- 4 misused belts</td>
<td></td>
</tr>
<tr>
<td>- 3 unknown</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Children</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>130</td>
<td></td>
</tr>
<tr>
<td>- 102 unrestrained</td>
<td></td>
</tr>
<tr>
<td>- 23 Improperly restrained</td>
<td></td>
</tr>
<tr>
<td>- 5 Properly restrained</td>
<td></td>
</tr>
<tr>
<td>- 22 Seated in the passengers lap</td>
<td></td>
</tr>
<tr>
<td>- 3 Seated in the lap of the driver</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Infants</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>23</td>
<td></td>
</tr>
<tr>
<td>- mostly in rear facing child safety seats or in occupants lap</td>
<td></td>
</tr>
</tbody>
</table>
Contributing Factors

- Host
- Agent (vehicle)
- Environment
Environmental Improvements

- Interstate Highways
- Energy Absorbing Barriers
- Breakaway Signs and Poles
- Access to Pre-Hospital Care
ABC’s of Vehicle Assessment

- **A** is for “Angle” or more precisely Principle Direction of Force (PDOF)
- **B** is for Belts and Bags
- **C** is for Crash Severity
PDOF and Occupant Response

The PDOF tells us the patient’s
– likely path of travel,
– side of body likely injured,
– the parts of the vehicle that are likely to be injury sources, and
– the direction from which unsecured cargo and/or unrestrained occupants may have struck the patient from the “backside” of the PDOF.
ABC’s of Vehicle Assessment

Remember
- The other occupants in the vehicle (injured or not) often interact during the crash sequence and can be the source of a patient’s injury

ABC’s of Vehicle Assessment

How to quickly assess the PDOF of a given vehicle
Quick Assessment of PDOF

- The “Superman” technique
  - if you could grab a piece of the vehicle with one finger and pull in one direction, what direction would you pull in order to restore the car to its original shape
ABC’s of Vehicle Assessment

- Precision is not required
- An “o’clock” interpretation is sufficient

O’CLOCK / PDOF
Vehicle 1

Honda Inova Fairfax Hospital CIREN Center

CIREN Case # 03-103-1-2

Left back contusion

Honda Inova Fairfax Hospital CIREN Center
ABC’s of Vehicle Assessment

B is for “Belts & Bags”

D-rings
Load Limiters

Post-Crash Belt Mode

Belt “locked” in extended mode post-crash - will not retract
Post-Crash Belt Mode

Belt “locked” in retracted mode post-crash - will not extend

Post-Crash Webbing Cut
ABC’s of Vehicle Assessment
“Bags”

ABC’s of Vehicle Assessment
Lower SW rim deformation is “usually” indicative of an unbelted driver.

Upper SW rim deformation is “usually” indicative of a belted driver.
Upper and lower SW rim deformation tends to occur in higher severity crashes and can be either be a belted or unbelted driver.

ABC’s of Vehicle Assessment

- Rule - belted occupants may still contact interior components in higher severity crashes
- Rule - in general, belt restrained occupants fare well in most crashes
- Exceptions - improperly belted, inappropriately belted, very young and the very old
ABC’s of Vehicle Assessment

- Rule - airbag restrained occupants generally enjoy good protection from head to abdomen
- Exception - unbelted occupants can often miss or skip off the airbag (angled PDOFs)
- Exception - occupants who are out-of-position (OOP) can sustain “inflation injuries” - eg flail chest, A-O dissociation, forearm fractures, brain injuries (angular acceleration)

ABC’s of Vehicle Assessment

- Rule - injury probability increases as crash severity increases
- Rule - near-side impacts have higher probability of injury than other crash modes (front, rear)
ABC’s of Vehicle Assessment

C is for “Crash Severity”

ABC’s of Vehicle Assessment

Minor - Frontal

Minimal hood deformation
No wheelbase reduction
Appears “driveable”
ABC’s of Vehicle Assessment

Minor - Side

- No wheelbase reduction
- 4 inches or less of door intrusion
- Vehicle generally driveable

ABC’s of Vehicle Assessment

Moderate - Frontal

- Moderate hood deformation
- Typically not driveable
- Minimal or no wheelbase reduction
- Minimal intrusion; typically limited to floor/toe pan
ABC’s of Vehicle Assessment
Moderate - Side

- 4-6 inches of door intrusion
- Minimal or no wheelbase reduction
- Doors may be jammed but no entrapment (physically pinned by vehicle component)

ABC’s of Vehicle Assessment
Severe - Frontal

- Significant hood deformation
- Obvious wheelbase reduction
- Remote buckling of roof due to A-pillar movement
- Dash, floor, & steering column intrusion common
ABC’s of Vehicle Assessment
Severe - Side

More than 6 inches of door intrusion
Roof buckling
Obvious wheelbase reduction
Vehicle may bow (banana shape)

Seat cushion & seat backrest deformation common
Occupant entrapment (physically pinned) more common

Five Crash Patterns
- Frontal
- Frontal Angle
- Side Impact
- Rear
- Rollover
FRONTAL IMPACT

Frontal Crash Injury Patterns

- Down-and-under Pathway
- Up-and-over Pathway
Down-and-Under Pathway (most common)
- Long Bone Fractures
- Open Knee/Fractures
- Hip Dislocation
- Abdominal Injuries
- Facial Trauma if Unbelted

Up-and-Over Pathway (less common)
- Head
- Neck
- Chest
- Abdomen
Rear Impact

Alanto-Occipital Dissociation
MOTORCYCLES

- 13% of all motor vehicle fatalities (5,154 in 2007)
- 3% of all registered vehicles
- 0.4% of total vehicle miles traveled
- 37 times more likely to die
- 37% = People turn left in front of them
Motorcycle Fatalities Are Rising

3,661 deaths in 2003

Source: FARS

QUESTIONS?