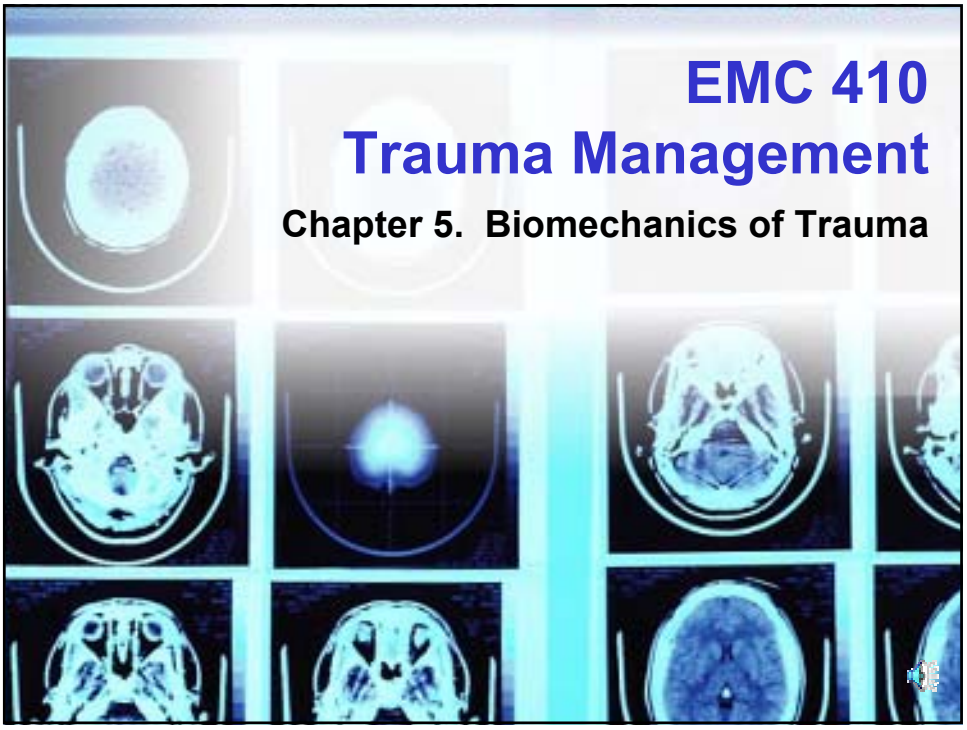


EMC 410
Trauma Management
Chapter 5. Biomechanics of Trauma

Unit Objectives

- **Upon completion of this chapter, you should be able to:**
  - List the 5 forms of energy.
  - Describe the physical properties of kinetic energy.
  - Discuss the role of kinetic energy in producing injury.
  - Describe occupant kinematics for the 5 types of motor vehicle collisions and discuss the clinical implications of each.
  - Describe the kinematics of motorcycle collisions.

Unit Objectives continued

- Describe the 4 impact configurations of motorcycle collisions and the clinical implications of each.
- Discuss the 6 components of wound ballistics and their clinical implications.
- List and describe the 4 types of blast injuries and their clinical implications.
- Define the role of injury biomechanics in the assessment of the trauma patient.

Introduction

- Major differences between trauma and medical assessment.
- Suspicion of injury requires thorough understanding of biomechanics.
- History and scene survey will predict 90% of patient's injuries ***prior*** to performing a physical exam

Introduction continued

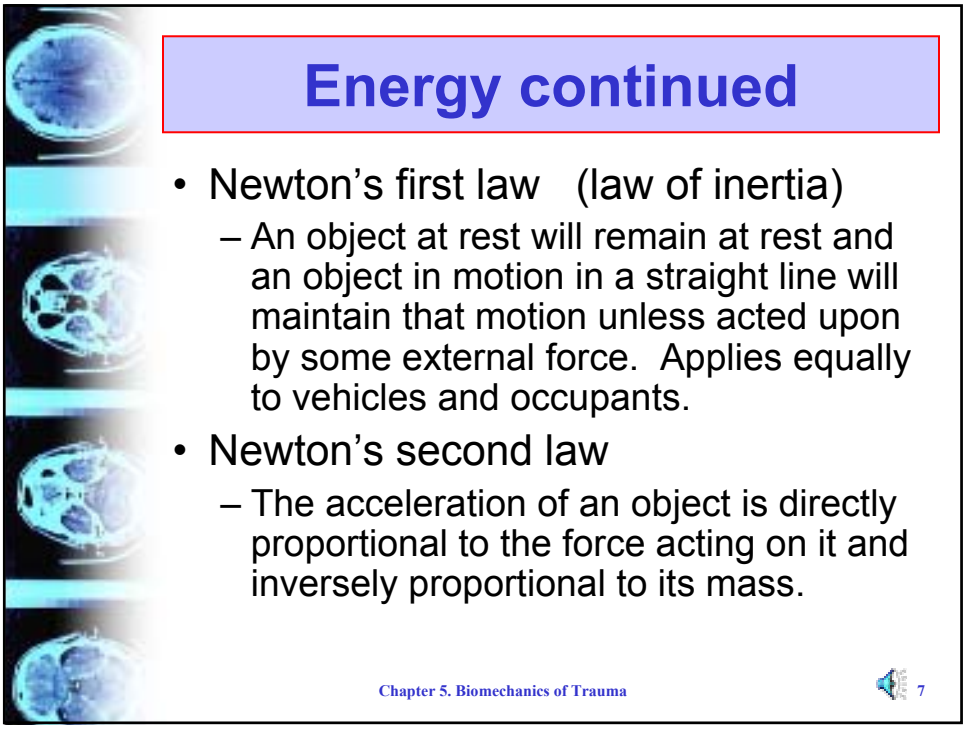
- Scene Assessment and the 3 phases of injury:
  - –Pre-event phase
    - –Medical conditions
    - –Events preceding collision
  - –Event phase
    - –Most important, but rarely witnessed by EMS
    - –Injury occurs
    - –Must rely on physical clues left at the scene
  - –Post-event phase
    - –Analyze physical evidence and predict injuries
    - –Kinematics and injury biomechanics

Energy

- Release of energy into human tissue is the origin of injury.
- Human tolerance
  - Magnitude, duration, physical condition of patient, form of energy
- Five forms of energy
  - Kinetic
  - Electrical
  - Chemical
  - Thermal
  - Radiation

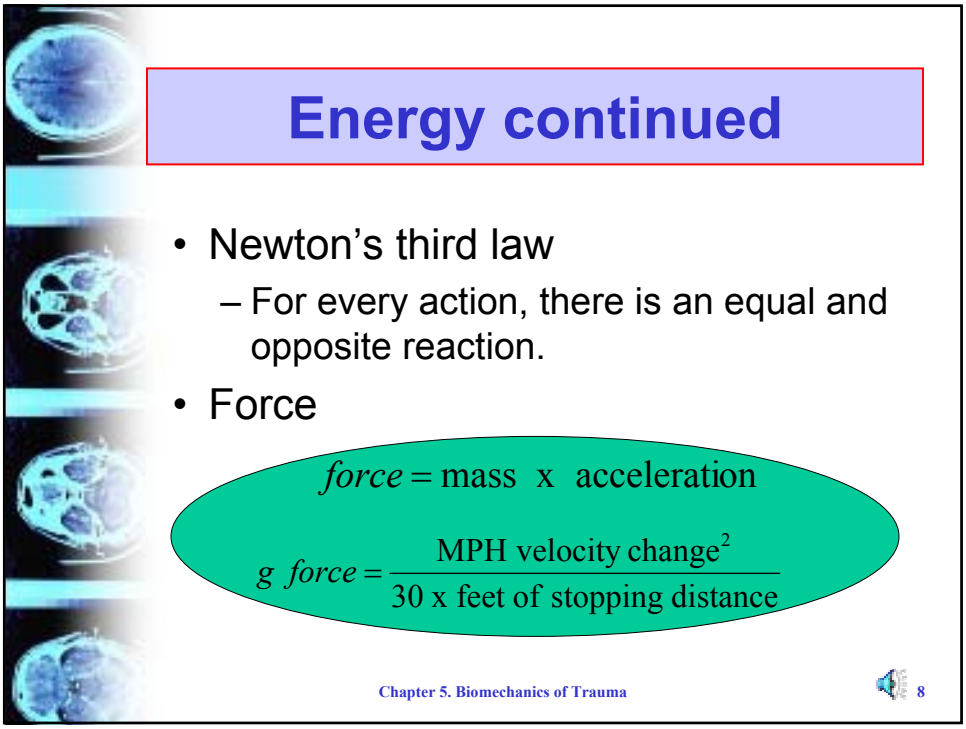






Energy continued

- Newton's first law (law of inertia)
  - An object at rest will remain at rest and an object in motion in a straight line will maintain that motion unless acted upon by some external force. Applies equally to vehicles and occupants.
- Newton's second law
  - The acceleration of an object is directly proportional to the force acting on it and inversely proportional to its mass.

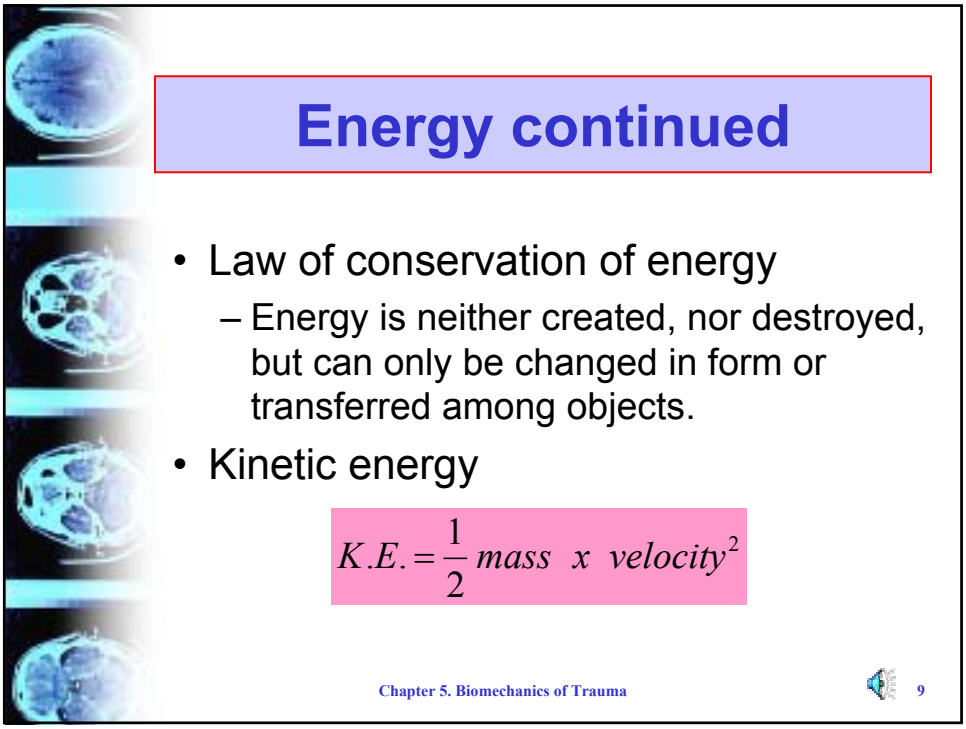


Energy continued

- Newton's third law
  - For every action, there is an equal and opposite reaction.
- Force

$$force = \text{mass} \times \text{acceleration}$$

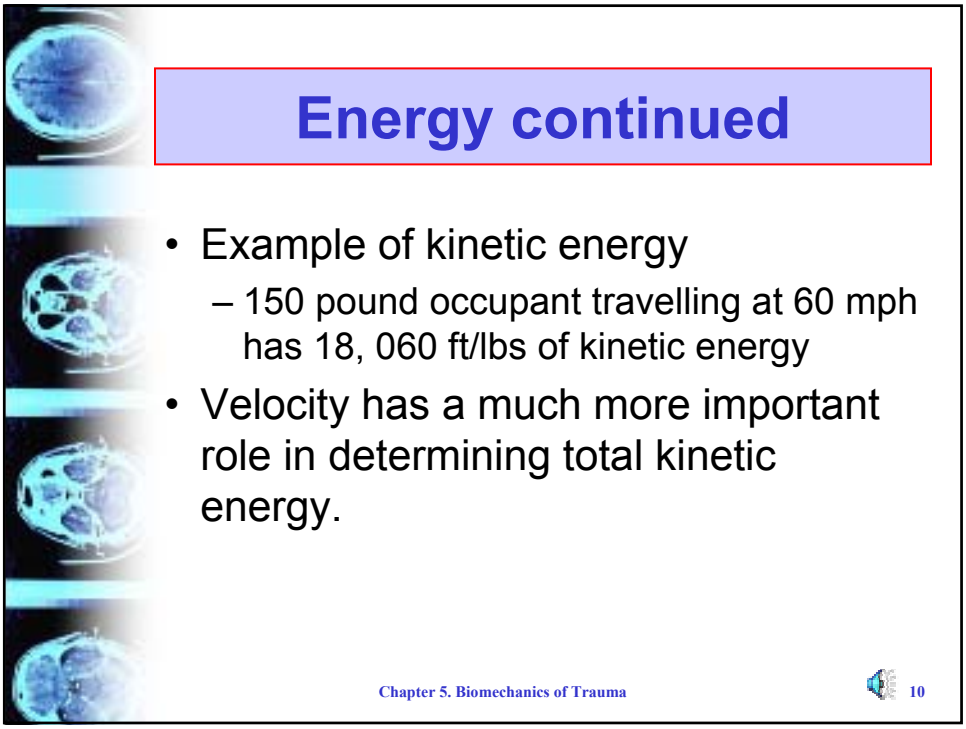
$$g\ force = \frac{\text{MPH velocity change}^2}{30 \times \text{feet of stopping distance}}$$



Energy continued

- Law of conservation of energy
  - Energy is neither created, nor destroyed, but can only be changed in form or transferred among objects.
- Kinetic energy

$$K.E. = \frac{1}{2}\, mass \;\; x \;\; velocity^2$$



Energy continued

- Example of kinetic energy
  - 150 pound occupant travelling at 60 mph has 18, 060 ft/lbs of kinetic energy
- Velocity has a much more important role in determining total kinetic energy.

Energy continued

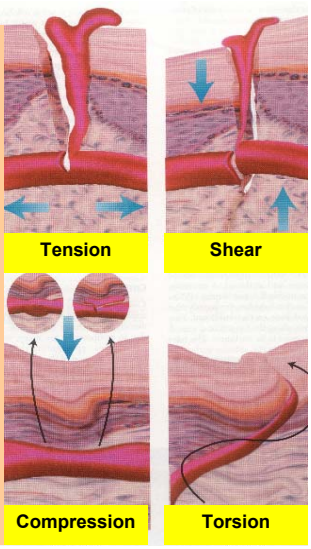
Unrestrained Occupant During 60 MPH Collision					
Weight (lbs.)	% Change in Weight	Velocity (mph)	% Change in Velocity	Kinetic Energy (foot-pounds)	% Change in Kinetic Energy
130	-13.33%	60	0.00%	15652	-13.33%
140	-6.67%	60	0.00%	16856	-6.67%
150	0.00%	60	0.00%	18060	0.00%
150	0.00%	70	16.67%	24582	36.11%
150	0.00%	80	33.33%	32107	77.78%

Energy continued

- Energy transfer and the five forms of energy
  - Motor vehicle collision
  - Bullet
- Preventing energy transfer
  - Injury prevention efforts
  - Engineering efforts

Blunt trauma

- Epidemiology
- Injury mechanisms
  - Tensile strain
  - Shear strain
  - Torsion
  - Compression

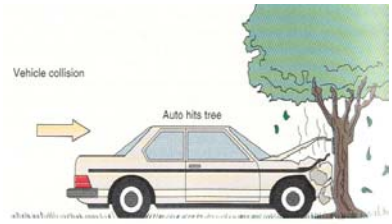


Motor Vehicle Collisions

Frequency of Collision Types for Fatal Collisions

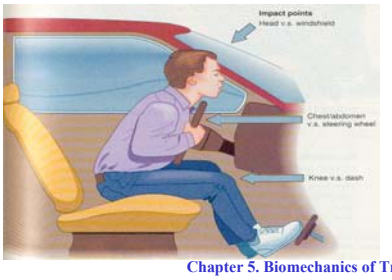
Collision Type	Percentage
Frontal	48.1%
Lateral	27.5%
Rear	34.0%
Rollover	14.3%
Other	12.0%
Unknown	5.5%

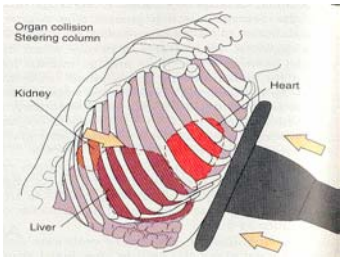
Motor Vehicle Collisions continued



3 Separate Collisions

- Vehicle
- Occupant
- Occupant's organs





Motor Vehicle Collisions continued

- 2 feet of "crush" at 30 mph
- Produces 15 g of force (average)
- Human tolerance
  - 15 g injury unlikely
  - 30 g injury likely
  - 45 g injury inevitable
- Restraints permit "riding down" the crush

Motor Vehicle Collisions continued

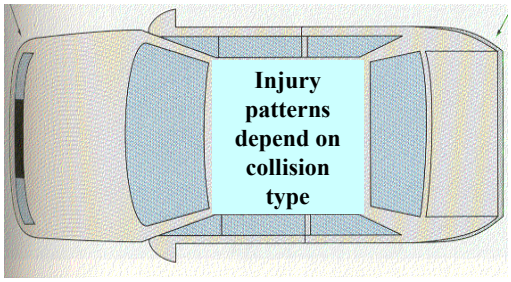
Local Deceleration Forces of an Unrestrained Occupant During a 30-mph Collision.				
	Knee to Dashboard	Chest to Steering Wheel	Head to Windshield	Head to Windshield Header
Contact Velocity (ft/s)	34	41	44	44
Local Crush (in.)	3	4	5	0.5
Local Deceleration (g)	72	78	72	721

Motor Vehicle Collisions continued

- Change of speed injuries
  - Extremity injuries
  - Chest and abdominal injuries
  - Head injuries
  - Neck injuries

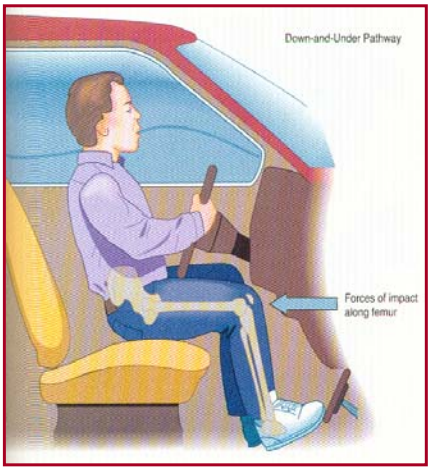
Patterns of MVC Injuries

- 5 types of motor vehicle collisions
  - Frontal
  - Rear
  - Lateral
  - Angular
  - Rollover



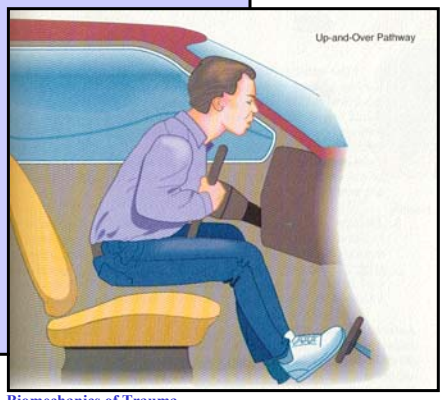
Patterns of MVC Injuries continued

- Frontal collisions
  - Down and under
    - Ankle fracture/dislocation
    - Tibia/fibula fractures
    - Knee dislocation
    - Femur fracture
    - Hip dislocation
    - Pelvic fracture
    - 2nd phase of injury includes upper torso injuries of up-and-over pathway



Patterns of MVC Injuries continued

- Frontal Collisions continued
  - Up and over
    - Chest
    - Abdomen
    - Head



Patterns of MVC Injuries continued

- Rear collisions

Patterns of MVC Injuries continued

- Lateral collisions

Patterns of MVC Injuries continued

- Angular collisions
- Rollover

Patterns of MVC Injuries continued

- Ejection accounts for 27 percent of MVC deaths.
- Restraints
  - Lap belts
  - Three point
  - Air bags

Patterns of MVC Injuries continued

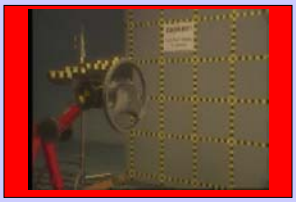
- **Air Bags**

Patterns of MVC Injuries continued

- **Air Bags**
  - Side impact

Patterns of MVC Injuries continued

- **Restraint related injuries**
  - **Airbags**
    - Inflate at 200 mph
    - Facial abrasions
    - Corneal abrasions
    - Upper extremity injuries
    - Chest injuries in children, elderly, and small adults
    - Occult abdominal injuries

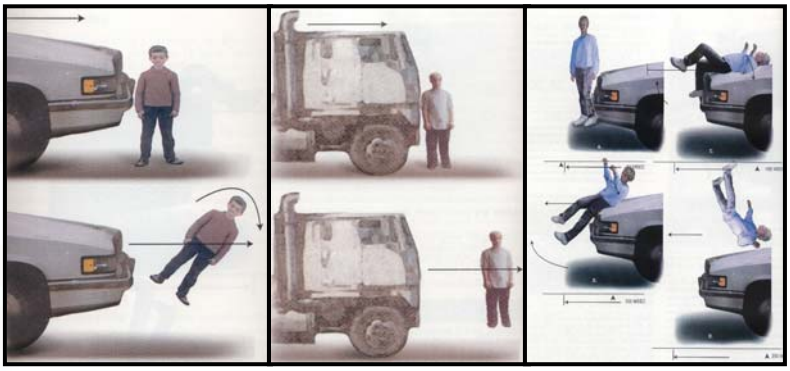


Patterns of MVC Injuries continued

- **Restraint related injuries**
  - **Seat belts**
    - **Abdominal injuries**
    - **Chest injuries**
    - **Clavicular fractures**
    - **Spine injuries**

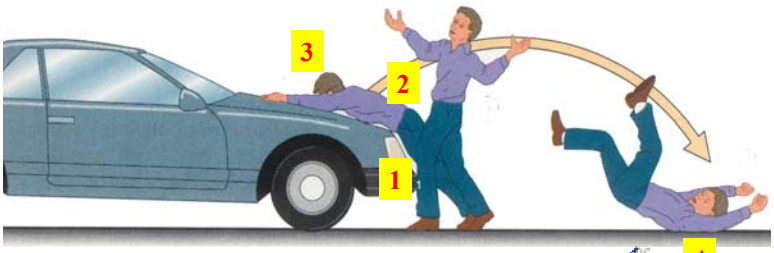
Pedestrian Injuries

- Injuries explained by large impulse
- Injury patterns depend on center of gravity



Pedestrian Injuries continued

- 4 impacts of pedestrian-MVC (Adult)
  - Primary
  - Secondary
  - Tertiary
  - Quaternary



Pedestrian Injuries continued

- Patterns of injuries
  - Toddlers
  - Children
  - Adults

Motorcycle Collisions

- Patterns of Injuries
  - Frontal impacts
  - Angular impacts
  - Sliding
  - Ejection

Falls

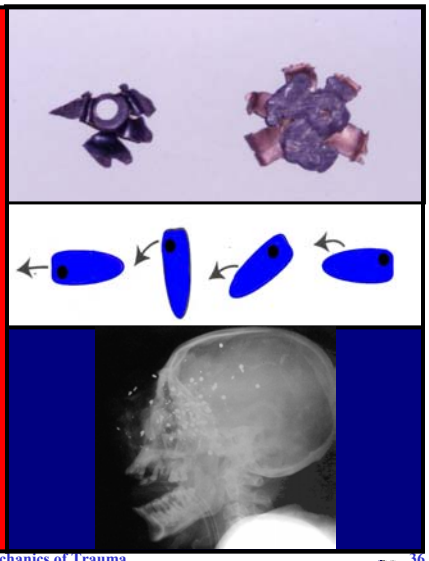
- Height determines velocity
- Landing surface determines stopping distance
- Point of impact determines magnitude of forces
- Patterns of injury

Penetrating Trauma

- Types of weapons
- Injury depends on:
  - Delivered energy
  - Size and profile of projectile
  - Path of the projectile through the body

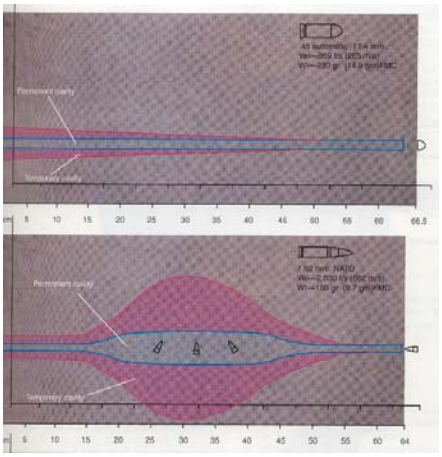
Wound Ballistics

- Weapon energy
- Distance
- Tissue density
- Surface area
- Profile
- Tumble
- Fragmentation



Wound Ballistics continued

- Cavitation
  - Temporary cavity
  - Permanent cavity
- Ricochet

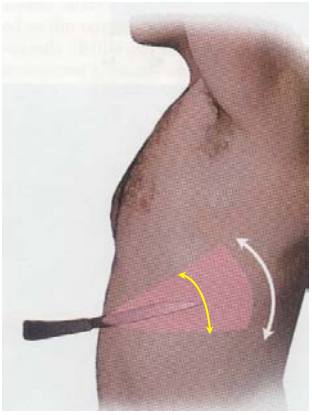


Wound Ballistics

- Entrance and exit wounds

Penetrating Trauma continued

- Knife wounds
  - Angle of the attack
  - Sex of assailant
  - Examine weapon



Blast Injuries

- **Types of blast injuries**
  - Primary blast injury
    - Shock wave
      - Spalling
      - implosion

Blast Injuries continued

- Types of blast injuries continued
  - Primary blast injury continued
    - Shock wave continued
      - Over/under pressurization
      - Spalling
      - Implosion
      - Propellants
        - » Gun powder
      - High explosives
        - » C4 (4M psi)
        - » Trinitrotolulene

Blast Injuries continued

- Types of blast injuries continued
  - Secondary blast injury
    - Debris may be carried miles away

Blast Injuries continued

- Types of blast injuries continued
  - Tertiary blast injury
    - Blast winds
    - Impact with ground
  - Blast-associated injury
    - Environment
    - 1993 world trade center

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