

Burns

Jason Ryan, MD, MPH



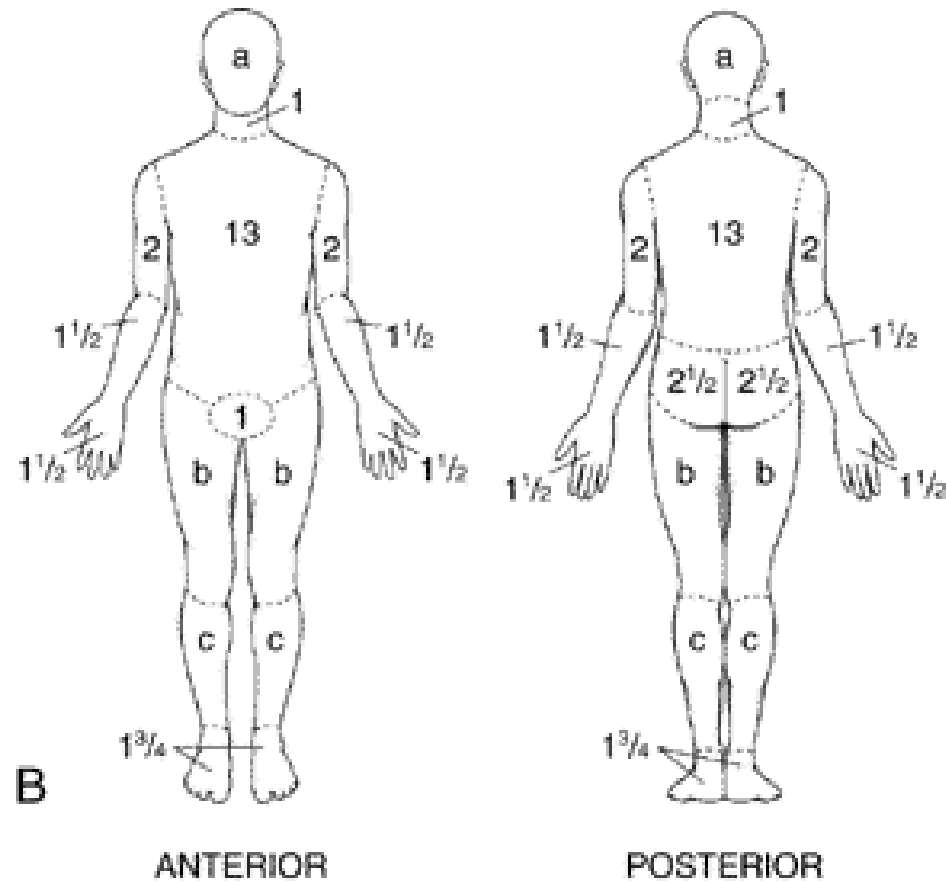
Burns

- Thermal injury to skin
- Diagnosed clinically
- Characterized by:
 - **Extent of injury**
 - **Depth**

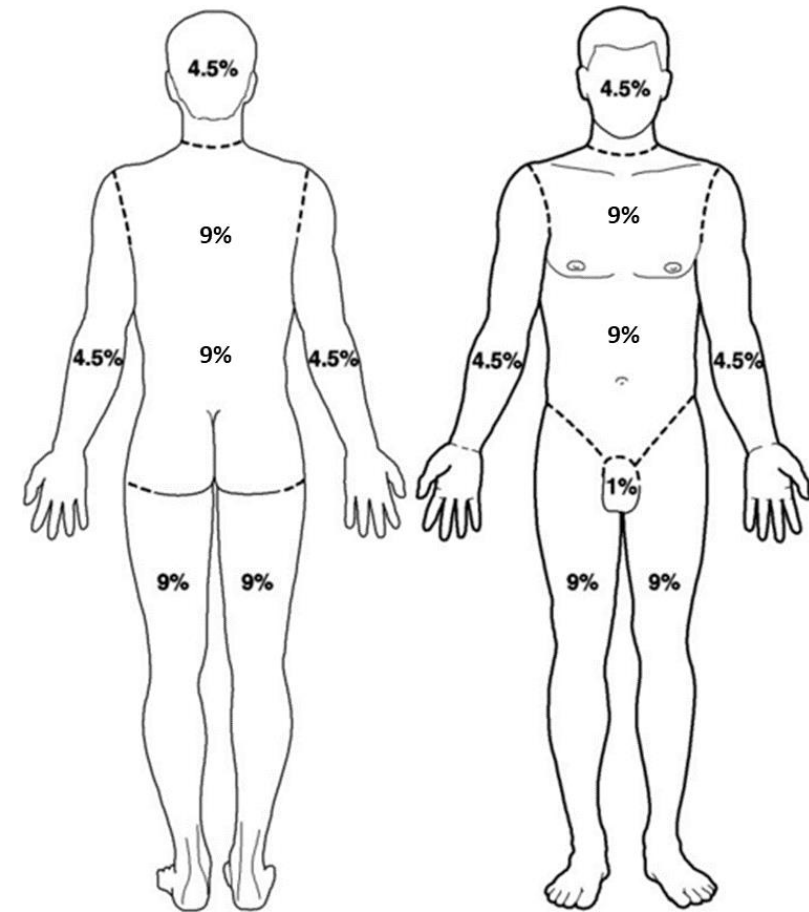


Burns

Extent of Injury



Lund-Browder Chart



Rule of Nines

Burns

Depth Classification

Depth	Degree	Skin layers
Superficial	1 st	Epidermis
Superficial partial thickness	2 nd	Epidermis, some dermis
Deep partial thickness	2 nd	Epidermis, most dermis
Full thickness	3 rd	Epidermis and dermis
4 th degree	4 th	Underlying tissue

Superficial Burn

1st Degree Burn

- Epidermis only
- Painful, red, blanch with pressure
- Looks like sunburn
- No blisters
- Heal within 7 days
- Minimal treatment required



Superficial Partial Thickness

- 2nd degree
- Epidermis and some dermis
- Often form blisters
- Painful, red
- Blanch with pressure
- Heal within 7 to 21 days



Snickerdo/Wikipedia

Deep Partial Thickness

- 2nd degree
- Epidermis, most dermis
- Erythematous, yellow or white
- Almost always blister
- Easily unroofed (tissue moves)
- **Painful to pressure only**
- **Do not blanch**
- Usually > 21 days to heal
- Heal with scarring



Full Thickness

- 3rd or 4th degree
- Entire epidermis and dermis
- Can involve underlying tissue (4th degree)
- Fat, fascia or muscle
- **Painless**
- Without surgery, scarring with wound contracture
- **Escharotomy**: incision of an eschar
 - Prevents burn-induced compartment syndrome

3rd Degree Burn



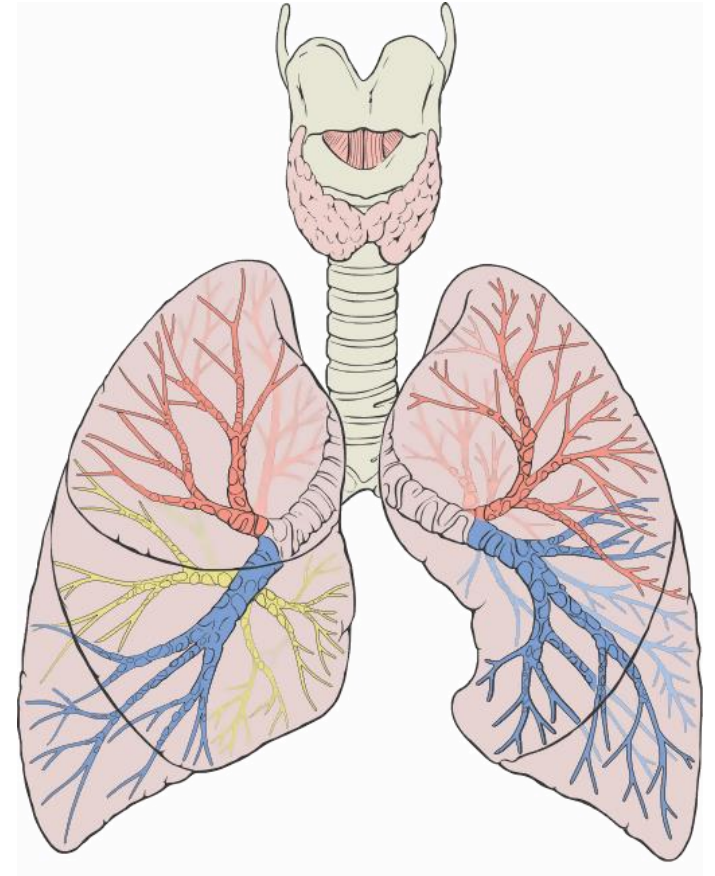
4th Degree Burn



Burns

Airway Management

- Watch for inhalation injury
- Can lead to airway edema → respiratory compromise
- Cough or wheezing
- Inflamed or singed nasal hair
- Respiratory distress
- Hypoxia or hypercapnia
- Elevated **carbon monoxide** or **cyanide** levels
- May require intubation and mechanical ventilation



Burn Treatment

Minor Burns

- Limited depth or extent
 - Partial-thickness burns < 5 to 10 percent TBSA
 - Full-thickness burns <2 percent TBSA
- Treatment:
 - Cooling
 - Cleaning (soap and water)
 - Dressing
 - Topical antibiotics
 - Acetaminophen or NSAIDs for pain control
- Tetanus immunization (if not current)



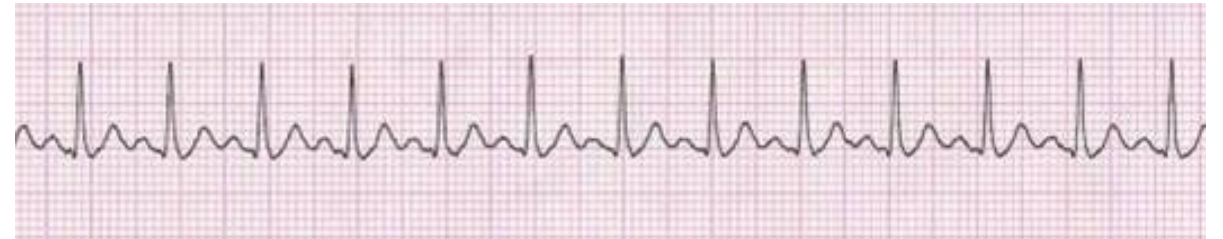
Wallpaper Flare

Burn Treatment

Severe Burns

- **Hypermetabolic state**
 - Massive protein and lipid catabolism
 - Protein loss with muscle wasting
 - Insulin resistance (hyperglycemia)
 - Increased body temperature
 - Tachycardia
 - Also occurs in other forms of trauma
- Sepsis criteria cannot be used to diagnose infection
 - Usually present in all severely burned patients

Sinus Tachycardia



Burn Treatment

Fluid Resuscitation

- Massive fluid losses with large burn areas
 - Greater than 10% TBSA in a child
 - Greater than 15 % TBSA in an adult
- **Parkland formula**
 - Used to estimate fluid requirement
 - $\text{mL of LR} = \text{weight (kg)} \times \% \text{BSA burned} \times 4 \text{ mL}$
 - Give half over first 8 hours
 - Second half over 16 hours
- Can titrate to urine output goal $> 0.5 \text{ mL/kg/hr}$



Burn Treatment

Topical Antimicrobial Agents

- Bacitracin
- Neomycin
- Polymyxin B
- Silver sulfadiazine
- Mafenide
- Chlorhexidine



Burn Treatment

Surgery

- Usually done 24 to 72 hours after injury
- Goal is excision of necrotic tissue and coverage of the burn wound
- Coverage of burn wounds
 - Direct wound closure
 - Skin grafting (transplanting healthy skin to burn site)
 - Flap surgery (stretching a flap of skin over wound)



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Burn Treatment

Infection Control

- High risk of bacterial infection
- First few days after injury
 - Skin flora infection
 - Staph and Strep
 - Prevented by topical antibiotics
- 5 days or more after injury
 - Gram negative bacteria colonize wounds
 - Acquired from respiratory/gastrointestinal tract or hospital
 - Pseudomonas and E. coli
 - Also fungi (candida)

Pseudomonas



Burn Treatment

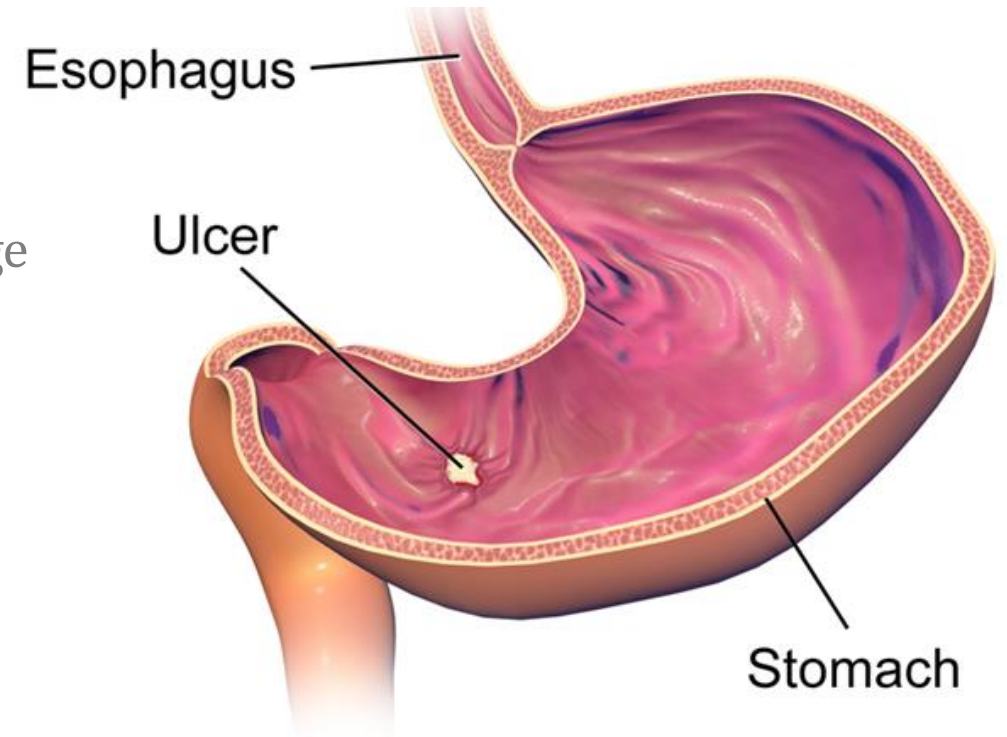
Infection Control

- Prophylactic systemic antibiotics not generally used
- Systemic antibiotics only with signs of infection
 - Fever
 - Changes in wound appearance (pus, erythema)
 - Worsening pain
- Wound cultures often done to identify specific bacteria
- Treatment: debridement, systemic antibiotics

Burn Treatment

Other Issues

- Pain control usually with opioids
- **Curling ulcers**
 - Unique form of ulcer in burn patients
 - Fluid loss → stomach hypotension → mucosal damage
 - Occur in stomach or duodenum
 - Ulcer prophylaxis: proton pump inhibitor
- **Nutritional support**
 - Hypermetabolic state
 - Many patients require tube feeds or TPN



Gastric Ulcer

Toxicology

Jason Ryan, MD, MPH



Carbon Monoxide

- Odorless, colorless gas
- Smoke from fires
- Heating systems
- Motor vehicles



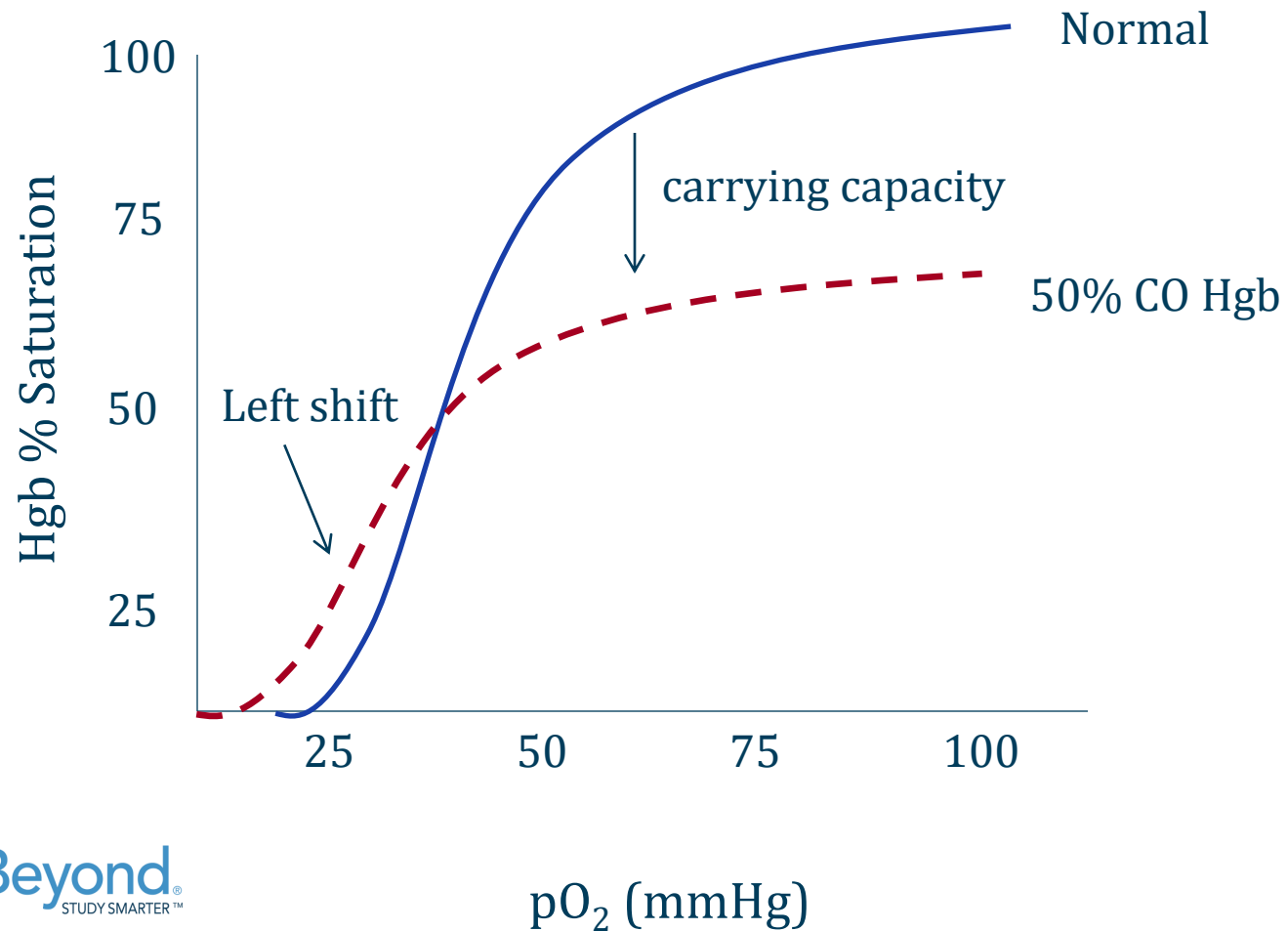
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Carbon Monoxide

- Binds to iron in heme 240x the affinity of O₂
- Forms **carboxyhemoglobin** (HbCO)
- Blocks O₂ binding sites (less O₂ can be absorbed)
- “Functional anemia”
- Other binding sites cannot offload O₂
 - Allosteric modification of hemoglobin
 - Shifts dissociation curve left

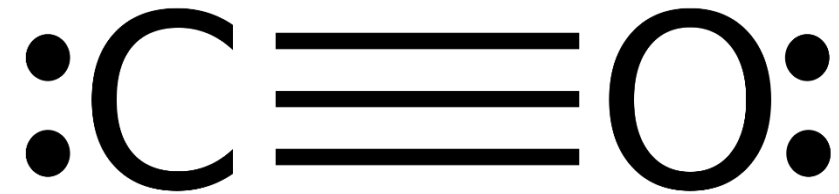


Carbon Monoxide



Carbon Monoxide Poisoning

- Nonspecific symptoms
- Headache most common
- Malaise, nausea, dizziness
- Classic but rare sign: **cherry red lips**
 - Carboxyhemoglobin is red
 - Do not see blue lips (cyanosis)



Carbon Monoxide Poisoning

- Standard pulse oximetry normal
 - Cannot differentiate carboxyhemoglobin/oxyhemoglobin
 - Often reads normal saturation despite low oxyhemoglobin
- Diagnosis: **carboxyhemoglobin level**
 - Determined by co-oximetry from arterial blood gas
 - Specialized wavelength analysis of blood
 - Normal < 3%
 - Smokers 10-15%
 - > 15% suggest poisoning
- Treatment: **100% oxygen**



Methemoglobinemia

- Most iron in hemoglobin normally reduced (Fe^{2+})
- Small amount oxidized iron: Fe^{3+}
 - **Methemoglobin**
 - Cannot bind O_2
- Excess methemoglobin: hypoxia



Methemoglobinemia

- Acquired methemoglobinemia from drugs
 - Local anesthetics (benzocaine)
 - Nitric oxide (inhaled pulmonary vasodilator)
 - Dapsone (tuberculosis)
- Treatment: **methylene blue**
 - Reducing agent
 - $\text{Fe}^{3+} \rightarrow \text{Fe}^{2+}$



Methemoglobinemia

Clinical Features

- Dyspnea
- **No improvement with oxygen**
- “Chocolate-brown blood”
- Standard O₂ pulse oximetry
 - Cannot detect methemoglobin
 - \uparrow methemoglobin $\rightarrow S_{aO_2} = 85\%$
- Co-oximetry: **methemoglobin level**

Normal



Methemoglobin
40%



Cyanide Poisoning

- Electron transport chain inhibitor
- Anaerobic metabolism: **lactic acidosis**
- **Bright red venous blood:** $\uparrow O_2$ content
- Confusion, coma, seizures
- Respiratory depression
- Arrhythmias, bradycardia, hypotension

Arterial
Blood

Venous
Blood

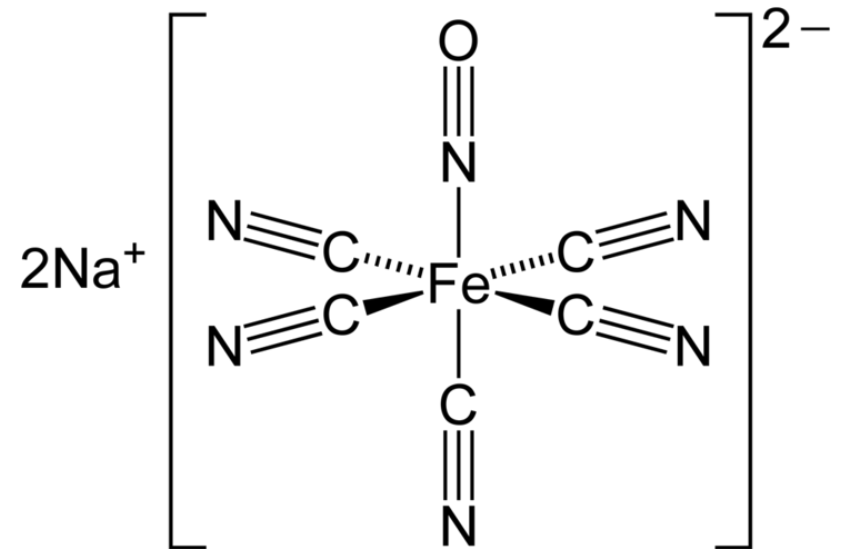


Cyanide Poisoning

Sources

- **Nitroprusside:** hypertensive emergencies
 - Contains five cyanide groups per molecule
 - Toxic levels with prolonged infusions
- Industrial exposures
- Combustion of plastics (fires)

Sodium Nitroprusside

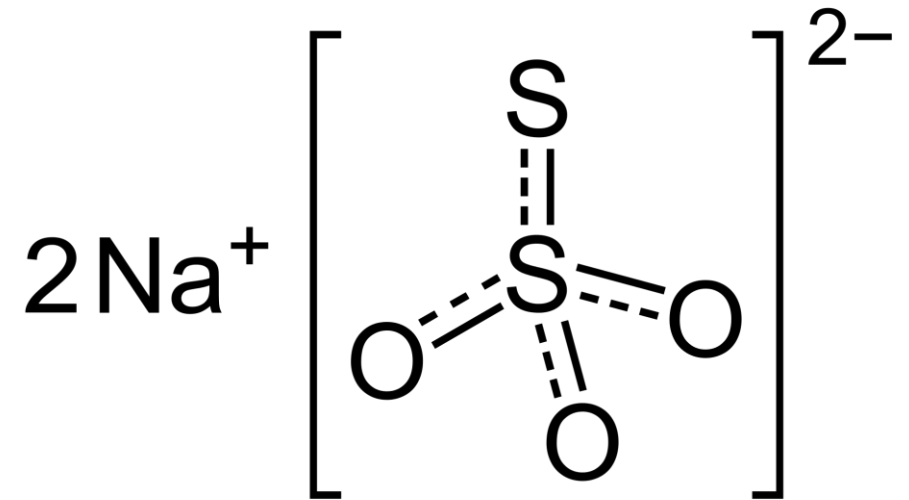


Cyanide Poisoning

Treatment

- **Hydroxocobalamin**
 - Precursor of vitamin B12
 - Contains cobalt that binds intracellular cyanide
 - Forms cyanocobalamin excreted in urine
- **Sodium thiosulfate**
 - Donates sulfur to rhodanese
 - Enzyme that transforms cyanide into thiocyanate
 - Thiocyanate renally excreted
- **Nitrites** (amyl nitrite)
 - Converts $\text{Fe}^{2+} \rightarrow \text{Fe}^{3+}$ in Hgb (methemoglobin)
 - Fe^{3+} in Hgb binds cyanide, protects mitochondria

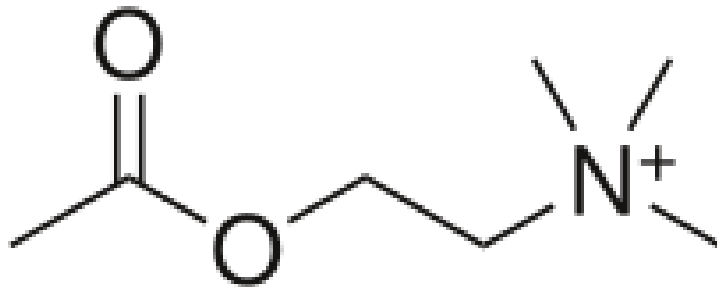
Sodium Thiosulfate



Organophosphate Poisoning

Cholinergic Toxidrome

- **Cholinergic** = related to acetylcholine and cholinergic receptors
- Toxidrome = signs/symptoms of poisoning or overdose
- Cholinergic and anti-cholinergic toxidromes

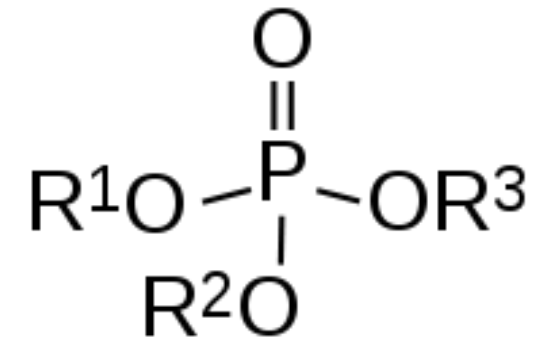


Acetylcholine

Organophosphate Poisoning

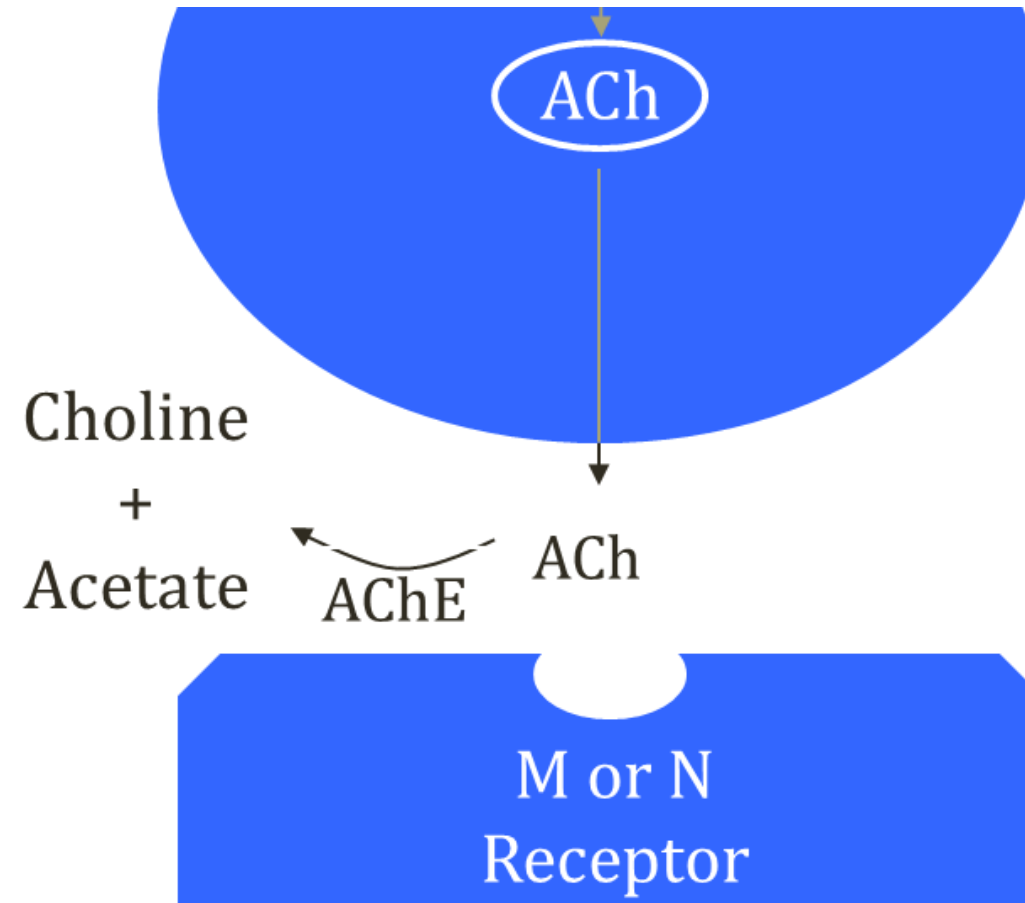
Cholinergic Toxidrome

- Classic cause of cholinergic toxidrome: **organophosphates**
- Found in pesticides and nerve gas
- Exposure through skin, ingestion, or inhalation
- Inhibit **acetylcholinesterase (AChE)**



Organophosphate Poisoning

Cholinergic Toxidrome



Organophosphate Poisoning

Cholinergic Toxidrome

- Increase GI motility
 - Nausea, vomiting, cramps, **diarrhea**
- Secretory glands
 - **Sweating, salivation**, lacrimation
- Bladder
 - Detrusor (smooth muscle) contraction: **urination**
- Diarrhea, drooling, incontinence

Organophosphate Poisoning

Cholinergic Toxidrome

- Heart
 - Decreased contractility
 - **Decreased HR**
- Lungs
 - Bronchoconstriction
 - **Wheezing**, dyspnea, flare of asthma/COPD
 - May lead to **respiratory distress**
- Bradycardia and wheezing

Sinus Bradycardia



Organophosphate Poisoning

Cholinergic Toxidrome

- Eyes: pinpoint pupils
- Muscles: twitching
- CNS receptors: confusion, lethargy, seizures



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Organophosphate Poisoning

Cholinergic Toxidrome

- **DUMBELS**
- **D**efecation
- **U**rination
- **M**iosis
- **B**ronchospasm/bradycardia
- **E**mesis
- **L**acrimation
- **S**alivation

Organophosphate Poisoning

Cholinergic Toxidrome

- A 44-year-old farmer presents to the ER with difficulty breathing. There is audible wheezing. He also reports diarrhea and unintentional loss of urine. He appears confused. On examination, he has pinpoint pupils. He is sweaty, drooling, and his eyes are watery. His pulse is 30.

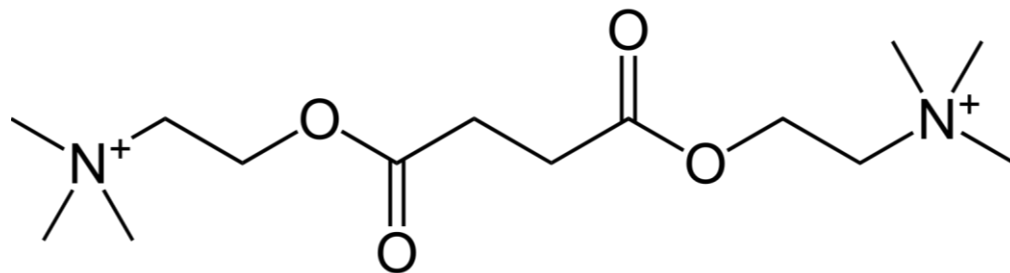


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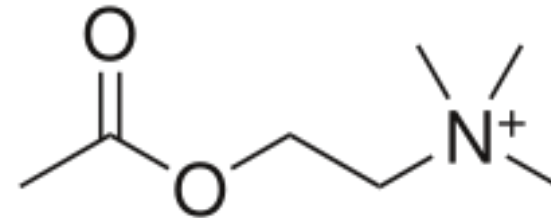
Organophosphate Poisoning

Treatment

- Major cause of death: **respiratory distress**
 - Bronchoconstriction, excessive secretions, neuromuscular weakness
- Intubation may be required
- **Avoid succinylcholine**
 - Paralytic used for rapid sequence intubation
 - Metabolized by acetylcholinesterase
 - Prolonged effects in poisoned patients



Succinylcholine



Acetylcholine

Organophosphate Poisoning

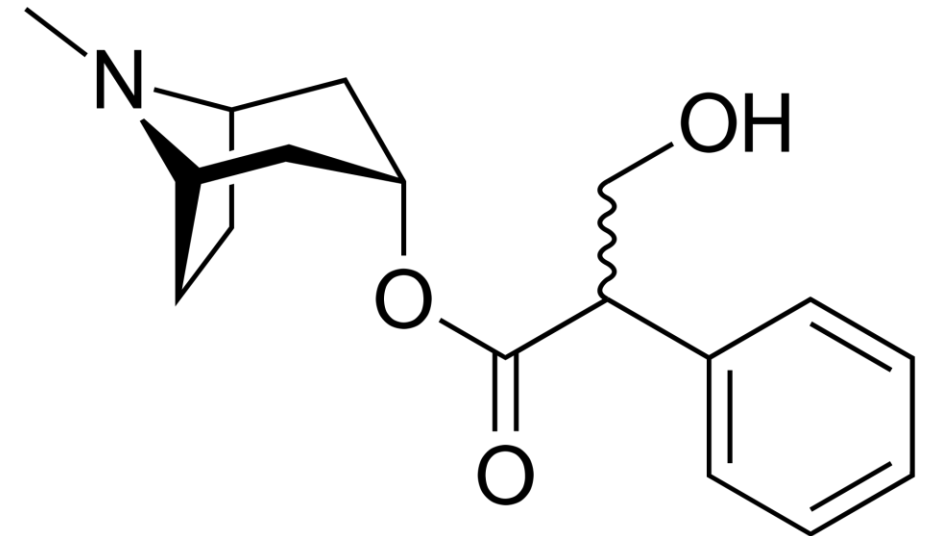
Treatment

- **Atropine**

- Muscarinic antagonist
- Improves bronchoconstriction and respiratory distress
- No effect on nicotinic acetylcholine receptors
- Does not improve neuromuscular symptoms

- **Pralidoxime**

- Cholinesterase reactivating agent
- Improves muscarinic and nicotinic symptoms
- Transiently inactivates acetylcholinesterase
- Must be given together with atropine



Atropine

Tylenol Overdose

Acetaminophen, Paracetamol, APAP (N-acetyl-para-aminophenol)

- Maximum recommended dose = **4 grams per 24 hours**
- Overdose causes acute liver failure
- **Rapid onset** of liver disease (hours)
- **Extremely high AST/ALT (up to 10,000)**
- Suspect in any patient with:
 - Sudden-onset liver failure
 - Extremely high AST/ALT
 - No evidence of shock

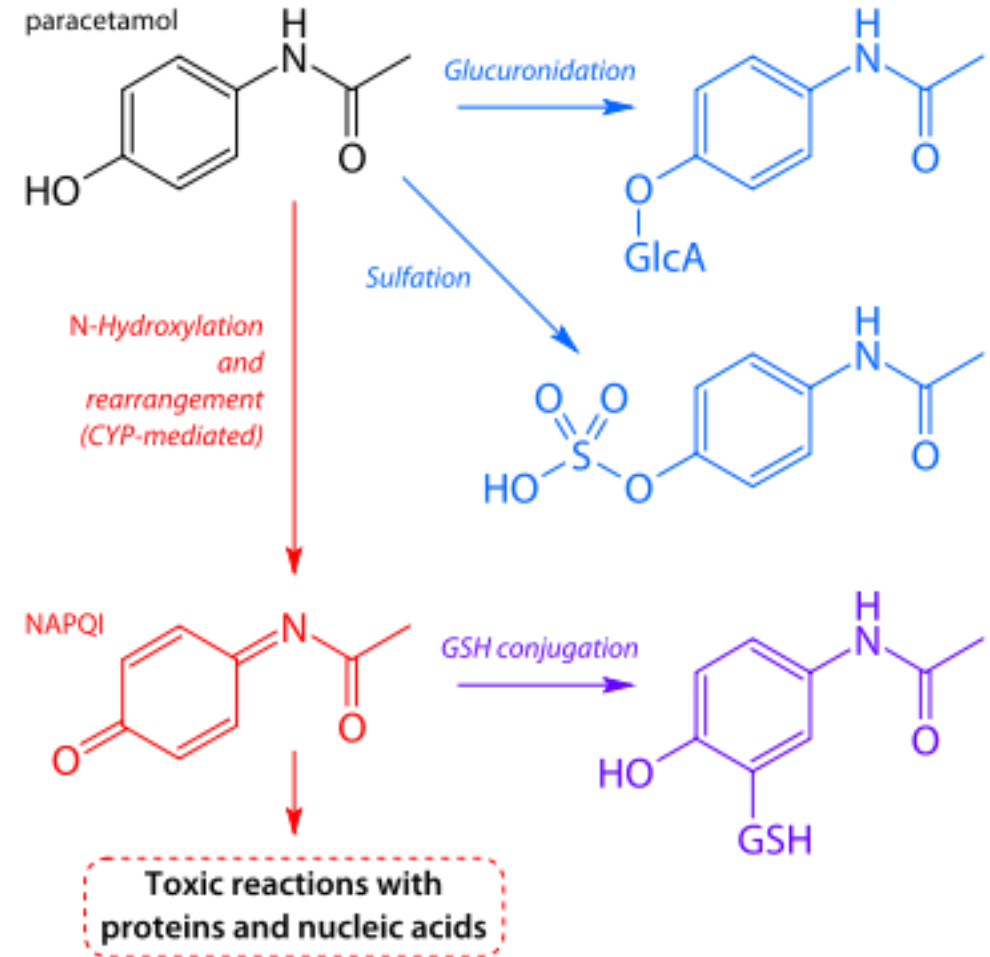


Katy Warner/Wikipedia

Tylenol Overdose

Treatment

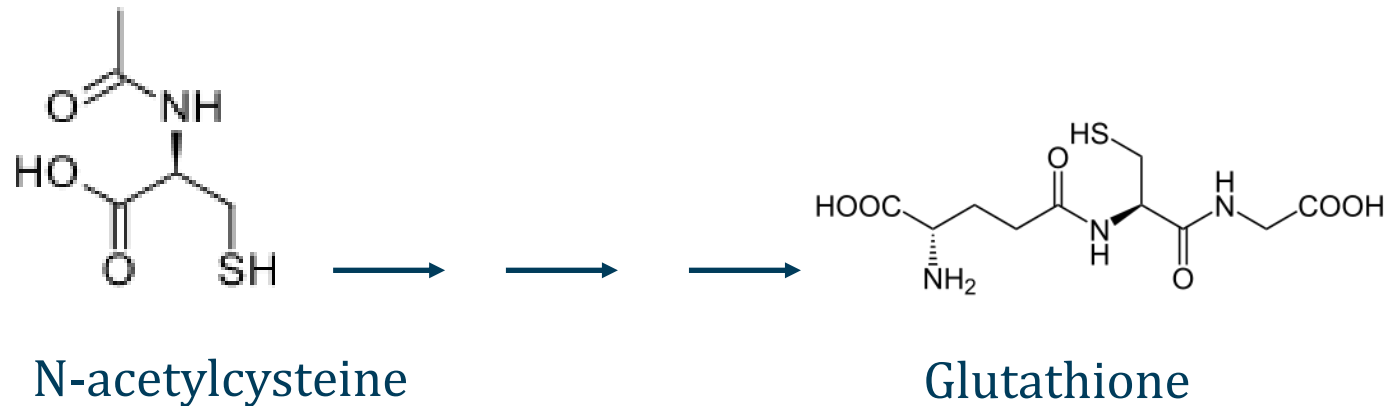
- Three metabolites of acetaminophen
- **NAPQI** is toxic to liver
 - N-acetyl-p-benzoquinone imine
- Metabolized by glutathione



Tylenol Overdose

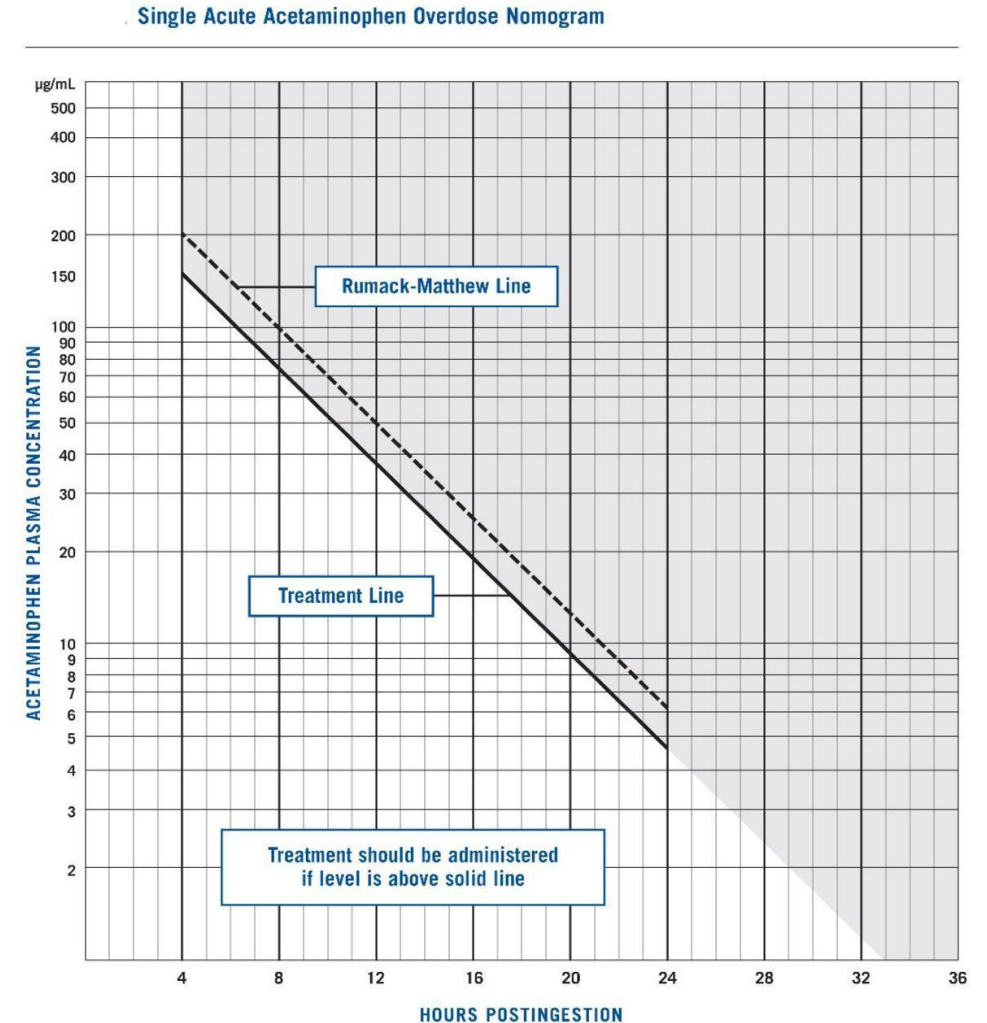
Treatment

- Within 4 hours: **activated charcoal** may prevent absorption
- **N-acetylcysteine (NAC)** is treatment of choice
- Used to replenish glutathione
- Survival ~100% if given within 8 hours of ingestion



Rumack-Matthew Nomogram

- Used to determine risk of hepatotoxicity
- Used after single dose exposure
- **NAC indicated:**
 - Above treatment line on RM nomogram
 - Any level > 10ug/mL
 - Liver injury



Other Treatments

- **No role for dialysis**
 - Acetaminophen is cleared by dialysis
 - But NAC effectiveness makes dialysis unnecessary
- **Cathartics rarely used**
 - Magnesium citrate, magnesium sulfate, sorbitol
 - Speed up GI transit time but do not alter absorption

Common Emergencies

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Heat Illnesses

- Group of disorders
- Failure of thermoregulation
- Usually occur during extreme heat/humidity
- May occur in athletes in hot weather



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Heat Cramp

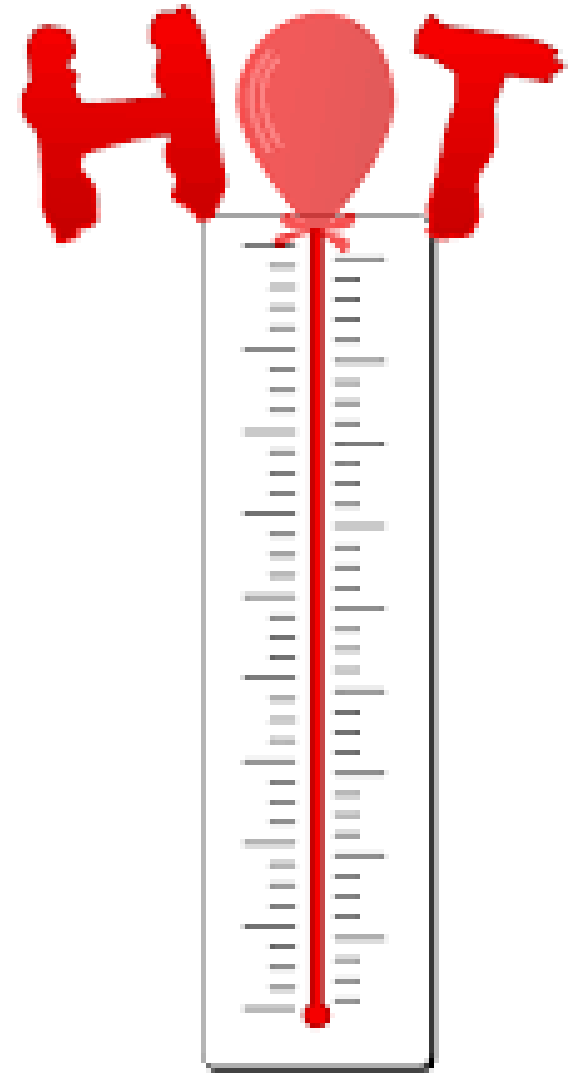
- Mildest form of heat illness
- Exercise-associated muscle cramps
- Probably unrelated to temperature
- Treatment:
 - Hydration
 - Replace sodium losses (sports drinks)
 - Stretch and massage muscle



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Heat Syncope

- Syncope due to exposure to high temperatures
- Body temperature **normal or mildly increased**
- Exertional or non-exertional
- Treatment: cooling, rehydration
- Must exclude other causes of syncope



FreeSVG

Heat Syncope

Exertional

- Occurs at **cessation of exercise activity**
 - Syncope *during* exercise: red flag for cardiac disease
- Common with endurance exercise (e.g., marathon)
- Vasodilation during exercise
- Cessation → abrupt loss of muscle pressure on veins
- Sudden decrease in venous return
- Drop in cardiac output



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Heat Syncope

Non-exertional

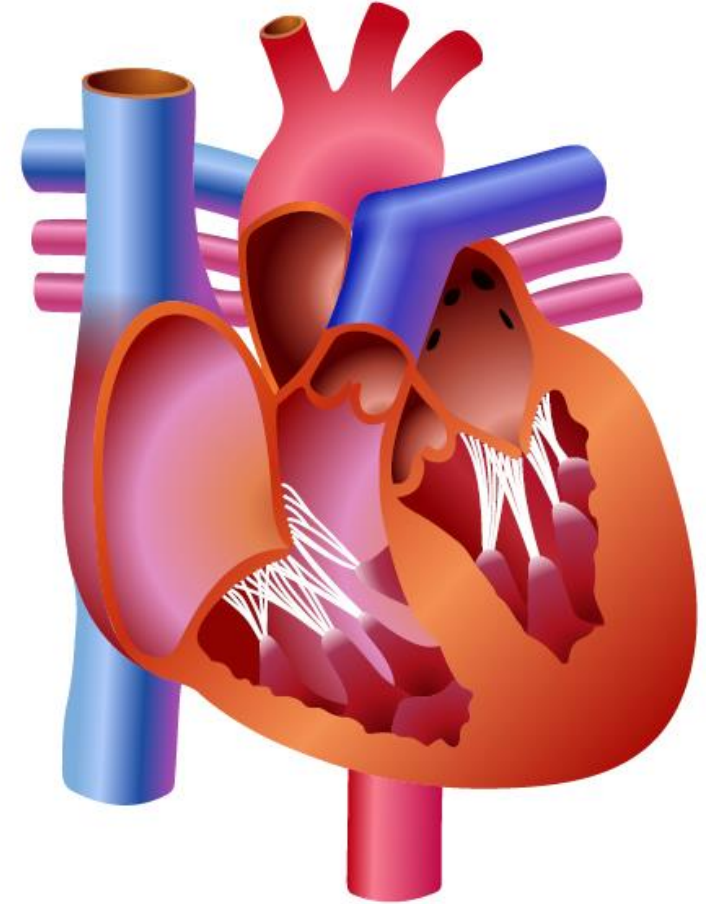
- Syncope when exposed to high temperatures
- Diffuse vasodilation to dissipate heat
- Fall in blood pressure → syncope



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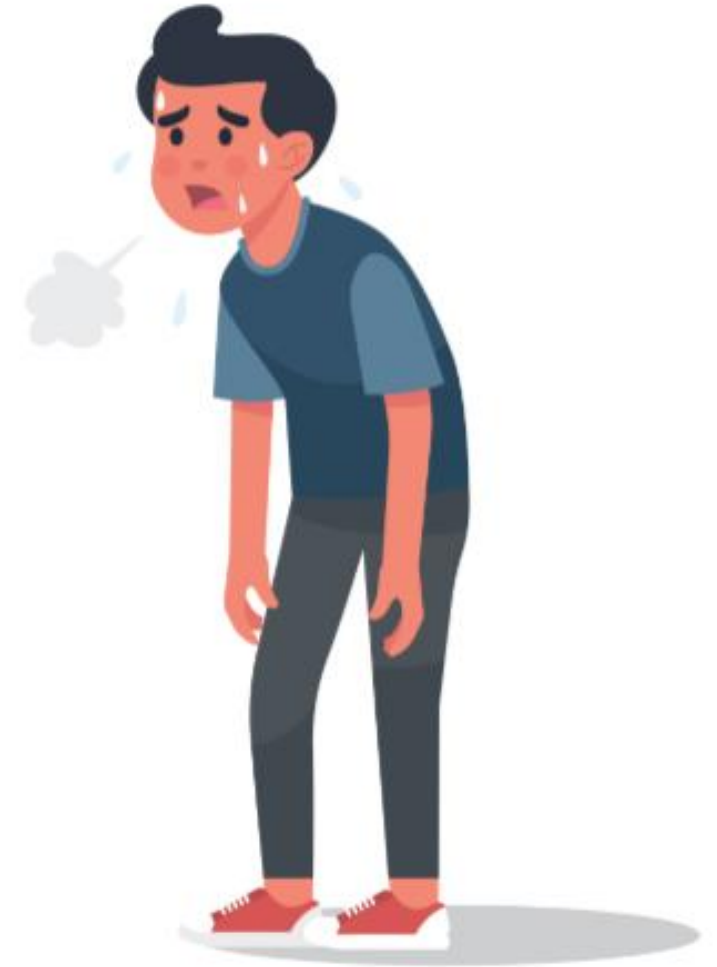
Heat Exhaustion

- Inability to continue exercise in heat
- Temperature usually between 101°F and 104°F
- Caused by **inadequate cardiac output**
 - Decreased circulating volume
- Absence of neurologic dysfunction
- Treatment: cooling, rehydration



Heat Injury

- Organ damage due to hyperthermia
- Presents as **collapse during exercise**
- Temperature $> 104^{\circ}\text{F}$
- Renal failure
- ARDS
- DIC
- If CNS dysfunction: heat stroke



Heat Stroke

- **Collapse during exercise**
- Requires temperature $> 104^{\circ}\text{F}$
- Central nervous system dysfunction
- Usually encephalopathy (confusion)
- May involve other organs



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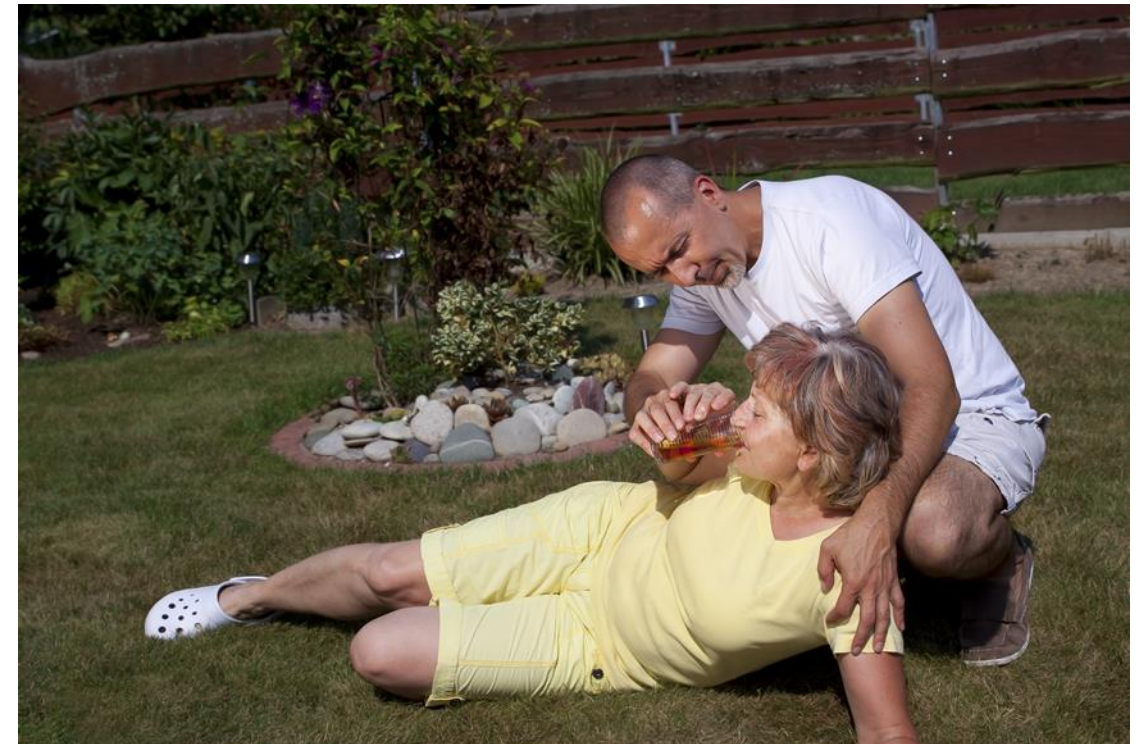
Heat Stroke

- **Exertional**
 - Occurs during exercise
 - Often occurs in young, healthy athletes
- **Nonexertional**
 - Usually affects older patients (often over 70)
 - Impaired ability to thermoregulate
 - Underlying cardiovascular or neurologic disease
 - May have obesity or physical disability
 - Often on medications (beta blockers, anticholinergics)

Heat Injury

Treatment

- **Cooling**
- Fluid and electrolyte replacement
- Specific treatment for organ dysfunction
 - Renal failure
 - ARDS
 - DIC



Cooling

- Cool room
- Cold water
- **Evaporative therapy**
 - Highly effective treatment for hyperthermia
 - Patient disrobed
 - Sprayed with lukewarm water mist
 - Fans blow air over moist skin
 - Used in heat injury and heat stroke
- **Cold water immersion**
 - Not always available
 - Can be harmful to elderly patients



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Hypothermia

- Temperature < 95°F (35°C)
- May be caused by exposure to cold environment
 - Outdoor exposure or cold water
- Many medical causes: sepsis, hypothyroidism

Class	Temp	Clinical Findings
Mild	32-35°C (90-95°F)	Shivering, tachycardia, tachypnea, ataxia, dysarthria
Moderate	28-32°C (82-90°F)	CNS depression, bradycardia, hypoventilation, no shivering
Severe	< 28°C (82°F)	Hemodynamic instability, severe CNS depression, coma, arrhythmias, death

Hypothermia

Warming

- **Passive external warming**
 - Used in mild hypothermia
 - Remove wet clothing
 - Blankets to limit heat loss
 - Shivering generates heat
- **Active external warming**
 - Moderate to severe hypothermia
 - Warm blankets
 - Heating pads



Pixabay

Hypothermia

Warming Treatments

- **Active internal warming**
 - Used in severe hypothermia
 - Warmed oxygen
 - Heated IV infusions
 - Irrigation of peritoneal/pleural cavities



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Cold Injuries

Injury	Clinical Features
Pernio	Reversible skin condition from cold exposure
Trench Foot	Foot exposure to wet and cold conditions
Frostnip	Paresthesias due to cold exposure. Reversible with warming
Frostbite	Freezing and necrosis of tissue

Pernio

Chilblains

- Blain: inflammatory swelling or sores
- Inflammation of small blood vessels in skin
- Reaction to repeated exposure of **damp cold**
- **Painful** red patches
- Occurs in hands and feet
- Resolves over weeks



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Trench Foot

- Exposure to **dampness and cold**
- Does not require freezing temperatures
- Vasoconstriction due to cold
- Capillary breakdown
- Tissue loss
- Pain, redness



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Frostnip

- Often precedes frostbite
- Blood vessels constricted
- **Numbness, pain, or tingling**
- Pale or red skin
- Skin retains normal texture
- Symptoms resolve with rewarming



Frostbite

- **Freezing and necrosis of tissue**
- Often occurs in fingers and toes
- May lead to amputation
- Severe loss of blood flow
- Stiffness, clumsiness
- **Loss of sensation**
- **Skin red, white, gray, or bluish**
- Hard or waxy to touch
- Bullae may occur with clear or bloody fluid
- Severe, longstanding forms: eschar formation



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Frostbite



Frost Nip
Red skin
No swelling
Normal texture



Superficial Frostbite
Red to pale skin
Swelling (necrosis)
Hard skin
Deep tissues intact



Severe Frostbite
Blue splotchy skin
Numbness
Blisters possible
Deep tissue loss

Frostbite

Diagnosis and Treatment

- Diagnosis usually clinical
- **Bone scan**
 - Technetium (Tc)-99m
 - Tracer uptake indicates viable tissue
 - Determines prognosis
- Treatment:
 - External warming
 - tPA/heparin
 - IV iloprost (vasodilator used in PAH)



Technetium 99
Bone Scan

Electrical Injuries

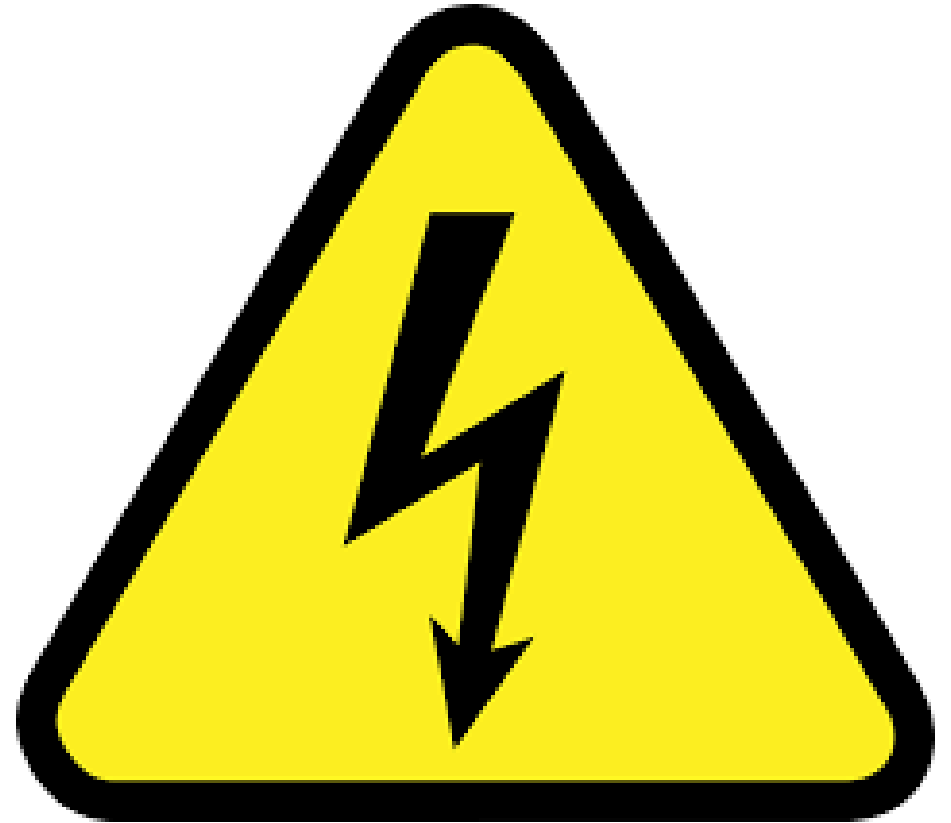
- Caused by electrical current
 - Lightning
 - Electrical workplace injury
 - Electrical weapons (Taser)
- Directly toxic to tissues
- May generate heat → heat injury



Mark Coldren/Public Domain

Electrical Injuries

- Cardiac arrhythmias
- Burns
- Rhabdomyolysis
- Loss of consciousness
- Weakness
- Amnesia
- Treatment: **supportive**



Puncture Wounds

- Penetrating injuries caused by a sharp object
- Risk of infection:
 - Cellulitis
 - Osteomyelitis
 - *S. aureus*, *P. aeruginosa*
- Treatment: debridement
- Antibiotics if evidence of infection



Puncture Wounds

Tetanus Immunization

- **Clean, minor wound**
 - Immunize if last dose ≥ 10 years ago
- **Dirty or severe wound**
 - Immunize if last dose ≥ 5 years ago
 - Also give tetanus immune globulin



Bites

- **Animal (90% dog)**
 - Pasteurella
 - Staph, Strep
 - Anaerobes
- **Human**
 - Staph
 - Strep
 - Eikenella (GN anaerobe)
 - Fusobacterium, Peptostreptococcus, Prevotella



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Bites

Treatment

- Wound cleaning and debridement
- Usually closure by secondary intention
- Closure by primary intention
 - Must be < 12 hours
 - No evidence of infection
 - Not on hands or feet



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Bites

Treatment

- **Antibiotics**
 - Amoxicillin-clavulanate
 - All infected wounds
 - Many uninfected wounds unless low risk, minor injury
- **Animal bites: tetanus and rabies**
 - Tetanus vaccination if last dose ≥ 10 years ago
 - Rabies prophylaxis if indicated



Tzuhsun Hsu/Flickr

Rabies

- Viral disease from animal bite or scratch
- Months after exposure: encephalitis, coma, death
- Poor prognosis if disease contracted
- Post-exposure prophylaxis
 - Rabies vaccine
 - Rabies immune globulin



Rabies

- PEP for high-risk exposure
 - Wild animal
 - **Bat**
 - Also foxes, racoons, skunks
 - Usually not given for pet dog/cat
- Low-risk exposure: no PEP
 - Squirrels, chipmunks, mice, rats, rabbits



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Chest Pain and Dyspnea

Jason Ryan, MD, MPH



Chest Pain and Dyspnea

Chest Pain	Dyspnea
Coronary Ischemia Aortic Dissection Pulmonary Embolism	Coronary Ischemia Pulmonary Embolism Pneumothorax Pneumonia Heart Failure

Chest Pain and Dyspnea

Workup

- First step: **vital signs**
- **Hypotension**
 - Treatment with fluids or vasopressors
- **Hypoxemia**
 - Treatment with oxygen, CPAP or mechanical ventilation

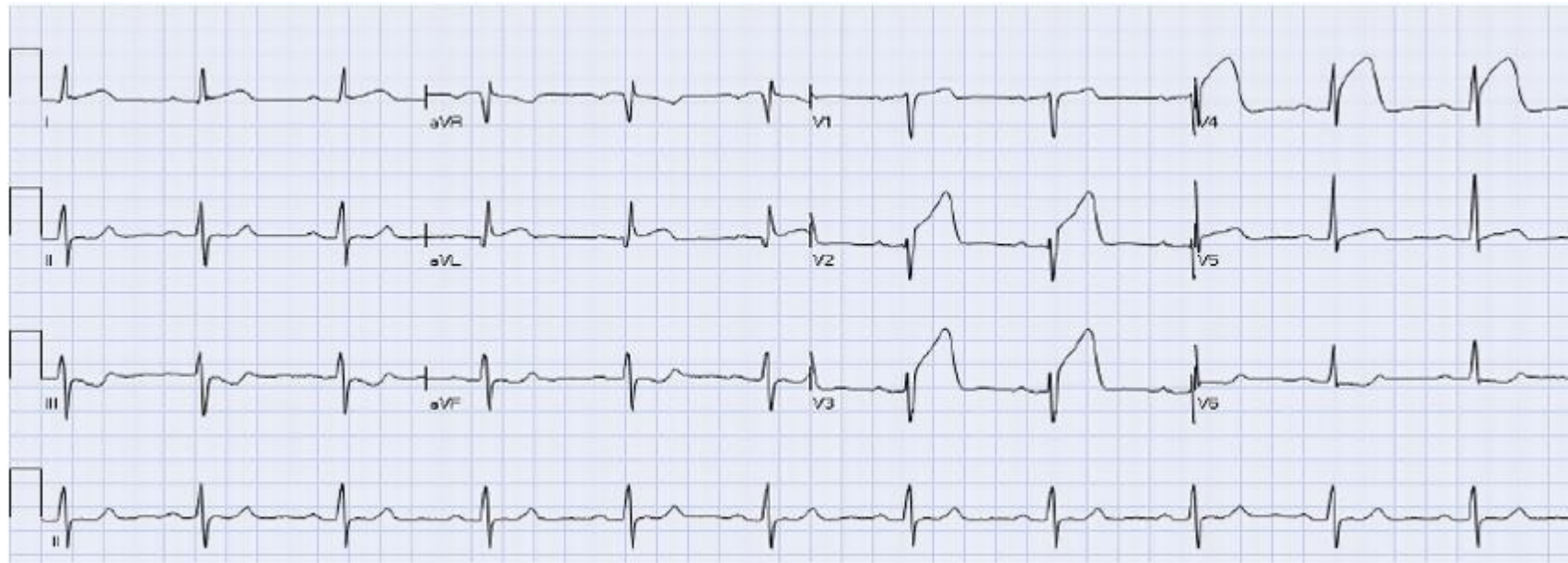


Chest Pain and Dyspnea

Workup

- Second step: **EKG**
- STEMI = medical emergency

Anterior ST-Elevation Myocardial Infarction



Chest Pain and Dyspnea

Workup

- Third step: **physical exam**
- Wheezing
- Absent breath sounds
- Distant heart sounds
- Weak pulses



Chest Pain and Dyspnea

Workup

- Next step (dyspnea): **chest X-ray**
- Pulmonary edema
- Consolidation
- Pneumothorax

RUL Consolidation

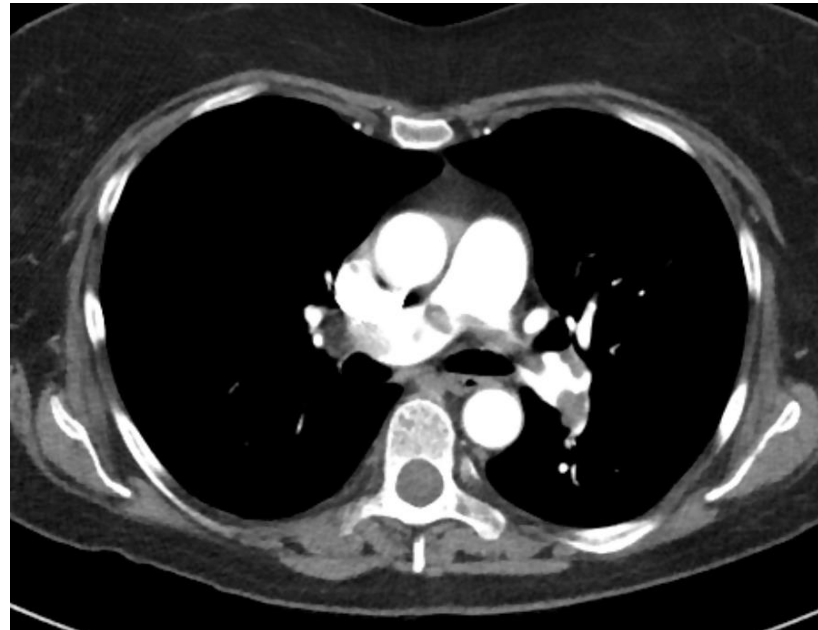


Chest Pain and Dyspnea

Workup

- Next step: **consider CT angiogram**
- Only if history suggestive of pulmonary embolism or aortic dissection
- Not done in all cases

Pulmonary Embolism



Chest Pain and Dyspnea

Workup

- D-dimer (PE or dissection)
- BNP (heart failure)
- CBC (anemia)

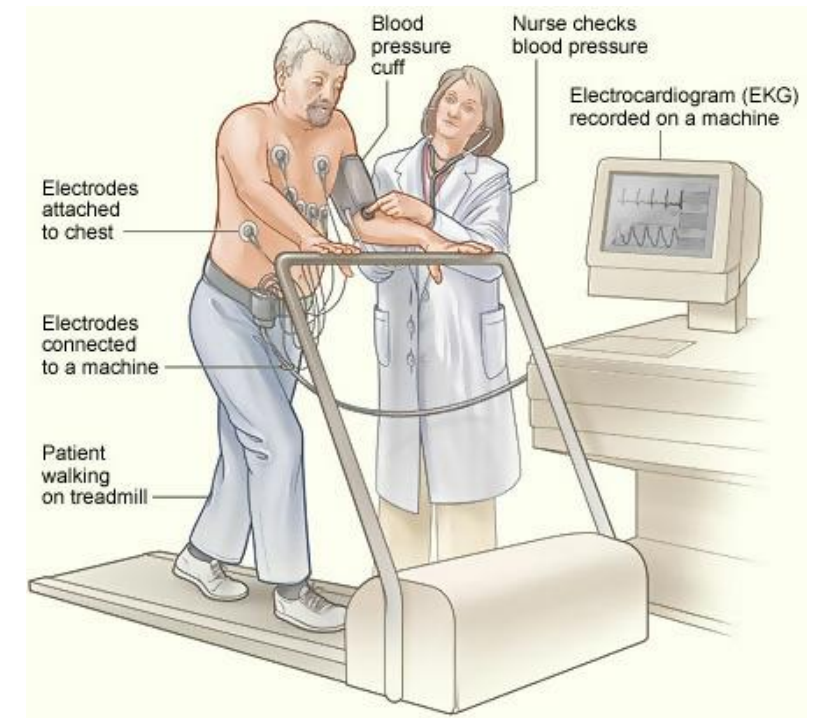
Chest Pain and Dyspnea

Workup

- Rule out myocardial infarction
- Usually requires “two sets” of cardiac biomarkers
- Patients must be on **telemetry** during evaluation
- Patients often kept in ER or admitted to hospital
- After rule out most patients have **cardiac stress test**



Stress Test

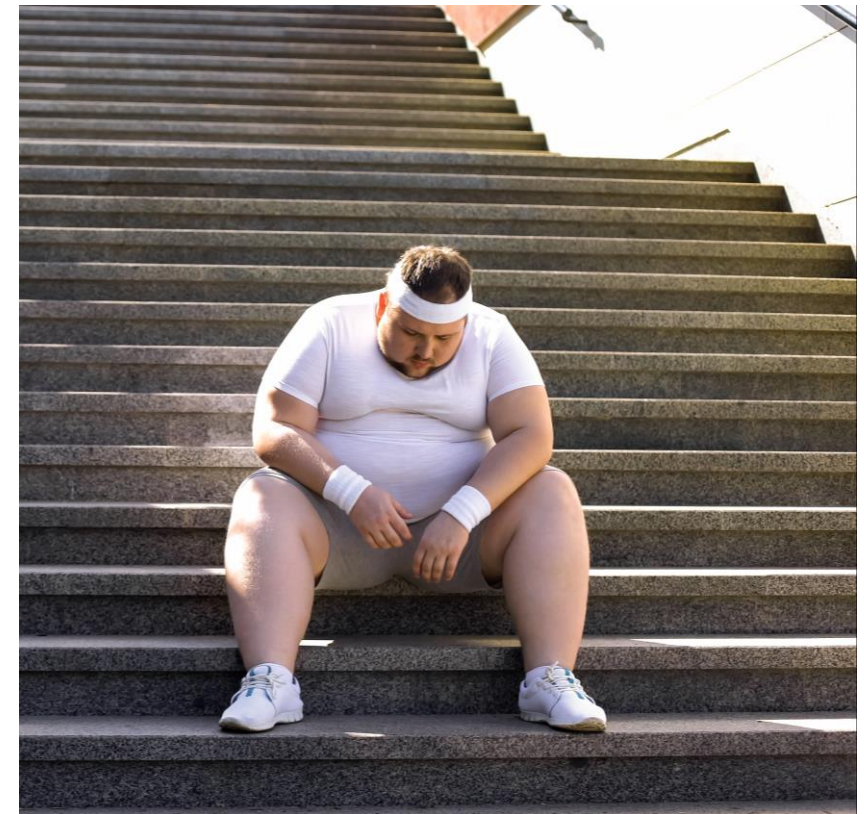


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Chest Pain and Dyspnea

Workup

- Further workup individualized to patient and symptoms
- **Non-specific chest pain**
- **Deconditioning**



Example Case

- 54-year-old man with diabetes and hypertension presents with 30 minutes of chest pain while walking that has resolved
- Vitals: normal
- EKG: normal
- Exam: normal
- Telemetry and ROMI: negative
- Stress test: positive
- Diagnosis: stable angina

Example Case

- 64-year-old woman with breast cancer presents with dyspnea for the past 1 hour
- Vitals: hypotension
- EKG: anterior ST-elevations
- Exam: rales, elevated JVP, cool extremities
- CXR: pulmonary edema
- Diagnosis: STEMI with cardiogenic shock

Abdominal Trauma

Jason Ryan, MD, MPH



Blunt Abdominal Trauma

- Commonly caused by motor vehicle accidents
- **Liver and spleen** most commonly injured organs
- Urgent surgery indications:
 - Hemodynamic instability (shock)
 - Peritonitis (acute abdomen)
- Milder cases treated with observation or embolization



Hidden Bleeding

- Shock requires loss of 25-30% of blood volume
- Only a few places this much blood can “hide”
 - Abdomen
 - Thighs (femur fracture)
 - Pelvis
- Shock with no hip or pelvis fracture usually indicates abdominal bleeding

Blunt Abdominal Injury

- Can cause abdominal pain, tenderness or distension
- **Seatbelt sign** strongly associated with internal injury
- Absence of abdominal pain/tenderness does NOT rule out injury



Beka Aberra/Slideshare

FAST Scan

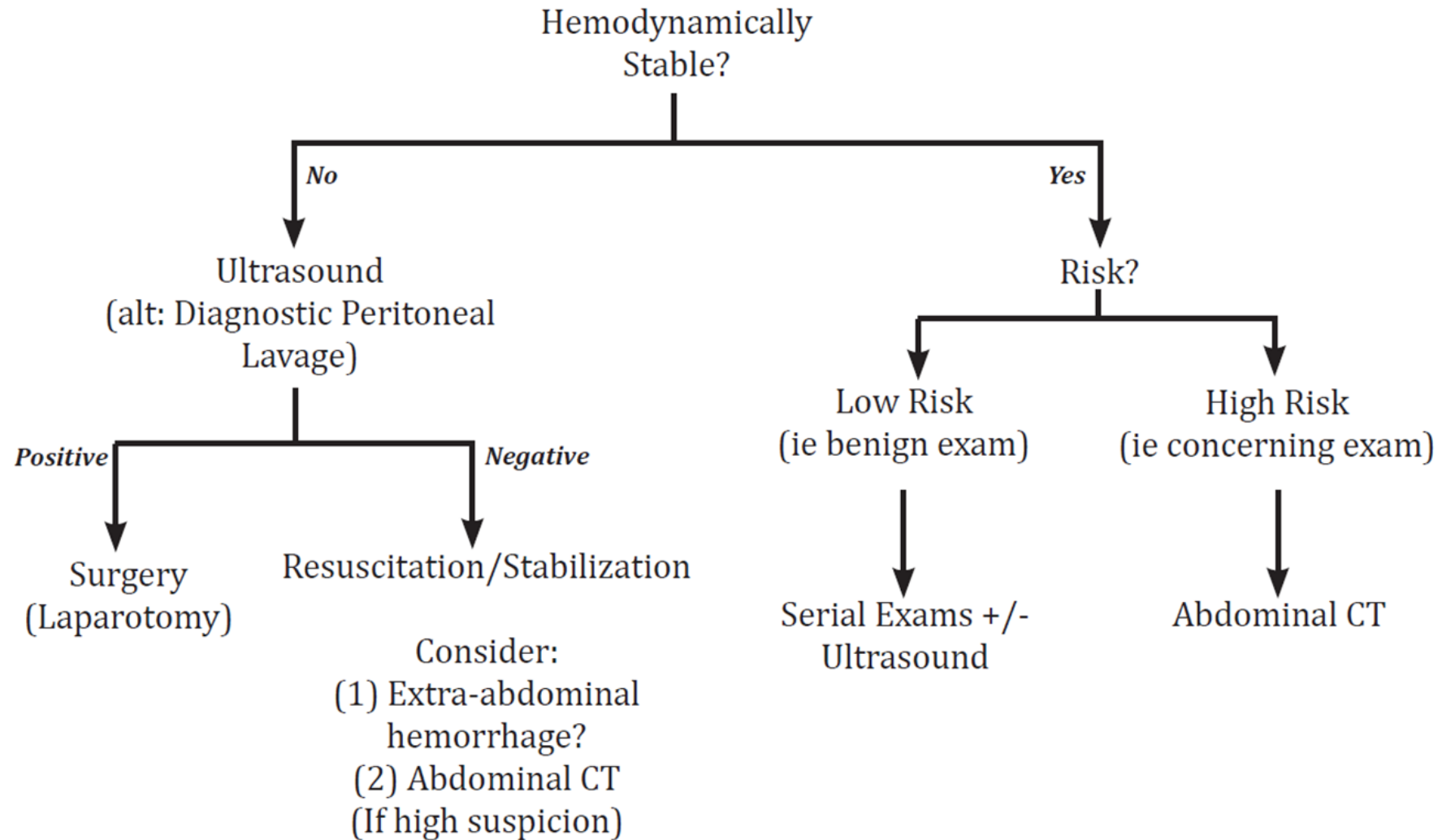
Focused Assessment with Sonography for Trauma Scan

- Bedside ultrasound exam used in trauma
- Goal is to **identify free fluid presumed to be blood**
- Used to examine key areas where blood collects
 - Right upper quadrant
 - Left upper quadrant
 - Pelvis
 - Heart
- Used in blunt chest and abdominal trauma
- Has replaced diagnostic peritoneal lavage
- Less useful for evaluating organ damage



Public Domain

Blunt Abdominal Injury



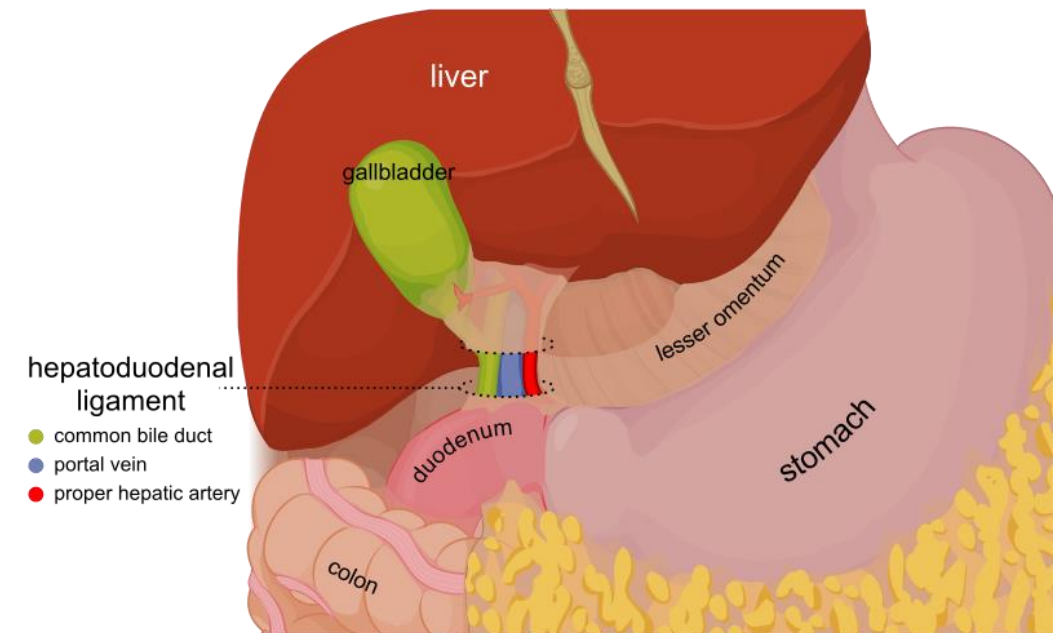
Liver Injury

- Most frequently injured abdominal organ in blunt abdominal trauma
- Less likely to cause major blood loss and shock (contrast with spleen)
- Diagnosis unstable patients: FAST
- Diagnosis stable patients: CT scan with contrast
- Hemodynamically unstable patients usually require surgery
- Most stable patients can be managed without surgery
- Some patients treated with hepatic embolization



Pringle's Maneuver

- Hepatoduodenal ligament connects liver to duodenum
- Contains:
 - Proper hepatic artery (branch of common hepatic)
 - Portal vein
 - Common bile duct
- **Pringle's maneuver**
 - Clamping of hepatoduodenal ligament
 - Used to control liver bleeding
 - If bleeding continues: IVC or hepatic veins



Olek Remesz/Wikipedia

Splenic Injury

- Most frequent cause serious bleeding in blunt abdominal trauma
- **Ruptured spleen** often causes major bleeding
- Commonly associated with **lower left rib fractures**
- Diagnosis unstable patients: FAST
- Diagnosis stable patients: CT scan with contrast
- Treatment: observation, embolization or surgery

Spleen



Penetrating Abdominal Trauma

- **Gunshot wounds**

- Most commonly injure liver or bowel
- Almost always requires exploratory laparotomy
- Wound exploration in ER not performed (cannot follow tract)

- **Stab wounds**

- Management based on severity of injury
- Surgery for hemodynamic instability or protruding viscera
- Stable patients: wound explored in ER (gloved finger) or CT scan
- Observation if no major internal injuries

Abdominal Gunshot Wound

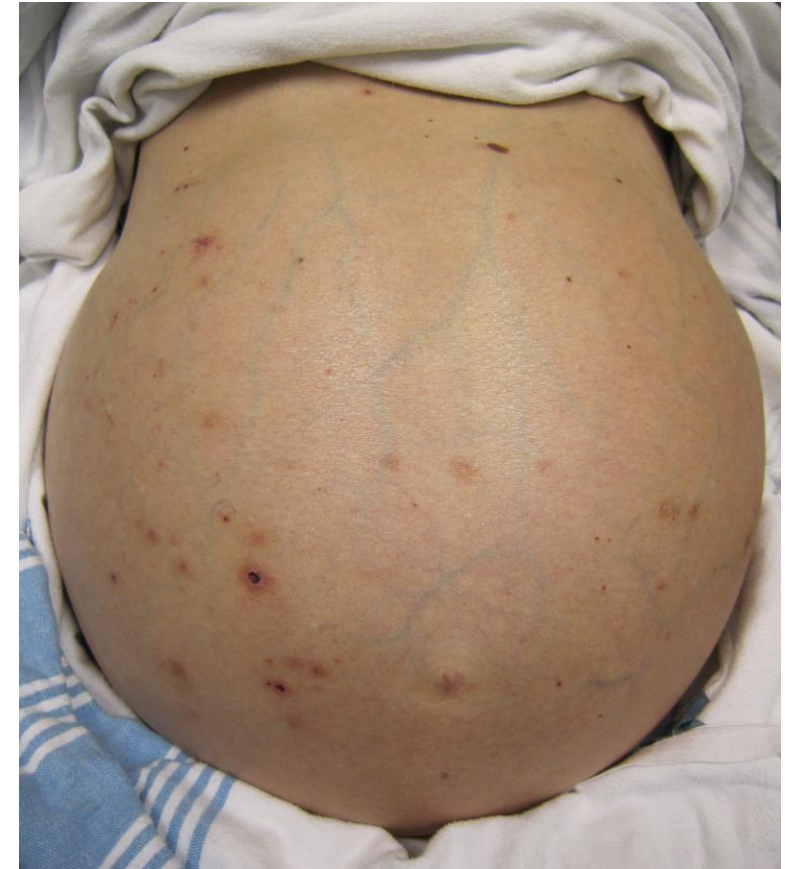


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Abdominal Compartment Syndrome

- Elevated intraabdominal pressure
- Occurs in critically-ill patients after fluid resuscitation
 - Trauma
 - Burns
 - Sepsis
- Presents as **tense, distended abdomen**
- May impair venous return, renal perfusion, ventilation
- May cause bowel ischemia
- Causes multiorgan dysfunction

Distended Abdomen



Wikipedia/Public Domain

Abdominal Compartment Syndrome

- Diagnosis: **bladder pressure**
 - Fill bladder with fluid → measure pressure
 - Normal : 5 to 7 mmHg
 - Intraabdominal Hypertension (IAH) ≥ 12 mmHg
- Treatment: **surgical decompression**
 - Temporarily open abdomen until pressure falls



Cirbosque #QuedateEnCasaColombia/Twitter

Neck and Spinal Trauma

Jason Ryan, MD, MPH



Penetrating Neck Injury

- Injury to neck that penetrates the platysma
 - Sheet-like muscle covering the neck
- Gunshot wounds
- Stab wounds
- Flying debris (glass or shrapnel)
- Life-threatening risk of:
 - Exsanguination
 - Airway obstruction

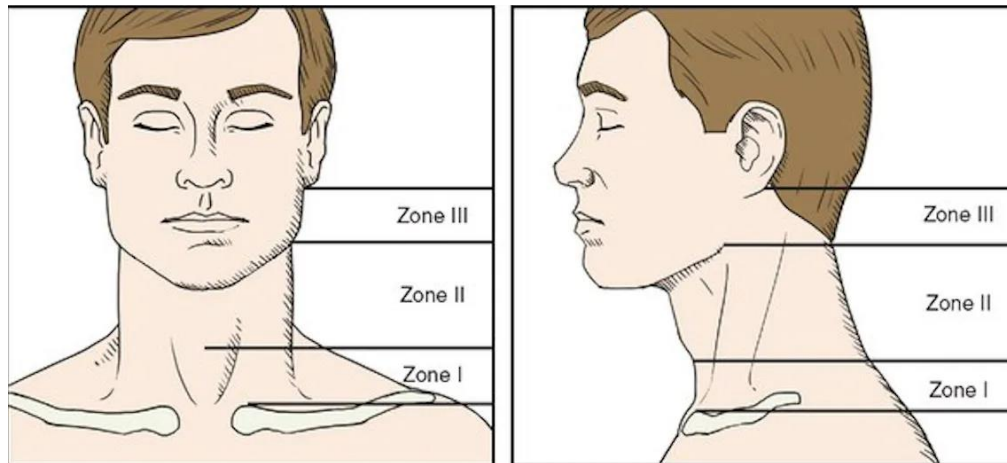
Platysma



Penetrating Neck Injury

- Zone 1: clavicle to cricoid
- Zone 2: cricoid to mandible
- Zone 3: mandible to base of skull

Zone 1	Zone 2	Zone 3
Common carotid Subclavian Vertebral Lung Apex Trachea Esophagus	Carotid Vertebral Jugular vein Pharynx Trachea Esophagus	Vertebral Distal carotid Distal jugular Cranial nerves



Penetrating Neck Injury

Clinical Features

- Look for **hard signs** of serious injury
 - Usually indicates need for emergent surgery
- Hard signs of vascular injury
 - Hemorrhage
 - Expanding hematoma
 - Shock
- Hard signs of airway/esophageal injury
 - Air bubbling from wound
 - Hemoptysis
 - Hematemesis
 - Respiratory distress

Penetrating Neck Injury

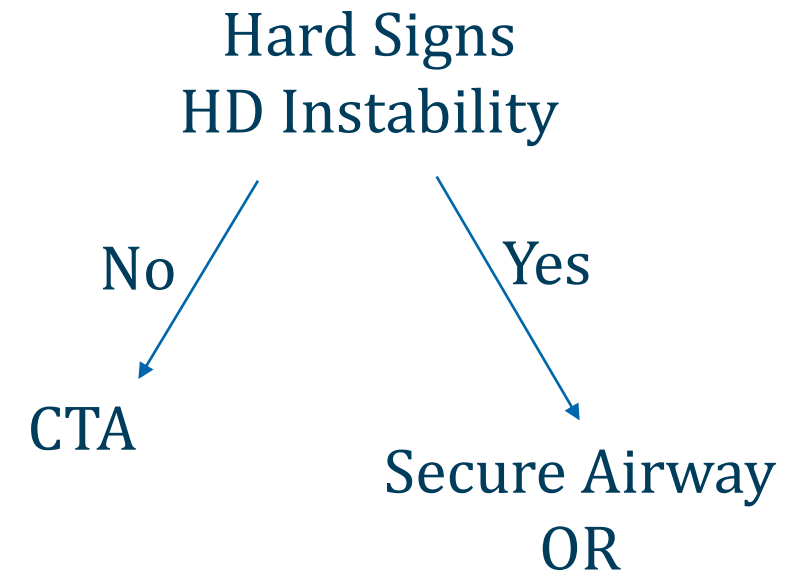
Clinical Features

- Soft signs = possible serious injury
- Minor hemoptysis or hematemesis
- Dysphonia
- Dysphagia
- Subcutaneous or mediastinal air
- Non-expanding hematoma

Penetrating Neck Injury

Diagnosis and Management

- Hard signs often require urgent surgery
- Stable patient with soft signs = **MDCT-A**
 - Multidetector CT angiography
 - Multiple detectors
 - Increases speed of image acquisition
 - Uses contrast (angiography)
- Treatment based on injuries
 - Intubation for airway compromise
 - Surgery



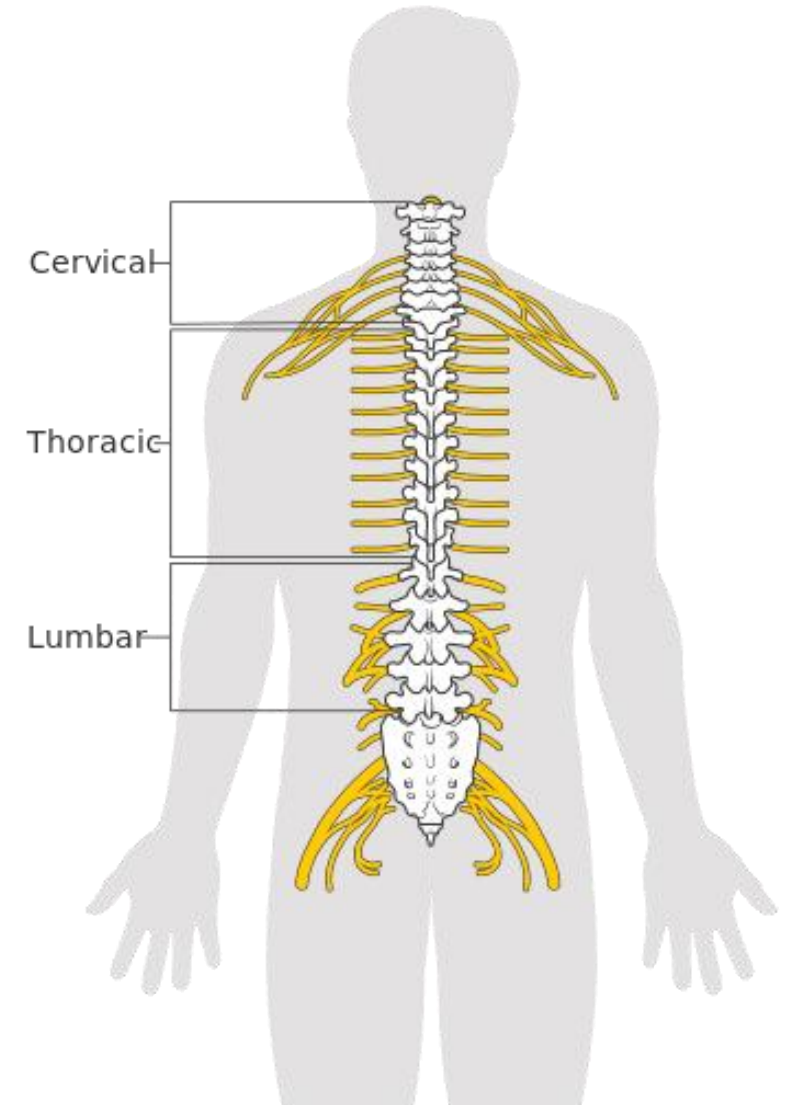
Spinal Trauma

- Most common cause: **motor vehicle accidents (48% cases)**
 - Falls: 16%
 - Violence (often gunshot wounds): 12%



Spinal Cord Injury

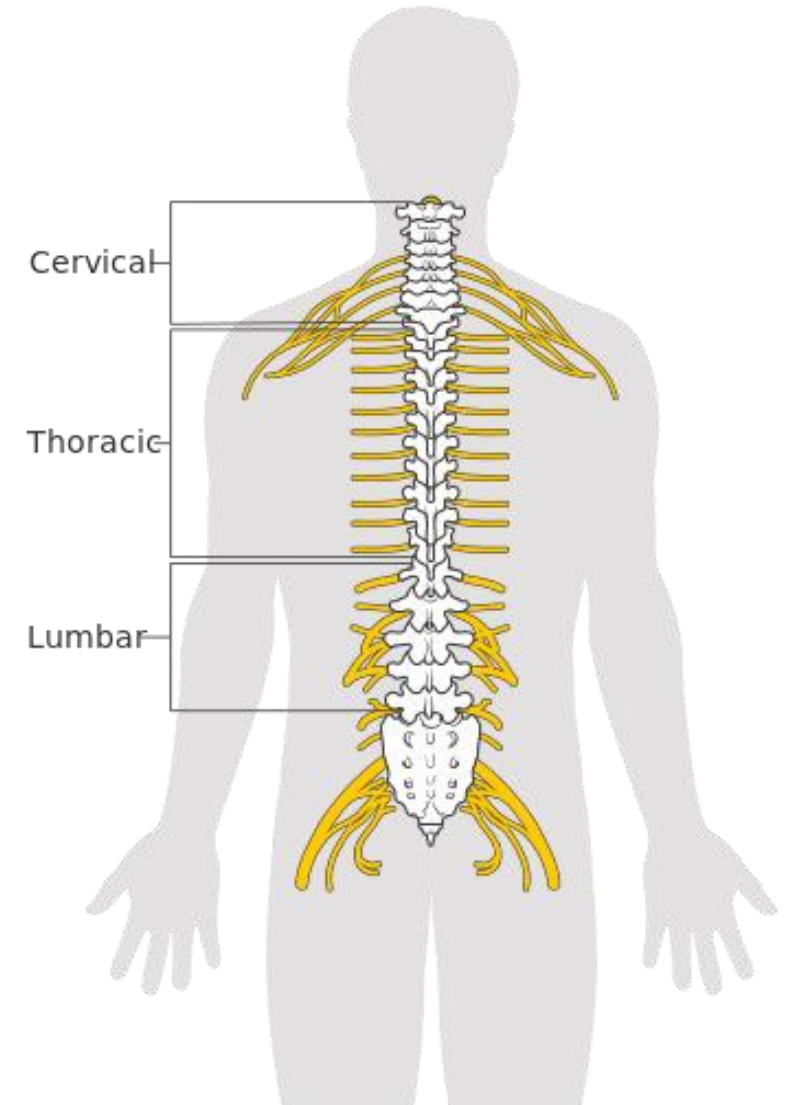
- Usually occurs with injury to vertebral column
- Bone fracture
- Joint dislocation
- Ligament tear
- Disc herniation



Spinal Cord Injury

Clinical Presentation

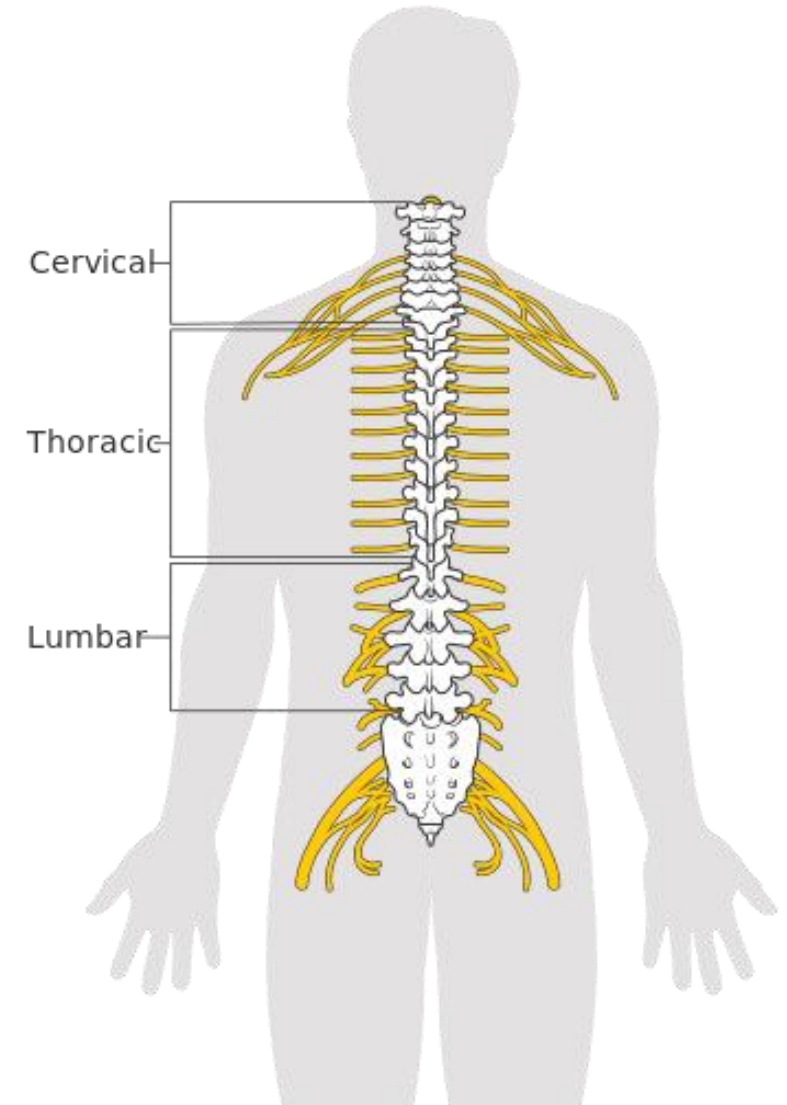
- Pain at site of spinal fracture (if present)
- 50% cases involve cervical cord (usually C4 or C5)
- Damage can lead to quadriparesis or quadriplegia
 - Paresis = weakness
 - Plegia = paralysis



Spinal Cord Injury

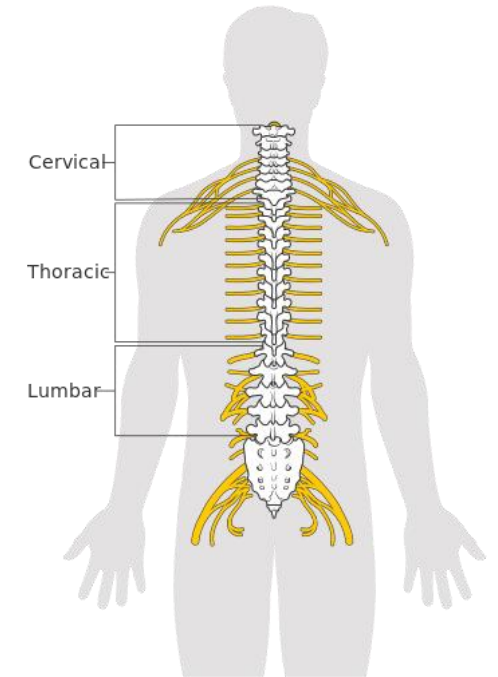
Clinical Presentation

- **ASIA Class A: Complete cord injury**
 - American Spinal Injury Association
 - Motor and sensory loss below a spinal level
 - Always includes loss of function in sacral segments S4-S5
- Class B through D lesions: Incomplete cord injuries
 - Incomplete motor and sensory loss
 - Sacral function present



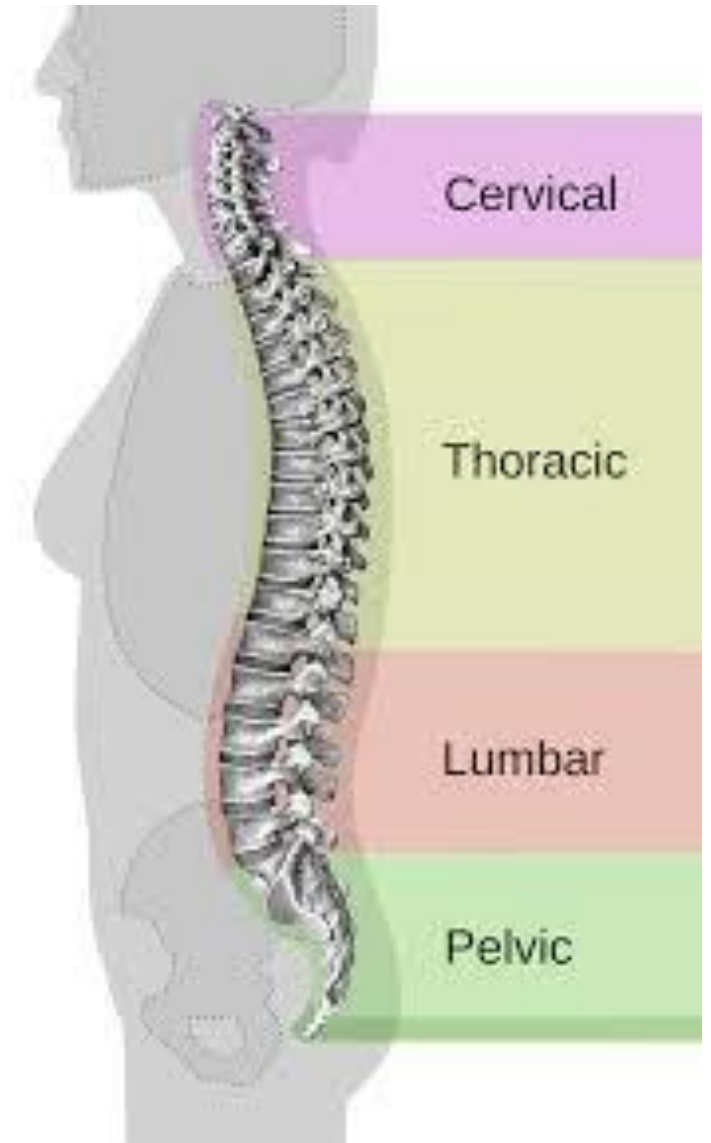
Sacral Testing

- Sacral nerves: **most distal spinal cord nerves**
- Sensation at anal mucocutaneous junction
- Sensation to deep anal pressure on digital rectal exam
- Voluntary anal contraction during a digital rectal exam
- **Determines complete versus incomplete**
- “Sacral sparing” = incomplete injury



Spinal Shock

- Concussion of the spinal cord
- Transient loss of spinal cord function
- Occur below level of injury
- Flaccid paralysis and sensory loss
- Absent bowel and bladder control
- **Loss of sacral reflexes**
- In males: priapism may occur
- Lasts hours to weeks



Bulbocavernosus reflex

- Squeeze glans penis or clitoris
- Or tug on indwelling Foley catheter
- Reflex response: anal sphincter contraction
- Absent only in low spinal cord trauma
- Absent reflex with high cord injury= spinal shock
- Complete cord injury:
 - Recovery of reflex with ongoing paralysis

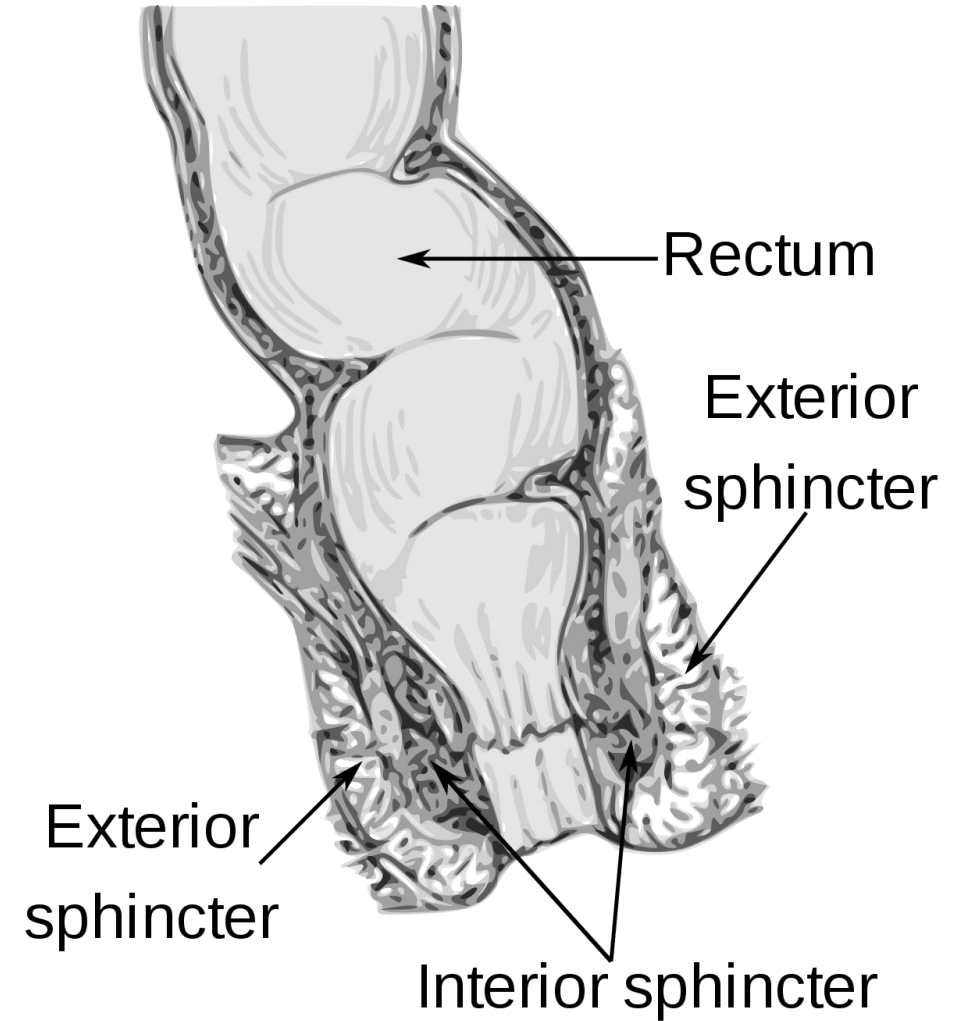


Coastone/Wikipedia

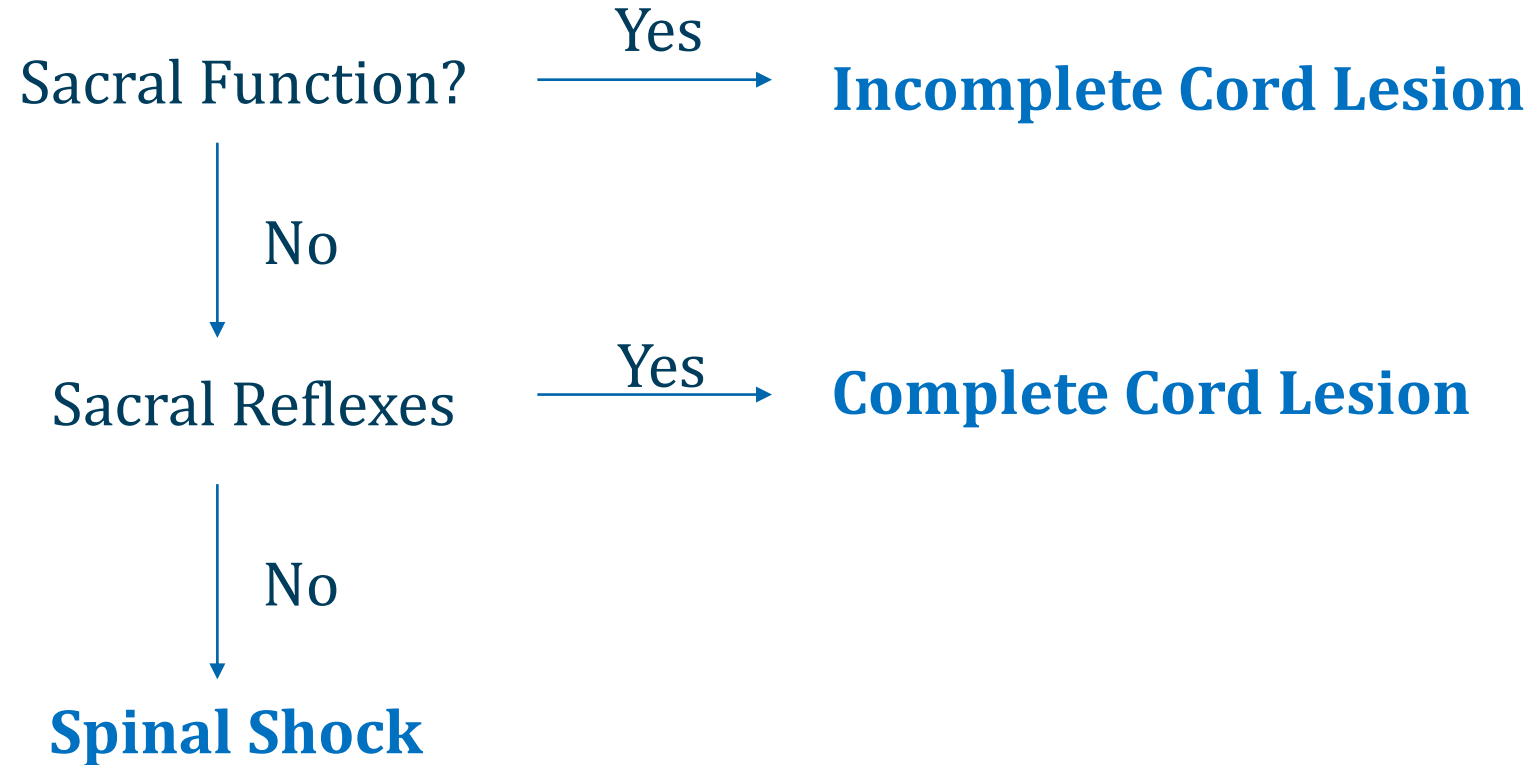
Anocutaneous Reflex

Anal Wink

- External anal sphincter
- Innervated by S4-5 (end of the spinal cord)
- Stroking the skin surrounding anus
- Reflex contraction of external anal sphincter
- Also absent in spinal shock but may recover



Spinal Cord Trauma



Spinal Cord Injury

Complete	Incomplete
Absence of sacral sparing Absent distal motor Absent distal sensory Bulbocavernosus reflex present	Sacral sparing Motor function below injury

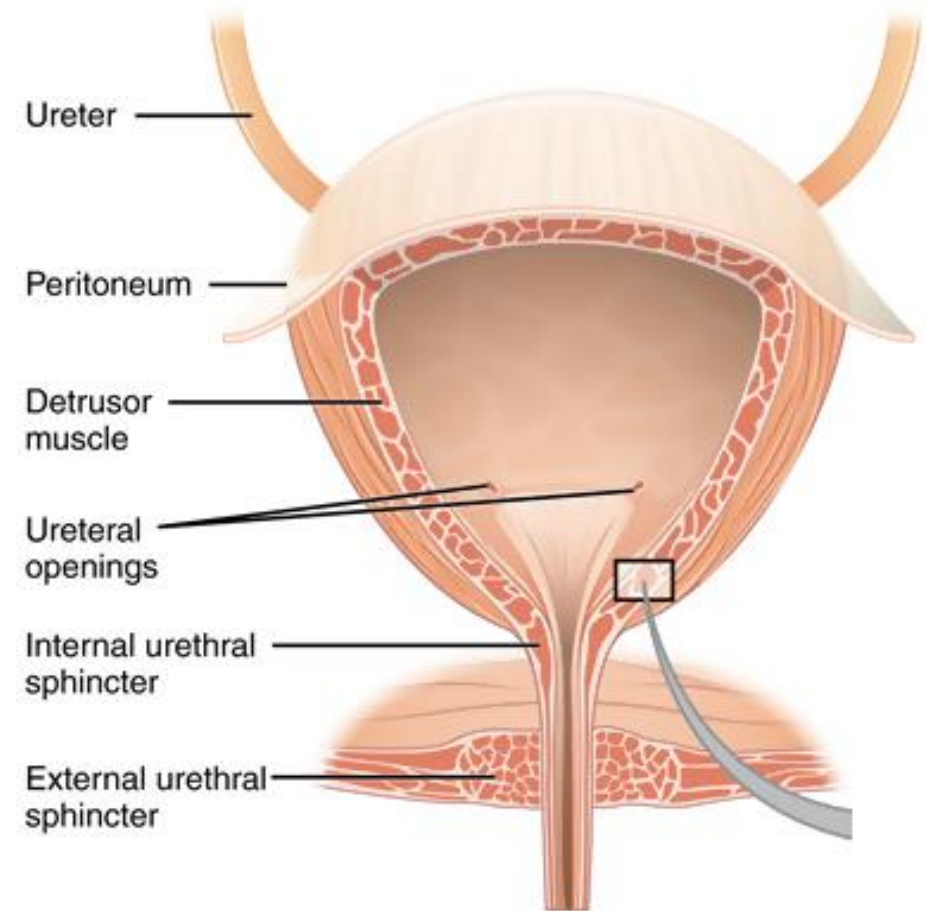
Neurogenic Shock

- Different from spinal shock
- Complication of spinal cord injury
- **Hypotension**
- **Bradycardia**
- **Hypothermia**
- Caused by loss of sympathetic tone
- Parasympathetic tone dominates
- May develop within 30 minutes of injury
- Most common with complete cervical injury



Bladder Control

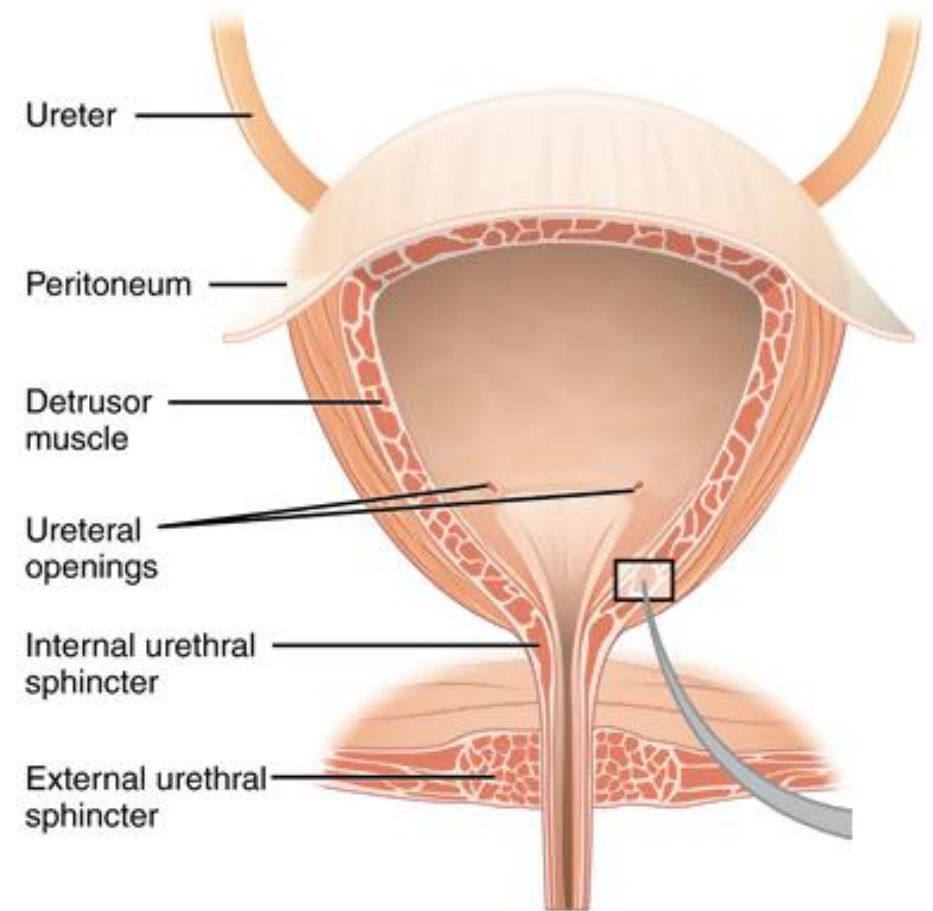
- Somatic control: S2-S4 level nerves
- Lesions above S2: **detrusor overactivity**
 - UMN lesion of bladder
 - Cannot be emptied voluntarily
 - Empties reflexively when expanded
 - Detrusor spasticity
 - Urge incontinence
 - Urinary urgency and incontinence



(a)

Bladder Control

- Injury at S2 to S4: **overflow incontinence**
 - Flaccid/hypotonic bladder
 - Bladder fills beyond capacity → incontinence



(a)

Incomplete Cord Injuries

- Can involve anterior cord or central cord
- Clinical features similar to other spinal cord conditions
 - ASA infarction
 - Syringomyelia

Syringomyelia



Wikipedia/Public Domain

Spinal Cord Injury

Diagnosis and Management

- **Imaging**

- Cervical spine often imaged in all major trauma patients
- X-ray or CT: initial test for bone injury (poor visualization of cord)
- MRI: imaging of cord injuries

- **Management**

- Spinal immobilization (often done in the field)
- Treatment of complications (respiratory paralysis, shock)
- Surgery for fractures or cord compression
- Glucocorticoids generally not used (little evidence of benefit)

Spinal Cord Injury MRI



Chest Trauma

Jason Ryan, MD, MPH



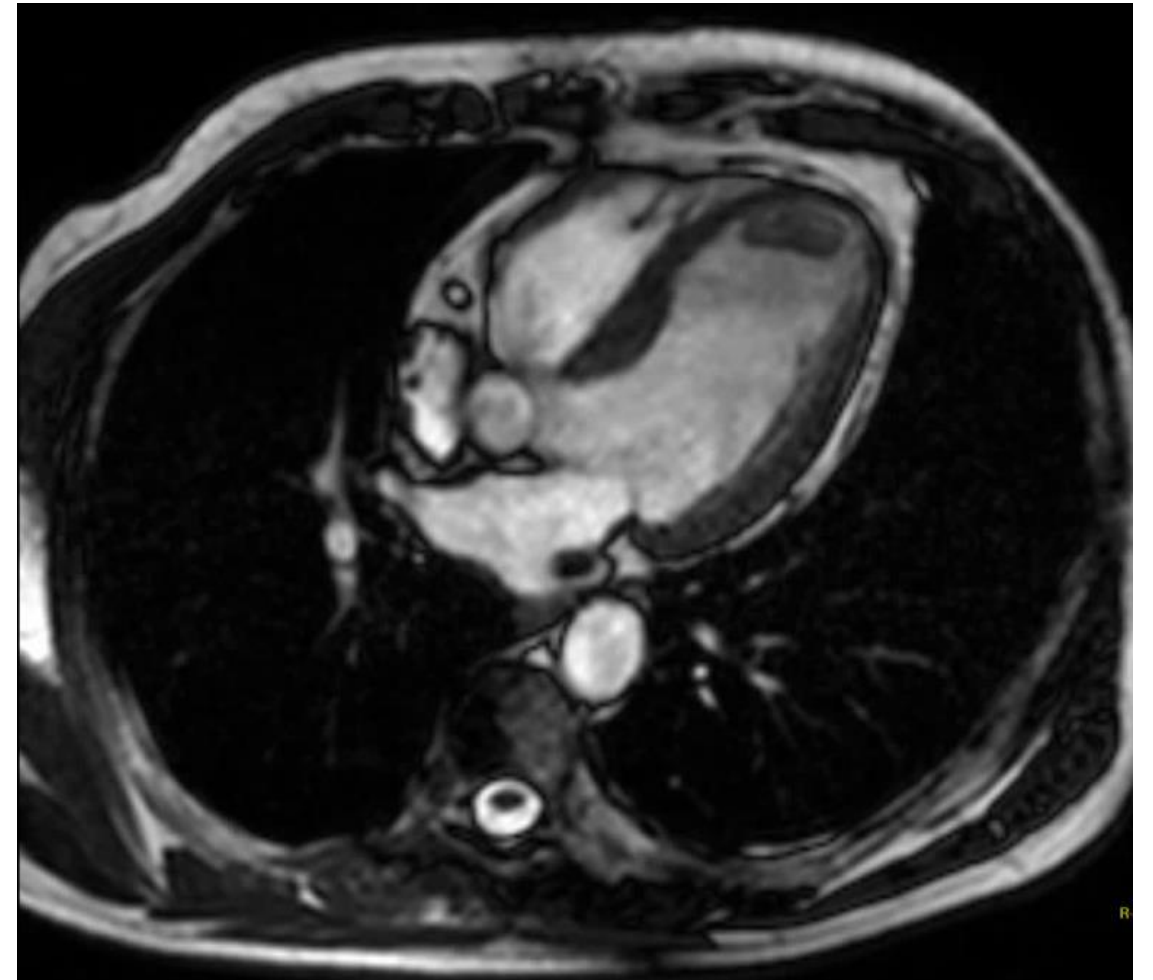
Blunt Chest Trauma

- Commonly caused by motor vehicle accidents
- May damage heart, lungs, aorta, and other structures



Blunt Cardiac Injury

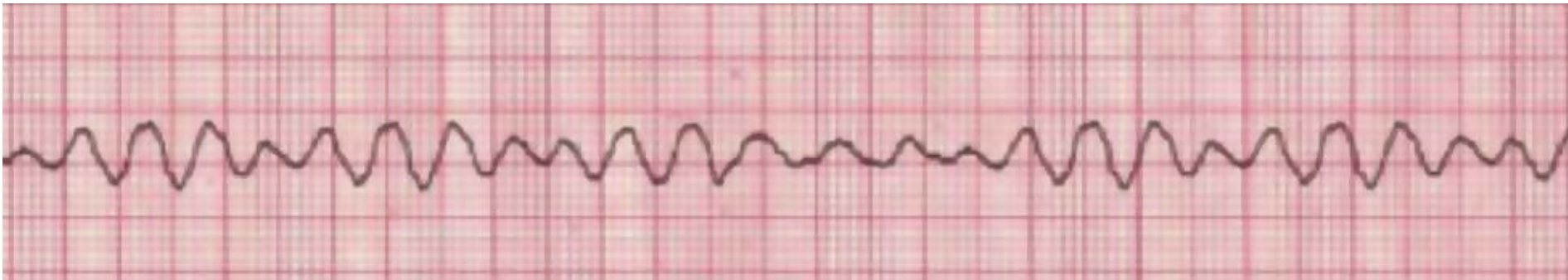
- **Right heart** most commonly injured
- Ventricular wall rupture
- Valvular damage
- Myocardial infarction
- Cardiac contusion
 - Focal area of decreased contractility
- Diagnosis:
 - EKG
 - Echocardiography
 - Cardiac biomarkers



Commotio Cordis

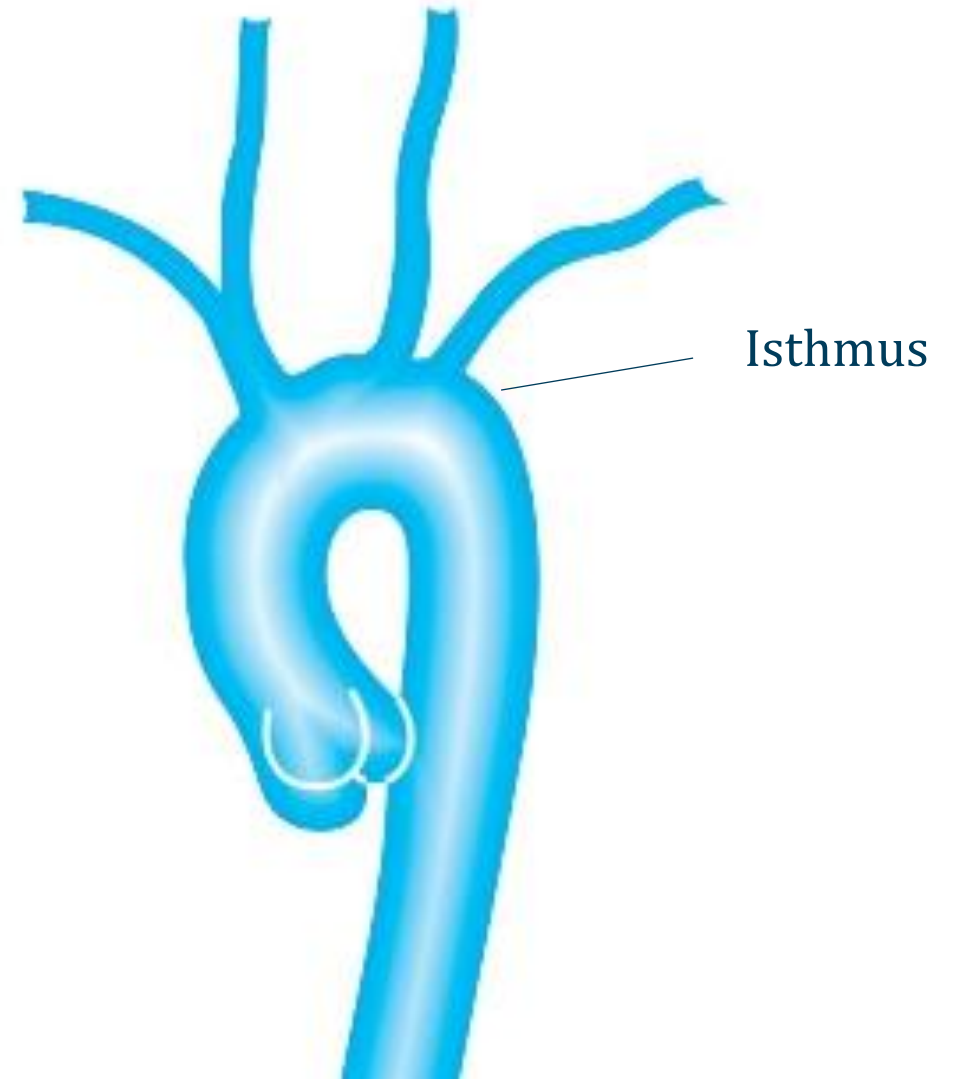
- Rare form of blunt cardiac injury
- Low impact chest trauma → sudden cardiac arrest (usually Vfib)
- Occurs from timing of blow during electrically-susceptible period

Ventricular Fibrillation



Traumatic Aortic Rupture

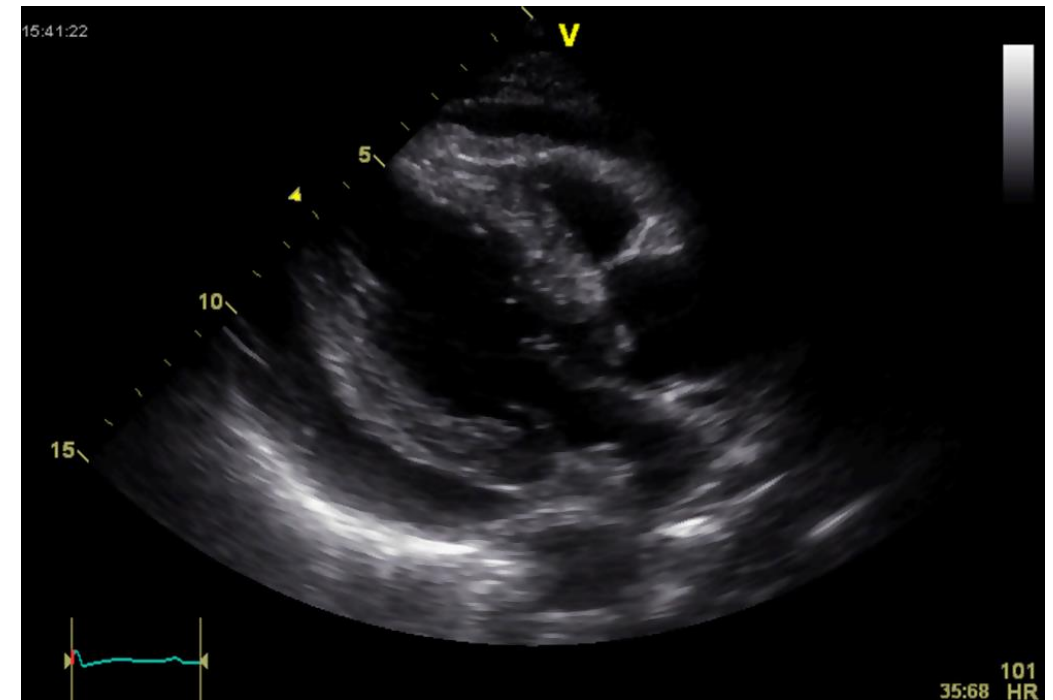
- Most common at **isthmus**
 - Just distal to the left subclavian artery
 - Transition zone
 - Ascending aorta and arch more mobile
 - Descending thoracic aorta less mobile
- Usually fatal
- Survivable if contained hematoma occurs
- Diagnosis: **CT scan with contrast**
 - Alternative: TEE (unstable patients)
- Treatment: urgent surgery



Pericardial Tamponade

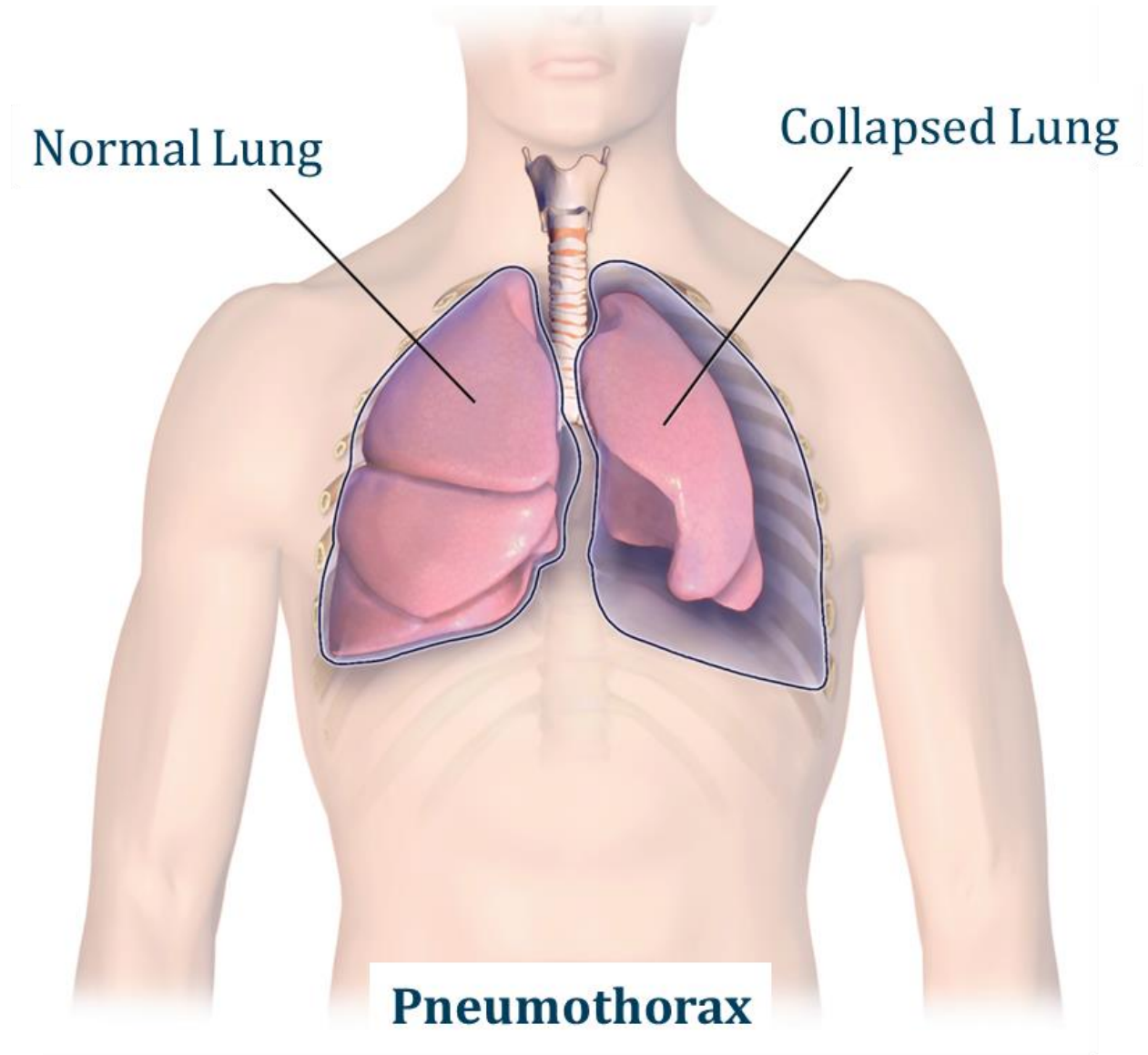
- Bleeding into pericardial space
- Impaired ventricular filling
- Distant heart sounds
- Hypotension
- Dyspnea with absence of pulmonary edema
- Elevated jugular venous pressure
- Diagnosis: echocardiogram
- Treatment: pericardiocentesis

Pericardial Effusion



Pneumothorax

- Air in pleural space
- Tension pneumothorax
 - High pressure in pleural space
 - Impaired venous return
 - Hypotension
- Treatment: thoracentesis



Hemothorax

- Bleeding into pleural space
- Many potential sources
 - Aorta
 - Myocardium
 - Lung vessels
 - Intercostal vessels
- Dullness to percussion over lung
- Easily visualized with **ultrasound**
- Treatment: chest tube or surgery
 - Surgery if > 1.5L blood drained

Hemothorax by Ultrasound

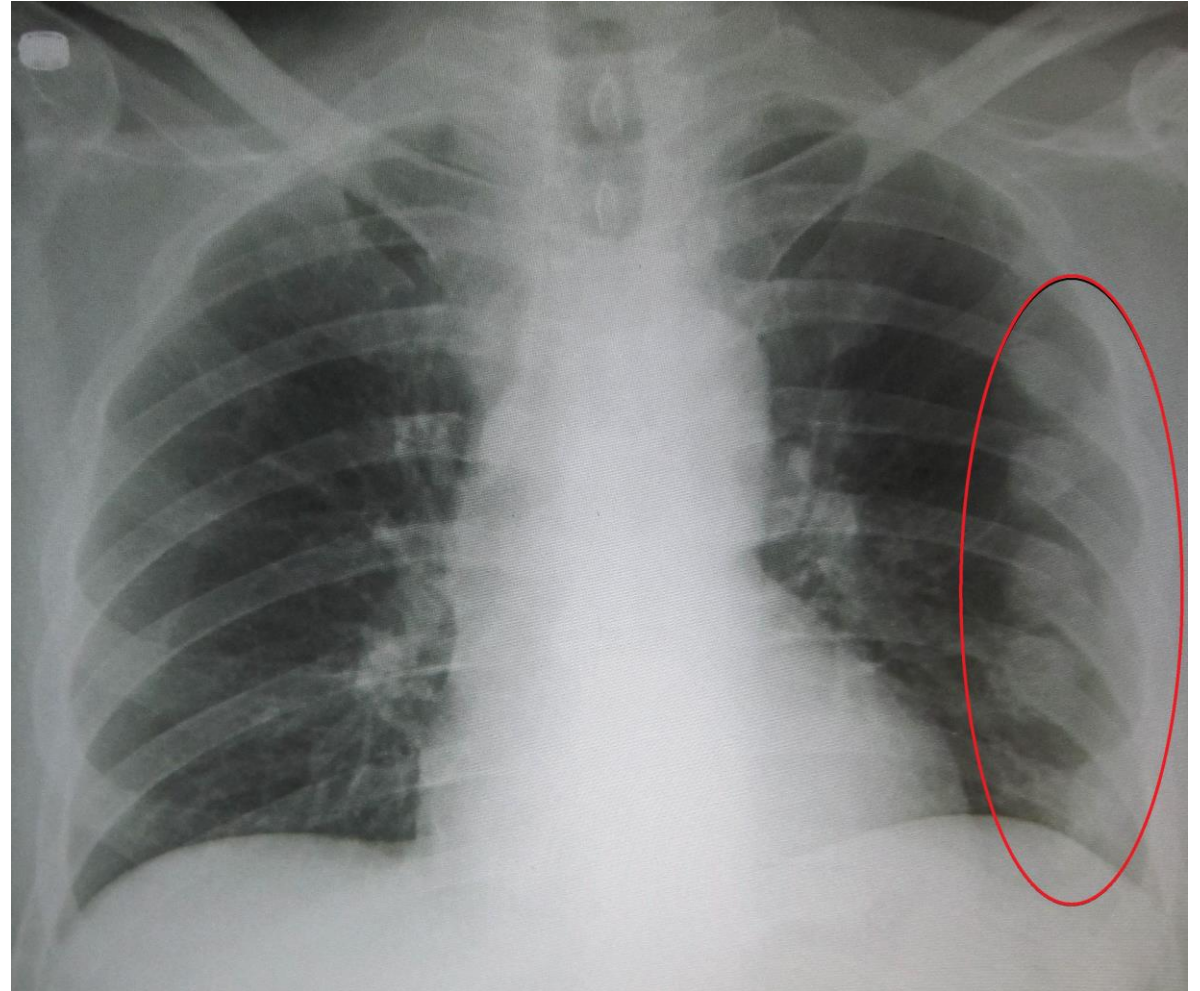


Terminology

Name	Definition
Chest Tube (tube thoracostomy)	Tube inserted into pleural space to drain air, fluid or blood
Needle decompression (thoracentesis)	Needle insertion into pleural space to drain air
Thoracotomy	Surgical incision in thorax

Rib Fractures

- Cause rib pain
- May lead to complications
 - Pneumothorax
 - Liver or spleen lacerations
 - Pulmonary and cardiac contusions
- Weak cough
 - May lead to atelectasis or pneumonia
- Diagnosis: CXR
 - Can be missed by x-ray
 - CT scan more sensitive



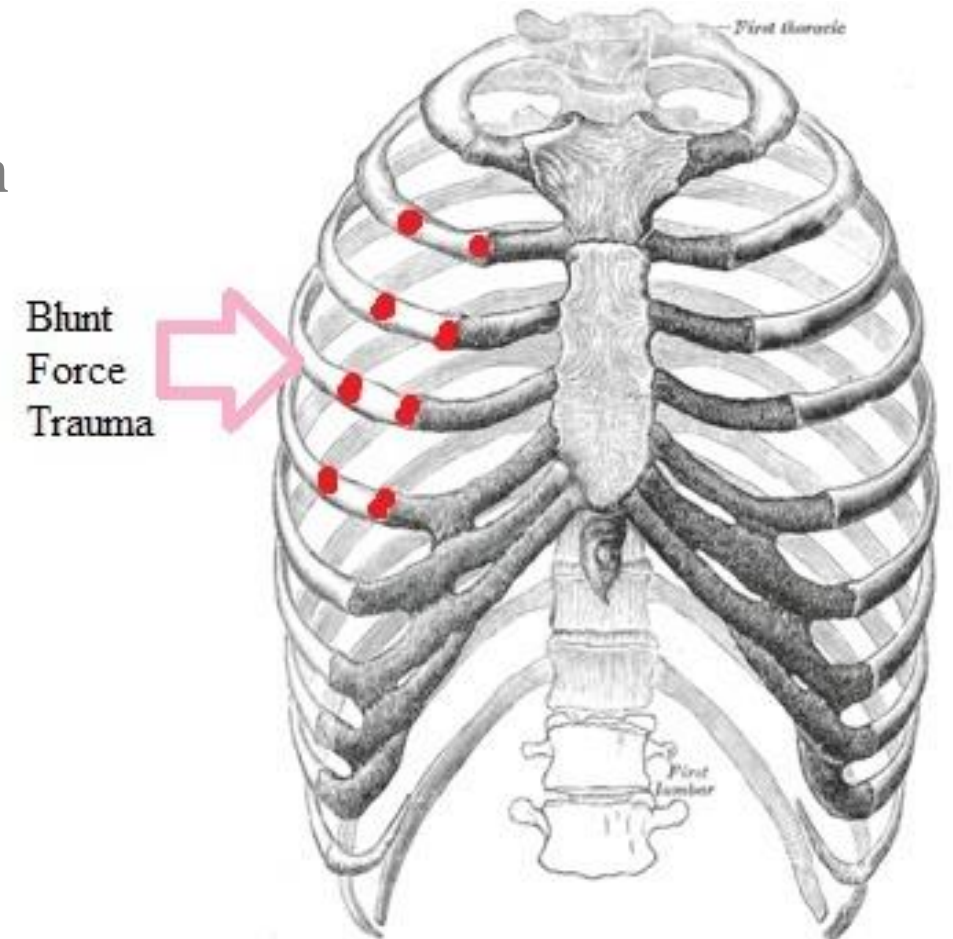
Rib Fractures

- Rarely require surgery
- Treatment: **analgesia**
 - NSAIDs, opioids
- **Incentive spirometry**
- Adequate treatment required for:
 - Normal ventilation
 - Effective cough



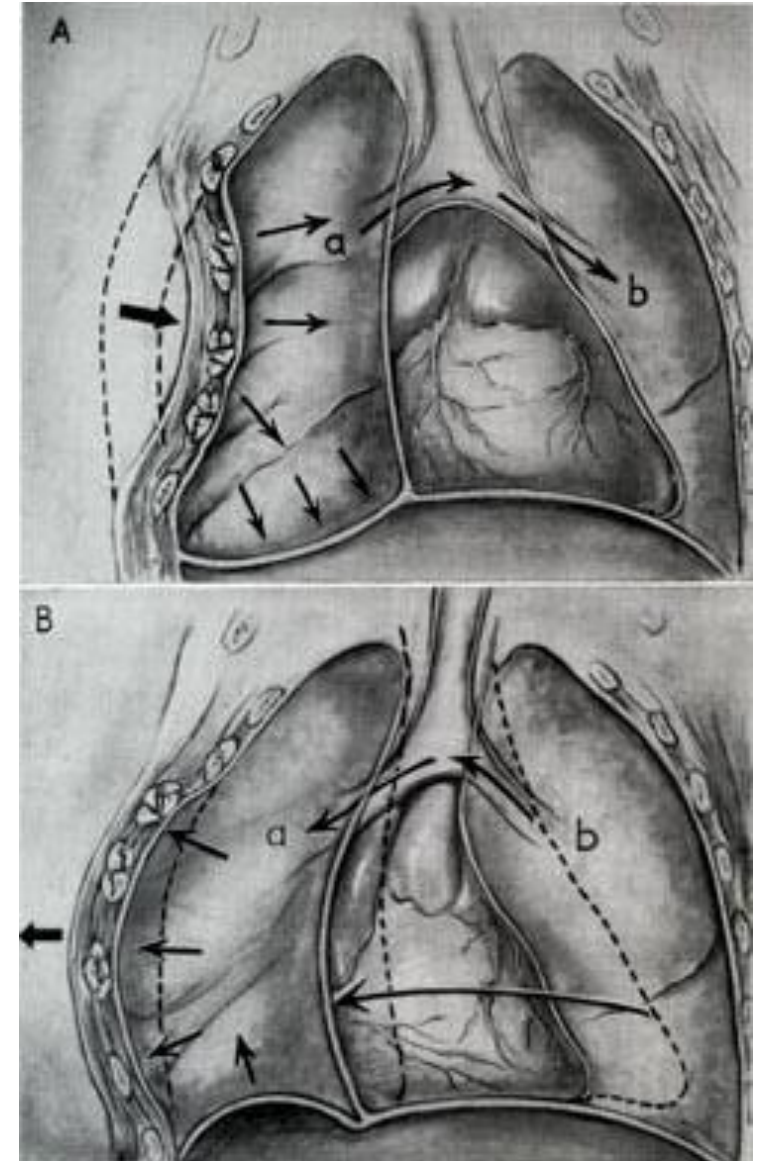
Flail Chest

- Multiple rib fractures from massive chest trauma
- Segment of rib cage detaches (“floats”)
- Two fractures in each broken rib
- At least three ribs with two fractures
- Decreased or absent breath sounds
- **Paradoxical motion** of flail segment
 - Flail segment will sink with inspiration
 - Budge with exhalation



Paradoxical Motion

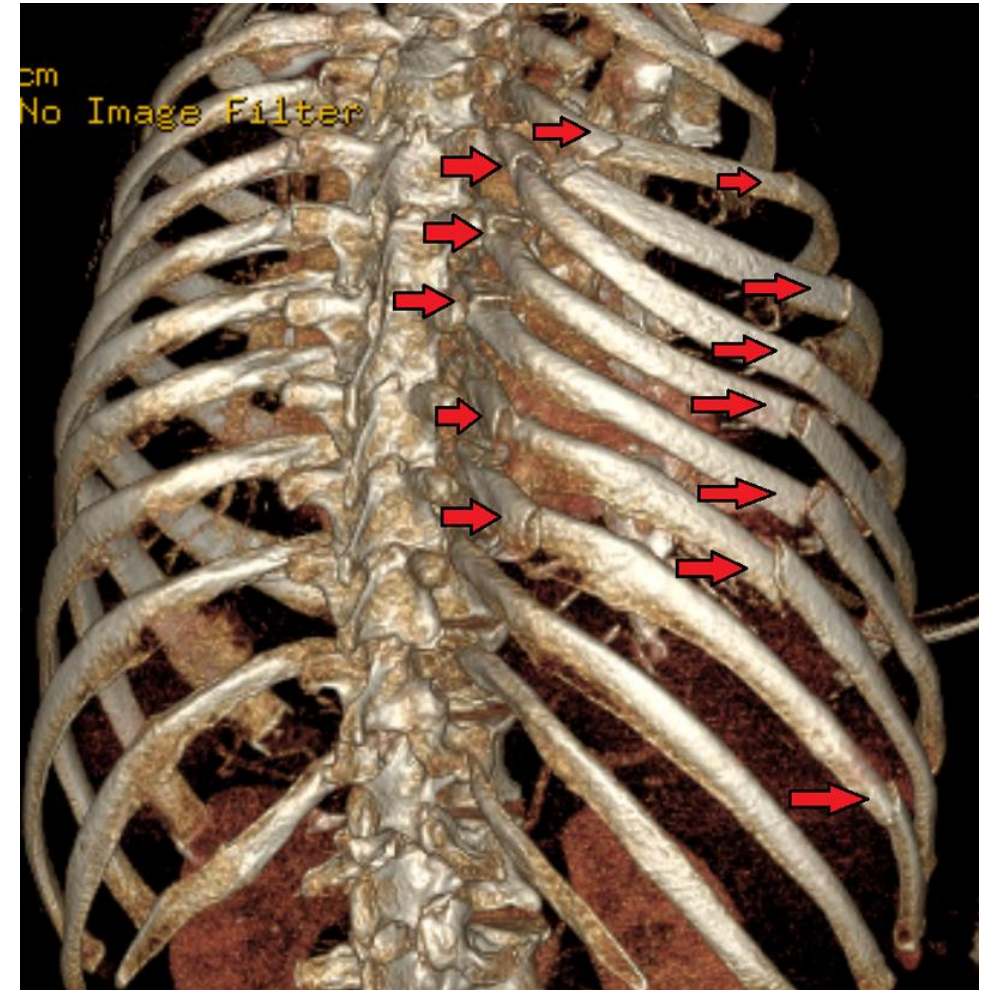
- During inspiration:
 - Diaphragm contracts
 - Intercostal muscles pull rib cage out
 - Negative pleural pressure → air in
- Flail segment pulled in during inspiration
- During expiration:
 - Diaphragm and intercostal muscles relax
 - Rising pleural pressure → air out
- Flail segment pushed out during expiration



Flail Chest

- Paradoxical motion impairs respiratory function
 - Pain with inspiration
 - Often causes **pulmonary contusion**
 - Pneumothorax
 - Hemothorax
- Leads to **respiratory distress**
- Treatment:
 - Pain control
 - Noninvasive positive pressure ventilation
 - Intubation and mechanical ventilation

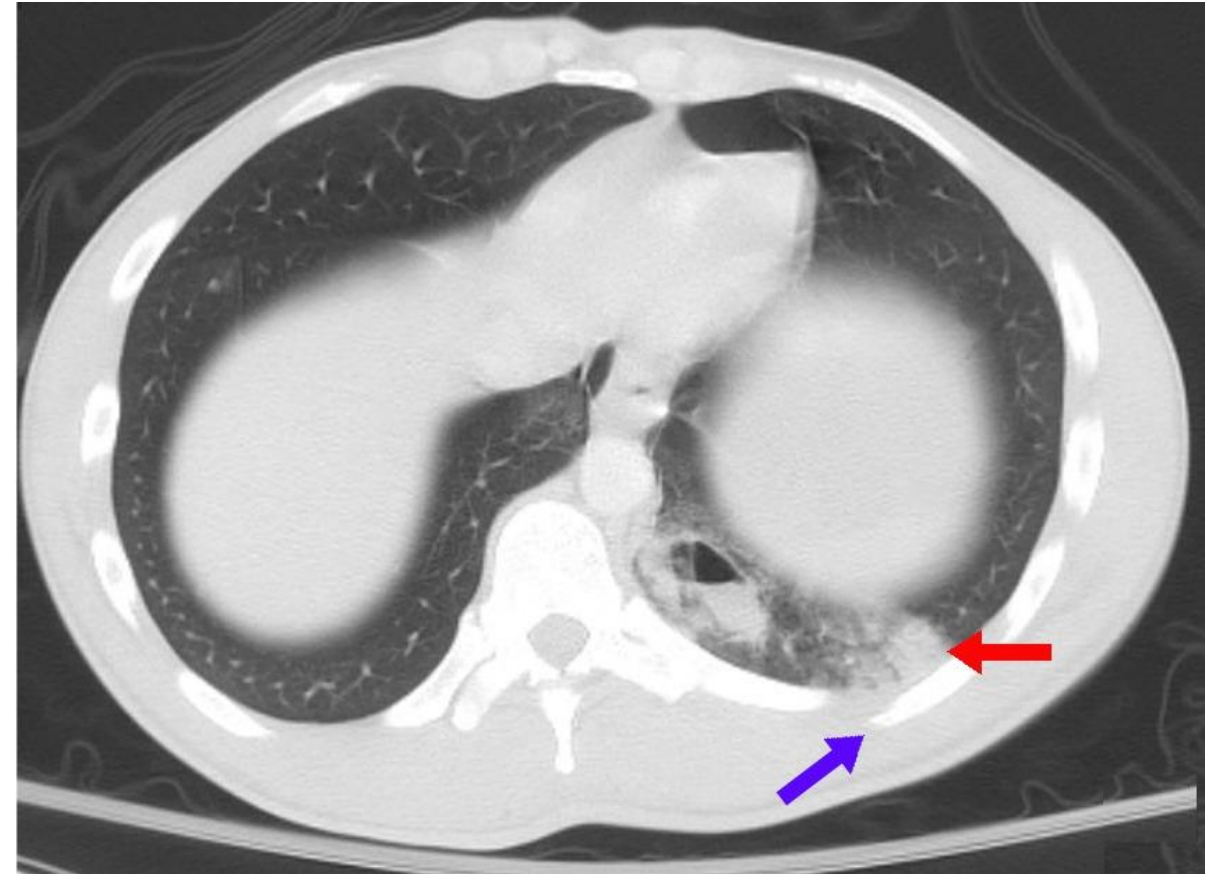
CT Reconstruction Flail Chest



Pulmonary Contusion

- Bruise in lung
- Caused by capillary damage
- Develops within 48 hours of injury
 - Potential hidden injury
 - Can be absent on initial presentation
- Often associated with rib fractures
- Causes respiratory failure
- Can lead to ARDS or PNA

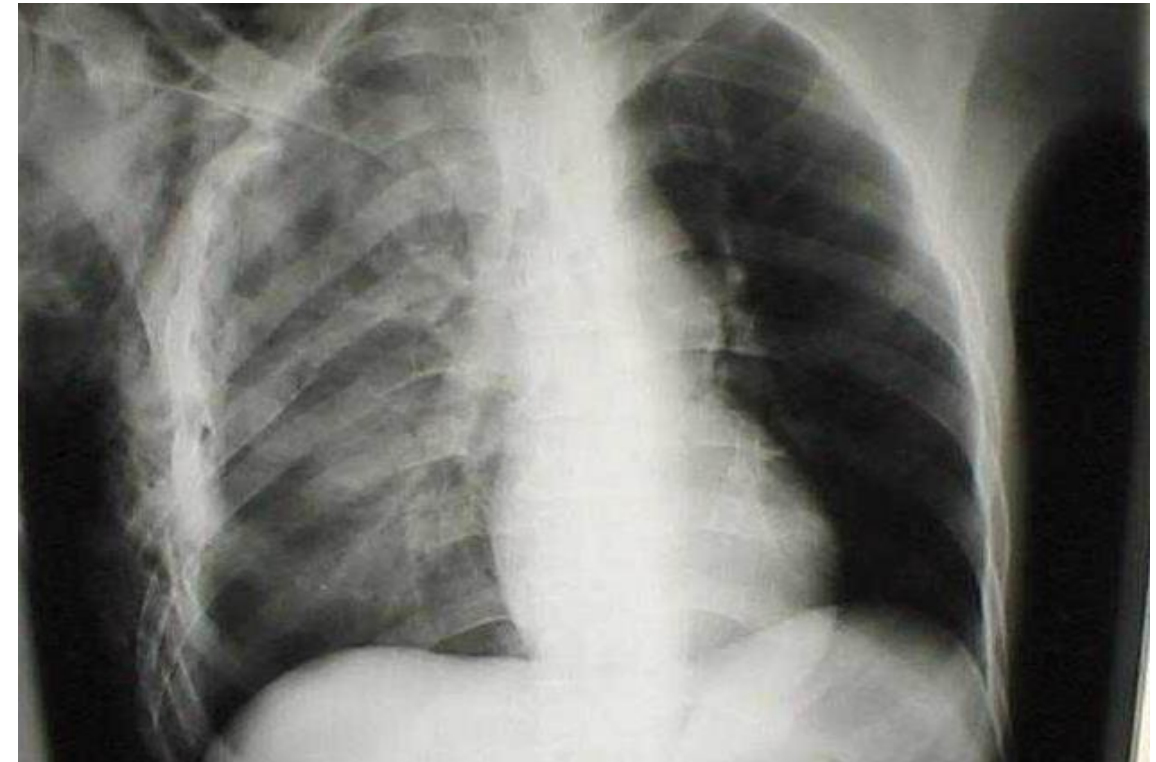
Rib Fracture with Pulmonary Contusion



Pulmonary Contusion

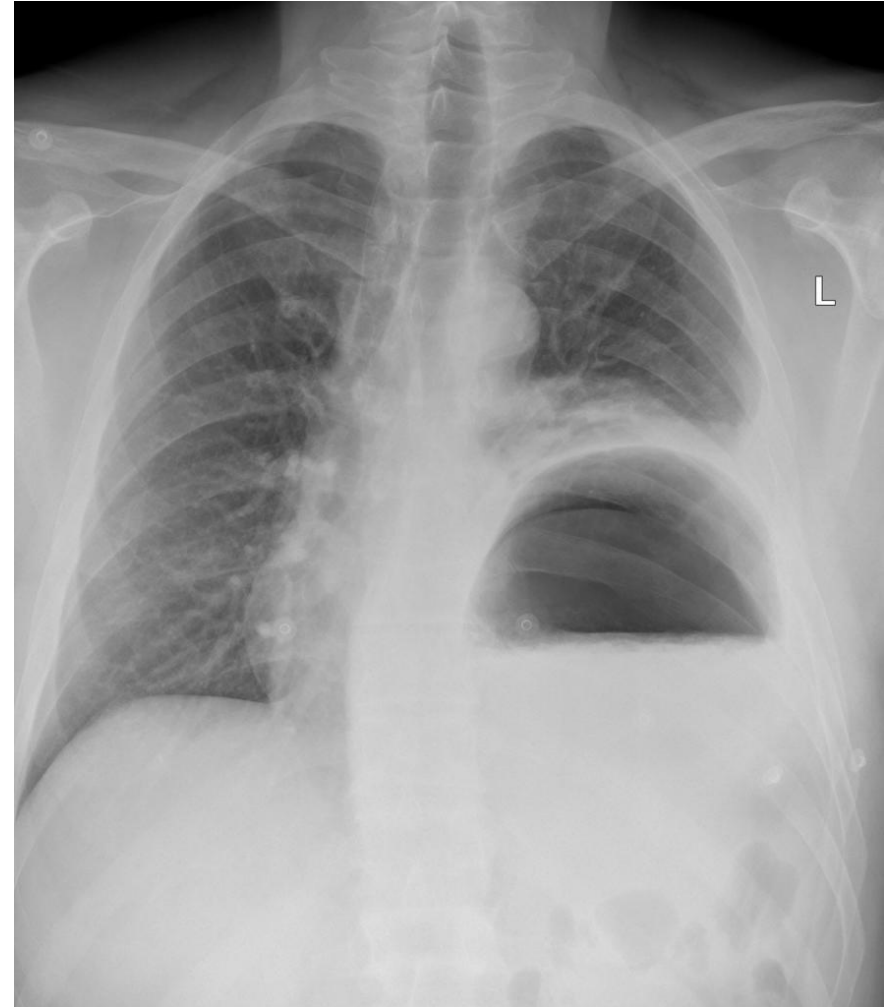
Diagnosis and Treatment

- Diagnosis: **chest x-ray**
 - Opacification of lung
 - Not bilateral (like pulmonary edema)
 - Does not follow anatomic borders (like PNA)
- Treatment:
 - Pain control
 - Respiratory support
 - Careful use of fluids (avoid pulmonary edema)



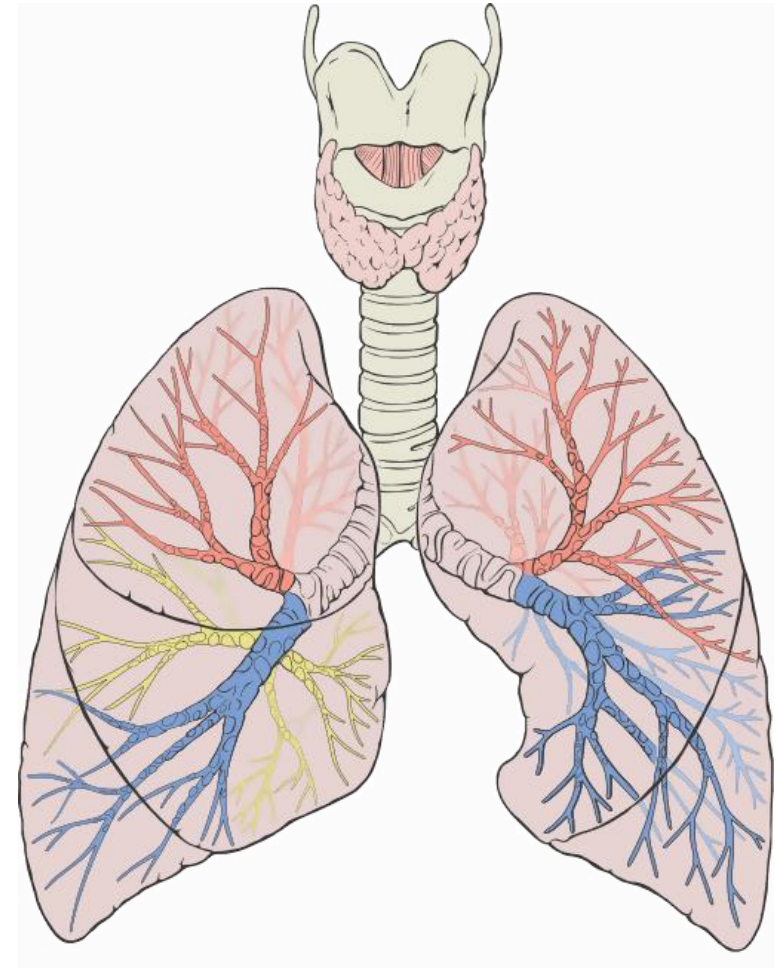
Diaphragmatic Rupture

- Stomach or bowel in chest
- Almost always on left side
- Treatment: surgery



Tracheal or Bronchial Rupture

- Allows air into chest
- **Subcutaneous emphysema**
 - Air beneath skin of chest and neck
 - Skin pressure causes crackles
 - Seen on x-ray
- Air leak into chest tube
- Diagnosis: **bronchoscopy**
 - Often in OR prior to treatment
- Treatment: surgery



Pelvic Trauma

Jason Ryan, MD, MPH

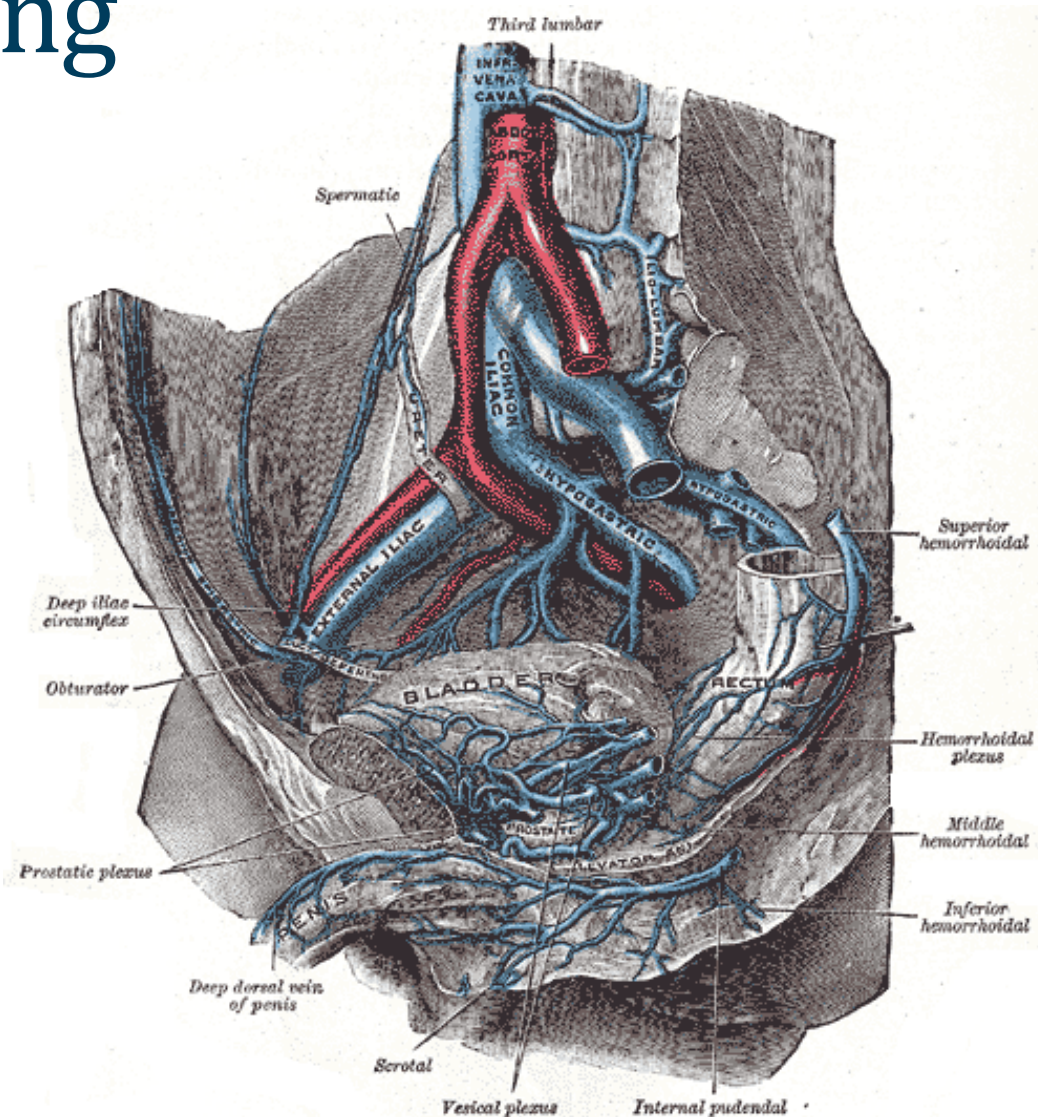


Pelvic Trauma

- Usually blunt trauma from motor vehicle accident
- Can cause life-threatening hemorrhage
- Bleeding from **iliac vessels** often caused by pelvic fractures
- Source of bleeding is usually **venous plexus** (80 to 90% of cases)
 - Small, thin-walled veins that drain to iliac veins
- Arterial bleeding can occur from iliac arteries



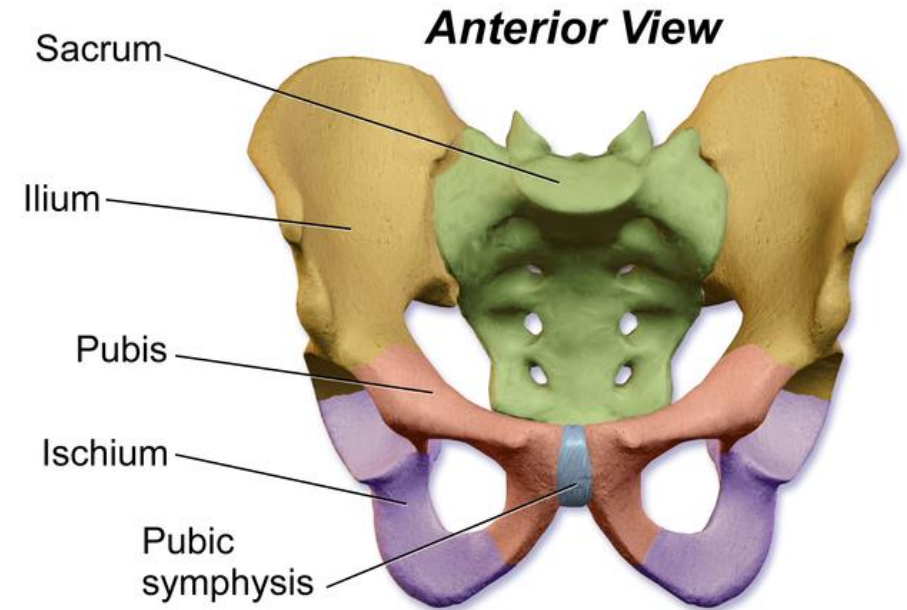
Pelvic Bleeding



Pelvic Fractures

Common Types

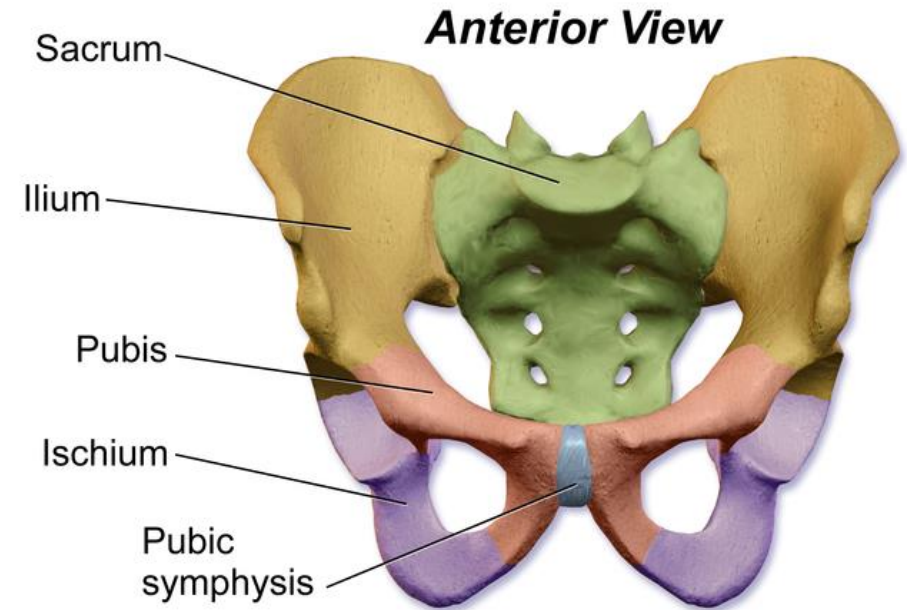
- **Pelvic ring fractures**
 - Ring formed by ilium, ischium, pubis, and sacrum
 - Stabilized by ligaments
 - Fracture: ring disrupted
 - Ring disruption usually requires two or more fractures
- **Sacral fractures**
- **Acetabular fractures**
 - Socket of the hipbone
 - Formed by ilium, ischium, and pubis
 - Insertion of head of the femur



Pelvic Fractures

Physical Exam Findings

- Pelvic instability
- Tenderness on compression of iliac crests
- Protrusion of iliac crests
- Misalignment of legs



Pelvic Fractures

Workup

- **Portable AP pelvis x-ray**
 - Used to identify fractures
 - Used in hemodynamically unstable patients
- Pelvic CT scan: gold standard
 - Used in stable patients
 - Identifies bleeding and fractures



Pelvic Trauma

Identification of Bleeding

- **Bedside ultrasound (FAST)**
 - Difficult to visualize hemoperitoneum
 - Low sensitivity, but high specificity
- **Diagnostic peritoneal aspirate (DPA)**
 - Used after negative FAST in patients with persistent hemodynamic instability
 - Aspiration of 10 mL or more of gross blood is considered positive

Pelvic Trauma

Workup

- Must evaluate for associated injuries
- Rectal exam
 - Palpate for rectal bleeding or wounds
 - Also bony fragments, sphincter function and prostate position
- Vaginal exam
- Ureteral imaging in men
- Bladder imaging

Pelvic Trauma

Management

- Few good surgical options to stop bleeding
 - Blood loss sites difficult to access and control
 - Contrast with abdominal bleeding
- **Pelvic binder**
 - Wraps and binds pelvis
 - Reduces pelvic volume
 - Creating a tamponade effect
 - Also stabilizes fractures to reduce hemorrhage from fracture sites



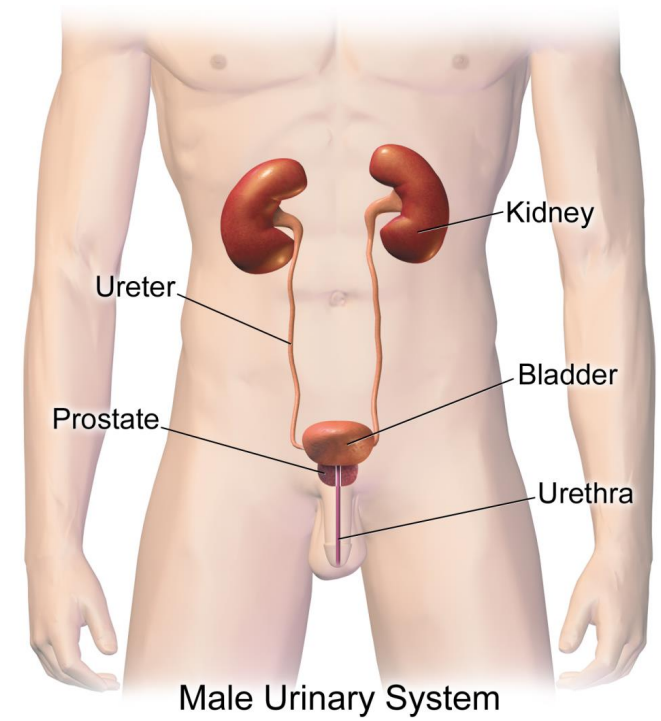
Pelvic Bleeding

Management

- Preperitoneal pelvic packing
 - Skin incision
 - Sponges placed between peritoneum and pelvic ring
- Resuscitative endovascular balloon occlusion of the aorta (REBOA)
 - Catheter/balloon insertion into aorta via femoral artery
- Surgical stabilization of pelvic fractures
- Embolization of bleeding pelvic vessels

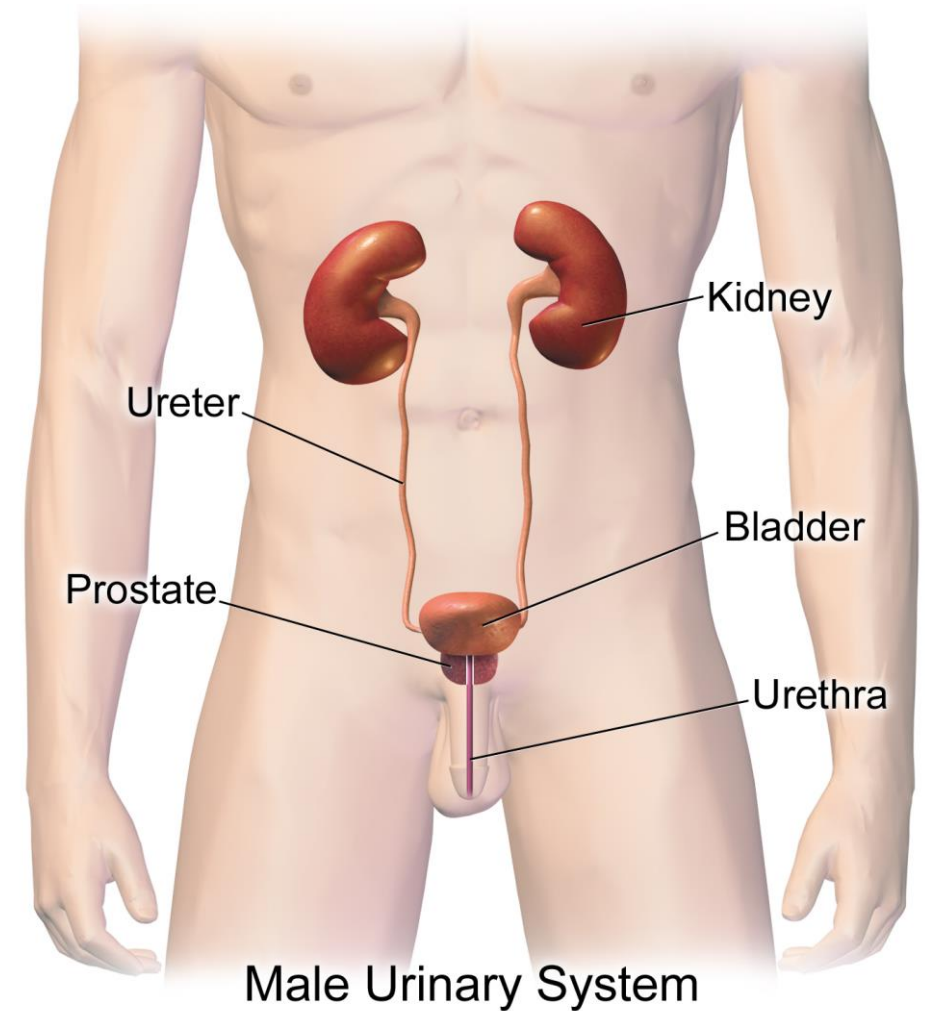
Genitourinary Trauma

- Often occurs in pelvic trauma
- Usually not life-threatening
- Can cause incontinence and impaired sexual function
- Treatment of life-threatening pelvic injuries takes priority
- Genitourinary evaluation after patient stabilized



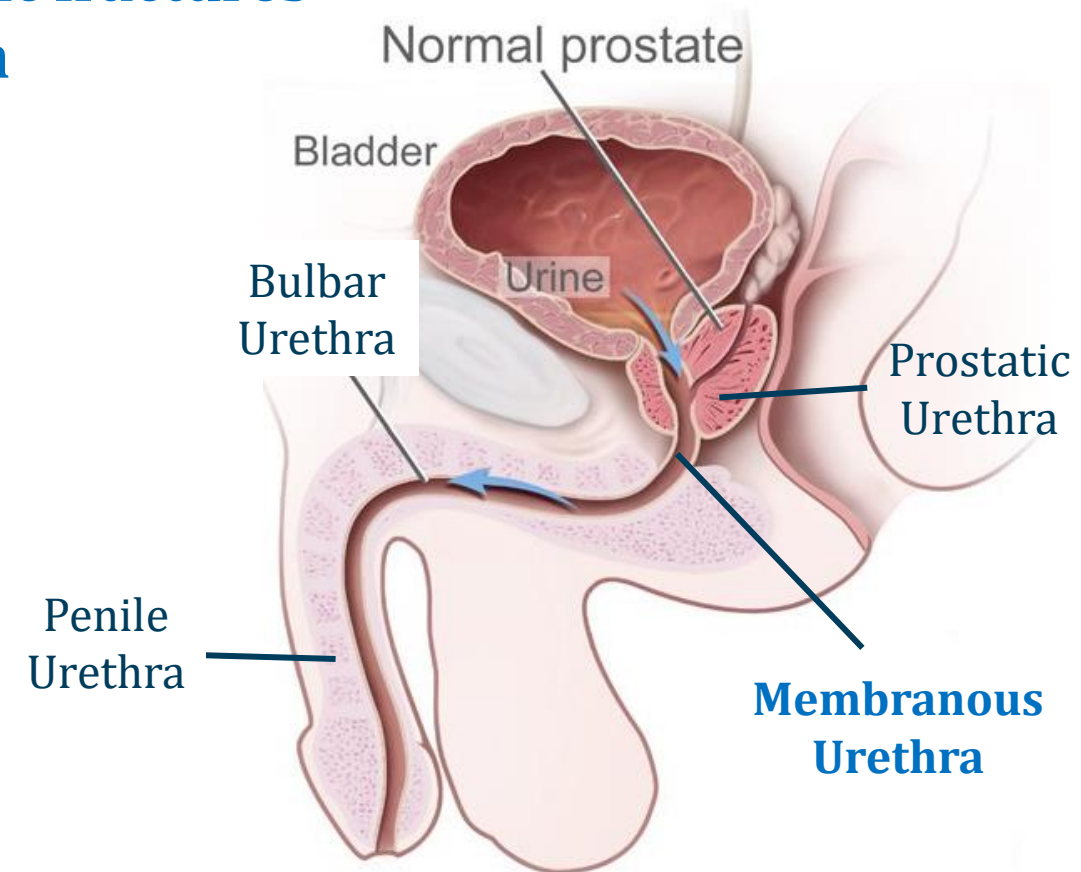
Urethral Injury

- **Almost always occurs in men**
- Blood at urethral meatus
- Gross hematuria
- Inability to void
 - Injury may cause sensation to void but can't
- Abnormal prostate position on rectal exam
- Ecchymosis/hematoma of penis or scrotum



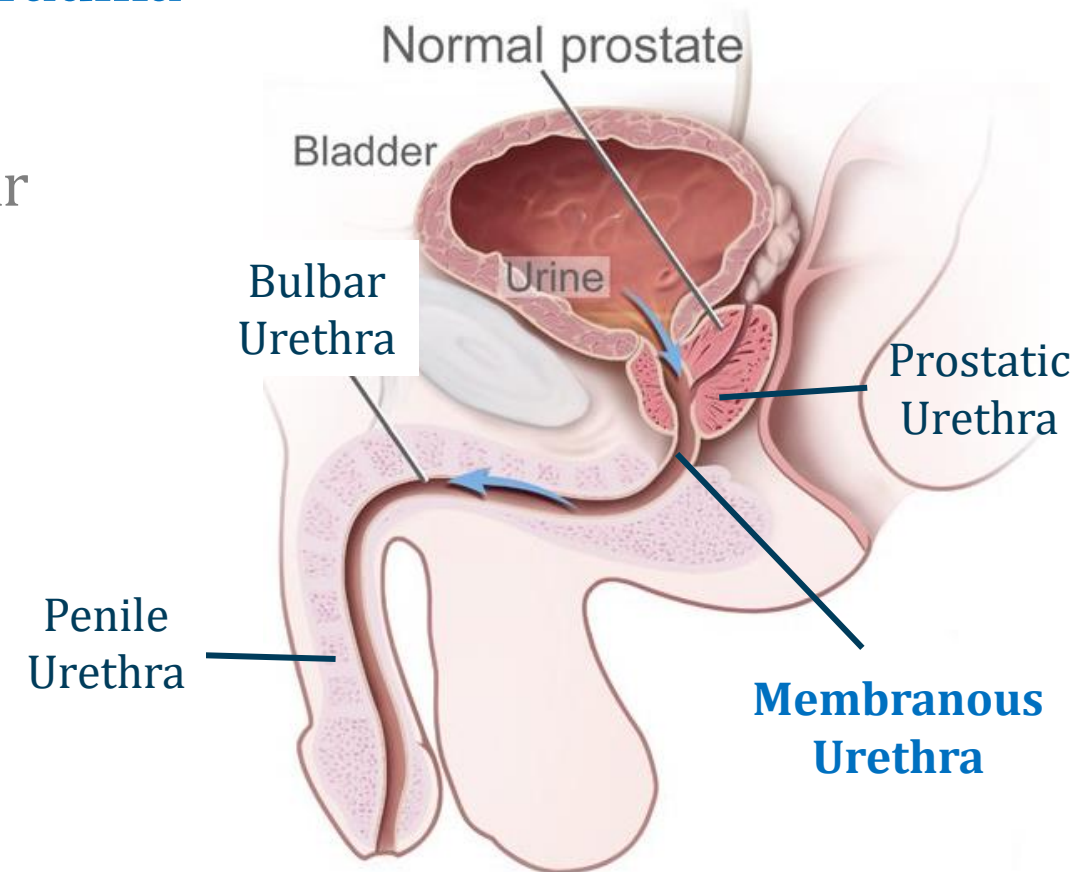
Urethral Injury

- **Posterior urethral injury** common with **pelvic fractures**
- Leads to damage of the **membranous urethra**
 - Distal to prostatic urethra
 - Proximal to bulbar and penile urethra
 - Rigid attachments
 - Highly susceptible to injury in pelvic trauma
- Bleeding into pelvis and around bladder
- Bladder and prostate displaced upward
 - “High-riding prostate”



Urethral Injury

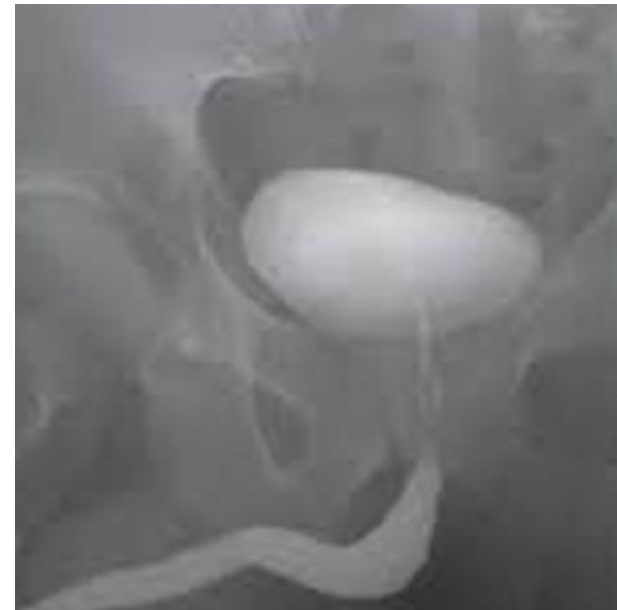
- Anterior urethral injury usually due to **direct trauma**
 - **“Straddle injuries”**
 - Bulbar urethra compressed against pubic bone
- Bleeding into perineum and scrotum may occur



Urethral Injury

- If suspected urethral injury: **do not place Foley catheter**
- First evaluate urethra by **retrograde urethrogram**
 - Inject saline-contrast mixture into urethra
 - Obtain KUB
- Treatment:
 - Suprapubic bladder catheter
 - Surgical repair (delayed)

Normal



Urethral Injury



Bladder Injury

- Occur in men and women
- Once urethral injury is excluded: Foley catheter can be placed
- Gross hematuria suggests renal/bladder injury
- Suprapubic tenderness may occur
- Diagnosis by **retrograde cystogram**
 - Baseline KUB
 - Fill bladder with saline-contrast
 - KUB with full bladder
 - Drain bladder → additional KUB

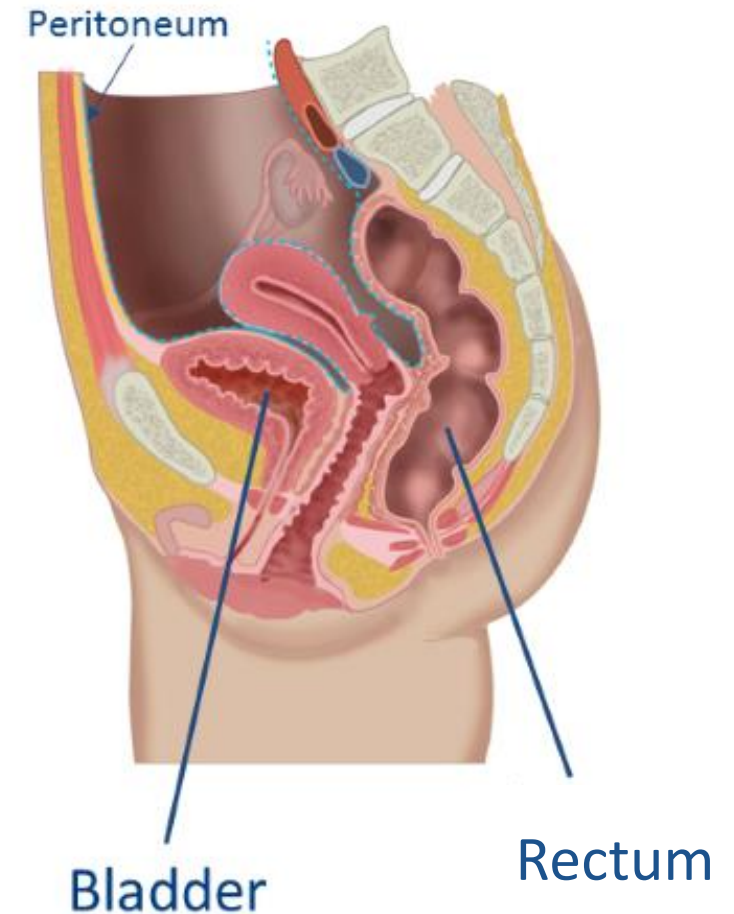
Cystogram



Aghaways, Ismaeel & Bapir, Rawa & Hawrami, Tahir & Thahir, Nishtman & Hassan, Mohammed & Hassan, Karzan. (2019). Conservative Management of Delayed presentation of Intraperitoneal bladder Rupture following caesarean delivery: A Case Report. International Journal of Surgery Case Reports. 59. 10.1016/j.ijscr.2019.04.050.

Bladder Injury

- Peritoneal lining sits on top of bladder
- Ruptures can be intraperitoneal or extraperitoneal
- **Extraperitoneal leaks**
 - Most common (85%)
 - Often caused by pelvic fracture
 - Usually heal spontaneously
- **Intraperitoneal leaks**
 - Injury to dome of bladder
 - Lead to signs of peritonitis
 - Usually require surgical repair



Bladder Injury

Extraperitoneal



Intraperitoneal



Trauma Basics

Jason Ryan, MD, MPH



Primary Survey

- Identify life-threatening injuries
- Airway
- Breathing
- Circulation
- Disability
- Exposure

A B C D E

Airway

- Normal if patient is **conscious** and **speaking with normal voice**



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Establishing An Airway

- Most commonly done through **orotracheal intubation**
- Backup option: **cricothyroidotomy**
 - Incision through skin and cricothyroid membrane



Major Indications for Intubation

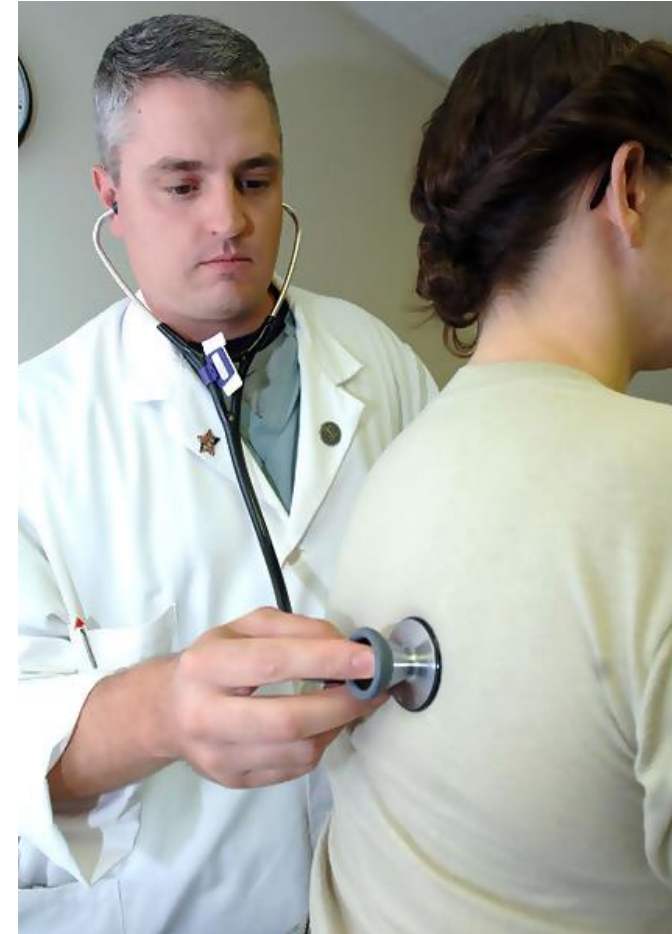
- GCS < 8
- Compromised airway (obstruction/collapse)
- Failure of oxygenation/ventilation
- Anticipation of rapid deterioration



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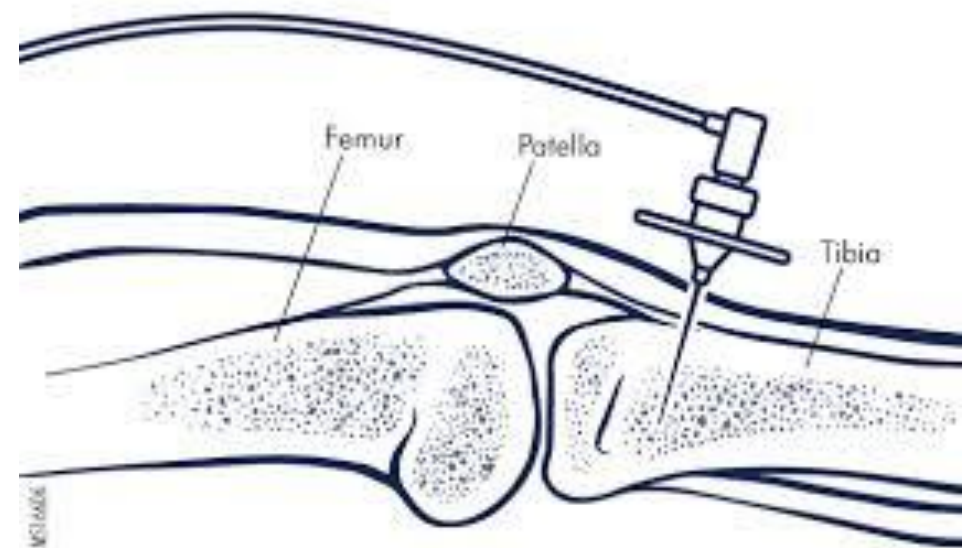
Breathing

- Check for breath sounds on both sides
- Measure oxygen saturation from pulse oximetry



Circulation

- Check pulses
- **Establish IV access**
 - Two 16-gauge peripheral lines
 - **Intraosseous line** (proximal tibia)
 - Central line
- If unable to get peripheral line: intraosseous line



Circulation

- Examine for signs of **shock**
- Hypotension
- Weak pulses
- Pale, cool skin
- Poor capillary refill
- Cool extremities



Shock in Trauma

- Most common cause: **hemorrhage**
- Hypovolemic shock from hemorrhage
- Weak pulses
- Cool skin
- Low jugular venous pressure



FAST Scan

Focused Assessment with Sonography for Trauma Scan

- Bedside ultrasound exam used in trauma
- Goal is to **identify free fluid presumed to be blood**
- Used to examine key areas where blood collects
 - Right upper quadrant
 - Left upper quadrant
 - Pelvis
 - Heart
- Supplements physical exam during primary survey



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Hemorrhagic Shock

- Requires loss of ~ 1.5 L of blood
- Several common locations for large blood loss
- External blood loss
- Chest: hemothorax
- Abdomen: liver, spleen injury
- Pelvis: pelvic fracture
- Long bones: femur fracture
 - Femur highly vascular
 - Blood loss into thighs

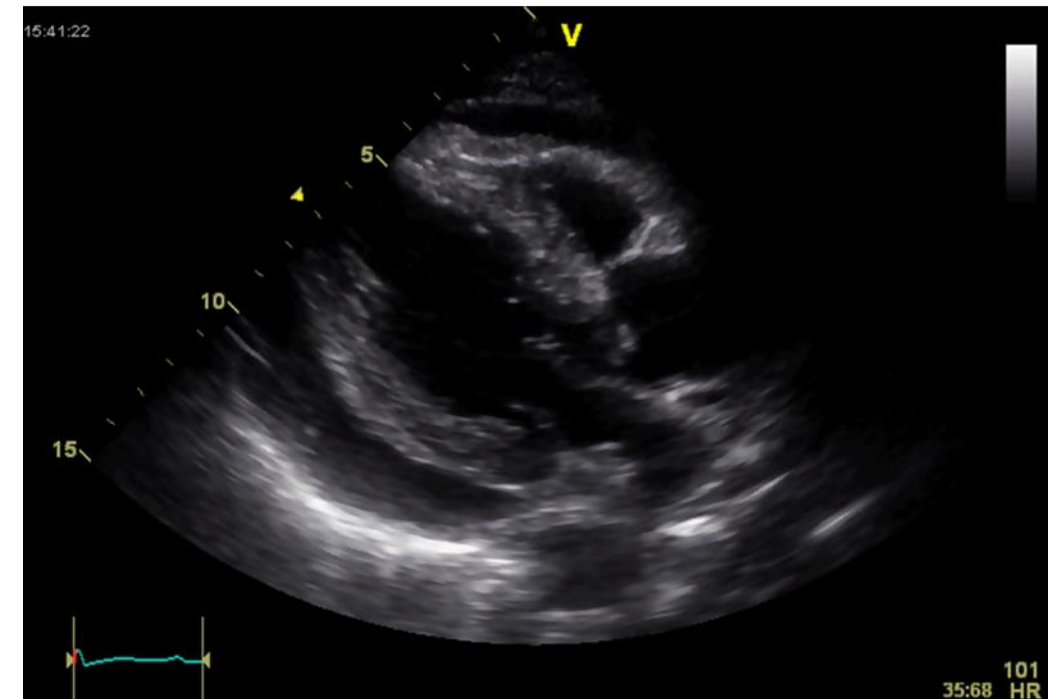
Femur Fracture



Shock in Trauma

- **Cardiac tamponade**
 - Chest trauma
 - Beck's triad
 - Distant heart sounds
 - Jugular venous distension
 - Requires pericardiocentesis
- **Cardiogenic shock**
 - Myocardial contusion in chest trauma
 - Pulmonary rales
 - Elevated jugular venous pressure
 - Rapid heart rate with weak pulse
 - Diagnosis with echocardiography

Pericardial Effusion



Shock in Trauma

- **Tension pneumothorax**
 - Chest trauma
 - Absent breath sounds
 - Jugular venous distension
 - Requires needle decompression
- **Neurogenic**
 - Hypotension and bradycardia
 - Occurs with spinal cord injury

Tension Pneumothorax



Slideplayer/Public Domain

Resuscitation

- Boluses of **intravenous crystalloid** (normal saline or LR)
- If obvious severe blood loss: transfuse with **type O blood**
- Massive transfusion protocol often required



Public Domain

Massive Transfusion Protocol

- Used in patients with **anticipated massive blood loss**
 - More than entire blood volume in 24 hours
 - Or > 50% of blood volume in 4 hours
 - Often activated after transfusion of 4 units
- Goal: replace cells and coagulation factors
- Blood products given **1:1:1 ratio**
 - Packed red cells
 - Fresh frozen plasma
 - Platelets

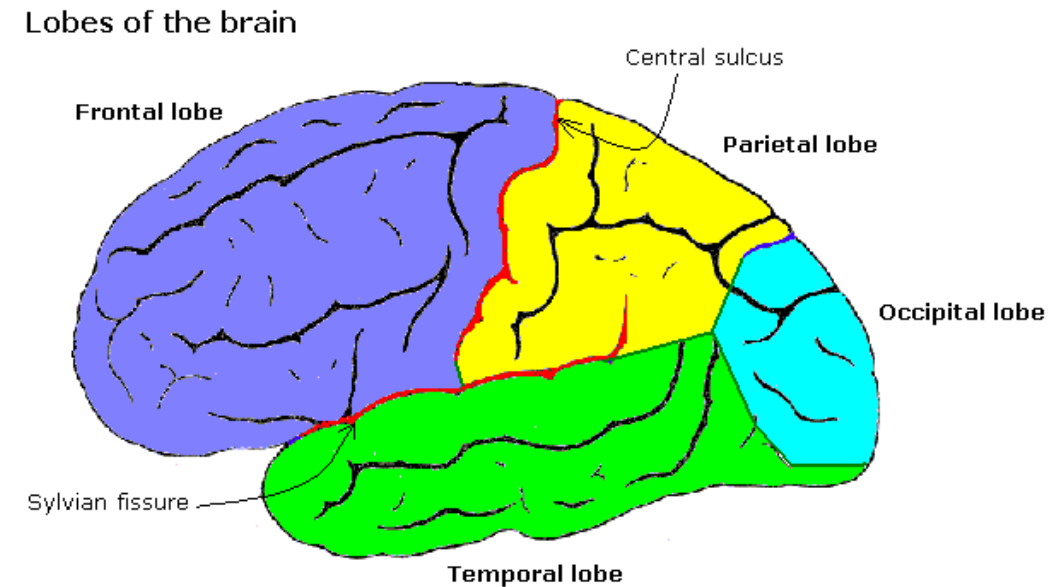
Platelets



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Disability

- Focused **neurologic exam**
- Determine GCS
- Examine pupils for size/response to light
- Gross extremity sensation and motor strength



Glasgow Coma Scale

- Three tests: eye, verbal, and motor
- GCS score: 3 to 15
- Eye (1-4 points)
 - Does not open, opens to painful stimuli, opens to voice, opens spontaneously
- Verbal (1-5 points)
 - No sound, incomprehensible sounds, inappropriate words, confused, oriented
- Motor (1-6 points)
 - No movements, decerebrate posturing, decorticate posturing, withdrawal to pain, localizes to pain, obeys commands

Exposure

- Completely undress the patient but avoid hypothermia
- Examine for injuries in key areas
 - Back of head
 - Back
 - Buttocks
 - Perineum
 - Axillae
 - Skin folds

Secondary Survey

- Careful head-to-toe examination
- Identify injuries missed in primary survey
- Head and face
- Neck
- Chest
- Abdomen
- Pelvis
- Back
- Extremities
- Other wounds

Tertiary Survey

- Repeat of the secondary survey
- Look for missed injuries
- May occur many times over hours or days

Fractures

Jason Ryan, MD, MPH



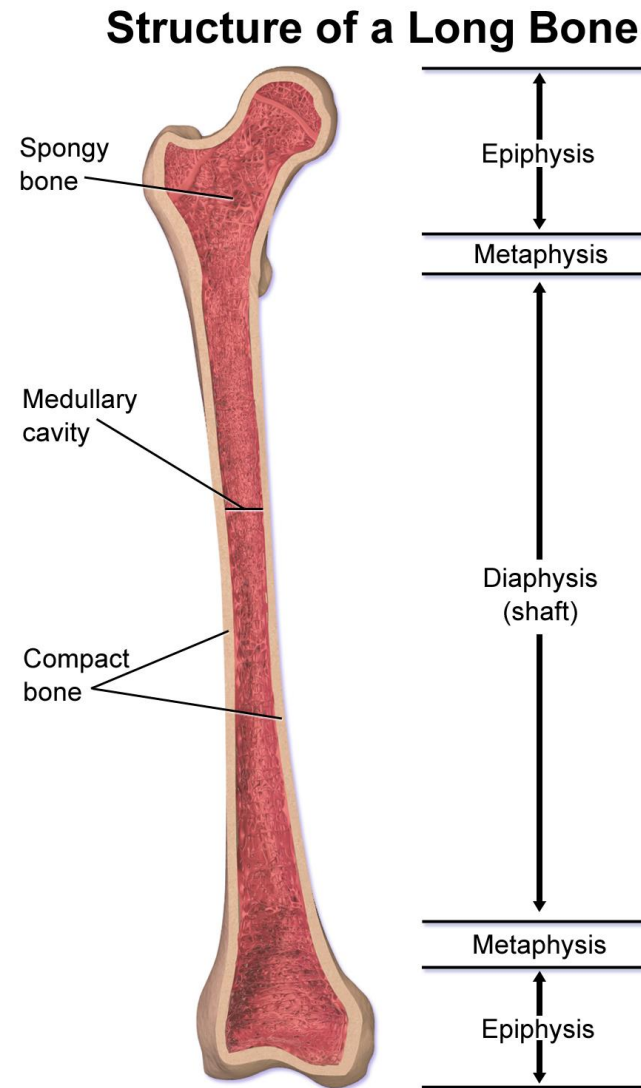
Bone Fractures

- Usually caused by trauma
- Pain, swelling, skin erythema
- Diagnosis: **plain x-ray**
- Treatment involves immobilization
 - Splints
 - Casts
- Other treatments based on type of fracture



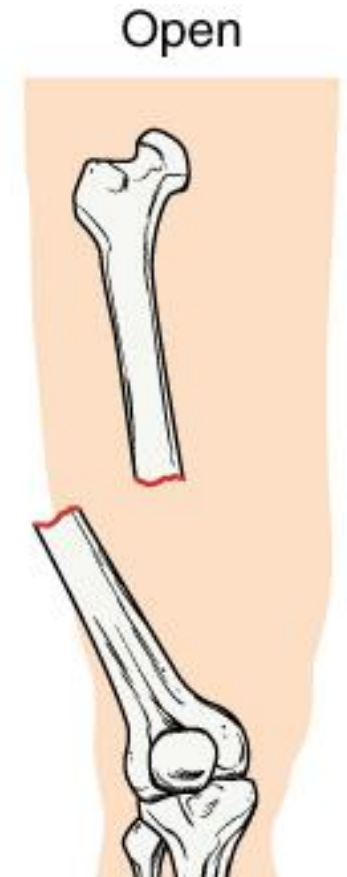
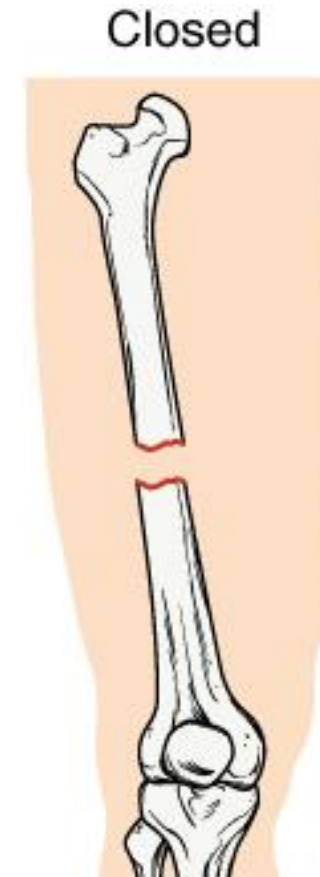
Hellerhoff/Wikipedia

Long Bones



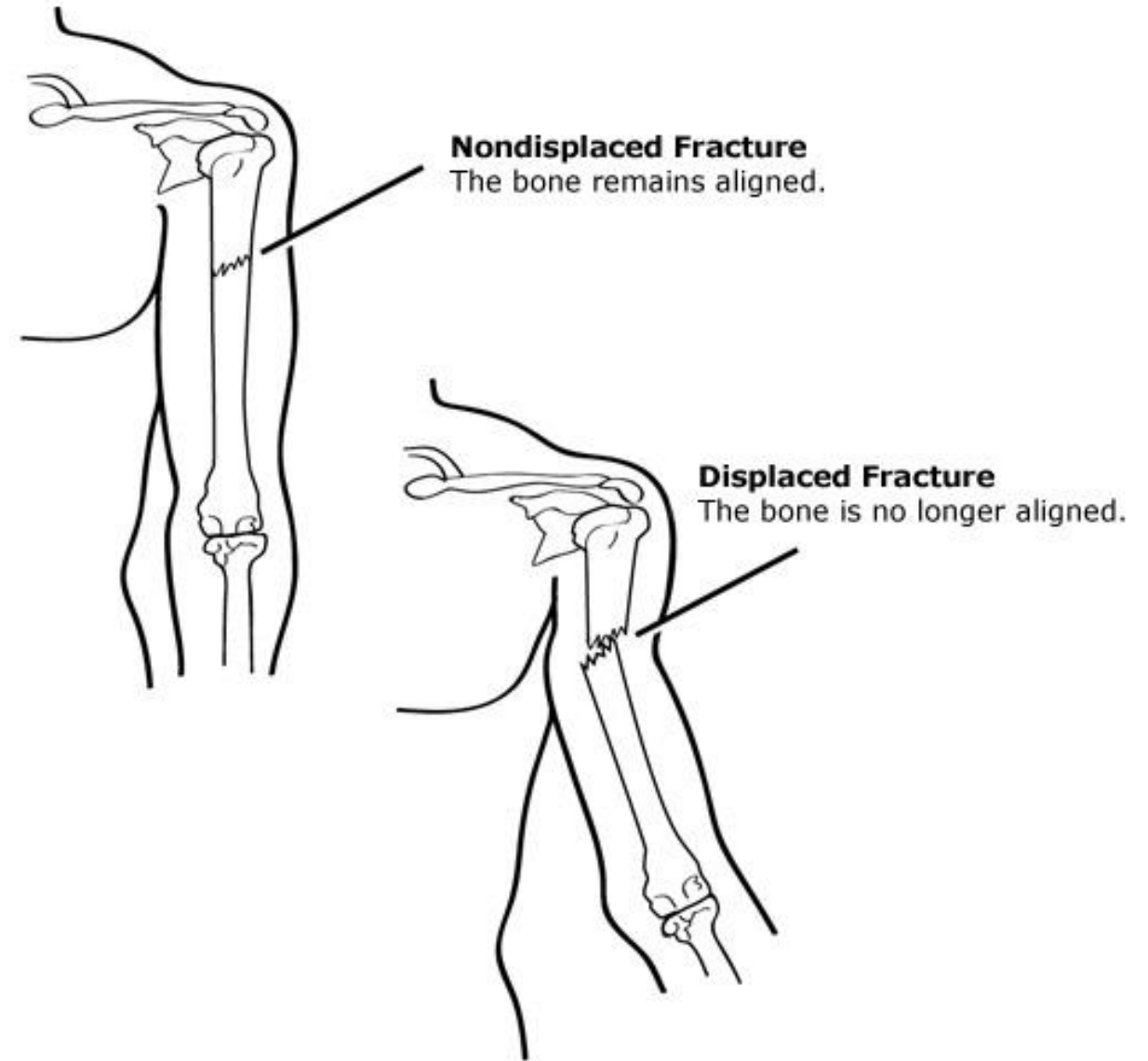
Open and Closed Fractures

- Open
 - Bone exposed
- Closed
 - Bone contained



Displacement

- Nondisplaced
 - Bone pieces aligned
- Displaced
 - Bone not aligned
 - Must be “reduced” for proper healing
 - Also called “resetting” of bone



Reduction

- Closed reduction
 - Reduction without opening skin
 - Maneuver of bone beneath skin
 - Followed by immobilization
- Open reduction
 - Surgical reduction of displaced fracture
 - Often done with “fixation”
 - Plates, screws, other devices
 - Open reduction internal fixation (ORIF)

Ulnar and Radial Fracture



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Types of Fractures

- Incomplete
 - Bone cracked but incomplete separation
- Complete
 - Bone broken into separate pieces
- Comminuted
 - Bone broken into several small pieces



Comminuted

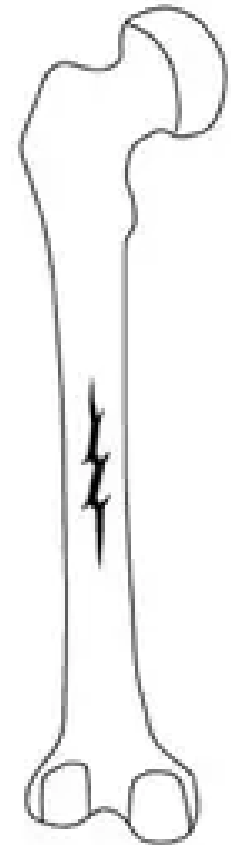
**Comminution fracture
radius and ulnar bones**



Shutterstock

Linear Fracture

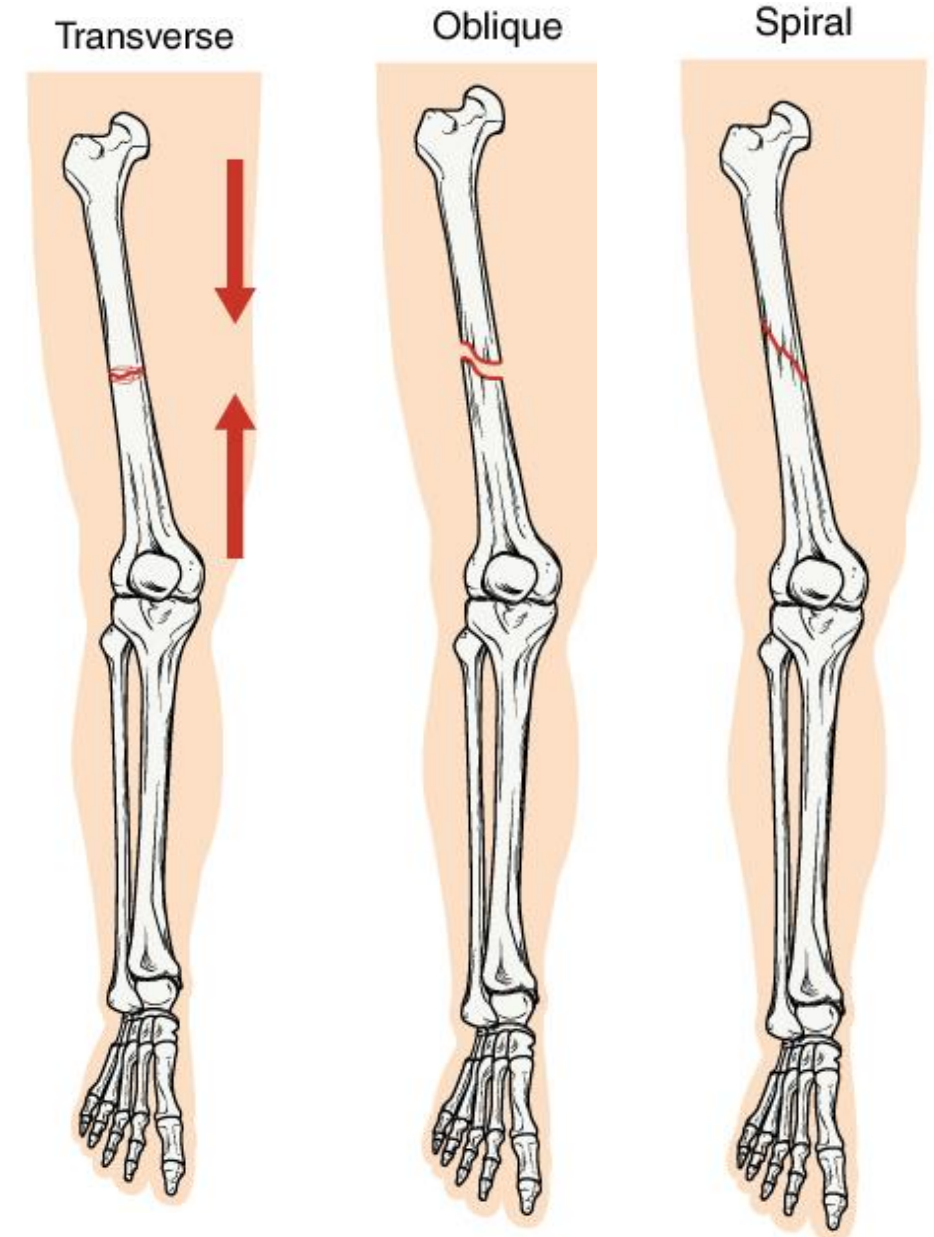
- Along the bone axis



Linear

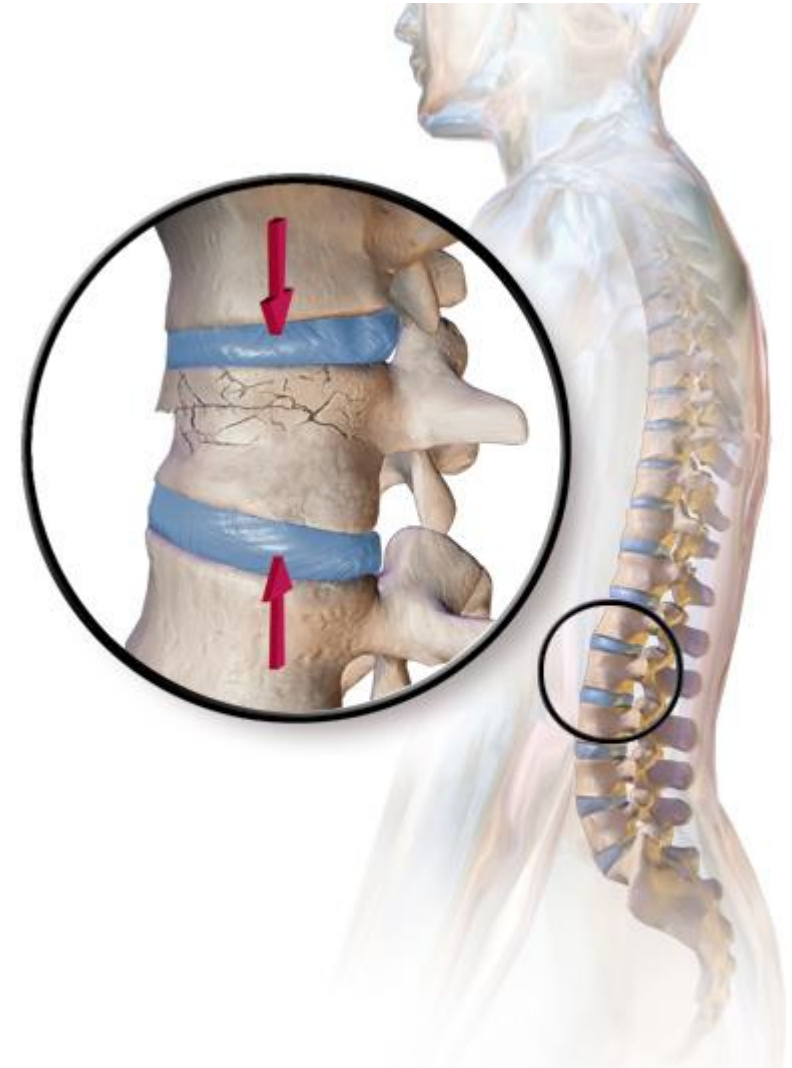
Fracture Patterns

- Transverse
 - Perpendicular to bone axis
- Oblique
 - Diagonal to bone axis
- Spiral
 - Severe form of oblique fracture
 - Twisting of bone
 - Caused by rotational torque applied to bone



Compression Fractures

- Bony collapse of vertebrae
- Caused by osteoporosis
- Mid-thorax (T7-T8)
- Thoracolumbar junction (T12-L1)
- Occur slowly over time
- Clinical features:
 - May be asymptomatic
 - Back pain
 - Height loss



Impacted Fractures

- Broken ends jammed together
- Caused by axial or compressive force

Distal Radial Fracture



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Avulsion Fractures

- Tendon or ligament **pulls** off a piece of bone



Mikael Häggström

Stress Fractures

- Tiny cracks in bones
- Caused by **repetitive force and overuse**
 - Jumping up and down
 - Running long distances
- Common locations:
 - Tibia
 - Metatarsals (foot)
 - Ankle
 - Femur



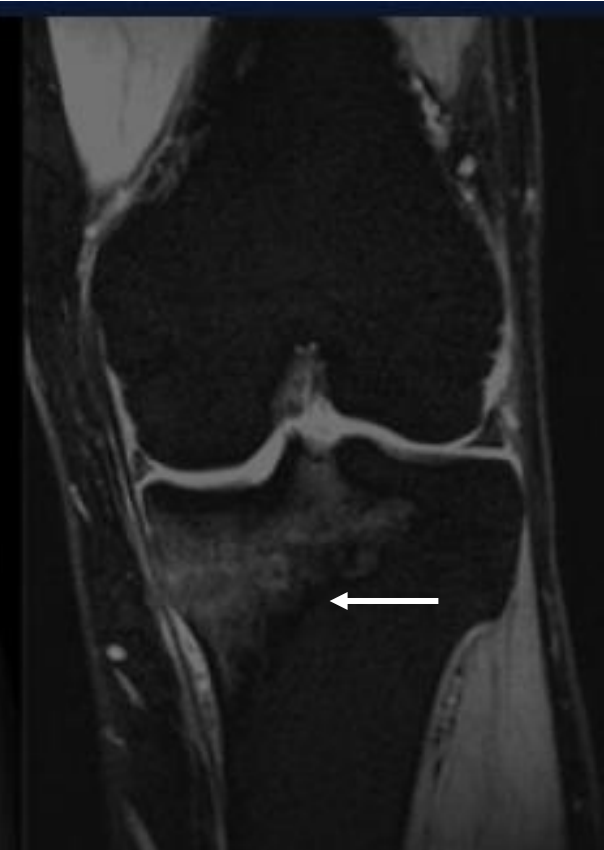
Stress Fractures

- Pain and tenderness
- Diagnosis:
 - X-ray (less sensitive)
 - MRI (if necessary; highly sensitive)
- Management:
 - Reduced weight bearing
 - Splint or boot
 - Rest, ice, analgesia

X-Ray



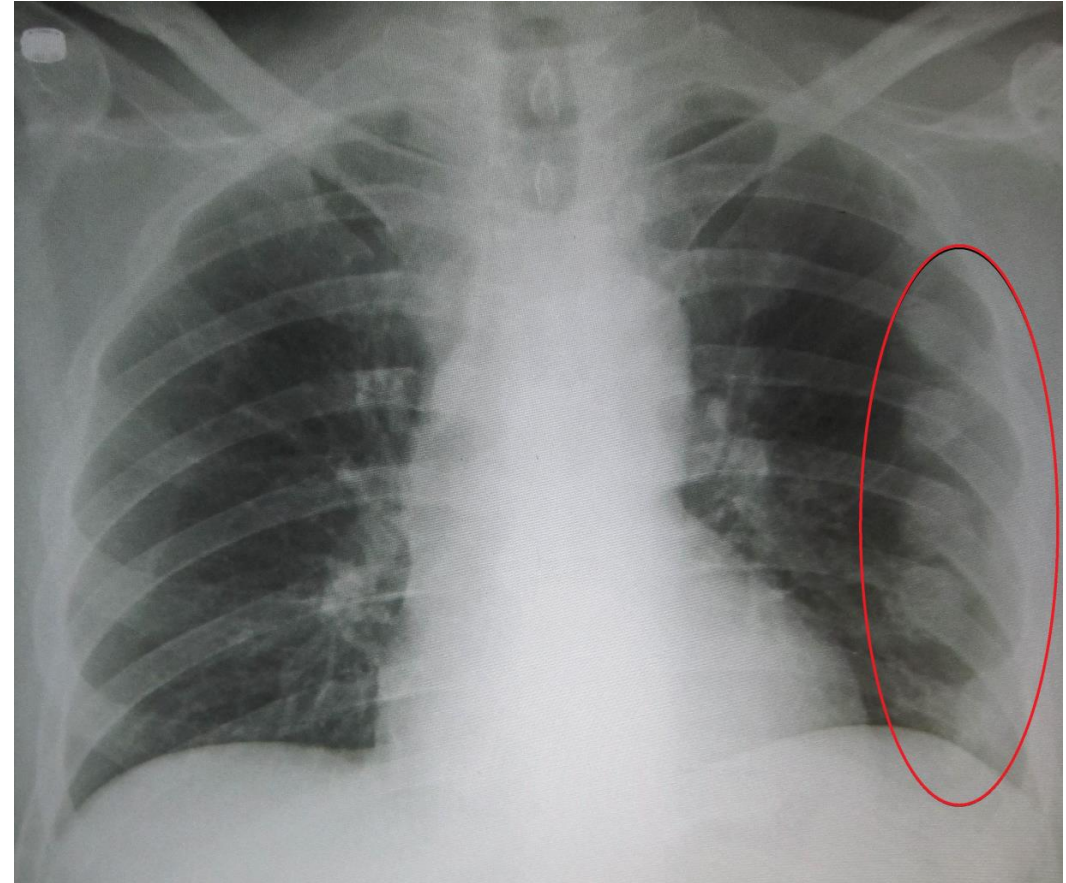
MRI



Radiology Assistant

Rib Fractures

- Blunt thoracic trauma
- Severe coughing
- May be pathologic (metastasis)



James Heilman, MD

Distal Radius Fracture

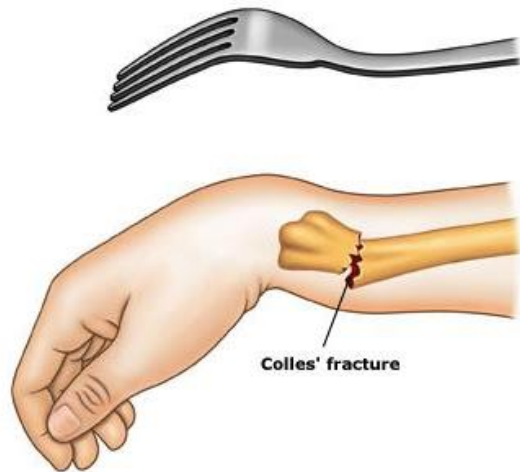
- Most common upper extremity fracture
- Often from fall on outstretched hand (FOOSH)
- Two key subtypes:
 - Colles' fracture
 - Smith fracture



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Colles' Fracture

- Distal metaphysis of radius
- Dorsal angulation and displacement
- “Silver fork deformity” of wrist



<https://strivept.ca/>



Smith Fracture

- Distal metaphysis of radius
- Palmar displacement



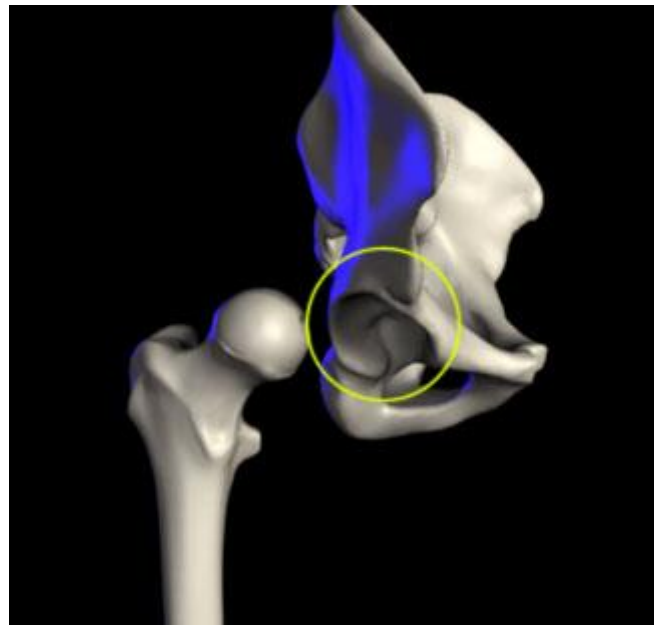
Lucas Moore/Slideplayer



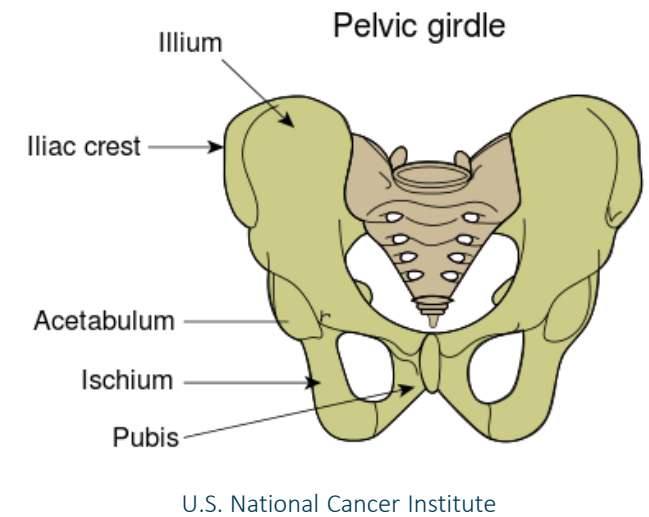
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Hip Joint

- Head of femur
- Acetabulum of pelvis



[Protohiro](#)



Hip Fractures

- Common in older adults
 - Peak incidence > 70 years
- Associated with **osteoporosis**
 - More common in women
- Usually caused by falls
- Associated with ↑ mortality
- Prevention: **exercise**



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Hip Fractures

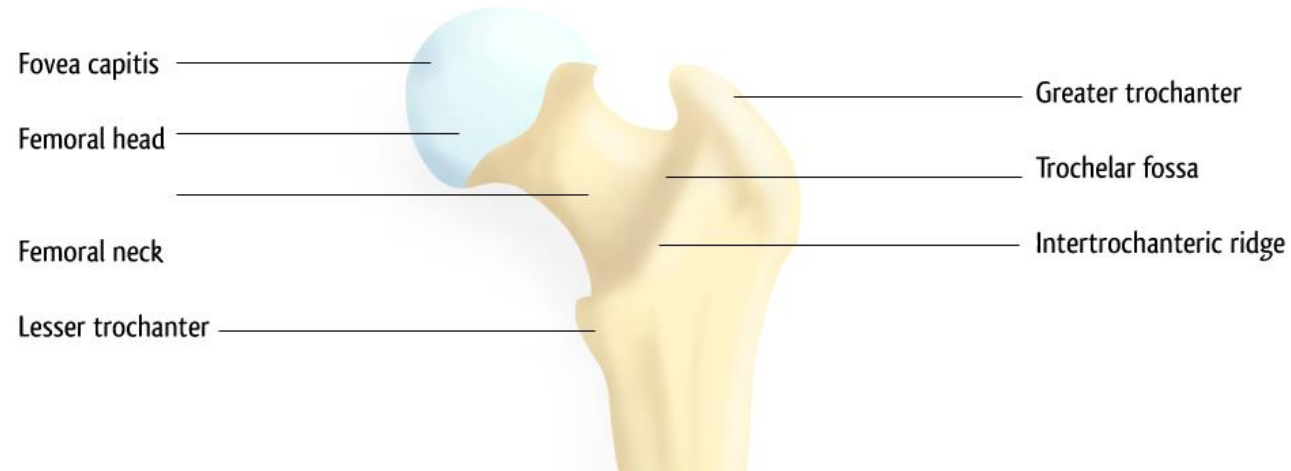
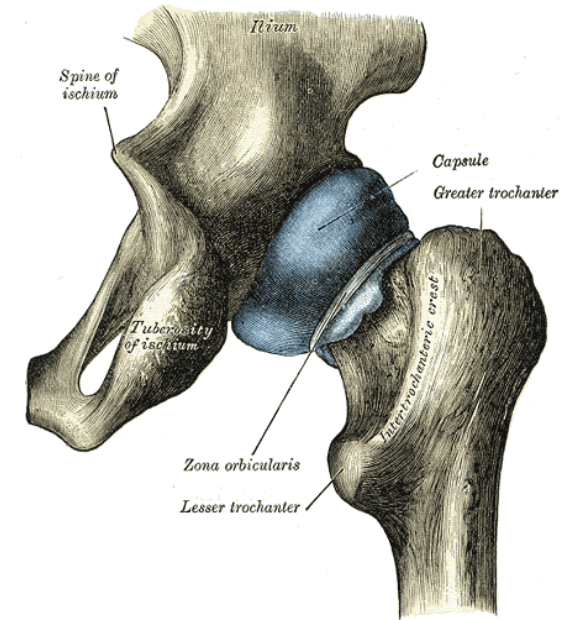
Classification

- **Intracapsular**

- Within capsular ligament of hip joint
- Femoral neck and head
- Tenuous blood supply → avascular necrosis

- **Extracapsular**

- Intertrochanteric (between trochanters)
- Subtrochanteric



Most Common Fractures

Hospitalized Patients

Fracture Site	Incidence/1000
Proximal Femur (hip)	1.31
Ankle	0.83
Radius/ulna	0.44
Spine	0.27
Proximal humerus	0.26

Source: Somersalo A, Paloneva J, Kautiainen H, Lönnroos E, Heinänen M, Kiviranta I.
Incidence of fractures requiring inpatient care. *Acta Orthop*. 2014;85(5):525-530.