The Dynamics of Trauma

Jamie Syrett, MD
Director of Prehospital Care
Rochester General Health System
Me

• Boarded EM physician
• Fellowship trained in EMS
• Volunteer
• EMT-B,D,P,L5.........etc etc etc
• Today - Commitment
Me

- “Funny Doctor”
- Lacrosse Player
- First 10 minute penalty
Feedback

• Please fill it out.......I do read it!
My Gift

- UGA
- WAGA
- Mass applause
THIS FILM IS NOT YET RATED
“Trauma”

- n. pl. trauˈmas or trauˈmaˈta
- A serious injury or shock to the body, as from violence or an accident.
- An emotional wound or shock that creates substantial, lasting damage to the psychological development of a person, often leading to neurosis.
- An event or situation that causes great distress and disruption.
A serious injury or shock to the body, as from violence or an accident.
Kinematics

- **Kinematics** noun (plural) /ˌkinəˈmatɪks/

- The branch of mechanics concerned with the motion of objects without reference to the forces that cause the motion.

- Incomplete - Mass and Force are important
Mechanics

- mechanics noun (plural)  /məˈkaniks/
- The branch of applied mathematics dealing with motion and forces producing motion
- Mechanism of trauma - Incomplete
Dynamics

- **dynamics** noun (plural) /dɪˈnamɪks/
dynamics, plural

- The branch of mechanics concerned with the motion of bodies under the action of force

- The branch of any science in which forces or changes are considered
Dynamics

- Concerned with the effect of forces on the motion of a body or system of bodies, especially when the forces do not originate in the system itself........
Attention to the dynamics can describe and predict the effects of a trauma.
Dynamics

- Considers forces on a system of bodies (vehicle, sidewalk, tree, animal etc).
- By understanding the Dynamics of Trauma we can more accurately assess patients.
Dynamics of Trauma

- EMS providers are the key (and only) people equipped to and in the situation to analyze these dynamics.
Lost in Translation

• Case in Rochester

• Transition of care from BLS-FR to ALS - ambulance arrived - ALS providers never saw the scene

• Med Phone Alert - “27 year old cyclist struck by a vehicle, immobilized prior to our arrival, possible LOC, HR - 140.......
The Trauma Scene

- The Trauma Scene is an interaction of
  - Different objects
  - Different speeds
  - Different directions
  - Different masses
Dynamics

• Understanding the dynamics = predict injury

• ............so lets go back to class
Newtons 1st Law

• An object at rest will remain at rest unless it is acted on by an external and unbalanced force.

• An object in motion will remain in motion unless it is acted on by an external and unbalanced force.

• Known as the law of inertia.
Newton’s Laws of Motion

Force

The marble speeds up rolling down the ramp.

Force

The marble slows down rolling up the ramp.

Force

The marble will neither slow down nor speed up rolling on a perfectly horizontal surface.
Newton’s 2nd Law

- Force = Mass x Acceleration
- Force = Mass x Change in Velocity
- Deceleration is a form of acceleration and is more pertinent to trauma
Newton's Laws of Motion

F = 100 N

m = 50 kg
Newton’s 3rd Law

• For every action there is an equal and opposite reaction

• Known as the law of force pairs
Conservation of Energy

- Energy is not created or destroyed, it only changes from form to form
Conservation of Energy

- Kinetic energy changes to
  - Heat
  - Sound
  - Vehicle Deformity
  - Patient Injury
$F = ma$

- Vehicle - 1 ton (909kg)
- 60 mph to 0 mph over 7 secs = $3.82\text{m/s}^2$
- Gravity = $9.8\text{m/s}^2$
- 60 mph to 0 mph over 0.5 secs = $53\text{m/s}^2$
\[ F = ma \]

- \( F \) if braking = 3472 N
- \( F \) is crashing = 48177 N
- 13 times the force!
- The force is the energy dissipated to the vehicle and the passengers during the crash
Kinetic Energy

\[ KE = \frac{1}{2} \times m \times v^2 \]

- m=mass, v=velocity
- 150lb at 30mph = 67,500
- 180lb at 30mph = 81,000
- 150lb at 40mph = 120,000
Inertia and Blunt Trauma

- Car strikes pole
- Driver continues to move forward
- Body strikes steering wheel
- Posterior body keeps moving forward
- Organs compressed
Vehicular Trauma

- There are 3 impacts
  - Vehicle with environment
  - Body with cabin
  - Organs with body structure
Falls

- 2 impacts
- Body with ground
- Organs with body
Pre-Impact Variables

- Mass (of the vehicle and the patient)
- Velocity
- Age
- Drugs/Alcohol
- Pre-morbid conditions
Impact Variables

• Acceleration

• Direction of Impact (impact variables)
  • 2 vehicles head on at 30mph = 60mph
  • Lateral impact (t-bone)
  • Tangential
  • Roll-over (multiple directions)
T-bone
T-Bone
Traumatic Aortic Shear Injury
Risk factors for LIBTAR (<40mph) were age >60 (p<0.0001), lateral impact direction (OR 2.041, RR 1.99, p=0.003), and struck side seat position (OR 1.934, RR 1.885 p=0.101). Low-impact crash scenarios were found to represent more than 95% of UK road traffic accidents.
40% overlap = 40% of the width of the widest part of the car (not including wing mirrors)

R-Point = hip point for a 95th percentile male
Impact Variables

- Affect Injury
  - Protective Gear
    - Seatbelt, airbags, child seats
  - Ejection from Vehicle
  - Additional Impacts between environment and patient will occur
What could be injured?

Improper Seatbelt Use
Seatbelt (even proper use!)

What might be injured?
Seatbelt Injuries

- Increasingly seeing
  - Sternal fractures (associated spinal and rib trauma)
  - Intestinal injury
## Seatbelt Sign

<table>
<thead>
<tr>
<th></th>
<th>No Seatbelt</th>
<th>Seatbelt</th>
<th>Seatbelt Sign</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Any Abdo Trauma</strong></td>
<td>10%</td>
<td>15%</td>
<td>64%</td>
</tr>
<tr>
<td><strong>Small Bowel Injury</strong></td>
<td>2%</td>
<td>6%</td>
<td>21%</td>
</tr>
</tbody>
</table>
Too late to fasten your seat-belt

Wearing a seat-belt reduces the risk of being ejected from a vehicle and suffering serious or fatal injury by between 40% - 65%.

Be part of the solution: wear a seat-belt.

www.who.int/roadsafety
Post Impact Variables

- Permits prediction of region of injury
  - Spider windshield
  - Broken Steering Column
  - Dashboard damage
Post Impact Variables

- Predicts force of injury
- Intrusion
- Need for extrication
- Roll over
- Height of fall
Chest vs Steering Column
Knee vs Dash
Knee vs Dash
Acetabular Fracture
Pedestrian Struck

- Adult
  - Initial impact to hips/lower extremity
  - Secondary Impact - head/torso
  - Onto vehicle then hit the ground
Pedestrian Struck

- Pediatric
  - Initial impact to torso
  - Secondary impact to head
  - Then under vehicle - run over or dragged
Other Considerations

• Falls
  • Increased height = increased velocity = increased force of injury
  • 3x patient height = significant increase in severity of injury
  • Landing mechanism hints at injury
Other Considerations

- Blast injury
- Combine blunt and penetrating components
Penetrating Trauma

• Still a transfer of energy between the patient’s body and the object causing the injury

• F=ma, m is small. So damage is highly dependent on velocity and where the impact is (stab = low velocity)
Cone of Injury

“Cone of injury” in penetrating wounds may extend beyond entrance point.
Cone of Injury

What might be injured?
Cone of Injury

What might be injured?
Cavitation Injury
Blast Injury
Blast Injury

- Primary - Pressure Wave (6800mph)
- Secondary - Shrapnel (High velocity)
- Tertiary - Blunt Trauma
Trauma Criteria

• Ejection from moving vehicle
• Death in same passenger compartment
• Prolonged extrication
• Falls > 20 ft
• Rollover
• Pedestrian Struck
• Motorcycle crash
• Electrocution
• Hanging
• Large animal falls
• Blast injury
• GSW
Trauma Criteria

• Each trauma suggests a dynamic mechanism of injury with a significant force involved

• Occult injuries are highly likely despite benign appearance of patient
Mechanism in C Spine

- Mechanism is one of the most important predictors of injury in c-spine injury
- You already have the knowledge base to determine the injury pattern
C-Spine Mechanisms

- 4 main mechanisms
  - Axial load
  - Flexion
  - Extension
  - Complex movement
Atlas
(the first cervical vertebra)

Axis
(the second cervical vertebra)

Spinous Process

Transverse process

Vertebral body

C1
C2
C3
C4
C5
C6
C7
TI
Forced Extension
• Historically from Hangings

• Extreme Hyperextension

• Head On Collision and Sudden Deceleration

• Unstable Fracture through Pedicle of C2: minimal cord injury
Posterior arch
Anterior arch
Odontoid process
Fracture lines extending through pedicles
Posterior cervical line
Axial Load
Jefferson

- Most commonly seen in diving into shallow water

- Not normally associated with neurological deficit although spinal cord injury may occur if there is a retropulsed fragment.

- 50% are associated with other C-spine injuries, 33% are associated with a C2 fracture, 25-50% of young children have concurrent head injury
Jefferson
Forced Flexion
Complex Movement
• type I: fracture upper part of the odontoid peg - rare and potentially unstable

• type II: fracture at the base of the odontoid; unstable, and has a high risk of non-union

• type III: through the odontoid and into the lateral masses of C2; best prognosis for healing because of the larger surface area of the fracture
• A fracture caused by 'sudden forward and backward movement of the head with respect to the trunk', with a shearing of the dens from the body of C2, with forward movement by the transverse ligament, with backward movement by the anterior arch of C1; flexion is the most common mechanism of injury; extension injuries result in posterior displacement of the dens.
• EMTs must be experts at reading the scene and seeing the mechanism

• Velocity is the most important factor in any calculation of the forces involved

• Mechanism predicts injury