



## Mechanisms of trauma

### Objectives:

- Not given.

### Resources:

- Davidson's.
- 436 Slides.

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COLOR INDEX:

NOTES , IMPORTANT , EXTRA , DAVIDSON'S

[EDITING FILE](#)

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# Introduction

- Trauma is the primary cause of death and disability between ages 1 to 44 years.
- Analyzing a trauma scene is a **vital skill**.
- Determining the events that lead to trauma, often predict the injuries encountered.

## Trauma

**Definition:** Injury occurs when an **external source of energy affects the body beyond its ability** to sustain and dissipate energy<sup>1</sup>.

**Types:** Different forms of energy produce different kinds of trauma. *We won't be tested on physics.*

- Mechanical energy<sup>2</sup>.
- Chemical energy<sup>3</sup>.
- Electrical energy<sup>4</sup>.
- Barometric energy

### Factors Affecting Types of Injury:

1. Ability of body to disperse energy delivered.
2. Force and energy (Size of object, velocity, acceleration or deceleration and affected body area)
3. Duration and direction (the **larger** the area, the **more energy** will be **dissipated**)
4. Position of victim.
5. The impact resistance of body parts has a bearing on types of tissue disruption
  - a. Organs that have **gas** inside are **easily** compressed.
  - b. **Liquid**-containing organs are **Less** compressible.

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<sup>1</sup> Another definition: Structural alteration or physiological imbalance as a result of energy transfer from an external agent to the host.

<sup>2</sup> It is an energy in an object due to its motion or position, or both.

<sup>3</sup> The potential of a chemical substance to undergo a transformation through a chemical reaction to transform other chemical substances.

<sup>4</sup> Energy derived from electric potential energy or kinetic energy



# Kinetics

**Definition:** Study of the relationship among **speed, mass, direction** of force and physical injury caused by these factors. PURE PHYSICS

## **Newton's first law of motion:**

A body **at rest** will remain at rest unless acted on by an **outside force**.

## **Newton's second law of motion:**

The force an object can exert is the product of its **mass** times its **acceleration**.

- ❖ **Velocity (V):** Distance per unit of time.
- ❖ **Acceleration (a):** Rate of change of velocity.
- ❖ **Gravity (g):** Downward acceleration imparted to any object moving toward earth.

$$\text{Kinetic energy} = \text{mass}/2 \times \text{velocity}^2$$

The bottom line here is that velocity plays a major role in trauma

**Kinetic energy of a subject in motion that stops suddenly must be transformed or applied to another object.**

## **Other factors that will affect energy dissipation in a crash include:**

- ❖ Vehicle's angle of impact
- ❖ Differences in sizes of the two vehicles
- ❖ Restraint status and protective gear of occupants

**Energy dissipation:** Process by which KE is transformed into mechanical energy

- Protective devices can manipulate the way in which energy is dissipated.

The mechanism of injury may be broadly subdivided into **blunt, penetrating, and miscellaneous (blast) trauma**. This distinction is critical for several reasons:

1. The anatomical and physiological consequences of different mechanisms of injury to a given body region or organ system vary significantly.
2. The investigation and management of these injuries is largely determined by injury mechanism.
3. Injury pattern and associations are determined largely by the wounding mechanism.



# 1) Blunt Trauma

Injuries in which tissues are **not penetrated** by external object. much more of a hit ex. Hammers, cars or fall from heights

Mechanisms of injury resulting in blunt trauma include:

- 1. Motor vehicle collision.
- 2. Motor vehicle versus pedestrian collision.
- 3. Fall from height.
- 4. Interpersonal assault.



## Motor Vehicle Crashes

<b>Five phases of trauma:</b>				
<b>Phase 1</b>	<b>Phase 2</b>	<b>Phase 3</b>	<b>Phase 4</b>	<b>Phase 5</b>
<b>Vehicle</b> Deceleration	<b>Occupant</b> deceleration	Deceleration of <b>internal organs</b>	Secondary <b>collisions</b>	<b>Additional</b> <b>impacts</b> received by the vehicle

Phase 1: sudden stop from the car by collision

Phase 2: the passenger still possesses the KE after the vehicle decelerates (a matter of seconds)

Car suddenly stops but KE is there in the objects inside the car (which leads the passenger hitting the car from inside)

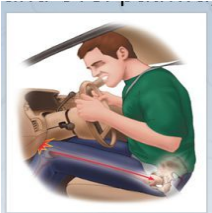
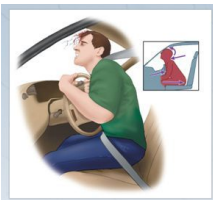
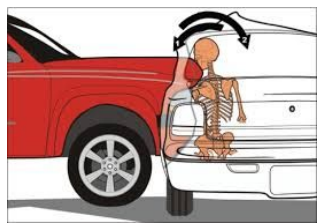

Phase 3: floating organs (who are in a cavity) are the perfect targets for MVCs resulting in a hit that would do the damage ex. Brain

**Coup-contrecoup injury:** [video](#)


A classic injury to the brain that primarily start the hit on the frontal lobe after deceleration and percussion will occur resulting in an occipital lobe injury {coup is the direction of the impact (depending on which lobe) ex. Temporal if the impact was lateral, contre means that it also occurred on the opposite side of the first hit or coup}.





Additional impact patterns		
<b>Frontal or head-on impacts</b>	<ul style="list-style-type: none"> <li>● Front end of the car distorts.</li> <li>● Passengers decelerate <b>at same rate</b> as vehicle.</li> <li>● Abrupt deceleration injuries are produced by a <b>sudden stop</b> of a body's forward motion.</li> <li>● Unrestrained occupants usually follow one of two trajectories:               <ul style="list-style-type: none"> <li>❑ Down-and-under pathway knees will be hit first, energy will be transmitted into an object that isn't mobile. The pelvis would make a perfect example, that's why pelvic fractures are more common than femur fractures, in small cars</li> <li>❑ Up-and-over pathway head, neck or chest injuries from impact with front glass in big cars. The up-and-over pathway has more traumatic brain injuries.</li> </ul> </li> </ul>	 
<b>Lateral or side impacts</b>	<ul style="list-style-type: none"> <li>● Impart energy to the <b>near-side occupant</b>.</li> <li>● Seat belts offer <b>little protection</b>.</li> <li>● The body is pushed in <b>one direction</b>, while the head moves <b>toward</b> the impacting object.</li> </ul> <p style="color: green;">It's less likely that the passenger would come out completely safe. You'd have to look for fractures or contusions on the same side of the impact.</p>	
<b>Rear impacts</b>	<ul style="list-style-type: none"> <li>● Have the <b>most survivors</b>.</li> <li>● Whiplash injury is <b>common</b>.</li> <li>● Energy is imparted to the front vehicle.</li> </ul> <p style="color: green;">Best prognosis! The seat would absorb the energy from the impact and act as good protection. Neck injuries are very common in this pattern.</p>	
<b>Rotational or quarter-panel impacts</b>	<ul style="list-style-type: none"> <li>● Occurs when a lateral crash is off center.</li> <li>● The vehicle's forward motion stops, but the side continues in <b>rotational motion</b>. Any types of injuries can be seen in this impact pattern.</li> </ul>	



<h2>Rollovers</h2>	<ul style="list-style-type: none"> <li>• Patients may be <b>ejected</b>.</li> <li>• Patients may be struck hard against the interior of the vehicle. <b>Unrestrained roll overs are the worst.</b></li> <li>• Ejection from the vehicle is a very bad sign, it indicates that the impact was severe enough to eject the patient from the car resulting in a secondary trauma.</li> <li>• Look for traumatic brain injury and a fractured pelvis.</li> </ul>	
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If a case came as a frontal impact unrestrained with no airbags in the car, it has a very bad prognosis

## Restrained Versus Unrestrained Occupants

Seat belts	Air bags
Seat belts <b>stop the motion</b> of an occupant traveling at the <b>same speed</b> as the vehicle.	Air bags have reportedly reduced deaths in direct frontal crashes by about 30%.
Associated injuries include <b>cervical fractures and neck sprains</b> . The seatbelt can't save you from these types of injuries (whiplash), that's why the most common cause of death in trauma is head injury.	Can also result in secondary injuries: <ul style="list-style-type: none"> <li>• Direct contact</li> <li>• Chemicals.</li> <li>• When airbags are deployed they are hot and have chemicals inside which may cause burns.</li> </ul>

## Pedestrian Injuries

<b>Three predominant MOIs<sup>5</sup>:</b>		
<b>First impact</b>	<b>Second impact</b>	<b>Third impact</b>
Car strikes <b>body</b> with its bumpers <sup>6</sup> . -In kids it would strike the femur,	Adult is <b>thrown</b> on <b>hood</b> and/or <b>grille</b> of vehicle.	Body strikes the <b>ground</b> or some <b>other object</b> .

<sup>5</sup> Mechanisms of injuries.

<sup>6</sup> structure attached to or integrated with the front and rear ends of a motor vehicle.

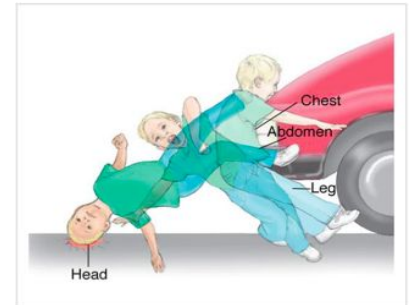


pelvis, or abdomen.  
 - In adults it usually injures the pelvis, femur and sometimes the knee

### Waddell triad:

Pattern of injuries in children and people of short stature.

- Bumper hits pelvis and femur.
- Chest and abdomen hit grille.
- Head strikes vehicle and ground.



## Falls from Heights

Severity of injuries impacted by:

1. Height. Measured by floors sometimes, 6 floors is fatal.
2. Position. Landing on knees would lead to fractures to pelvis and spine
3. Surface
4. Physical condition

Usually older patients have blunt injuries from falling from heights unlike younger ones who have it from MVCs.

## 2) Penetrating injury

### Penetrating Trauma:

Involves **disruption** of skin and tissues in a **focused area**<sup>7</sup>, they are usually more predictable than blunt injuries.

Low velocity	Medium and high velocity
Caused by sharp edges (produce a permanent cavity as a bullet or missile tract as it passes through creating a relatively local damage by crushing the tissues).	<b>Medium and high velocity:</b> Object might flatten out, tumble, or ricochet (also produce a permanent cavity, but of more concern is the large temporary cavity created as part of the blast effect. This results in massive tissue damage at some distance from the permanent cavity).

<sup>7</sup> When an object transfers energy to the tissue by passing through it.



Mechanisms of injury resulting in penetrating trauma include: **stab wounds from a sharp implement**, and **gunshot wounds**.

**Stab Wounds:**

Severity depends on:

- Anatomic area involved
- Depth of penetration
- Blade length
- Angle of penetration

**Gunshot Wounds:**

Severity depends on:

- Type of firearm.
- Velocity of projectile.
- Physical design/size of projectile.
- Distance of victim from muzzle.
- Type of tissue struck.


Gunshot Wounds		
Handgun <sup>8</sup>	Shotguns <sup>9</sup>	Rifles
<ul style="list-style-type: none"> <li>❖ Revolver holds 6 to 10 rounds of ammunition.</li> <li>❖ Pistol holds up to 17 rounds of ammunition.</li> <li>❖ Accuracy is limited.</li> </ul>	<p>Fire round pellets.</p> <p>The closer they are the worse the injury.</p>	<ul style="list-style-type: none"> <li>❖ Fire single projectile at a very high velocity.</li> <li>❖ Impart a spin for accuracy.</li> </ul>

- **The most important factor** for seriousness of wound is **type of tissue involved**.
- **Entry wound** is characterized by the **effects of the initial contact** and **implosion**.

Deformation/ tissue destruction is based on:

- Density
- Compressibility



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- Missile velocity
  - Missile fragmentation

**Projectile creates a permanent cavity.** Most of the blood and thermal findings are at the site of the entry

May be **straight** line or **irregular** pathway

**Pathway expansion:** Tissue displacement that results from low-displacement sonic pressure.

**Missile fragmentation:** Projectile sends off fragments that create paths through tissues.

Exit wounds occur when projectile's energy is **not** entirely dissipated.

Smaller area of fired objects = more concentrated power

**Size** depends on **energy dissipated** and **degree of cavitation**. Usually the entry wound is clean and small due to the timing of the penetration and the concentrated force of the fired object, making the exit wound much more larger than the entry wound. The entry wound may be identical to the exit wound when there is less dissipation, for example a shot to the forearm.

**Wounding potential depends on:**

- Powder charge
- Size and number of pellets
- Dispersion of the pellets
  - Range at which the weapon was fired
  - Barrel length
  - Type of choke at the end of the barrel

**Try to obtain the following:**

- Weapon used
- Range fired
- Bullet used

**Look for:**

- Powder residue around the wound
- Entrance and exit wounds



### 3) Blast Injuries

Blast injury is a result of detonated explosives which causes injury through several mechanisms:

<b>Primary Blast Injuries</b>	<ul style="list-style-type: none"> <li>❖ Damage is <b>caused</b> by pressure wave generated by explosion.</li> <li>❖ <b>Close</b> proximity to the origin of the pressure wave carries a <b>high risk of injury or death</b>. Most common injuries occur to the ear.</li> </ul>
<b>Secondary Blast Injuries</b>	<ul style="list-style-type: none"> <li>❖ Result from being <b>struck by flying debris</b>.</li> <li>❖ A blast wind occurs.</li> <li>❖ Flying debris may cause blunt and penetrating injuries.</li> </ul>
<b>Tertiary Blast Injuries</b>	<ul style="list-style-type: none"> <li>❖ Occur when a person is hurled against stationary, rigid objects.</li> <li>❖ <b>Ground shock</b>: Physical displacement when the body impacts the ground.</li> </ul>
<b>Quaternary (Miscellaneous) Blast Injuries</b>	<p>Occur from the miscellaneous events that occur during an explosion May include:</p> <ul style="list-style-type: none"> <li>• Burns.</li> <li>• Respiratory injury.</li> <li>• Crush injury.</li> <li>• Entrapment.</li> <li>❖ <b>Caused by</b>: biologic, chemical or radioactive contaminants added to an explosive.</li> <li>❖ Associated with “<b>dirty bombs</b>”.</li> </ul>

### Summary “from slides”

- ❖ Trauma is the primary cause of death and disability in people between ages 1 and 44 years.
- ❖ Understanding mechanisms of injuries will help in management of trauma victims by predicting injuries.



### Important Qs to ask about in the history:

<b>Motor vehicle crashes (blunt)</b>	<b>Fall from heights (blunt)</b>	<b>Stab wounds (penetrating)</b>	<b>Gunshot wounds (penetrating)</b>
<ul style="list-style-type: none"><li>• Type of impact</li><li>• Seatbelted or not</li><li>• Any rollovers occurred</li><li>• Any ejections from the vehicle</li></ul>	<ul style="list-style-type: none"><li>• From where</li><li>• On what</li><li>• What did he land on first</li></ul>	<ul style="list-style-type: none"><li>• What is the object</li><li>• How long was it</li></ul>	<ul style="list-style-type: none"><li>• Type of firearm</li><li>• Was it in a room or an open area</li></ul>



## Summary

**Trauma** is the Injury which occurs when an **external source of energy affects the body beyond its ability** to sustain and dissipate energy.

The source of energy can be: 1) **Mechanical** 2) Chemical 3) Electrical 4) Barometric

The factors that affect the force and energy of the trauma:

- 1) **Velocity** 2) Size of the object 3) Acceleration or deceleration
- 4) **Affected body area** ( body area arranged in the ability of compressibility, Gas containing organs > liquid containing organs > solid organs ) more compensability less injury will occur with the trauma.

### Types of Trauma:

- 1) **BLUNT** (NO TISSUE PENETRATION WITH EXTERNAL OBJECT)

#### **a) MVC**

Impact patterns:

- 1) Frontal “Down and under pathway” (the energy affects lower body more: Pelvic or Femur fracture)
- 2) Frontal “**Up and over pathway**” (the energy affects head more and can lead to an ejection from the car if unrestrained)
- 3) Lateral (No significant protection with seat belts vs Frontal)
- 4) Rear (Leads to **WHIPLASH** injury, But it has better prognosis than the previous two types)
- 5) Rotational “Quarter-panel” (Mix of the previous types)
- 6) Rollover (Patients may be **EJECTED** And/or got **many strikes** inside the vehicle)

- Seat belts can help in many injuries except 1) **cervical fractures** 2) **neck sprains**

#### **b) Falls**

Factors affecting the severity:

- 1-Height. **Measured by floors sometimes, 6 floors is fatal.**
- 2- Position (head first “**MORE FATAL** or leg first)
- 3- Surface (water , sand or grass)
- 4- Physical condition (age and weight of the patient)

- 2) **Penetrating Trauma:** Involves **disruption** of skin and tissues in a **focused area**

#### **a) Stab Wounds**

- #### **b) Gunshot** (Hand gun, Shotgun, Rifles) **EXIT AND ENTRANCE WOUND**

- 3) **Blast Injuries** (1ry due to pressure wave, 2ry due to flying debris, 3ry hurled against stationary object, 4ry any miscellaneous event during the blast like burn and respiratory injuries)



## Questions

**Q1: A 32 year-old male was involved in MVC. On the field, the paramedics found out the patient has bruises on his RUQ of the abdomen with rigidity and tenderness. BP is 90/50, HR: 140, spO2 is 88%. What is the most likely injured organ?**

- a) Kidney
- b) IVC
- c) Liver
- d) Small intestine

**Q2: Which one of the following is the most common cause of death in car accident even when using seat belt?**

- a) Hip fracture
- b) Head trauma
- c) Liver shutter
- d) Rupture of major blood vessel

**Q3: What is the classical 3 phases of Waddell triad?**

- a) Bumper hits pelvis and femur -> Chest and abdomen hit grille -> Head strikes vehicle then the ground
- b) Chest and abdomen hit grille -> Bumper hits pelvis and femur -> Head strikes vehicle then the ground
- c) Head strikes vehicle then the ground -> Bumper hits pelvis and femur -> Chest and abdomen hit grille
- d) Bumper hits pelvis and femur -> Chest and abdomen hit grille -> Head strikes the ground then the vehicle

**Q4: Which one of these scenarios is the most dangerous gunshot trauma?**

- a) Gunshot penetrating the abdomen by handgun 5 meters away from the victim
- b) A trauma surgeon did FAST and found the bullet stopped at the anterior abdominal muscle
- c) Gunshot penetrating the chest from 23 cm away from the victim by handgun
- d) Gunshot penetrating the chest from 23 cm away from the victim by rifles

**Q5: What is the most affected organ in Primary Blast Injuries?**

- a) Skin
- b) Trachea
- c) Vertebrae
- d) Ears

Answers:

1.C

2.B

3. A

4.D

5.D

**Best of luck!**