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Advanced Emergency Trauma Course

Ballistics and Penetrating Trauma to the Extremities

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Ghana Emergency Medicine Collaborative

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Projectiles

- Any material that travels has the ability to injure
  - Glass, falling object, bullet.
- The energy within that projectile is dependent on the velocity, weight (or mass in zero gravity), and distance
- Air resistance slows an object, as do barriers, gravity can accelerate.
- Material makeup and design of a projectile can determine how energy is transferred to the target, Which determines the tissue damage

Projectiles

- Can injure soft and hard tissue
- One projectile can be a multi – system trauma
- Damage is a factor of design, velocity, and distance
- Entry and exit wounds can lie!!! Projectiles do not have to follow a straight line

Introduction to Penetrating Trauma

- Mechanisms of penetrating trauma
  - Bullets, Knives, Arrows, Nails, etc
- Understanding principles of energy exchange increase the index of suspicion for associated injuries with a mechanism of injury

Physics of Penetrating Trauma

- Kinetic Energy= (Mass x Velocity^2)/2

SO,

- Greater the mass the greater the energy
  - Double mass = double KE
- Greater the speed the greater the energy
  - Double speed = 4x increase KE

Physics of Penetrating Trauma

- Thus, Small & Fast bullet can cause greater damage than large and slow.
  - Different objects of different weights traveling at different speeds
    - Low Energy/Low Velocity
      - Knives and arrows
    - Medium Energy/Medium Velocity Weapons
      - Handguns, shotguns, low-powered rifles
      - 250-400 mps (meters per second)
    - High Energy/High Velocity
      - Assault Rifles
      - 600-1,000 mps

Physics of Penetrating Trauma

- Rifling
  - Bullet spins as it travels down barrel
  - Allows bullet to travel straight with slight yaw (wobble)
- Weapon forced backward and absorbs energy
  - Recoil

Physics of Penetrating Trauma

- Remainder of energy propels bullet forward at a high rate of speed.
- Trajectory is curved due to gravity
- As bullet strikes object, it slows and energy is transferred to object.

Ballistics

- Ballistics: Study of the characteristics of projectiles in motion and the effects upon that object that is impacted
- Factors affecting energy exchange between a projectile and body tissue
  - Velocity
  - Profile
  - Stability
  - Expansion & Fragmentation
  - Secondary Impacts
  - Shape

Ballistics

- Energy Dissipation
  - Drag:
    - Wind
  - Stability
    - Allows for straighter trajectory
    - ↓ after striking object results in tumbling

Ballistics: Definitions

- Stability
  - Bullet length increases bullet tumbling
    - Can reduce the accuracy of the shot
    - Reduced by Rifling in barrel (spinning)
- Yaw
  - Tumbling of bullet once it strikes object
    - Reduces kinetic energy but can result in greater tissue damage

Ballistics: Definitions

- Profile
  - Portion of bullet you see as it travels towards you
    - Larger profile = greater energy exchange
- Caliber
  - Diameter of a bullet (ID of gun)
    - 0.22 caliber = 0.22 inches

Ballistics

- Expansion & Fragmentation
  - Results in increased profile
  - Initial impact forces may result in fragmenting
  - Greater tissue damage

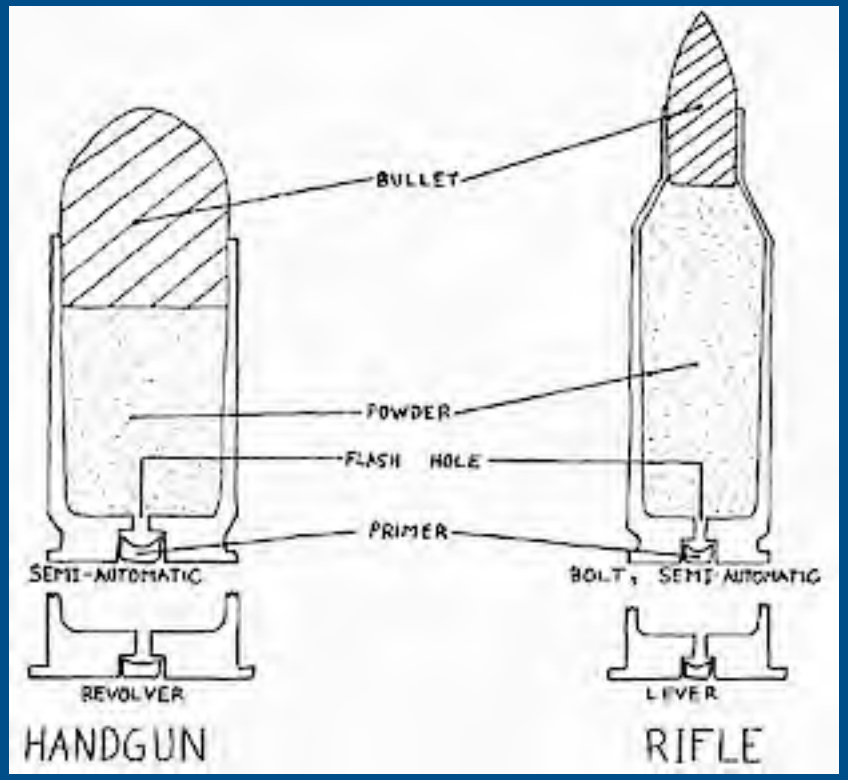
Ballistics

- Secondary Impacts
  - Bullet striking other objects can cause yaw and tumble
- Shape
  - Handgun Ammunition = Blunt = Tumble
  - Rifle Ammunition = Pointed = Piercing

Specific 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
- Assault Rifles
  - Large magazine, semi- or full-automatic
  - Similar injury to hunting rifles
  - Multiple wounds

Handgun vs. Rifle Bullet



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http://library.med.utah.edu/WebPath/TUTORIAL/GUNS/GUNBLST.html

Specific Weapon Characteristics

- Shotgun
  - Slug or pellets at medium velocity
    - 00 (1/3”) to #9 (pin head sized)
    - Larger the load, the smaller the number of projectiles
    - Deadly at close range
- Knives & Arrows
  - Low-energy & low-velocity
  - Damage related to depth and angle of attack
  - Movement of the victim can increase damage

Damage Pathway

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

Damage Pathway

- Not all projectiles are fire arms
- 3000 pound car
- 30 miles per hour (44 feet/second
- kE = 91,000 foot pounds of energy to a pedestrian (361,194 foot pounds at 60 mph
- Very low velocity but very high mass

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

Wound Characteristics

- 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
  - Appears to be “Blown” outward
    - Pressure wave

Gunshot Patterns

PD-GOV http://commons.wikimedia.org/wiki/File:Gunshot_patterns.jpg

Close Range Wounds

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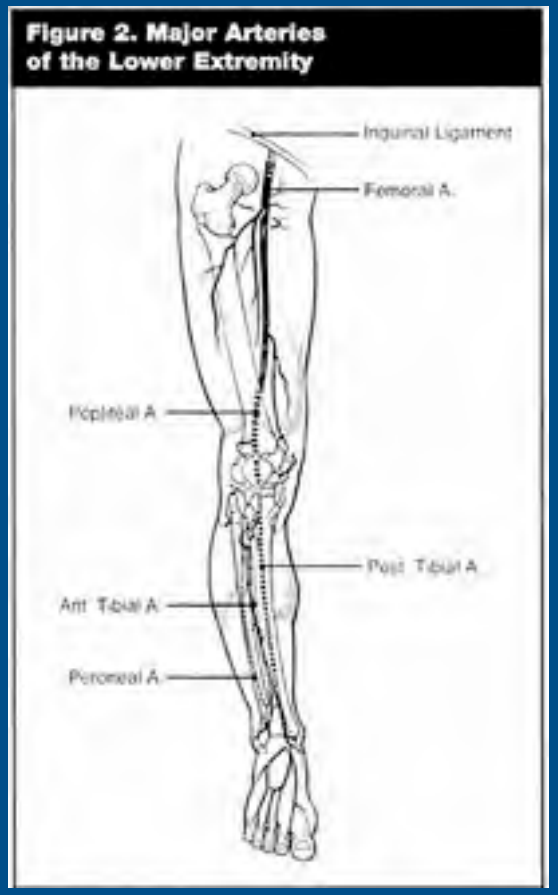
Penetrating Wounds to the Extremities

- Vascular Injuries
- Orthopedic Injuries
- Wound Management

Vascular injury: anatomy

PD-INEL Source undetermined



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Vascular injury: hard signs

- Hemorrhage
  - Pulsatile
  - Exsanguinating
- Expanding hematoma
- Bruit
- Thrill
- Ischemia (“6 P’s”)
  - Absent pulse

Vascular injury: Soft signs

- History of significant hemorrhage
- Hematoma: small, non-expanding
- Neurologic deficit (non-progressive)

Vascular Injury

- Complications:
  - Hemorrhage
  - Thrombosis / Emoblism
  - Aneuryism / pseudoaneuryism
  - Compartment syndrome

Vascular: investigations

- Pressure Index: Ankle Bracheal Index(ABI)
  - Sensitivity: 45-95% for wounds requiring OR
  - The ABI is an easy to perform non-invasive test which compares the highest systolic brachial pressure to the highest ankle pressure by dividing the ankle pressure by the brachial pressure.
  - The resulting number is the Ankle Brachial Index.
  - A number below .99 shows the presence of decreased arterial blood flow.

Vascular: Investigations

- Arteriogram
  - Sensitivity: 98%
  - Specificity: 99%
  - Too Sensitive:
    - 4% False Pos --> unecessary OR
  - Expensive
  - Thrombosis / Allergic reaction Risk
- Duplex
  - Sensitivity: 50-60% (compared to angio)
  - Sensitivity: 100% (wounds requiring OR)
  - Specificity: 99-100%

Orthopedic injury: Bone

- Low Velocity
  - Drill Hole
  - Divot
- High Velocity
  - Complicated
  - Comminuted
  - Fragments act as 2^{o} missiles
- Stab wounds

Orthopedic injury

- Joints
- Lead Toxicity
- Nerves

When to use Antibiotics?

- Bacterial innoculum
- Devitalized tissue
- Age of wound
- Location of wound
- Foreign bodies
- Immune compromized

GSW Wound Care: Indications for OR

- Hard signs
- Progressive neuro deficit
- Open fracture
- Unstable fracture
- Significant soft tissue damage or necrosis
- Compartment syndrome
- >8h post-injury

Prognosis for Limb Salvage

- Time- between delay in revascularization and limb loss.
- Mechanism- Blunt or high-velocity penetrating trauma has a worse outcome than simple, low-velocity penetrating trauma.
- Anatomy- Lower extremity vessels have worse prognosis of salvage than upper extremity vessels;
  - The popliteal artery has the overall single worst prognosis for salvage.
- Associated Injuries
- Age and Physiologic

Questions?

Dkscully (flickr)

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