



Penetrating Trauma in Pediatric Patients

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Introduction

- * Trauma is the leading cause of death between ages of 1-18 years
- * Penetrating injury accounts for 10% -20% of all trauma in pediatric patients
- * Firearms account for the majority of penetrating wounds
- * Penetrating wounds are more lethal than blunt trauma

Introduction

- * Mortality is even higher for younger children (compared to adolescents)
- * Major physiologic consequence of penetrating trauma outside of the brain = Hemorrhage

Gun Shot Wounds

* Lethality related to:

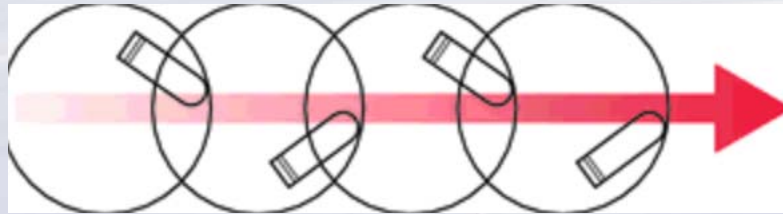
- Projectile dispersion
- Higher kinetic injury
- Impulse
- Yaw
- Deformation
- Fragmentation

* Shot-gun wounds

- Multiple pellet incursions
- Spread out over a large area

Ballistics

- * Yaw – rotation of the nose of the bullet away from the line of its flight



Ammunition

- * Complete cartridges containing the projectile of a firearm aka "the bullet"
- * The bullet = actual projectile = primarily lead with a rounded or pointed tip; various sizes and calibers
- * Caliber = width of the bullet in proportion of an inch or millimeter
- * Range of designs that affect their energy transference:
 - Pointed tips
 - Round tips
 - Hollow points
 - Full metal jackets
 - Partial metal jackets
 - Scored bullets

Bullets

* Expanding:

- Designed to maximize tissue damage

* Nonexpanding:

- Greater penetration
- Pointed tip
- Coated with a thin metal covering/jacket of copper
 - Limits lead residue (dangerous mechanical malfunctions)
 - Bullet maintains its shape

Ammunition

* Birdshot

- Spherical
- Small, soft lead or similar metal

* Buckshot

- Spherical
- Shells contain only a few tightly packed balls – larger diameter
- Lead or steel

Ammunition

* Slugs

- Single, large solid projectile
- May or may not have rifling built into the lead – gives it a spiral path which increase accuracy
- Low velocity, limited range

Damage Caused by Bullets

- * Lacerate or crush tissue or bone
- * Fluid-filled organs (heart, lungs, bowel) can burst by the pressure
- * Fragments of bone shards can further cause damage
- * Cavitation
 - Temporary
 - Formed by continuous acceleration of the medium (air or tissue)
 - Permanent
 - Caused by the pathway

Zones of Injury of Ballistic Wounding

* Primary wound tract

- Permanent cavity, dead crushed tissue

* Contusion zone

- Tissue adjacent to primary wound tract
- Inflammatory with cellular debris

* Concussion zone

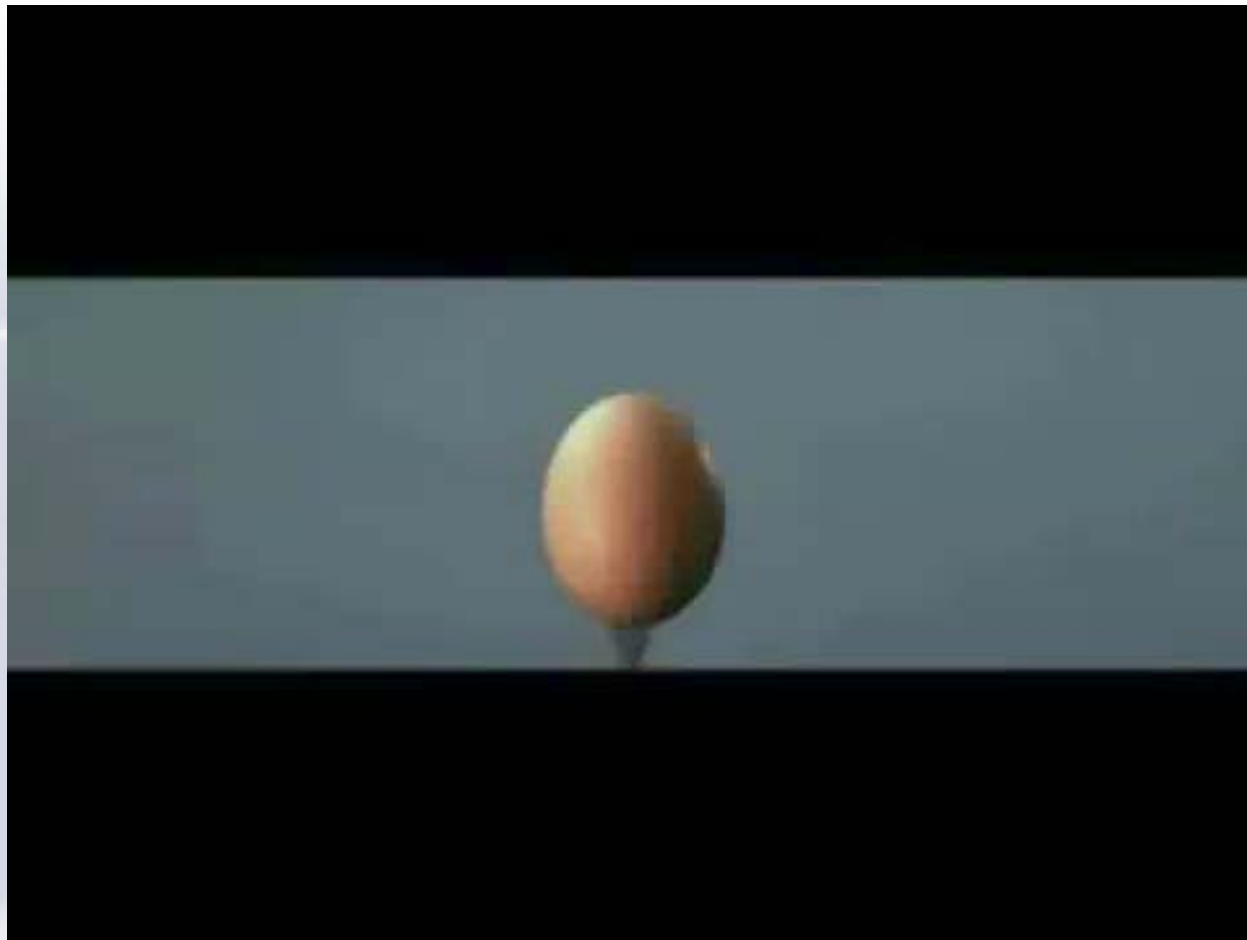
- Temporary cavity
- Tissue damage by stretching, shearing and compression
- Inelastic tissue (bone, brain, liver, spleen) susceptible

Bruner, 2011

Air-Rifle Injuries

* More fatal if:

- Suicide attempt
- Close range
- Projectile entered the cranium through the orbit or cranium
- 30% mortality

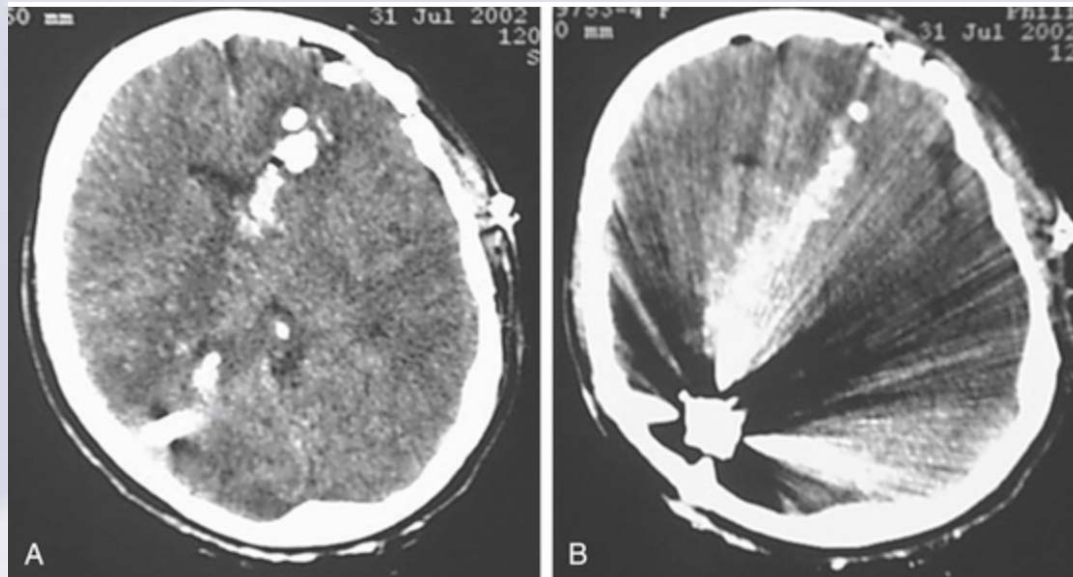


Non-firearm Related Injuries

- * More difficult to predict which wounds would be fatal

Head

- * 3 times more likely to die
- * GCS < 8, unilateral dilated pupil, transventricular or bi-hemispheric trajectories = High mortality!

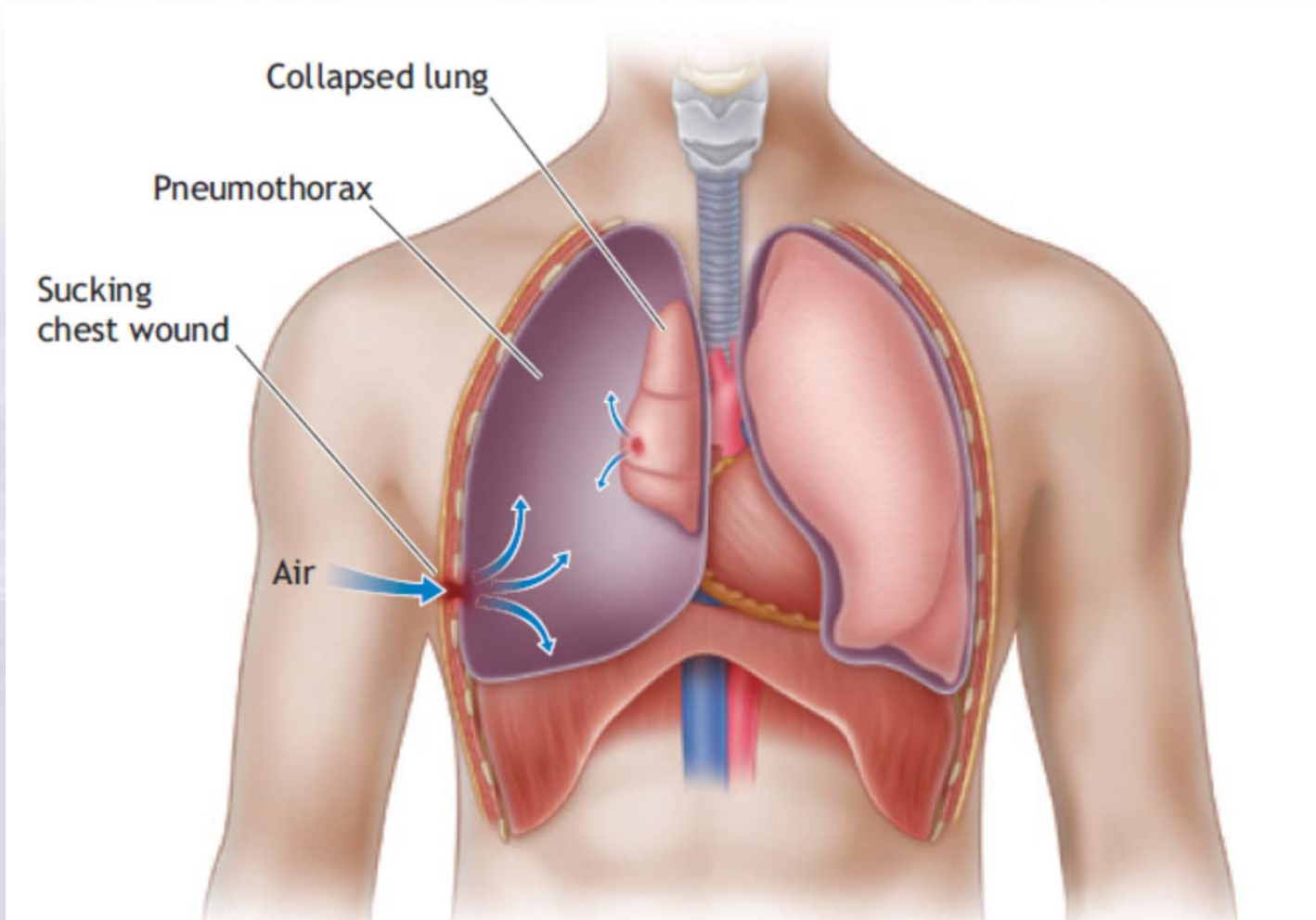


<https://neupsykey.com/management-of-penetrating-brain-injury/>

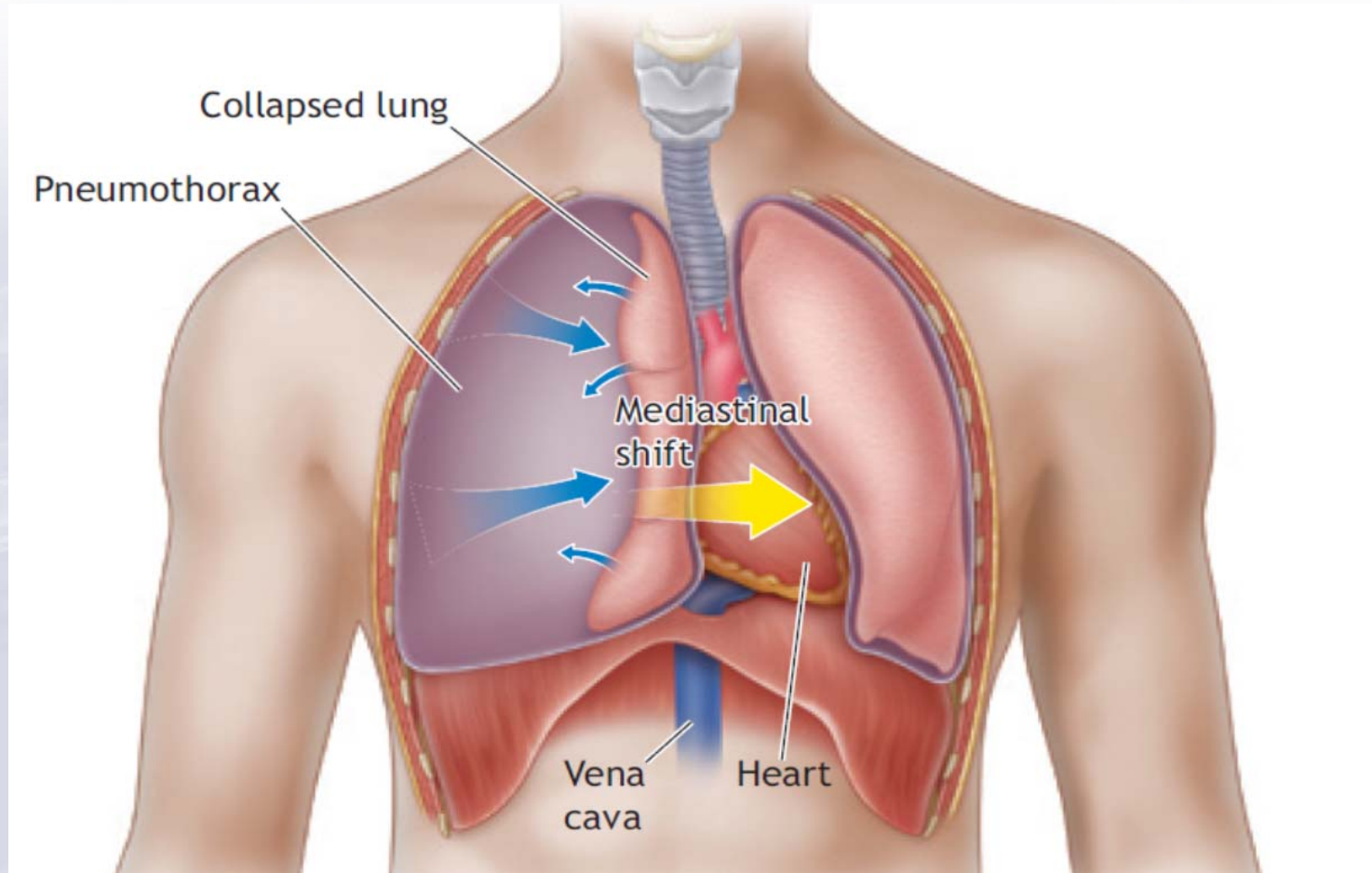
Thorax

- * Most common non-intracranial lethal wound
- * Most likely noted in adolescent males
- * Anterior mediastinum penetration: tamponade
- * Lung = Pneumothorax
- * Hemothorax
- * Major vascular structures
- * Fatal immediately if object removed by victim or bystander

Penetrating Chest Wound



Tension Pneumothorax



Needle Decompression



Thorax

- * Each hemithorax can hold up to hold of a patient's total blood volume
- * Lung tissue is low density and high elasticity
- * Children have:
 - diminished functional residual capacity
 - Higher oxygen consumption
 - Prone to rapid evolution of hypoxia
 - Remain compensated with blood loss up to 40%

Thorax

* Low-velocity GSWs

- Limited minimal chest trauma to the bullet entry and exit sites
- Minimal injuries, lacerations and contusions to the lungs

* High-velocity GSWs

- More extensive damage at the exit of the bullet
- Severe tissue damage beyond the initial tract of penetration
- More intense cavitation, laceration and contusion

Thorax

- * Dyspnea
- * Anxiety
- * Tachycardia
- * Pleural pain
- * Asymmetric chest wall expansion
- * Decreased breath sounds

Spinal Injuries

- * Direct path and concussive effects of the missile contribute to the destruction of both spine and cord
- * GSW to spine have potential for instability if missile fractures pedicles and facets as it traverses the spinal canal
- * Incomplete injury or partial motor function should remain immobilized – children have the greatest likelihood of regaining ambulatory function

Cotton, 2004

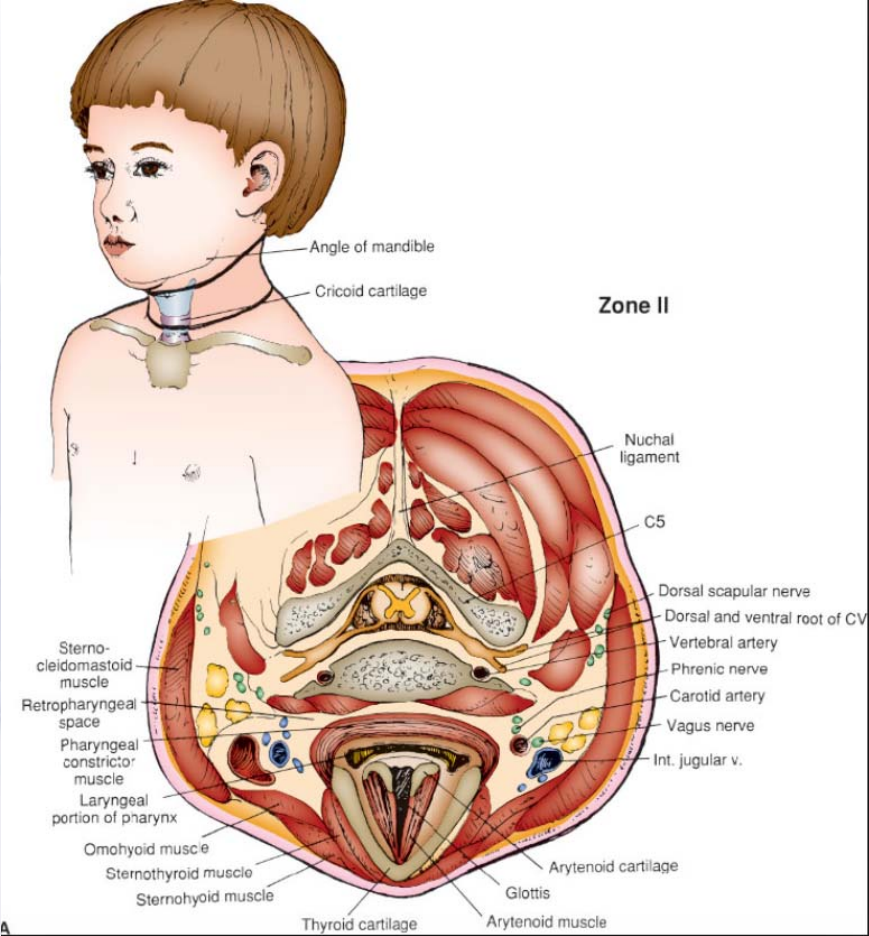
Neck Injuries

- * Uncommon in children
- * Protected by:
 - spine posteriorly
 - Mandible anteriorly and superiorly
 - Large head
 - Short neck
- * ~ 25 % will require urgent intubation
- * Vascular injury is the most common complication

Neck Injuries

- * Multiple structures within the neck and cervical spine are at risk
- * Identify and manage injuries
- * Prevent progression of injuries
- * Injuries to blood vessels can be dramatic or subtle
- * Cervical injuries and physical findings may not be straight forward

Neck Trauma



<https://aneskey.com/neck-trauma/>

Neck Trauma

- * Rapidly expanding neck hematoma
- * Laryngotracheal injury
- * Pulsatile bleeding
- * Bruit
- * Lateralizing neurological signs
- * Hoarseness
- * Hemoptysis

Rapid First Impression

* Gather much information by quickly assessing:

- Position found
- Obvious injuries
- Breathing effort
- Skin color
- Mental status

Abdominal Injuries

- * Distension from hemorrhage or hollow visceral injury – free air
- * Tenderness – secondary to
 - peritoneal irritation – blood and/or enteric content
 - Local tissue destruction

Frequency of Intraabdominal Organs Injury

Table 3. Frequency of Intraabdominal Organs Injury

Organ	Frequency (%)
Gastrointestinal tract	70
Stomach	13
Duodenum	4
Jejunum/ileum	24
Colon/rectum	27
Liver	27
Major vessel	19
Kidney	10
Spleen	9
Genitourinary tract	8
Pancreas	6

Cotton, 2012

Extremity Injuries

- * Bony defects
- * Joint involvement
- * Peripheral nerve damage
- * Vascular injuries

THANK YOU



References

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- * Cotton, BA et al. Penetrating Trauma in Children. *Seminars in Pediatric Surgery*, Vol 13, No 2 (May), 2004: pp 87-97
- * Martin RS, Siqueria MG, Santos MT, et al: Prognostic factors and treatment of gunshot wounds to the head. *Surg Neurol* 60:98-104, 2003