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Kinetics of Trauma

Advanced Care Paramedicine

Module: 08
Section: 03

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Kinetics of Trauma

TRAUMA AND TRAUMA SYSTEMS

Trauma

- A physical injury or wound caused by external force or violence

Introduction

- Fourth leading killer in Canada
  - Number one cause of death for persons under age 45
- Most expensive problem in terms of:
  - Productivity losses
  - High cost of initial care, rehabilitation and lifelong patient maintenance

Trauma

- Penetrating
  - Injury caused by an object breaking the skin and entering the body.
- Blunt
  - Injury caused by the collision of an object with the body in which the object does not enter the body.

Trauma

- Presentation often masks patient's true condition
  - Extremity trauma is often obvious and grotesque
  - May be a distraction from internal bleeding and shock which may have a more subtle presentation
- Serious life-threatening injuries occur in less than 10% of injuries
  - Recognition and priority management (triage) become critical to effective management

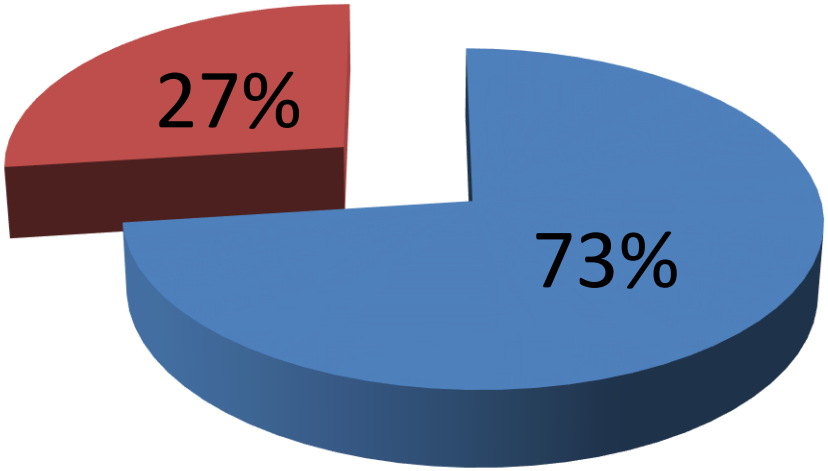
Trauma

- Trauma is a major cause of morbidity and mortality.
- The paramedic must have an appreciation of the trauma system and be able to recognize mechanisms of injury to enhance patient assessment.
- Whether we are dealing with a minor or a major trauma, our plan should be consistent and follow an organized routine!

Gender Breakdown

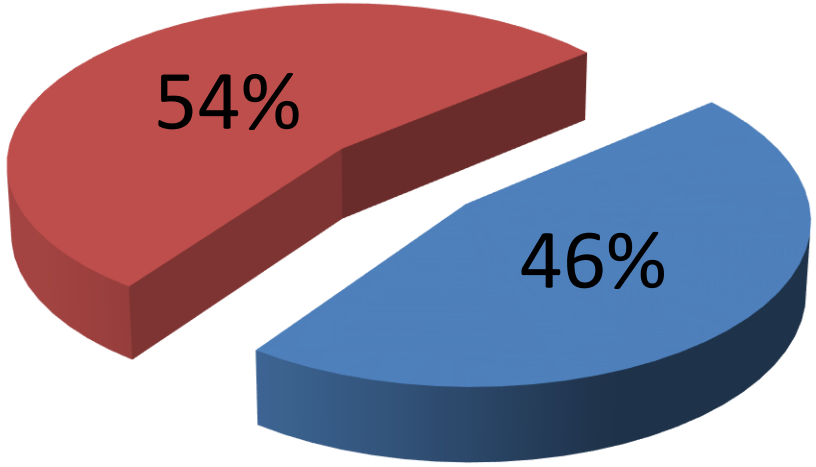
Major Trauma

(Comprehensive Data Set)



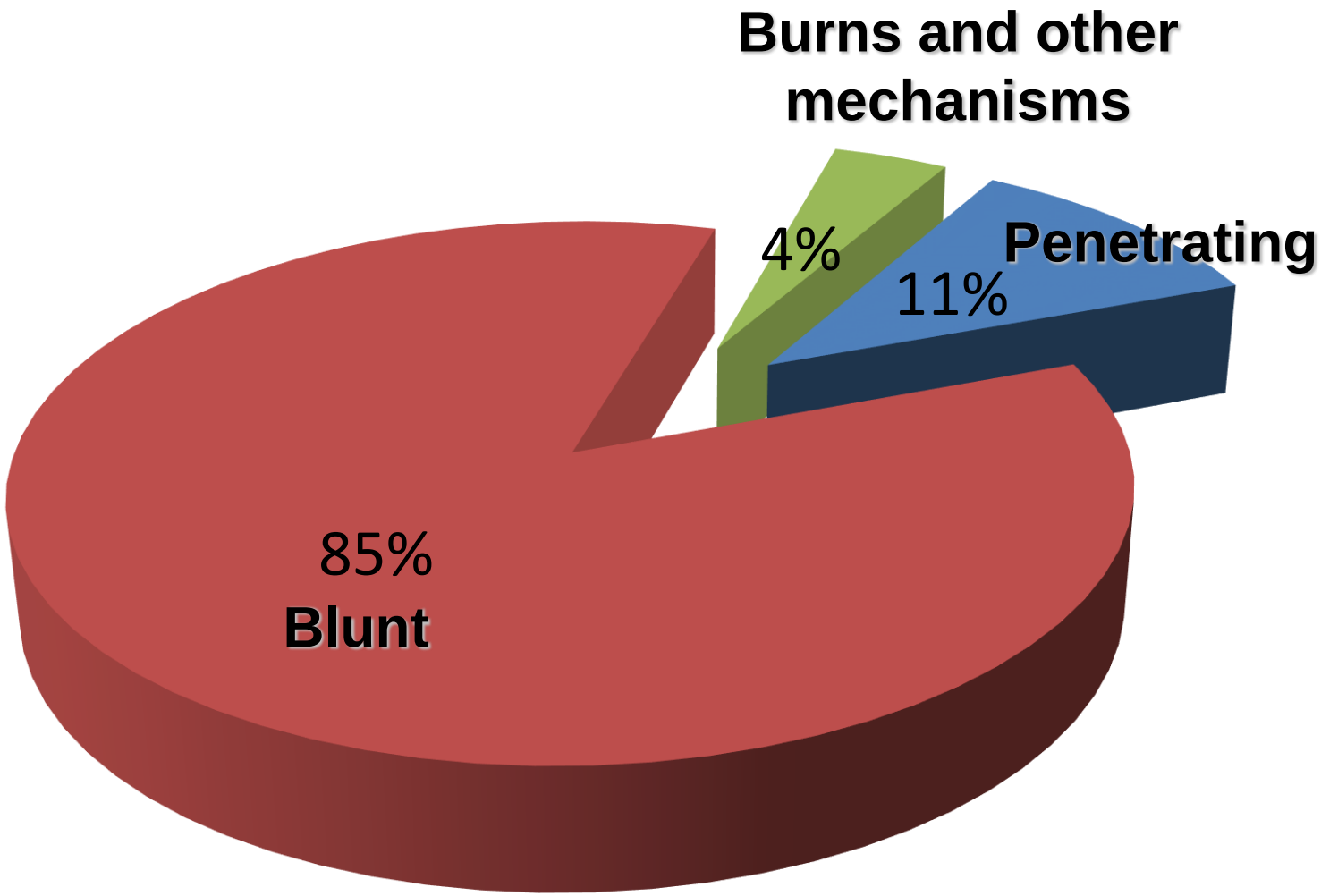
Minor Trauma

(Minor Data Set)



Male Female

Injury Type



Other Findings…

- Injury Location (body):
  - Head and Neck > 60%
- Age:
  - Minor > 65 y/o
  - Major 20 – 49 y/o
- Location:
  - Minor Home (Falls)
  - Major Street & Highway (MVC's)
- Time:
  - Major traumas tend to occur more on the weekends
  - Major trauma tends to occur during the summer months

Injury

- It is essential that gruesome, non-life-threatening injuries do distract you from more subtle, life threatening problems.

Trauma Care System

- Serious trauma is a surgical disease
  - Proper care is often immediate surgical intervention
- Care for seriously injured trauma patients is expensive and complicated
  - Well-designed EMS systems allocate limited resources to provide the most efficient and effect care

Trauma Care System

- Integration of:
  - EMS
  - Hospital Care
- Reduces:
  - Cost
  - Time to surgery
  - Mortality
- Proper Care:
  - Immediate surgical intervention to repair hemorrhage sites

Trauma Centres

- Current Canadian model for trauma care involves the designation of trauma centres:
  - Tertiary Trauma Centres (TTC)
  - District Trauma Centres (DTC)
  - Primary Trauma Centres (PTC)
  - Or graded Level 1-5, Level 1 = Tertiary Centre
- Trauma systems should be flexible enough to meet local needs
  - Urban versus rural

Trauma Centre Designations

Table 16–2 Trauma Triage Criteria Indicating Need for Immediate Transport

Mechanism of Injury

- Falls greater than six metres (three times the victim's height)
- Pedestrian/bicyclist versus auto collisions
  - — Struck by a vehicle travelling more than 10 km/h
  - — Thrown or run over by vehicle
- Motorcycle impact at greater than 30 km/h
- Ejection from a vehicle
- Severe vehicle impact
  - — Speed at impact greater than 60 km/h
  - — Intrusion of more than 30 cm into occupant compartment
  - — Vehicle deformity greater than 50 cm
- Rollover with signs of serious impact
- Death of another occupant in the vehicle
- Extrication time greater than 20 minutes

Significant mechanism of injury considerations with infants and children include the following:

- A fall of greater than three metres (three times the victim's height)
- A bicycle/vehicle collision
- A vehicle collision at medium speed
- Any vehicle collision in which the infant or child was unrestrained

Physical Findings

- Revised Trauma Score less than 11
- Glasgow Coma Scale less than 14
- Systolic blood pressure less than 90
- Respiratory rate less than 10 or greater than 29
- Pulse less than 50 or greater than 120
- Two or more proximal long-bone fractures
- Flail chest
- Pelvic fracture
- Limb paralysis
- Burns to more than 15 percent of body surface area
- Burns to airway or face
- Complete amputation of limb, thumb, or penis; eye avulsion; partial limb amputation (partial amputation of the thumb and penis, depending on severity of the injury)
- Tender, distended abdomen secondary to blunt/penetrating trauma
- Head injury with unilaterally dilated pupil, and/or patient unconscious or level of consciousness decreased or decreasing during assessment

Specialty Centers

- Neurocentres
- Pediatric trauma centres
- Microsurgery
- Hyperbaric centres
- Burn units

Role of the Paramedic

- Triage
  - Trauma triage guidelines
- Rapid assessment
- Trauma care
- Transport to the appropriate facility

Trauma

- Trauma care is divided into 3 separate sections:
  - Pre-incident
  - Incident
  - Post-Incident

Pre-incident Injury Prevention

- One of the best and most cost effective way to reduce mortality and morbidity is to prevent the trauma in the first place
- Designed to help promote safe practices to the public to help prevent injuries
  - "Injury is No Accident" Campaign
  - P.A.R.T.Y. Program (Prevention of Alcohol & Risk Related Trauma in Youth)
  - Bicycle safety programs
  - Firearm safety
  - Boat safety
  - Child Safety Seat classes and checking

Incident

- Prehospital care
  - Management
  - Transportation
  - Triage Guidelines

Incident

- Acute care
  - Emergency Department
  - Interfacility Transport
  - Definitive Care
  - Trauma Critical Care

- Rehabilitation
  - Improving ‘return to home’
  - Assisting the patient to regain or retrain

Post Incident

- Data and Trauma Registry
  - Data retrieval system for trauma patient information
  - Used to evaluate and improve the trauma system
  - Requires accurate documentation
  - Supports research

Post Incident

- Quality Improvement
  - Quality improvement (QI) and quality management (QM)
    - Another way of examining system performance with an aim of providing better patient care
  - Recommendations may include:
    - Continuing education
    - Protocol modifications
  - Peer review is often a critical component of this process

Decision to Transport

- Often a difficult decision with significant consequences
- Based on trauma triage criteria
  - Designed for “over-triage””
  - Ensures that patients with subtle signs and symptoms do not get missed
- Best to err on the side of caution

Trauma Triage Criteria
MOI-Adults

- >6 m fall (3 x height of patient)
- Pedestrian/Bicyclist versus auto
  - Thrown or run over by vehicle
  - Struck by vehicle traveling >10 kph
- Motorcycle impact >30 kph
- Ejected from a vehicle

Trauma Triage Criteria
MOI-Adults

- Severe vehicle impact
  - > 60 km/hr
  - > 30 cm intrusion
  - > 50 cm vehicle deformity
- Rollover with signs of serious impact
- Death of another occupant
- Extrication time > 20 minutes

Trauma Triage Criteria
Infants & Children

- >3 m fall (3 x height of patient)
- Bicycle/vehicle collision
- Vehicle collision at medium speed
- Any vehicle collision involving an unrestrained infant or child

Trauma Triage Criteria
Physical Findings

- Revised Trauma Score <11
- Pediatric Trauma Score <9
- Glasgow Coma Scale <14
- Systolic blood pressure <90
- Respiratory rate <10 or >29

Trauma Triage Criteria
Physical Findings

- > 2 proximal long bone fractures
- Flail chest
- Pelvic fracture
- Limb paralysis
- Burn > 15% BSA
- Burn to face or airway
- Penetrating trunk, neck and head trauma

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Kinetics of Trauma

MECHANISM OF INJURY

MOI Analysis

- Processes and forces that cause trauma
- Identify:
  - Forces involved
  - Direction of the forces
  - Affected areas of the patient
- First step in focused history is the physical assessment of the trauma patient

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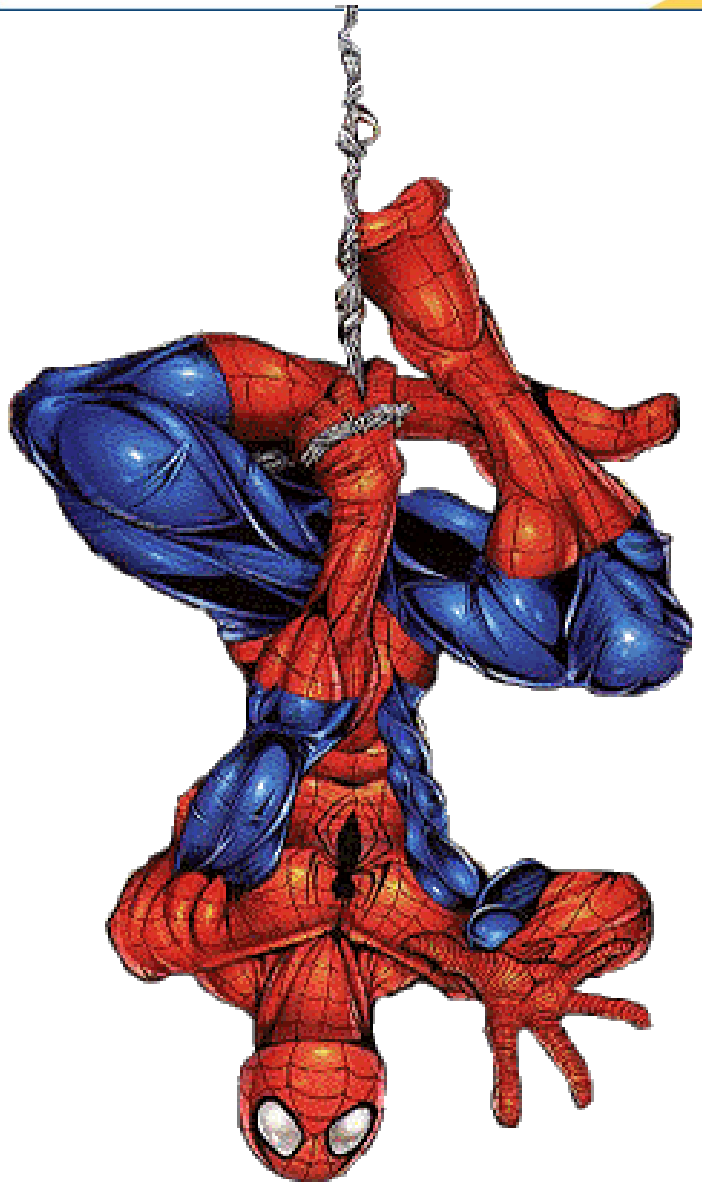
Mechanism of Injury

Index of Suspicion



- Anticipation of injury to a body region, organ or structure based on analysis of mechanism of injury
- Shock and head injuries are the principle killers in trauma
  - May present subtly at first
  - Trauma patients require frequent reassessment and trending

Golden Hour

- Research demonstrates that survival rates go up as time to surgery is decreased
- Golden Hour
  - Current goal for incident to surgery time
- Platinum 10 Minutes
  - Limit scene time to 10 minutes
- Air transport
  - Usually governed by protocol
  - Balance of speed versus need

KINETICS OF TRAUMA

Energy

- Transfer of energy from an external source to the body causes injury.
- The extent of injury is based on:
  - Type of energy
  - Amount of energy applied
  - Speed of force applied
  - Location of body force is applied to

Kinematics

- Process of examining the MOI of an incident to determine what injuries likely resulted from the forces and motion and changes in motion involved

Kinematics

- Consider:
  - Individual factors
    - Age
    - Protective devices (seat belts, helmets, etc)
  - Other applicable factors
    - Force of energy applied
    - Anatomy
    - Energy

Kinetics

- Branch of physics dealing with:
  - Forces affecting objects in motion
  - Energy exchanges that occur as objects collide
- Helps appreciate and anticipate the results of auto and other impacts
- Two basic principles:
  - Law of inertia
  - Law of conservation of energy

Laws of Motion

- Law of Inertia (Newton's First Law of Motion)
  - Tendency of an object to remain at rest or remain in motion unless acted upon by an outside force
    - Car into tree
    - Passenger collisions within a car
    - Organ collisions within a body

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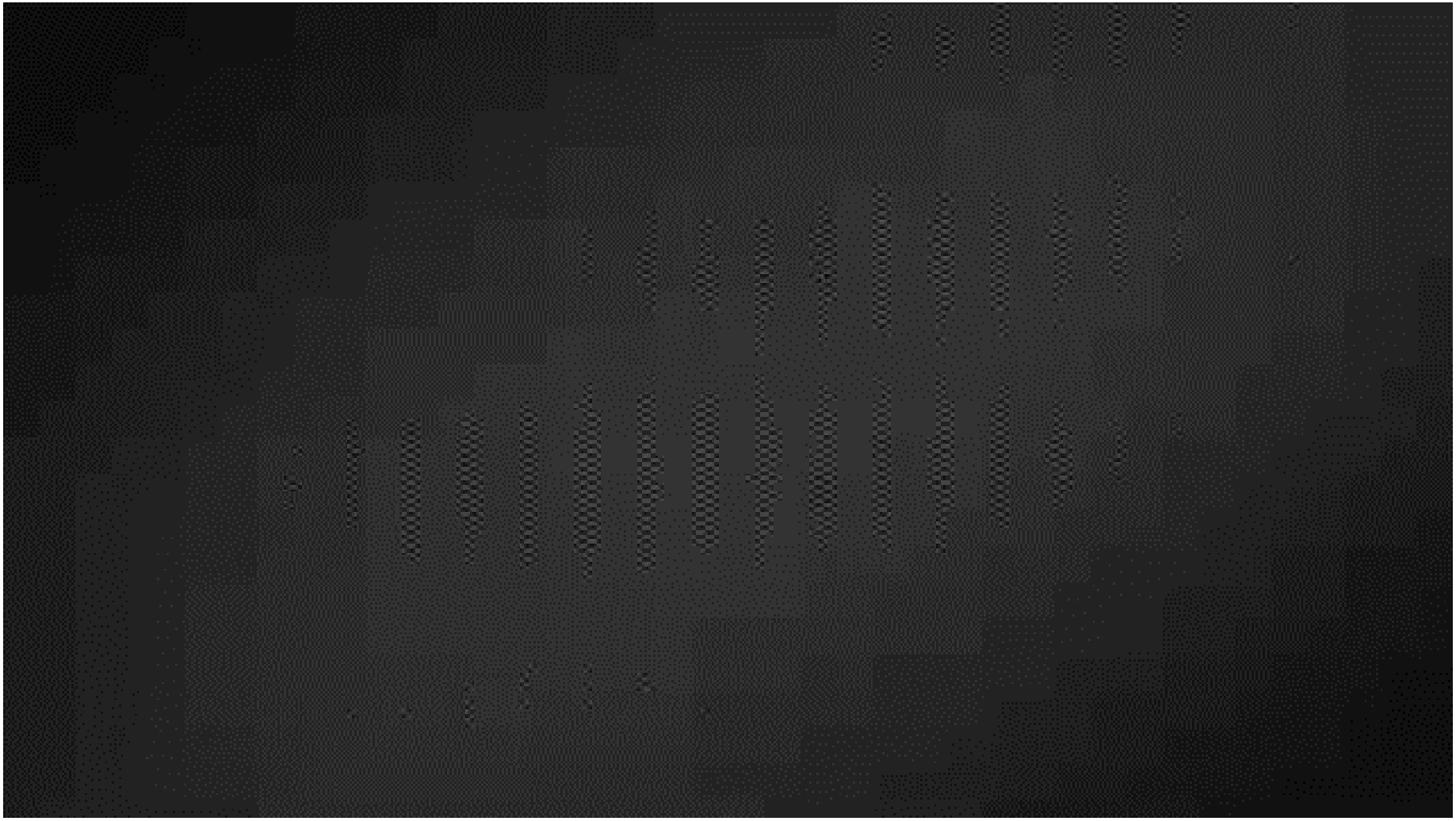
Inertia and MVC's

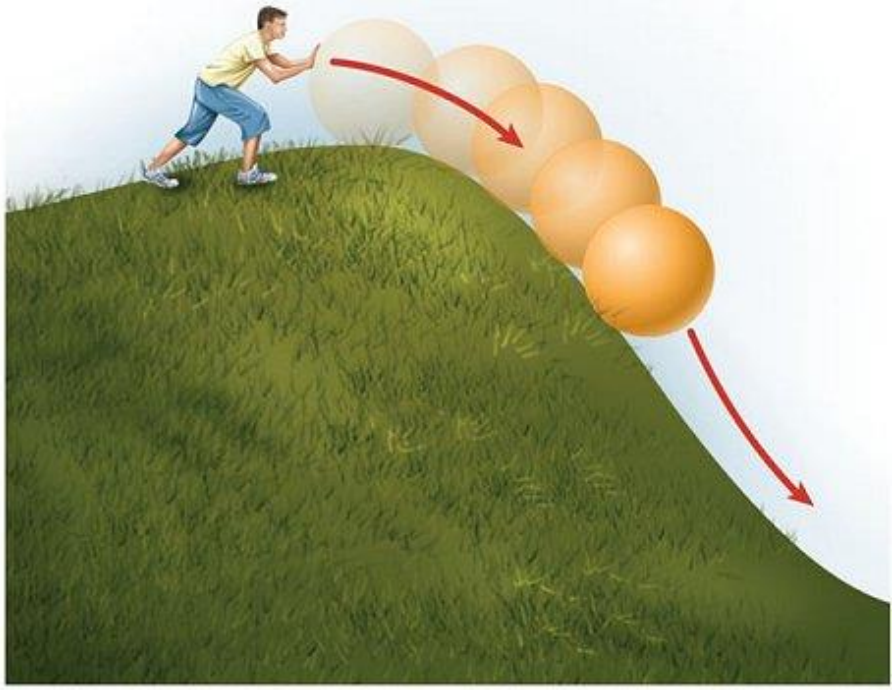


Mechanical Principle

- General principles of rapid deceleration mechanisms (MVCs, falls, etc.)
  - Car strikes object and stops
  - The rest of the car continues forward, causing deformation

Forms of Energy

a) Potential energy



(b) Kinetic energy

Conservation of Energy

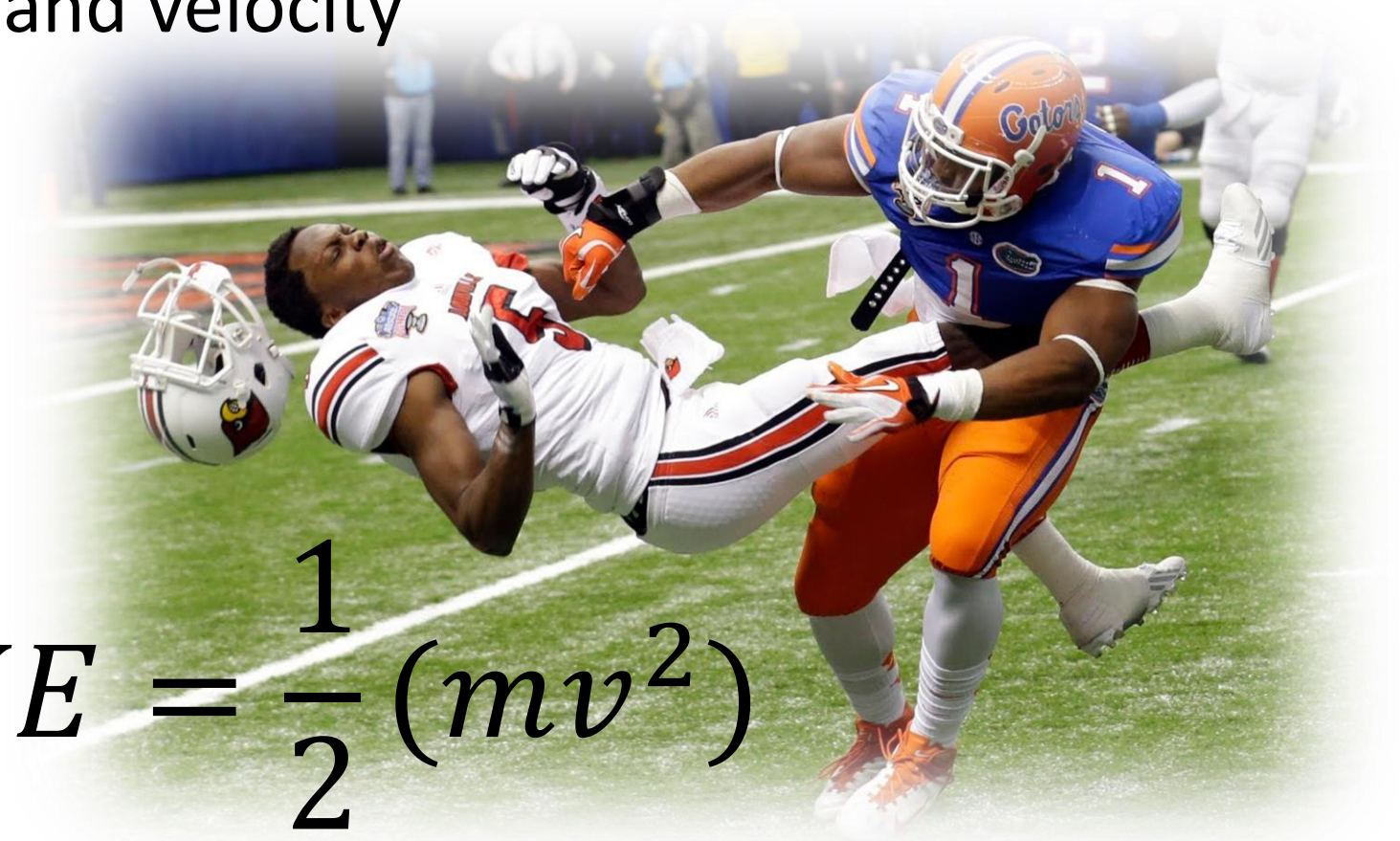
- Energy cannot be created nor destroyed but can change in form

Conservation of Energy

- When our car hits the brick wall, the kinetic (motion) energy is dissipated by heat and noise and by destruction of the frame
- Whatever energy remains is transferred to the occupants and their internal organs

Kinetic Energy

- Kinetic Energy is a function of an object's mass and velocity



$$KE = \frac{1}{2}(mv^2)$$

Kinetic Energy

- Let's take a look at this in other terms:
  - How much kinetic energy would a 70 kg person travelling at 50 km/hr have?

$$KE = \frac{1}{2}(mv^2)$$

$$KE = \frac{1}{2}(70\ kg\ X\ (14\ m/s)^2)$$

$$KE = 6860\ Joules$$

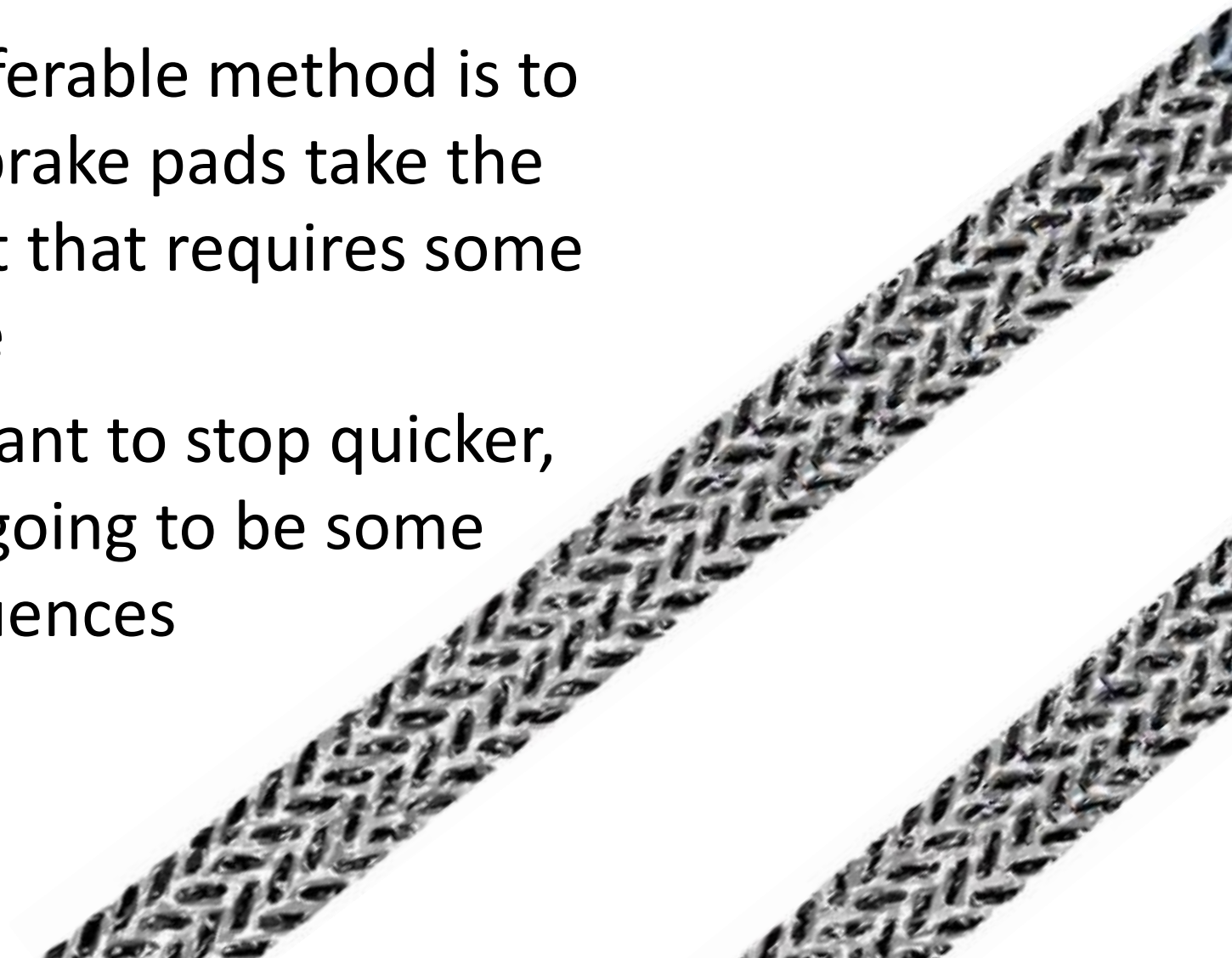
Kinetic Energy

- This means that, in order to stop, the driver of the vehicle will have to convert all of that energy (6860 J) into something else.

Bending this stop sign for instance

Kinetic Energy

- The preferable method is to let the brake pads take the heat but that requires some distance
- If you want to stop quicker, there's going to be some consequences



Kinetic Energy

- If sudden deceleration occurs, the 77,184 Joules still needs to be converted but in a much shorter time-frame

Kinetic Energy

- Crumple zones, seat belts and airbags are able to absorb a great deal of energy, but the potential for tissue damage is still significant if the stopping distance is instantaneously reduced to nothing

Kinetic Energy

- Since kinetic Energy is a function of an object's mass and velocity, what happens when we change the values?
- Let's consider our 67 kg driver travelling at 48 kph and change those two values one at a time

Kinetic Energy

INCREASING MASS

If we double the mass

$$KE = \frac{1}{2}(mv^2)$$

$$KE = \frac{1}{2}(\mathbf{140}\ kg\ X\ (14\ m/s)^2)$$

$$KE = 13720\ kgm^2/s^2$$

$$KE = 13720\ Joules$$

Double Energy

INCREASING SPEED

If we double the speed

$$KE = \frac{1}{2}(mv^2)$$

$$KE = \frac{1}{2}(70\ kg\ X\ (\mathbf{28}\ m/s)^2)$$

$$KE = 27440\ kgm^2/s^2$$

$$KE = 27440\ Joules$$

Quadruple Energy

Kinetic Energy

- This exercise demonstrates that even a moderate increase in velocity creates much more kinetic energy than does a substantial increase in mass
- How do you think this principle relates to firearms?

Force

- Newton's Second Law of Motion
  - Emphasizes the importance of rate at which an object changes speed (acceleration or deceleration)

$$Force = Mass\ X\ Acceleration\ (or\ deceleration)$$

Laws of Motion

- Newton's Third Law of Motion
  - For every action there is an equal and opposite reaction

Events of A Collisions

- Newton's First Law of Motion shows us that…
- During a collision the body will be impacted by 5 separate collisions:
  - Vehicle Collison
  - Body Collision
  - Organ Collision
  - Secondary Collision
  - Additional Impacts

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Events of A Collisions

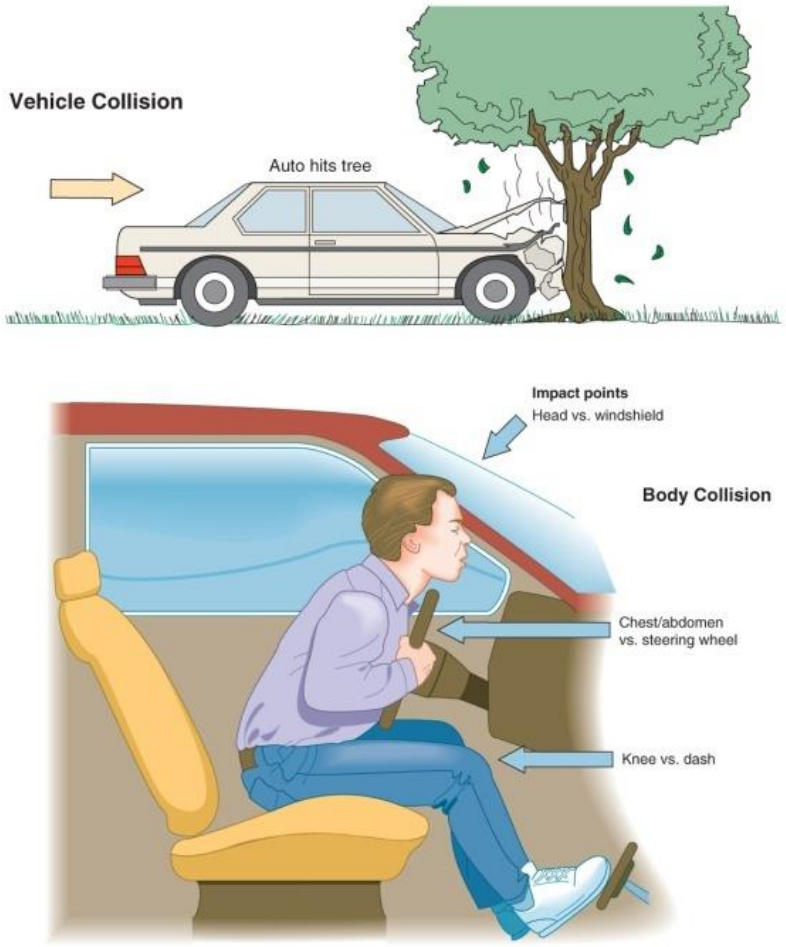
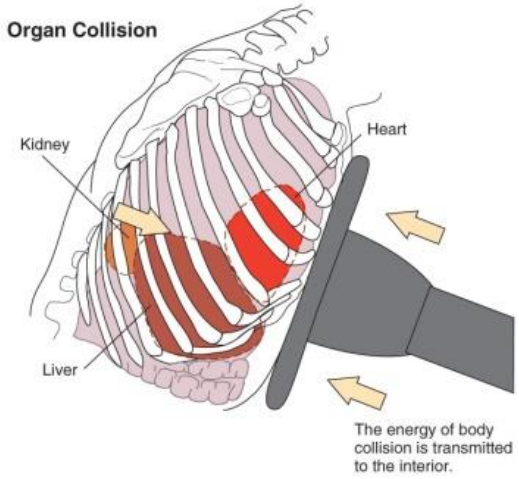


FIGURE 17-4 An automobile crash generates four major collisions: the vehicle collision, the body collision, the organ collision, and secondary collisions.



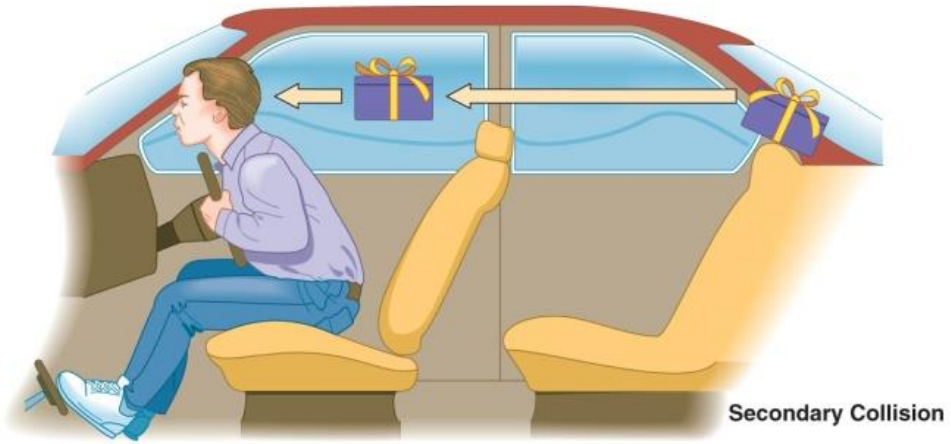


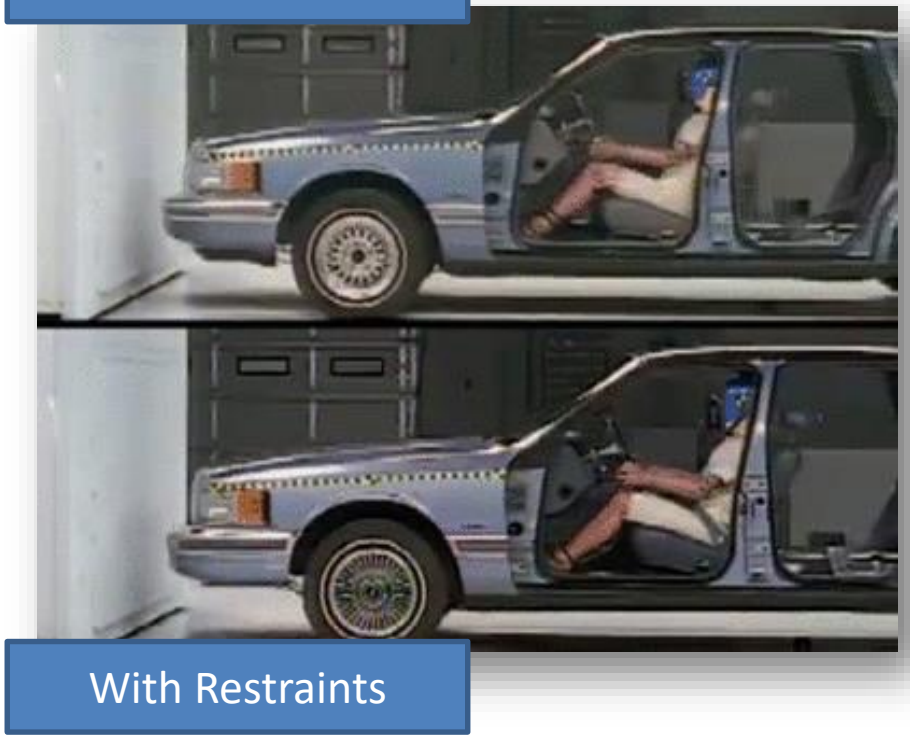
FIGURE 17-4 (CONTINUED)

Restraints

- Profound effect in reducing collision-related deaths
  - Seat Belts
  - Airbags
  - Child Safety Seats
- It is important to determine whether restraint devices were used (and used properly)

Restraints

- Seatbelts
  - Occupant slows with vehicle
  - Shoulder and lap belts should be worn together
    - Injuries occur if they are worn separately
- Airbags (SRS)
  - Reduce blunt chest trauma
  - Cause: Hand, Forearm, & Facial Injury
  - Check for steering wheel deformity
  - Side Airbags



Restraints

- Child Safety Seats
  - Provide the best protect for infants and small children riding in vehicles
- Infants and Small Children
  - Rear facing
- Older Child
  - Forward facing

Kinetics of Trauma

TYPES OF TRAUMA

Types of Trauma

- Blunt Trauma
  - Occurs when a body is struck by or strikes an object
  - Closed injury
  - Transmission of energy injures underlying tissues and organs
    - Tearing of muscle, vessels and bone
    - Rupture of solid organs
    - Organ injury

Type of Trauma

- Penetrating Trauma
  - Wounds that break the skin, energy source enters into body
  - Low energy
    - Knives
    - Injury limited to the path of the weapon
  - High energy
    - Guns
    - Energy may be transmitted to surrounding tissue, extending the trauma

Blunt Versus Penetrating Trauma

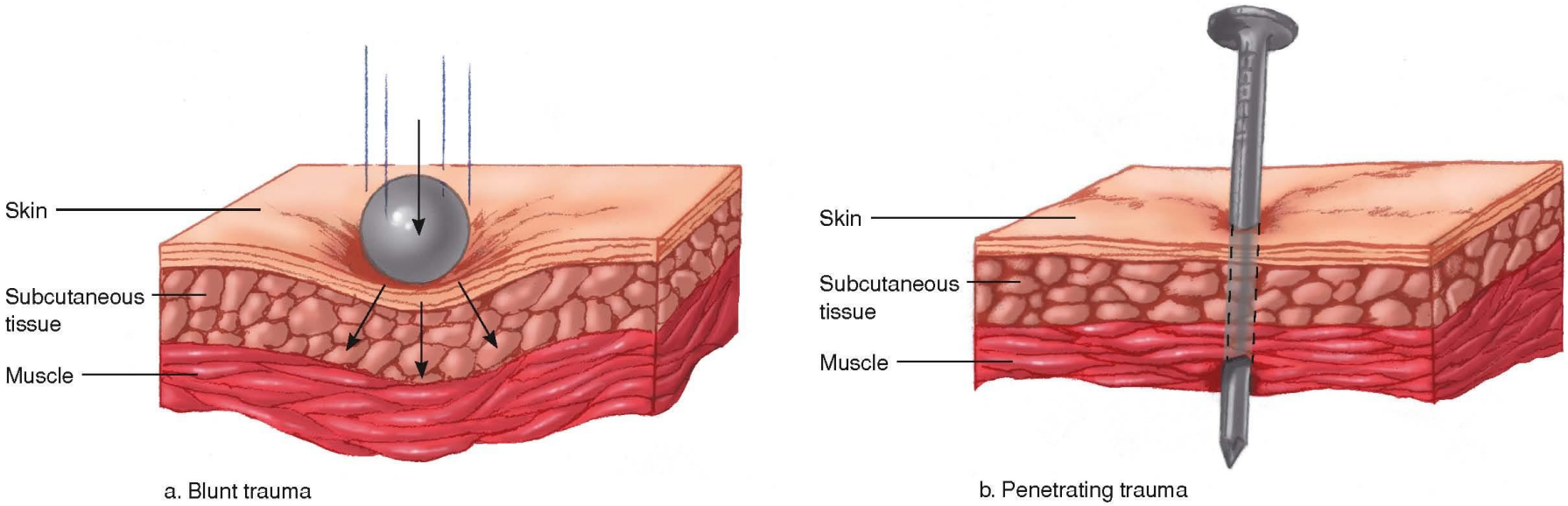


FIGURE 17-3 Blunt trauma results when an object or force hits the body and kinetic energy is transferred to the involved body tissues. Penetrating injury is produced when an object enters the body resulting in direct injury.

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Kinematics of Trauma

BLUNT TRAUMA

Introduction to Blunt Trauma

- Most common cause of trauma death and disability
- Energy exchange between an object and the human body, without intrusion through the skin
- Can be deceptive
  - The true nature of the injury is often hidden
  - Evidence of the serious injury may be very subtle or even absent

Blunt Trauma

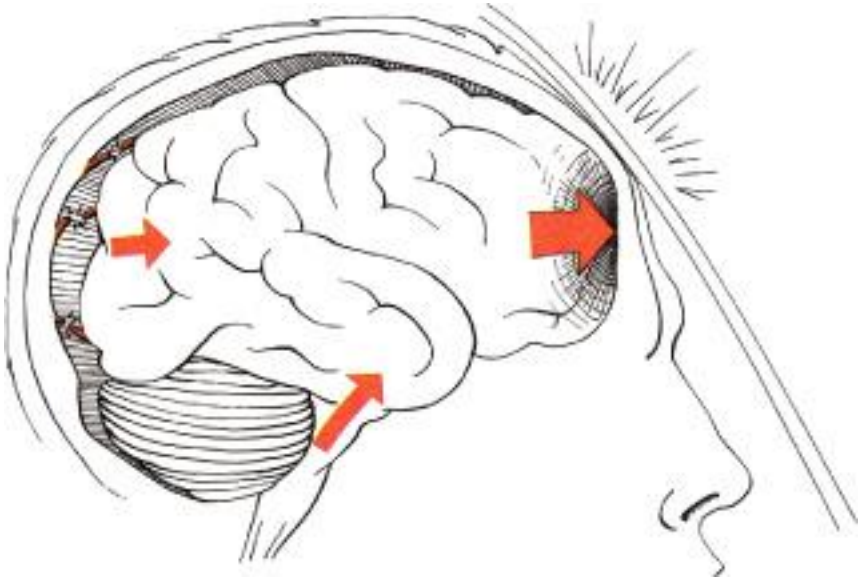
- Most commonly from motor vehicle collisions
  - Automobiles
  - Motorcycles
  - Pedestrians
  - Recreational vehicles
- Explosions
- Falls
- Crush injuries
- Sporting injuries

Deceleration Injuries

- After impact organs continue to pull against structures that attach them to the body
  - Organs may separate from attachments
  - Vascular pedicle or mesenteric attachment injury may cause hemorrhage

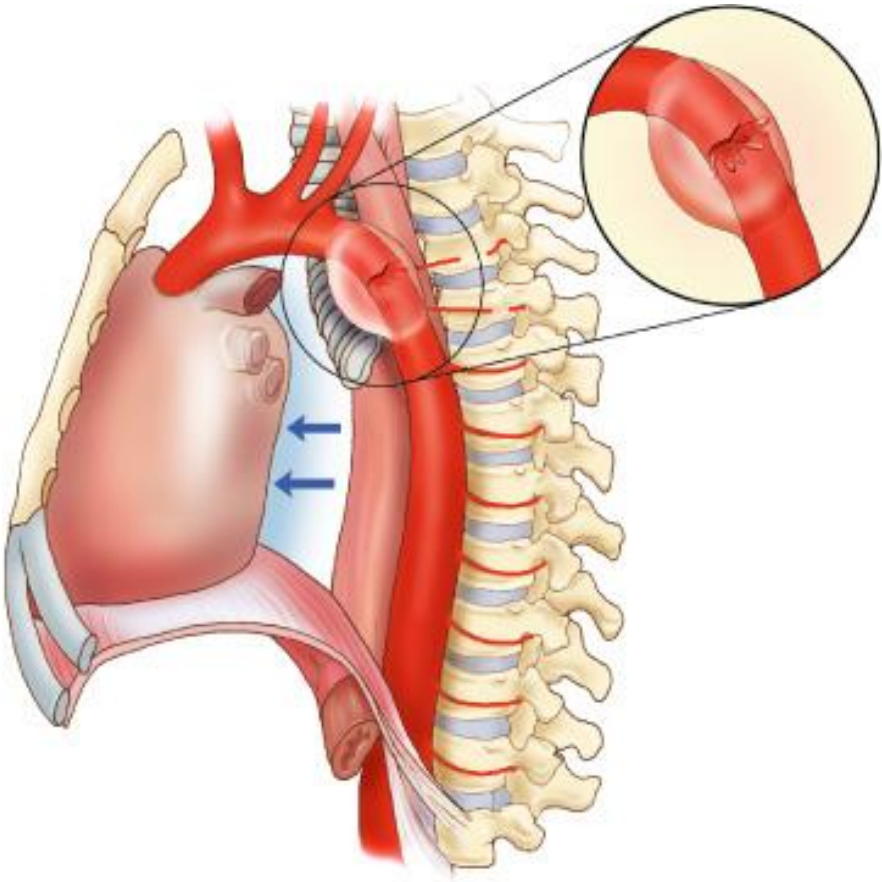
Head Injuries

- Head strikes stationary object
- Cranium stops abruptly
- Brain continues moving and is compressed against skull



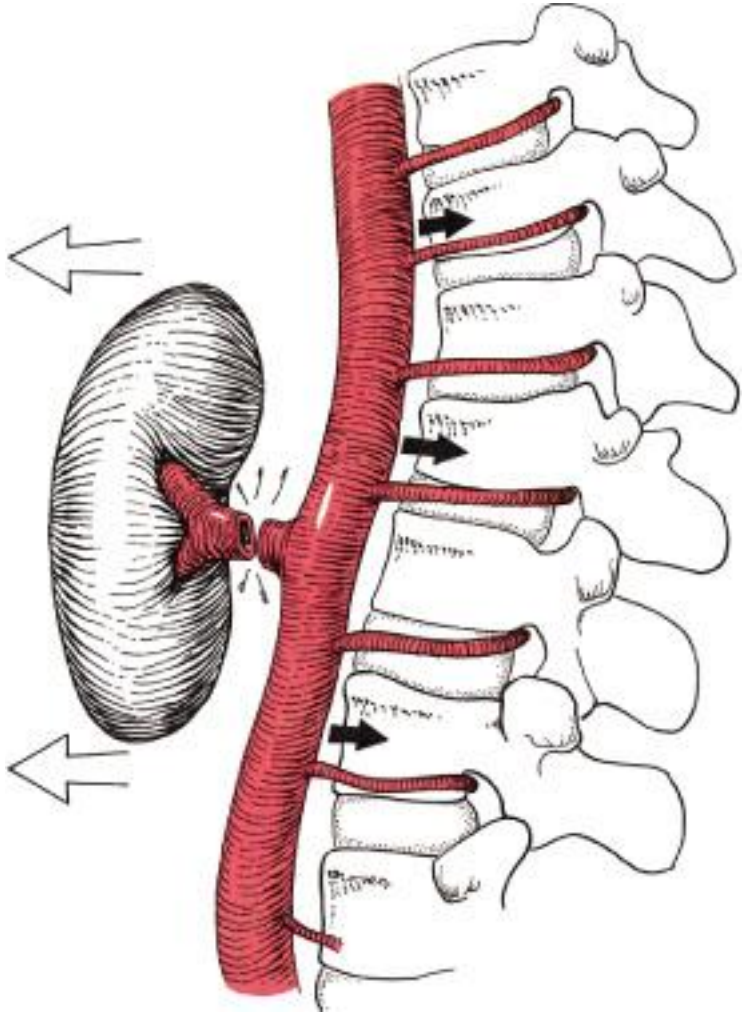
Thoracic Injuries

- Aorta often injured by severe deceleration forces
  - Usually sheared at ligamentum arteriosum attachment
- Rupture causes rapid exsanguination



Abdominal Injuries

- Abdominal organs and retroperitoneal structures (most commonly the kidneys) may be affected by deceleration forces



Crush Injuries

- Causes
  - Structural collapse, explosion, industrial; or agricultural
- Pathophysiology
  - Tissue stretching and compression
  - Extended pressure results in anaerobic metabolism distal to compression
  - Return of blood flow, toxins to entire body
  - Severe hemorrhage due to severe damaged blood vessels

Mechanical Principle

- Severity and pattern depend on:
  - Direction of impact
  - For vehicle crashes—energy absorbed by vehicle
  - Part(s) of body to which energy is transmitted
  - Use of protective equipment
  - Compression, deceleration, acceleration
  - Density and contact area of object
  - Velocity at impact

Mechanical Principle

- Again, a crash is any impact between the body and an object
- Assessment and management of the injured patient must consider three phases:
  - Pre-crash
  - Crash
  - Post-crash

Pre-crash

- Pre-crash factors must be considered in the assessment and management of the trauma patient:
  - Patient age and size
  - Drugs/alcohol
  - Preexisting medical conditions and
  - Medications

Crash

- The Crash phase begins at the moment of initial impact
- Remember, there are at least three impacts in most collisions
- Our understanding of Newtonian physics help

Post-crash

- Post-crash
  - Patient outcome is affected by conditions after the crash
    - Response time and resources available
    - Providers' knowledge of kinematics, assessment, and management
  - Providers' response depends on knowledge of energy and anatomy

Types of Impact

- Motor vehicle crashes come in many varieties:
  - Frontal impact
  - Rear impact
  - Lateral impact
  - Rotational impact
  - Rollover
  - Motorcycle crashes
  - Pedestrian–motor vehicle crashes

Types of Impact

- Frontal: 32%
- Lateral: 15%
- Rotational: 38%
  - Left & Right – Front & Rear
- Rear-end: 9%
- Rollover: 6%

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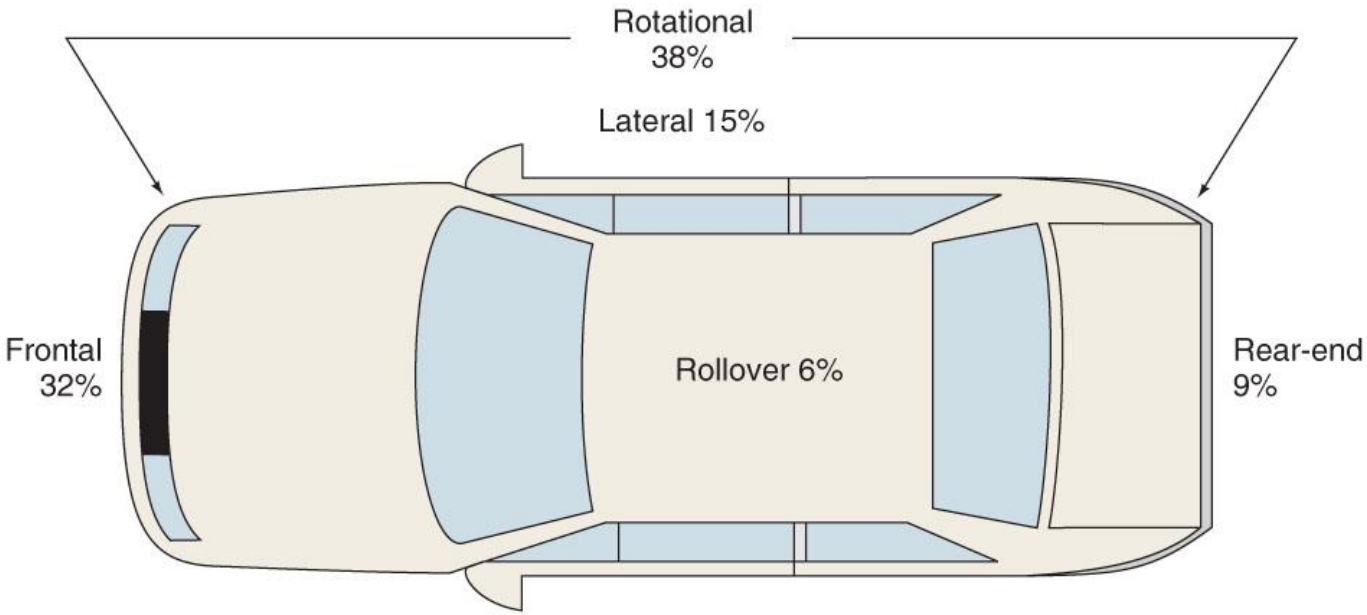
Types of Impact



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Blunt Trauma

FRONTAL IMPACT

Frontal Impacts

- Most common type of impact
- Often result in significant exchange of energy and serious injuries
- Produces three pathways of occupant travel
  - Down and under pathway
  - Up and over pathway
  - Ejection

- Frontal impacts often result in significant exchange of energy and serious injuries

Down and Under Pathway

- Occupant slides downward as vehicle comes to a stop
- Knees come into contact with firewall and absorb the initial impact
  - Knee, femur, and hip fracture or dislocations
- Upper body rotates forward and hits steering wheel
  - Chest trauma
- Driver may take a deep breath in anticipation of the impact
  - Paper Bag Syndrome

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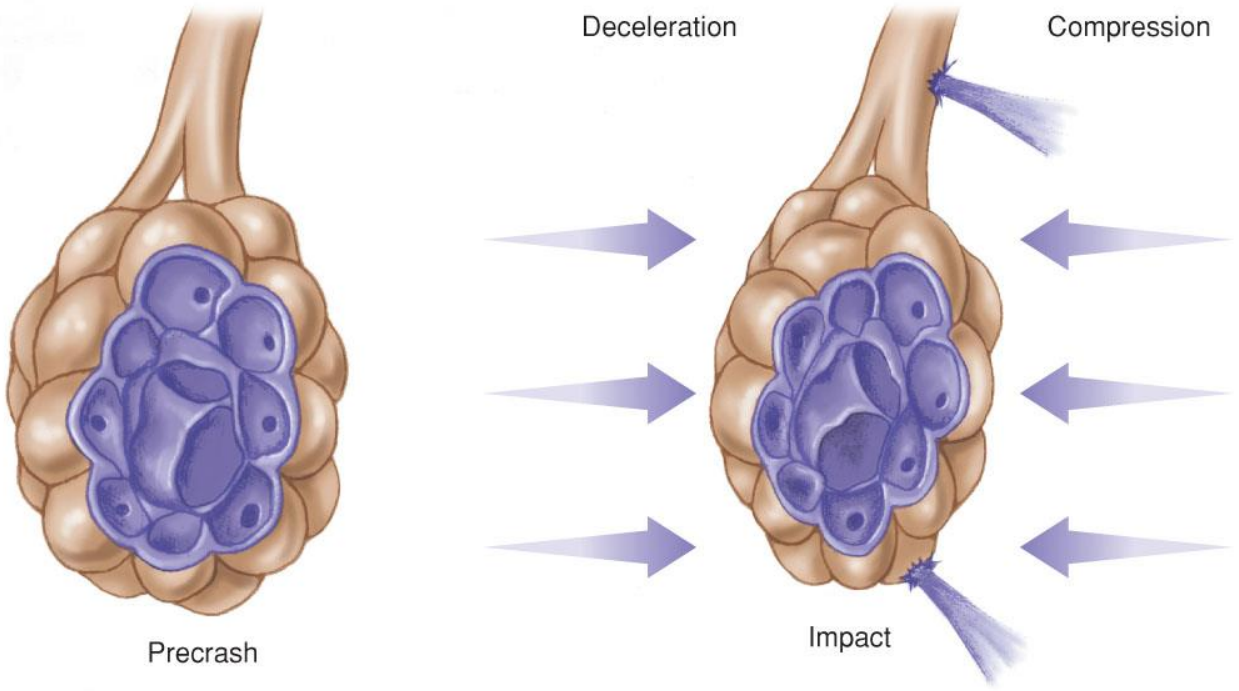
Injury Prediction?

Paper Bag Syndrome



Up and Over Pathway

- Occupant tenses legs in anticipation of the impact
- Upper body pivots forward and upward
- Steering wheel impinges on the femurs
  - Possible bilateral fractures
  - Compresses and injures abdominal contents
- Lower chest strikes steering wheel
  - Thoracic injuries
- Forward motion propels head into windshield
  - Head and neck injuries
  - Axial loading

Up and Over Pathway

- Head leads the way
- Compression of cervical spine
- Chest/abdomen impacts steering wheel
- Compression of hollow and solid organs
- Shearing injuries

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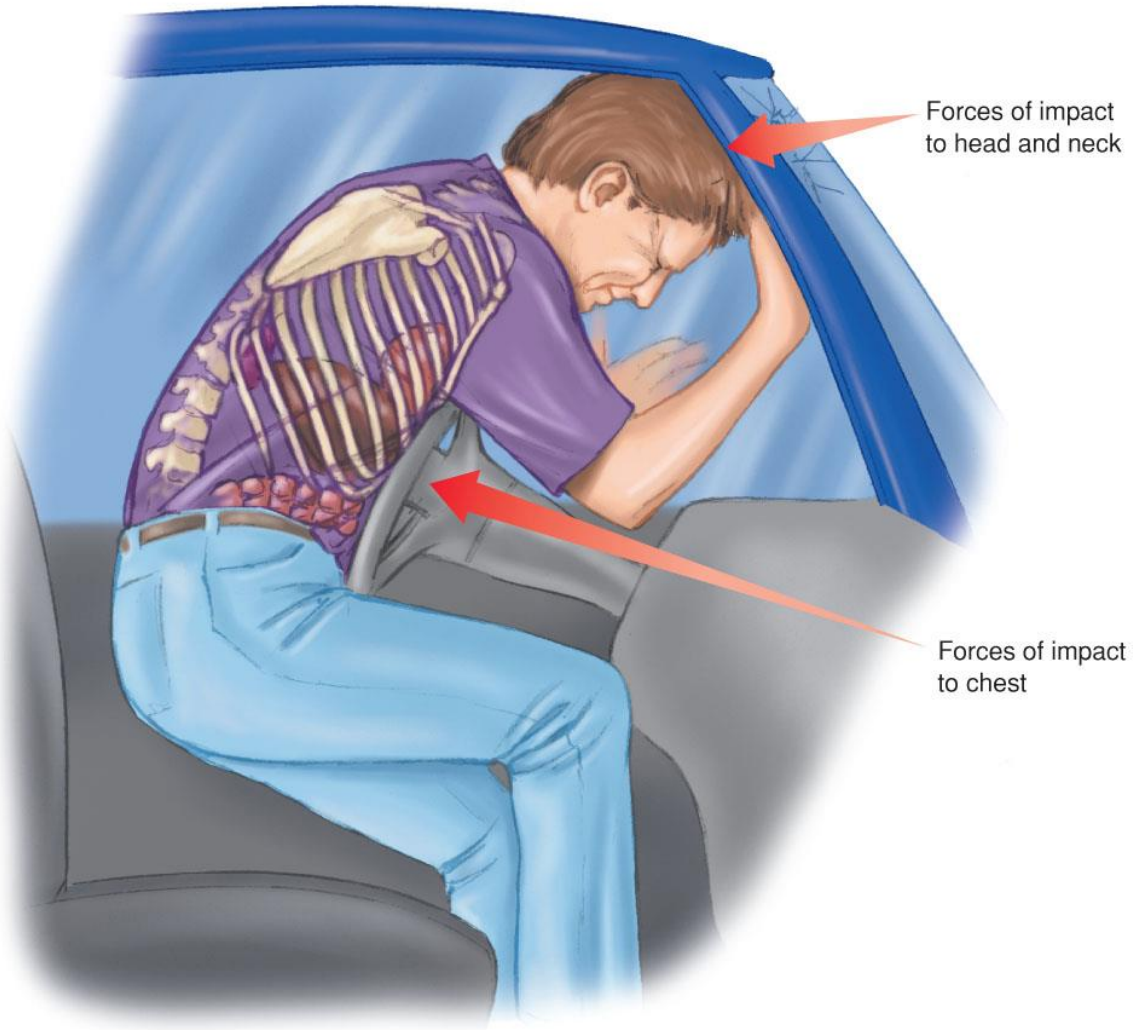
Up and Over Pathway



Injury prediction?

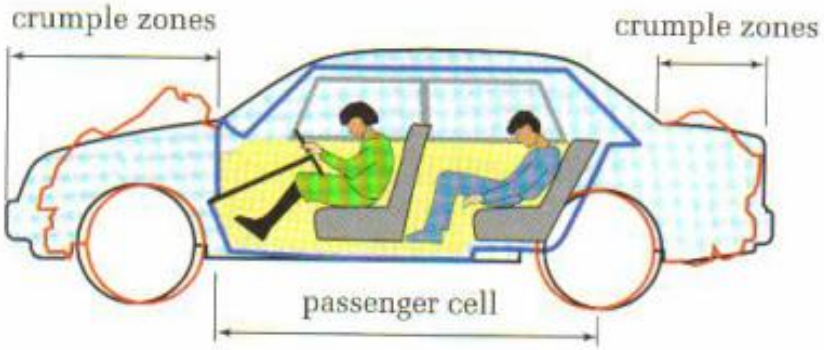
- Closed/open head injury - ALOC
- Facial fractures
- Airway problems
- Chest
- Abdomen

Ejection

- Due to up-and-over pathway
- Victims experience two impacts
  - Contact with vehicle interior and windshield
  - Impact with ground, trees or other objects
- Responsible for ~27% of vehicular fatalities

Crumple Zones

- Frontal impacts interpose more vehicle between the point of impact and patients
- Modern vehicles use this area to absorb impact forces and limit occupant injury
- Patients in collisions involving vans or lateral impacts do not benefit the same way



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Crumple Zones

- A lateral impact presents the least amount of crumple zone

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Case Study

Case Study

- Pre-Crash Considerations
  - Age of patients
    - Co-morbid factors, medications
    - Intoxication
  - Age of vehicles
    - Safety measures (50 years of research)
      - Crumple zones, airbags, seatbelts, telemetry
  - Speed, mass, impact type

Case Study

- Post-Crash Considerations
  - Response time – 5 minutes
  - Resources needed?
  - Prediction of injuries based on paramedic's knowledge of anatomy, kinematics?

Case Study

Driver A (Ford)

- Possible whiplash
- Cuts from flying glass
- Minor upper extremity injuries

Driver B (Toyota)

- Head
- Neck
- Face (Airway)
- Chest (multiple)
- Abdomen – shearing / compression
- Pelvis
- Upper & Lower extremities

Blunt Trauma

LATERAL IMPACT

Lateral Impact

- 15% of MVC's but 22% of deaths
- Kinetics the same as in a frontal impact
- Two exceptions:
  - Occupants present a different profile
  - Less structural steel to protect occupants

Lateral Impact

- Intrusion into the passenger compartment
- Often an intersection crash
- Vehicle is accelerated in the direction of impact
- What would Newton say about this?

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Lateral Impact

Lateral Impact

- Increased upper extremity injuries
  - Lateral rib fractures
  - Head and neck injuries
- Lateral compression
  - Ruptured diaphragm, spleen fracture, aortic injury
- Consider any unrestrained passengers
  - Becomes an object that will collide with driver

Blunt Trauma

ROTATIONAL IMPACT

Rotational Impact

- Vehicle struck at oblique angle
- Energy exchange generally more gradual
  - Deflected form path rather than stopped
  - Longer stopping distance
  - Deceleration more gradual
- Less serious injuries unless there are multiple impacts

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REAR END IMPACT

Rear-End Collision

- Seat propels the occupant forward
  - Generally good protection for the body
  - Poor protection for the head
- Head is forced backwards and then forwards
  - Stretching of neck muscles and ligaments
  - Hyperextension & hyperflexion

Rear-End Collision

a. Victim moves ahead while head remains stationary. Head rotates backward. Neck extends.

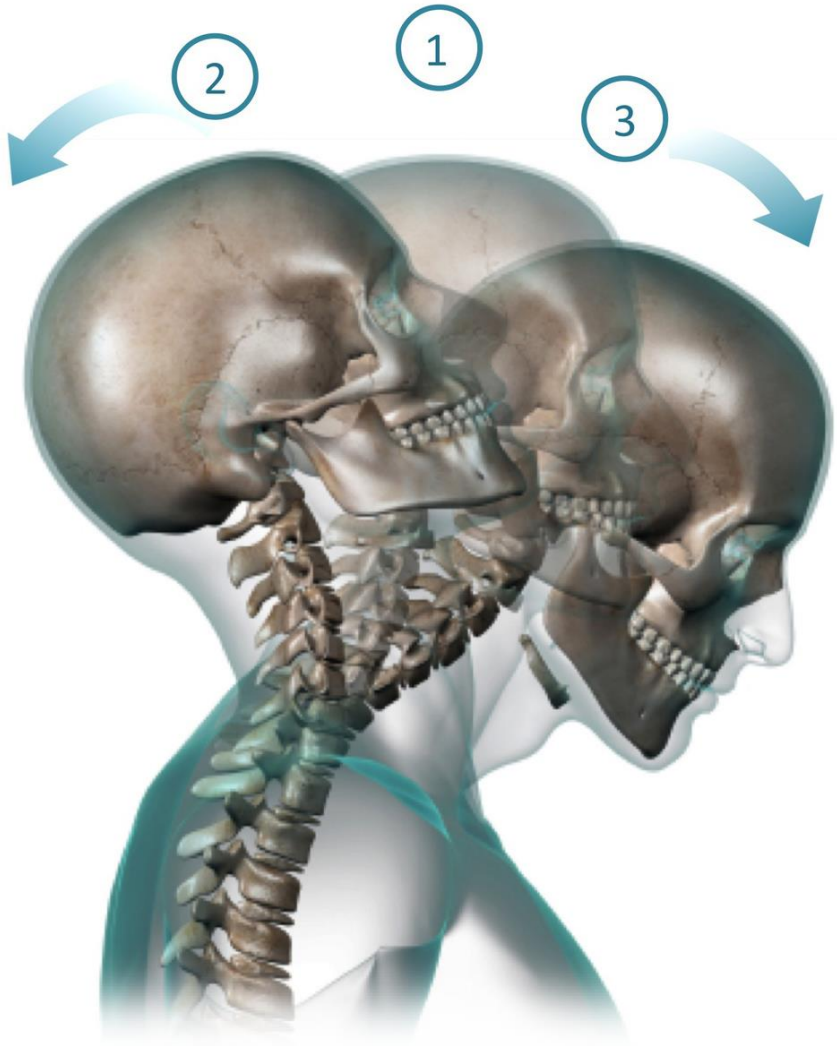
b. Head snaps forward. Head rotates forward. Neck flexes.

Rear-End Collision

- Properly placed headrests help lessen injury
- Frontal impact on the target car after rear impact increases the likelihood of injury

Injury Prediction?

- Hyperextension of the neck may occur with improperly placed/absent headrest
- Rapid deceleration may follow if the target car strikes another object or brakes



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Injury Prediction?

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ROLL OVER

Rollover

- Generally caused by:
  - Change in elevation
  - Vehicle with high centre of gravity
- Occupant experiences impact at each impact of vehicle
- Often involves ejection or partial ejection
- Injuries are usually compounded by multiple subsequent impacts

- Rollover collisions result in multiple impacts and potentially multiple injuries

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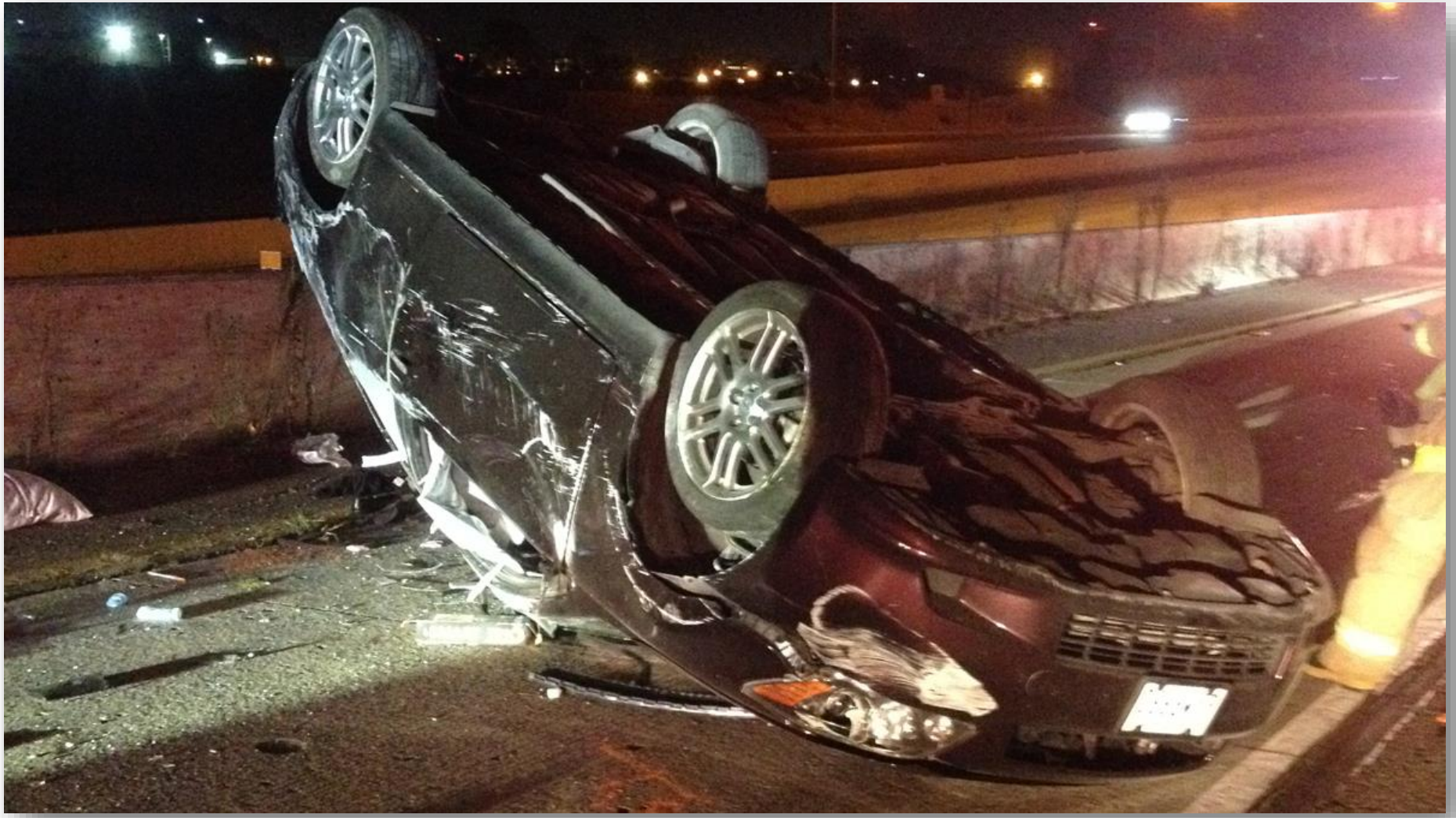
Injury Prediction?



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COLLISION ANALYSIS

Vehicle Collision Analysis

- Hazards
- Crumple Zones
- Intrusion
- Deformity of Vehicle
- Use of Restraints

Hazards

- Heat
  - Hot engine and transmission parts
  - Hot fluids (radiator coolant, engine oil)
- Caustic substances
  - Battery acid, automatic transmission fluid, steering fluids
- Sharp jagged edges of metal and broken glass

Intoxication

- 36.5% of deaths on Canadian Highways were alcohol related (2001 CCMTA statistics)
- Patient effects:
  - Alters level of consciousness
  - Masks signs and symptoms of injury
  - Anesthetizes patient somewhat
- Makes mechanism of injury analysis and index of suspicion even more important
  - Otherwise significant injuries may be missed

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Vehicular Trauma

Table 17-1 Motor Vehicle Injuries

(Incidence by Body Area)

Head	4 067	26.2%
Orthopedic	3 944	25.4%
Superficial	3 847	24.8%
Internal	2 425	15.6%
Spinal Cord	337	2.2%
Blood Vessels	301	1.9%
Burns	223	1.4%
Nerves	194	1.3%
Other	158	1.0%

Source: NTR/CIHI, 2003. Percentages don't add to 100 due to rounding.

Collision Evaluation

- Collision Questions
  - How did the objects collide?
  - From which direction did they come?
  - At what speed were they travelling?
  - Were the object similarly or different sized?
  - Were there any secondary collisions or additional transfers of energy?

Collision Evaluation

- Cause of Collision
  - Did wet roads or poor visibility contribute to the crash?
  - Was alcohol involved?
  - Are there skid marks? Was the driver prevented from braking?

Collision Evaluation

- Auto Interior
  - Does the windshield show evidence of an impact?
  - Is the steering wheel deformed or collapsed?
  - Is the dash indented where the knees or head hit it?
  - Has the impact extended into the passenger compartment?

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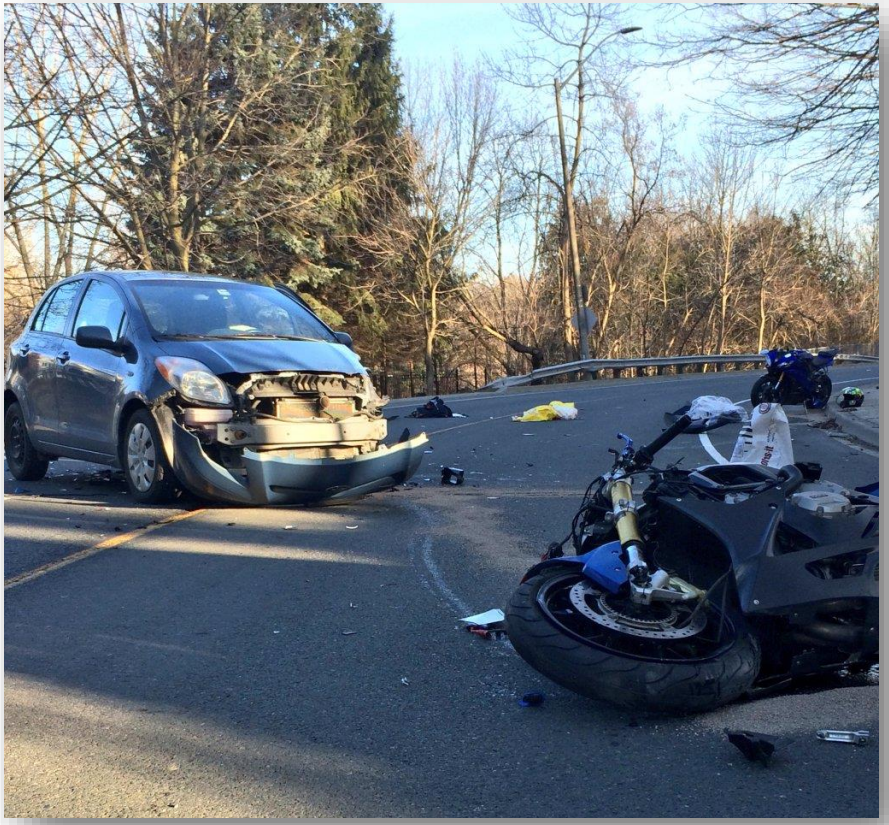
MOTORCYCLES

- Motorcycles provide little protection for their riders during a collision

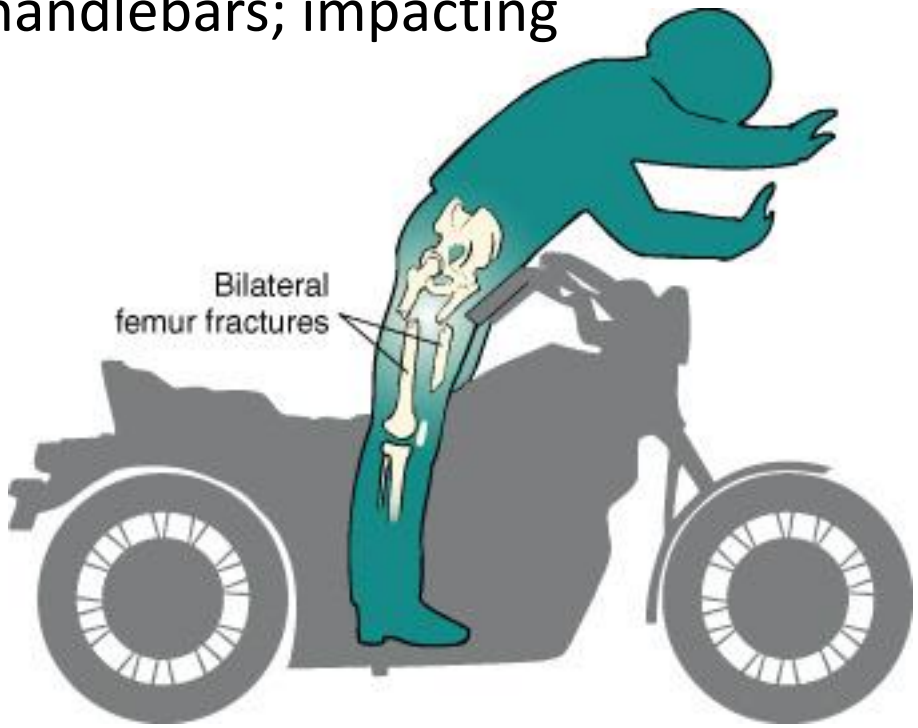
Motorcycle Collisions

- Often result in serious trauma even at low speed
  - Driver absorbs most of impact
- Impacts
  - Frontal
  - Angular
  - Sliding
  - Ejection
    - Initial Bike/Object Collision
    - Rider/Object
    - Rider/Ground



Motorcycle Collisions

- Impact stops the vehicle
- Center of gravity is above and behind the front axle, making it the pivot point
- Riders are ejected over the handlebars; impacting thighs
- Bilateral femur / pelvic fractures are common
- Secondary impact with stationary object or ground
- Tertiary impact with moving traffic including target vehicle



Motorcycle Collisions

- Angular impact
  - Rider caught between bike and another object
  - Crush injuries to affected side
    - Open fractures of femur, tibia, fibula
    - Fracture dislocation of malleolus

Motorcycle Collisions

- Laying the motorcycle down
  - Massive abrasions
  - Fractures of affected side

Motorcycle Collision Ejection

- Injury occurs at point of impact and radiates throughout body as energy is transformed
- Laying down the bike can result in extensive skin damage in unprotected riders

Personal Protective Equipment

- Riders of small motor vehicles
  - Boots
  - Leather clothing
  - Eye protection
  - Helmets
    - Absorb energy, reduce head and facial injuries
    - Helmet non-use increases head injuries > 300%

Case Study

- Two occupants on a motorcycle strike a moving car in a frontal/lateral impact pattern

Motorcycle Collisions

- Pre-Crash Considerations
  - Age of patients
    - Co-morbid factors, medications
    - Intoxication
  - Ejection issues
    - Other traffic, protective equipment
  - Speed, mass, impact type

Case Study

- Post-Crash Considerations
  - Response time – 3 minutes
  - Resources needed?
  - Prediction of injuries based on paramedics knowledge of anatomy, kinematics?

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Blunt Trauma

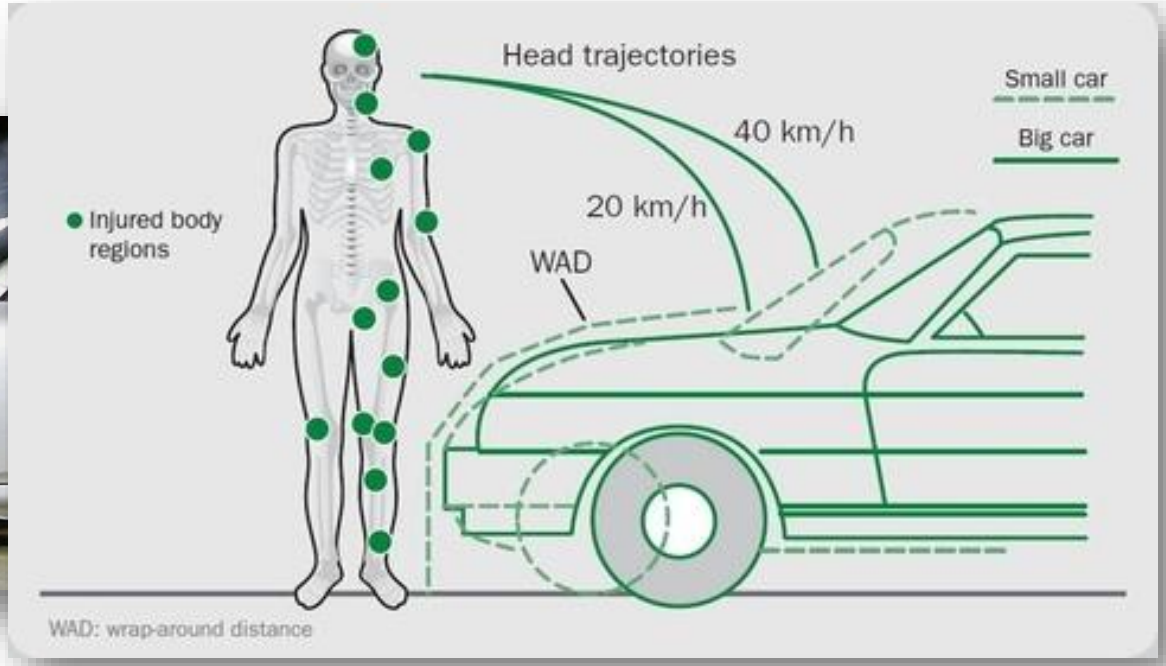
PEDESTRIAN

Pedestrian Accidents

- Adults
  - Adults turn away
  - Bumper strikes lower legs first
  - Victim rolls up and over and thrown
- Children
  - Children turn toward
  - Thrown in front of car
  - Femurs, pelvis often injured

Car-Pedestrian - Adult

- Crash phases vary by height relative to vehicle
  - Initial impact to lower extremities/hips
  - Torso rolls onto hood
  - Victim falls to ground, often head-first



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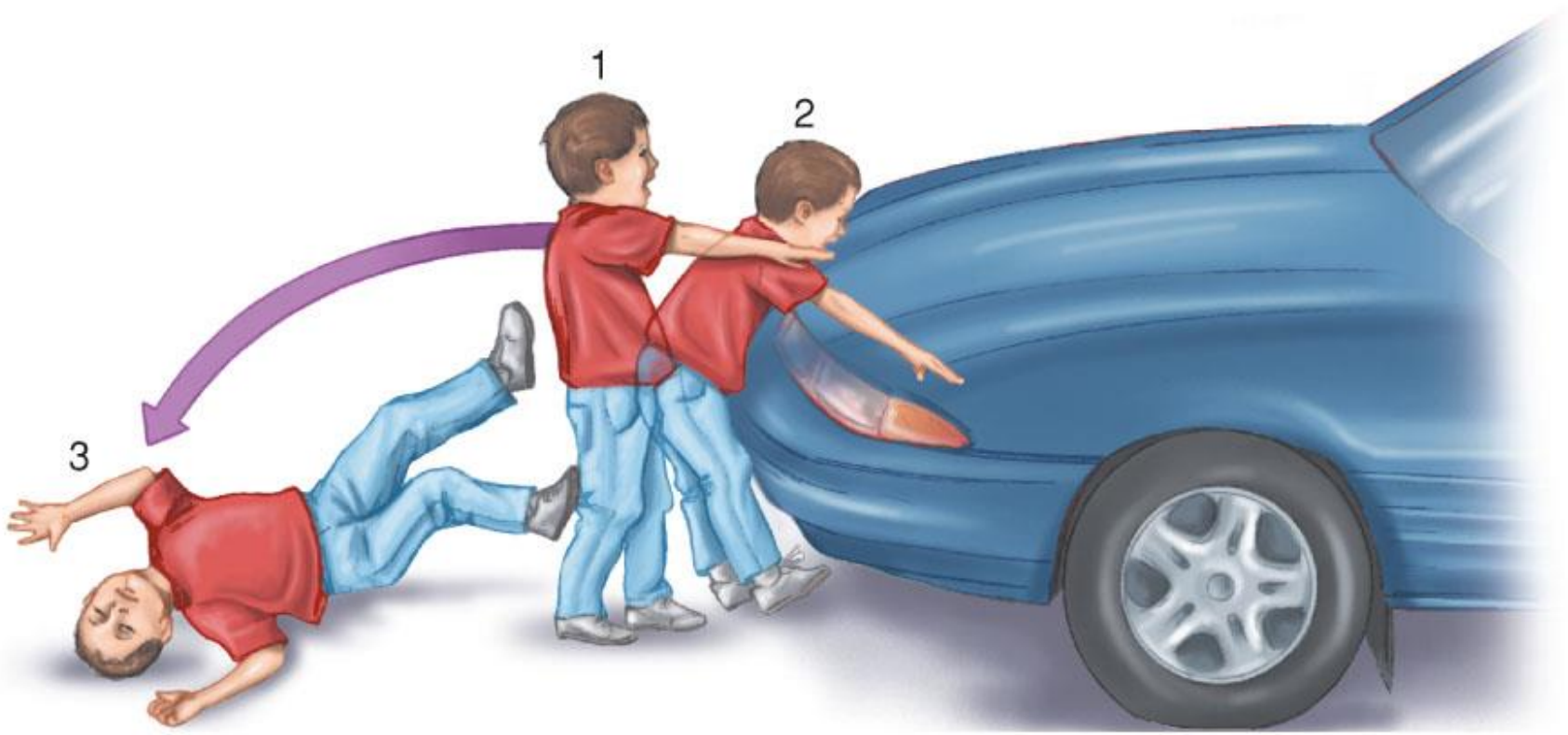
Pediatric Pedestrian



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RECREATIONAL VEHICLES

Recreational Vehicles

- Lack structure and restraint system
  - Little protection offered to occupants
- Types of Vehicles
  - Snowmobiles
  - Personal watercraft
  - ATV's

Recreational Vehicles

- Speeds can be comparable to cars and motorcycles
- Usually result in ejection and/or rollover injuries

Recreational Vehicles

- Watercraft accident also present risks of drowning and hypothermia

Recreational Vehicles

- ATVs cause a multitude of injuries due to speed, instability and lack of protection

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Blunt Trauma

BLAST INJURIES

Blast Injuries

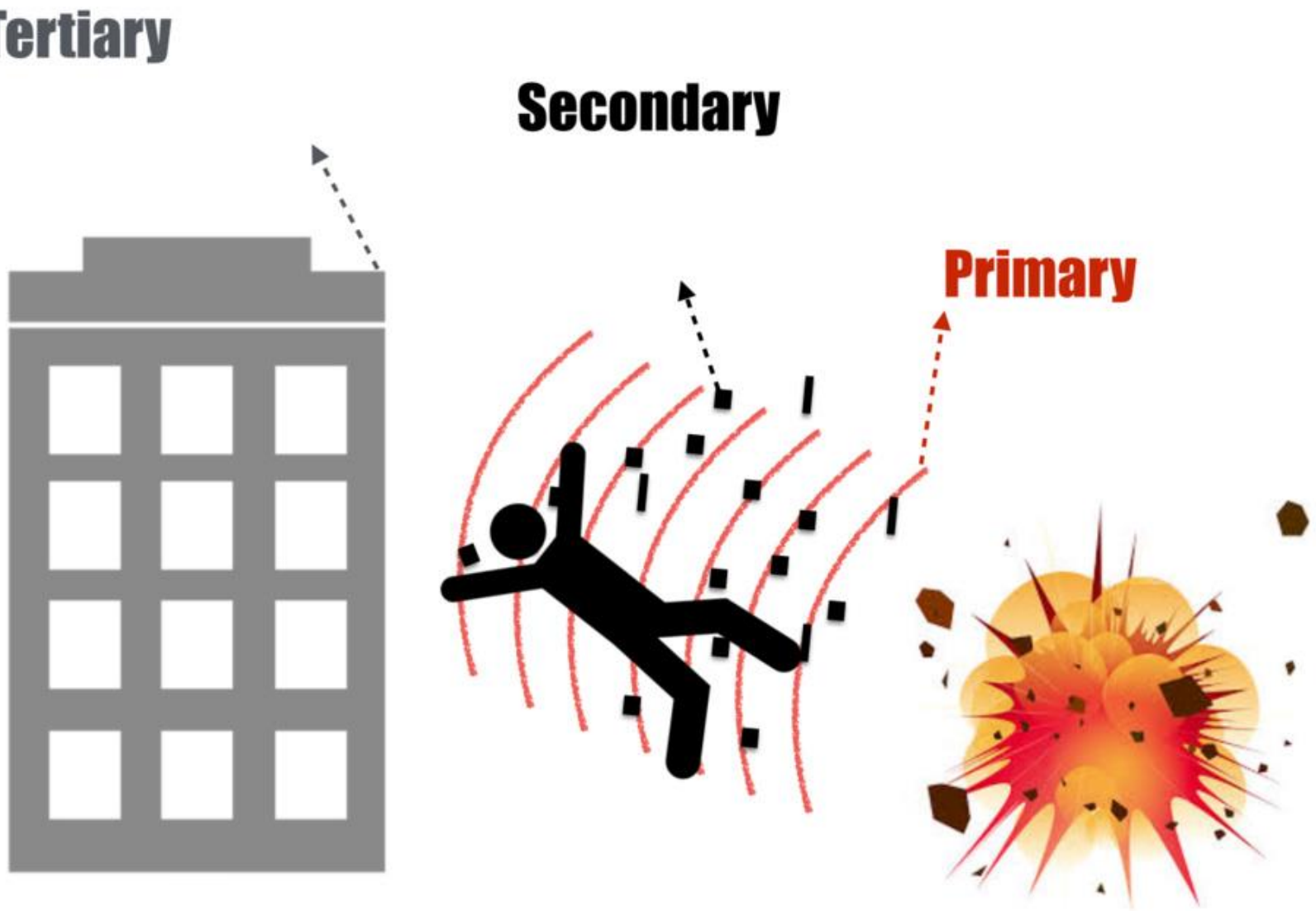
- Causes:
  - Dust (e.g. grain elevator)
  - Fumes (e.g. gasoline or natural gas)
  - Explosive compounds
- Magnitude ranges from small fire cracker to a nuclear explosion
- May be accidental or an act of terrorism

Mechanisms of a Blast

- Explosion
- Pressure wave
- Blast wind
- Projectiles
- Personnel displacement
- Confined space explosions and structural collapses
- Burns

Blast Injury Phases

- Primary
  - Caused by heat of explosion and pressure wave
- Secondary
  - Caused by blast projectiles
- Tertiary
  - Caused by personnel displacement and structural collapse


Tertiary
Secondary
Primary

Blast Injury Assessment

- Survey and assess scene
  - Be aware of potential for secondary device
  - Secure further EMS operations
- Triage
- Establish Incident Command System if necessary
- Evaluate for secondary hazards

Common Injuries

- Lungs
  - Pressure wave rapidly compresses and distorts chest, lungs and alveoli
  - Ruptures alveolar walls
  - Fluid accumulation and hemorrhage
  - High risk of emboli formation
- Abdomen
  - Rapid compression and decompression
  - Bowel wall may hemorrhage or rupture
  - Release of bowel contents into abdomen

Common Injuries

- Ears
  - Eustachian tube cannot equalize pressure
  - Stretching or rupture of tympanic membrane
  - Often fracture of small bones of hearing
  - Hearing loss may be temporary or permanent
- Penetrating Wounds
  - Care as any serious open wound or impaled object
- Burns
  - Treatment consistent with traditional management

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FALLS

Falls

- Release of stored gravitational energy
- Potential for injury depends on:
  - Height
  - Stopping distance

Factors

- Nature of impact surface contour
  - Stairway may focus force of impact , increasing seriousness of injury
- Area of contact and pathway of energy transmission
  - Energy transmitted up skeletal structure
- Age related factors
  - Common problem in elderly

Falls

"It's not so much the falling, it's the stopping"

- Falls from more than 3X patient height are severe
- Velocity increases with height
- Landing surface affects stopping distance (deceleration)

Falls

- Colle's fractures, clavicle fractures, shoulder dislocation
- Other patterns: consider pathway of energy exchange

Falls

- Energy absorption occurs vertically through lower extremities to spine
- Compression occurs because of continued downward movement of body
- Expect hyperflexion and compression injuries of spine; shearing injuries

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SPORTS INJURIES

Sports Injuries

- Injuries most commonly produce by extreme exertion, fatigue or direct trauma
  - Variety of injury patterns
  - Often exchange of great kinetic forces producing serious injuries
- Alterations in patient LOC result in:
  - Exclusion from further activity
  - Follow up with a physician

- Contact sports result in the exchange of great kinetic forces

Protective Gear

- Greatly reduces potential for injury
  - May also cause injuries e.g. cleats may cause torn ligaments as the foot is fixed while the knee is twisted
- Helmet
  - If loose remove
  - If tight, remove face mask and immobilize in place
  - Take helmet to hospital

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Kinetics of Trauma

PENETRATING TRAUMA

Introduction

- The number and severity of penetrating traumas increased greatly
- Additional mechanisms
  - Knives
  - Arrows
  - Nails
  - Pieces of glass or wire

Physics

- Recall kinetic energy equation
  - Double the mass, double the energy
  - Double the speed, quadruple the energy
- Explains why small fast bullets have the potential to do great harm
- Wounds from rifle bullets are two to four times more lethal that handguns
  - Heavy bullets travelling very fast

Physics

- Different projectiles of different weights traveling at different speeds cause:
  - Low Energy/Low Velocity
    - Knives and arrows
  - Medium Energy/Medium Velocity Weapons
    - Handguns, shotguns, low-powered rifles
  - High Energy/High Velocity
    - Assault Rifles

Ballistics

- Study of the characteristics of projectiles in motion and effects upon objects impacted
- Aspects of projectile motion
  - Trajectory
  - Energy dissipation

Trajectory

- The path a projectile follows
- Bullets are pulled down by gravity as the travel through the air
  - Causes a curved path
  - The faster the bullet the straighter the path

Factors in Energy Dissipation

- Drag
- Cavitation
- Profile
- Stability
- Expansion
- Shape

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Weapons

Weapon Characteristics

- Handguns
  - Small caliber, short barrel, medium-velocity
  - Effective at close range
  - Severity of injury based upon organs damaged
- Rifle
  - High-velocity, longer barrel, large caliber
  - Increased accuracy at far distances

Weapon Characteristics

- Assault Rifles
  - Large magazine, semi- or full-automatic
  - Similar injury to hunting rifles
  - Multiple wounds
- Shotgun
  - Slug or pellets at medium velocity
  - Larger the load, the smaller the number of projectiles
  - Deadly at close range

Weapon Characteristics

- Knives & Arrows
  - Low-energy & low-velocity
  - Damage related to depth and angle of attack
  - Movement of the victim can increase damage
  - The extent of the damage is often difficult to assess

Projectile Injury Process

- Tip impacts tissue
- Tissue pushed forward and to the side
  - Tissue collides with adjacent tissue
- Shock wave of pressure forward and lateral
  - Moves perpendicular to bullet path
  - Rapid compression, crushes and tears tissue
- Cavity forms behind bullet pulling in debris with suction.

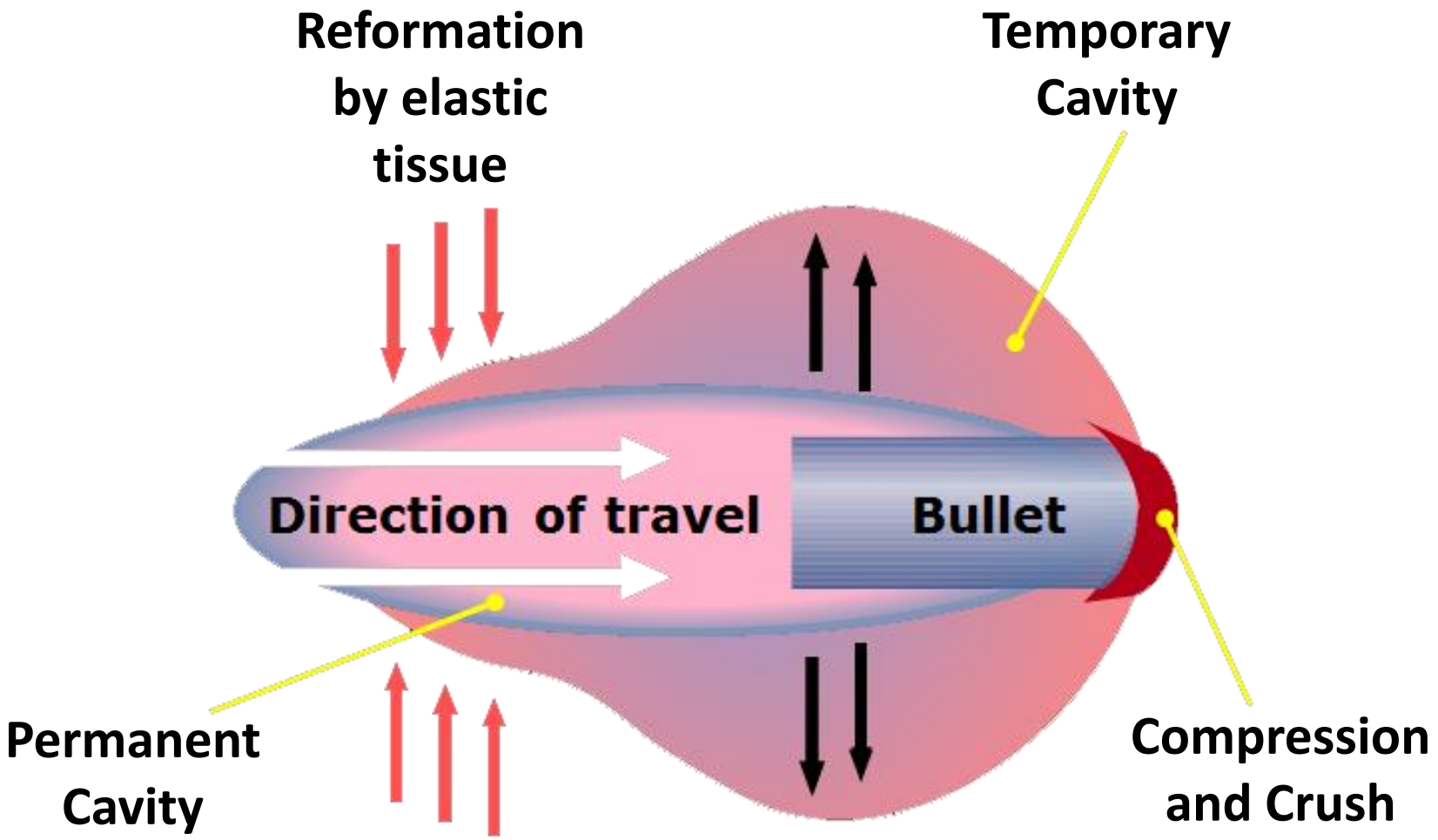
Damage Pathway

- Direct Injury
  - Damage done as the projectile strikes tissue
- Pressure Shock Wave
  - Human tissue is semi-fluid
  - Solid and dense organs are damaged greatly

Damage Pathway

- Temporary Cavity
  - Due to cavitation
- Permanent Cavity
  - Due to seriously damaged tissue
- Zone of Injury
  - Area that extends beyond the area of permanent injury

Cavitation


Reformation by elastic tissue
Temporary Cavity
Direction of travel
Bullet
Permanent Cavity
Compression and Crush

Wounds

- Entry wound
  - Smaller
  - May be darkened, burned
- Exit wound
  - One, none, or many
  - Larger
  - May be ragged

Low-Velocity Wounds

- Objects
  - Knives, Ice-picks, Arrows
  - Flying objects or debris
  - Slow speed limits kinetic energy exchange as the object enters the body
- Injury limited to tissue impacted
  - Object pathway
  - Object may be twisted or moved
  - May be inserted at an oblique angle

Case Study

- 20 y/o male involved in a fight with another male at a bar.

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Human Characteristics

- Male attacker
  - Most often strike with forward, outward or crosswise stroke
- Female attacker
  - Strike with an overhand, downward stroke
- Victim
  - Initially attempt to shield themselves with their arms
  - Often receive upper extremity lacerations (defensive wounds)

Injuries to Tissue and Organs

- Extent of damage varies by the particular type of tissue that a projectile encounters
- Density of tissue affects the efficiency of energy transmission
- Resiliency:
  - Strength and elasticity of an object

Connective Tissue

- Dense, elastic and held together very well
- Limited tissue damage
  - Characteristically absorbs energy
  - Wound track closes quickly due to resilience, limiting projectile's pathway

Organs

- Solid Organs
  - Have density but not resiliency
  - Tissues compress and stretch in relation to cavitational wave
  - Hemorrhage tends to be severe
- Hollow Organs
  - Filled with noncompressable fluid that rapidly transmits energy
  - Energy can tear organ apart explosively
  - Slower, smaller projectiles may produce small holes and create slow leaks

Lungs

- Air in lung absorbs energy
- Parenchyma is compressed and rebounds
- Injury less extensive than with other tissue
- Significant disruption of chest wall integrity may result in pneumothorax or hemothorax

Bone

- Densest, most rigid and nonelastic body tissue
- Resists displacement until it fractures often into numerous pieces
- Significantly alter projectile's path through the body

General Body Regions

- Extremities
  - Injury limited to resiliency of tissue
  - 60-80% of injuries with <10% mortality
- Abdomen (Includes Pelvis)
  - Highly susceptible to injury and life-threatening hemorrhage
  - May perforate bowel resulting in irritation and infection

General Body Regions

- Thorax
  - Rib impact results in explosive energy
  - Heart & great vessels have extensive damage due to lack of fluid compression
  - Any large chest wound compromises breathing

General Body Regions

- Neck
  - Traversed by several critical structures
  - Penetrating trauma likely to damage vital structures:
    - Airway compromise
    - Hemorrhage
    - Neurological deficits
  - Associated swelling and hematoma may lead to similar complications

General Body Regions

- Head
  - Skull is a hollow strong and rigid container
  - Brain is a delicate semisolid organ very susceptible to injury
  - If bullet penetrates the skull, cavitational energy trapped, damage extensive
  - Suicide attempts often result in facial trauma as a result of weapon recoil

Entrance Wounds

- Size of bullet profile for non-deforming bullets
- Deforming projectiles may cause large wounds
- Close Range
  - Powder Burns (tattooing of powder)
  - 1-2 mm circle of discoloration
  - Localized subcutaneous emphysema

Exit Wounds

- Caused by the physical damage
  - Passage of bullet
  - Cavitational wave
- Blown outward appearance
- May more accurately reflect damage caused by bullet

Scene Assessment

- Ensure that police have secured the scene before you enter it
  - Potential for violence
- Consider the possibility
  - Additional assailants
  - Victim may be armed
- Preserve crime scenes as much as possible
  - Cut around bullet or knife holes and preserve clothing as evidence

Penetrating Wound Assessment

- Determine pathway of object
  - Projectiles do not always travel in straight lines
  - Look for entrance and exit wounds
- Anticipate potential organ injury
- Bullet wounds to head, chest or abdomen
  - Rapid transport
  - Treat aggressively for shock

Facial Wounds

- Gunshot wounds may destroy airway landmarks
- May have to consider more invasive procedures

Chest Wounds

- Chest wall is thick and resilient
- Requires a large wound to create opening for air movement
  - Smaller wounds usually result in no air movement
- May have to utilize:
  - Three sided dressing or chest seal
  - Needle decompression
- Consider the possibility of trauma to the heart and great vessels

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Chest Wounds

Impaled Objects

- Mainly a low velocity wound, dangerous to remove
  - May cause more damage on exit
  - May be restricting blood loss
- Immobilize as the object is found
- Objects to be removed
  - Lodged in cheek or trachea that inte airway
  - Interfering with CPR