

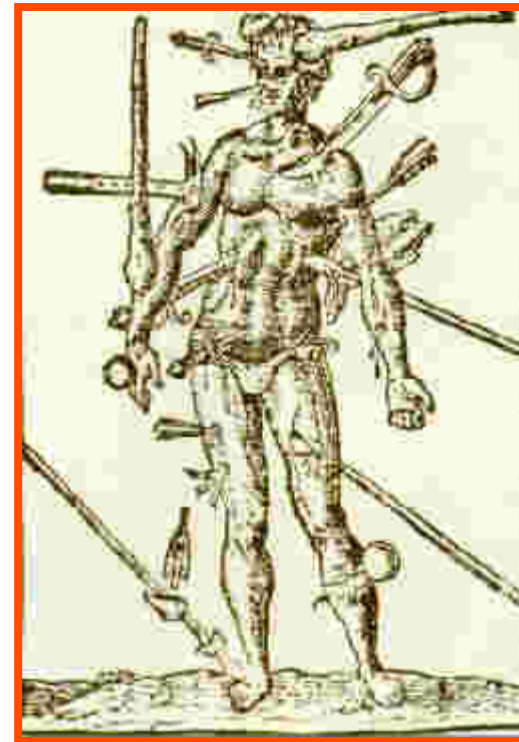
# Trauma Systems

- Vary from state to state
- States are responsible for designating trauma centers and regionalization of trauma care
  - American College of Surgeons' guidelines
- Level 1 essential components
  - 24/7 availability of all surgical subspecialties
  - Neurosurgery, hemodialysis 24/7
  - Injury prevention and education programs
  - Trauma research program
- Trauma triage based on physiology, anatomy and mechanism

# ATLS: Initial Approach

1° → rapid resuscitation → 2° → diagnostic tests →  
ultimate triage

- Primary survey: identify and treat life-threatening injuries
  - Airway obstruction
  - Tension pneumothorax
  - Massive hemorrhage
  - Open pneumothorax
  - Flail chest
  - Cardiac tamponade



# ATLS: Primary Survey A-B-C-D-E

- Airway, C-spine control
  - Intubate: GSC  $\leq 8$  or uncontrolled agitation
  - RSI with C-spine stabilization is the airway procedure of choice
  - NEXUS criteria: If no midline tenderness, neuro deficits, distracting injury, AMS or intoxication, C-spine x-rays are not indicated
  - The tongue is the most common cause of airway obstruction in trauma patients
  - Nasotracheal intubation is contraindicated in maxillofacial trauma, basilar skull fracture, apnea

# ATLS: Primary Survey

- Breathing
  - Occlusive dressing for sucking chest wound
  - Reposition ETT (R bronchus, esophagus)
  - Chest tube or needle to relieve tension pneumothorax
  - Hemopneumothorax; if  $>1,500$  mL initially, thoracotomy is indicated



# ATLS: Primary Survey

- Circulation
  - Radial pulse = BP > 80  
Femoral pulse = BP > 70  
Carotid pulse = BP > 60
  - Normal blood volume 7% of body weight = 5 L
  - Blood loss from femur fracture = 1000 mL
  - Blood loss from pelvic fracture = 1500-2000mL

Significant hemorrhage may be clinically  
silent in young, healthy adult

# ATLS: Initial Approach

- Circulation : Assess for shock
  - Blood loss of  $>15\%$  =  $\downarrow$  cap refill, narrowing of pulse pressure
  - $>30\%$  = BP finally drops
  - Replace blood loss: 3 mL crystalloid = 1 mL blood
  - Blood replacement
    - Whole blood or PRBCs can be used
    - Full crossmatch preferred (takes 1 hour)
    - Type-specific ABO + Rh compatible (10 mins)
    - If type-specific unavailable
      - Type O neg (universal donor)
      - Type O pos can be used in males

# Shock Classification

- Hemorrhagic shock
  - Class I: <15% blood loss = no significant changes
  - Class II: 15-30% blood loss = ↓ cap refill, ↑ heart rate
  - Class III: 30-40% blood loss = shock, ↓ BP, altered mental status
  - Class IV: >40% blood loss = preterminal
- Consider other forms of shock (neurogenic?)

# ATLS: Primary Survey

- Disability: abbreviated neurologic exam
  - Intoxication should not be considered cause of AMS until significant head injury is ruled out
  - AMS requires early head CT
  - Early head CT identifies patients who may benefit from:
    - Relative hyperventilation ( $pCO_2$  30-35)
    - ICP monitor (GCS 3-8 & intracranial lesion)
    - Early surgical decompression/craniotomy

# Glasgow Coma Scale

|                 |                            |   |
|-----------------|----------------------------|---|
| Eye opening     | Spontaneous                | 4 |
|                 | Eyes open to command       | 3 |
|                 | Eyes open to pain          | 2 |
|                 | No reaction                | 1 |
| Verbal response | Oriented                   | 5 |
|                 | Confused, disoriented      | 4 |
|                 | Inappropriate words        | 3 |
|                 | Unintelligible sounds      | 2 |
|                 | No verbal response         | 1 |
| Motor response  | Obeys commands             | 6 |
|                 | Localized pain             | 5 |
|                 | Withdraws from pain        | 4 |
|                 | Flexion posturing to pain  | 3 |
|                 | Extensor posturing to pain | 2 |
|                 | No reaction                | 1 |

**3 = worst**

**15 = best**

# ATLS: Primary Survey

- **E**xposure: “Strip-Flip-Touch and Smell”
  - Examination of total body surface
  - T- and L-spine, back for tenderness
  - Gluteal cleft and perineum for injury
  - Prevent hypothermia (warming blankets)
- Secondary survey: Compulsive Head-Toe
  - Identify as many injuries as possible
  - Set priorities for evaluation and management
  - Secondary consultations (OMF, ENT, GYN)

# Traumatic Arrest: ED Thoracotomy

- Absolute indication
  - Penetrating chest trauma + signs of life (pre-hospital or ED) + cardiac activity in ED
- Liberal indications
  - Abdominal trauma and cardiac activity requiring aortic cross clamping to get to operating room
  - Blunt chest trauma with loss of vital signs in ED

# Pediatric Trauma

- Most common cause of pediatric death >1 year
- Trauma causes 50% of all pediatric deaths
- Evaluation / treatment priorities same as adults
- Pediatric anatomy and physiology contribute to several key management differences
- Airway anatomy considerations
  - Large occiput tends to flex neck
  - Obligate nose breathers <6 months
  - Increased tongue size
  - Anterior larynx
  - Narrow subglottic area

Head injury: The most common lethal injury



# Pediatric Trauma

## *Airway Considerations*

- Airway treatment
  - Straight blade
  - ET size (mm) =  $(\text{age} + 16) / 4$
  - Depth of insertion = 3 x tube size
  - No cricothyroidotomy if <8 years old
- Transtracheal jet ventilation if ET intubation impossible
  - Allows oxygenation
  - Poor ventilation
  - Temporizing measure
- Consider pediatric LMA or ILMA

# Pediatric Trauma

## *Vascular Access*

- Peripheral line(s) when able
- Intraosseous line
  - Fluid resuscitation
  - Blood products and drugs
  - Complications (rare)
    - Growth plate injury
    - Fluid leakage
    - Fat emboli
    - Osteomyelitis
    - Compartment syndrome
- Femoral line: identifiable landmarks



**Contraindicated in limb with fracture**

# Pediatric Trauma

## *Fluid Resuscitation*

- Normal blood volume = 8-10% of body weight
  - Compared to 7% of 70kg in adults which = 5 L blood volume
- Initial fluid bolus 20 ml/kg crystalloid
- Hypovolemic shock
  - Crystalloid 20 ml/kg bolus (x 2 if poor response)
  - PRBC 10 ml/kg
- Avoid hypothermia: Warm fluids to 40 °C
- Abdominal injuries are frequently managed non-operatively (spleen and liver)

# Pediatric Trauma

- C-spine fractures
  - Rare
  - C1-C4 most common <8 yrs
  - Flexion injury
- Pulmonary and cardiac contusions: Common, often delayed
- Fractures of ribs and sternum: Rare, imply great force

**Cord injuries are more common than fractures / SCIWORA diagnosed by MRI**

**Burns: 2<sup>nd</sup> most common cause of death <5yrs (many have inhalation injury)**

# Child Abuse (1)

- Injury inconsistent with history, delay in treatment, certain injury patterns
- Abuser
  - Young age
  - Increased stress
  - Unemployed
  - History of abuse
  - Substance abuse
- Burns
  - Contact
  - Immersion
  - Stocking glove distribution
  - Cigarette burns
- Contusions
  - Buttocks
  - Genitalia
  - Neck
  - Face
  - Low back

# Child Abuse





# Child Abuse



## Child Abuse (2)

Shaken baby syndrome:  
Diffuse cerebral injury with edema  
Retinal hemorrhages, poor prognosis

- Suspicious Fractures
  - Any <1 year
  - Rib (posterior)
  - Skull, spine, sternum
  - Bilateral, multiple, various stages of healing
  - Long bone
  - Metaphyseal
- Head injury
  - Subdural
  - Cerebral
  - SAH
  - Shaken baby syndrome

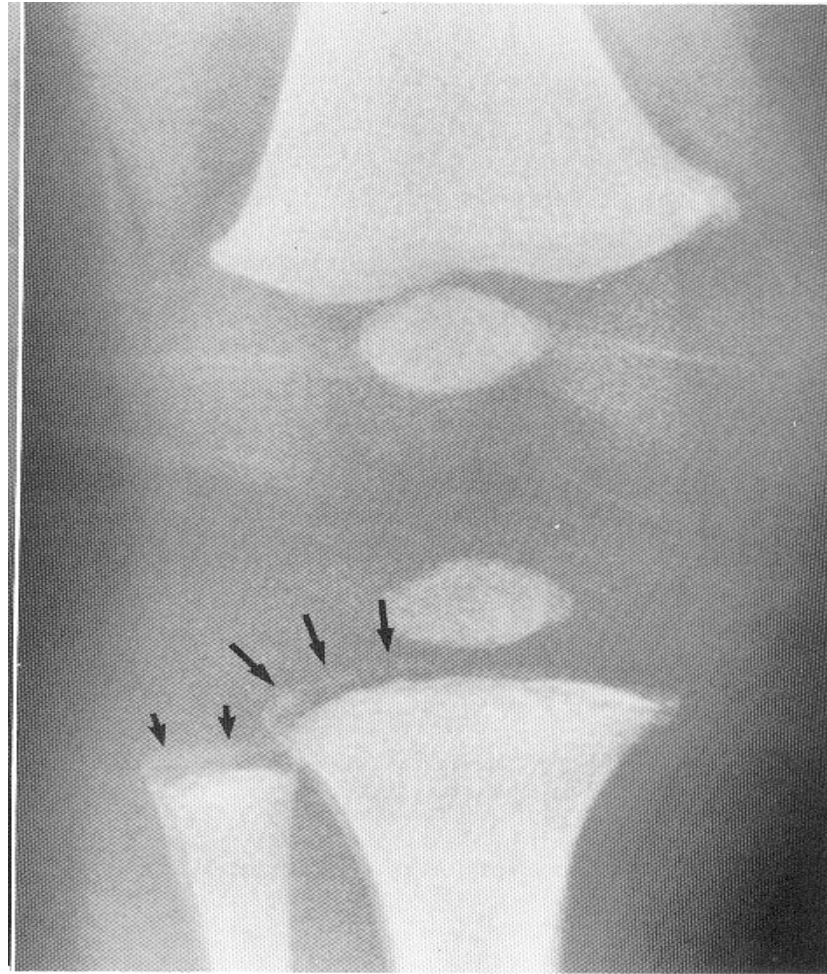
Undiagnosed child abuse:  
Significant 2 year mortality



# Suspicious fracture for Child Abuse



# Suspicious fracture for Child Abuse



**Metaphysial deformity (bucket handle)  
due to shearing / rotational forces  
Pathognomonic for child abuse**

# Geriatrics Trauma

- MVA is leading cause of unintentional injury and death <75 years old
- Falls
  - Common cause of unintentional injury and death >75 years old
  - Most occur on a level surface due to wrong shoes or environmental hazards
  - Fractures in elderly patients may be difficult to see on x-ray

# Domestic Violence (1)

- Inconsistencies in history
- Many women presenting to the ED have experienced domestic violence
- Suspicious injuries: Fractures, bruising
- **May present as depression or suicide attempt**
- Mandatory reporting is state specific, most states do not require reporting
- Increased risk of lethal outcome
  - Firearms involved
  - Child abuse
  - Public displays of violence
  - Sexual assault
  - Partner ends relationship

## Domestic Violence (2)

- Elements common in victims of DV
  - Pregnancy (increased incidence)
  - Injuries: Head, neck, abdomen, thorax
  - Injury and reported mechanism do not correlate
  - Injuries in different stages of healing
  - Delay in seeking treatment
  - Fingernail scratches, cigarette burns, rope burns, bites, defensive injuries
  - Multiple medical visits, vague complaints

# Pregnancy and Trauma (1)

- MVA, falls, assaults (DV again)
- Increased injuries to spleen, retroperitoneum, uterus (seat belt injuries)
- Uterus rises out of pelvis at 12 weeks
- Penetrating trauma
  - Maternal mortality is low
  - Fetal mortality is high
- Signs of fetal demise
  - Loss of movement
  - Absent heart tones
  - Extended extremities

**Blunt trauma:**  
Leading cause  
of maternal death

**Maternal stabilization is the most important  
factor in preventing fetal demise**

# Pregnancy and Trauma (2)

- Uterine rupture
  - Uncommon, late 2<sup>nd</sup>-3<sup>rd</sup> trimester, previous C-section, VBAC patients
  - Fetal mortality almost 100%, maternal mortality lower
  - Presentation may be non-specific: loss of uterine contour, palpable fetal parts
  - Shock, abdominal pain, fetal demise

# Pregnancy and Trauma (3)

- Abruptio placentae
  - A leading cause of fetal death, leading cause of maternal death
  - Minor fall, airbag deployment, bump into counter
  - Vaginal bleeding: If neg = “concealed abruptio”
  - Abdominal pain and uterine tetany
  - Check Kleihauer-Betke (fetal nucleated RBCs in maternal circulation) (controversial)
  - RhoGAM if Rh negative
  - Fetal distress (first tachycardia, then bradycardia)
  - DIC is a common complication



## Pregnancy and Trauma (4)

- **External fetal monitoring** is indicated for all blunt trauma patients >20 weeks gestation
- Frequent uterine activity is more predictive of abruption than ultrasound
  - >8 contractions/hr x 4 hrs: Risk for abruption
  - 3-7 contractions/hr x 4 hrs: Extend monitoring for 24 hrs
  - <3 contractions/hr x 4 hrs: Safe for discharge
- Fetal distress (>23 weeks)
  - Tachycardia, bradycardia, and decelerations
  - May indicate emergent C-section

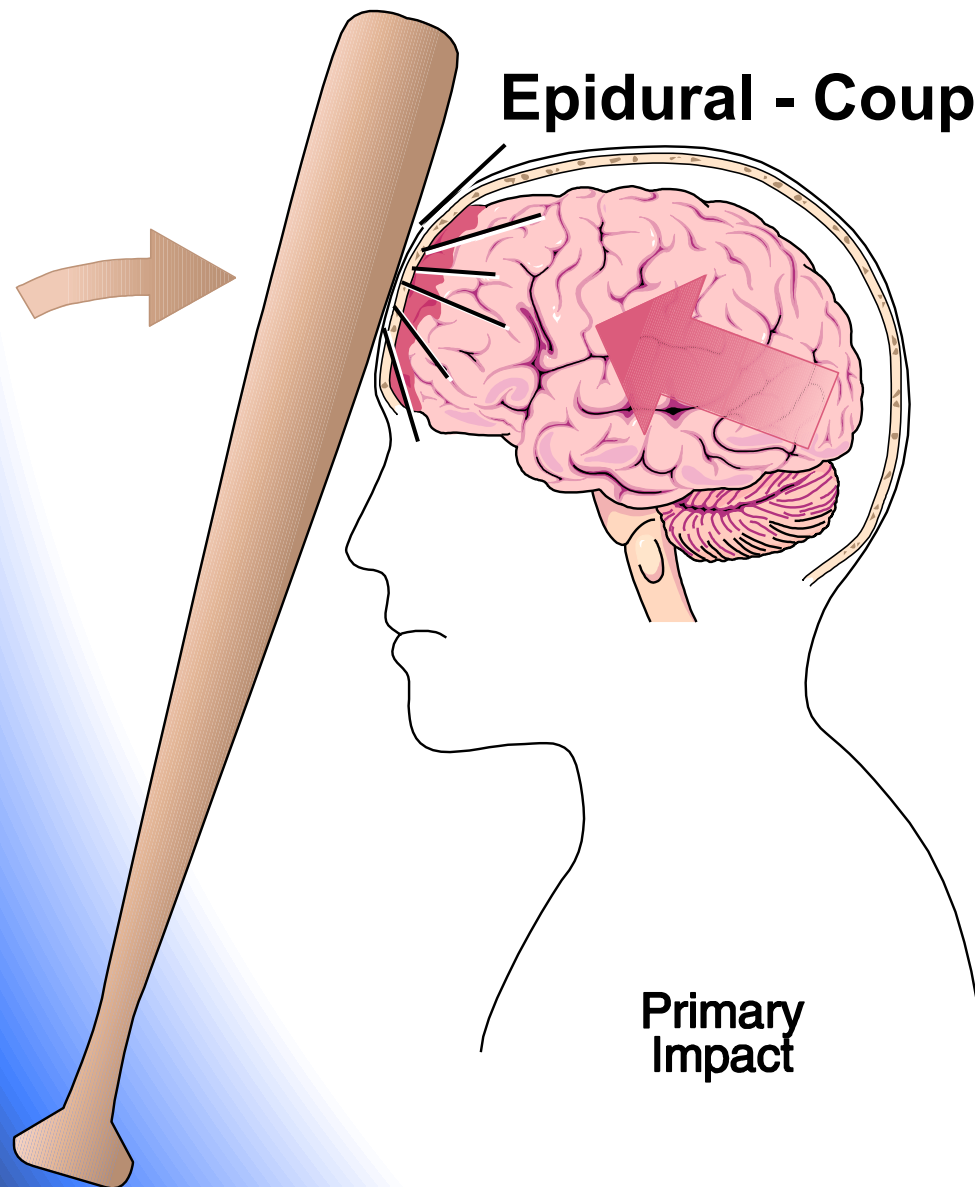
# Head Trauma (1)

- Accounts for half of all trauma deaths
- Males, ages 15-30: MVA, assaults, falls, bicycle accidents
- Cushing reflex
  - Late and unreliable sign of increased ICP
  - Hypertension
  - Bradycardia
- Scalp lacerations may bleed profusely, leading to shock in children
- CT is still the imaging study of choice

**Hypotension in head injury: Look for other causes**

## Head Trauma (2)

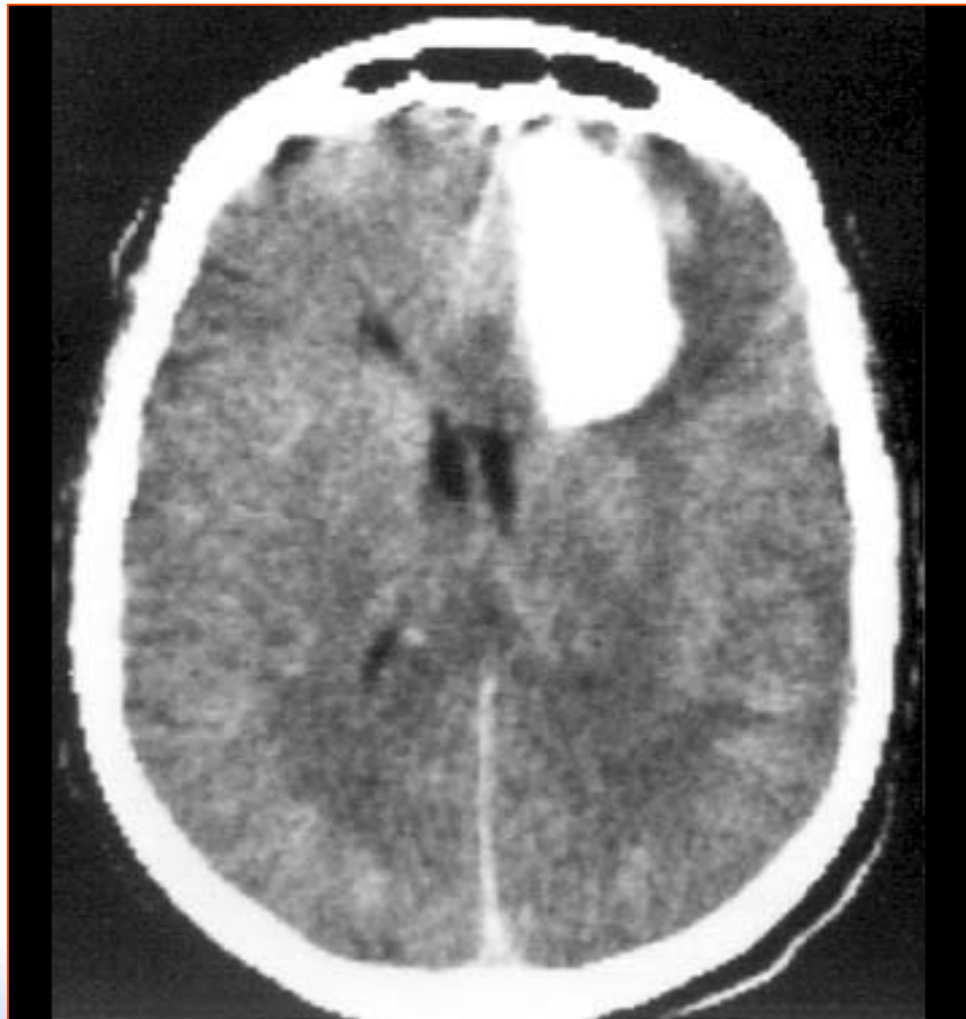
- No CT if minor mechanism of injury, no intoxication, GCS = 15, no skull fracture, non-focal exam, normal mental status
- Skull X-ray indications: Foreign body, vertex, linear or depressed skull fractures (very few)
- Cerebral perfusion pressure (CPP) = MAP-ICP
  - Increased ICP: CSF pressure > 15 mm Hg
- Autoregulation: Constant blood flow despite intracranial pressure changes
- Rule out cervical spine fracture when serious head injury occurs



### Subdural - Contrecoup



# Contrecoup Injury with Acute Intracerebral Hematoma



# Diffuse Cerebral Edema

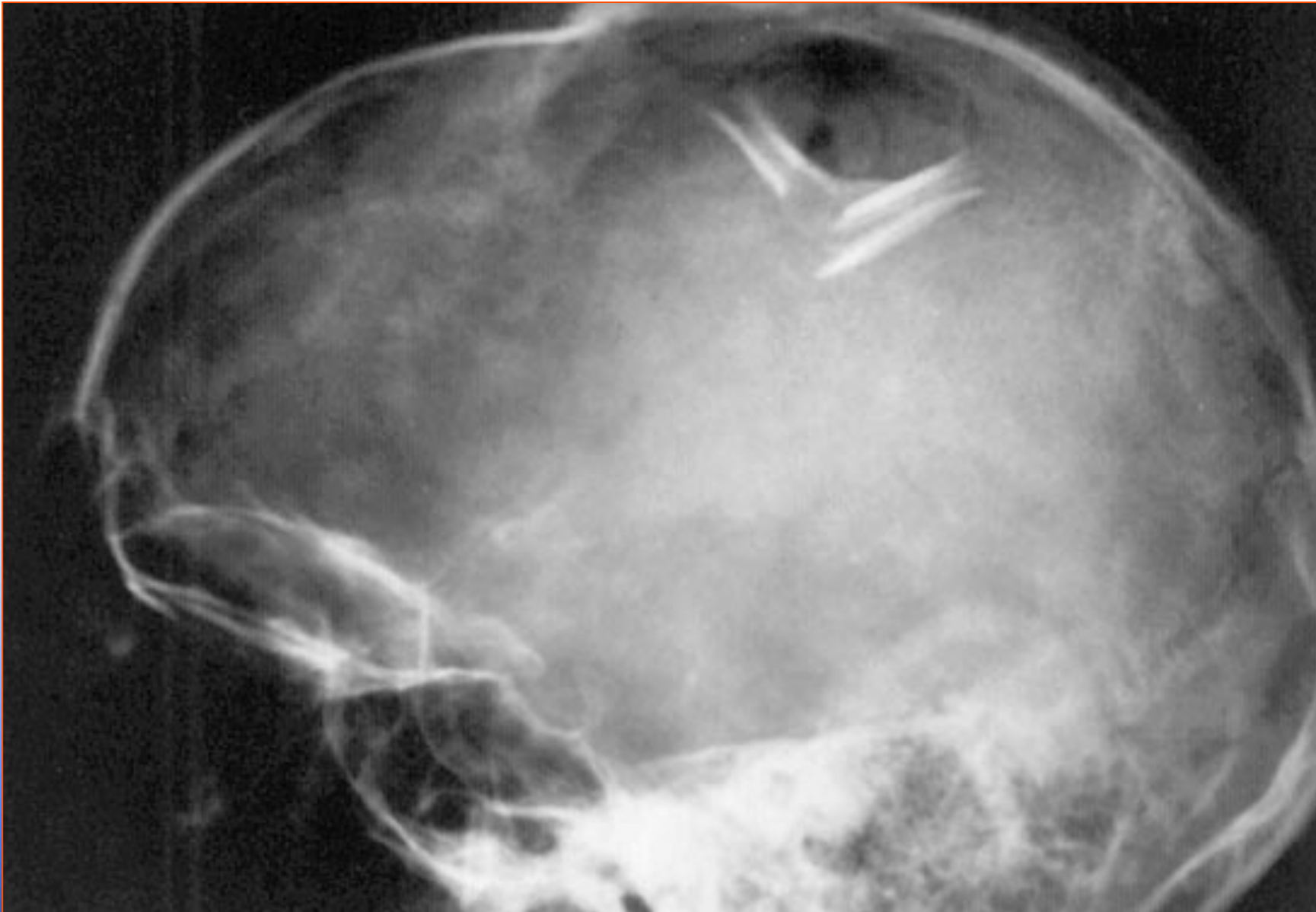


# Skull Fractures

- Rule out abuse in stellate, complex fractures
- Linear non-depressed fracture does not require treatment
- Temporal skull fracture (middle meningeal artery) associated with epidural hematoma
- Open skull fracture: Antibiotics and neurosurg
- Depressed skull fracture (one bone- table width): Neurosurgery
- Occipital skull fracture: Rule out SAH, contrecoup injury, posterior fossa hematoma, cranial nerve injury

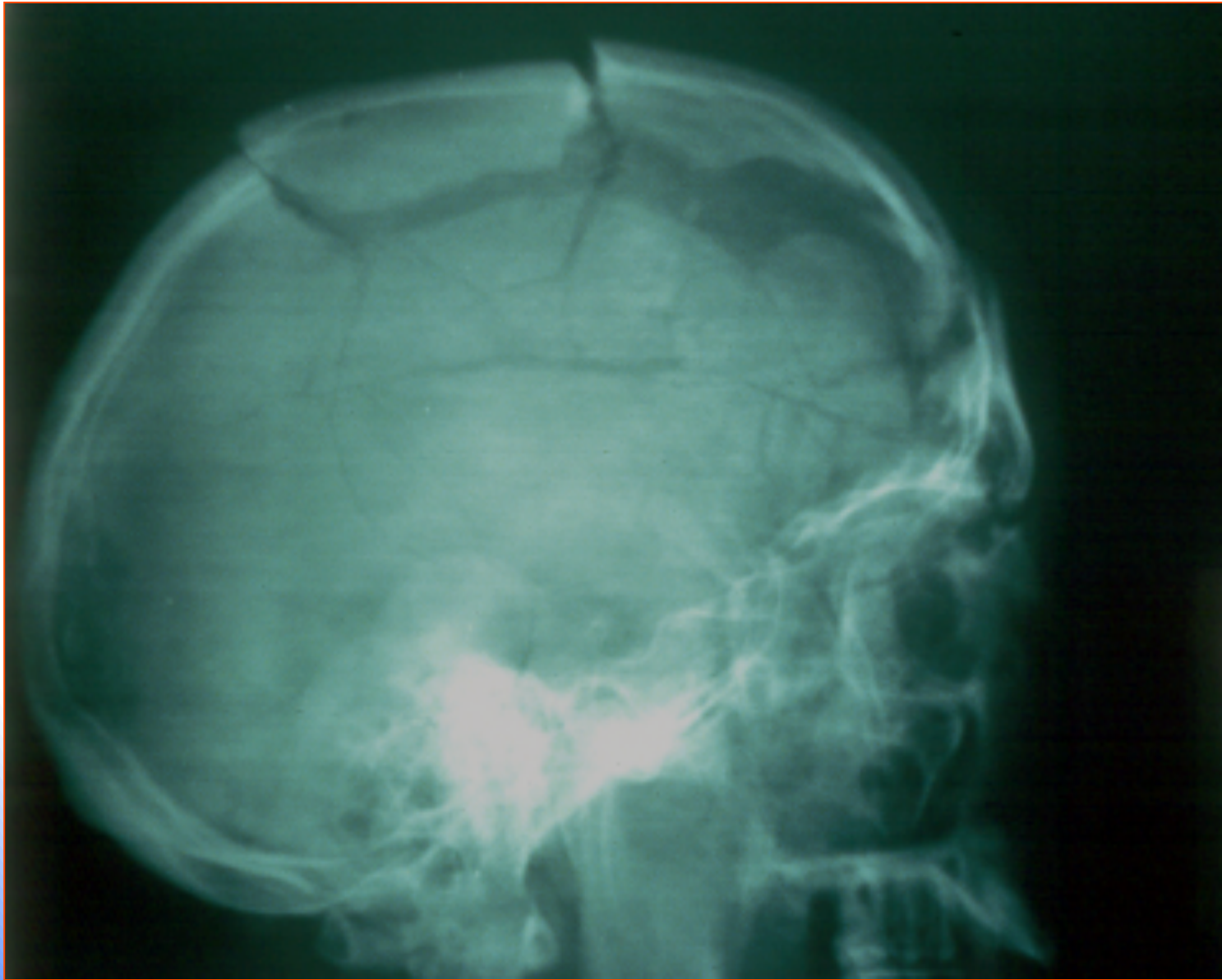


# Depressed Parietal Skull Fracture





# Skull Fracture



# Basilar Skull Fracture

- Clinical diagnosis – can cause CSF oto- or rhinorrhea, bleeding from the ear canal, ecchymosis of the mastoid area or orbital area, cranial nerve deficits (V, VI, VII and VIII [hearing loss, nystagmus, ataxia])
- Most CSF leaks resolve spontaneously within a week
- **Prophylactic antibiotics don't decrease the risk of meningitis with CSF leaks**
- **Skull x-rays and CT are often negative**
- CT findings: Air-fluid level in sphenoid sinus, air in the posterior fossa
- Ring test for CSF: Halo of clear fluid beyond blood-tinged fluid / CSF fluid is glucose-positive

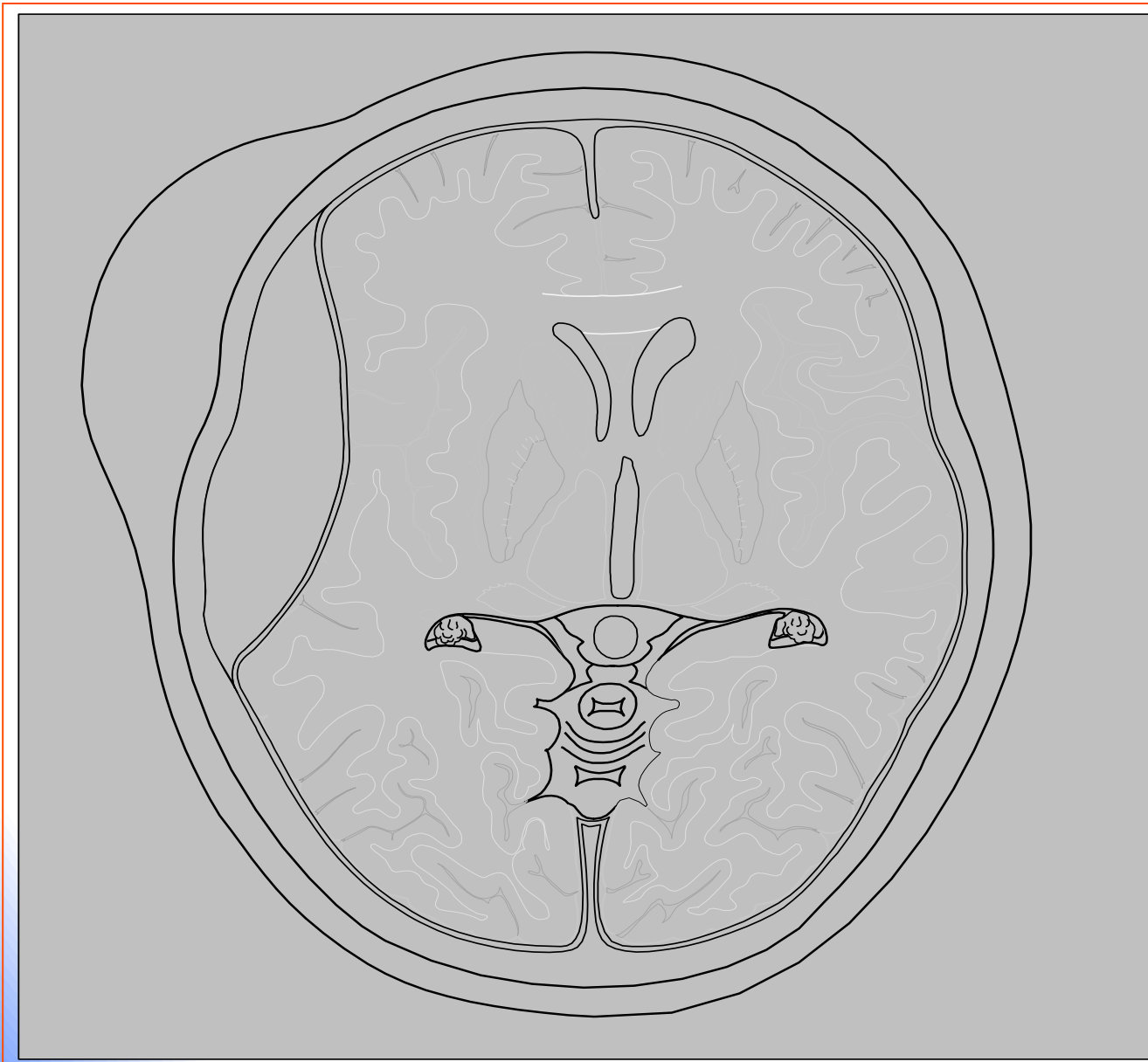
# Basilar Skull Fracture Findings (Battle's Sign / Hemotympanum)



# Epidural Hematoma

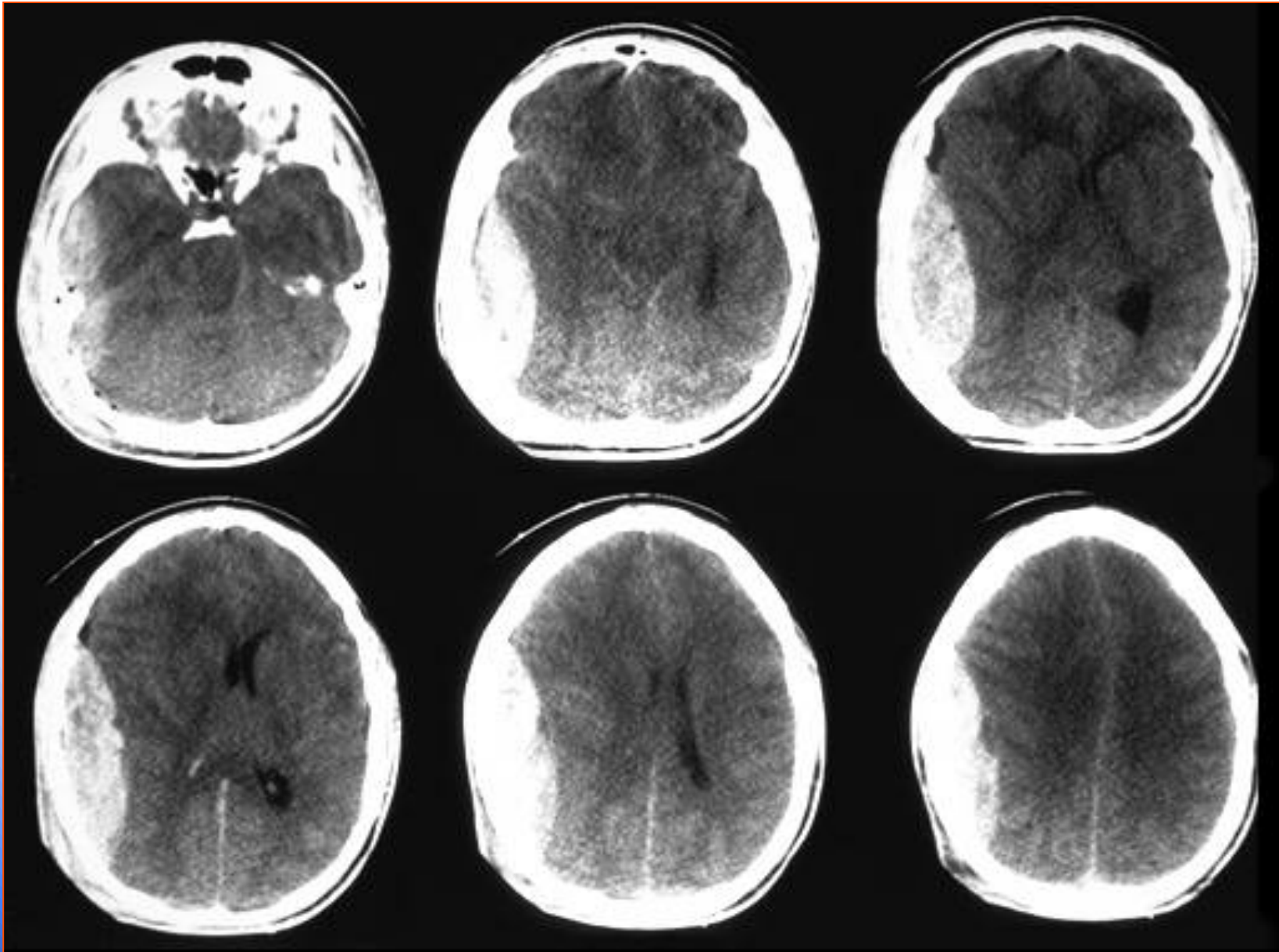
- Usually arterial bleed (middle meningeal artery) between skull and dura
- Early underlying brain injury may be mild
- Presentation (classic)
  - Immediate LOC
  - Lucid interval
  - Skull fracture
  - Dilated ipsilateral pupil in 85% (indicates impending herniation)
- CT: Biconcave (lens-shaped) bleed

# Epidural Hematoma





# Epidural Hematoma



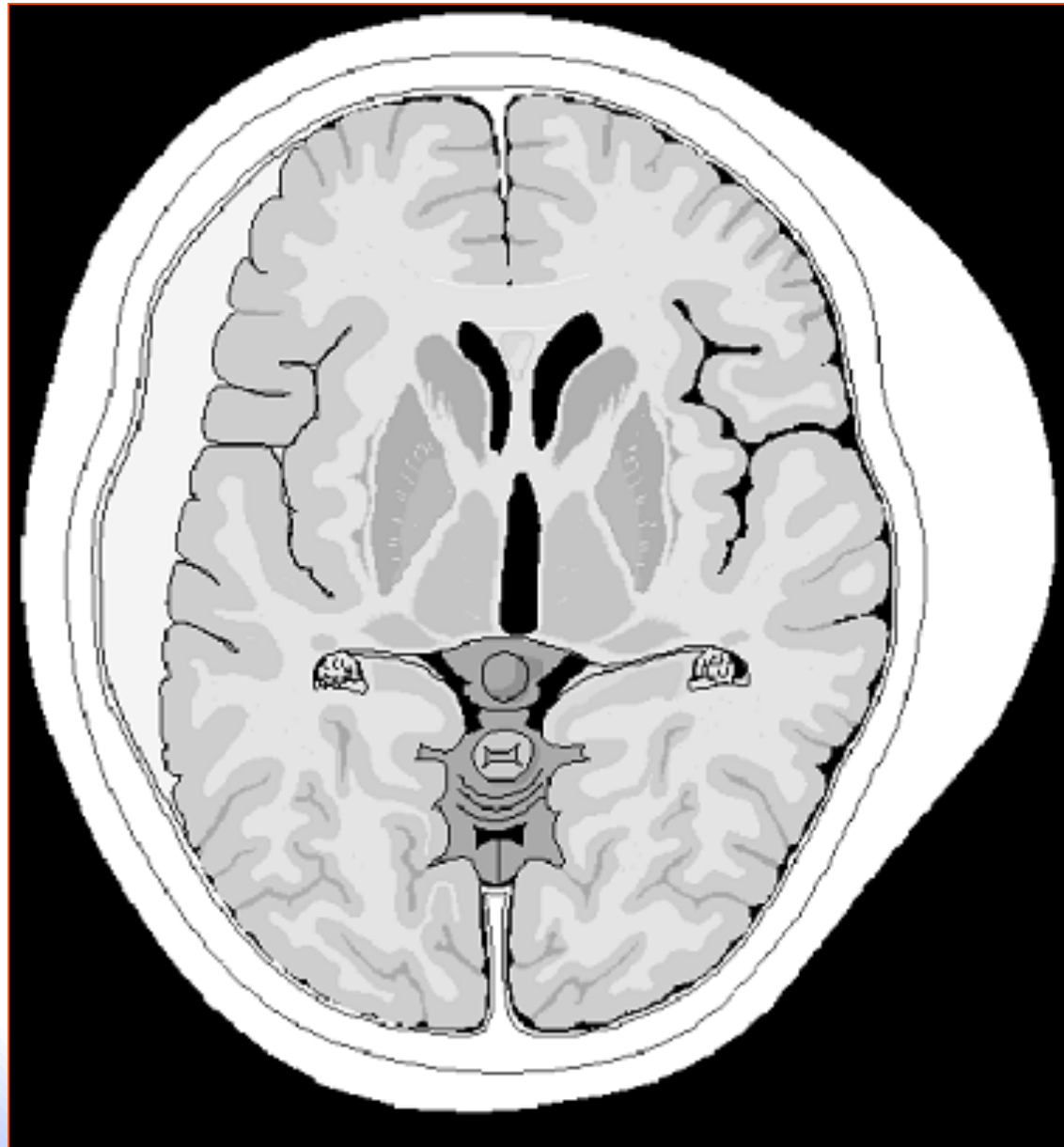
# Subdural Hematoma

- Bridging veins between dura and arachnoid
- Elderly, alcoholics at increased risk
- Presentation
  - Pupil less reactive
  - Decreased mental status, LOC
  - May have lucid interval (more common in epidurals)
- Classification
  - Acute: <24 hours (white on CT)
  - **Subacute: 24 hours-2 weeks (isodense on CT)**
  - Chronic: >2 weeks (dark on CT)
- CT: Crescent-shaped bleed

**Six times more common than epidurals**

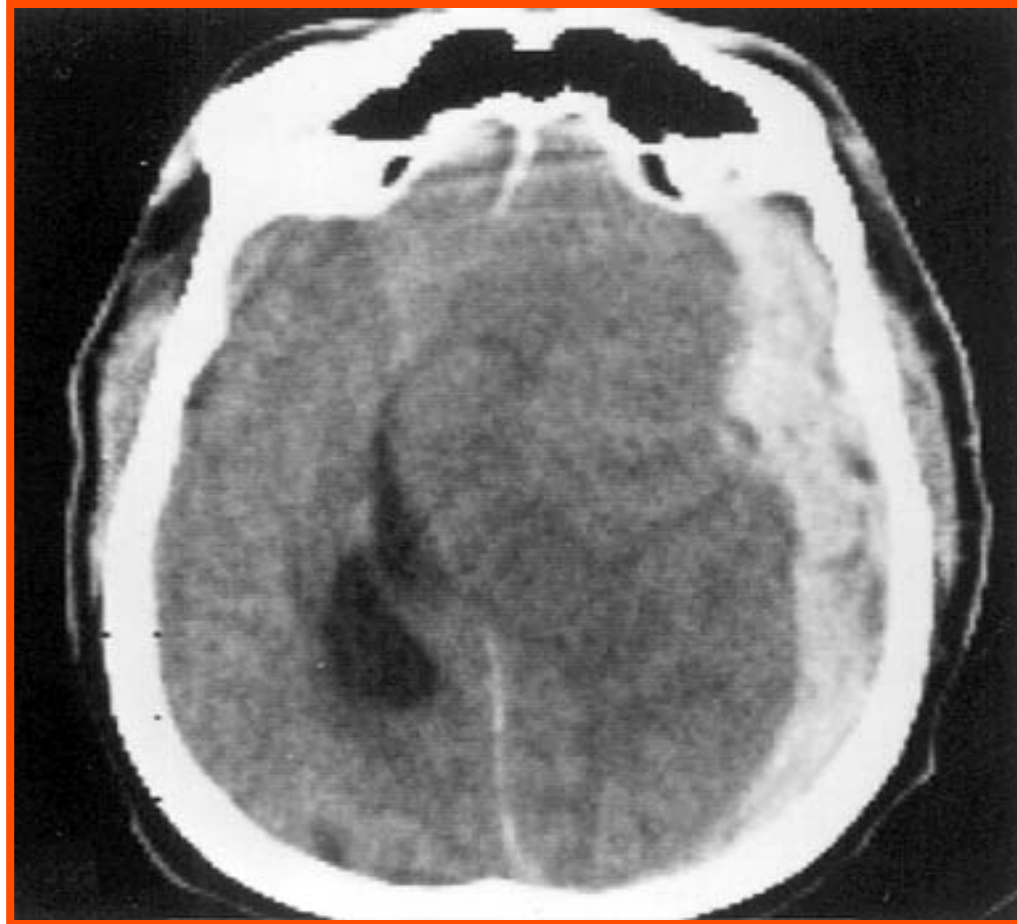
**Higher mortality rate than epidurals**

# Subdural Hematoma : Contrecoup





# Subdural Hematoma



Subdural blood is free to spread over the convexity of the brain while extension of epidurals is restricted by attachments of the dura to the skull

# Intracerebral Hemorrhage (1)

- Transtentorial herniation
  - Mass effect (hemorrhage, edema) pushes medial temporal lobe (uncus) through the tentorial notch
  - Compression of CN III causes **ipsilateral fixed, dilated pupil**
  - Compression of ipsilateral corticospinal tract causes contralateral hemiplegia
    - Sometimes the opposite corticospinal tract is compressed producing ipsilateral hemiplegia
  - Brainstem compression causes coma

# Intracerebral Hemorrhage (2)

- Central herniation
  - Mass effect causes downward displacement of entire brainstem
  - Earliest sign is CN VI (lateral rectus) palsy
  - Bilateral uncal herniation
- Tonsillar herniation (rare)
  - Cerebellar tonsils herniate through foramen magnum
  - Respiratory arrest and death

# Increased ICP Treatment

- Intubate if GCS  $\leq 8$
- Hyperventilation is controversial
  - Decreased pCO<sub>2</sub>, increased pH, decreased ICP, vasoconstriction
  - Goal: pCO<sub>2</sub> 30-35 mm Hg
  - Avoid excessive hyperventilation
- Mannitol
  - Osmotic diuretic (1 g/kg)
  - Controversial in children
- Steroids not beneficial

Cerebral perfusion pressure =  
(mean arterial pressure) – (intracranial pressure)

# Traumatic Seizures

- Immediate, brief seizure with non-focal exam after trauma is usually benign: No therapy needed!
- High risk for seizures when:
  - Mass effect or focal examination
  - Depressed skull fracture
  - Penetrating injury
  - GCS < 10
- Anticonvulsant prophylaxis: Phenytoin, levetiracetam (Keppra)
- Delayed posttraumatic seizures
  - Increased incidence with intracranial bleed, depressed fracture
  - Most occur within the first year
  - Treatment: Phenytoin, levetiracetam (Keppra)

# Pediatric Head Trauma

- Poor pressure/volume curve
- More non-surgical lesions
  - Diffuse cerebral edema
  - Diffuse axonal shear
  - Contusions
  - Peds concussion syndrome (diffuse cerebral hyperemia)
- GCS may wax and wane
- Skull is much weaker

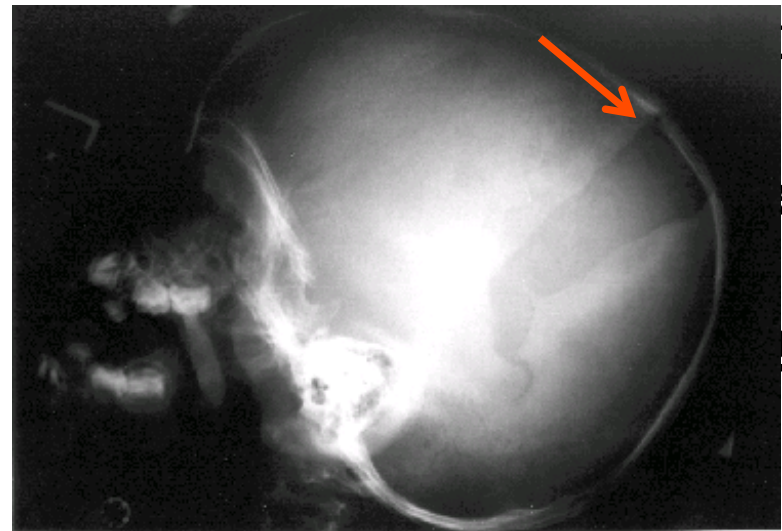
# Pediatric “Minor” Head Trauma (1)

- Children less than 2 (and particularly under 6 months) are considered at increased risk for initially serious head injuries
  - Skulls are thinner / fracture more easily (60%-70% parietal area)
    - A skull fracture increases the risk by a factor of 4-20 fold
    - Scalp hematomas are considered potential markers for fractures
    - Some consider scalp hematomas (particularly large ones) are important predictors of fracture, especially in the temporal and parietal area (90% of fractures have scalp hematomas)



## Pediatric “Minor” Head Trauma (2)

- IC injury has been associated with “minor mechanisms” in infants
- “Growing fractures” = Leptomeningeal cyst that enlarges over time, associated with a tear of the underlying dura and initially have  $> 4\text{mm}$  fragment separation
  - May feel a skull defect or local swelling, seizures, neuro deficits
  - Median age 18 months / require surgical repair
  - All fractures are advised to re-x-rayed in two months evaluate for signs of a fracture



# Pediatric “Minor” Head Trauma

- Concussion = A transient alteration in mental status after head trauma [e.g., LOC, amnesia] with a lack of focal neurologic findings **(may not have LOC)**
  - Patients (adults or children) with a normal CT can still have a concussion, MRI may show some subtle abnormalities / Grade III = LOC = no sports for variable time thereafter
- Post-concussive syndrome = Long-term neuropsychologic sequelae (insomnia, irritability, inability to concentrate, headache, dizziness, anxiety, etc)
- “Second impact syndrome” = Irreversible brain injury triggered by a fairly routine second head impact after a prior concussion
  - speculated mechanism = disordered autoregulation



## Penetrating Neck Injuries

Slash, from Guns  
and Roses.....

# Penetrating Neck Injury (1)

- Any wound which violates platysma
- Most injuries occur in Zone II
  - Vascular > CNS
  - Peripheral nerves > brachial plexus
- Vascular injuries need proximal and distal control
- Death from CNS injury, exsanguination, airway compromise (intubate early)
- Air embolism is potentially fatal complication
  - Machinery murmur
  - Trendelenburg + left lateral decubitus position to prevent bubble migration

## Penetrating Neck Injury (2)

- Hard signs (significant injury probably exists)
  - Hypotension
  - Arterial bleeding
  - Expanding hematoma
  - Thrill, bruit
  - Focal deficits
  - Hemothorax >1,000 mL
  - Bubbling wound
  - Hemoptysis, hematemesis
- Soft signs (require full diagnostic evaluation)
  - Stridor
  - Hoarseness
  - Vocal cord paralysis
  - Subcutaneous air
  - Facial nerve injury

## Penetrating Neck Injury (3)

- Hard signs: Unstable require surgical exploration
  - Zone I: Requires thoracic surgical approach
  - Zone II: Exploration technically least difficult
  - Zone III: May require disarticulation of mandible
- Stable patients (evaluation)
  - Zone I: Angiogram, esophagram, endoscopy, bronchoscopy
  - Zone II: Exploration or angiogram, esophagram, endoscopy, bronchoscopy
  - Zone III: Angiography



# Stab Wound Neck



**Zone III**

**above angle  
of the mandible**

**Zone II**

**between  
mandible - cricoid**

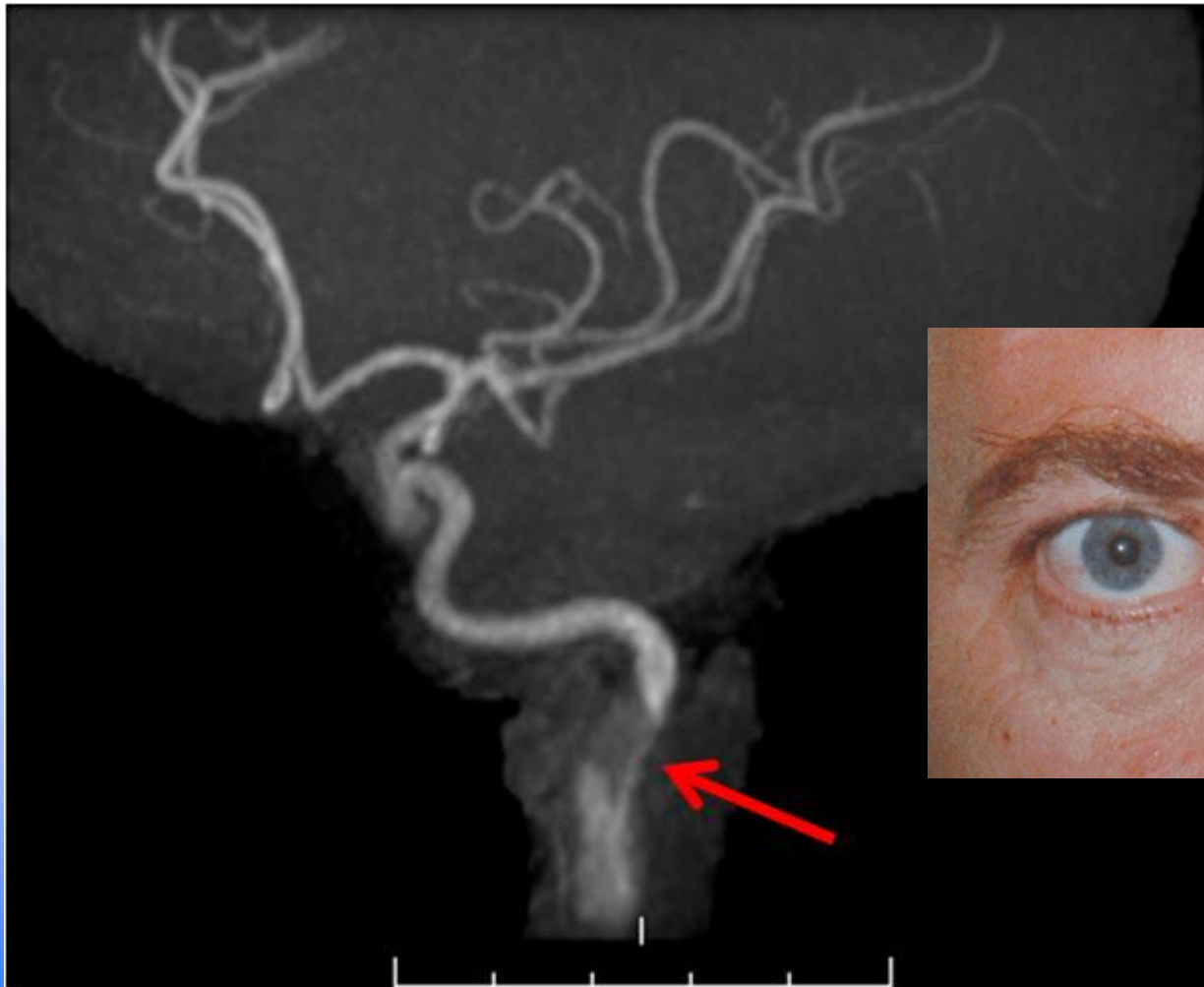
**Zone I below  
cricoid cartilage**



## Blunt Neck Trauma

- Mechanism: Steering wheel, dashboard, shoulder belt shearing forces, clothesline injuries
- Laryngotracheal and pharyngoesophageal injuries can be subtle; require diagnostic imaging
- Carotid/vertebral artery injury: Pseudoaneurysm or dissection
  - Mechanism: Hyperextension, hyperflexion, direct blow, intraoral trauma, basilar skull fracture
  - Neurologic symptoms may be delayed
- CT with contrast

# Carotid Artery Dissection



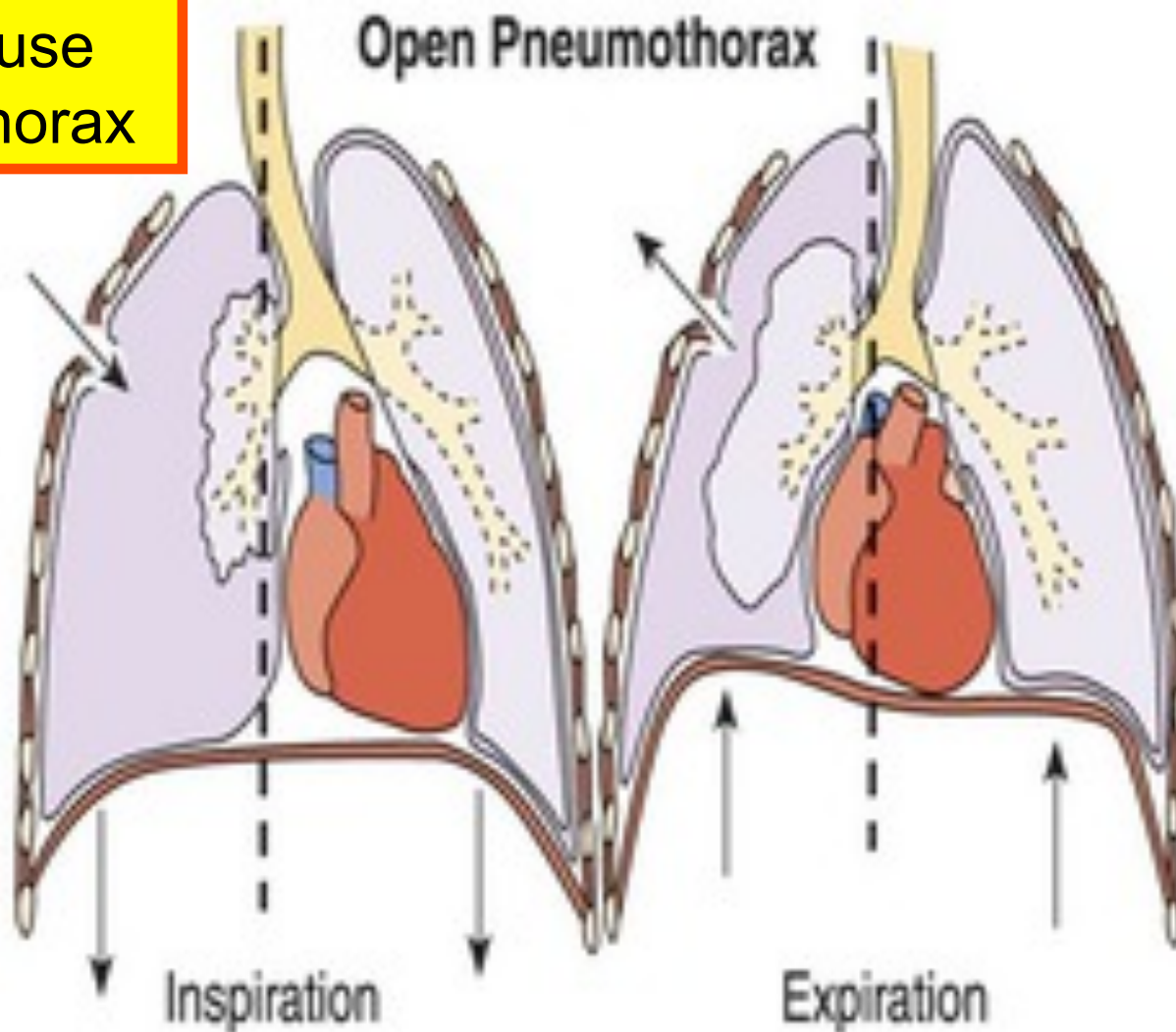
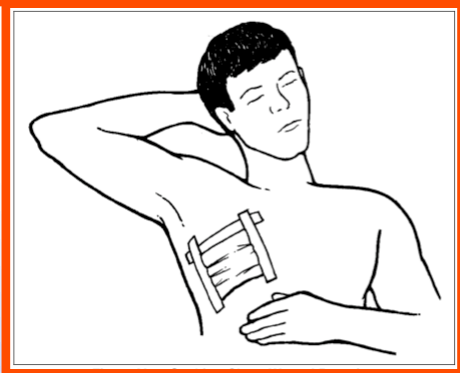
**Neck trauma + TIA, stroke, or Horner's syndrome**

# Chest Trauma

- Thoracic trauma causes  $\frac{1}{4}$  of trauma deaths
- Hypotension + blunt trauma: Pelvic fracture > intraabdominal injury > intrathoracic injury
- Hypotension + penetrating trauma: Lung > heart > great vessels
- Open (sucking) chest wound: Occlusive petrolatum gauze can cause tension pneumothorax
  - Immediate treatment: Remove dressing
  - Definitive treatment: Chest tube
- Needle thoracostomy: 2<sup>nd</sup> intercostal space, midclavicular line

# Sucking Chest Wound

Application of occlusive dressing can cause tension pneumothorax



# Chest Trauma

- Open thoracotomy
  - Penetrating trauma and loss of vital signs
  - Poor outcome for blunt trauma
  - Incision at 5<sup>th</sup> ICS, open pericardium vertically, anterior to phrenic nerve

Because of their anterior location, the right ventricle and right atrium are most commonly injured in penetrating trauma

# Rib Fractures

- Clinical diagnosis: Localized pain, tenderness
- May not be seen on X-ray
- Rule out
  - Pneumothorax
  - Pulmonary contusion
  - Vascular injury
- Multiple rib fractures
  - Two or more: Increased risk of internal injuries
  - Lower ribs: Increased risk of liver, kidney, spleen injuries
  - Admit: Elderly, pre-existing pulmonary disease
  - Delayed findings: Pneumothorax, aspiration, pulmonary contusion
- Treatment: Pain medication, nerve block

## 1<sup>st</sup> and 2<sup>nd</sup> Rib Fractures

- Often have associated occult injury
- Great force involved
- Significant mortality
- Rule out
  - Myocardial contusion
  - Bronchial tear
  - Vascular injury (consider angiogram)
- If no evidence of neurovascular compromise
  - No increased morbidity, angio not mandatory

**Scapular fractures are also associated with occult chest injury**



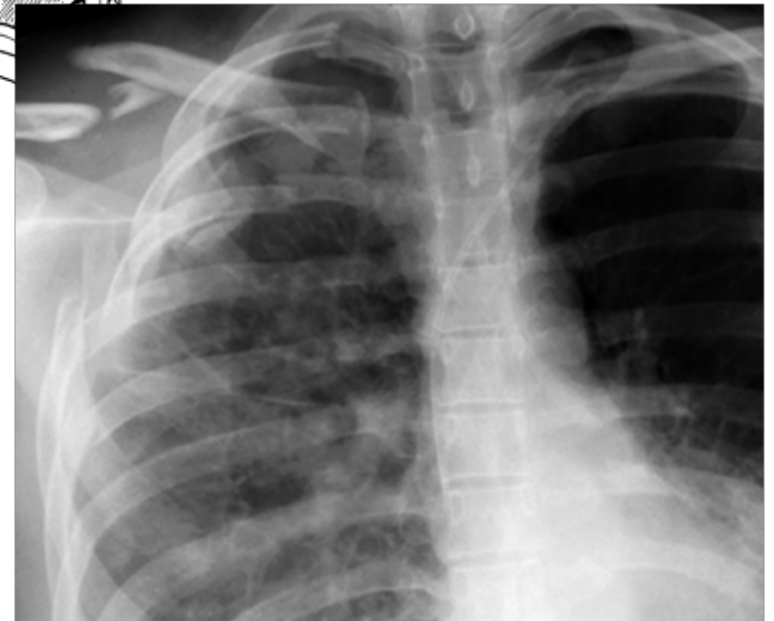
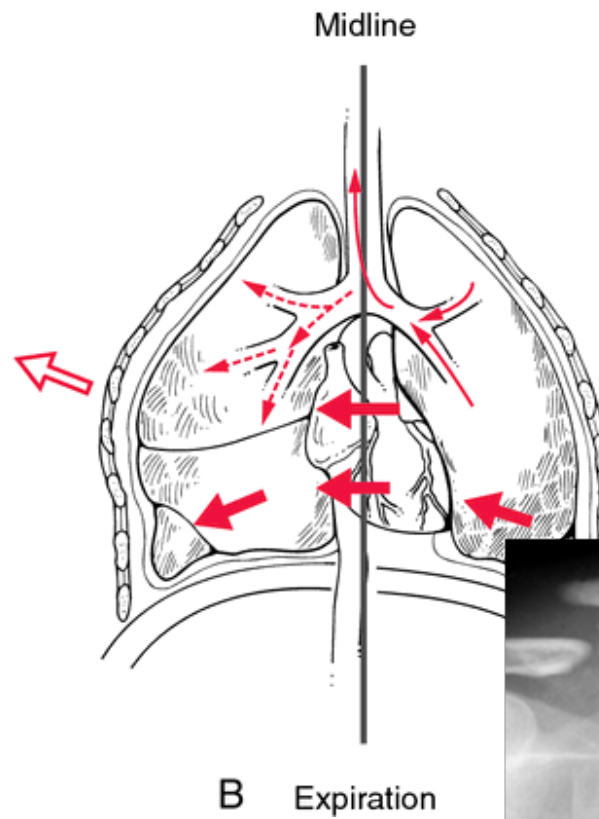
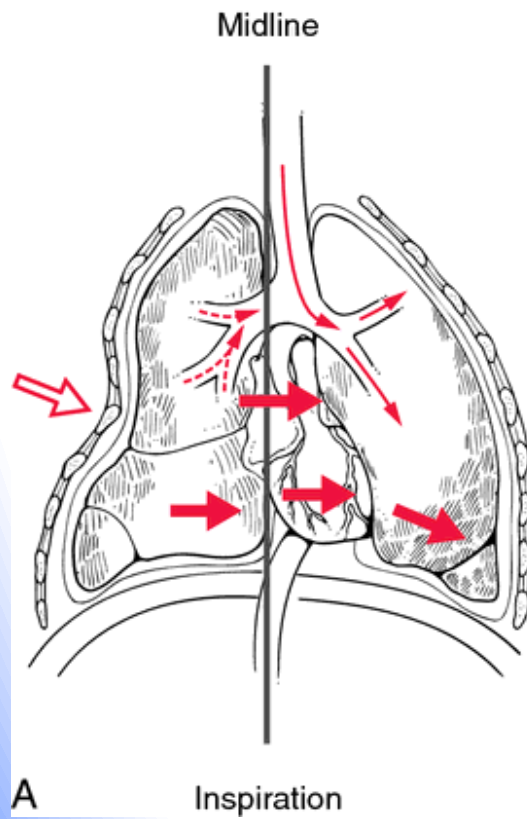
## Flail Chest

- Segmental fracture of 3 or more ribs
- Paradoxical chest wall movement
- Decreased ventilation and venous return
- Treatment: Direct pressure, intubation, consider chest tube
- Main cause of hypoxemia: Pulmonary contusion

## Sternal Fracture

- MVA is most common cause (steering wheel, seat belt)
- Associated with myocardial contusion
- Consider cardiovascular injury

# Flail Chest

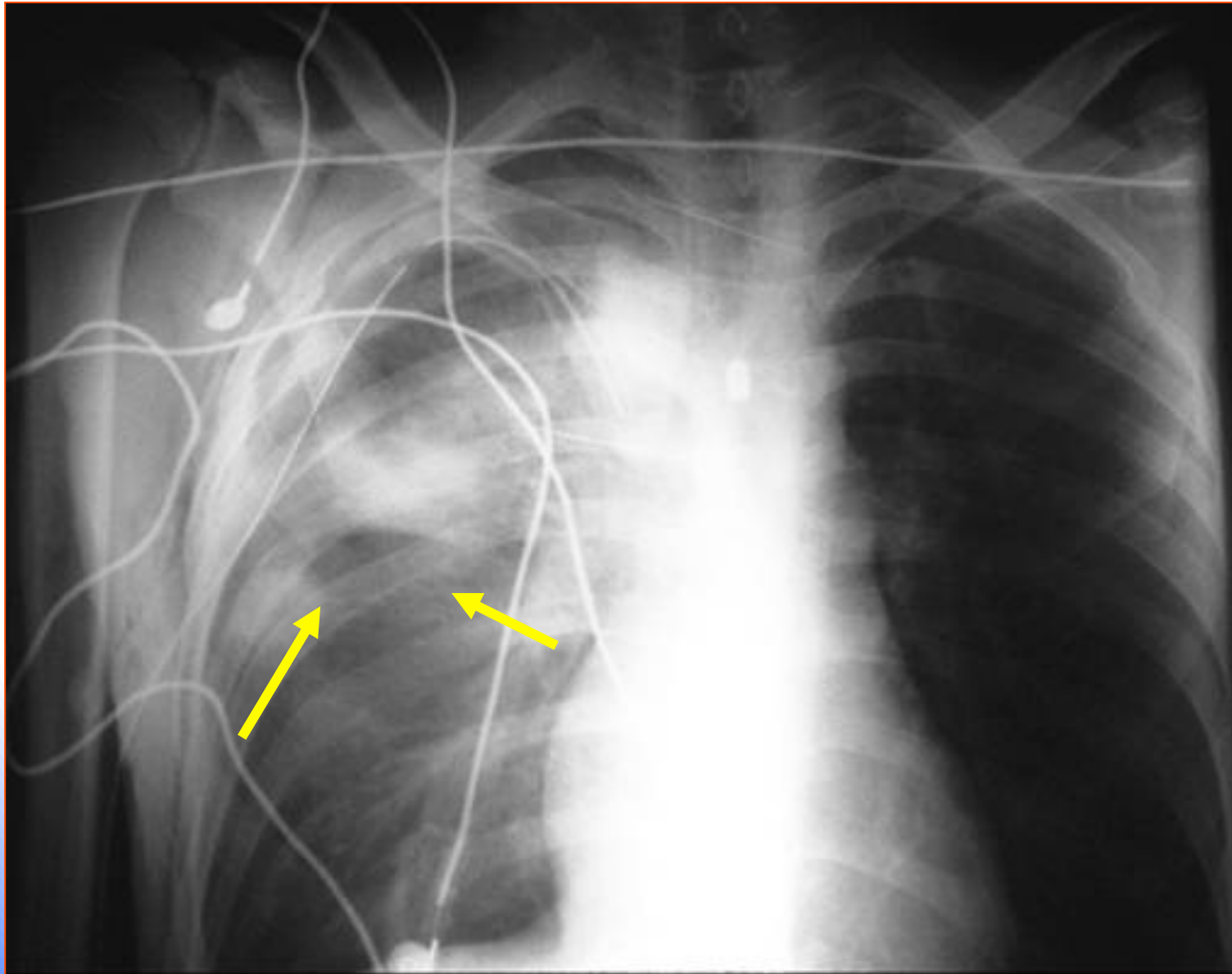


# Pulmonary Contusion

- Interstitial edema, capillary damage, bleeding
- Hemoptysis is common
- Decreased compliance, hypoxemia, atelectasis
- X-ray findings range from patchy alveolar infiltrates to consolidations; can be delayed up to 6 hours
- Aggressive fluid resuscitation can be harmful
- Treatment: Oxygenation, ventilation, PEEP or permissive hypercapnia, keep dry

**Commonly associated with flail chest**

# Pulmonary Contusion



# Tracheobronchial Injury

- Seen with deceleration and shear forces
- Most blunt injury occurs within 2 cm of carina
- Continuous bubbling in chest tube is a sign of bronchopleural fistula
- High mortality with rupture
  - Symptoms / signs
    - Chest pain
    - Dyspnea
    - Hypoxemia
    - Hamman's crunch  
(mediastinal friction rub  
w/ heart beat)
    - Hemoptysis
    - Subcutaneous  
emphysema
  - CXR
    - Pneumothorax
    - Pneumomediastinum
    - Tension pneumothorax
    - Rib fracture
  - Treatment
    - Oxygenation
    - Ventilation
    - Chest tube

# Hemothorax (1)

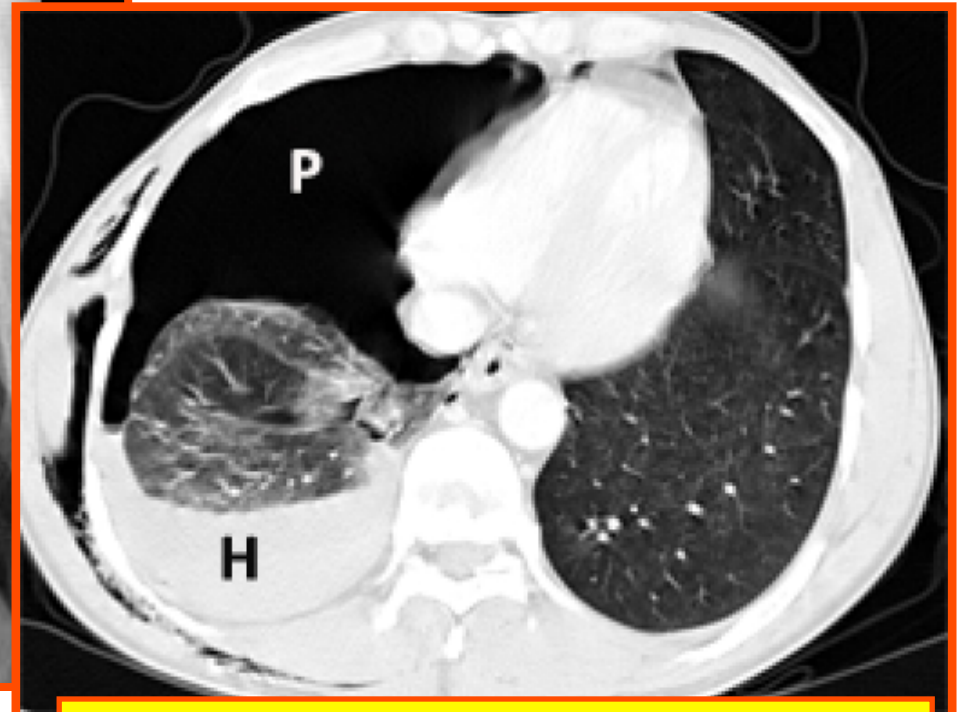
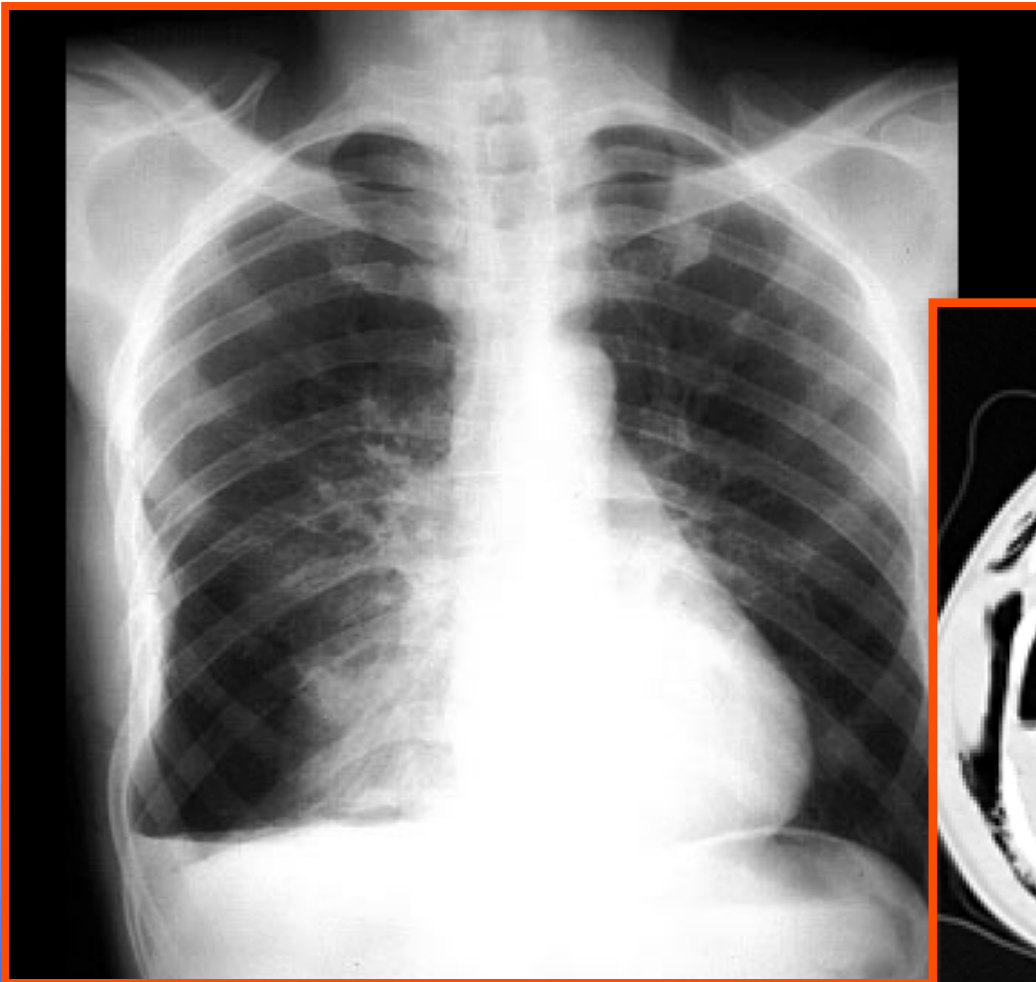
- Decreased breath sounds, dullness to percussion
- Intercostal artery injury is a common cause
- Upright CXR: Blunting of CPA (200-300 mL)
  - Volumes of up to 1000 mL may be missed on supine CXR
- Beware of right mainstem intubation with white-out of opposite lung (don't confuse with hemothorax)
- Often associated with pneumothorax
- Layers out on a supine film (CT)

## Hemothorax (2)

- Diagnosis: CXR, ultrasound, CT
- Treatment: Thoracentesis, chest tube (36-40F)
- Autotransfusion if capability exists
- Thoracotomy indications
  - Unstable
  - Initial output >1500 mL
  - >100 mL/ hr x 6 hours
  - Persistent air leak



# Hemothorax



(Pneumothorax also present)

# Pneumothorax

- Chest pain, dyspnea, subcutaneous emphysema
- CXR: Findings can be delayed; repeat in 4 to 6 hours if symptoms persist
- Treatment: Oxygen, chest tube
- Open pneumothorax
  - Air moves in and out of wound
  - 3-sided petrolatum gauze, one-way valve, chest tube
  - Dressing can create a tension pneumothorax; remove dressing if patient has increased SOB



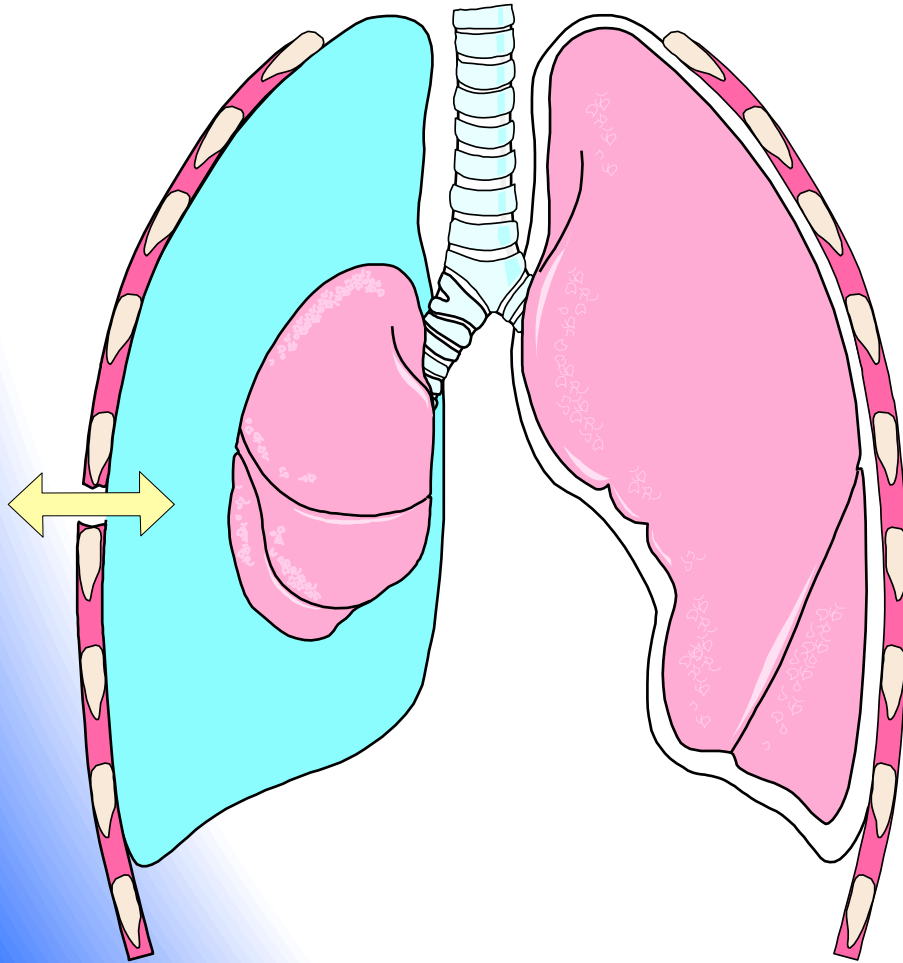
**Expiratory chest X-ray is the most helpful diagnostic test**

# Tension Pneumothorax

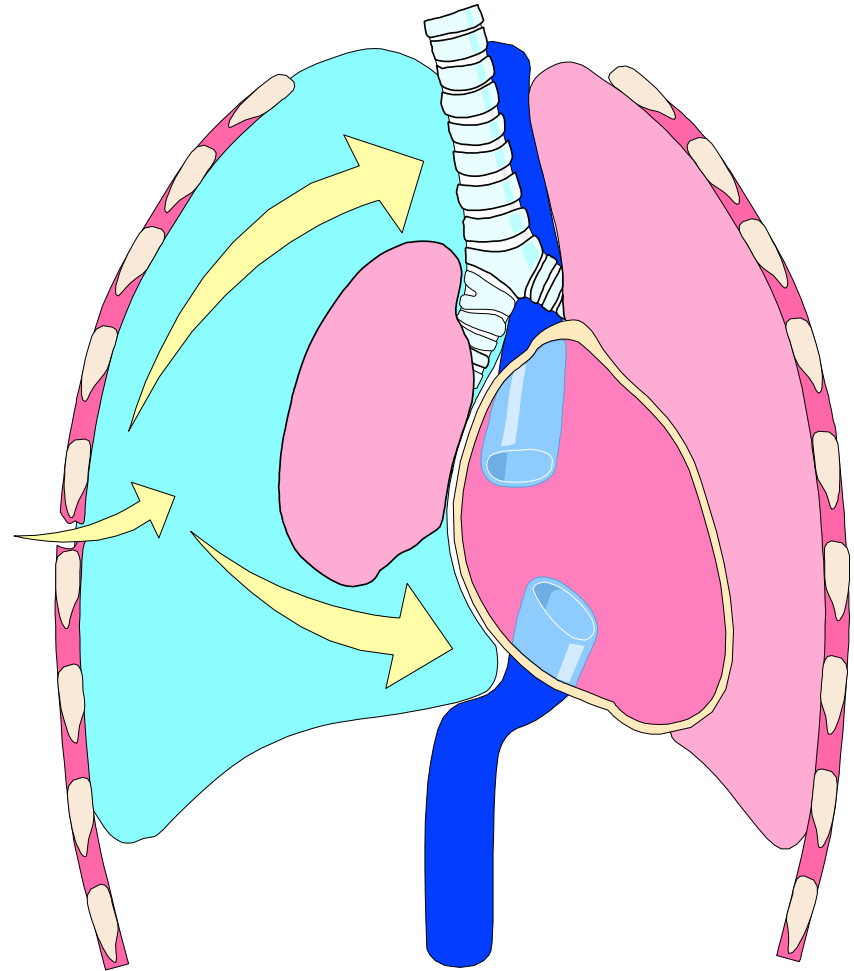
- Severe dyspnea, decreased breath sounds, distended neck veins
- Classic findings: Tracheal deviation to opposite side, hyperresonance, no breath sounds
- Decreased venous return, hypoxemia, cardiac arrest
- Treatment: Immediate needle thoracostomy, chest tube thoracostomy

**Do not wait for X-ray**

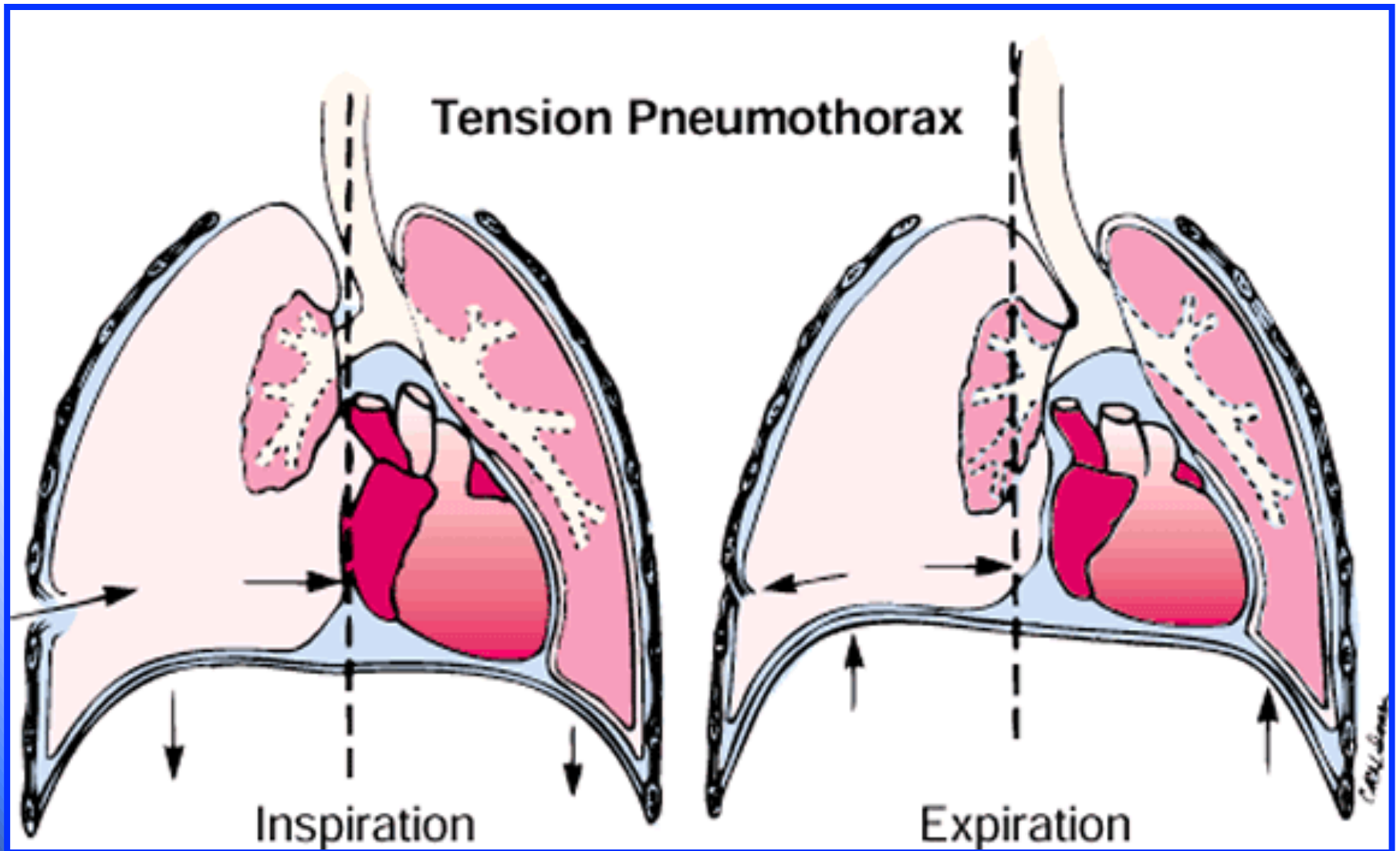
## Normal Pneumothorax



## Tension Pneumothorax



# Tension Pneumothorax



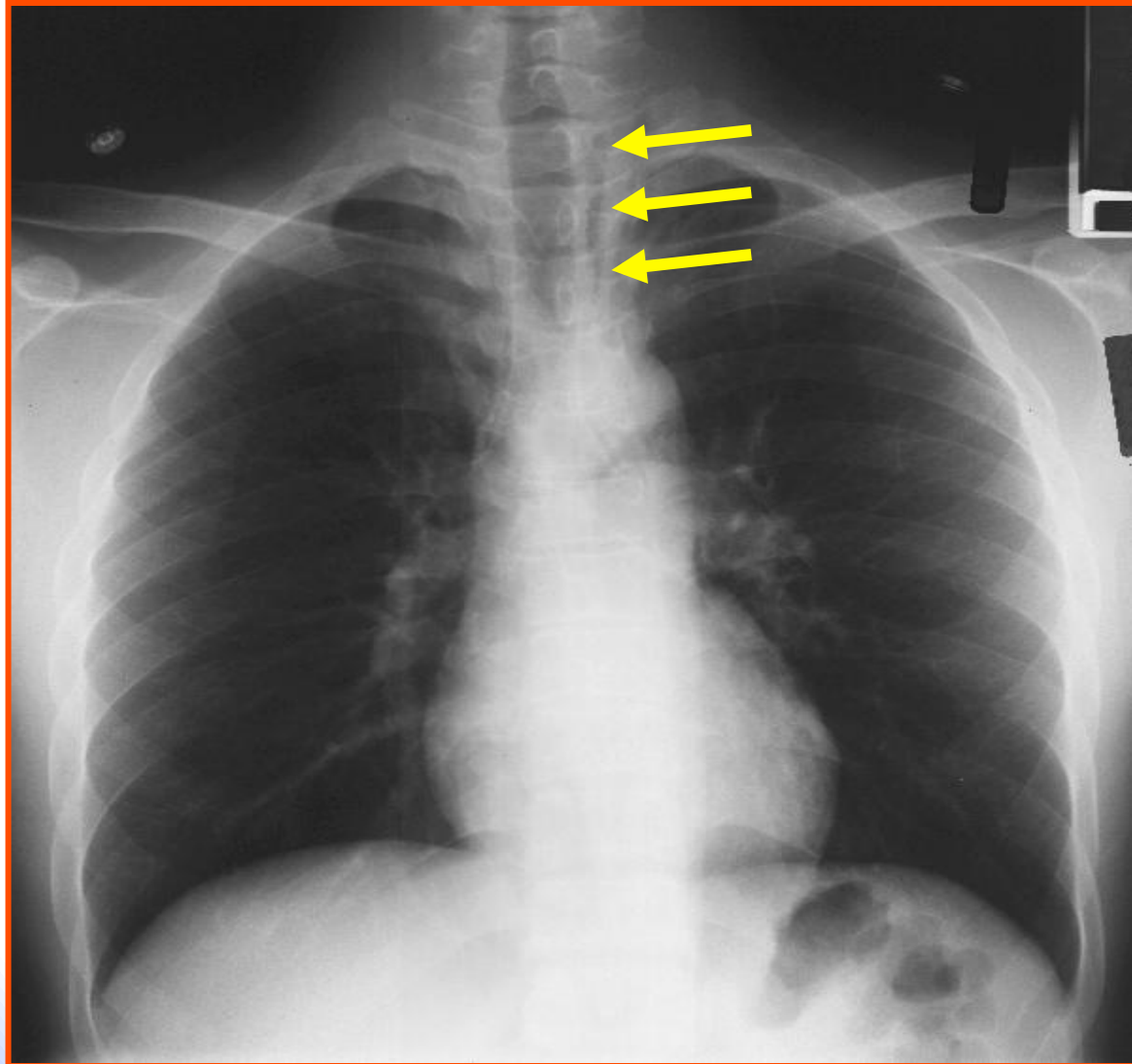
# Pneumomediastinum

- Subcutaneous emphysema
- Hamman's sign: Crunching sound during systole
- Spontaneous due to increased intrabronchial pressure
  - Mechanical ventilation
  - Valsalva with drug abuse
  - Restraint of a combative pt
  - Sneezing
  - Ruptured bleb
- Tension pneumomediastinum
  - Decreased cardiac output
  - Decompression via neck dissection





# Pneumomediastinum





# Diaphragm: Traumatic Injuries

- Usually penetrating trauma to chest or upper abdomen
- Location: Usually left posterolateral (right handed assailant)
- Right side more often missed (masked by liver)
- CXR often abnormal, but not diagnostic
- DPL, CT, ultrasound may not be diagnostic
- Often diagnosed at laparotomy
- Treatment: Surgical repair
- Small injuries will continue to enlarge

**Diagnosis is often missed or delayed**

# DIAPHRAGM SUMMARY

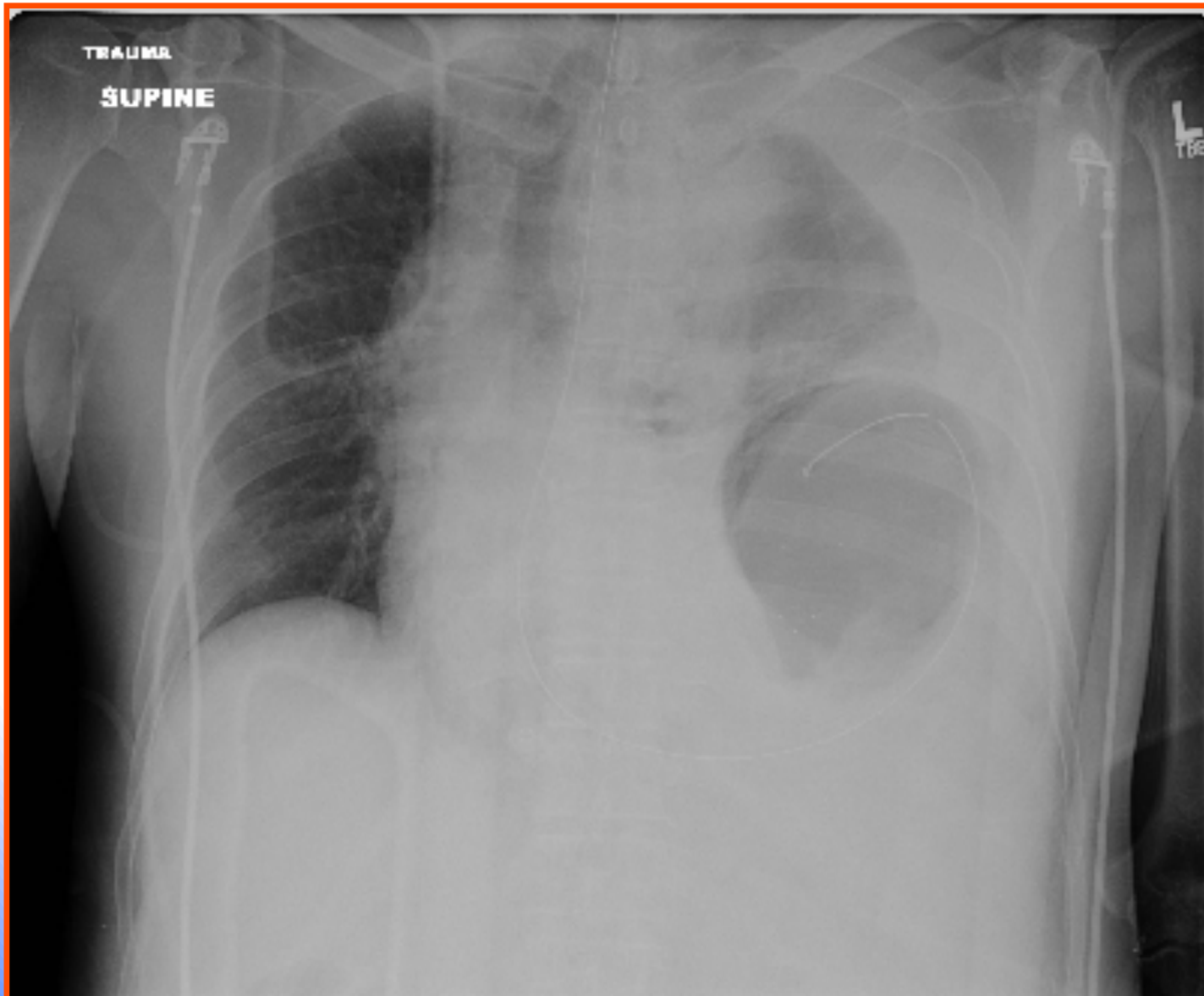
## Blunt Mechanism

- L > R
- Anterior aspect
- Large rent (6-10cm)
- Delayed diagnosis (by 48 hours)
- L hemothorax
- Translocation 50%
- CXR abnormal but not diagnostic

## Penetrating Mechanism

- L > R
- Posteriorly (SW in L flank)
- Small tear (2-3 cm)
- Delayed diagnosis (by years until herniation)
- Normal CXR
- Translocation rare
- Late herniation and strangulation

# Ruptured Diaphragm

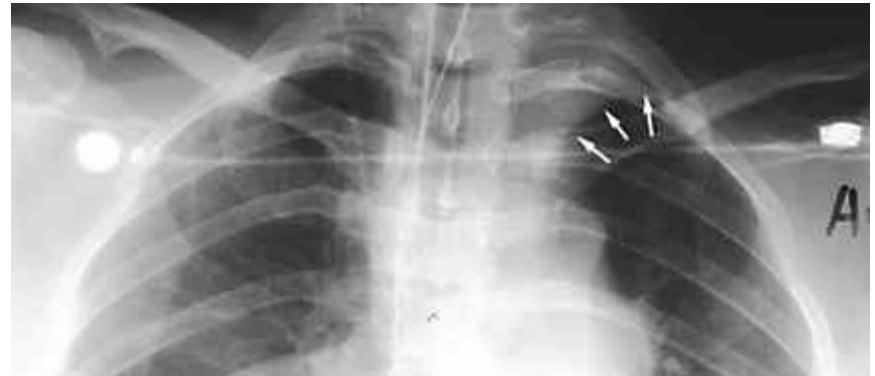


# Traumatic Ruptured Aorta (TRA) (1)

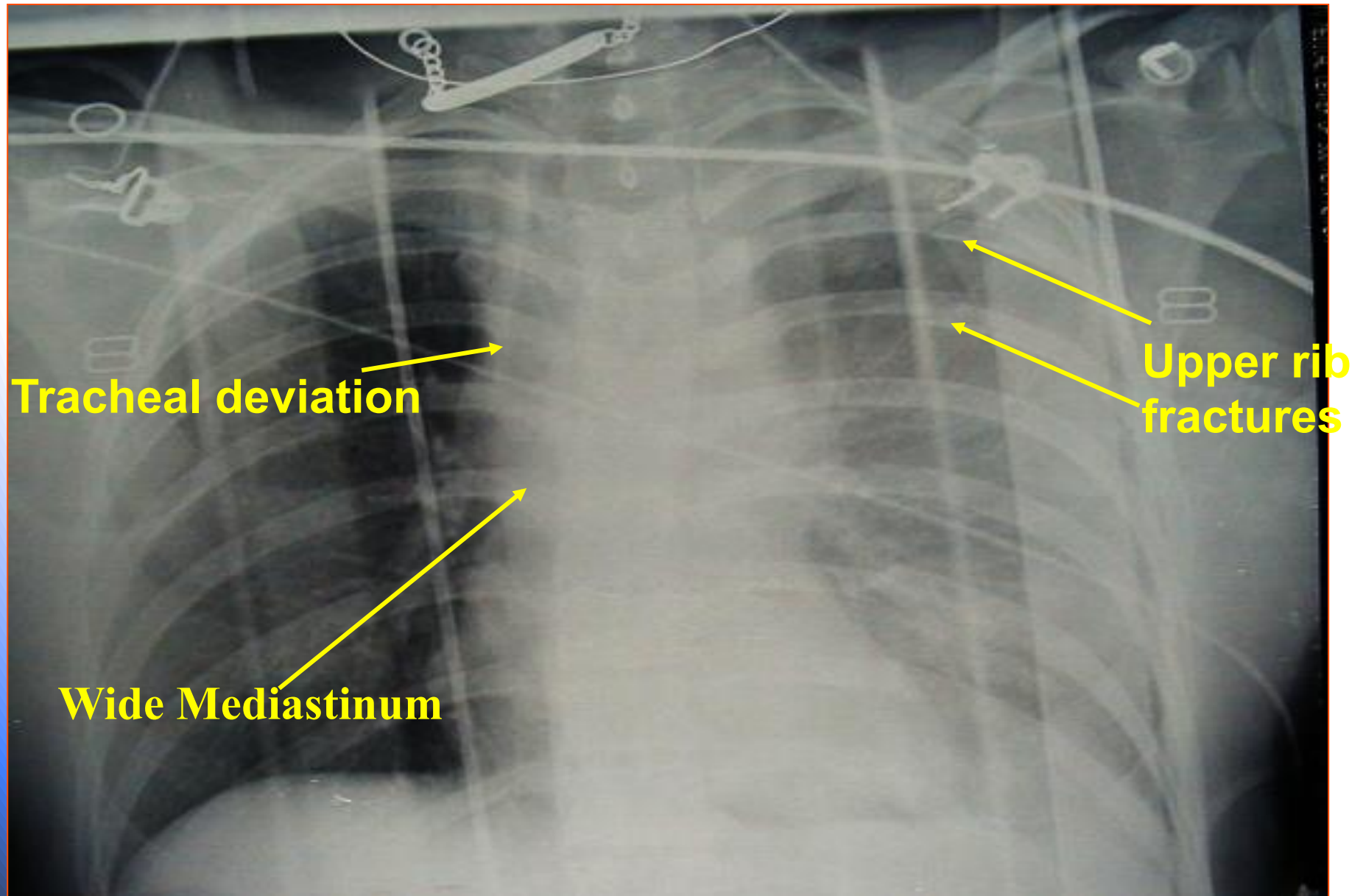
- Most often, tear at isthmus 2° to deceleration (victims die immediately at scene)
- Survivors who reach ED usually have tear at the ligamentum arteriosum
- Preexisting vascular disease (atherosclerosis) does not predispose to injury
- Retrosternal pain, dyspnea, stridor, dysphagia
- Harsh diastolic murmur (aortic valve)
- Pulse difference between upper and lower extremities

## Traumatic Ruptured Aorta (TRA) (2)

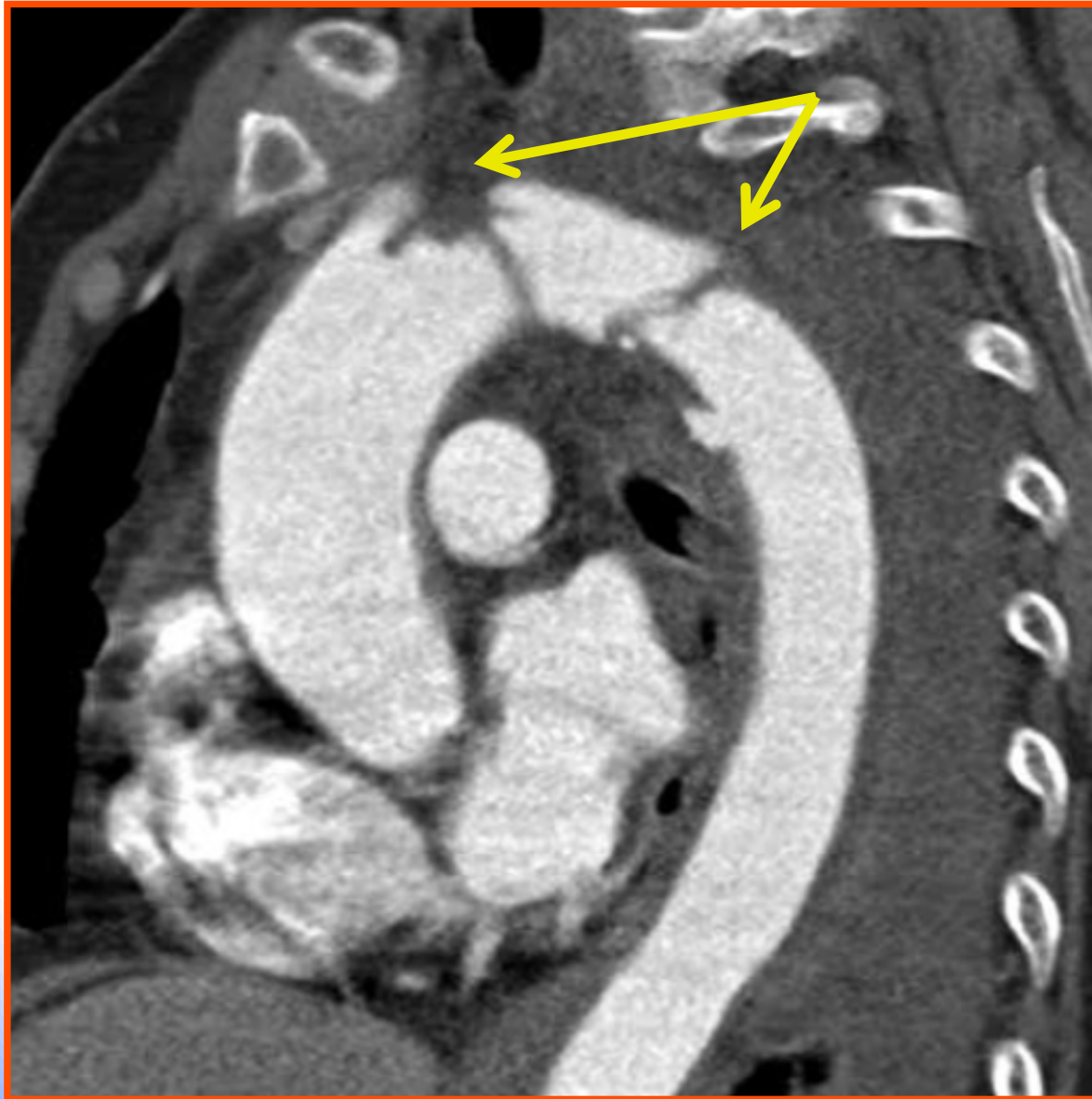
- Widened mediastinum on upright CXR: Most sensitive and specific X-ray finding associated with TRA
- Controversial if 1<sup>st</sup> and 2<sup>nd</sup> rib fractures are associated with TRA
- X-ray findings
  - Left apical cap
  - Blurred aortic knob
  - Left hemothorax, trachea deviated to right; NG tube deviated to right
  - Depressed left mainstem bronchus
  - Loss of aortic-pulmonary window



# Traumatic Ruptured Aorta (TRA)



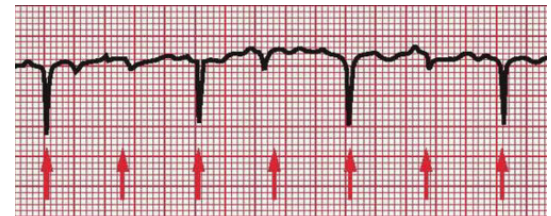
# Traumatic Aortic Transection





# Cardiac Tamponade

- More common in penetrating trauma
- Beck's triad: Hypotension, JVD, muffled heart sounds
- Pulsus paradoxus (weaker pulse, lower systolic pressure with inspiration)
- Electrical alternans: Alternating QRS  direction
- Diagnosis: Ultrasound
- Treatment: Pericardiocentesis, thoracotomy



**Cardiac rupture: most die at scene from shock, hemorrhage or tamponade**

# Myocardial Contusion

- Blunt trauma with deceleration forces
- Chest pain, sternal or rib fracture, dyspnea
- EKG: Slowed conduction, ectopy, ST-T wave changes, and tachycardia
- Diagnosis: Echocardiogram (wall motion defect), increased CK-MB (poor sensitivity)
- Significant associated trauma is most predictive (rarely isolated)
- Most heal without specific treatment
- Complications (rare)
  - Effusion                      - Aneurysm
  - Thrombosis                - Dysrhythmia

# Abdominal Trauma (1)

- $\frac{2}{3}$  blunt,  $\frac{1}{3}$  penetrating
- Blunt: MVA, direct blow, falls
- Seatbelt injuries
  - 3-point (lower rib fx and abdominal injuries)
  - Lap belt: frequent cause of abdominal injuries
  - Bowel compresses against vertebrae
  - Seatbelt sign
  - Injuries: Mesenteric laceration, hollow viscus tear, ruptured diaphragm, Chance fracture

## Abdominal Trauma (2)

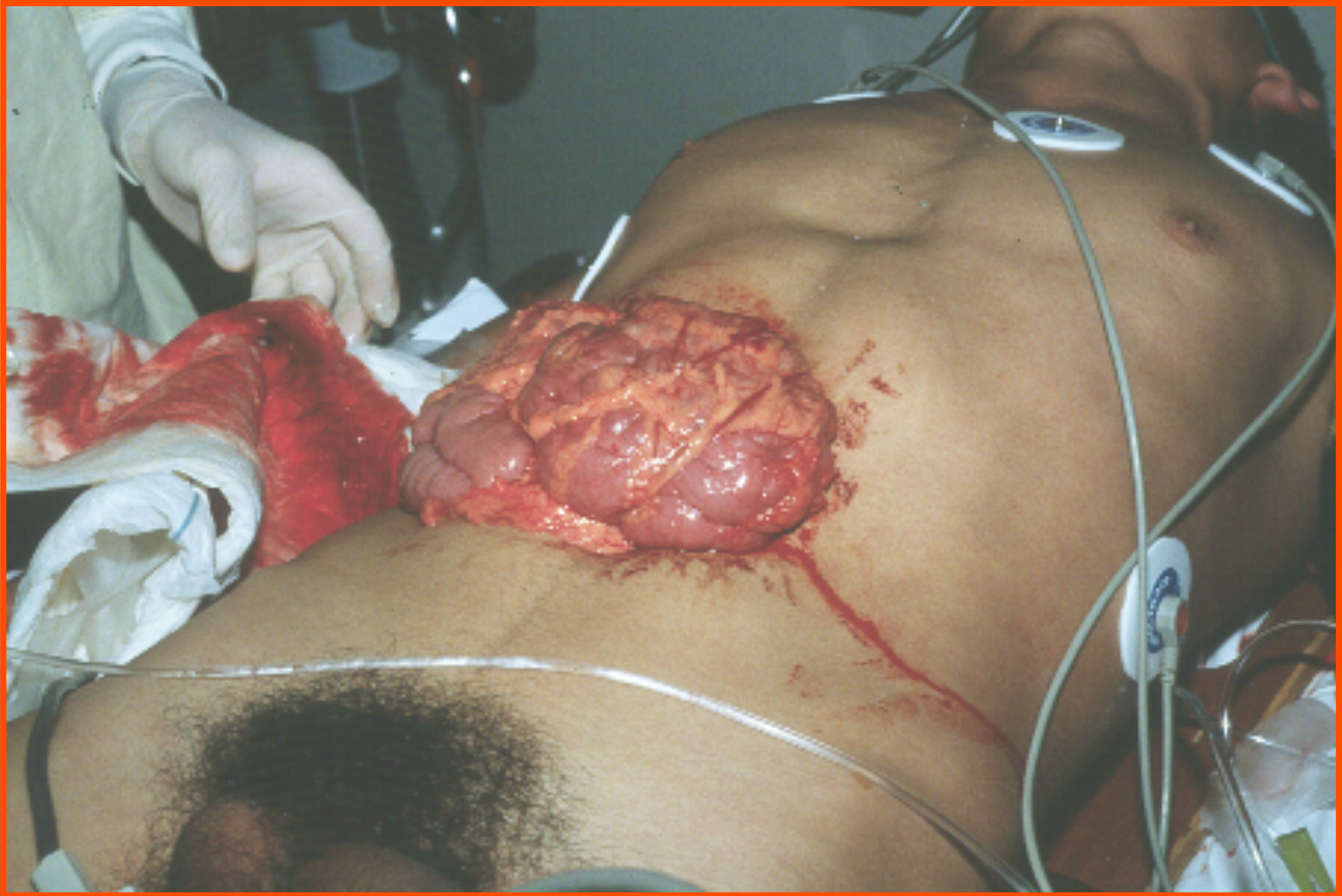
- Laparotomy indications
  - Evisceration, GSW, impalement, gross blood by NG, rectal or DPL, positive FAST scan if unstable



**+** Hypotension

- CT as opposed to laparotomy if stable & + FAST

# Stab Wound Abdomen





# Abdominal Trauma

- Stab wounds to the anterior abdomen
  - Only some penetrate the peritoneum and only some of these cause surgical injuries
  - Rule of thumb: 1/3 no penetration, 1/3 penetration and no surgery, 1/3 require surgery
  - Conservative management is appropriate for patients without positive findings

**Because of diaphragm movement, consider abdominal injury in trauma between the nipple and the navel:**

- 4<sup>th</sup> ICS anterior
- 6<sup>th</sup> ICS posterior, lateral

# Thoracoabdominal Penetrating Wounds Nipple to Navel in “No Mans Land”....



**Chest and abdominal wounds in this area**



# Abdominal Trauma

- Imaging
  - Routine plain abdominal films not indicated
  - CT
    - Insensitive to hollow organ injury, pancreas, and diaphragm
    - Sensitive to retroperitoneum, solid organs, bony structures
- CT or cystourethrogram for gross hematuria
- Ultrasound (FAST scan) possibly during the Primary Survey **A-B-C-D-E-Fast Exam**

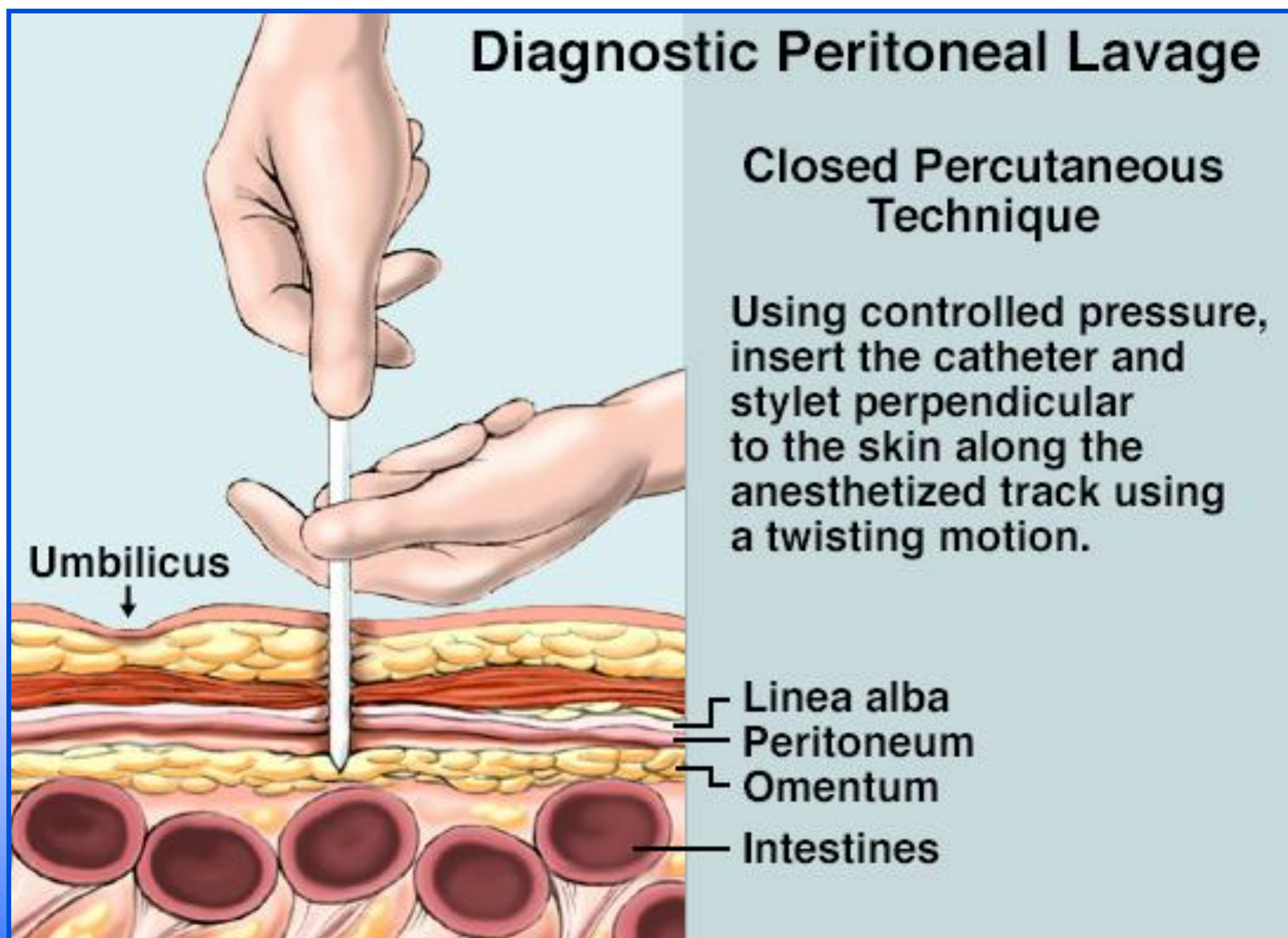
# Diagnostic Peritoneal Lavage (DPL) (1)

- Ultrasound now preferred for most cases
- Positive test
  - Aspiration of 10 mL of free-flowing blood (DPA)
  - $>100,000$  RBCs/mL in lavage fluid (BAT)
  - 10,000 RBCs/mL is threshold for laparotomy in penetrating trauma
  - Bile, feces, urine
- May see false negatives
  - Pelvic fractures
- Poor sensitivity for diaphragm injuries

# Diagnostic Peritoneal Lavage (DPL) (2)

- Laparotomy decision is based primarily on hemodynamics, associated injuries, FAST scan and CT
- In a stable patient without peritonitis, a positive DPL can be managed conservatively

# DPL



# Abdominal Signs

- Grey Turner's sign: Flank discoloration (late sign of retroperitoneal hematoma; seen in hemorrhagic pancreatitis)
- Kehr's sign: Referred left shoulder pain due to subdiaphragmatic irritation or splenic rupture
- Cullen's sign: Periumbilical ecchymosis (in hemorrhagic pancreatitis, ectopic pregnancy)
- Rovsing's sign: RLQ pain with LLQ palpation (due to peritoneal irritation e.g. acute appendicitis)

# Cullen's Sign





# Grey-Turner (Flank Ecchymosis)





# Spleen

**Most common organ injured in blunt trauma**

- Shock, LUQ pain, Kehr's sign
- Diagnosis: CT
- Treatment
  - Consider non-operative management
  - Give Pneumococcal and HIB vaccines post-splenectomy
  - Post-splenectomy sepsis has high mortality

## Liver

**Most common organ injured in penetrating trauma**

**Capsular hematoma: false-negative DPL**

**Diagnosis: CT scan**

# Pancreas / Small Intestine

- Pancreas
  - Commonly injured in blunt trauma
  - Handlebar, steering wheel
  - Pain delayed as enzymes leak and cause irritation
  - Serum amylase is often normal
  - Diagnosis: CT (DPL may be false negative)
- Small intestine
  - Multiple injuries in penetrating trauma
  - Symptoms often delayed
  - Associated with lap belt injury and lumbar spine fractures

# Stomach / Duodenum / Bowel

- More common in penetrating trauma (except in children)
- Most duodenal injuries have associated liver injury
- Abdominal wall ecchymosis from seatbelt: Consider intraabdominal injury (especially hollow viscus)
- Bike handlebar: Consider associated duodenal hematoma
- Bowel injuries may be delayed in presentation

**If colon injured, usually transverse**

# Urethral Trauma

## General

- Blood at meatus
- Boggy prostate
- Perineal bruising
- Dx: Retrograde urethrogram (before Foley)

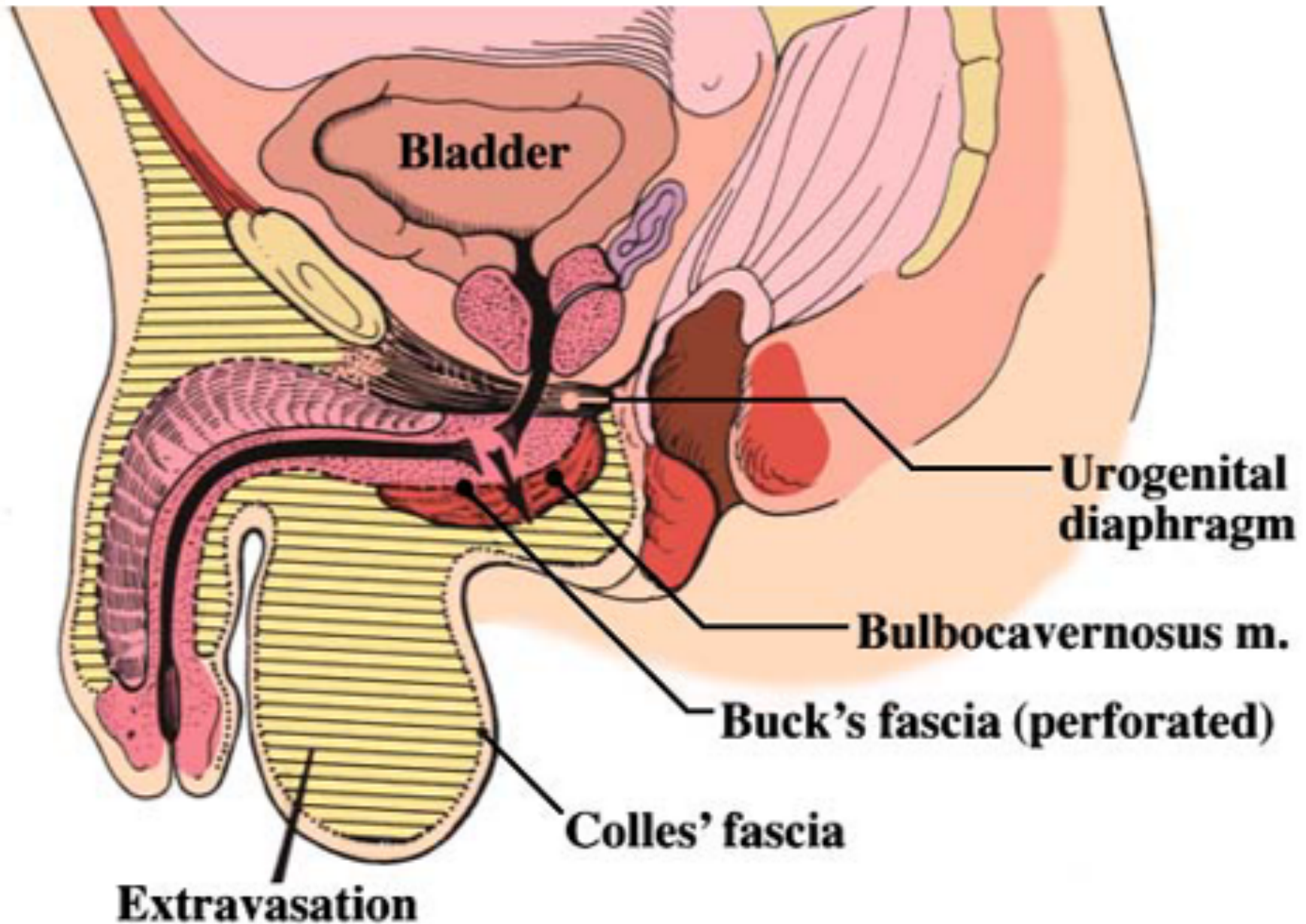
## Anterior

- Straddle injury
- Fracture penis
- Iatrogenic (foreign body)
- Hematuria
- Urethrogram
- Rx: Primary repair
- Complications: fistula, stricture

## Posterior

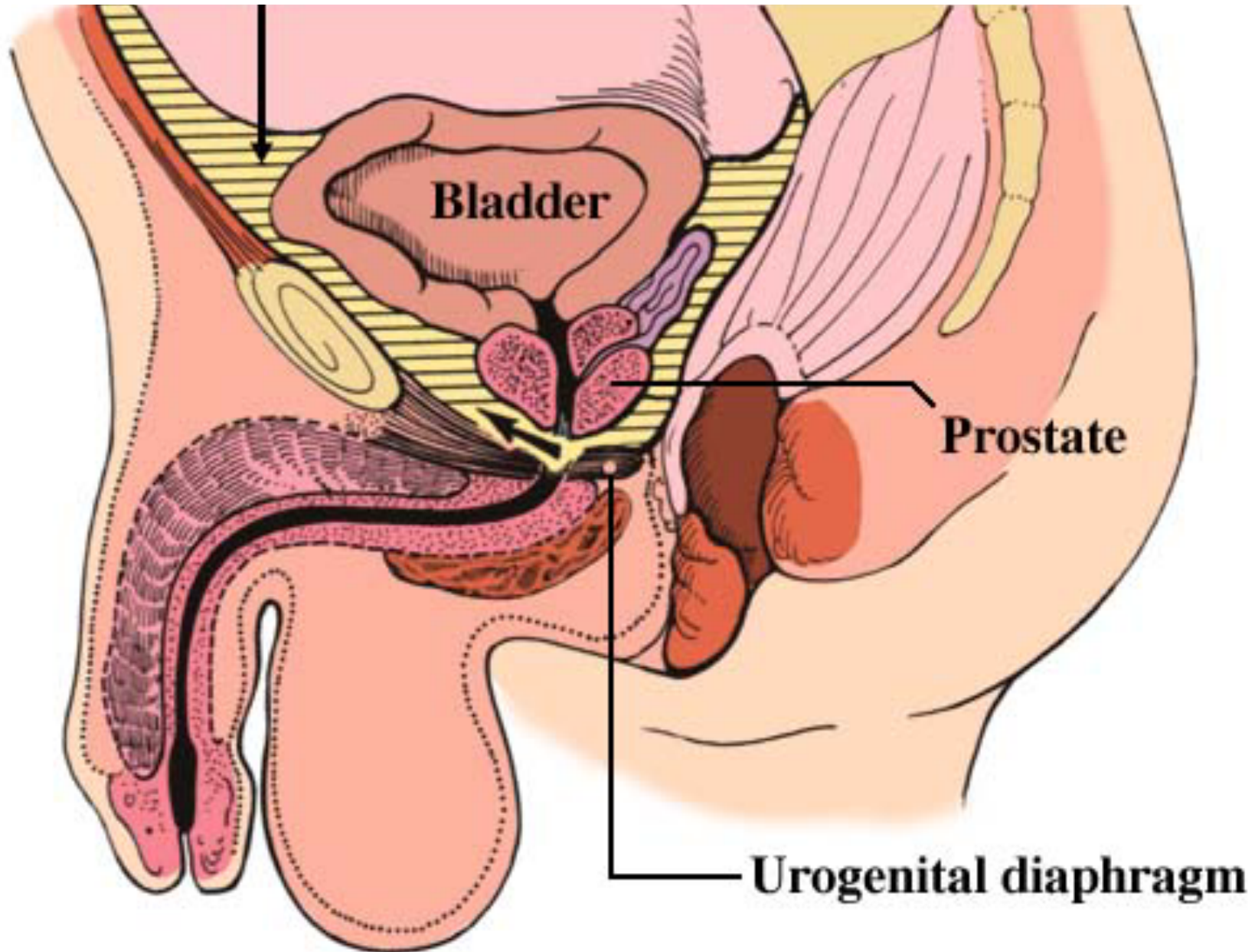
- Pelvic fracture
- Distended bladder
- Lower abdominal pain
- Dysuria
- Blood at meatus
- Scrotal hematoma
- Complications: Impotence, incontinence

# Extravasation with Anterior Urethral Rupture





# Extravasation with Posterior Urethral Rupture



# Urethra Trauma: Urethrogram

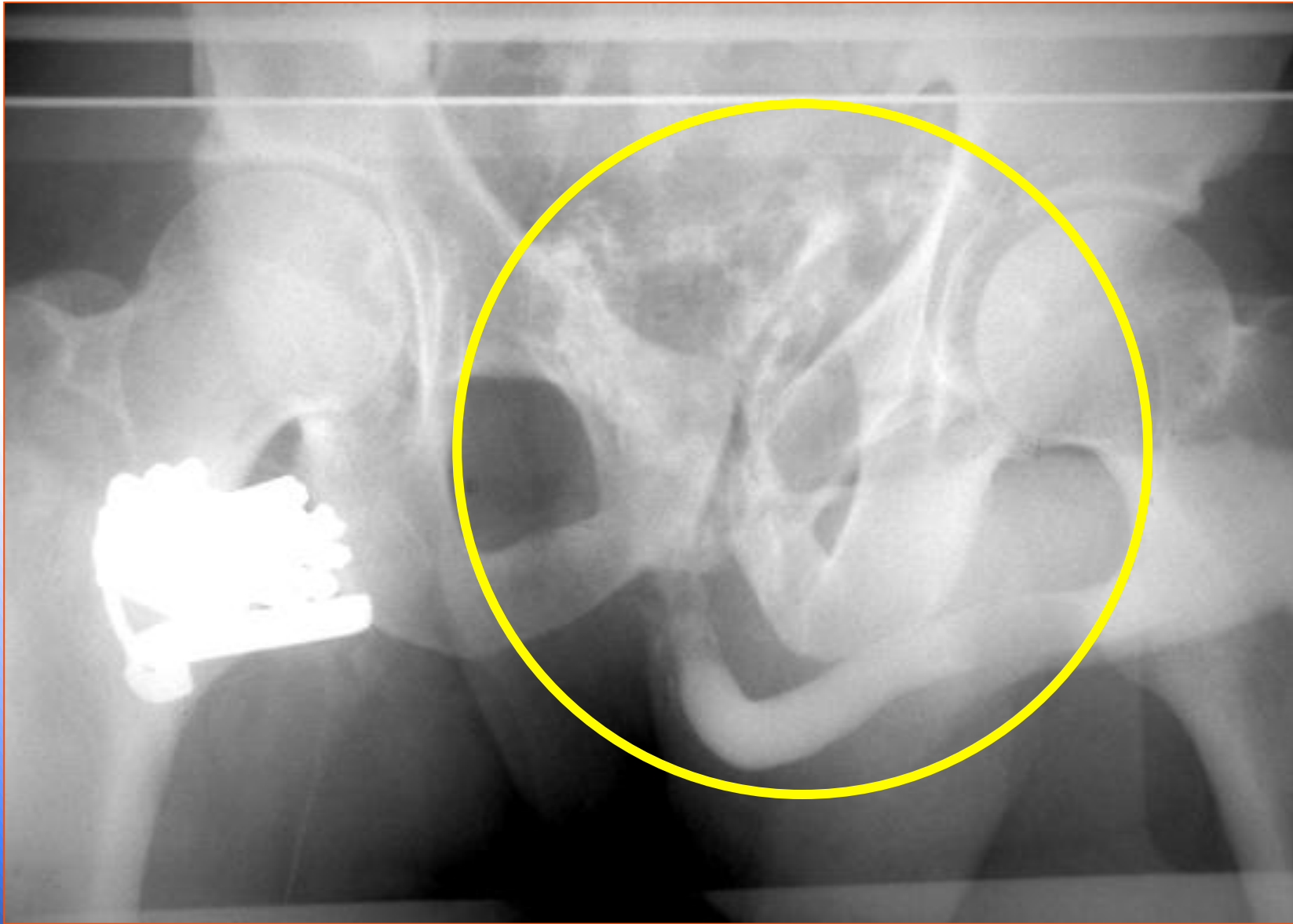




# Normal Urethrogram



## Contrast Extravasation Due to Posterior Urethral Tear



# Suprapubic Cystostomy

- Seldinger technique to gain bladder access
- Indications
  - Need drainage but Foley cannot be passed
  - Urethral stricture (severe)
  - Transection of urethra (trauma), GU burns (severe)
- Contraindications
  - Empty bladder (wait, use ultrasound)
  - Higher risk of bowel injury: History of abdominal surgery, radiation treatment (no blind placement)
  - Any patient who can have a urethral catheter
- Pregnancy is not a contraindication
- Complications: Bowel injury, extravasation, infection, urethral injury

# Testicular Trauma

- Most common in blunt or straddle injury
- Presentation
  - Edema
  - Ecchymosis
  - Tenderness
  - Hematuria
- Diagnosis: Ultrasound, nuclear scan, exploration
- Complications: Abscess, hydrocele, infertility

# Scrotal Hematoma





# Renal Trauma (1)

- Rapid deceleration, compression, penetrating trauma
- Associated with lower rib fractures, L1-L2 transverse process fractures

Renal injuries can present without hematuria

- Gross hematuria: IVP, contrast CT
- Renal vascular injury requires angiogram



## Renal Trauma (2)

- Penetrating injury: IVP or CT
- KUB is used to verify two kidneys
- Renal vascular injury
  - Associated with multiple trauma
  - May not have hematuria

**Must revascularize within 12 hours**

- Ureter injury is usually due to penetrating trauma → IVP or CT urogram
- Bladder injury associated with pelvic fracture, gross hematuria → retrograde urethrogram
- Bladder rupture with intraperitoneal extravasation → surgery

# Laceration Repair (1)

- Cosmesis and infection prevention tend to be major objectives
- Laceration infection rate <5%
- Most have low bacterial counts
  - Well below the critical mass needed to cause infection  
= 100,000 organisms per gram of issue
- Most lacerations: Young males, head, face and upper extremities, blunt trauma
- Delayed healing: Diabetes, obesity, malnutrition, renal failure, advanced age, steroids, chemotherapy, immunosuppressives
- Increased infection risk: Foreign body, crush injury, bite

# Tetanus

- Clostridium tetani (anaerobic Gram positive bacillus) produces tetanospasmin, a potent neurotoxin
- 60 cases/year in US, elderly predisposed
- Wounds at increased risk
  - >24 hrs old, crush injury, devitalized tissue
  - Burns, IVDA, early postpartum wounds
  - Soil in wounds
- Muscle spasm, rigidity, risus sardonicus, opisthotonus, fever
- Often occurs after minor wounds or without known injury
- Neonatal tetanus: 3-10 days after birth, poor prognosis
- May have unexplained tachycardia

# Laceration Repair (2)

- Tetanus guidelines
  - Clean minor wounds (all wounds except contaminated wounds, punctures, avulsions, burns and crush injuries)
    - If less than three prior immunizations in the past or unknown – give Tdap
    - If three prior immunizations – give Tdap only if prior immunization more than 10 years previously
  - All other wounds
    - If less than three prior immunizations or unknown, Tdap and tetanus immune globulin (TIG)
    - If three prior immunizations, give Tdap if last prior immunization more than 5 years prior

# Laceration Repair (3)

- Local anesthesia
  - “Amides” and “esters”
  - Most “reactions” due to the methylparaben preservative (resembles antigenically “esters”)
  - **One “i” in generic name: Ester. Two “i”s: Amide**
  - Esters = Tetracaine / pontocaine
  - Lidocaine = Amide (duration without epi = 1-2 hr)
    - Maximum safe dose without epi = 4.5mg/kg (7 with)
  - Bupivacaine = Amide (duration without epi = 4-8 hr)
    - Maximum safe dose without epi = 2mg/kg (3 with)
  - Minimize injection pain:
    - Buffering with  $\text{HCO}_3$ , 27-30 gauge needle, warmed, slow injection, inject through wound edges, subcut. injection (not intradermal), pretreat with topical anesthetics

# Local Anesthetics

| Anesthetic                      | Formulations                        | Duration of Action | Maximum Dosage                                           |
|---------------------------------|-------------------------------------|--------------------|----------------------------------------------------------|
| Lidocaine                       | 1% (10 mg/ml)<br>2% (20 mg/ml)      | 30-60 min          | 4.5 mg/kg, max<br>300 mg<br>(30ml of 1%; 15 ml<br>of 2%) |
| Lidocaine with<br>epinephrine   | 1% (10 mg/ml)<br>2% (20mg/ml)       | 120-360 min        | 7 mg/kg<br>(50 ml of 1%; 25<br>ml of 2%)                 |
| Bupivacaine                     | 0.25% (2.5 mg/ml)<br>0.5% (5 mg/ml) | 120-240 min        | 2.5 mg/kg, max<br>175 mg<br>(70 ml 0.25%; 35<br>ml 0.5%) |
| Bupivacaine with<br>epinephrine | 0.25% (2.5 mg/ml)<br>0.5% (5 mg/ml) | 180-420 min        | 225 mg<br>(90 ml 0.25%; 45<br>ml 0.5%)                   |



# Laceration Repair (4)

- Clipping is preferable to shaving (re: infection rate)
- Avoid shaving eyebrows
- Can clean dirty wounds with a sponge and tissue surfactant (e.g. Shur-Clens)
- Pressure irrigation (decreases bacterial counts)
  - Avoid excess pressure and delicate tissues
  - Not routinely needed in areas of good vascular supply
- Normal saline or tap water are effective
- Detergents, peroxide and povidone iodine at full strength is not advised in wounds (tissue toxic)
- The “golden period” for primary closure varies by wound site, nature, risk of infection
- Delayed primary closure for contaminated wounds 3-5 days later when infection risk is decreased is under-utilized

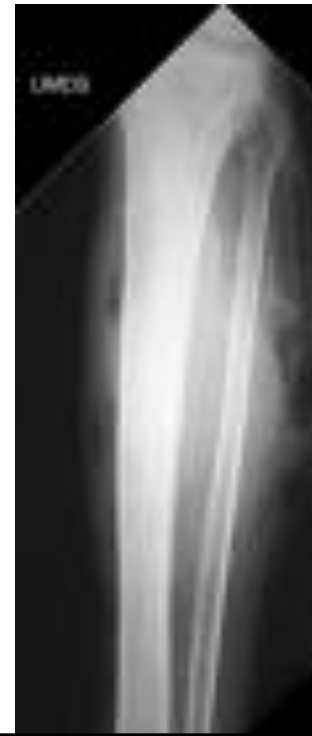
# Antibiotic Wound Prophylaxis

- Consider in
  - High risk sites (hands, feet)
  - Puncture wounds, foreign bodies
  - Contaminated wounds, bites
  - Extensive soft tissue injury
  - Through-and-through mouth lacerations
  - Open fractures, exposed joints and tendons
  - Prosthetic valves (endocarditis prophylaxis)
  - Immunocompromised

**Puncture through sneakers:  
Increased risk of Pseudomonas infection  
and osteomyelitis. Treatment: Fluoroquinolones  
and debridement**

# Gas Gangrene

- C. perfringens produces exotoxin
- Anaerobic infection in contaminated wounds
- Pain out of proportion to physical findings
- Dusky, brawny, “woody” edema with crepitance
- Low grade fever, tachycardia
- Gram's stain not helpful
- X-ray shows air in tissues
- Treatment: fluids, high dose penicillin, debridement, hyperbaric O<sub>2</sub>



# Necrotizing Fasciitis

- Anaerobes, group A Strep, Staph aureus
- Risk factors: CRF, diabetes, vascular disease, alcohol, immunosuppressed
- High mortality.....and low sodium
- Tachycardia, high fever, toxic appearance
- Erythema, edema, very painful, crepitance
- WBCs, Gram's stain, blood cultures, X-ray
- Fluid resuscitation, imipenem-cilastatin
- Surgical debridement

## Trauma Trivia (1)

- Blood bank transfusion: Decreased clotting factors, decreased platelets, decreased temperature (the most common sequelae of massive transfusion is hypothermia)
- Auto vs. pedestrian
  - Adults: Tibial plateau fracture, knee injury
  - Pediatrics: Chest and abdominal injury, closed head (contrecoup) injury
- Pediatric trauma patients in shock
  - Loss of >30% of blood volume
  - Treatment: 20 mL/kg crystalloid bolus x 2, then 10 mL/kg blood
  - Urine output: 1 mL/kg per hour

## Trauma Trivia (2)

- Human bite: *Eikenella*
- Reptile bite: *Salmonella*
- Cat bites: *Pasteurella multocida* (prophylactic antibiotics)
- Air embolism
  - “Machinery murmur” with neck vascular injury; tachypnea, tachycardia, hypotension
  - Place patient in left lateral decubitus and Trendelenburg position
- Capillary refill is not reliable in hypothermia



# TRAUMA QUESTIONS

## Which of the following best characterizes Cushing's reflex?

- A. Reliable sign of head injury
- B. Hypotension and bradycardia
- C. Hypertension and tachycardia
- D. An early sign of head injury
- E. Hypertension and bradycardia

**A 15 y/o has a brief generalized seizure after a head injury from a fall. Which of the following is true regarding post-traumatic seizures?**

- A. The majority occur within the first day
- B. A large percentage are delayed
- C. Seizures that are immediate, brief and non-focal require no treatment
- D. There is no increased risk of seizures with penetrating injury
- E. Recurrent seizures rarely require anticonvulsants

**A 38 y/o male was found unconscious after a motorcycle accident. Examination reveals a 6mm pupil on the left and a GCS of 6. Which formula correctly represents the cerebral physiology important to avoiding secondary brain injury?**

- A.  $ICP = CCP / MAP$
- B.  $CPP = MAP - ICP$
- C.  $MAP = ICP - CPP$
- D.  $CPP = ICP / MAP$
- E.  $CPP = ICP / 2 - MAP$

**A patient with a sucking chest wound has an occlusive petroleum dressing in place. Enroute to the hospital he develops severe SOB, what should the on-line medical advice be?**

- A. 500cc fluid challenge
- B. MAST suit inflation
- C. Sand bag application
- D. Temporary removal of the occlusive dressing
- E. Needle thoracostomy through the wound

**An 18 y/o sustains a head injury following an assault. Which statement regarding skull fractures is true?**

- A. Basilar skull fractures are best diagnosed clinically
- B. Linear, non-depressed skull fractures require phenytoin therapy
- C. Plain radiographs are the diagnostic study of choice
- D. “Battle’s sign” is an early finding in basilar skull fractures
- E. Hemotympanum is only seen with barotrauma

**TR 5**

# Regarding subdural hematomas, which statement is true?

- A. Subdurals are rarely from contrecoup injuries
- B. Subdural hematomas have a lower mortality rate than epidural hematomas
- C. Subdural hematomas are more common than epidural hematomas
- D. Subdurals are lens shaped
- E. Subdurals are uncommon in the elderly



**A 14 y/o boy sustained a brief loss of consciousness following a bicycle accident. On examination he opens his eyes when spoken to, he is oriented x 3 and able to follow instructions. What is his GCS?**

- A. 3
- B. 7
- C. 9
- D. 12
- E. 14

**An 18 y/o sustains a large stab wound to the neck just below the angle of the mandible. Examination reveals no airway compromise, no active hemorrhage and stable vital signs. Which of the following is true regarding this injury?**

- A. Cranial nerves IX, X and XI are located in this zone
- B. Vascular control (proximal control) of zone 1 is more easily achieved than in zone 2
- C. This is a zone 2 injury
- D. This is a zone 1 injury
- E. This is a zone 3 injury

**A lethargic one year old is found to have a midshaft femur fracture. Which finding is associated with the worst prognosis?**

- A. Transverse fracture with a full bone width displacement
- B. Funduscopic exam with retinal hemorrhages
- C. Distal femur involvement
- D. A pulse deficit which improves with splinting
- E. A large thigh hematoma

**A patient has an allergy to an amide anesthetic. Which local anesthetic would be safe to use?**

- A. Lidocaine
- B. Mepivacaine
- C. Tetracaine
- D. Bupivacaine
- E. LET

**A 56 y/o presents with abdominal pain status post MVC. He has a seatbelt sign across the epigastrium. CT of the abdomen is most sensitive for which of these injuries?**

- A. Diaphragmatic rupture
- B. Splenic laceration
- C. Duodenal hematoma
- D. Urethral transection
- E. Traumatic hydrocele

**Which of the following is an independent risk factor for high mortality from head trauma?**

- A. Associated skull fracture
- B. The mechanism of injury
- C. History of previous head trauma
- D. Age > 65 yrs
- E. Female gender

## Which statement is true regarding renal pedicle avulsion injuries?

- A. Early surgical intervention is often needed to control hemorrhage
- B. They are usually isolated injuries
- C. All such injuries result in nephrectomy
- D. Up to 20% have associated hematuria
- E. Nephrectomy is rarely necessary in patients with injuries to the main renal artery



**A 46 y/o gentleman is evaluated following a MVC. His abdomen reveals diffuse tenderness with peritoneal signs and a transverse contusion of the lower abdominal wall. Which injury is associated with this description?**

- A. Pulmonary contusion
- B. Flail chest
- C. Lumbar fractures (Chance fractures)
- D. Pneumobilia
- E. Liver laceration

**A 4 y/o is evaluated for a neck injury following a MVC. Which statement is true regarding cervical spine fractures in children?**

- A. More common than in adults
- B. Usually in the lower cervical segments(C 5-7)
- C. Most fractures are from extension injuries
- D. C1-4 fractures are the most common in children < 8 years old
- E. Spinal cord injuries with normal radiographs are less common in children

**An 18 y/o male sustains a gunshot wound to the upper abdomen. With regard to ruling out an injury to the diaphragm, which of the following is true?**

- A. DPL is very sensitive for diaphragm injury
- B. CXR is the most important initial diagnostic modality
- C. 90% occur on the right side
- D. Delayed diagnosis is rare
- E. CT visualizes the diaphragm very well

**A 24 y/o male involved in an MVC has a wide mediastinum and obscured aortic knob on CXR. Which of the following statements is true regarding this injury?**

- A. It is associated with a high pitched, blowing, diastolic murmur
- B. 25% mortality at scene
- C. Rarely associated with other injuries
- D. A normal mediastinum on CXR rules out this diagnosis
- E. Occurs with blunt and penetrating trauma with similar frequency

**A bubbling slash wound to the neck is found to be associated with a “machinery” murmur. After placing pressure on the wound, the immediate response should be:**

- A. (L) Lateral decubitus, reverse Trendelenburg
- B. (R) Lateral decubitus, Trendelenburg
- C. (R) Lateral decubitus, reverse Trendelenburg
- D. (L) Lateral decubitus, knee chest position
- E. (L) Lateral decubitus, Trendelenburg

**A 30 y/o male patient presents following a deceleration injury. He has 1<sup>st</sup> and 2<sup>nd</sup> rib fractures, a fractured scapula and a fracture dislocation of his ankle. What is the most appropriate next step?**

- A. Splint the extremity after reduction and plan for the patient's discharge
- B. Order a CT of the chest if V.S. are stable
- C. Place a prophylactic chest tube on the affected side
- D. Order an arch aortogram if V.S. are stable
- E. Transfer the patient for a TEE

**A 45 y/o patient presents with chest wall trauma after falling off of his forklift. The chest radiograph shows a hemothorax. You performed a chest tube thoracostomy. Which is an indication for emergent thoracotomy?**

- A. Initial chest tube output  $\geq 500$  cc
- B. Persistent air leak
- C. Chest tube output of 500cc in the first hour
- D. Mild tachycardia
- E. Chest tube output of 100 cc/hr x 3 hours



## Trauma Answer Key

- |       |       |
|-------|-------|
| 1. E  | 11. B |
| 2. C  | 12. D |
| 3. B  | 13. A |
| 4. D  | 14. C |
| 5. A  | 15. D |
| 6. C  | 16. B |
| 7. E  | 17. A |
| 8. C  | 18. E |
| 9. B  | 19. B |
| 10. C | 20. B |