Nordic Forum for Trauma Radiology 2024 Stockholm

Penetrating Trauma: Bullets and Ballistics

Ken F Linnau MD MS FASER

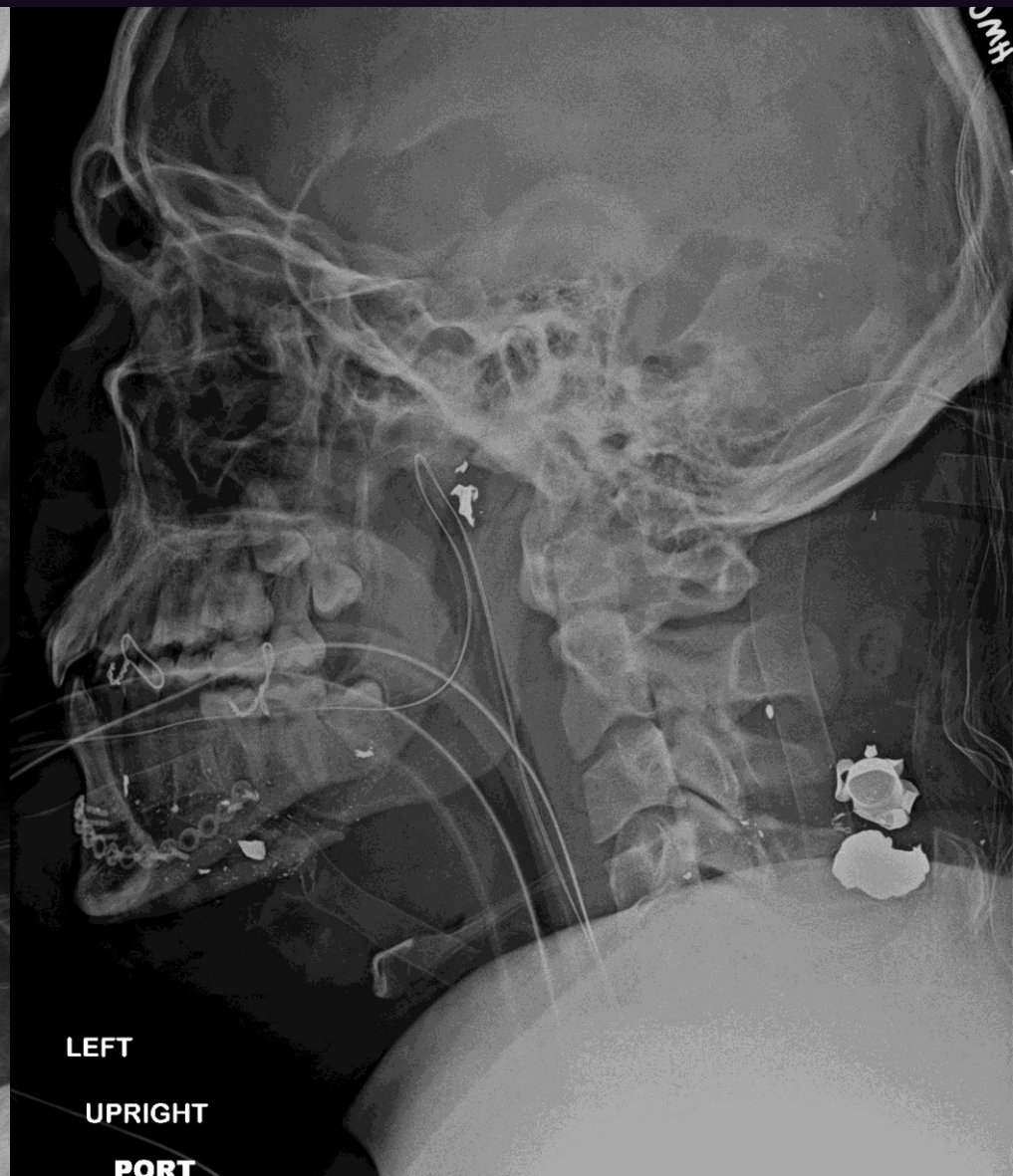
Emergency Radiology
University of Washington, Seattle, WA, USA
klinnau@uw.edu

Anthony J. Wilson, MB ChB

Case 1: 25 yom GSW to neck

What type of firearm caused this injury?

A. Assault rifle
B. Shotgun
C. Handgun
D. Hunting rifle
E. Don’t know



Gun Shot Wounds (GSW) Epidemiology

- **2008 Firearm deaths 31,593 (MVC: 39,973)**
- **Injury Rate Higher Than Estimates**
- **Many Do Not Seek Medical Attention**
- **Many Injuries Are Concealed**

TYPES OF PENETRATING INJURY

High energy:

- **Automatic rifles (military)**
- **Rifles**
- **Handguns**
- **Shot guns**

Low energy

- **Knives, swords**

TYPES OF PENETRATING INJURY

High energy:

- **Rifles**
- **Handguns**
- **Shot guns**

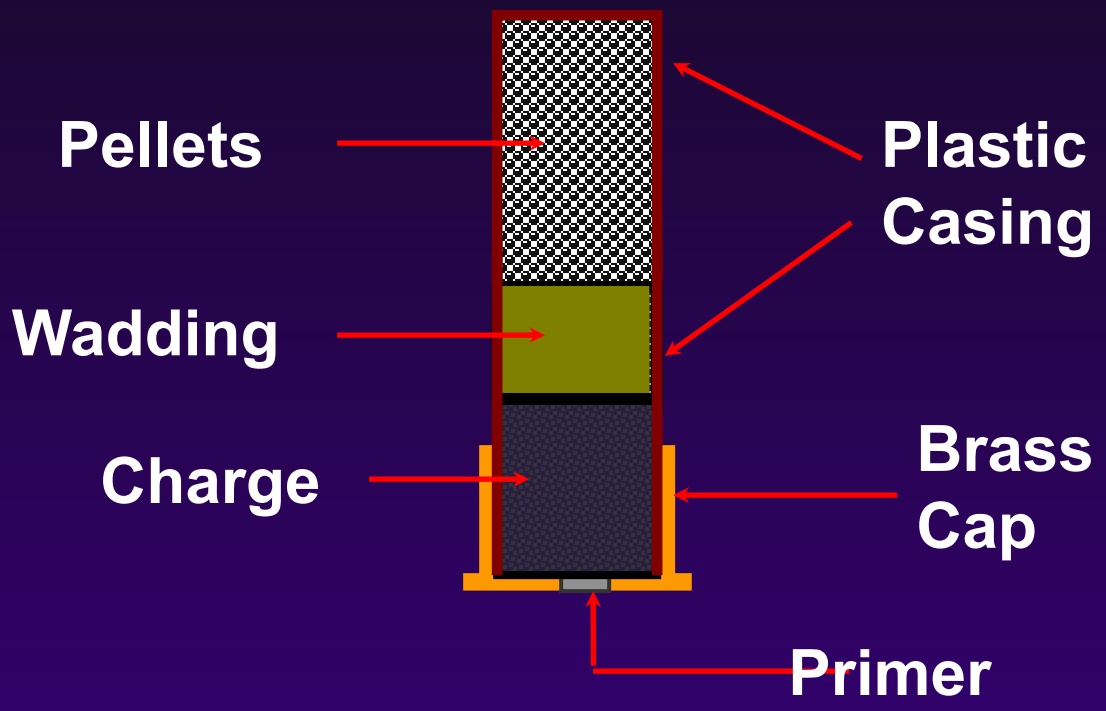
Shotguns

Different from Rifles & Handguns

- **Smooth Bore**
- **Fire Pellets & Slugs**
- **Classified by Gauge**

SHOTGUNS

SHOTGUN CARTRIDGE



SHOTGUN PELLETS

- Birdshot = Small & Common

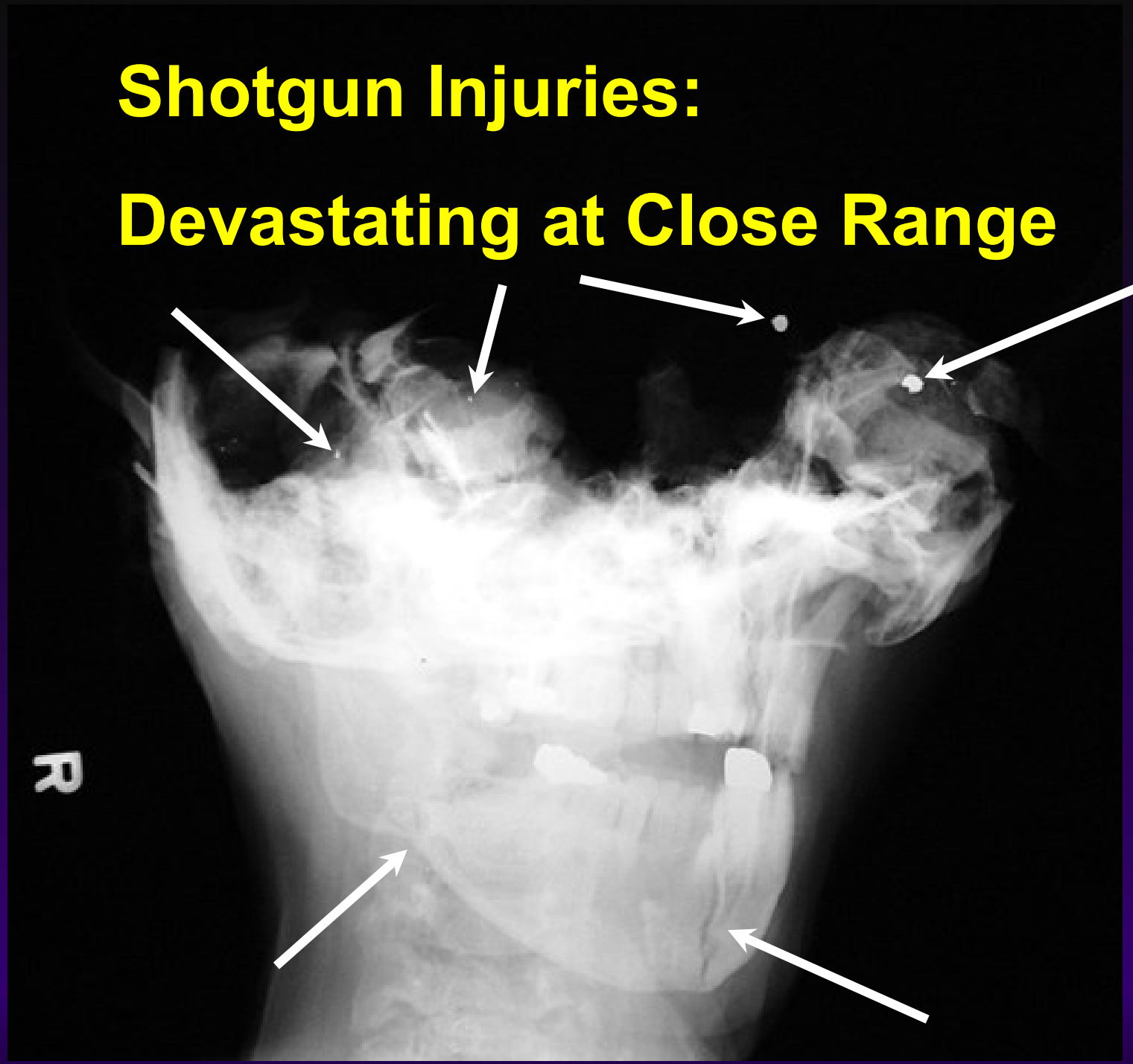
- Buckshot = Large & Uncommon

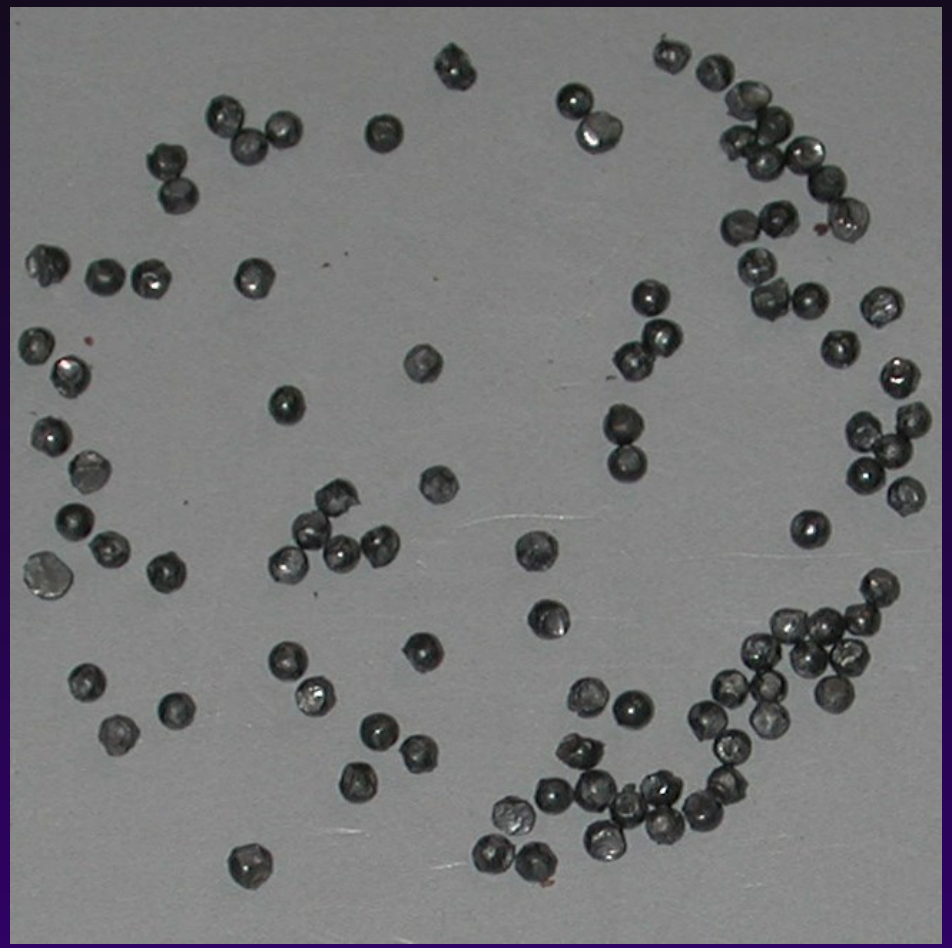
SHOTGUN WOUNDS

- **Multiple Pellets: Spread**
- **Pellets Rarely Exit**
- **Total Energy Transfer**
- **Increasing Range = Fewer Pellets**
- **Severity Varies Inversely with Range**
- **Devastating at Close Range**

Shotgun Injuries:

Devastating at Close Range

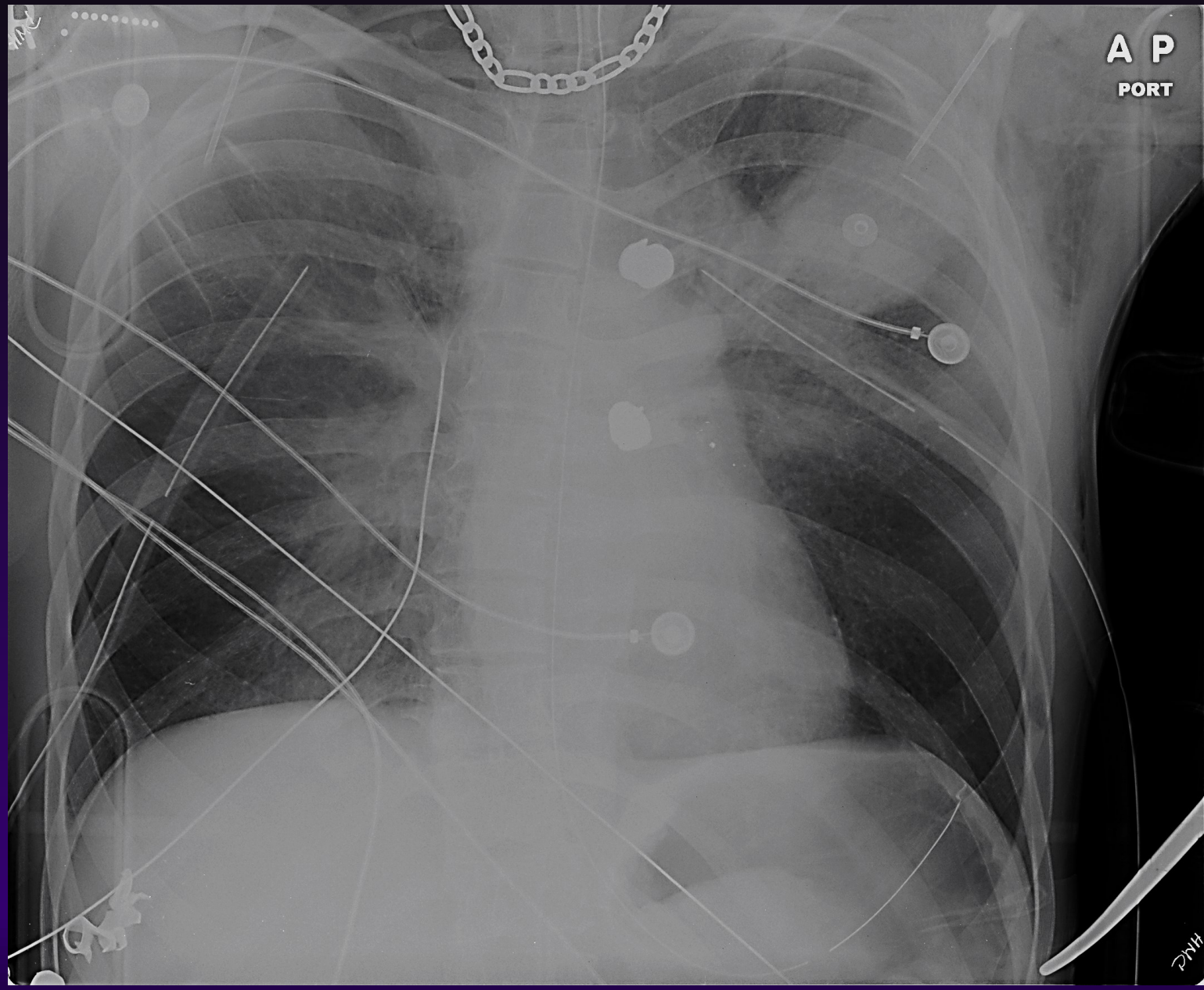




Case 2: 19 yom GSW

How many bullets are retained in this patient?

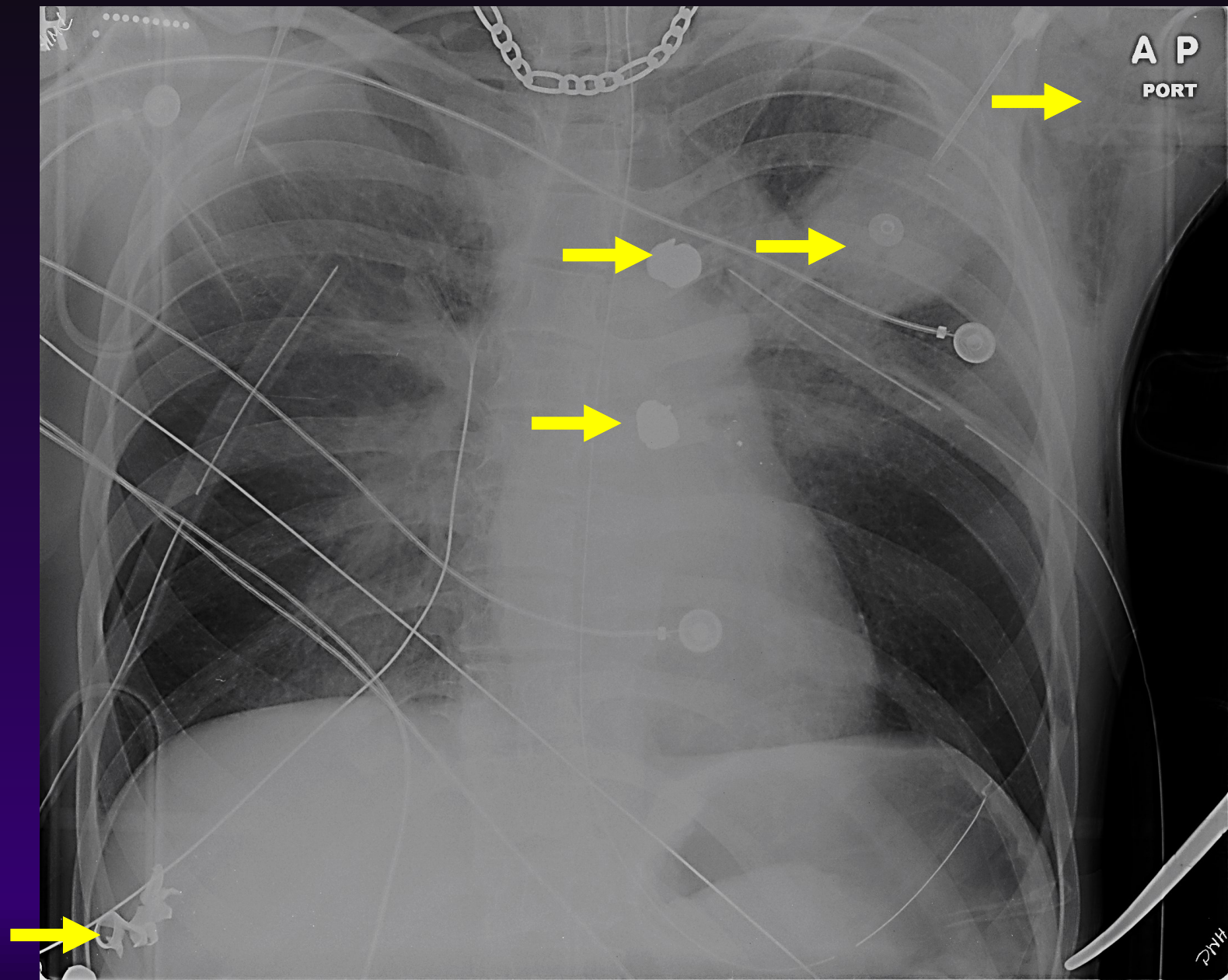
A. One
B. Two
C. Three
D. Four
E. None



Case: 19 yom GSW

How many bullets are retained in this patient?

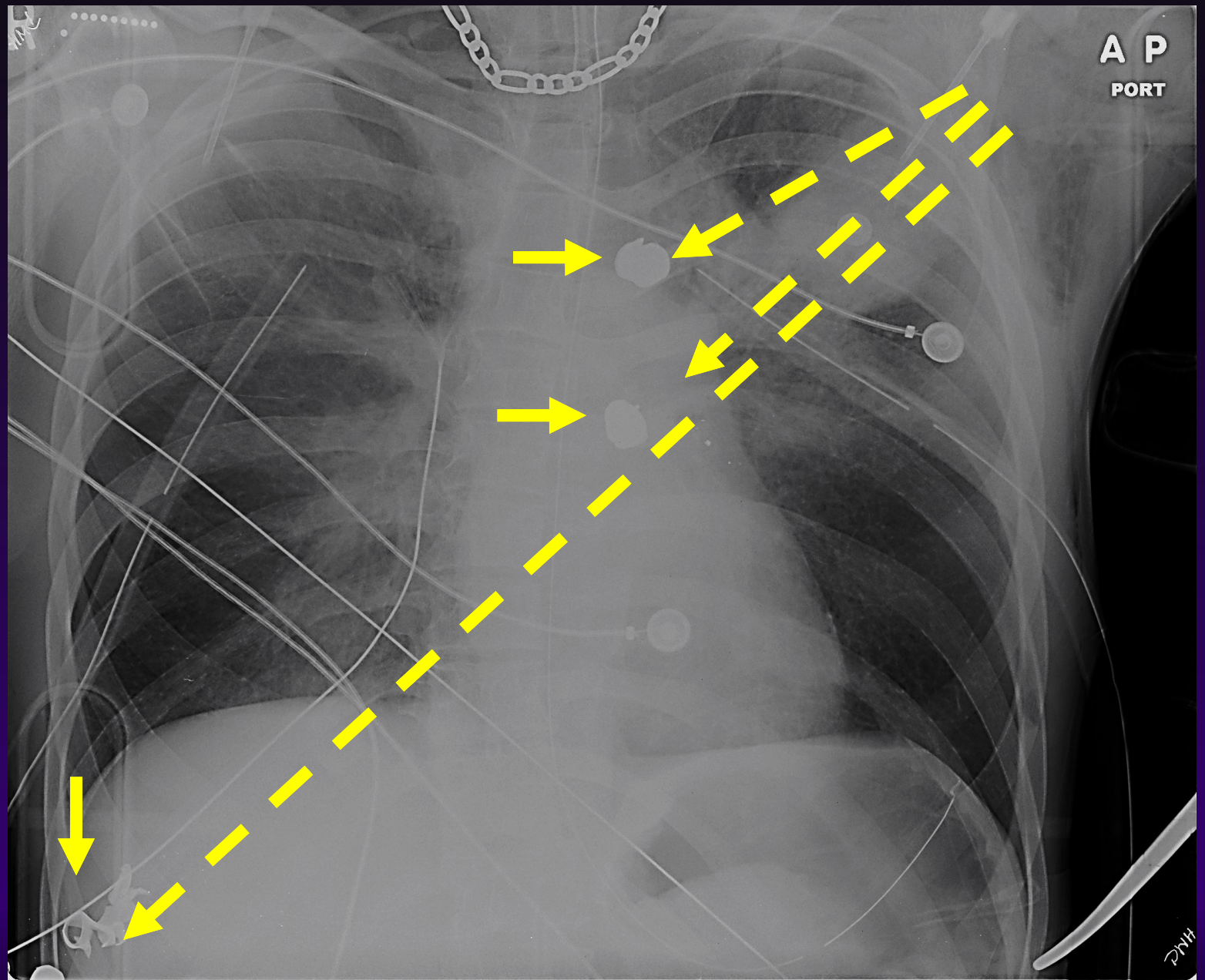
A. One
B. Two
C. Three
D. Four
E. None



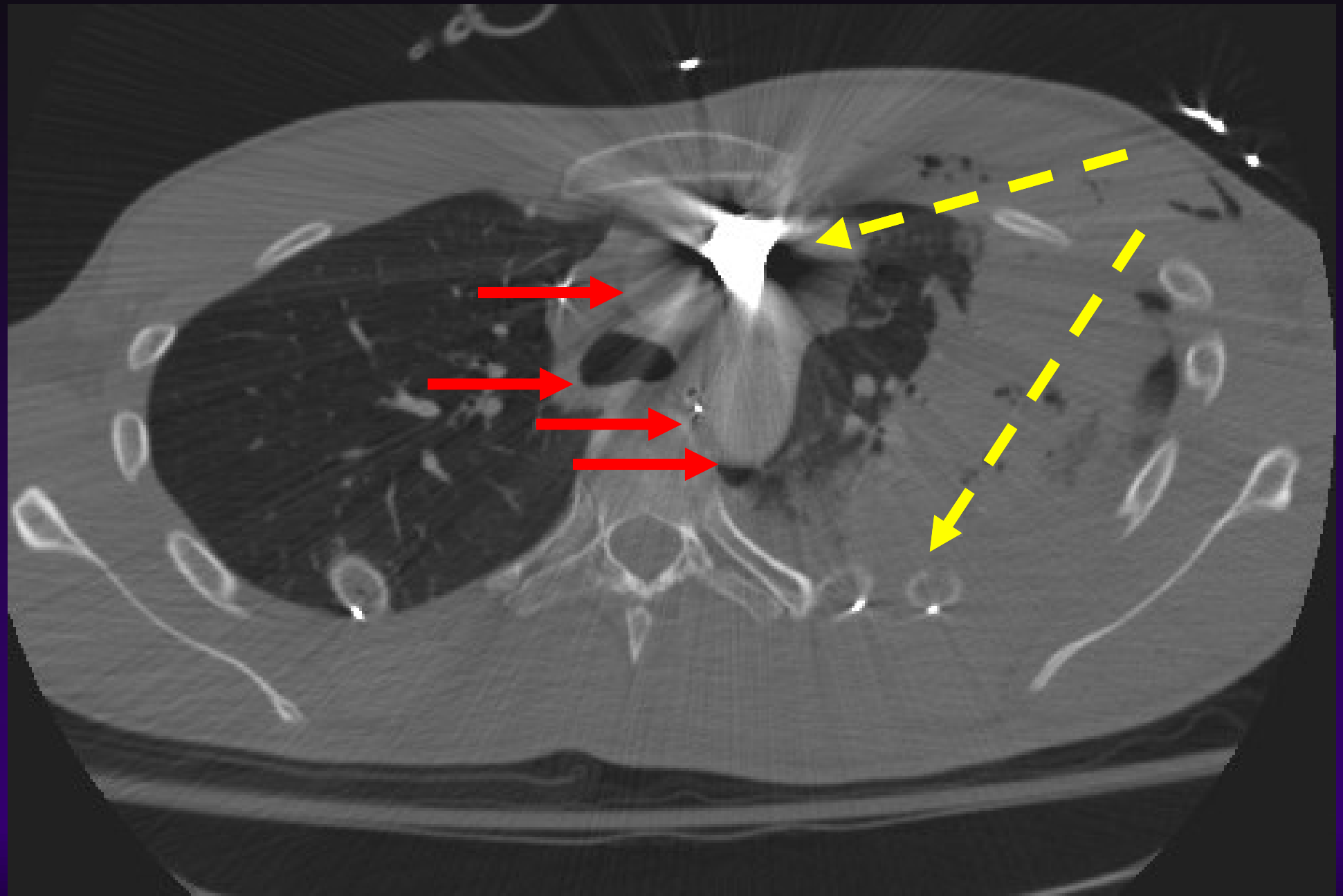
WHAT IS THE TRAJECTORY OF THE BULLET?

- **Trajectory identifies organs at risk**
- **Allows to adjust search pattern on CT**

Case: 19 yom GSW



Case: 19 yom GSW



Penetrating Transmediastinal Evaluation

- **Vascular structures**
  - **CTA: heart, aorta, arch vessels, axillae**
- **Airways**
  - **CT: trachea, bronchopleural fistula**
- **Digestive tract**
  - **Esophagram (CT, fluoro), oral contrast**
- **Similar principles apply to transperitoneal injuries**

Rifle vs Handgun Comparison

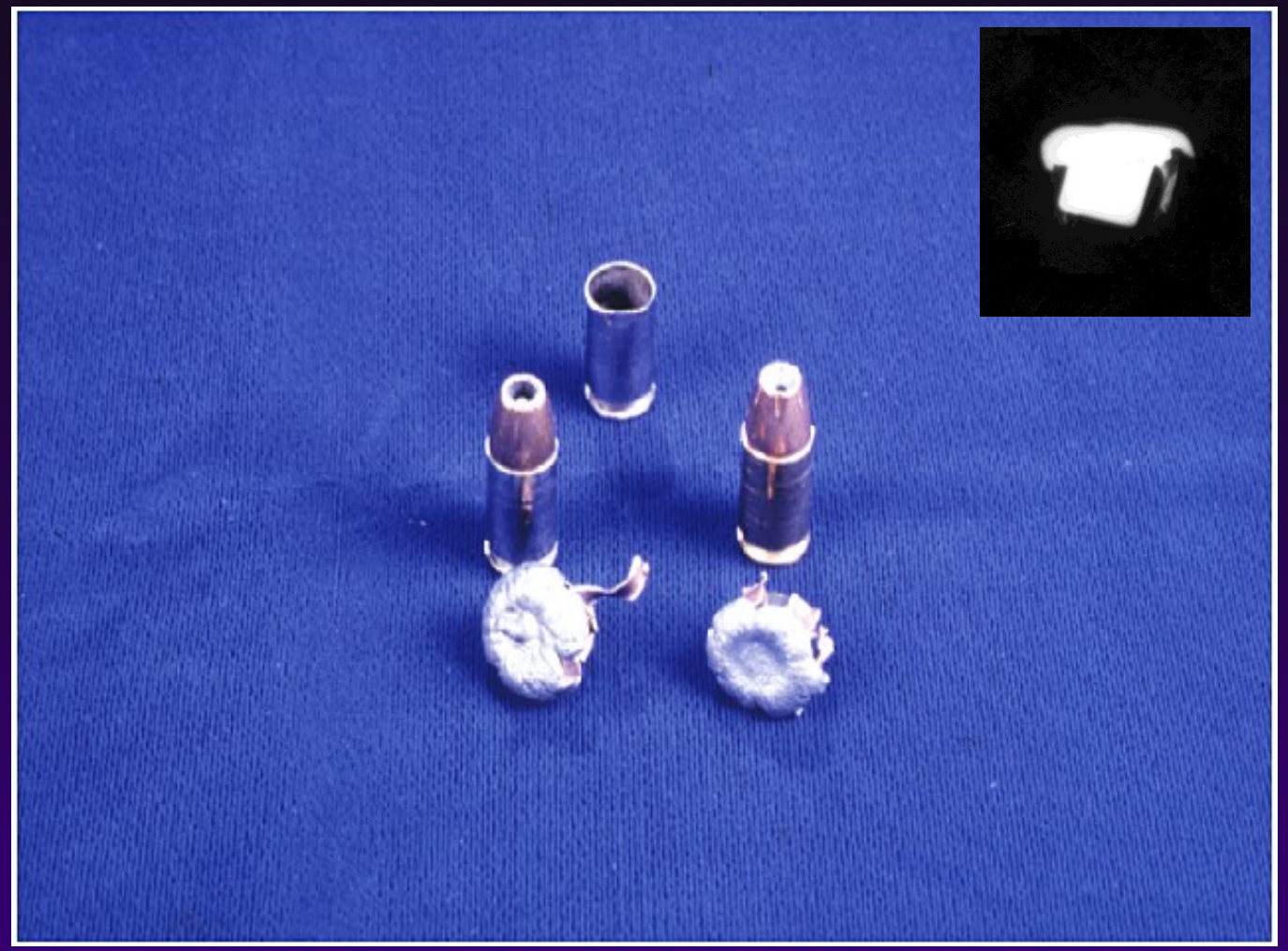
BULLET CONSTRUCTION

Full Jacket

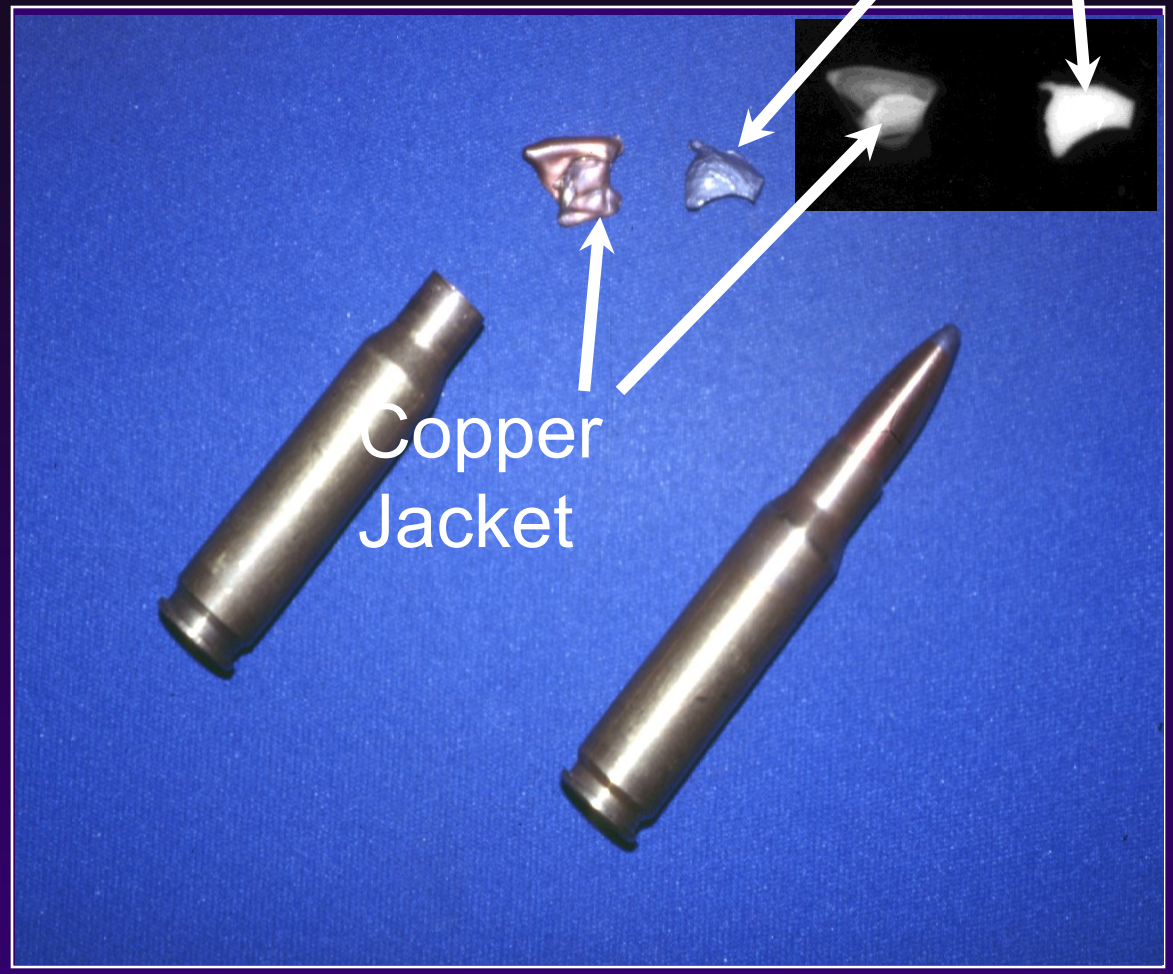
Soft Nose

Hollow Nose

Hollow Nosed Handgun Rounds



Rifle Rounds



Appearance on Radiographs

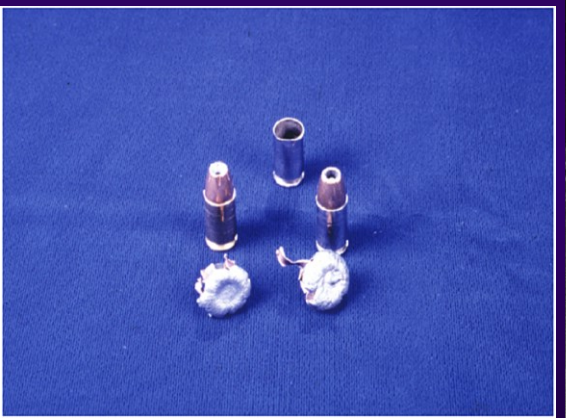
Handgun

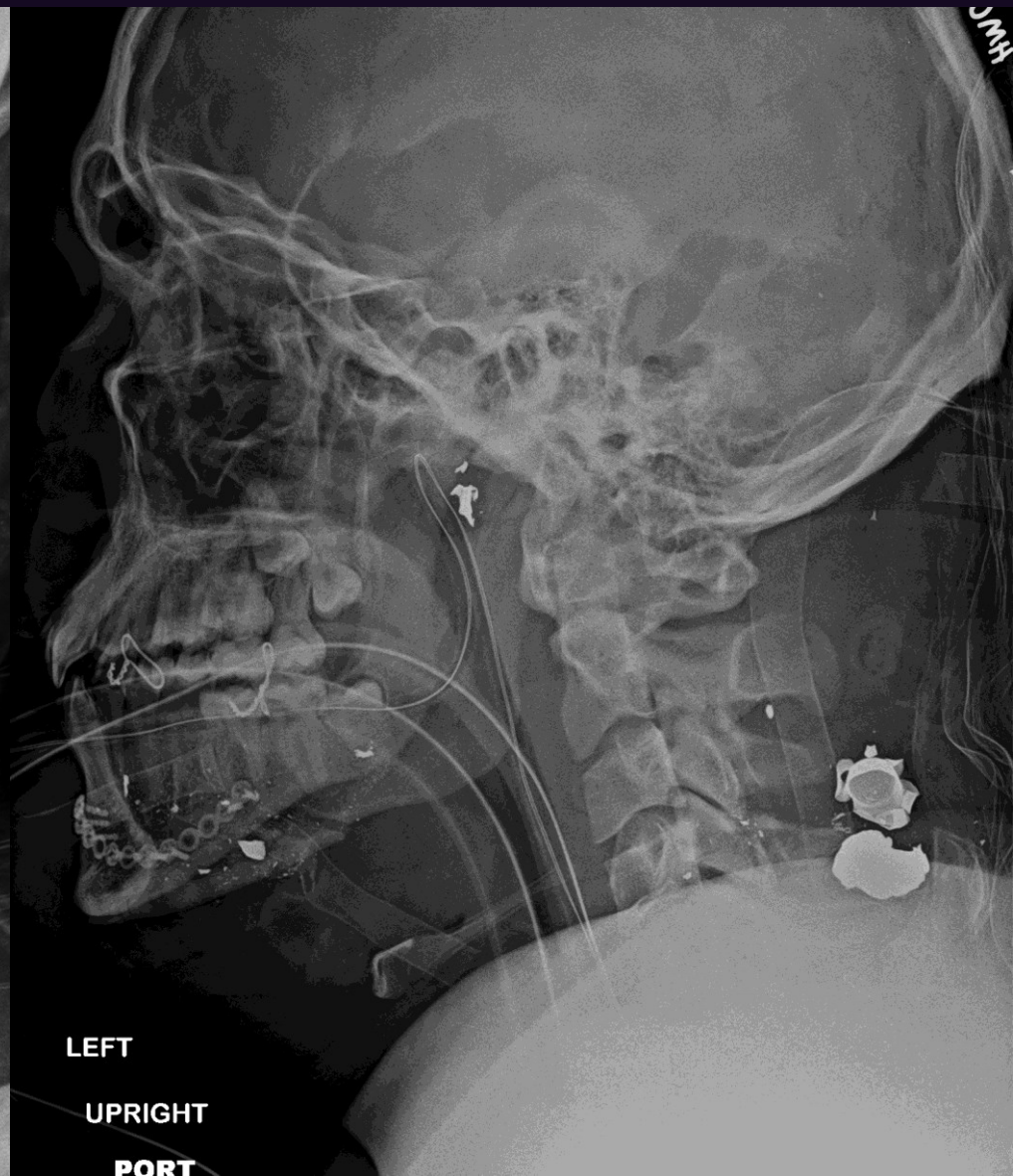
Rifle

Case 1: 25 yom GSW to neck

What type of firearm caused this injury?

A. Assault Rifle
B. Shotgun
C. **Handgun**
D. Hunting rifle





Appearance on Radiographs

Handgun

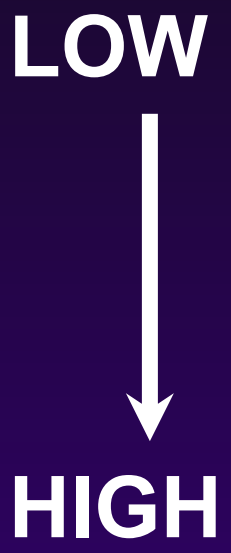
Rifle

Rifle - Handgun Comparison

Gun	Bullet weight	Muzzle velocity of bullet	Kinetic energy of bullet
Hunting rifle (270)	9 g	945 m/s	4019 J
Big handgun (44 Magnum)	16 g	411 m/s	1351 J

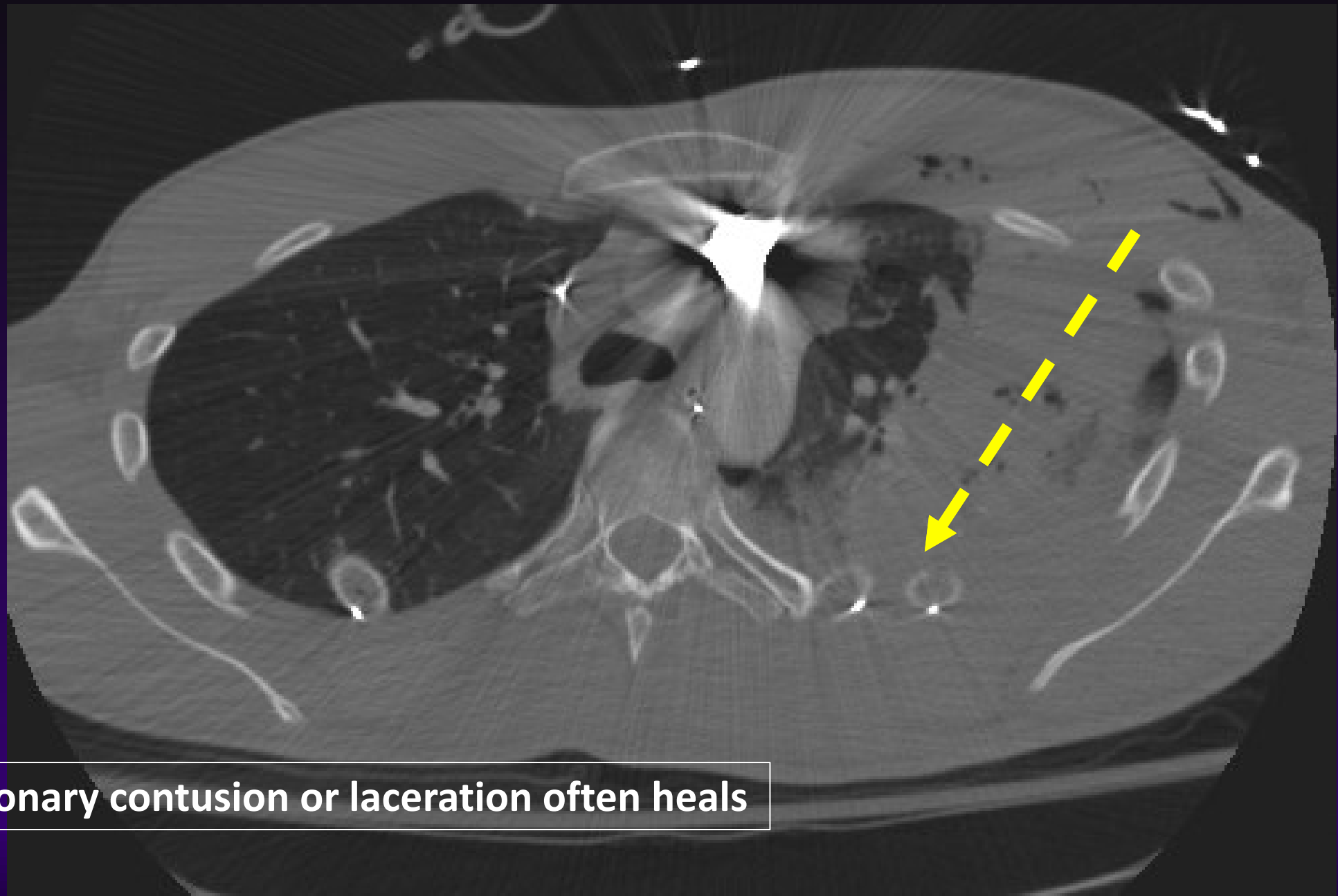
$$E = {}^{1}/_{2}\, mv^{2}$$

Damage Increases with Specific Gravity



- Lung
- Fat
- Liver, Brain, Skin, Muscle
- Bone

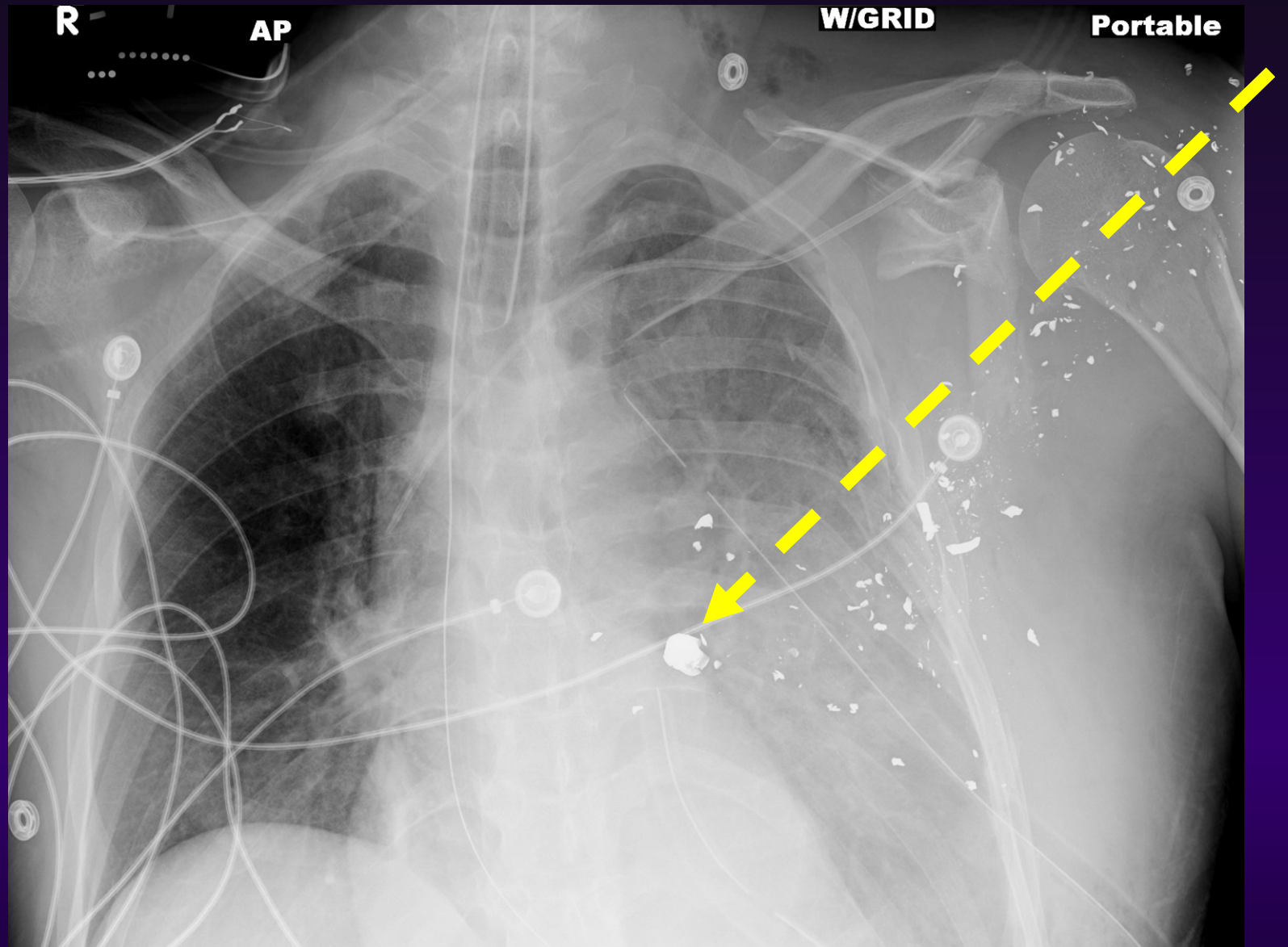
Case: 19 yom GSW



Pulmonary contusion or laceration often heals

59 yom in stand off with police

Impact on bone results in high degree of fragmentation and damage: “snowstorm of lead”



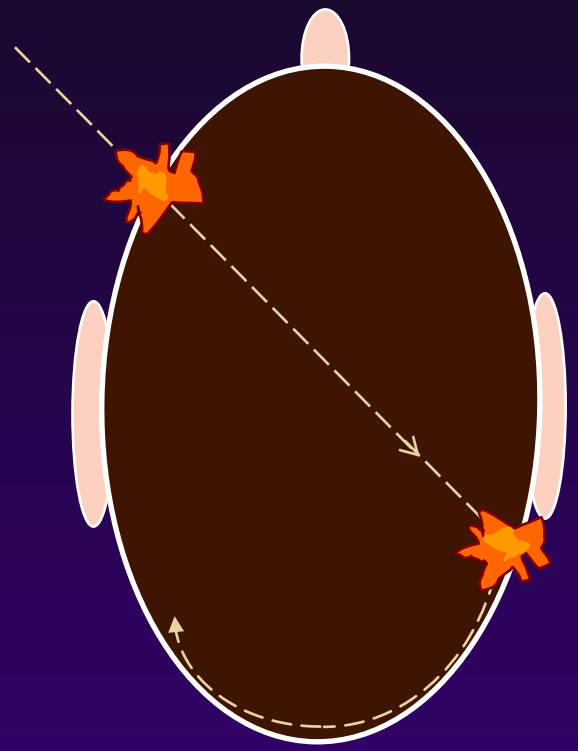
Bullet Trajectory

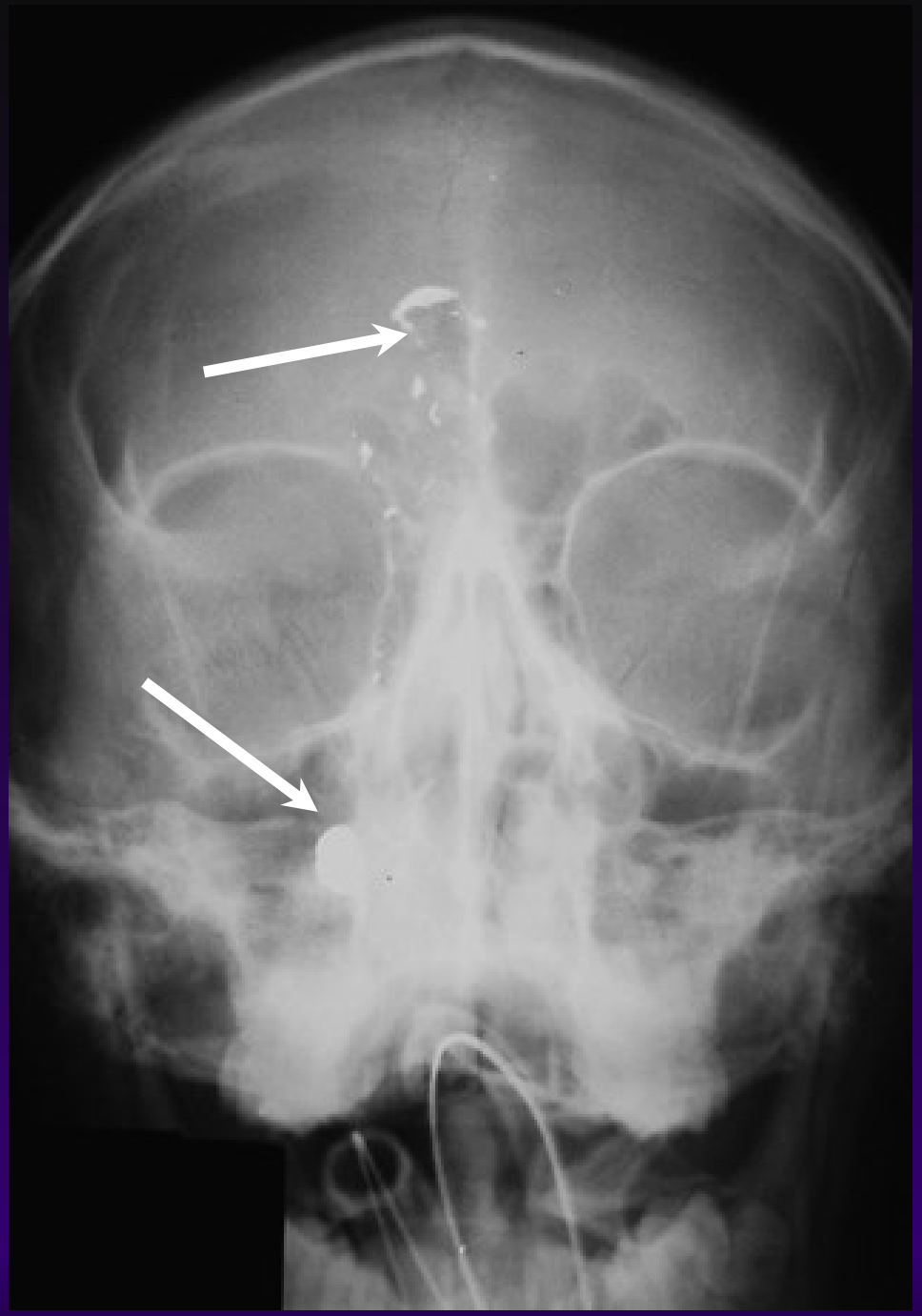
- Intact Bullet = Straight Trajectory
- Bullets do NOT “Bounce Around”
- Fragmentation MAY Occur
- Deflection MAY Occur

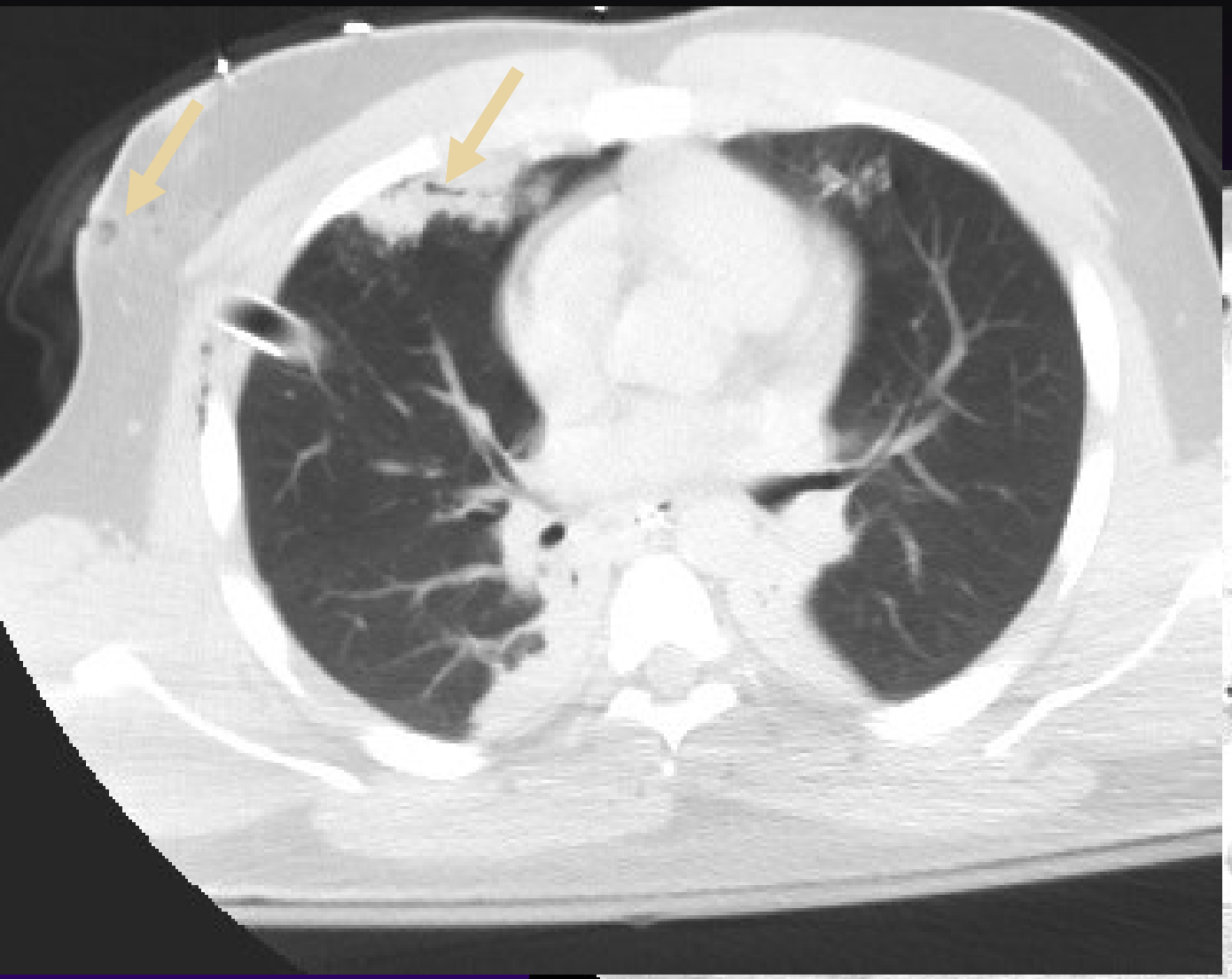
Factors Causing Bullet Deflection

- Fragmentation
- Mushrooming
- Contact With Bones
- Contact With Fascia
- Effects Differ in Different Tissues
- Slow Bullets Most Likely to Deflect

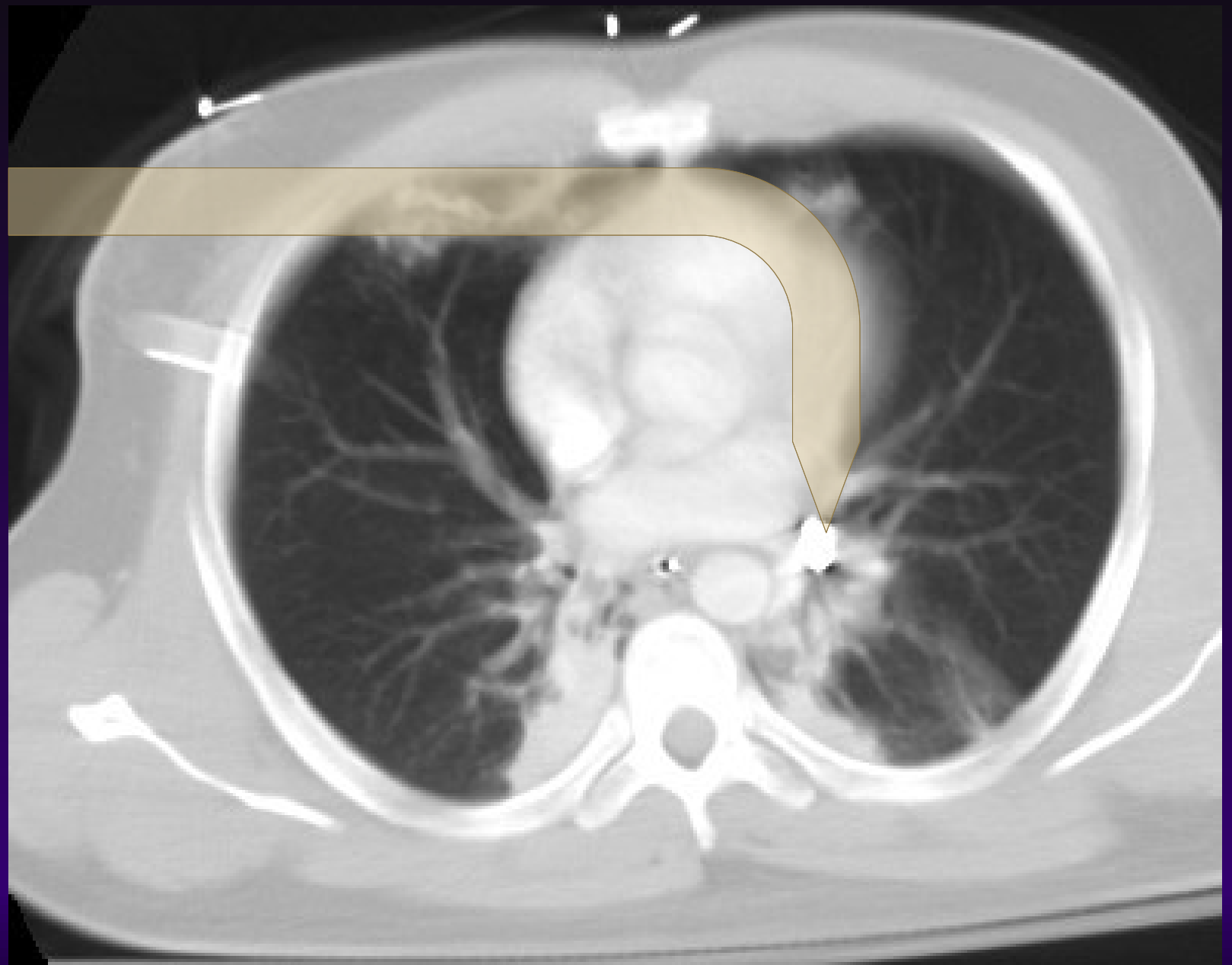
“RICOCHET”







Case: 20 yom GSW



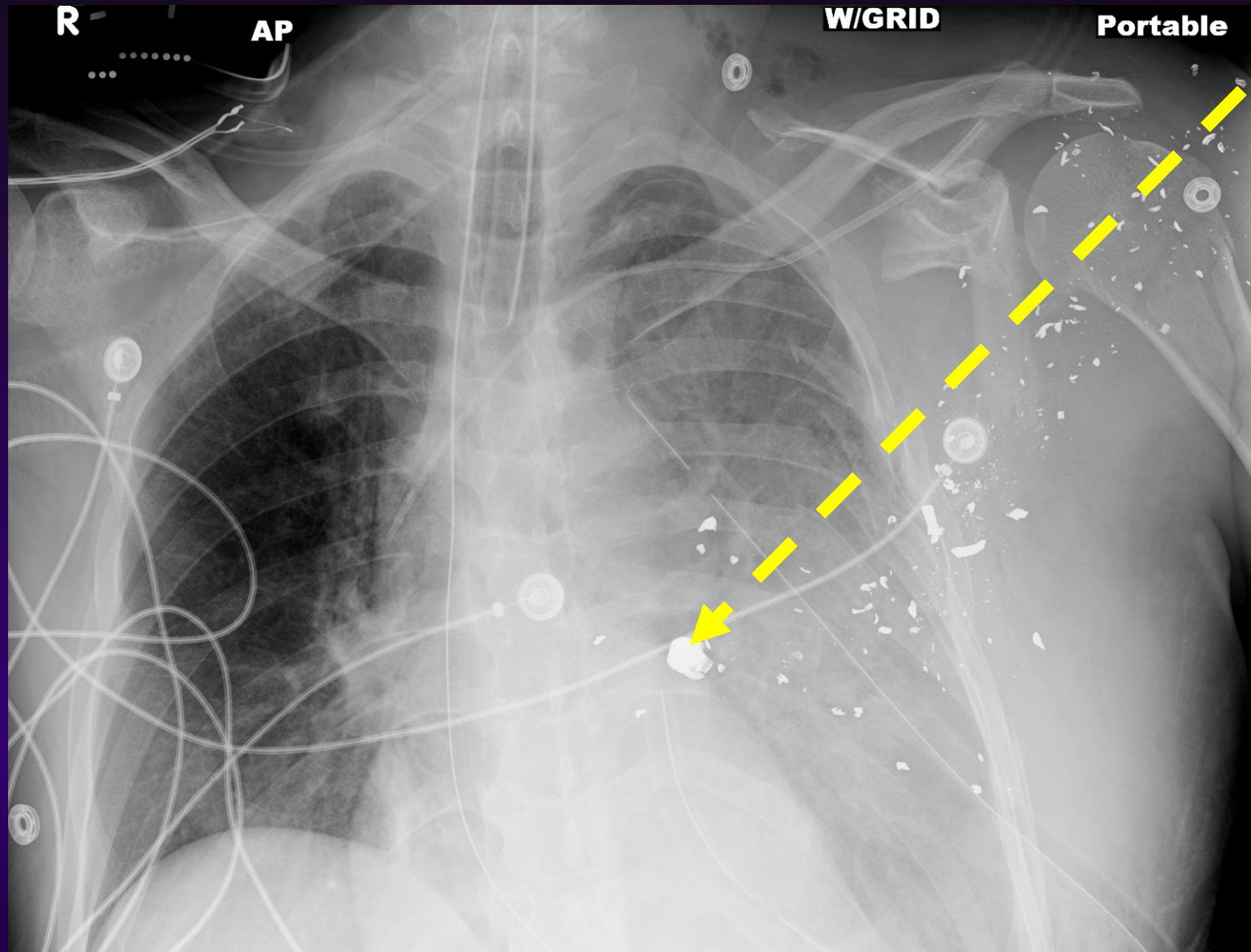
IMAGING:

Adequate Radiographs
are Essential

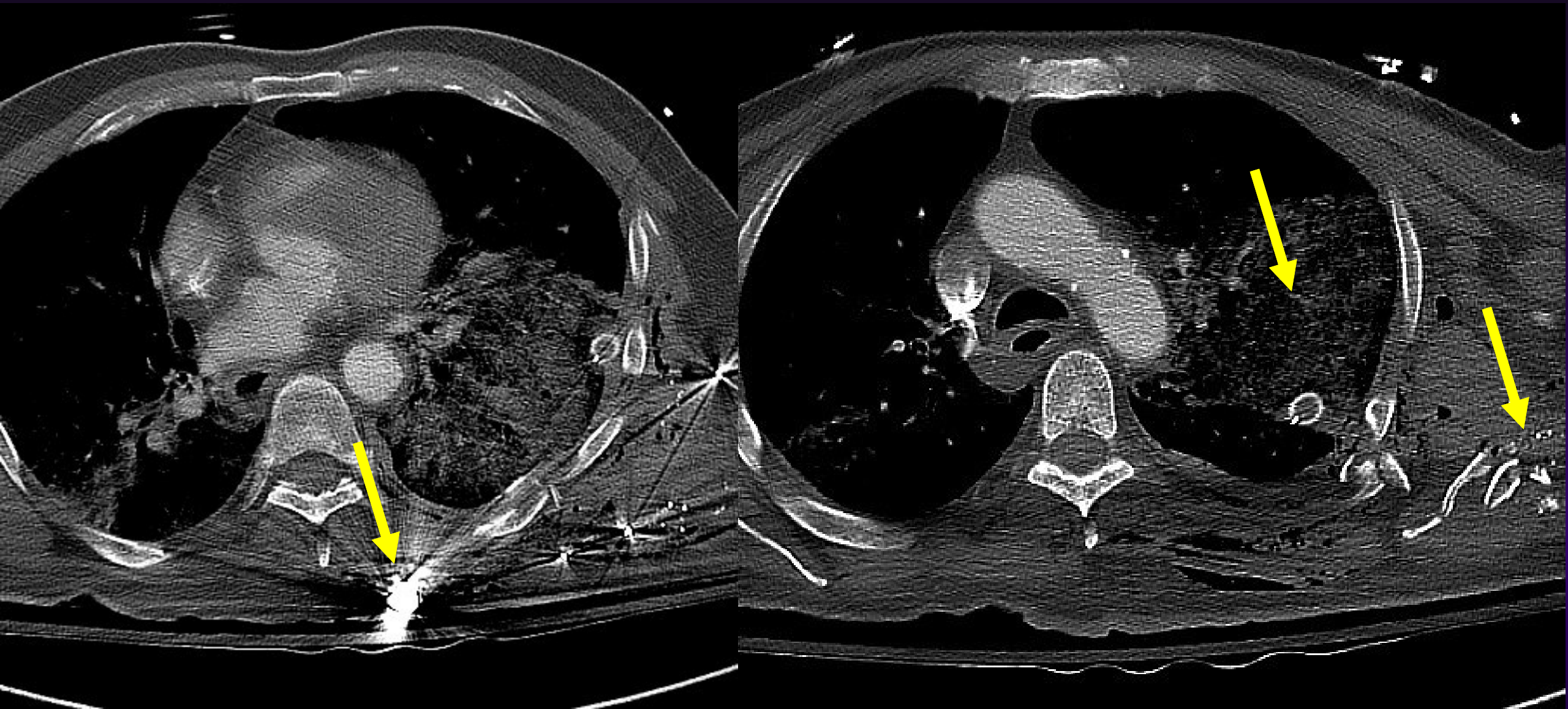
Case: 59 yom in stand off with police

What type of firearm caused this injury?

A. Sniper rifle
B. Shotgun
C. Handgun
D. Hunting rifle
E. Don’t know



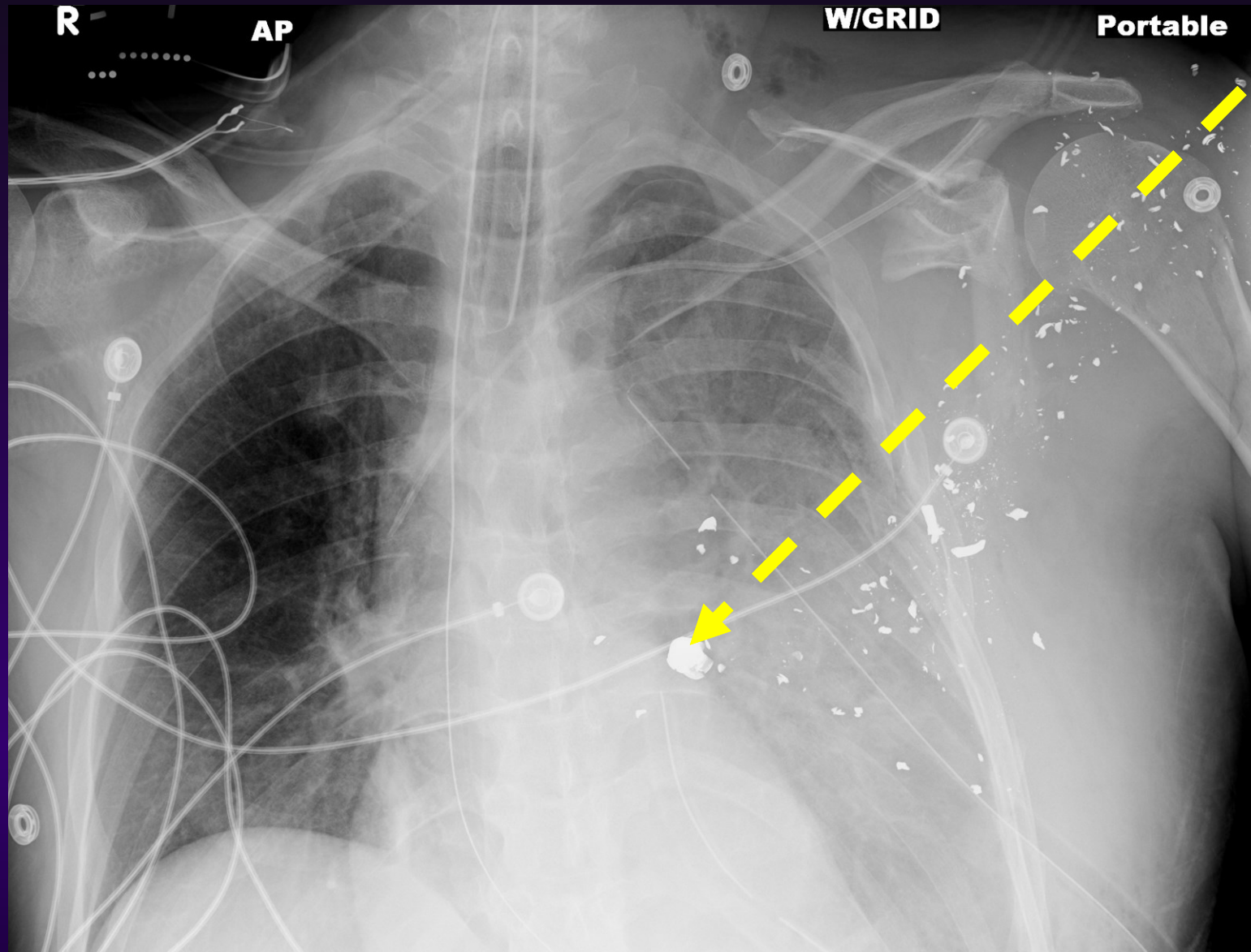
59 yom in stand off with police



Case: 59 yom in stand off with police

What type of firearm caused this injury?

A. Sniper rifle
B. Shotgun
C. Handgun
D. Hunting rifle
E. Don’t know



Summary: Bullets and Ballistics

- Injury depends on type of missile and energy
- Injury severity worse in dense tissue (bone)
- Shot guns: multiple pellets, devastating at short range
- Hand guns: lead core with jacket, deforms
- Rifles: high energy (velocity), fragmentation, “snowstorm of lead”
- Trajectory defines organs at risk
- Knowing the trajectory allows to adjust search pattern on CT

Selected references

- Wilson AJ. Gunshot injuries: what does a radiologist need to know? Radiographics. 1999 Sep-Oct;19(5):1358-68. doi: 10.1148/radiographics.19.5.g99se171358. PMID: 10489188.
- Gunn ML, Clark RT, Sadro CT, Linnau KF, Sandstrom CK. Current concepts in imaging evaluation of penetrating transmediastinal injury. Radiographics. 2014 Nov-Dec;34(7):1824-41. doi: 10.1148/rg.347130022. PMID: 25384283.
- Dreizin D, Munera F. Multidetector CT for Penetrating Torso Trauma: State of the Art. Radiology. 2015 Nov;277(2):338-55. doi: 10.1148/radiol.2015142282. PMID: 26492022.
- Ditkofsky N, Colak E, Kirpalani A, Mathur S, Deva D, Pearce D, Bharatha A, Dowdell T. MR imaging in the presence of ballistic debris of unknown composition: a review of the literature and practical approach. Emerg Radiol. 2020 Oct;27(5):527-532. doi: 10.1007/s10140-020-01781-6. Epub 2020 May 17. PMID: 32418149.