Kinematics of Trauma
Kinematics

- The process of predicting injury patterns
- Consider the following when evaluating the trauma patient:
  - Age
  - Protective factors
  - Mechanism of injury
  - Force of energy applied
  - Anatomy
  - Energy
Velocity
Trauma injuries are caused by a transfer of energy from an external source to the human body.

Extent of injury is determined by:

- Type of energy applied
- How quickly it is applied
- To what part of the body it is applied
Sir Isaac Newton, English Physicist, 1643-1727

Laws of Motion
Newton’s 1st law

The motion of an object does not change unless it is acted on by a net force.

- **Objects at Rest** \( (v = 0 \text{ m/s}) \):
  - \( a = 0 \text{ m/s}^2 \)
  - Stay at Rest

- **Objects in Motion** \( (v \neq 0 \text{ m/s}) \):
  - \( a = 0 \text{ m/s}^2 \)
  - Stay in Motion (same speed and dir’n)
Newton’s 3rd law

- For every action, there is an equal and opposite reaction.
Law of Conservation of Energy

- Energy cannot be created
- And most important:

**Energy cannot disappear**

But, energy can change forms and can be converted

Can you give an example?
How does the Law of Conservation of Energy pertain to trauma?

Can you give some examples?
Acceleration and Deceleration
Deceleration and Acceleration

Compression Injury
Shear Injury

Deceleration and Acceleration
Abdominal Injuries

Intra-abdominal organs and retroperitoneal structures (most commonly the kidneys) may be affected by deceleration forces.
Thoracic Injuries

Aorta frequently injured by severe, lethal deceleration forces
Head Injury

- Fractures
- Ligament injuries
- Soft tissue injury
- Brain injury
- Cord damage
Head Injuries

When the head strikes a stationary object, the cranium comes to an abrupt stop.

Brain tissue continues to move until it is compressed against the skull.
**Torso Injury**

- Rib fractures
- Heart & lung damage
- Abdominal organ damage
- Major vessel damage
Thoracic Injuries

Lungs and heart are frequently involved in compression injury to the thorax.

Serious lung injury can occur from compression forces due to a “paper-bag effect”.

![Diagram of flail chest and lung injury]
Extremity Injury

- Fractures
- Ligament injury
- Soft tissue injury
Types of Motor Vehicle Accidents

- Frontal impact
- Lateral impact
- Rotational impact
- Rear impact
- Rollover
Head-on (Frontal) Impact

Occupant usually travels in one of two pathways in relationship to dashboard:

- Down and under
- Up and over
Injuries with Up & Over Pathway

- Head injuries
- Spine injuries
- Chest injuries
  - Fractures
  - Pneumothorax
  - Hemothorax
  - Contusions
  - Great vessel injury
- Abdominal injuries
  - Solid organs
  - Hollow organs
  - Diaphragm
- Fractured pelvis
Down-and-under Pathway

Occupant travels downward into vehicle seat and forward into dashboard or steering column

- Knees strike dashboard
- Upper legs absorb most of the impact

- Posterior knee/hip dislocations
- Femur fractures
- Lower extremity fractures
- Pelvic/acetabular fractures
Lateral Impact

Occurs when a vehicle is struck from the side

Injury patterns depend on whether the damaged automobile remains in place or moves away from the point of impact

⇒ Neck
⇒ Chest
⇒ Pelvis
Rear Impact

In rear-end collisions, the difference between the two vehicles speeds is the damaging velocity.
**Headrest Importance**

- During rear impact, the headrest prevents hyperextension of the neck.
- The head is moving together with the seat & the body.
- Injury to the neck is minimized.
Rotational Impact
Rollover Accidents

Occupant tumbles inside auto and is injured wherever body strikes vehicle

- Impacts occur at many different angles
- Potential for multiple-system injuries

Predictable injuries difficult to categorize

- May produce any of the injury patterns associated with other types of collisions
Restraints

- Lap restraint
- Diagonal shoulder straps
  - ✔️ Properly positioned restraint
  - ✗ Improperly positioned restraint
- Airbags
- Child safety seats

"It's the latest innovation in office safety. When your computer crashes, an air bag is activated so you won't bang your head in frustration."
Motorcycle Collisions

Mandatory helmet laws have been associated with up to 300% fewer head injuries and deaths.
How many impacts did this collision involve?

What types of injuries would you expect to see?
Types of Impact: Lateral

How many impacts did this collision involve?
What types of injuries would you expect to see?
Bilateral Femoral Fractures
Pedestrian Injuries

Predictable injuries depend on:

- Whether the pedestrian is an adult or a child
- Variations in the height of the pedestrian in relation to the bumper and hood of the car
- Velocity of the vehicle
Pedestrian vs. Motor Vehicle

How would the injury patterns differ between the adult and the child?
Falls

- Impact surface
  - (Harder surface = greater injury)

- Height
  - (Greater height = greater injury)

- Falls from a distance of more than three times the patient’s height produce critical injuries
  - Deceleration injuries:
    - Liver
    - Aorta
    - Spleen
    - Kidney
Injuries seen in patients landing feet first:

- Bilateral heel fractures
- Ankle fractures
- Distal tibia/fibula fractures
- Knee dislocations
- Femur fractures
- Hip injuries
- Spine compression fractures
Physical findings:

- Colles’ fractures of wrists
- Shoulder dislocations
- Fractures of the clavicles
Physical findings:

- C-spine injuries
- Facial injuries
- CNS damage
Sports & Recreational Activity Mechanisms

- Acceleration
- Deceleration
- Hyperextension
- Hyperflexion
- Twisting
- Falling
Predicting Sports-Related Injuries

- Kinematics & forces involved
- Equipment contributing to injury
- Involvement of protective equipment
- Nature of the sport
Blast Injuries

- Warfare
- Civilian areas
  - Mines
  - Shipyards
  - Chemical plants
  - Tank trucks
  - Refineries
  - Fireworks firms
  - Gas tanks

Do you have any of these in your area?
Blast-Related Injuries

Three mechanisms of injury:

- Primary
- Secondary
- Tertiary
Primary Phase Injuries

Cause: pressure wave from blast.

Affected area: gas-containing organs.

Injuries:

- Pulmonary bleeding
- Pneumothorax
- Air emboli
- Perforation of the GI tract
- Burns

Death may occur in absence of outward signs
Secondary Phase Injuries

Cause: flying debri

Affected area:
- Body surface
- Skeletal system

Injuries:
- Lacerations
- Fractures
- Burns
Tertiary Phase Injuries

Cause: victim thrown against an object

Affected area: area of impact or referred energy

Injuries: similar to those sustained in a vehicle ejection
Penetrating Trauma

- Physics
- Weapon velocity
- Bullet design
How does the length of the weapon relate to the cone of damage?
Penetrating Trauma

Newton’s First Law and ballistics:

- Bullet in brass cartridge is at rest
- Bullet propelled by rapid combustion of powder
- Bullet leaves barrel of gun
- Bullet strikes a body
- Bullet transfers energy to victim
Gunshot Wounds

Describe the difference between entrance and exit wounds.
Wounding Forces

Bullet passing through tissue. Outward stretching of the permanent cavity as the tissue particles move away from the penetrating missile cause the temporary cavity.
Gunshot Wounds - Cavitation

- Reformation by elastic tissue
- Direction of travel
- Temporary cavity
- Permanent cavity
- Compression
- Bullet
Bullet Wound

Powder marks show this 0.22-caliber bullet wound was inflicted at close range.
Short-range shotgun wound to forearm.
Some projectiles are designed to tumble. Tumbling creates greater tissue damage and more tissue destruction.
The shotgun round is the ultimate in fragmentation.
Considerations for Penetrating Trauma

- Scene safety
- Patient care is the priority!
- Weapon type
- Range at which weapon was fired
- Number of entrance and exit wounds
- Underlying anatomy and track
- Crime scene preservation.
Kinematics Summary

The cornerstone of assessment is early consideration of kinematics to predict hidden injury.