

# **KINEMATICS**

**An Introduction to the Physics of Trauma**

# Kinematics

- **Physics of Trauma**
- **Prediction of injuries based on forces, motion involved in injury event**

# Physical Principles

- Kinetic Energy
- Newton's First Law of Motion
- Law of Conservation of Energy

# Kinetic Energy

- Energy of motion
- $K.E. = 1/2 \text{ mass} \times \text{velocity}^2$
- Major factor = Velocity
- “Speed Kills”

# Newton's First Law of Motion

- **Body in motion stays in motion unless acted on by outside force**
- **Body at rest stays at rest unless acted on by outside force**

# Law of Conservation of Energy

- Energy cannot be created or destroyed
- Only changed from one form to another

# Conclusions

- **When moving body is acted on by an outside force and changes its motion,**
- **Kinetic energy must change to some other form of energy.**
- **If the moving body is a human and the energy transfer occurs too rapidly,**
- **Trauma results.**

# Motor Vehicle Collisions

- **Five major types**
  - **Head-on**
  - **Rear-end**
  - **Lateral**
  - **Rotational**
  - **Roll-over**

# Motor Vehicle Collisions

- In each collision, three impacts occur:
  - Vehicle
  - Occupants
  - Occupant organs

# Head-on Collision

- **Vehicle stops**
- **Occupants continue forward**
- **Two pathways**
  - **Down and under**
  - **Up and over**

# Head-on Collision

- **Down and under pathway**
  - Knees impact dash, causing knee dislocation/patella fracture
  - Force fractures femur, hip, posterior rim of acetabulum (hip socket)

# Head-on Collision

- **Down and under pathway**
  - **Upper body hits steering wheel**
    - **Broken ribs**
    - **Flail chest**
    - **Pulmonary/myocardial contusion**
    - **Ruptured liver/spleen**

# Head-on Collision

- **Down and under pathway**
  - Paper bag pneumothorax
  - Aortic tear from deceleration
  - Head thrown forward
    - C-spine injury
    - Tracheal injury

# Head-on Collision

- **Up and over pathway**
  - **Chest/abdomen hit steering wheel**
    - Rib fractures
    - Flail chest
    - Cardiac/pulmonary contusions
    - Aortic tears
    - Abdominal organ rupture
    - Diaphragm rupture
    - Liver/mesenteric lacerations

# Head-on Collision

- **Up and over pathway**
  - **Head impacts windshield**
    - **Scalp lacerations**
    - **Skull fractures**
    - **Cerebral contusions/hemorrhages**
  - **C-spine fracture**

# Rear-end Collision

- Car (and everything touching it) moves forward
- Body moves, head does not, causing whiplash
- Vehicle may strike other object causing frontal impact
- Worst patients in vehicles with two impacts

# Lateral Collision

- Car appears to move from under patient
- Patient moves toward point of impact

# Lateral Collision

- **Chest hits door**
  - Lateral rib fractures
  - Lateral flail chest
  - Pulmonary contusion
  - Abdominal solid organ rupture
- **Upper extremity fracture/dislocations**
  - Clavicle
  - Shoulder
  - Humerus

# Lateral Collision

- Hip hits door
  - Head of femur driven through acetabulum
  - Pelvic fractures
- C-spine injury
- Head injury

# Rotational Collision

- Off-center impact
- Car rotates around impact point
- Patients thrown toward impact point
- Injuries combination of head-on, lateral
- Point of greatest damage =  
Point of greatest deceleration =  
Worst patients

# Roll-Over

- Multiple impacts each time vehicle rolls
- Injuries unpredictable
- Assume presence of severe injury
- Justification for:
  - Transport to Level I or II Trauma Center
  - Trauma team activation

# Restrained vs Unrestrained

- **Ejection**
  - 27% of motor vehicle collision deaths
  - 1 in 13 suffers a spinal injury
  - Probability of death increases six-fold

## **Restrained with Improper Positioning**

- **Seatbelts Above Iliac Crest**
  - Compression injuries to abdominal organs
  - T12 - L2 compression fractures
- **Seatbelts Too Low**
  - Hip dislocations

# **Restrained with Improper Positioning**

- **Seatbelts Alone**
  - Head, C-Spine, Maxillofacial injuries
- **Shoulder Straps Alone**
  - Neck injuries
  - Decapitation

**What injury is likely to occur even  
if a patient was properly  
restrained?**

# Pedestrians

- **Child**

- **Faces oncoming vehicle**

- **Waddell's Triad**

- **Bumper** —————→ **Femur fracture**
    - **Hood** —————→ **Chest injuries**
    - **Ground** —————→ **Head injuries**

# Pedestrians

- **Adult**

- Turns from oncoming vehicle

- O'Donohue's Triad

- Bumper → Tib-fib fracture  
→ Knee ligament tears
- Hood → Femur/pelvic fractures

# Conclusion

- Look at mechanisms of injury
- The increased index of suspicion will lead to:
  - Fewer missed injuries
  - Increased patient survival

# Self Study

- Always check for \_\_\_ of injury
- Children are more likely to face away/towards a car as it hits them
- The major factor in an MVA is v\_\_\_\_\_
- The two types of pathways a person takes in an accident are the up and \_\_\_ or down and \_\_\_ pathways
- An occupant in a roll-over accident is likely to sustain m\_\_\_\_\_ impacts as the vehicle rolls