The Dynamics of Trauma

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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. trau·mas or trau·ma·ta
- 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.

Kinematics

- kin·e·mat·ics noun (plural) /ˌkinəˈmatiks/
- 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

- me·chan·ics noun (plural) /məˈkaniks/
- The branch of applied mathematics dealing with motion and forces producing motion

- Mechanism of trauma - Incomplete


东方大厦
商场出入口

Dynamics

- dy·nam·ics noun (plural) /dīˈnamiks/ 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.....

Dynamics

- 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

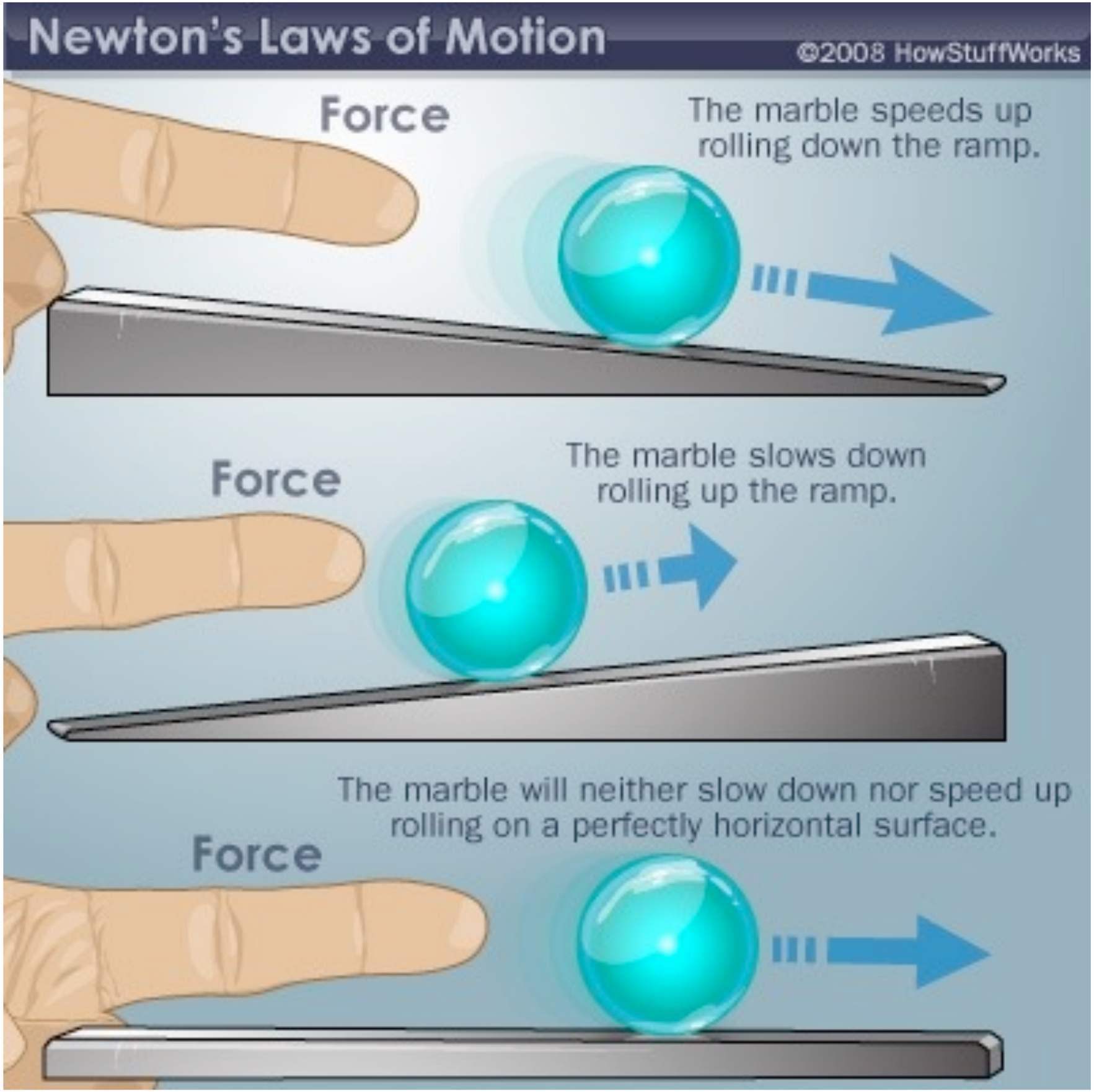
- The Trauma Scene is an interaction of
  - Different objects
  - Different speeds
  - Different directions
  - Different masses

Dynamics

- Understanding the dynamics = predict injury
- .....so lets go back to class

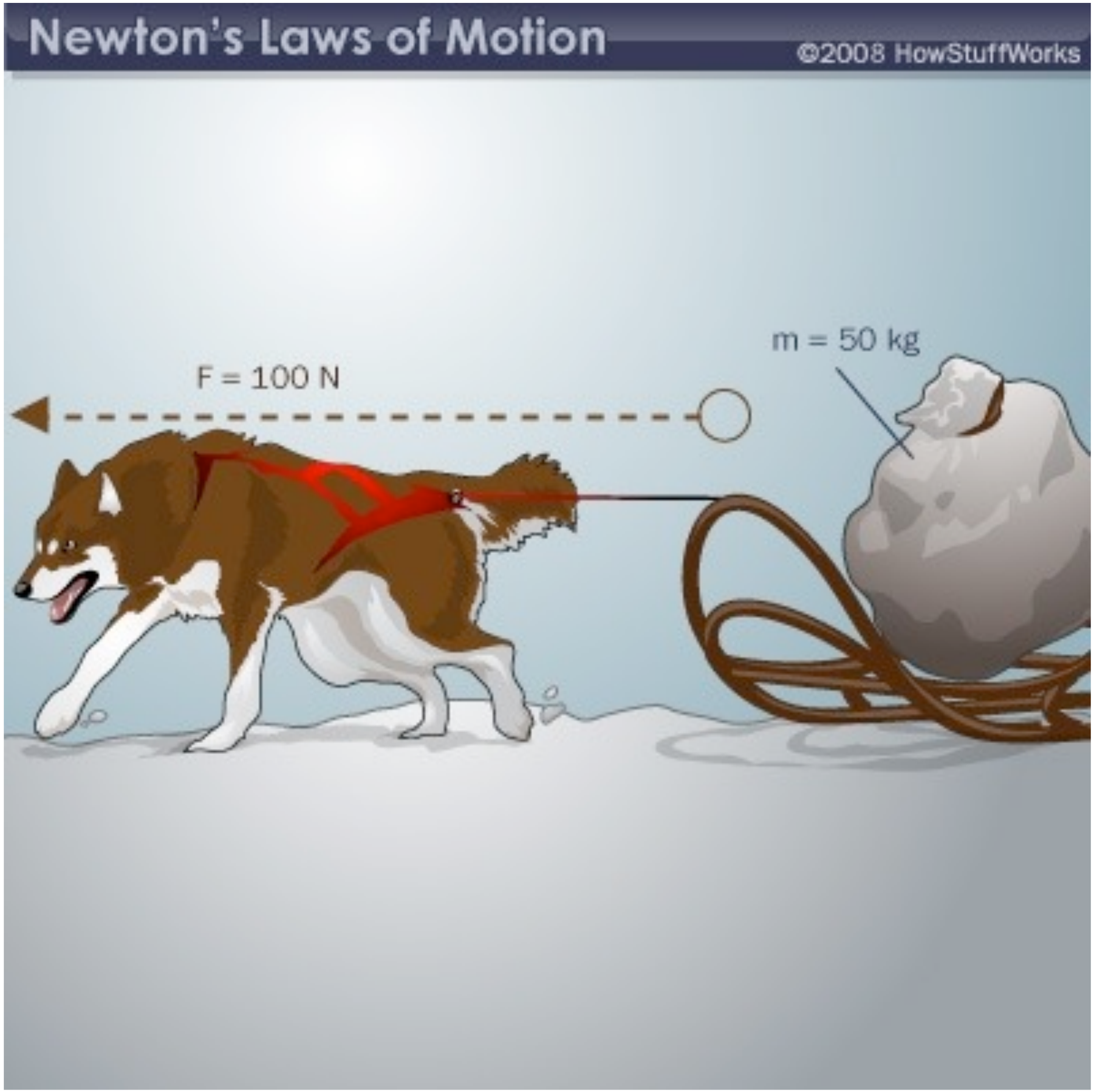
Newtons 1st Law

- 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
©2008 HowStuffWorks
Force
The marble speeds up rolling down the ramp.
Force
The marble slows down rolling up the ramp.
The marble will neither slow down nor speed up rolling on a perfectly horizontal surface.
Force

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
©2008 HowStuffWorks
F = 100 N
m = 50 kg

Newton's 3rd Law

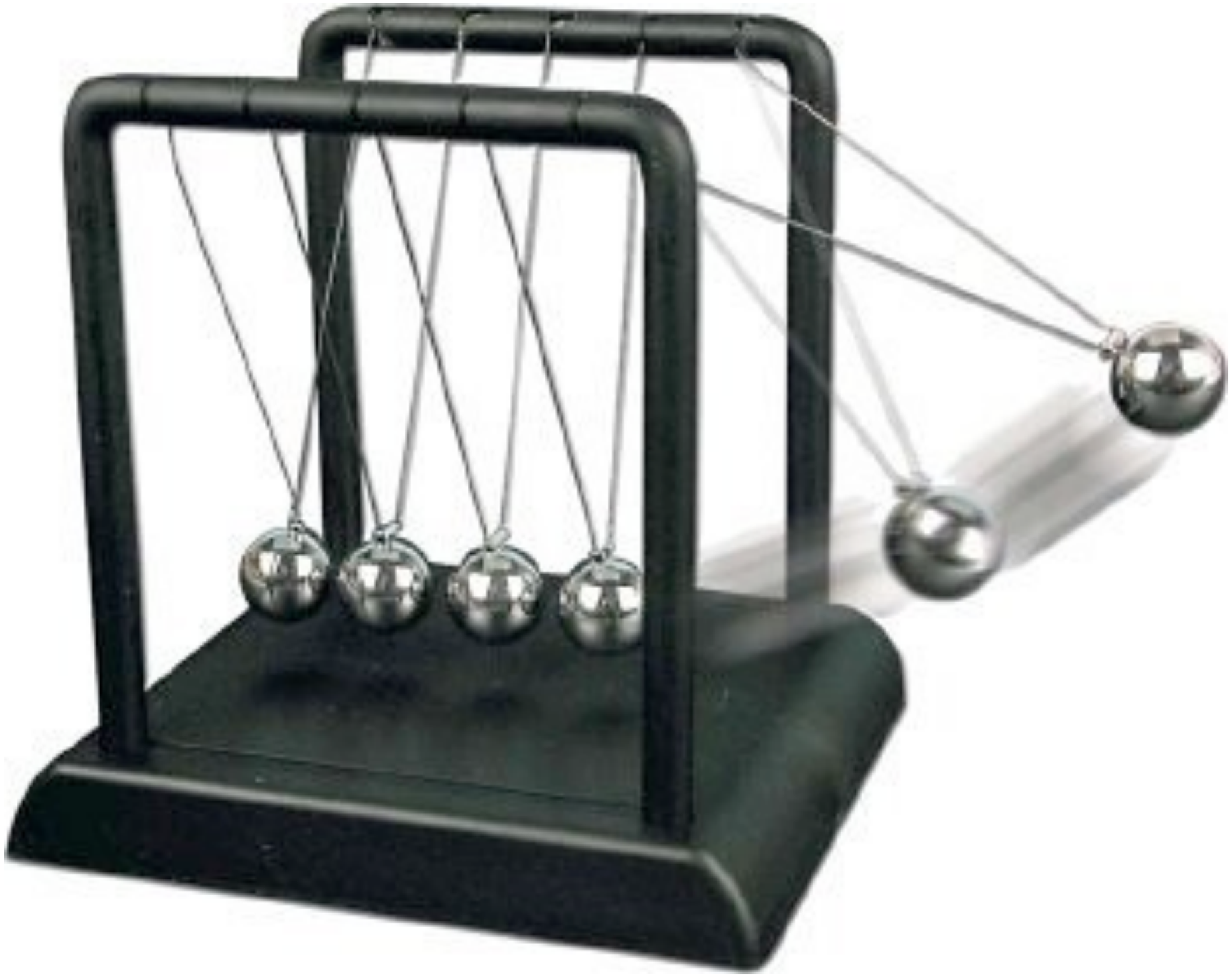
- For every action there is an equal and opposite reaction
- Known as the law of force pairs


PR


Sanex
arena

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 = 3.82m/s^2
- Gravity = 9.8m/s^2
- 60 mph to 0 mph over 0.5 secs = 53m/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

$$KE = \frac{1}{2} * m * v^2$$

- 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

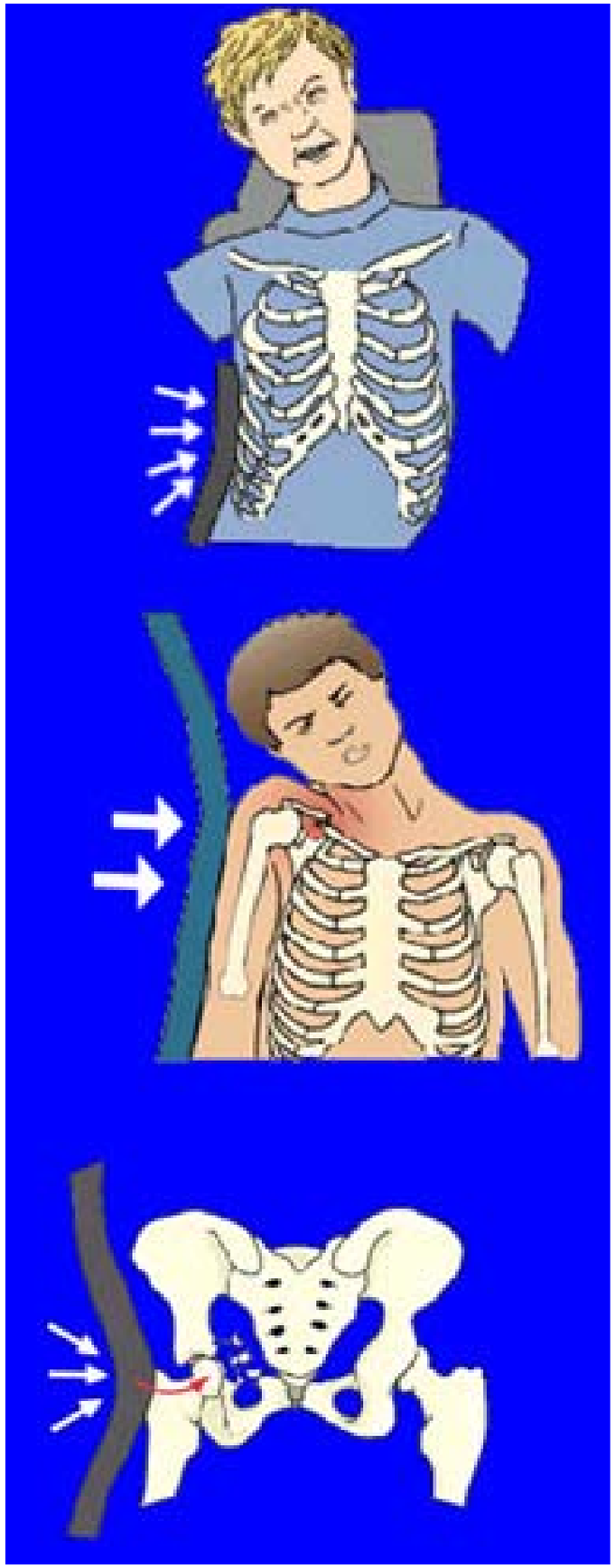
- Mass (of the vehicle and the patient)
- Velocity
- Age
- Drugs/Alcohol
- Pre-morbid conditions

Impact Variables

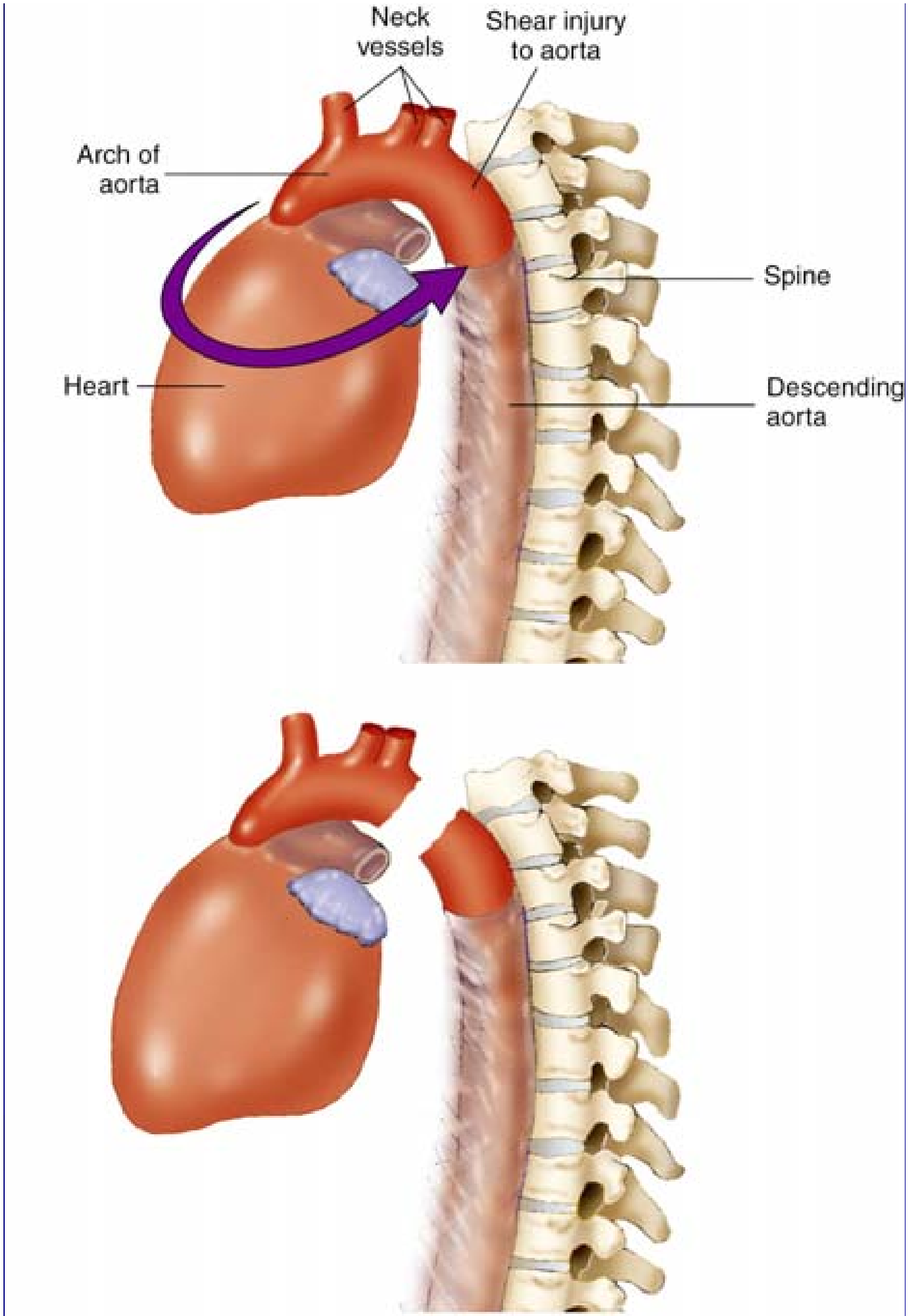
- Acceleration
- Direction of Impact (impact variables)
  - 2 vehicles head on at 30mph = 60mph
  - Lateral impact (t-bone)
  - Tangential
  - Roll-over (multiple directions)

T-bone

T-Bone

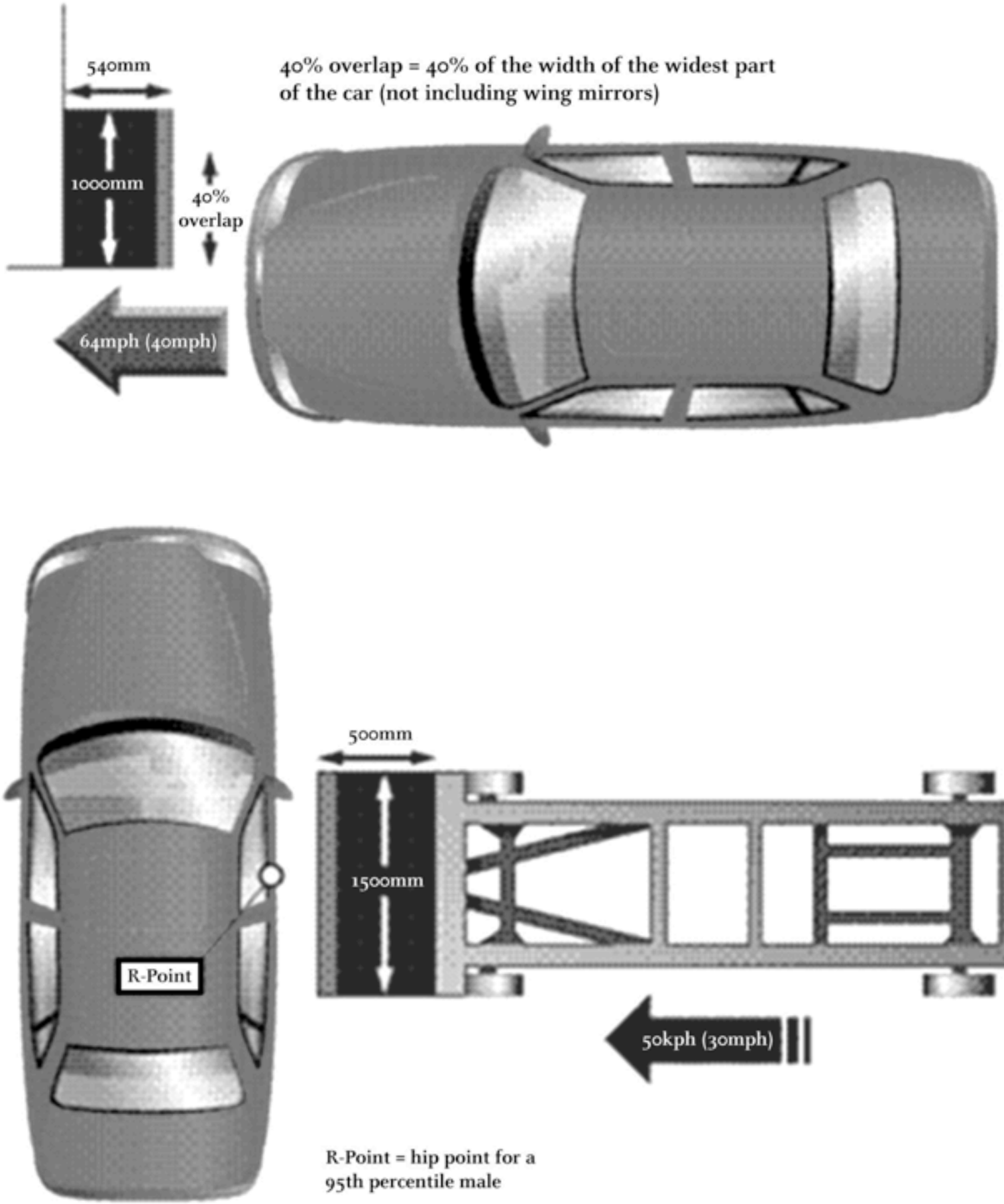


Traumatic Aortic Shear Injury



EMJ May 2010

- Risk factors for LIBTAR (<40mph) were age >60 (p<0.00001), 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.

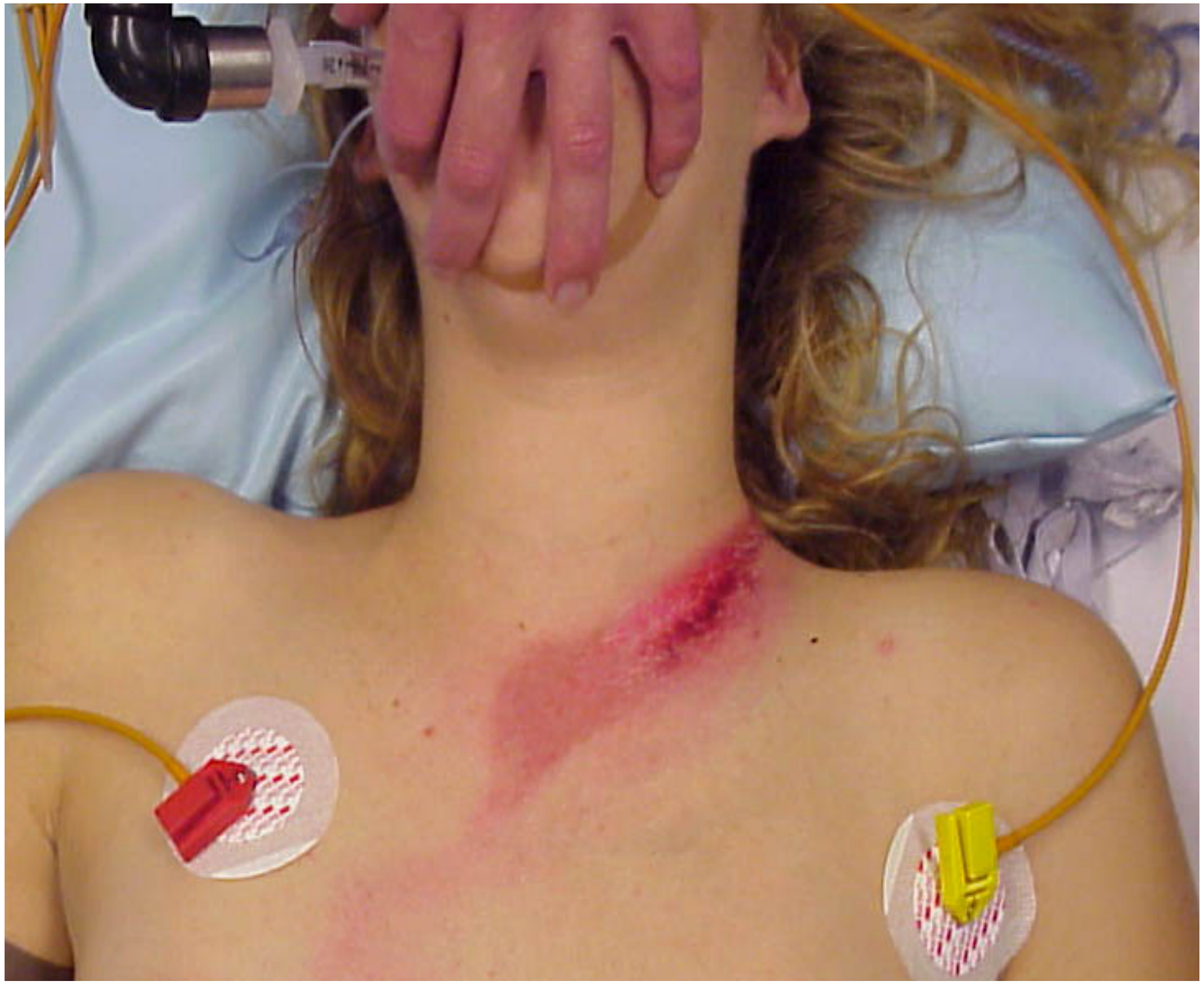

540mm
1000mm
40%
overlap
64mph (40mph)
40% overlap = 40% of the width of the widest part
of the car (not including wing mirrors)
500mm
1500mm
50kph (30mph)
R-Point
R-Point = hip point for a
95th percentile male

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?

Seatbelt
(even proper use!)



Seatbelt Injuries

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

Seatbelt Sign

	No Seatbelt	Seatbelt	Seatbelt Sign
Any Abdo Trauma	10%	15%	64%
Small Bowel Injury	2%	6%	21%


CUFF


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.
ROAD SAFETY IS NO ACCIDENT
www.who.int/roadsafety

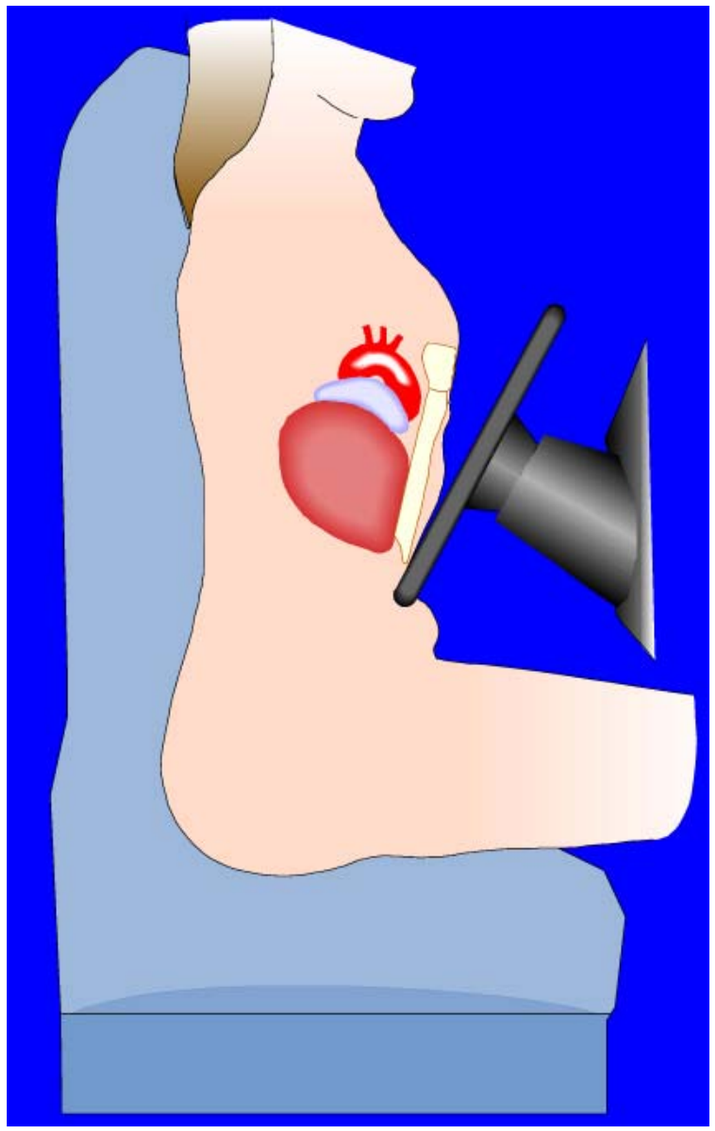
Post Impact Variables

- 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

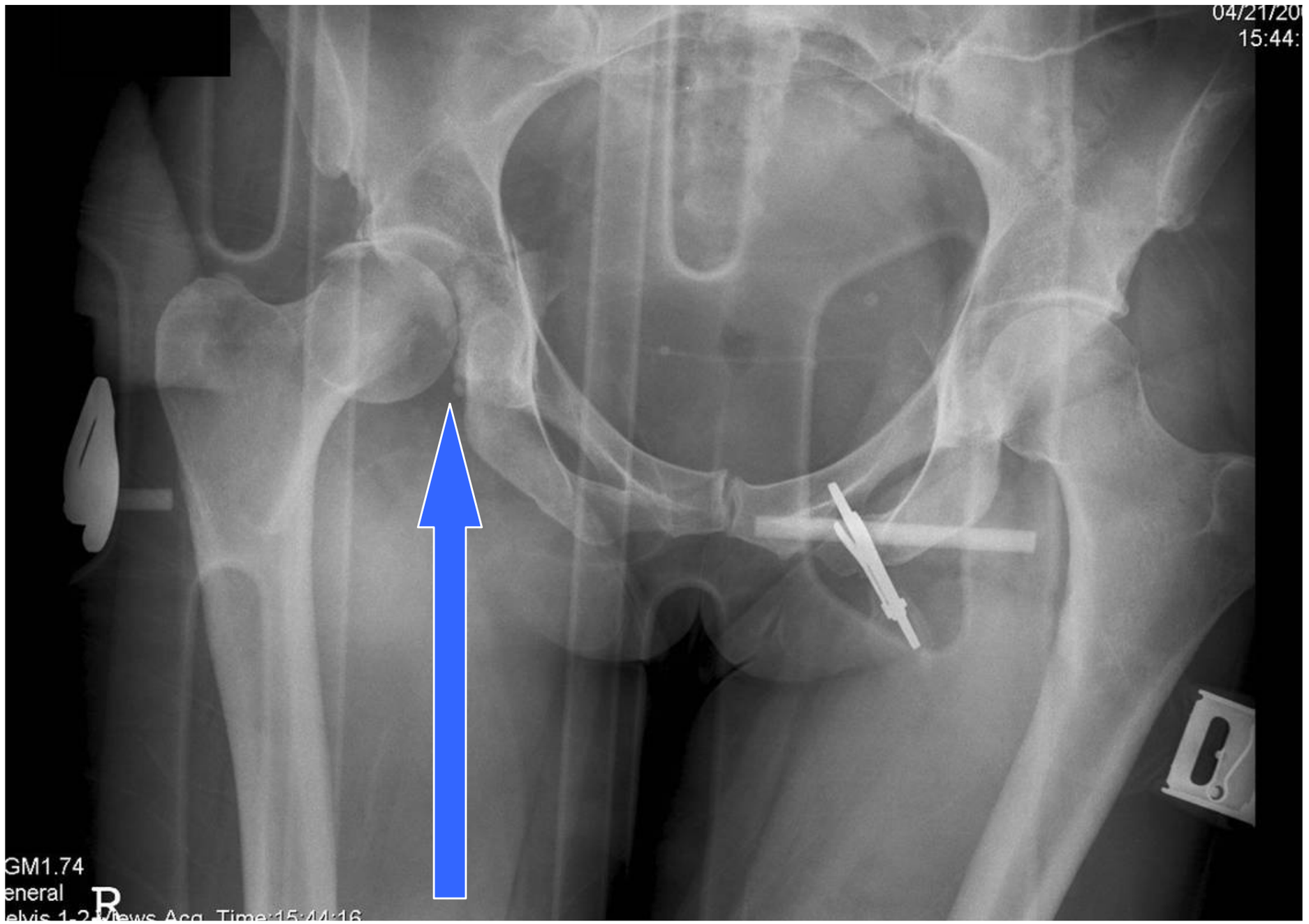
Chest vs Steering Column



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

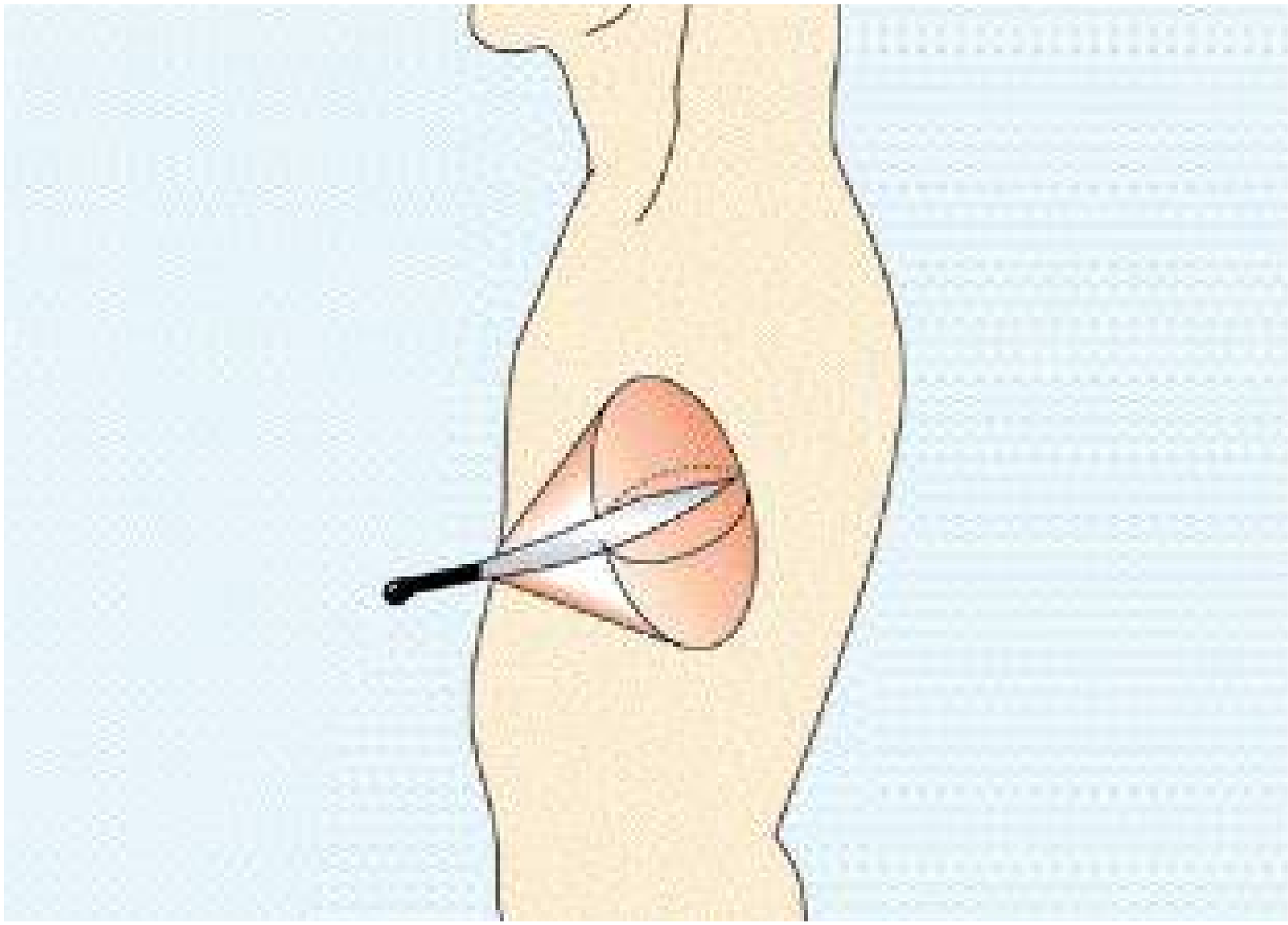
Other Considerations

- Blast injury
  - Combine blunt and penetrating components
  - Pressure wave (6800 mph). Shrapnel injury. Blunt Injury.

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)

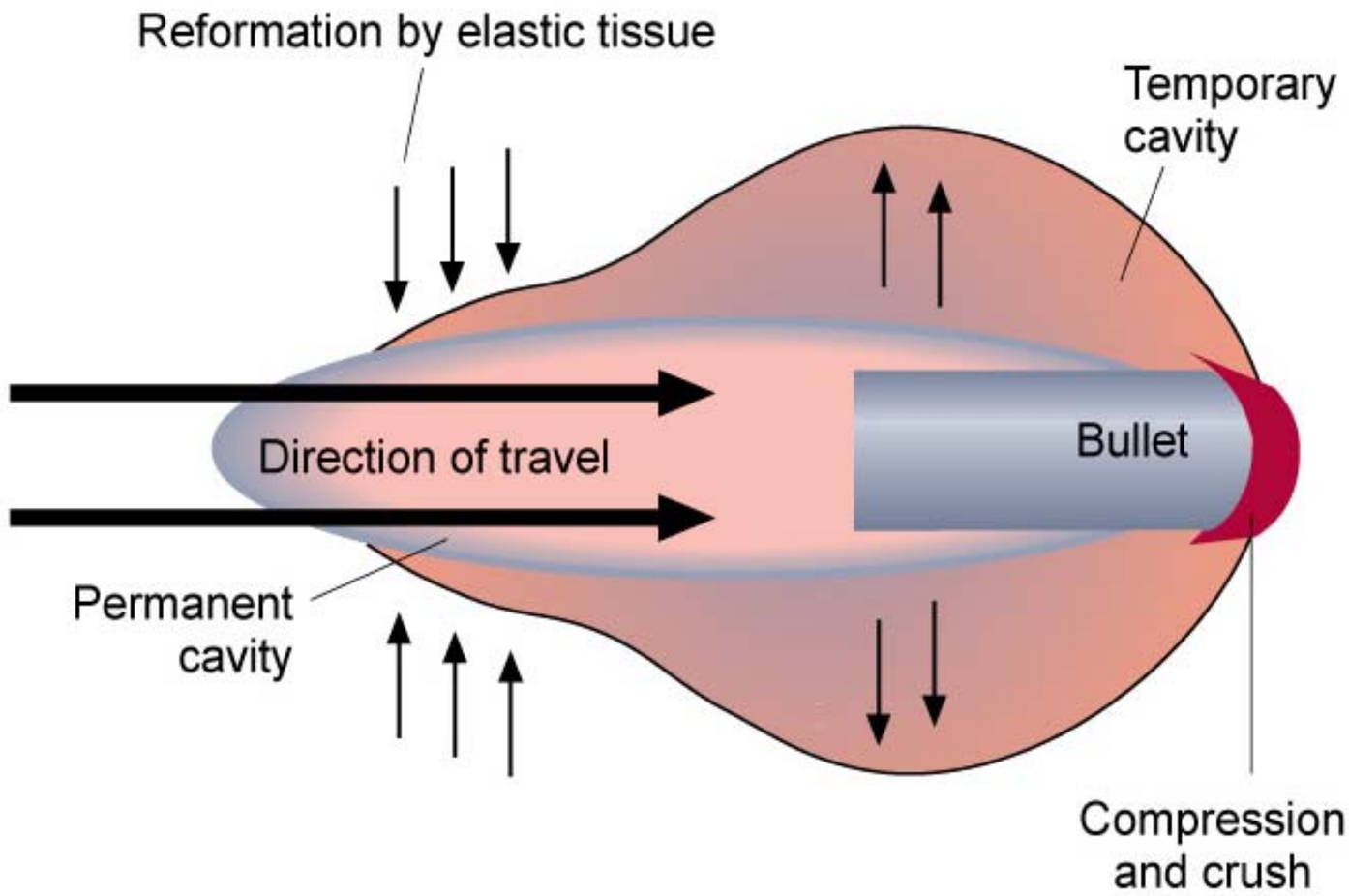
Cone of Injury



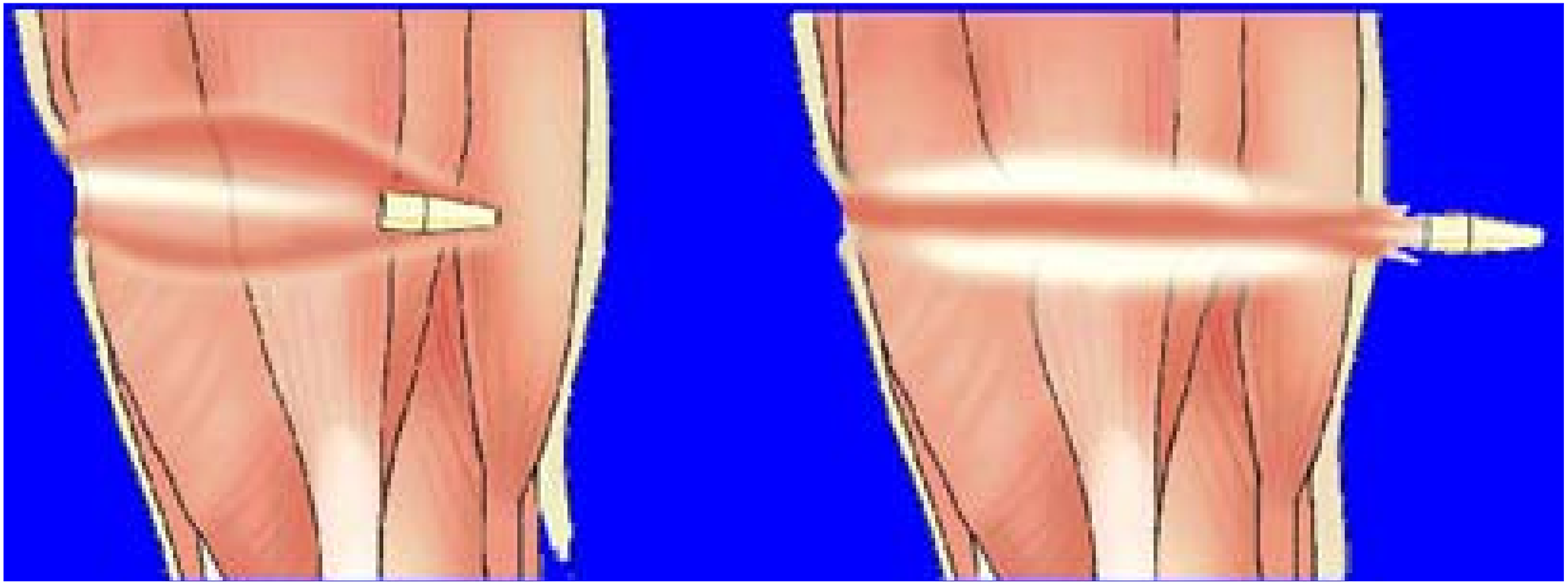
Cone of Injury

Cone of Injury

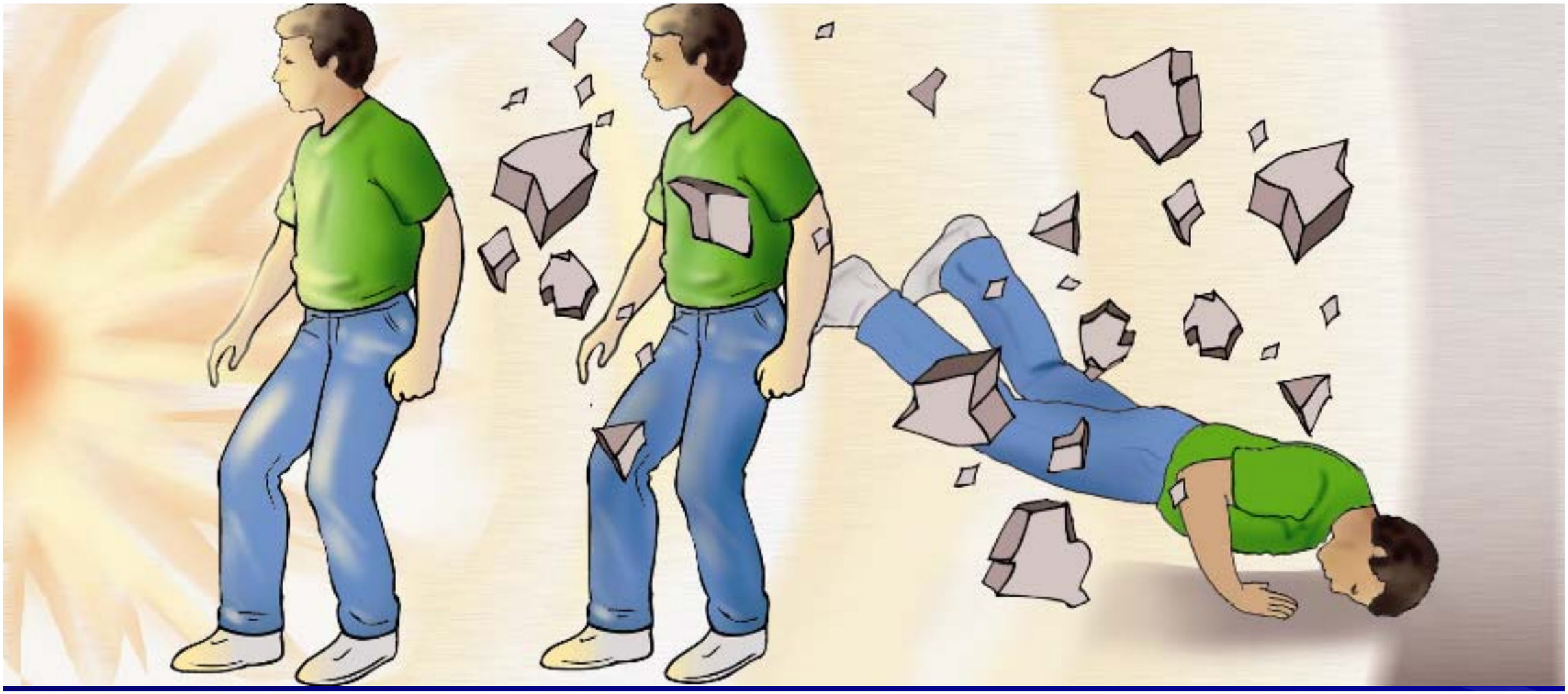
Cavitation


Reformation by elastic tissue
Temporary cavity
Direction of travel
Bullet
Permanent cavity
Compression and crush

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

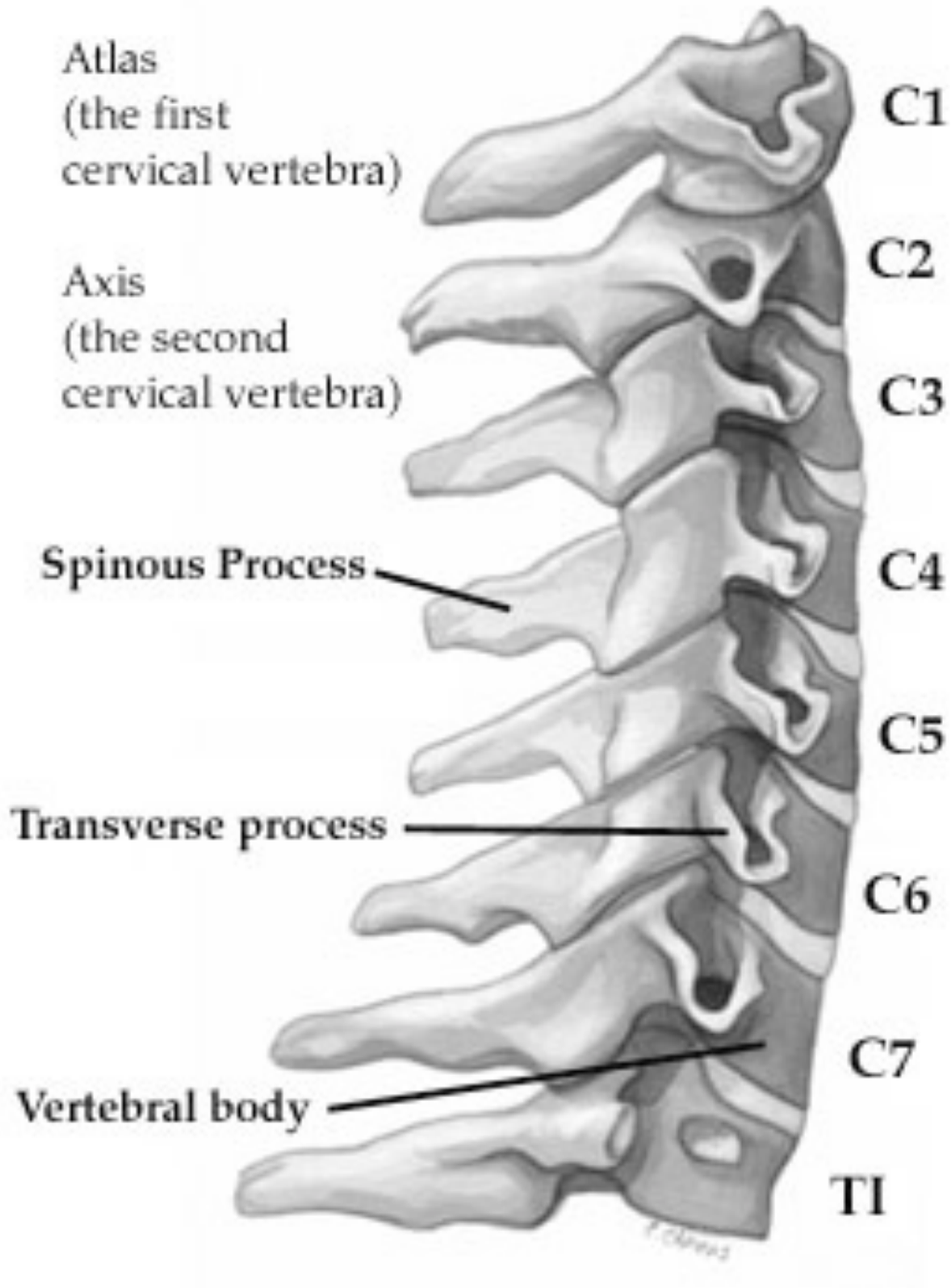
- Each trauma suggests a dynamic mechanism of injury with a significant force involved
- Occult injuries are highly likely despite benign appearance of patient

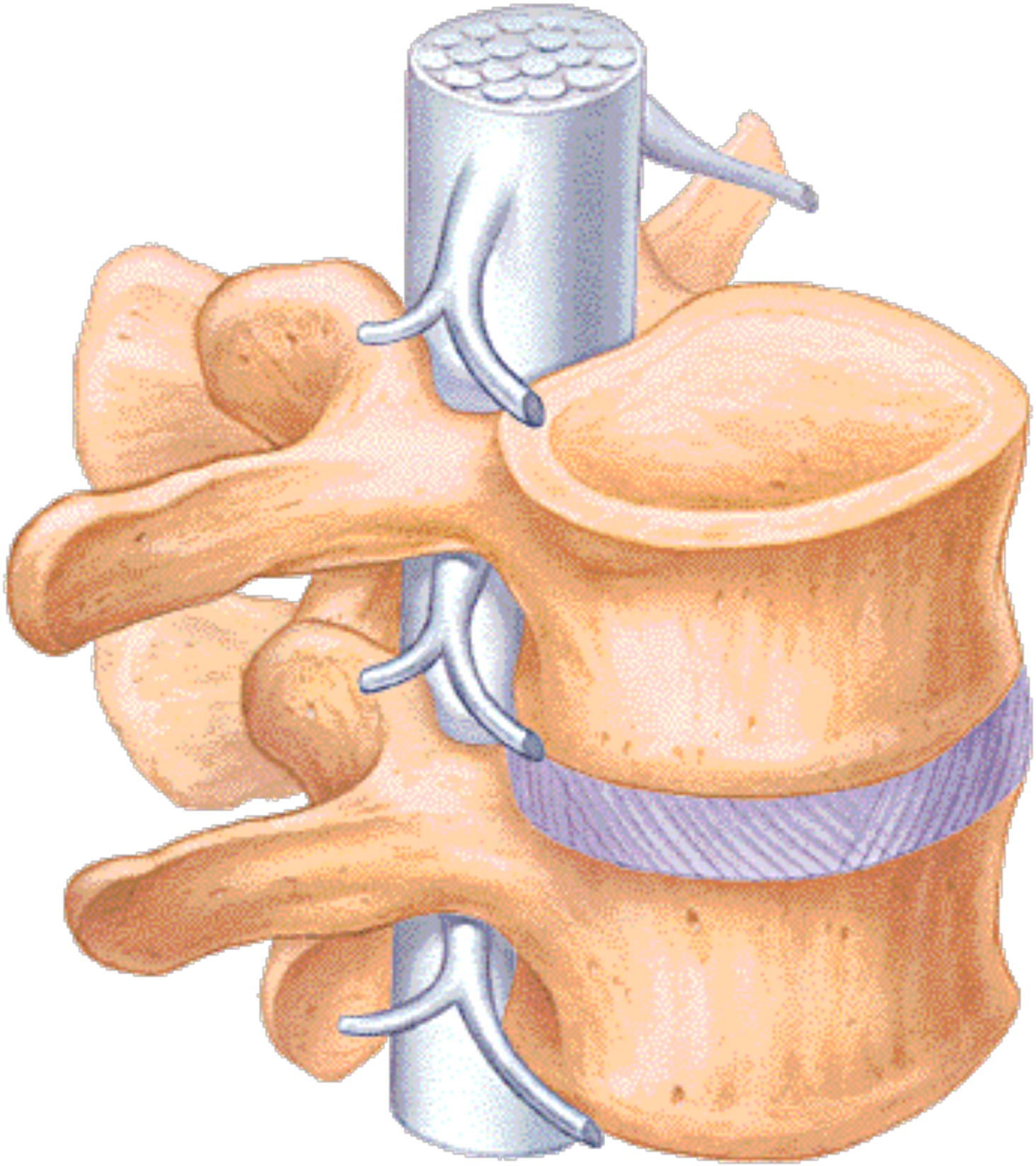
Mechanism in C Spine

- 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


2
HOSTED AT
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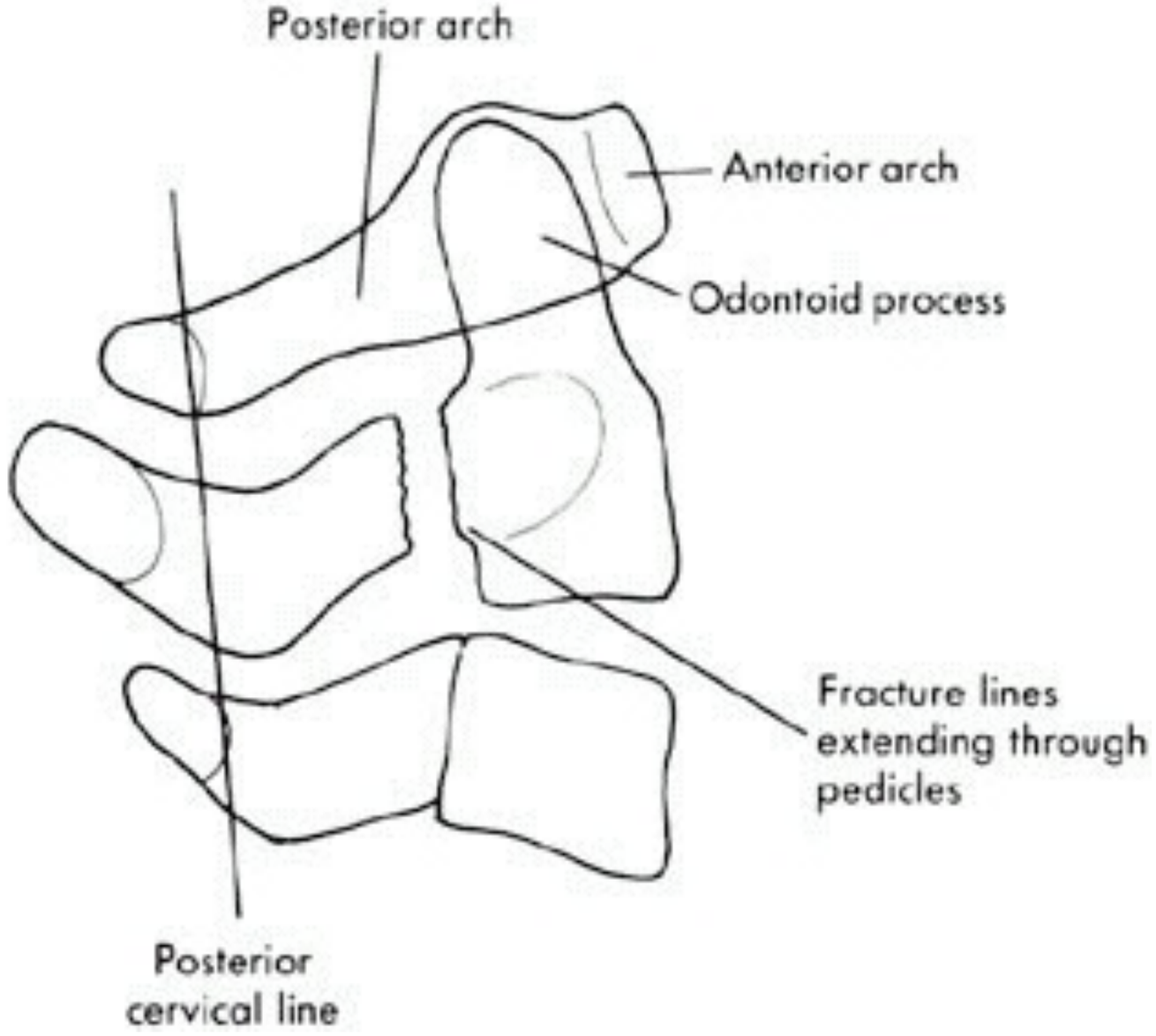
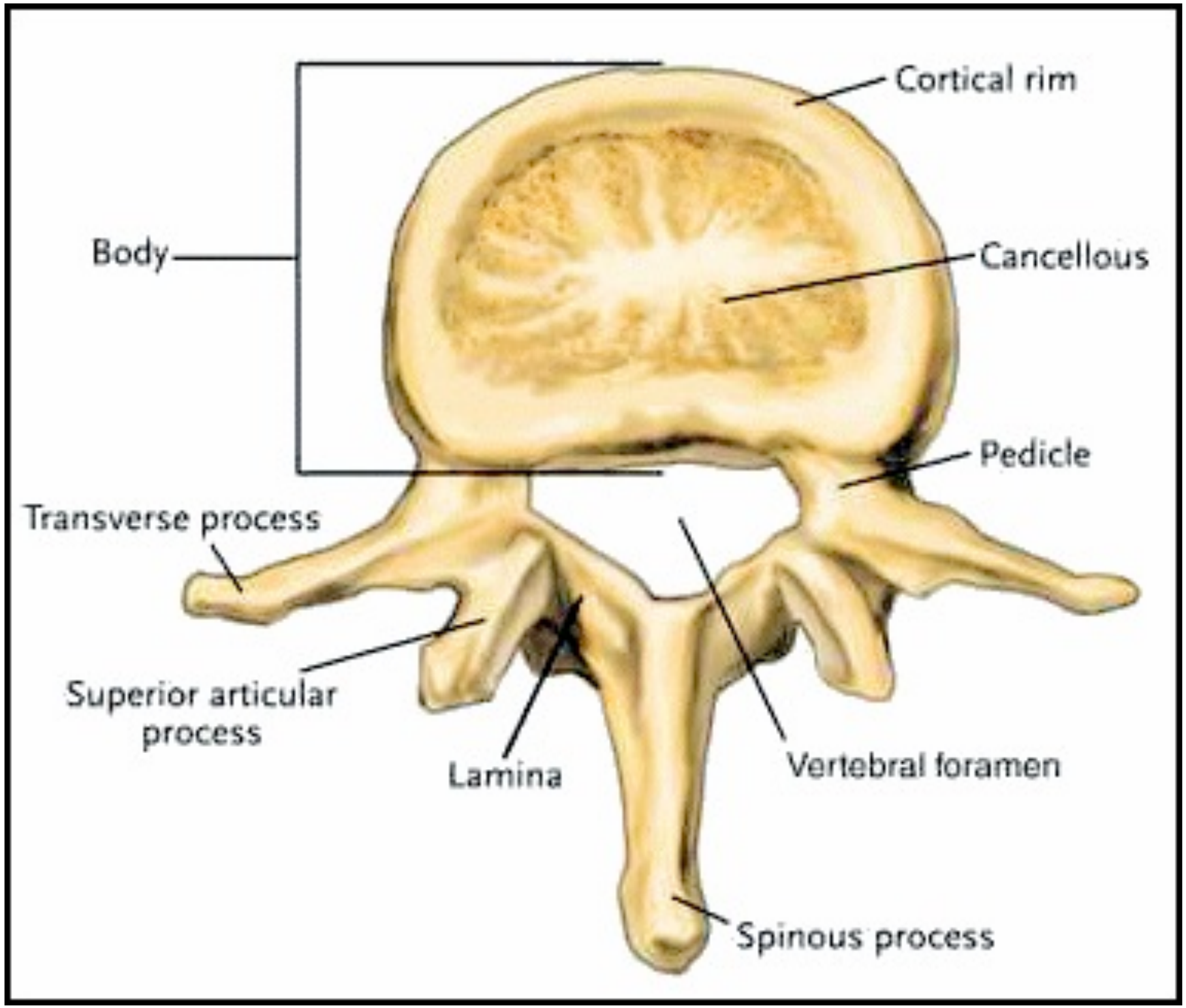
- Historically from Hangings
- Extreme Hyperextension
- Head On Collision and Sudden Deceleration
- Unstable Fracture through Pedicle of C2: minimal cord injury


Posterior arch
Anterior arch
Odontoid process
Fracture lines extending through pedicles
Posterior cervical line


7
W 1775 : L 887

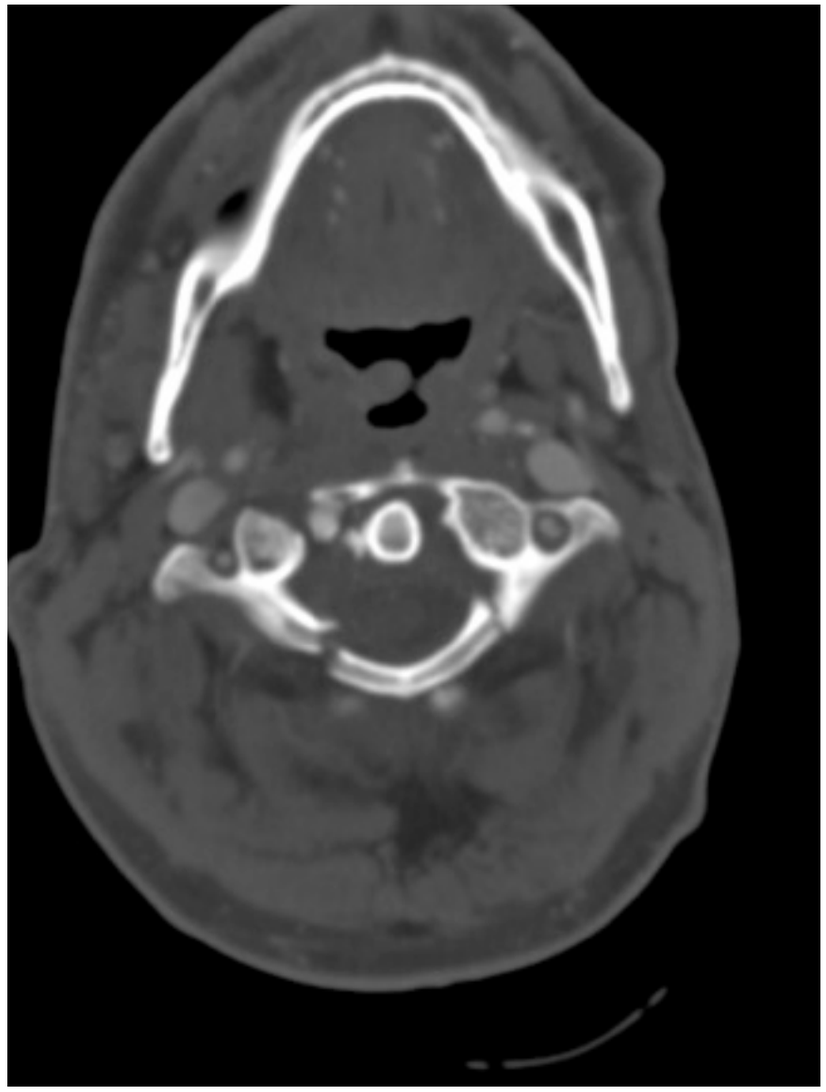
Axial Load


Cortical rim
Body
Cancellous
Pedicle
Transverse process
Superior articular process
Lamina
Vertebral foramen
Spinous process

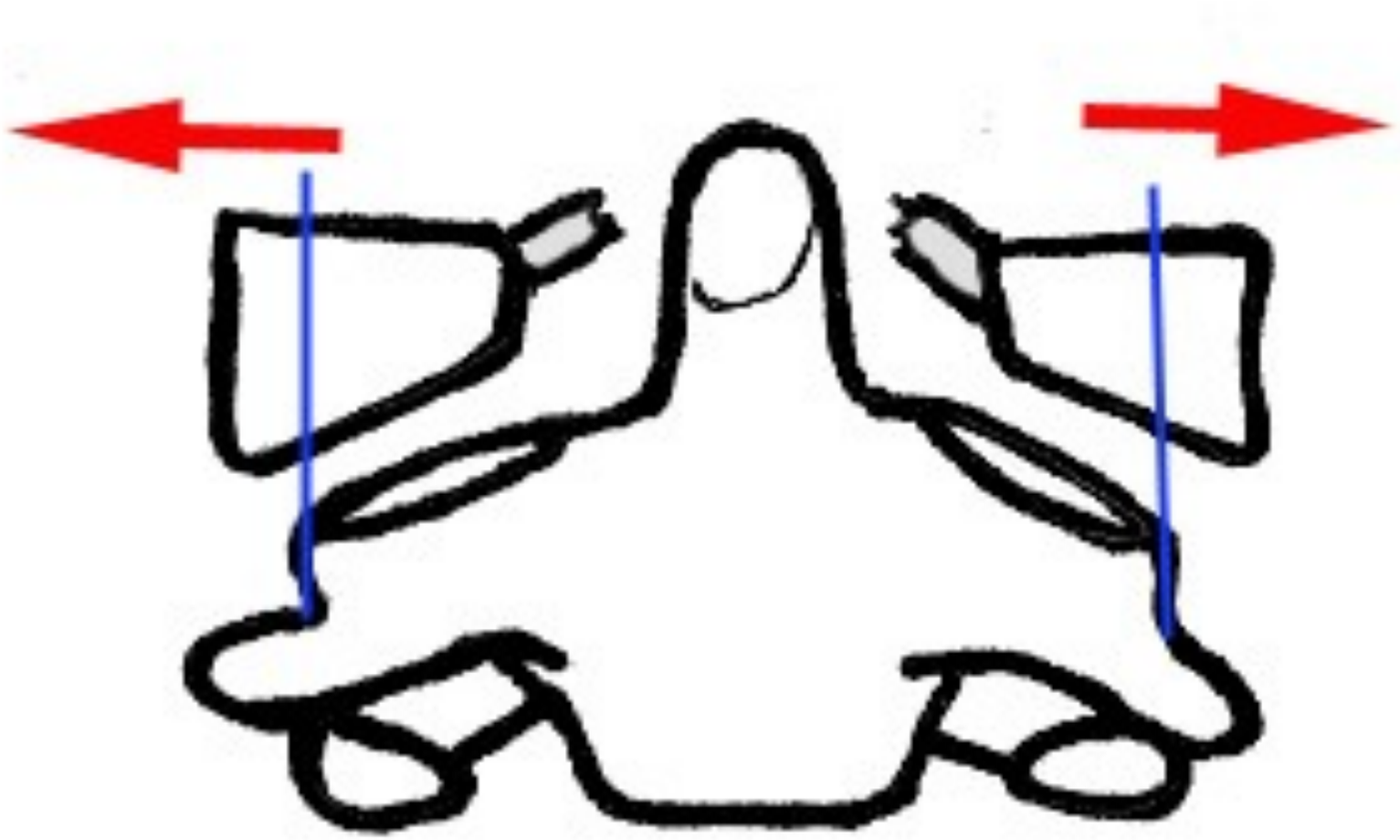

SPORTV
AO VIVO

Jefferson

- Most commonly seen in diving into shallow water
- Not normally associated with neurological deficet 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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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

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