

Ballistic Injuries

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Disclosures

- The views expressed in this presentation are those of the speaker and do not necessarily reflect the official policy or position of OHSU, the Department of Defense, or the US Government
- Consulting fees from Merck Sharp & Dohme Corporation for author contributions to The Merck Manual – Abdominal Trauma Chapter

Content Warning

**This presentation contains images and
descriptions of ballistic injuries and bullets**

Overview

- Common misconceptions
- Physics and bullet types
- Physical examination
- Tissue damage and injury patterns
- Treatment priorities and antibiotics
- Protective equipment

Common misconceptions

- Injury trajectories follow a straight line
- Injuries are treated by removal and/or closure of wound
- Cause immediate incapacitation
- “Entry” and “exit” wounds are obvious

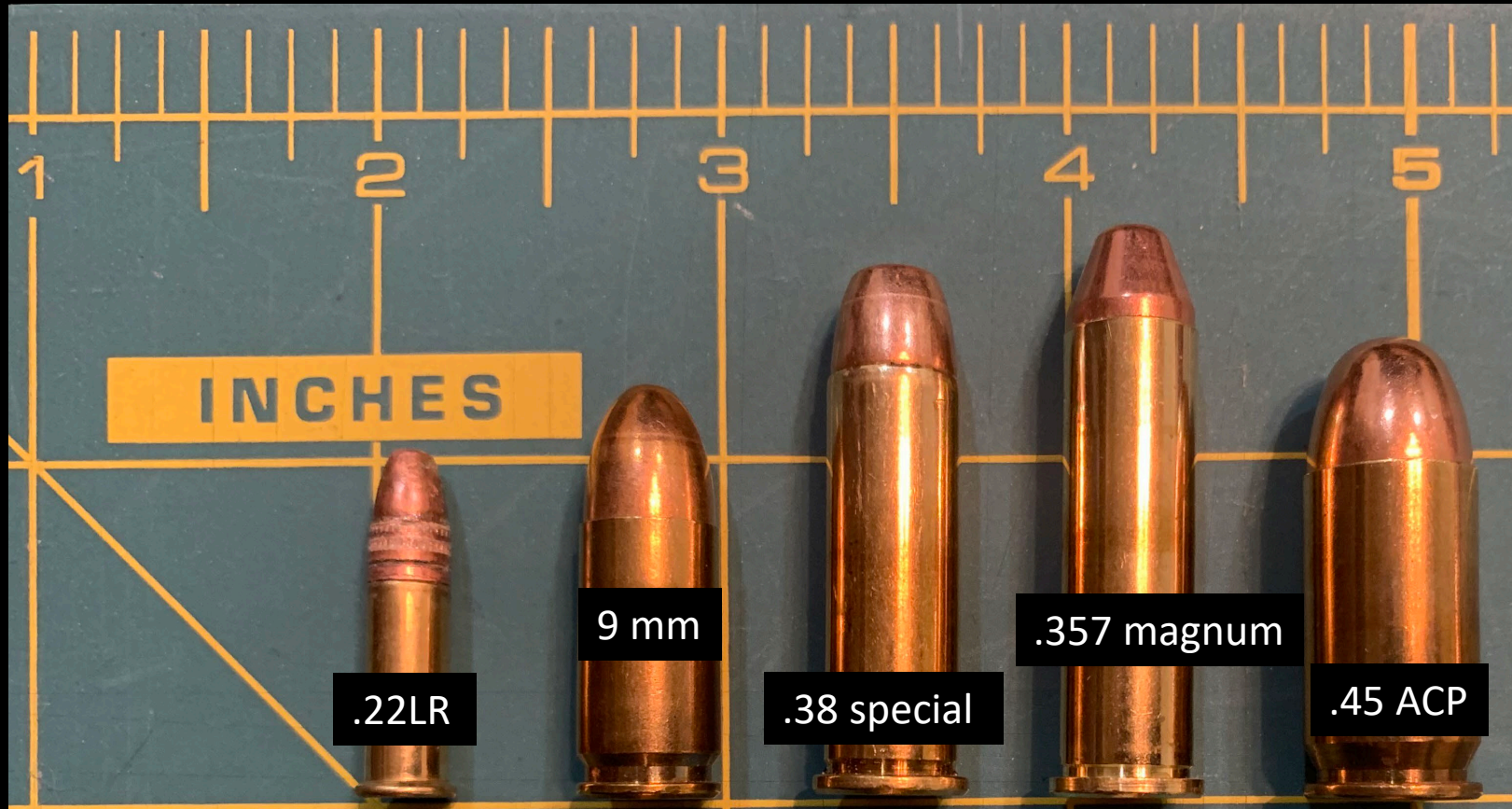
Bullet Physics

- Kinetic energy generated determines the potential tissue damage
- Kinetic energy = $\frac{1}{2}$ mass x velocity²
- Mass or weight of the bullet is a factor, however
- Muzzle velocity (speed) of the bullet plays a much greater role

Bullet Physics – Muzzle Velocity (Speed)

- Caliber (diameter) of the bullet
 - Larger is heavier and less velocity is generated
 - Handgun versus rifle bullet
- Amount of powder in the casing
 - More powder, more expanding gas produced]
 - Handgun versus rifle casing
- Barrel length of the weapon
 - Longer the barrel, the more time expanding gas can push the bullet faster
 - Handgun versus rifle barrel length

Common Handgun Calibers



Bullet types – Full Metal Jacket (FMJ)

- Bullets covered with a metal alloy
- Prevents deformation during flight
- Allows bullet to retain shape and to penetrate into tissue
- May allow for easier passage entirely through tissue
- Over-penetration and injury to unintended targets
- May cause severe tissue damage from “tumbling” effect

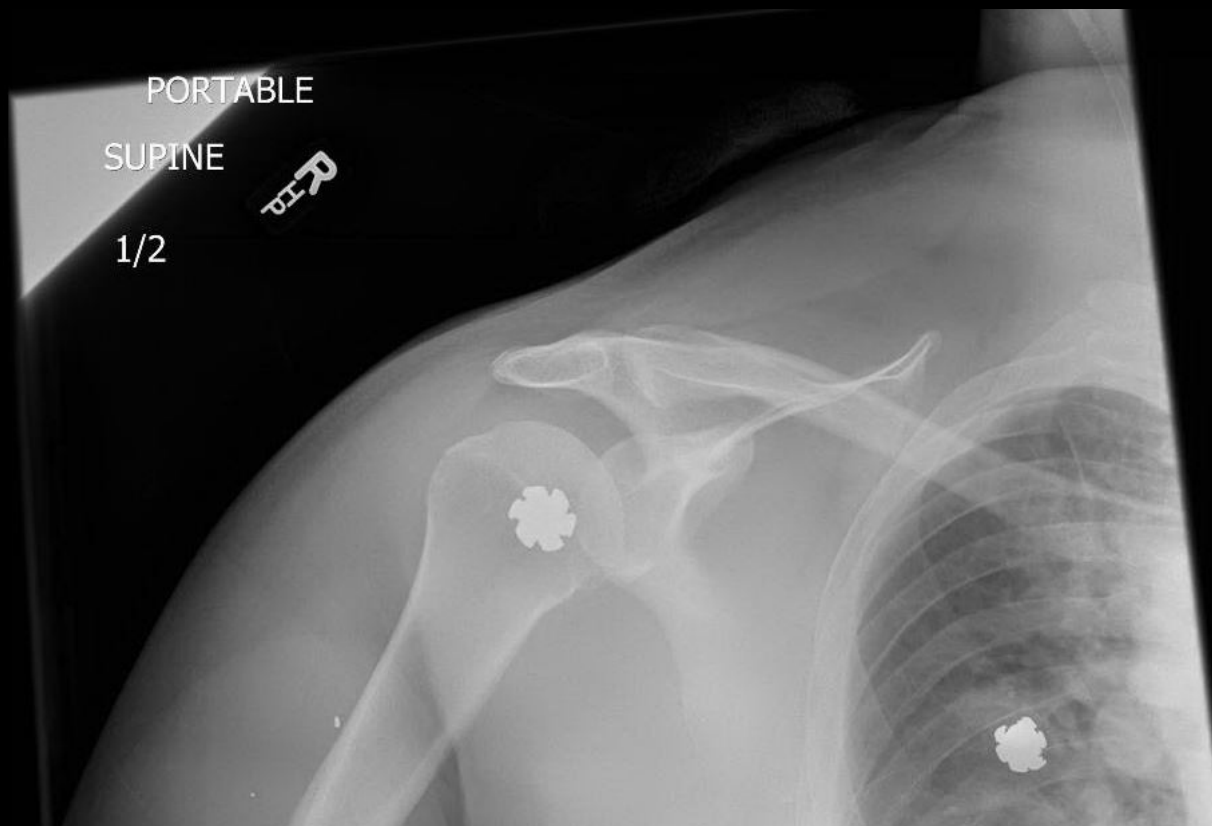
Bullet types – Jacketed Hollow Point (JHP)

- Designed to deform upon contact with tissue
- More damage to tissue with cavitation, shock waves
- May not completely pass through tissue
- Lower risk of over-penetration and injury to unintended targets

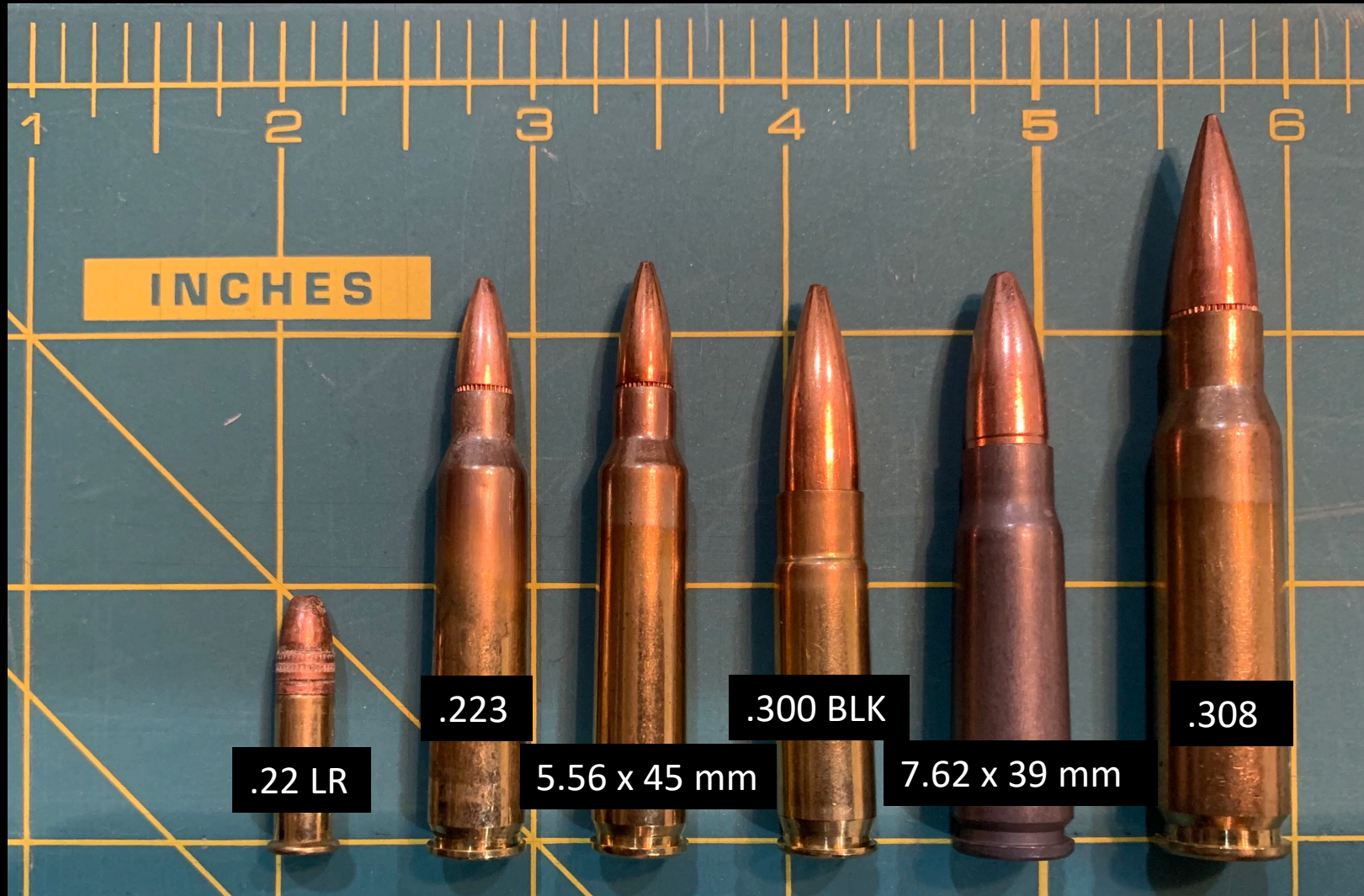
FMJ versus JHP



JHP



Common Rifle Calibers



Caliber	Weight (grains)	Average Muzzle velocity (feet per second)
HANDGUN		
.22 LR	40	1800
9 mm	115	1150
.357 magnum	158	1500
.38 special	158	1090
.45 ACP	230	890
RIFLE		
.223	55	2275
5.56 x 45 mm	62	3130
.300 BLK	150	1925
7.62 x 39 mm	122	2360
.308	147	3350

$$\text{Kinetic Energy} = \frac{1}{2} \text{ mass} \times \text{velocity}^2$$

Common Shotgun Shell Types



Shotgun Wound Considerations

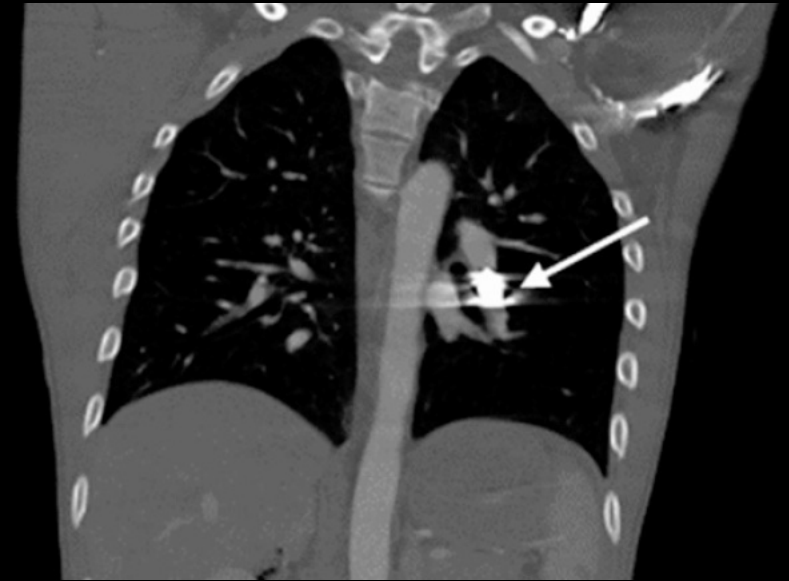
- Projectiles from shotgun shell scatter rapidly over distance
- At close range
 - Wadding may cause tissue injury
 - More extensive tissue injury

Patient Examination

- Thorough exam – avoid distraction caused by “gruesome” wound
 - Bilateral axilla
 - Bilateral groins
 - Perineum
 - Roll patient to LEFT and RIGHT
- Resist temptation to describe/document as “entry” or “exit” wound
- Imaging to determine possible injury trajectories
- Even number rule
 - Number of wounds + number of retained bullets = EVEN number
 - 2 wounds + 1 bullet = ODD number
 - Missing a wound or missing a bullet
 - Retained bullet from previous encounter

Bullet Embolus

- Rarely can traverse into arteries and embolize to distant locations



Tissue Damage

- Permanent cavity
 - Direct path of bullet
 - Larger bullet results in larger wound
- Temporary cavity
 - Formed by displacement of adjacent tissue as bullet travels through the body
 - Affects an area much larger than the diameter of the bullet itself
 - Tissue elasticity affects the size and clinical significance

Treatment Priorities

- Hemorrhage control
 - Ligate, shunt, or repair vessels
 - Almost all veins can be ligated
 - Pack, resect, or remove organs
 - Angio-embolization
- Control of contamination
 - Resection of gastrointestinal tract +/- anastomosis
 - Irrigation
- Debridement of devitalized tissue
 - Return for second look, zone of injury may progress

Treatment Priorities - Bullet Removal

- Not routinely performed; not the sole indication for surgery
- If encountered during wound exploration and accessible
- Can be deceptively difficult to find, even in subcutaneous tissue
- May be considered if bullet within cardiac chambers

Antibiotic Use

- Not routinely given, except when associated with bony injuries
- Highly variable among institutions and providers
- OHSU guidelines
 - Spine fracture with bowel injury – 14 days of ciprofloxacin and metronidazole
 - Non spine fx with bowel injury – 4 days of ciprofloxacin and metronidazole
 - Isolated non-operative fracture – 24 hours of first-generation cephalosporin
- Update tetanus, if necessary

Self Inflicted



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Calf

30 year old shot by DShK machine gun

- Soviet-made heavy machine gun
- 12.7 x 108 mm round



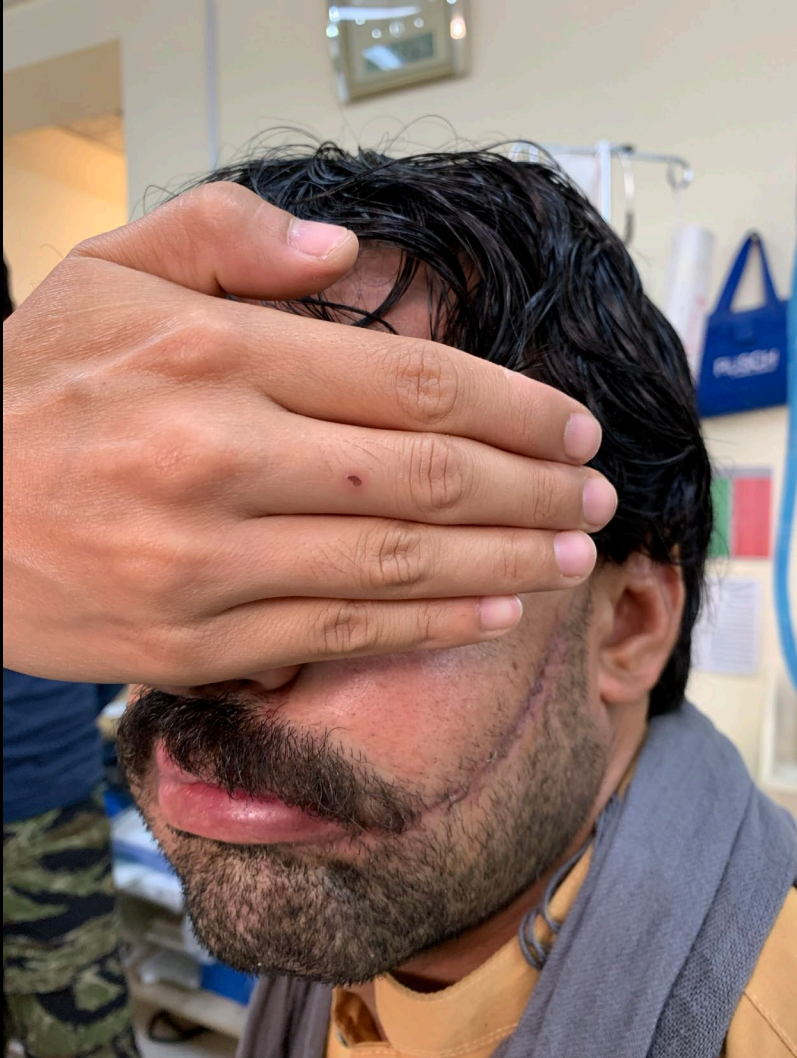
30 year old- GSW to face



30 year old- GSW to face



4 week follow up



Protective Equipment

- Use of protective vests and eye protection drastically reduces injury to law enforcement officers and soldiers
- Many varieties of armored plates and vests
 - Soft armor – protection from handgun threats
 - Steel or ceramic plates – protection from handgun and rifle threats
 - Not generally protective against knives or other sharp objects
 - Level of ballistic resistance classified by the National Institute of Justice (NIJ) Standard 0101.06

Protective Equipment – NIJ 0101.06

- Type IIA – 9 mm and .40 S&W FMJ up to 1125 ft/s
- Type II – 9 mm and .357 magnum up to 1430 ft/s
- Type IIIA – .357 SIG and .44 magnum up to 1470 ft/s

- Type III – 7.62 mm lead core 2780 ft/s
- Type IV – .30 caliber steel core 2880 ft/s



Protective Equipment

- Plates are commercially available for purchase by civilians
 - Laws regarding purchase and possession vary by state
 - Generally, convicted felons are not legally able to purchase
- No plate is completely protective against ballistic threats
- Even without bullet penetration, energy is transferred
 - Significant pressure waves affect hollow and solid organs
 - Chest wall, pulmonary, and cardiac contusions
 - Maintain high index of suspicion of blunt injury

Key Points

- Velocity of the bullet is the main determinant of kinetic energy
- Larger bullet \neq more severe injury
- Not all ballistic injuries require surgery
- Thorough examination; some wounds may be small
- EVEN number rule
- Control hemorrhage & contamination then debride dead tissue