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

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 generation 1998
  - 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
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 = \[ \text{Mass} \times \text{Velocity}^2 \]

- 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

**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
  \[ \uparrow \text{velocity} = \uparrow \text{cavity} \]
  \[ \uparrow \text{yaw } \& \text{ tumble} = \uparrow \text{cavity} \]
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?