Mechanism of Injury/ Anticipation of Injury in Pediatric Patients

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Peds trauma resus

“The world is full of obvious things that nobody ever observes”

Sir Arthur Conan Doyle

Kinematics

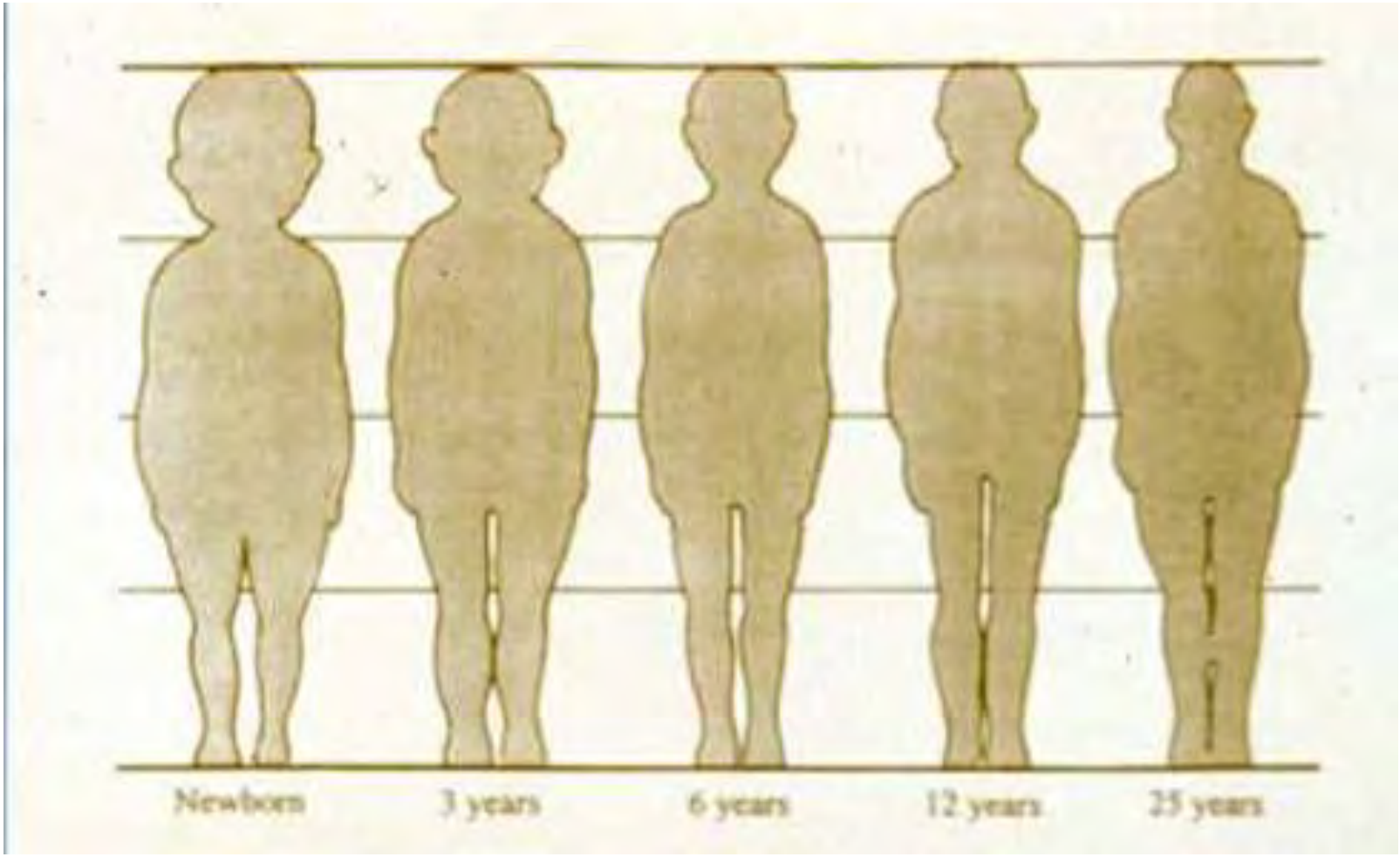
- The science of describing the motion of objects
- Health care provider's role: Evaluating the probability of injury based on
  - Forces
  - Motion

Why are Children So Different?

Developmental Differences

- Impulsive and easily distracted
- Constant need for motion
- Limited ability to assess speed, distance
- Limited ability to localize sound
- Limited knowledge base
- Dependent on adults for protection

Larger Head; Higher Center of Gravity



Differences in the Childhood Spine

- Ligamentous laxity
- Shallow and angled facet joints,
- Vertebral bodies are anteriorly wedge-shaped and have not completely formed
- The fulcrum of motion in the cervical spine in children is at the C2-C3 level; after age 8 the fulcrum is at the C5-C6 level
- This less stable spine has to support an oversized head using underdeveloped neck muscles

Additional Physical Differences in Children

- Abdomen has less muscle mass
- Solid organs are larger compared to size of abdominal cavity
- Bones more compliant and not fully formed

Overview

- Blunt Injury Mechanisms
  - Motor vehicle crashes
  - Bicycle crashes
  - Pedestrian injuries
  - Falls
- Penetrating Injuries
- Blast Injuries

Motor Vehicle Crashes: Specific Concerns with Children

In children 0-14, average of 2.4 deaths per day, 446 injuries per day in 2013 (NHTSA)

- Unrestrained children become missiles
- Poorly restrained children frequently sustain seat belt injuries

From: Dunn, L., Holliday, A., & Vegega, M. (2016, March). *Motor vehicle occupant protection facts – Children, youth, young adults* (Fact book. Report No. DOT HS 812 251). Washington, DC: National Highway Traffic Safety Administration.

Law of Energy

Energy can neither be created nor destroyed;

It can change form, but the amount of energy stays constant

Rear-facing

As long as possible until child reaches the maximum height or weight allowed for their rear facing seat

Forward-facing

As long as possible until child reaches the maximum height or weight for their seat

Belt positioning booster seat

Until 57" (4 ft. 9 in) & between 8-12 years of age

Children< 13 should be in the back

Transport of kids with special health needs: aappolicy.aappublications.org

Restraints

- Spread energy of crash across bony surfaces; NOT soft tissue

Seatbelts: Proper Fit

- Lap belt snug across iliac crests - NOT across the abdomen
- Shoulder belt across middle of chest & shoulder - NOT across neck or face

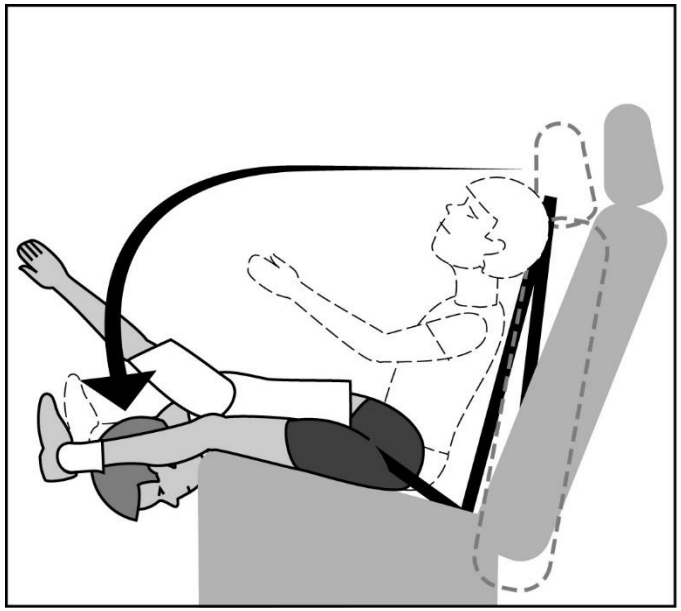
Why Are Children More Vulnerable?

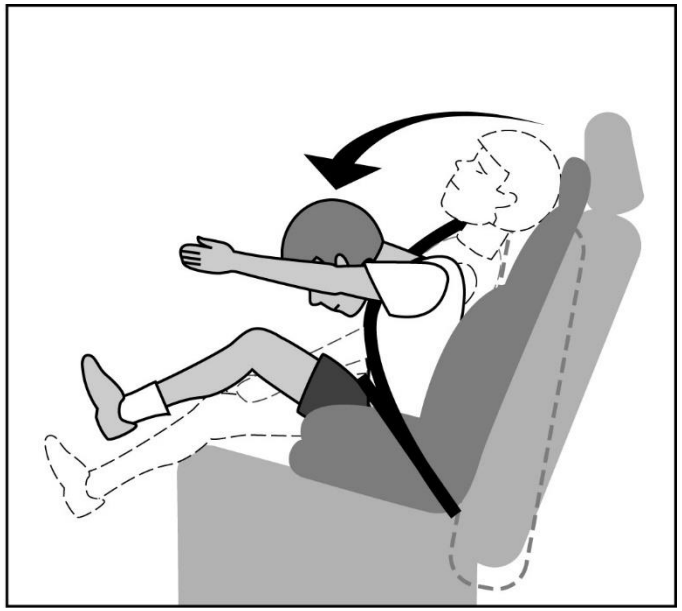
Anatomy

- Higher center of gravity
- Iliac crests not fully developed

Behavior

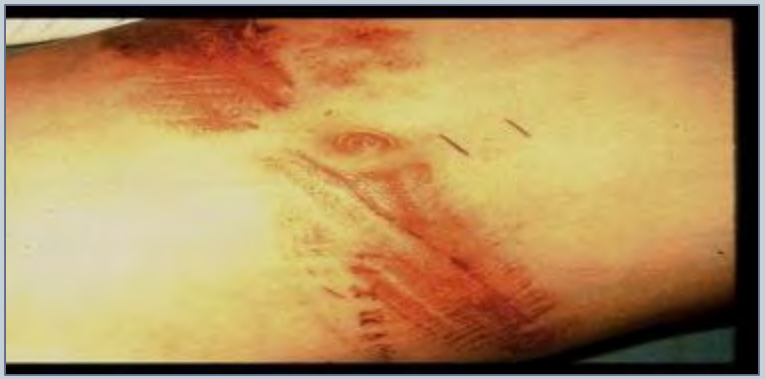
- Place shoulder strap behind back
- Sit towards front of the seat





Injuries Due to Improper Restraints

- Abdominal Injuries



- Spine Injuries – Chance fracture

Frontal Impact

- Down and under

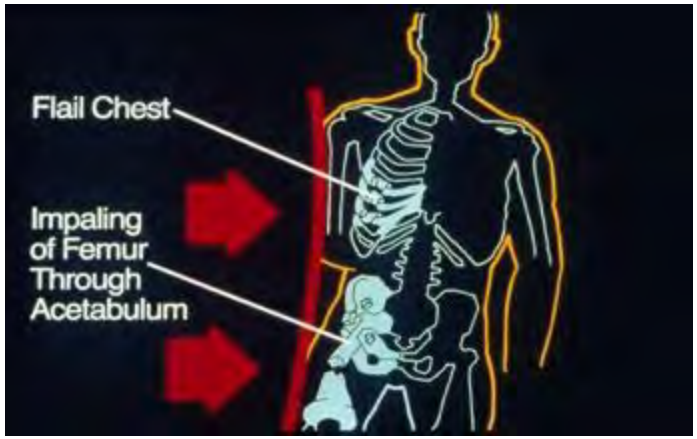
- Up and over

  Injuries to head, neck, chest, and abdomen

- Front Seat Passengers

  Potential for multiple injuries

Side Impact



Children

- Typical injury pattern: head, chest, lower extremity
- Isolated rib fractures, no flail chests
- Pulmonary contusions

Side Air bags: decreases injury by ~ 60%

Airbags

- 1st generation
  - Created to protect unrestrained adult males
  - Deployed @150-200 mph
  - Can cause severe head & neck injuries & burns in children
- 2nd generation1998
  - Sensors act as safety controls
  - Adjusts deployment to various conditions

  - Designed to protect belted and unbelted occupants
  - Takata airbag explosions
    - Ammonium nitrate and moisture

Bicycle Injuries

Childhood Risk Factors

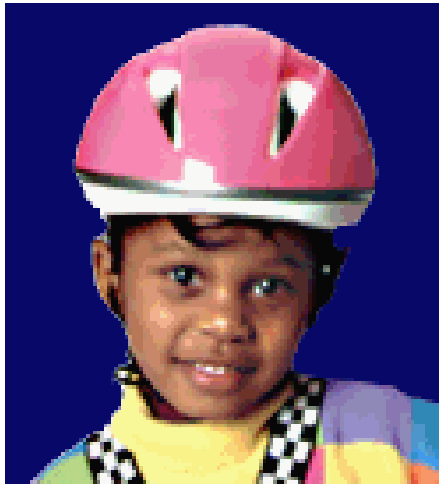
- **Age**
  - 5-14 year olds: ¼ of all bike related deaths and ½ of all injuries
  - Children age 5 -14 years made up the majority of the ED visits among 0-19 y/o for bicycling in 2015
- **Time and place**
  - Non-intersections
  - Close to home/minor roads
  - Summer/late afternoons
- **Mortality**
  - 90% of deaths – Collisions with Motor Vehicles

www.safekids.org

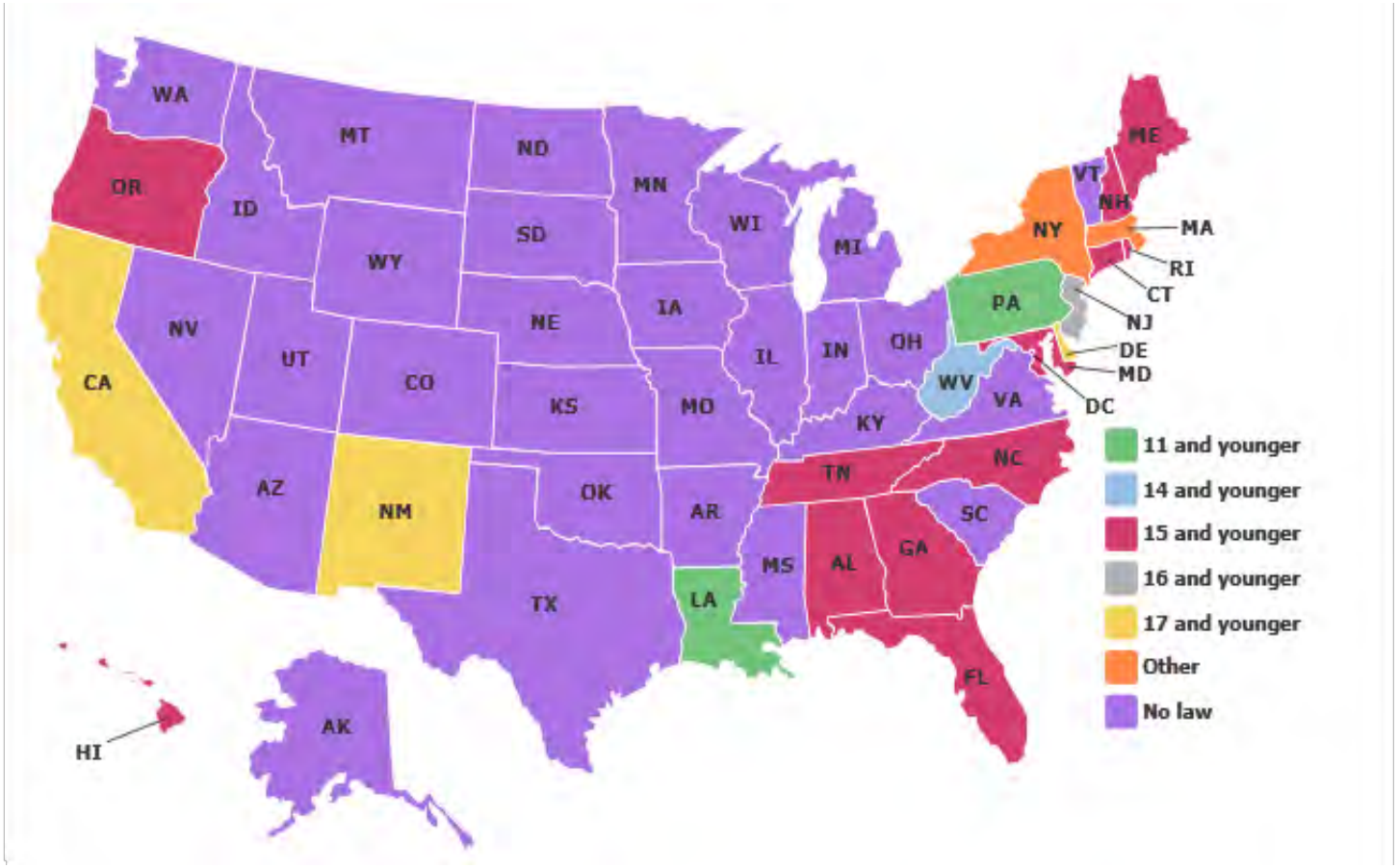
Bicycle Crashes

- 70% of the time child's head hits the ground first
- Helmet use can reduce the risk of injury by 85%
- 40 Percent of Parents Say Children Don't Always Wear Helmets While Riding

www.safekids.org



Bicycle Helmet Laws



http://www.iihs.org/iihs/topics/laws/bicycle-laws

Over the Handlebars

Head, neck , chest, abdominal, extremity injuries

Bicycle Handlebar Mechanism

- Abdomen speared by handlebars:
  - Small round bruise
  - Energy concentrated
  - Pancreas, intestine, kidney, liver, spleen injuries

Pedestrian Injuries

Adolescent/Adult Pedestrian Injuries

- Bumper and hood hit leg
- Fractures above and below joint
- Thrown causing pelvic fractures

Pediatric Pedestrian Injuries: Waddell's Triad

Waddell's Triad

Age 0-14: 11,000 pedestrians struck in 2011
(NHTSA)

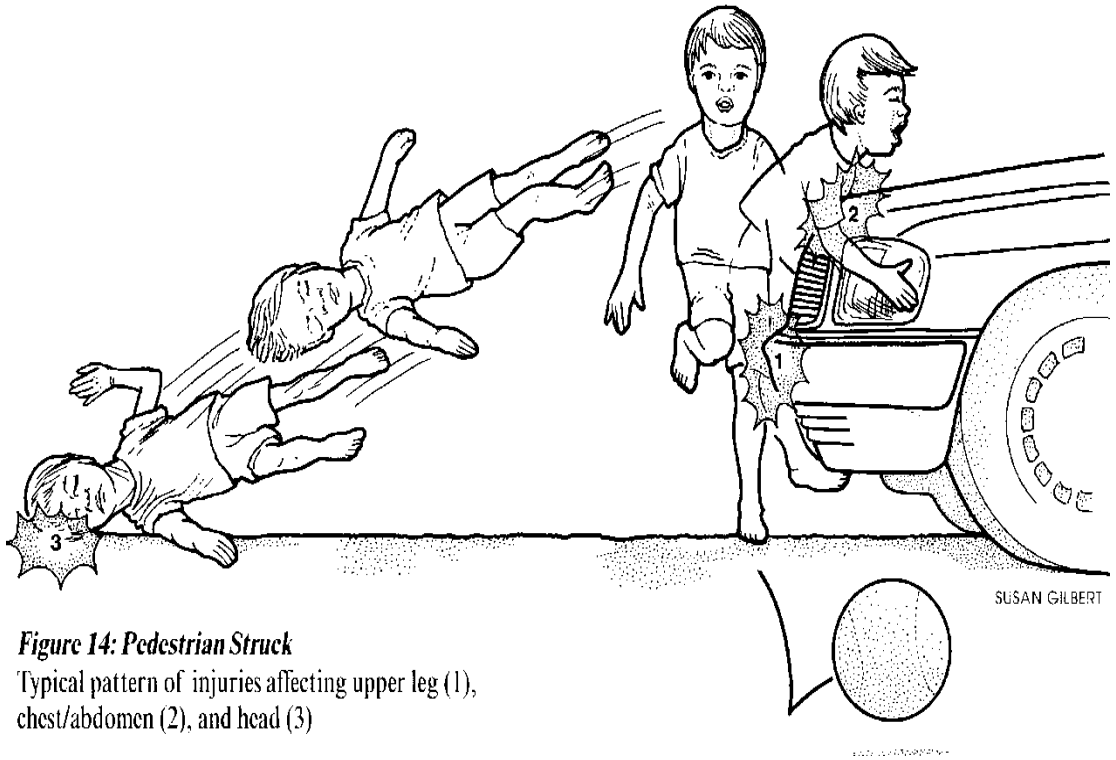
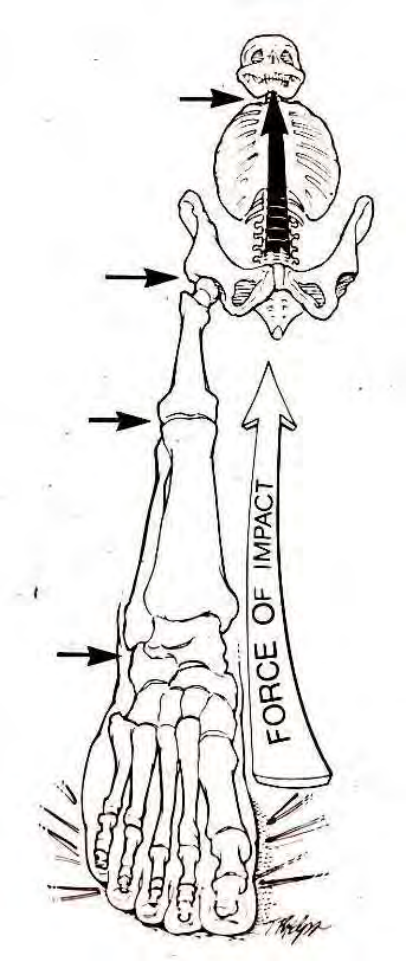


Figure 14: Pedestrian Struck
Typical pattern of injuries affecting upper leg (1), chest/abdomen (2), and head (3)

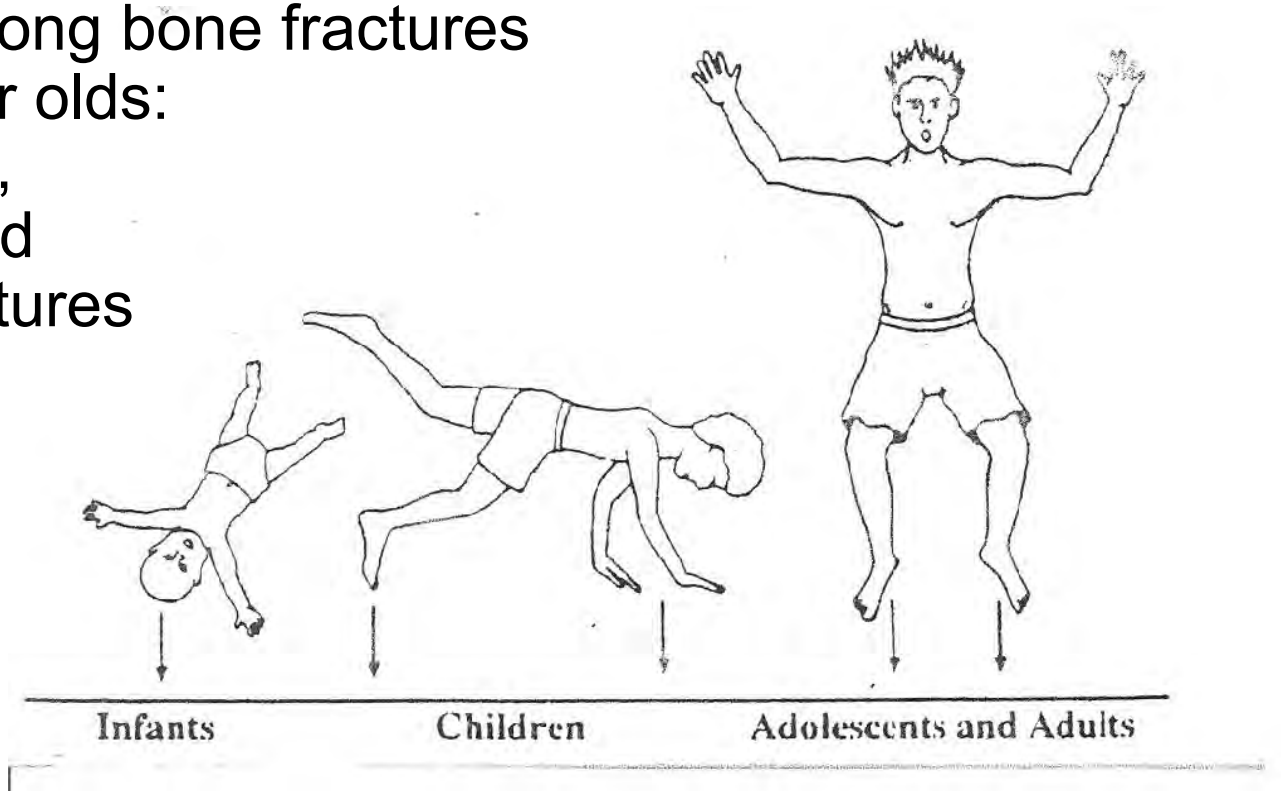
Falls



- Bilateral calcaneous fractures
- Femoral shaft fractures
- Hip dislocation
- Thoracolumbar vertebral fractures
- Fractures of upper extremities

Differences Between Age Groups

- Study of falls >10 feet
  - 0-2 y/o: head injuries
  - 3-10 y/o: long bone fractures
  - 11-21 year olds:
    Vertebral,
    Hand, and
    Foot fractures

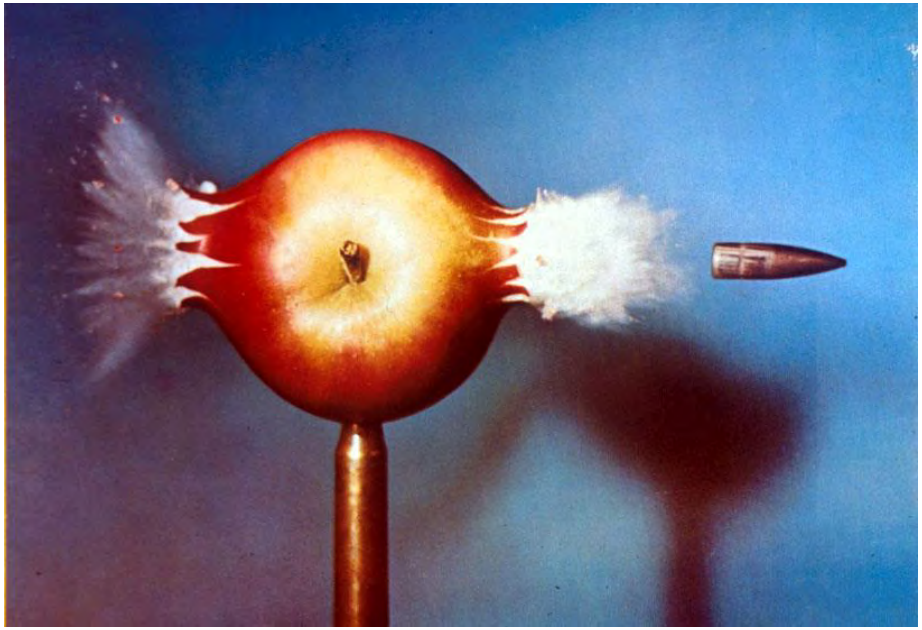


Sawyer et al, Journal of Pediatric Orthopaedics, 2000

Minor Falls

- Stairways
- Parents arms
- Playgrounds

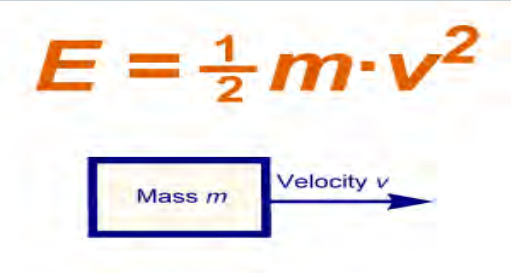
Penetrating Injuries



- Stab wounds
- Gun shot wounds
- Impalements

Kinetic Energy

- Kinetic Energy = $\frac{\text{Mass x Velocity}^2}{2}$

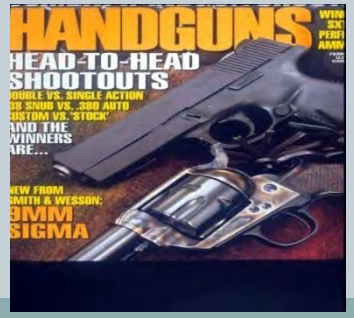


- Low velocity: Impalements, stab wounds
- Medium velocity: Handguns, BB guns
- High velocity: rifles (e.g. M-16's)

Weapons

Medium Velocity

- Handguns
  - Velocity ~800 feet/second
- Air powered BB or pellet guns
  - ~400-900 feet/second
  - Victims usually < 18



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High Velocity

Rifles

Velocity > 3,000 feet/second

Shotguns

- Low velocity pellets

- Devastating injury up close

Ballistics

- Internal ballistics
  - Motion within the gun (rifling)
- External ballistics
  - Range
  - Drag (air resistance)
- Terminal ballistics

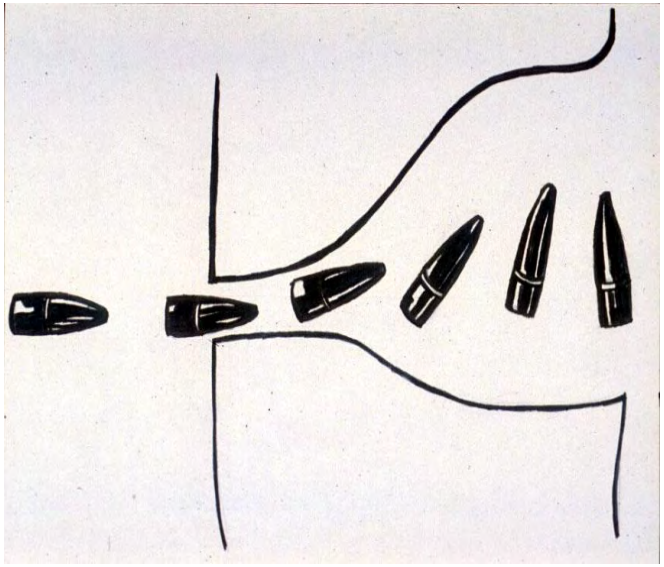
Terminal Ballistics

- Bullet composition

- Yaw and Tumble
- Cavitation

↑velocity = ↑cavity

↑yaw & tumble = ↑cavity



Terminal Ballistics

- Density & compressibility of tissue

  Increased density = increased damage

Fascia & Skin	Muscle & Fat	Solid organs	Bone

Blast Injuries

- Primary: Blast shockwave stress & shear waves in tissues
- Secondary: Ballistic injuries from primary & secondary fragments
- Tertiary: Blast wave translocation of people/objects
- Quaternary: Explosion related e.g. burns, inhalation
- Quinary

  Bacteria & radiation additives

Enclosed Spaces

- Increased power and secondary fragments
- Increased injury/death

Injuries: Children & Adolescents vs Adults

- 5 year study of 49 children (0-10), 65 Adolescents (11-15) and 723 adults in Israel.
- Children more likely to sustain severe injury and brain injury than adults
- Children less likely to sustain extremity injury or open wounds than adults
- Adolescent = Adult except less internal injuries, more contusions/superficial injuries to extremities

Jaffe et al, Annals of Surgery, 2010

Summary

- Injuries can be predicted
- Gather and document information
- Keep a high index of suspicion

Questions?