Trauma Surgery and Burns

2024 Edition

إعداد محمود بركات

الملاحظات

- الملف شامل لمواضيع ال"trauma and burns" سنة رابعة وسادسة
- مصادر الملف هي المحاضرات والسمينارات و amboss و uptodate
- الملف معمول بشكل عام لسادسة بمعنى فيه زيادات عن رابعة وتركيز في بعض السلايدات على خوارزميات التشخيص المطلوبة عموما من سادسة وليس رابعة
- الكلام الأخضر: معلومات إضافية
- الكلام الأزرق: ملاحظات أو إضافات مفيدة
- الكلام الأحمر: مهم

Management of trauma patients

Introduction

❖Epidemiology

- 5th leading cause of death “Data are for the U.S. , 2010”
- Accounts for approximately 30 percent of all ICU admissions

❖Deaths from trauma

- Immediate deaths in the first minutes at the scene are either due to massive hemorrhage (laceration of great vessels) or due to massive CNS trauma.
- Early deaths during the (Golden hour) are often because of hemorrhage or hypoxia. Need rapid intervention as they may be preventable
- Late deaths are chiefly due to sepsis, septicemia, pulmonary embolism, multiple organ failure.

❖The risk factors in trauma injuries

- **RTA risk factors**: Car speed; Rolled over car; Thrown out person; Dead passenger; Car indentation >30cm; Extraction time >20 minutes
- **Falling down risk factors**: Way of fall, The height, and the ground
- **Burn risk factors**: Flame with close space; Associated with other trauma

Overview of injury mechanisms		
	Mechanisms of injury	Potential injuries
Blunt trauma	• Motor vehicle collision • Fall from a height • Pedestrian struck • Bicycle crash • Assault	• **Head**: traumatic brain injury, facial fractures • **Thoracic**: pulmonary contusions, cardiac contusions, rib fractures, pneumothorax, hemothorax, blunt thoracic aortic injury, diaphragmatic rupture • **Abdominopelvic**: splenic injuries, liver injuries, pelvic fracture, genitourinary trauma • **Musculoskeletal**: spinal fractures, crush injury, lower extremity fractures
Penetrating trauma	• Stab injuries • Gunshot wounds	• **Neck**: vascular injury • **Thoracic**: cardiac tamponade, hemothorax, pneumothorax, diaphragmatic injury • **Abdominopelvic**: hollow viscus perforation, hemorrhage, genitourinary trauma • **Musculoskeletal**: neurovascular injuries, fractures, compartment syndrome
Thermal injury	• Thermal burns • Electrical injury • Inhalation injury	• **Thermal burns**: circumferential eschar, compartment syndrome • **Electrical injury**: cardiac arrhythmias, myonecrosis, compartment syndrome • **Inhalation injury**: airway swelling, pulmonary edema, carbon monoxide toxicity
Blast injuries	• Pressure-related injury • Blunt trauma • Penetrating trauma • Burns • Exposure to toxic fumes	• **Pressure-related injury**: barotrauma, blast lung, tympanic membrane rupture • **Blunt and/or penetrating injury**: due to flying debris, shrapnel, falls • **Burns**: thermal burns, inhalation injury
Other environmental injuries	• Drowning • Cold-related injury • Diving-related injury	• **Drowning**: respiratory failure, cardiac arrest • **Cold-related injuries**: Hypothermia, frostbite, and nonfreezing cold injuries • **Diving-related injuries**: decompression disease, arterial gas embolism, barotrauma

Advanced trauma life support (ATLS)

- A framework for managing patients with serious injuries in prehospital and hospital settings.
- Describes management sequences that prioritize the most immediately life-threatening injuries first.
- Aims to standardize trauma care across centers with varying resources and experience with trauma management
- **Sequence of trauma care**
  - Prehospital trauma care and transportation to hospital
  - Primary survey
  - Transfer to trauma center (if needed)
  - Secondary survey
  - Tertiary survey

Key components of ATLS

1ry survey	• **A**irway assessment with C-spine stabilization and airway management • **B**reathing assessment with respiratory support and related procedures • **C**irculation assessment with immediate hemodynamic support and hemorrhage control • **D**isability assessment with TBI management and neuroprotective measures • **E**xposure with environmental survey and hypothermia management • Diagnostic adjuncts, e.g., FAST, portable CXR • Transfer to trauma center (if needed) • Treatment of traumatic cardiac arrest (if needed)
2ry survey	• The secondary survey aims to detect and treat any other trauma injuries (the secondary survey should not be started until the primary survey is complete) • AMPLE history • Head-to-toe physical examination • Comprehensive diagnostic studies and imaging • Supportive care
3ry survey	• Detailed history and physical to identify missed injuries • Additional diagnostics (if needed) • Quality and safety measures

Primary survey (The ABCDE algorithm)

❖Airway (and C-spine stabilization) management

1. **Assess the airway**
    1. Ask the patient to state their name; the ability to answer typically correlates with a patent airway.
    2. Evaluate for signs of airway compromise and signs of respiratory distress.
    3. Examine the airway for foreign bodies or injury (e.g., facial fractures, soot, burns).
2. **Perform initial interventions**
    1. Suction oropharyngeal secretions and/or blood.
    2. Perform airway opening maneuvers.
    3. Insert basic airway adjuncts.
3. **Intubate patients with**:
    - Airway obstruction and/or respiratory failure
    - Depressed mental status (GCS ≤ 8)
    - Severe shock and/or cardiac arrest
    - At-risk inhalation injury
4. **Stabilize the cervical spine**
    - Assume cervical spine injury in patients with significant blunt trauma.
    - Immobilize the cervical spine with a cervical collar.
    - Manually stabilize the cervical spine during airway management.

Note: Consider early intubation for impending airway obstruction in patients with signs of inhalation injury, moderate to severe facial and oropharyngeal burns, and extensive body burns.

Primary survey (The ABCDE algorithm)

- Airway management notes
  - Airway obstruction is a major cause of death immediately following trauma
  - The airway may be obstructed by the backward tongue displacement, a foreign body, aspirated material (e.g., vomitus, bleeding, loose or missing teeth, dentures), facial trauma, tissue edema, or expanding hematoma
  - Definitive guidelines for tracheal intubation in trauma do not exist, when in doubt, it is generally best to intubate early, particularly in patients with hemodynamic instability, or those with significant injuries to the face or neck, which may lead to swelling and distortion of the airway
  - Unconscious patients with small pneumothoraxes that are not visible or missed on the initial chest radiograph may develop tension physiology after tracheal intubation from positive pressure ventilation. It is important to re auscultate the lungs of trauma patients

Primary survey (The ABCDE algorithm)

❖ Breathing (and ventilation) management

1. **Assess oxygenation**: Evaluate SpO2 and start continuous pulse oximetry.
2. **Assess ventilation**
   a. **Vital signs**: Monitor rate and quality of respirations.
   b. **Neck**: Inspect for jugular venous distension and tracheal deviation
   c. **Chest**: Auscultate and inspect for chest wall injuries: e.g., penetrating wounds, subcutaneous emphysema, absent breath sounds, paradoxical chest movement
   d. Consider eFAST to help identify pneumothorax at the bedside.
3. **Perform initial interventions.**
   - Supplemental O2
   - Emergency chest decompression for suspected tension pneumothorax.
   - Thoracostomy tube for massive hemothorax
   - 3-sided dressing for sucking chest wound
   - Bag-mask ventilation or mechanical ventilation for respiratory failure

Primary survey (The ABCDE algorithm)

❖Circulation management

1. **Assess hemodynamic status**
   - Assess central pulses, level of consciousness, and capillary refill time.
   - Monitor vitals and continuous cardiac telemetry.
2. **Perform initial interventions**
   - Place two large-bore IVs (at least 18-gauge).
   - Consider intraosseous access if peripheral IV cannot be obtained.
   - Administer 1 L warmed isotonic crystalloid bolus.
   - If unresponsive to IV fluid, proceed to blood transfusion.
3. **Localize hemorrhage**: Perform FAST
4. **Treat hemorrhagic shock**
   - Administer emergency transfusion with universal donor blood products (e.g., type O blood) if required.
   - Provide crossmatched blood products as soon as they are available.
   - Follow local massive transfusion protocol if indicated, e.g., plasma, platelets, and pRBCs at a 1:1:1 ratio.
5. **Perform bedside hemorrhage control**
   - Apply pressure or tourniquet to control active external hemorrhage.
   - Apply pelvic binder for suspected bleeding pelvic fractures
   - Insert chest tube for suspected massive traumatic hemothorax

Primary survey (The ABCDE algorithm)

- Disability management
  - Identify life-threatening traumatic brain injury (TBI)
  1. Perform rapid neurological evaluation
     a. Calculate GCS
     b. Assess pupillary light response
     c. Assess motor and sensation functions
  2. Initiate TBI management
     - Consult neurosurgery.
     - Start neuroprotective measures.
     - Start ICP management if a cerebral herniation syndrome is present

- Exposure (and environmental control) management
  - Undress the patient completely.
  - Examine the entire patient for signs of occult injury.
    - Examine the patient's back with spine precautions
  - Regions often neglected include
    - Posterior scalp
    - Gluteal folds, axillary folds, perineum
    - Abdominal folds in obese patients
  - Prevent and/or manage hypothermia with rewarming techniques.

Adjuncts to primary survey

- Pulse Oximeter
- Cardiac monitors
- BP monitor
- ECG
- X-rays: Cervical spine, CXR, pelvis
- Trauma blood work
- ABG

Secondary survey

- **History**
  - **AMPLE history**: a focused history approach recommended in the rapid evaluation of patients with trauma
    - **A**llergies
    - **M**edications
    - **P**ast medical history and pregnancy status
    - **L**ast meal
    - **E**vents and environment related to the injury
  - **Mechanism of injury**
    - Injury patterns can provide clues to the mechanism of injury (e.g., direction, amount of energy).
    - Commonly divided into blunt trauma and penetrating trauma
    - Relate to the previous table

Secondary survey

❖ Physical examination

- A systematic head-to-toe physical examination must be completed to identify additional injuries.
  - Assess each body part for open wounds, lacerations, abrasions, foreign bodies, and/or bruising.
  - Identify any bony deformities, areas with focal tenderness, or edema.
  - Document all findings.

❖ Further management

- Provide tetanus prophylaxis for open wounds.
- If intraperitoneal injury is suspected, administer empiric antibiotics for intraabdominal infections.

Head-to-toe physical examination

- **Head**
  - **Observe and palpate skull** (anterior and posterior) for signs of trauma like deformity, Wounds (bruising/bleeding, lacerations, Raccoon eyes or Battle's sign)
  - **Check the face for** deformity
  - **Check eyes for** equality and responsiveness of pupils, movement and size of the pupils, foreign bodies, discoloration, contact lenses, prosthetic eye
  - **Check nose and ears for** bleeding, CSF leaks
- **Neck**: look for any swelling, wounds, jugular venous distention, use of neck muscles for respiration, or tracheal shift
- **Cervical spine**: bruise, swelling, tenderness, or wounds

Head-to-toe physical examination cont.

- **Chest**: symmetrical expansion, paradoxical movement, wounds/bruising, deformity, respiratory rate and depth, tenderness, and breath sounds
- **Abdomen**: bruising/wounds, distension, tenderness, rigidity, guarding, and bowel sounds
- **Pelvis/Genito-urinary**: deformity, bruise (scrotal or perineal), bleeding per urethra
- **Back**: wounds/bruising, swelling, or tenderness
- **Arms and Legs**: wounds, deformity, tenderness, movement, pulses, and sensation

إضافي

Diagnostics

Consider clinical judgment, mechanism of injury, and patient factors (e.g., age, hemodynamic status) when choosing diagnostic studies.

- **ECG**: Indications: mechanisms that may result in cardiac injury (e.g., in blunt chest trauma)
- **Laboratory studies**
  - Routine studies: CBC, BMP, LFTs
  - Preoperative studies: coagulation studies, type and screen
  - Pregnancy test (e.g., serum or urine β-hCG)
  - POC glucose
  - Urinalysis
  - Lactate
  - ABG: to evaluate PaO2, PaCO2, pH and base deficit
- **FAST and eFAST**
  - Focused assessment with sonography for trauma (FAST): thoracoabdominal POCUS used in trauma patients to detect free fluid within the peritoneal, pericardial, and pleural cavities
  - Extended FAST (eFAST): an extension of the FAST scan that includes evaluation of the chest for lung sliding
- **Radiography**
  - Bedside chest and pelvic x-rays are commonly performed during the primary survey, while extremity and spine X-rays are typically reserved for the secondary survey.

Shock

من المحاضرة

Shock *definition* and pathophysiology

1. *Circulatory system failure that results in inadequate organ perfusion and tissue hypoxia → →*
   - O2 Delivery: volume of gaseous O2 delivered to the LV/min
     - O2 delivery is an interaction of Cardiac Output, Blood Volume, Systemic Vascular Resistance
   - O2 Consumption: volume of gaseous O2 which is used by the tissue/min.
   - O2 Demand: volume of O2 needed by the tissues to function in an aerobic manner
   - Demand > consumption = anaerobic metabolism
2. → → *leading to metabolic disturbances → →*
   - Acidosis results from the accumulation of acid when during anaerobic metabolism the creation of ATP from ADP is slowed
   - H+ shift extracellularly and a metabolic acidosis develops
3. → → *and, ultimately, irreversible organ damage*
   - ATP production fails, the Na+/K+ pump fails resulting in the inability to correct the cell electronic potential.
   - Cell swelling occurs leading to rupture and death.

Blood Pressure in shock

- Blood Pressure is often used as an indirect estimator of tissue perfusion
- Hypotension in adults is defined as one of the following
  - systolic BP $\leq$ 90 mm Hg
  - mean arterial pressure $\leq$ 60 mm Hg
  - $\downarrow$ systolic BP > 40 mm Hg from the patient's baseline pressure
- Hypotension may be absent in some patients with shock
- **Shock index** = pulse rate/systolic blood pressure
  - Normal range: 0.4–0.7
  - > 1 (positive shock index): consistent with circulatory shock
  - The shock index has a limited role in emergency care since it is very nonspecific. This is especially the case for children, as they have a better ability to compensate for blood loss. The appearance of a circulatory response in this age group occurs quite late and is, therefore, less reliable as a clinical sign of shock when compared with adults.

Shock hemodynamic parameters

- CVP: central venous pressure (right heart preload)
- PCWP: pulmonary capillary wedge pressure (a surrogate marker for preload)
- CO: cardiac output (CO = HR × stroke volume)
- SVR: systemic vascular resistance (a surrogate marker for afterload)
- HR: heart rate
- SV02: mixed venous content
  - Used as a main marker of end organ perfusion and oxygen delivery
  - True mixed venous is drawn from the pulmonary artery (mixing of venous blood from upper and lower body)
  - Often sample will be drawn from central venous catheter (superior vena cava, R atrium)
  - Normal oxygen saturation of venous blood 68% – 77%
  - Low SCVO2 indicates that tissues are extracting far more oxygen than usual, reflecting sub-optimal tissue perfusion (and oxygenation)
  - Following trends of SCVO2 to guide resuscitation (fluids, RBC, inotropes, vasopressors)

Common Features of Shock

- Hypotension (not an absolute requirement)
  - SBP < 90mm Hg, not seen in “pre-shock”
- Cool skin
  - Vasoconstrictive mechanisms to redirect blood from periphery to vital organs
  - Exception is warm skin in early distributive shock
- Oliguria (↓kidney perfusion)
- Altered mental status (↓brain perfusion)
- Metabolic acidosis

Shock Work-up

❖Shock is a clinical diagnosis

1. History to determine etiology
   - Bleeding (recent surgery, trauma, GI bleed)
   - Allergies or prior anaphylaxis
   - Sx consistent with pancreatitis, EtOH history
   - Hx of CAD, MI, current chest pain
2. Physical examination
   - Mucous membranes, JVD, lung sounds, cardiac exam, abdomen, rectal (blood), neuro exam, skin (cold or warm)
3. Labs/Tests directed toward suspected dx
   - Next slide

Diagnostics

- Routine investigations; Findings allow for evaluation of the following:
  - Global hypoperfusion: ABG and lactate levels
  - Underlying etiology: CBC, BMP, Septic workup, ECG, CXR
  - Complications or end-organ dysfunction
    - Hypoglycemia or hyperglycemia
    - Electrolyte abnormalities
    - Renal function tests: ↑ BUN, ↑ creatinine, other signs of AKI or ATN (e.g., on urinalysis)
    - Liver chemistries: elevated in shock liver
    - Coagulation panel: suggestive of DIC, acute traumatic coagulopathy, or acute liver failure
  - **Note**: In all patients with shock, immediately measure ABGs, lactate levels, capillary glucose, perform an ECG, and order a chest x-ray and general laboratory studies

Monitoring parameters for patients with shock

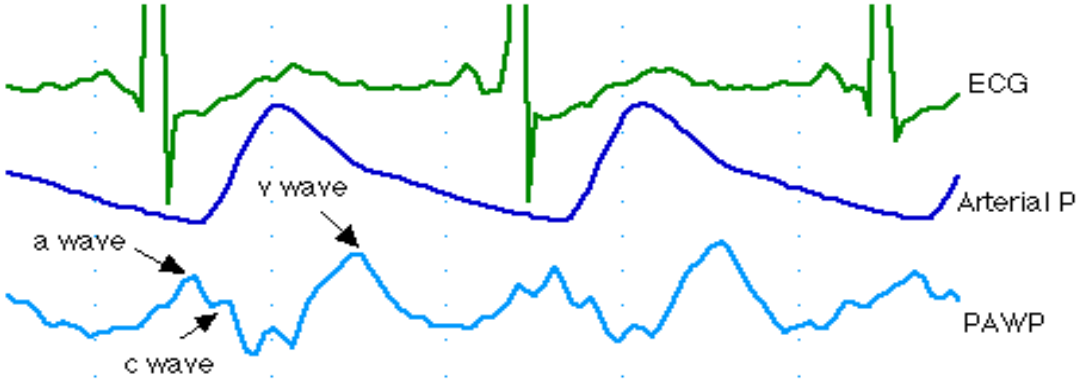
Variable	Parameters
Vital signs	• Heart rate: Aim for resolution of compensatory tachycardia and correction of arrhythmias. • Blood pressure: For most patients, target an MAP of ≥ 65 mm Hg.
Urine output	Urine output (for most patients): target > 0.5 mL/kg/hour
Lactate	Aim for a lactate level ≤ 2 mEq/L
CVP	Commonly used target for patients in shock: 8–12 mm Hg (normal CVP: 4-10 mmHg)
Cardiac function	• Normal cardiac output: 4–8 L/minute • Cardiac index*: > 2.2 L/min/m^2; (CI = 4.5 L/min/m^2)
Oxygen	• Keep O2 sats >92%, intubate if necessary • Oxygen Delivery (DO2I) = 600 mL/min/m^2; (< 400 is bad sign) • Oxygen Consumption (VO2I) = 170 mL/min/m^2; (If VO_2I < 100 suggest tissues are not getting enough oxygen)

*Cardiac index: The measure of the volume of blood ejected from the heart (cardiac output, L/min) in relation to body surface area (m^2). Normal range at rest is 2.8–4.2 L/min/m^2.

Extras

Waveform Analysis

- A wave - atrial systole
- C wave - tricuspid valve closure at ventricular systole
- V wave - venous filling of right atrium



Hemodynamic Calculations

Parameter	Normal
Cardiac Index (CI)	2.8 - 4.2
Stroke Volume Index (SVI)	30 - 65
Sys Vasc Resistance Index (SVRI)	1600 - 2400
Left Vent Stroke Work Index (LVSWI)	43 - 62

A 5 - lumen Swan Ganz catheter has either an **infusion port or a pacing port,** allowing insertion of a transvenous pacing wire; usually color coded white.

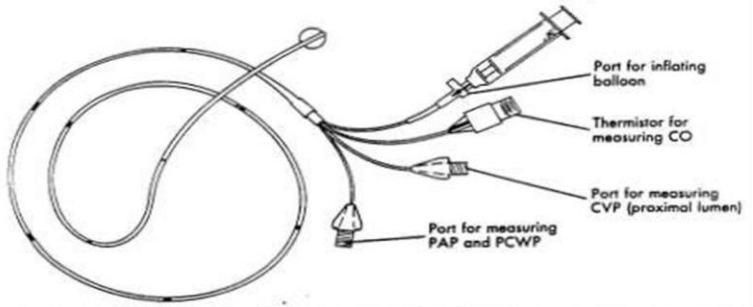


FIGURE 26-16 Four-lumen thermodilution pulmonary artery catheter for measuring cardiac output *(CO)*, central venous pressure *(CVP)*, pulmonary artery pressure *(PAP)*, and pulmonary capillary wedge pressure *(PCWP)*.

Hypovolemic Shock

❖Etiology

- Hemorrhage
- Non-hemorrhagic fluid loss: GI loss, Increased insensible fluid loss (e.g., burns), Third space fluid loss (e.g., bowel obstruction), Renal fluid loss

❖Pathophysiology

- Loss of intravascular fluid volume → ↓ preload and SV → ↓ CO → compensatory ↑ SVR and HR

❖Clinical features

- Hypotensive
- Flat neck veins
- Clear lungs
- Cool, cyanotic extremities
- Evidence of bleeding (e.g., anticoagulant use, trauma, bruising)
- Oliguria

Hypovolemic Shock

Classification of hemorrhagic shock				
Class	**I**	**II**	**III**	**IV**
Blood loss (% of total blood volume)	< 15%	15–30%	30–40%	> 40%
Volume loss (in an average adult)	~ 750 mL	~ 750–1500 mL	~ 1500–2000 mL	> 2000 mL
Heart rate (bpm)	70–99	100–120	120–140	> 140
Systolic blood pressure	Normal	Normal	↓	↓
Pulse pressure	Normal or ↑	↓	↓	↓
Respiratory rate (rpm)	Normal	20–30	30–40	> 35
Urine output	> 30 mL/hour	20–30 mL/hour	5–15 mL/hour	Absent
Mental status	Normal	Mildly anxious	Anxious, confused	Confused, lethargic

Hypovolemic Shock Management

- The priority of immediate hemodynamic support is **aggressive fluid resuscitation** to achieve euvolemia.
- Further treatment depends on the etiologic category of hypovolemia
  - Hemorrhagic shock
    - Transfuse blood products ASAP
      - Consider emergency transfusion of uncrossmatched blood type O rhesus negative units.
      - Switch to crossmatched blood transfusions as soon as available.
      - If massive transfusion is expected: Consider transfusing packed RBC, FFP, and platelet concentrate in a 1:1:1 ratio
    - Hemostatic control
  - Non-hemorrhagic hypovolemic shock
    - Treat the underlying cause
    - correct any concomitant electrolyte abnormalities
- Correct shock induced acidosis, coagulopathy and/or hypothermia

Cardiogenic shock and obstructive shock

	Etiology of shock	Parameters	Clinical features	Treatment options
Cardiogenic shock	• Cardiac ischemia • Arrhythmias • Valvulopathy • Cardiotoxic substance exposure	• ↑ CVP • ↑ PCWP • ↓↓ CO • ↑ SVR • Variable HR • ↓ SV02	• Cold, clammy extremities, poor capillary refill • Elevated JVP and distended neck veins • Clinical features of heart failure • Features of underlying etiology	• Administration of IV fluids according to fluid responsiveness • Inotropic support • Vasopressors • Diuretics (only once the systolic BP > 90 mmHg) • Treatment of refractory acute heart failure
Obstructive shock	• Impairment of diastolic filling of the right ventricle (e.g., cardiac tamponade) • Obstruction of venous return (e.g., tension pneumothorax) • ↑ Ventricular afterload (e.g., massive pulmonary embolism)	• ↑ CVP • ↑or↓ PCWP • ↓↓ CO • ↑ SVR • ↑ HR • ↓ SV02	• Cold, clammy extremities, poor capillary refill • Elevated JVP and distended neck veins • Features of underlying etiology	• Fluid resuscitation for patients who are preload-dependent and/or fluid responsive • Consider vasopressors or inotropic support. • Interventions to relieve obstruction

Management of cardiogenic shock

Management of cardiogenic shock

Classification	Treatment

Dry and cold	• Fluid bolus only in cases of hypotension and/or PCWP < 15 mm Hg
	• Consider a fluid challenge (250–500 mL). [46][55]
	• If shock persists, start a vasopressor, ideally, norepinephrine.
	• Administer inotropic support if hypoperfusion persists despite fluids and vasopressors. [45]
	  ◦ **Dobutamine**
	  ◦ Milrinone
	  ◦ Dopamine

Wet and cold	• Administer inotropic therapy to maintain perfusion. • If shock persists, start a vasopressor (ideally, norepinephrine). • Once systolic BP is > 90 mm Hg, start diuretic therapy for AHF. • If symptoms persist, start treatment for refractory AHF.

Dry and cold: No evidence of congestion. **Wet and cold**: Evidence of congestion

Distributive shock

	Etiology of shock	Parameters	Clinical features	Tx options
Septic shock	• Infection • Bacteremia	• ↓ CVP • N or ↓ PCWP • ↑ or ↓ CO • ↓↓ SVR • ↑ HR • ↑ SV02	• Early: flushed, warm skin, normal capillary refill • Late: cold, pale skin with delayed capillary refill • Features of sepsis: e.g., fever, SIRS criteria • Features of underlying infection: e.g., signs of typical pneumonia, meningismus	• Fluid resuscitation • Vasopressors • Antibiotics • Infectious source control
Anaphylactic shock	Exposure to allergens	• ↓ CVP • ↓↓ PCWP • ↑ or ↓ CO • ↓↓ SVR • ↑ HR • ↑ SV02	• Suspected or confirmed allergen exposure • Rapid onset (minutes to hours) • Clinical features of anaphylaxis	• Epinephrine • Fluid resuscitation
Neurogenic shock	CNS injury (e.g., spinal cord injury ICH, TBI)	• ↓ CVP • ↓↓ PCWP • ↓ CO • ↓↓ SVR • ↓ HR • N or ↑ SV02	• Flushed, warm skin • Bradycardia • Features of underlying etiology: neurological deficits (e.g., flaccid paralysis in spinal trauma)	• Fluid resuscitation • Vasopressors • Atropine for bradycardia

Septic Shock – Definitions

- **Infection**: Inflammatory response to microorganisms, or invasion of normal sterile tissues
- **Systemic inflammatory response syndrome (SIRS)**
  - Temperature: > 38°C or < 36°C
  - Heart rate: > 90 bpm
  - Respiratory rate: > 20 bpm or PaCO2 < 32 mmHg
  - WBC count: > 12,000/mm^3, < 4,000/mm^3 or > 10% immature bands
- **Sepsis**: Infection + 2 or more SIRS criteria (Note that SIRS criteria are not specific for sepsis)
- **Severe sepsis**: Sepsis + organ dysfunction (Lactic acidosis, oliguria, altered mental status)
- **Septic shock**: Severe sepsis + Hypotension despite fluid resuscitation
- **Multiple organ dysfunction syndrome (MODS)**: altered organ function in acutely ill patient + homeostasis cannot be maintained without intervention

Sequential [Sepsis-Related] Organ Failure Assessment Score

System	Score 0	1	2	3	4
Respiration					
Pao_2/Fio_2, mm Hg (kPa)	≥400 (53.3)	<400 (53.3)	<300 (40)	<200 (26.7) with respiratory support	<100 (13.3) with respiratory support
Coagulation					
Platelets, $\times 10^3/\mu L$	≥150	<150	<100	<50	<20
Liver					
Bilirubin, mg/dL (μmol/L)	<1.2 (20)	1.2-1.9 (20-32)	2.0-5.9 (33-101)	6.0-11.9 (102-204)	>12.0 (204)
Cardiovascular	MAP ≥70 mm Hg	MAP <70 mm Hg	Dopamine <5 or dobutamine (any dose)[b]	Dopamine 5.1-15 or epinephrine ≤0.1 or norepinephrine ≤0.1[b]	Dopamine >15 or epinephrine >0.1 or norepinephrine >0.1[b]
Central nervous system					
Glasgow Coma Scale score[c]	15	13-14	10-12	6-9	<6
Renal					
Creatinine, mg/dL (μmol/L)	<1.2 (110)	1.2-1.9 (110-170)	2.0-3.4 (171-299)	3.5-4.9 (300-440)	>5.0 (440)
Urine output, mL/d				<500	<200

Abbreviations: Fio_2, fraction of inspired oxygen; MAP, mean arterial pressure; Pao_2, partial pressure of oxygen.

[a] Adapted from Vincent et al.[27]

[b] Catecholamine doses are given as μg/kg/min for at least 1 hour.

[c] Glasgow Coma Scale scores range from 3-15; higher score indicates better neurological function.

qSOFA (Quick SOFA) Criteria

- Respiratory rate ≥22/min
- Altered mentation
- Systolic BP ≤ 100 mmHg

- Organ dysfunction can be identified as an acute change in total SOFA score ≥2 points consequent to the infection.

Sepsis management

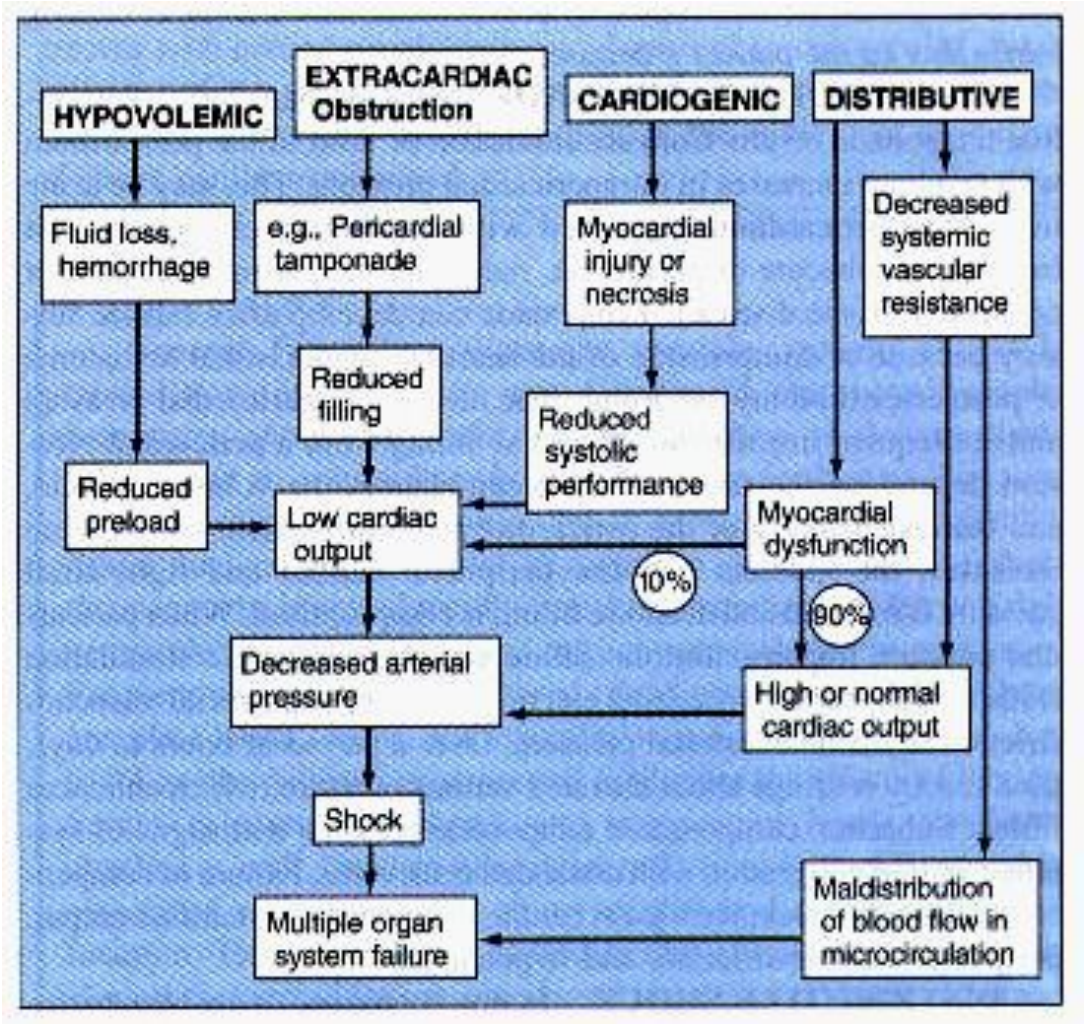
- Perform a clinical evaluation using the ABCDE approach and establish IV access.
- **Hour-1 bundle for sepsis**
  - **Definition**: a group of critical measures that should be performed within 60 minutes of recognizing patients with septic shock or a high pretest probability (PTP) of sepsis.
  - **Five essential elements**
    1. Obtain serum lactate. (Repeat if initial lactate is > 2 mmol/L)
       - Elevated lactate predicts sepsis severity and helps guide resuscitation.
    2. Draw blood cultures prior to antibiotic administration.
       - Two sets of blood cultures (aerobic and anaerobic) if possible
    3. Begin rapid IV fluid bolus if MAP < 65 mm Hg or lactate ≥ 4 mmol/L.
    4. Use vasopressors to keep MAP ≥ 65 mm Hg. Administer if hypotension persists (during or after fluid resuscitation)
    5. Administer broad-spectrum antibiotics within 1–3 hours.
- For refractory septic shock consider 200-300 mg/day of hydrocortisone in divided doses for 7 days; 50µg po q day of fludrocortisone can be also added

Adrenal Crisis

- **Definition**: a life-threatening condition caused by a sudden deficiency of cortisol and sometimes aldosterone, hormones produced by the adrenal glands.
- **Causes**: Autoimmune adrenalitis, Adrenal apoplexy, heparin may predispose
- In terms of shock classification, an adrenal crisis doesn't neatly fit into the categories of distributive, cardiogenic, or hypovolemic shock because it's primarily a result of hormonal imbalance rather than a circulatory issue. However, its clinical presentation can resemble distributive shock in some ways due to severe hypotension, vasodilation, and vascular collapse.
- **Management**: Steroids may be lifesaving in the patient who is unresponsive to fluids, inotropic, and vasopressor support.

Summary

Type	Estimated CO	PCWP	SVR
Hypovolemic	↓	↓	↑
Cardiogenic	↓↓	↑	↑
Obstructive	↓↓	↓ or ↑	↑
Distributive	Early septic: ↑ Late septic: ↓	Usually, ↓	↓↓



Vasopressors

- Assure adequate fluid volume
- Administer via CVL
- Do not use dopamine for renal protection
- Requires arterial line placement
- Vasopressin:
  - Refractory shock
  - Infusion rate 0.01 – 0.04 Units/min
- Augments contractility, after preload established, thus improving cardiac output.
- Risk tachycardia and increased myocardial oxygen consumption if used too soon
- increased C.I. improves global perfusion

Vasopressors & Inotropic Agents

	Dose	MOA	Notes
Dopamine	• Low dose (0.5 - 2 μg/kg/min) = dopaminergic • Moderate dose (3-10 μg/kg/min) = β-effects • High dose (> 10 μg/kg/min) = α-effects		Side effects • Tachycardia • > 20 μg/kg/min Δ to norepinephrine
Dobutamine	5-20 μg/kg/min	• β-agonist • Potent inotrope, variable chronotrope	Caution in hypotension (inadequate volume) may precipitate tachycardia or worsen hypotension
Norepinephrine	1-100 μg/min	• Potent α-adrenergic vasopressor • Some β-adrenergic, inotropic, chronotropic	Unproven effect with low-dose dopamine to protect renal and mesenteric flow
Epinephrine	1-10 μg/min	• α- and β-adrenergic effects • Potent inotrope and chronotrope	Increases myocardial oxygen consumption particularly in coronary heart disease
Amrinone	load dose = 0.75-.5 mg/kg → 5-10 μg/kg/min drip	Phosphodiesterase inhibitor, positive inotropic and vasodilatory effects	• Increased cardiac stroke output without an increase in cardiac stroke work • Most often added with dobutamine as a second agent • Main side-effect: thrombocytopenia

Head trauma

Surgical Anatomy

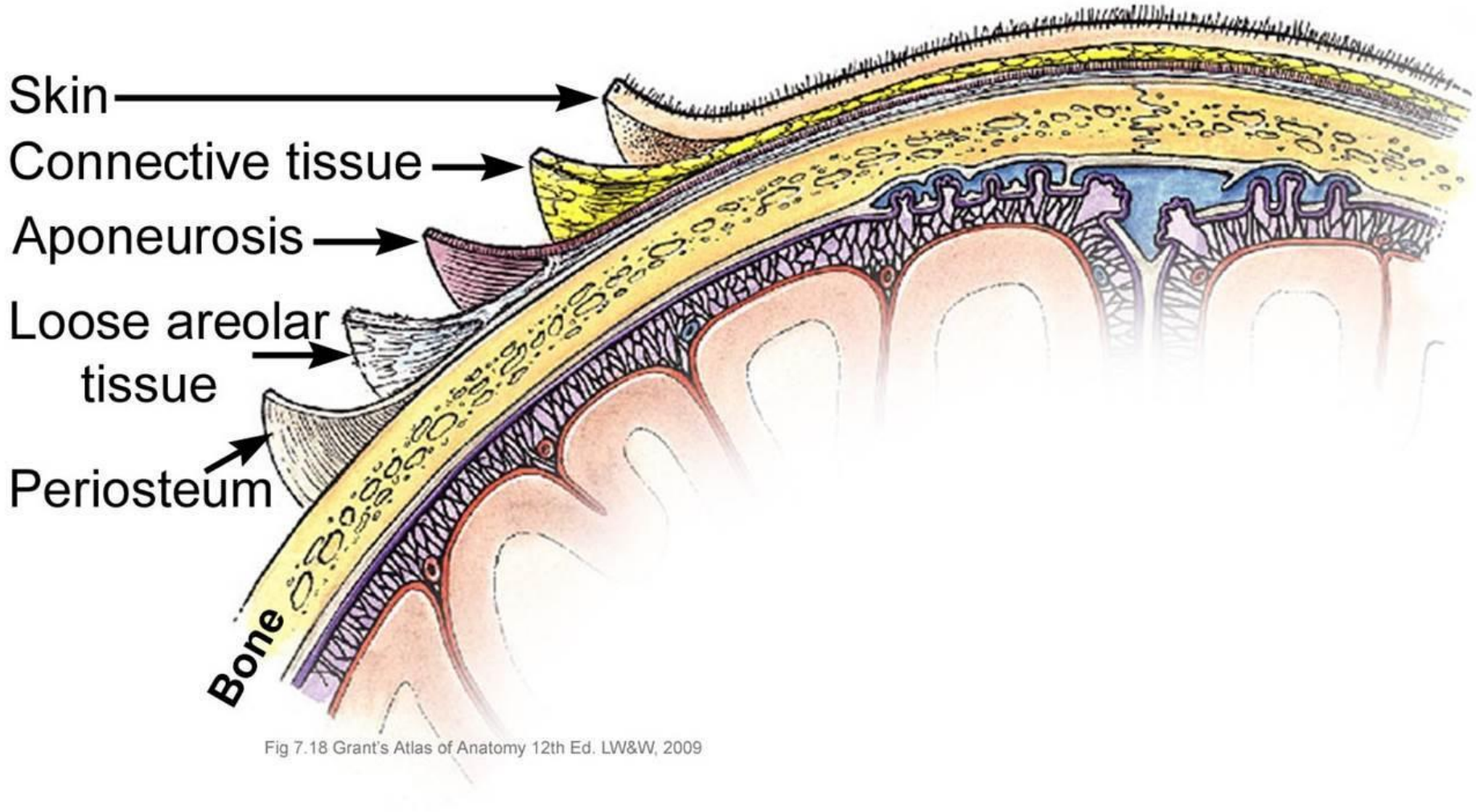


Fig 7.18 Grant's Atlas of Anatomy 12th Ed. LW&W, 2009

Head trauma

❖ Definition

- Traumatic brain injury (TBI): structural or physiological disruption of the brain resulting from a head injury
- Head injury: trauma to the head that may or may not be associated with soft tissue injury, skull fractures, and TBI
  - Closed head injury (most common): head injury with intact dura mater
  - Open head injury: head injury with a breach in the dura mater exposing the cranial contents to the environment; associated with skull fractures

❖ Epidemiology

- Age: especially children 0–4 years, teenagers and young adults 15–24 years, and adults > 65 years
- Sex: ♂ > ♀

Head trauma

❖ Pathophysiology

- Brain is contained within the skull, a rigid and inelastic container.
- Hence only small increases in volume within the intracranial compartment can be tolerated before pressure within the compartment rises dramatically.
- A second crucial concept in TBI pathophysiology is the concept of cerebral perfusion pressure (CPP),which is the difference between the mean arterial pressure (MAP) and intracranial pressure (ICP)
- CPP = MAP - ICP

❖ Classification

- Type of injury: open/closed or blunt-penetrating
- Site of injury
- Pathology of injury
- Severity of injury

Head trauma – Etiology

- **Blunt head injury (common)**
  - Injuries resulting from rapid deceleration of the head causing the brain to move within the cranial cavity and to come into contact with the bony protuberances withing the skull
  - Falls: leading cause of TBI; more common in children, adolescents, and elderly
  - Motor vehicle accidents: second most common cause of TBI
  - Contact sports (e.g., football) (Important cause of mild TBI)
- **Penetrating head injury (less common)**
  - High-velocity (missile) injury: gunshot wounds
  - Low-velocity (non-missile) injury: assault or accidental injury with a penetrating foreign body to the head or face (e.g., knife, screwdriver, nail gun)
- **Blast injuries**: injury caused by the high-pressure wave (blast wave) generated from an explosion; common in active military or war zones

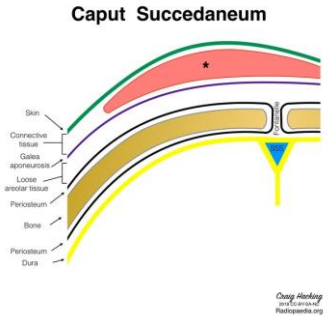
Traumatic head injury summery

Injury	Treatment	Injury	Treatment
Superficial injuries		**Extra axial intracranial hemorrhage**	
Abrasion	Dressing	Epidural hematoma	Craniotomy & evacuation
Laceration	Dressing or suturing	Acute subdural hematoma	Craniotomy & dura slitting
Scalp Hematomas		Chronic subdural hematoma	Burr holes
Caput succedaneum	Expectant	Subarachnoid hematoma	Expectant
Subgaleal hematoma	Strict observation	Intraventricular hematoma	Drainage
Cephalohematoma	Expectant	**Intra axial intracranial injuries**	
Skull fractures		Intracerebral hematoma	Expectant
Liner fracture	Expectant	Cerebral contusion	Expectant
Depressed fracture	Surgical elevation	Diffuse axonal injury	

Scalp Hematomas

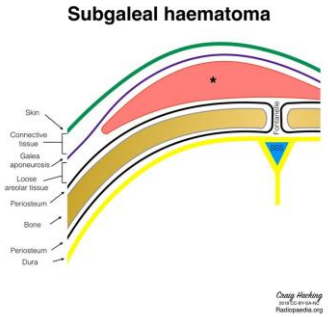
❖Caput succedaneum

- Benign edema of the scalp that extends across the cranial suture lines
- Firm swelling; pits if gentle pressure is applied
- No treatment required; resolves within hours or days



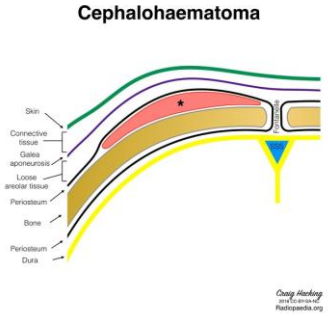
❖Subgaleal hemorrhage

- Rupture of the emissary veins and bleeding between the periosteum of the skull and the aponeurosis that may extend across the suture lines
- Associated with a high risk of significant hemorrhage and hemorrhagic shock



❖Cephalohematoma

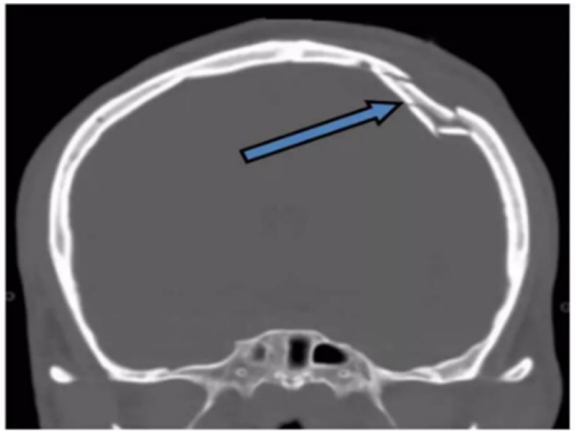
- Subperiosteal hematoma that is limited to cranial suture lines
- Complications: calcification of the hematoma, secondary infection
- No treatment required; resolves within several weeks or months



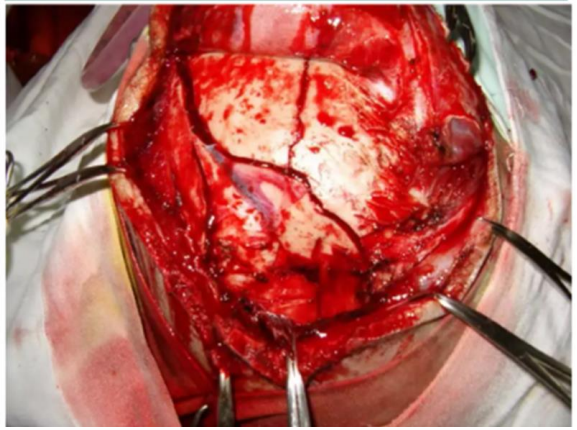
Skull fractures

- **Closed fractures**: has a significant chance of associated intracranial hematoma.
- **Open fractures**: have the potential for serious infection,
- Any foreign material in the skull should be left in place to be removed by neurosurgeons. It should be covered with light sterile dressing that has been moistened with a sterile saline.

• Open fractures



Closed fractures

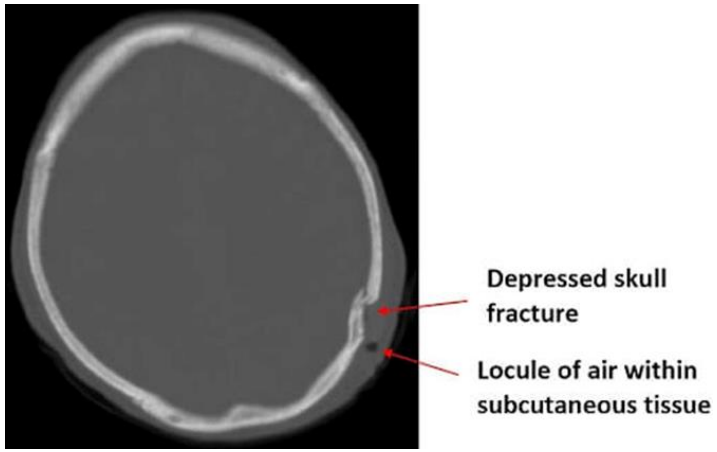


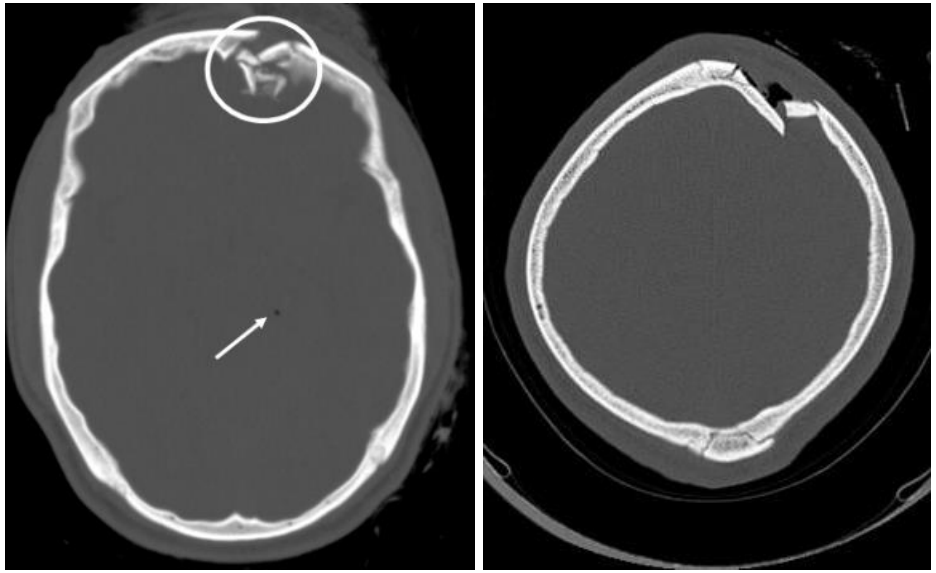
Skull fractures

Liner fracture	Depressed fracture	Basal skull fracture
A single fracture that extends through the entire width of one or more bones of the skull; most common type of skull fracture	A skull fracture in which the skull depresses inward toward the brain parenchyma	A skull fracture involving ≥ 1 bone of the skull base (the ethmoid, sphenoid, occipital, paired frontal, and/or paired temporal bones)
Clinical features • Number of fracture lines: simple or comminuted fracture • Soft tissue involvement: closed fracture or open fracture • Fractures crossing the middle meningeal groove or dural venous sinuses may result in epidural hemorrhage. **Management**: Expectant except in • Children <3 years old • Neurological abnormalities • CSF leakage	**Clinical features** • Number of fracture lines: typically, a comminuted fracture • Often an open skull fracture • Often penetrates the dura (i.e., causing open head injury) • Location: most commonly involves the parietal and frontoparietal regions **Management** • Expectant unless surgery is indicated (surgical elevation)	**Clinical features** • **Liquorrhea**: CSF rhinorrhea and/or CSF otorrhea • **Raccoon eyes**: subcutaneous hematoma around the eyes • **Battle sign**: subcutaneous hematoma overlying the mastoid process • **Hemotympanum**: a collection of blood in the tympanic cavity behind the tympanic membrane • Signs and symptoms of traumatic brain injury **Management** • Conservative management • Emergency surgery may be indicated for comminuted or displaced fractures, large CSF leaks, or significant neurovascular complications

Depressed skull fracture

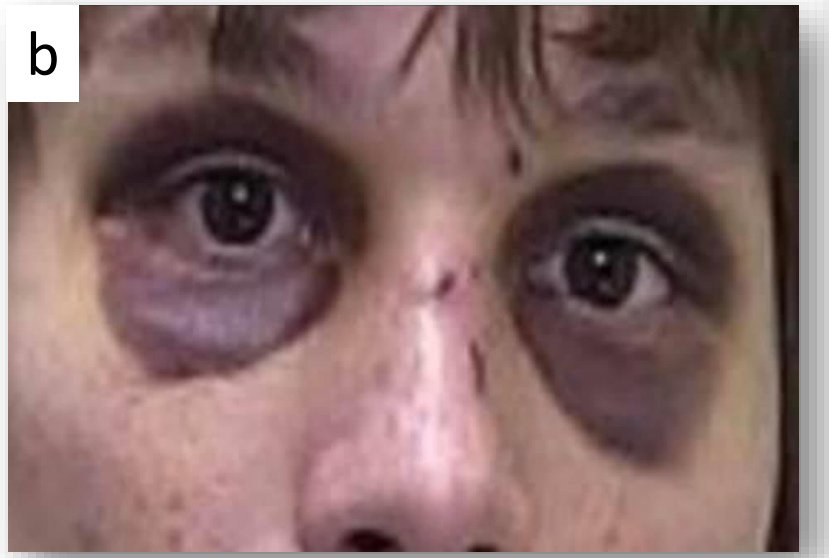
- **What is your spot diagnosis ?**
  - Depressed skull fracture
- **What is the management ?**
  - Surgical elevation
- **Mention 2 indications for surgery**
  - Cosmetic disfigurement
  - Depressed more than 1 cm
  - Presence of neurological deficits
  - CSF leakage
  - Seizures

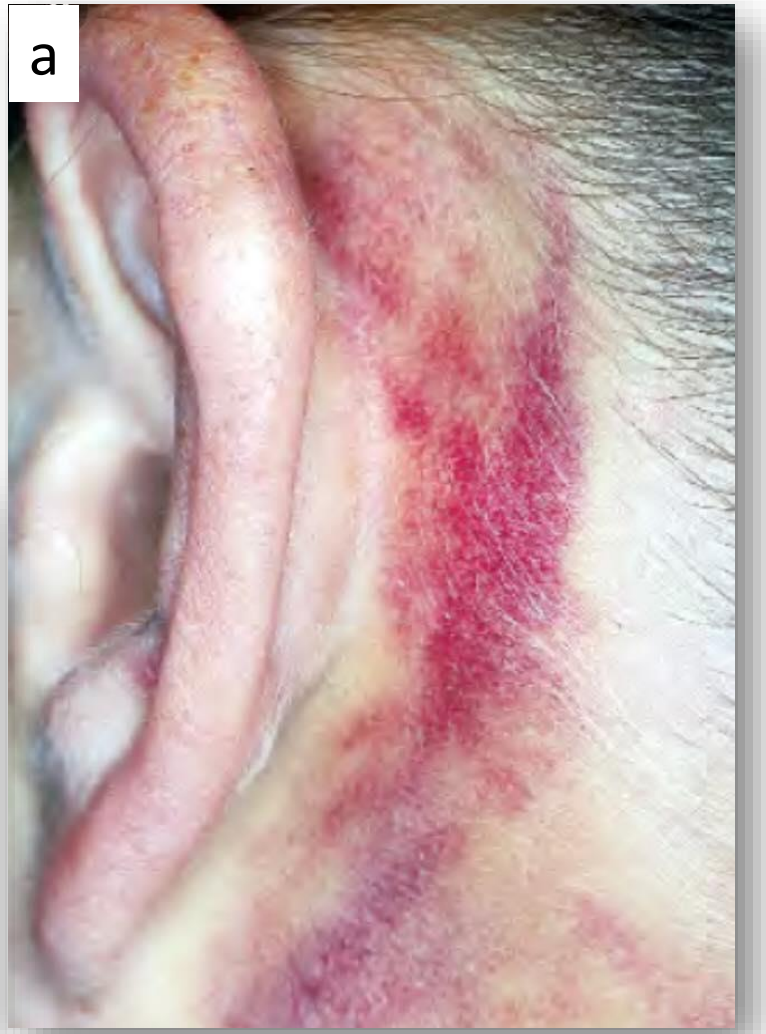




Basal skull fracture

- **What is the name of this sign ?**
  a. Battle's sign
  b. Raccoon eyes
- **What does this sign indicate ?**
  - Basal skull fracture



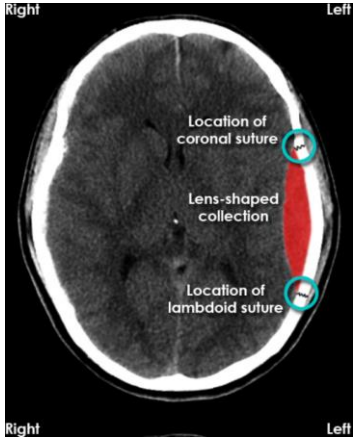


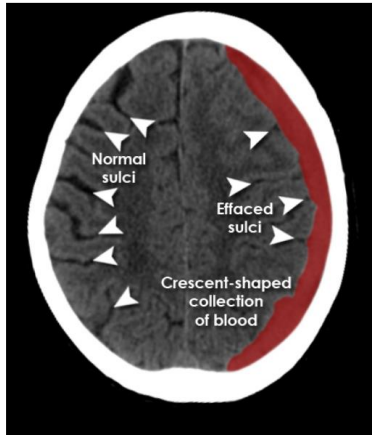
Brain injury

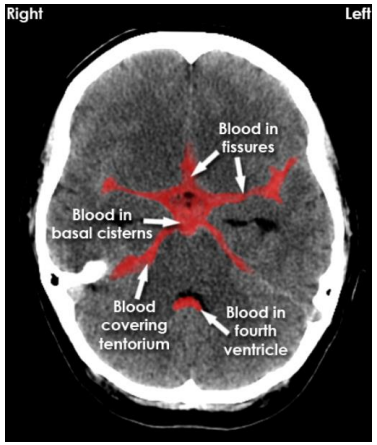
Primary injury	Secondary injury
Definition: brain injury that occurs at the time of the trauma as an immediate consequence of head injury	**Definition**: indirect brain injury resulting from physiological changes following acute CNS insults and/or their treatment
Intracranial hemorrhage, Cerebral contusion, Coup-contrecoup injury, concussion	**Examples**: disrupted blood-brain barrier, hypoxic-ischemic encephalopathy, Generalized cerebral edema

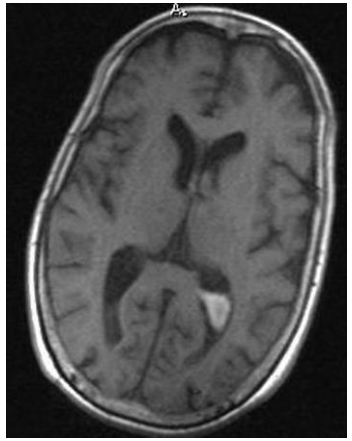
Extra Axial Hematomas

Epidural hematoma	Subdural hematoma	Subarachnoid hematoma	Intraventricular hematoma
• **Shape**: Lens (biconvex) • Respect the sutures • Can cause mass effect • **Most common from** the middle meningeal artery • **Venous EDH** (rare) from the middle meningeal vein or dural venous sinus injury • **Treatment**: Craniotomy & evacuation	• **Shape**: Lacunar • Doesn't respect suture • Less likely to cause mass effect • **Most common from** the bridging veins • **Treatment**: Craniotomy & dura slitting	• Bleeding in sulci & citterns • Usually found centrally (around the circle of Willis) but can occur in other parts of the brain • **Most commonly due to** rupture of an intracranial aneurysm (berry aneurysm) • Commonly present with "The worst headache in my life" complain • **Treatment**: Expectant	• Inside cerebral ventricles • Can be primary or secondary to a large extraventricular component with secondary extension into the ventricles • **Treatment**: Drainage



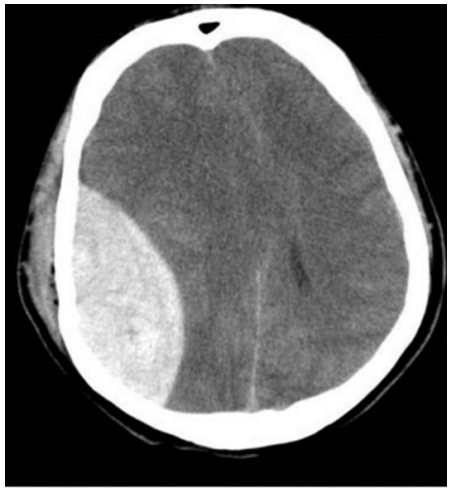


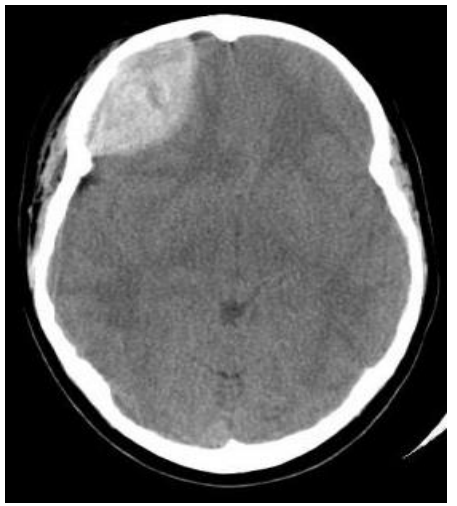




Epidural hematoma

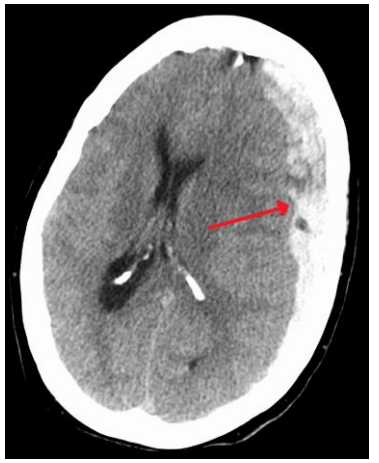
- **Definition**: Hematoma in the extradural space
- **Commonest site**: Temporal region
- **Affected vessel**: Middle meningeal artery
- **Clinical presentation**: Commonly presents with lucid interval with featured of increased ICP
- **CT scan**: lentiform hyperdense lesion
- **Definitive management**: Craniotomy and evacuation

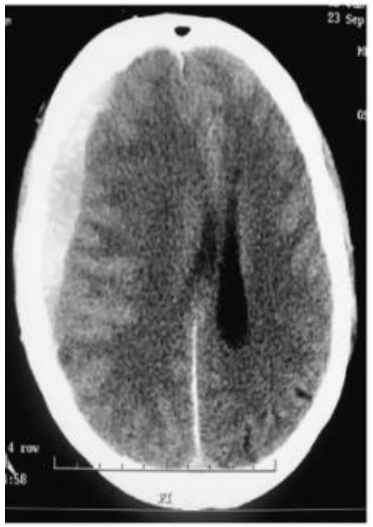




Acute subdural hemorrhage

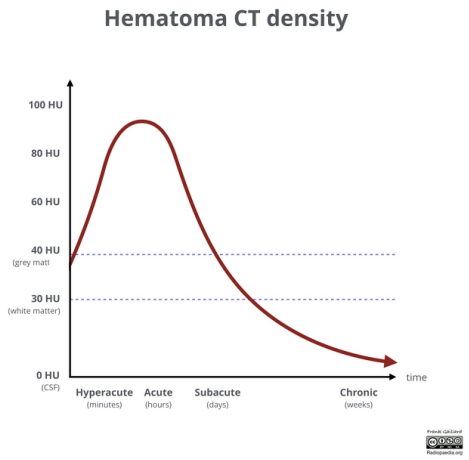
- **Definition**: Hematoma between dura and brain
- **Affected vessel**: The bridging veins
- **Clinical presentation**: headache, cognitive decline, focal neurological deficits and seizures
- **CT scan**: convex lesion
- **Definitive management**: Craniotomy & dura slitting

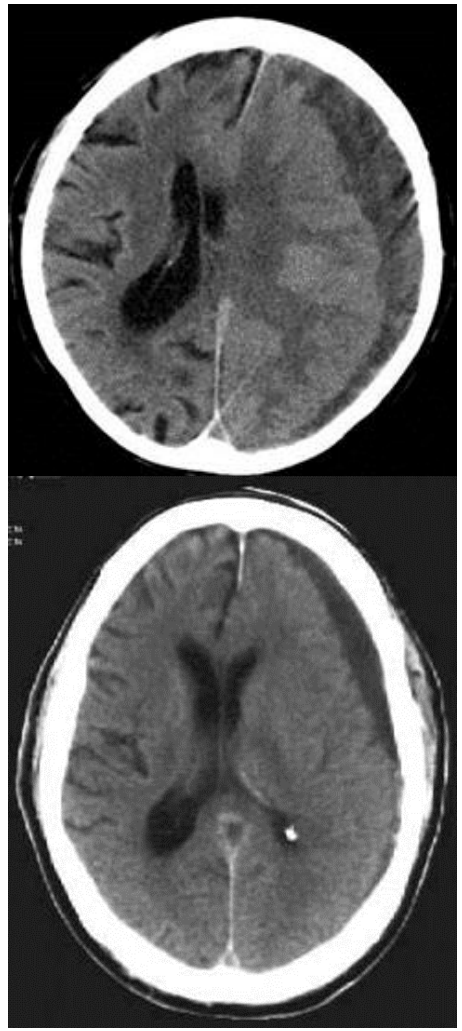




Chronic subdural hemorrhage

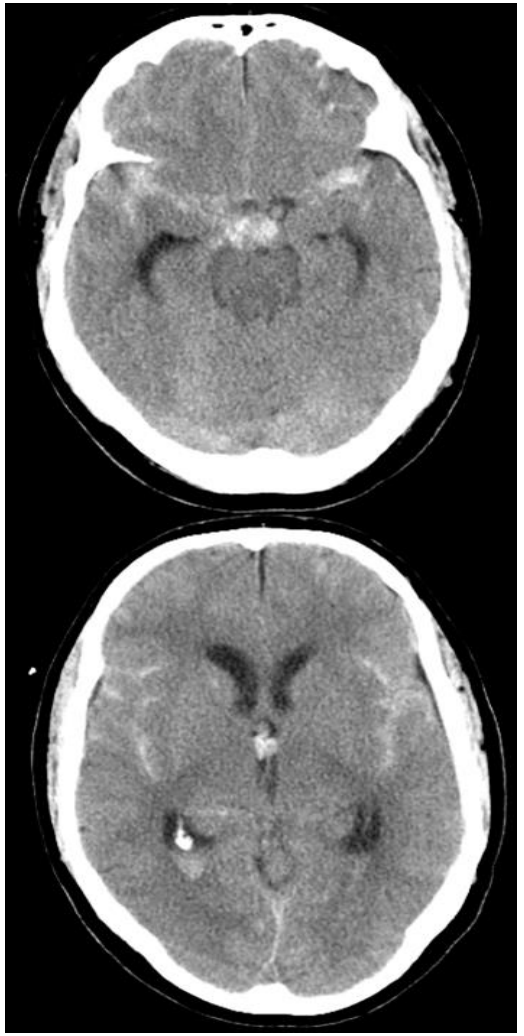
- **What is the diagnosis ?**
  - Left side chronic subdural hemorrhage
- **What is the treatment ?**
  - Burr holes
    - Acute: Craniotomy and evacuation
    - Chronic: Burr holes
- **Is there a midline shift ?**
  - Yes
- **What is the timing ?**
  - symptom onset ≥ 21 days after the inciting event





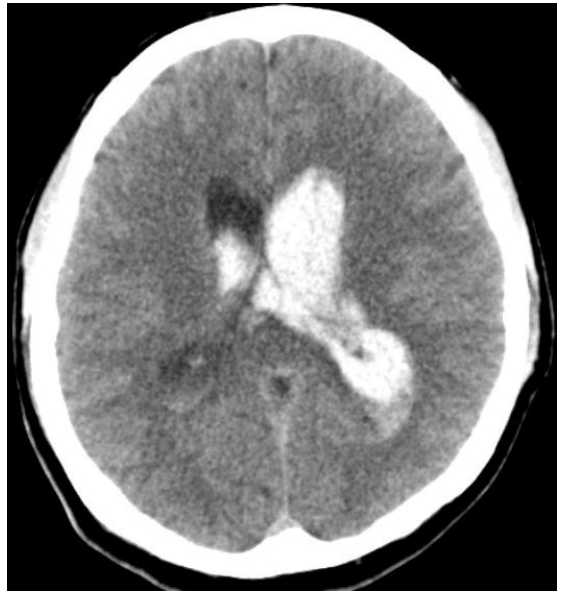
Subarachnoid hemorrhage

- **Definition**: Hematoma in the space between the arachnoid space and the pia mater (subarachnoid space)
- **Etiology**: May be spontaneous (intracranial aneurysm) or due to trauma.
- **Clinical presentation**: Features of increase ICP
- **Diagnosed with** LP, CT scan, or Angiogram.
- **Treatment** : Mainly expectant; but if indicated: clipping, embolization, or craniotomy



Intraventricular haemorrhage

- **What is your diagnosis ?**
  - Intraventricular haemorrhage
- **Mention one complication for it ?**
  - Hydrocephalus
- **How to treat ?**
  - Drainage by extraventricular device



Intra Axial injuries

- **Intracerebral hemorrhage**
  - **Definition**: Refers to bleeding within the brain parenchyma
  - **Characteristic clinical features**: headache, focal neurological deficits, LOC
  - **Non-contrast CT**: Traumatic ICH usually present with multiple intraparenchymal hematomas or hemorrhagic contusions
  - **Management**: Usually resolves alone but might require evacuation
- **Cerebral contusion**: focal area of heterogeneous brain injury, varying from a bruise to a focal area of necrosis
- **Coup-contrecoup injury**
  - **Coup injury**: injury on the side of an impact
  - **Contrecoup injury**: additional injury (typically a contusion) on the opposite side of impact

Effects of brain injury

- **Brain edema**: is accumulation of fluid in both the intracellular and extracellular, its due to congestion and dilatation of blood vessels, it may be diffuse or localized.
- **Brain necrosis**: is due to hemorrhagic infarction and has a variety of destruction.
- **Brain ischemia**: is due to increased pressure, this in turn leads to alteration in the perfusion of brain which itself aggravates the ischemia and this forms a vicious cycle, causing progressive diffuse ischemia of brain.

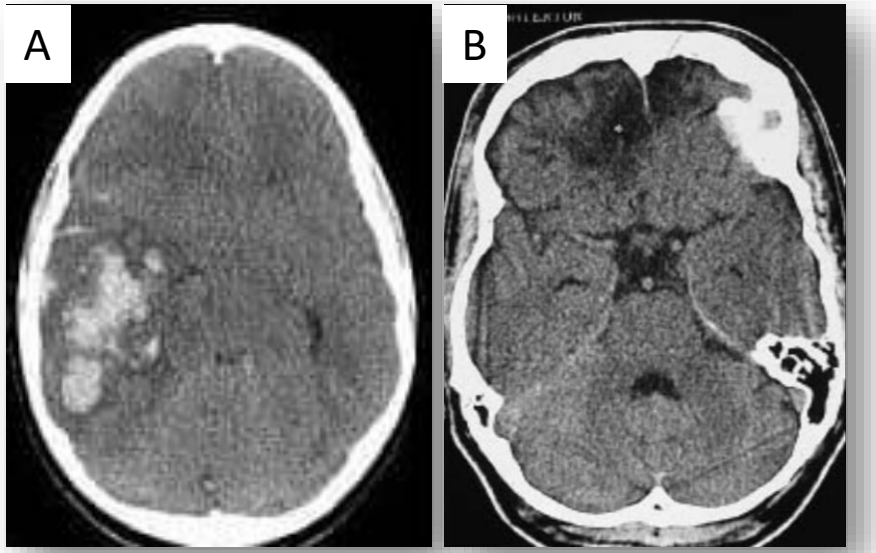
Acute hemorrhagic contusion

❖**What is your interpretation**

A. hyperdense area in the Rt parietal lobe
B. hypodense area in the frontal lobes

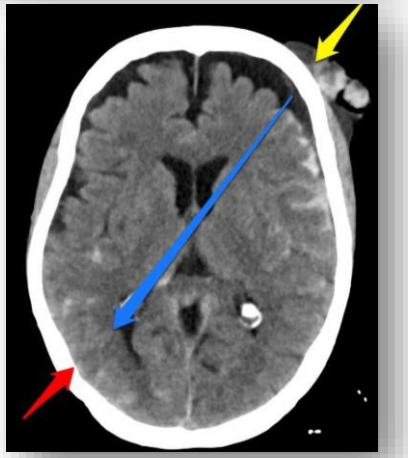
❖**What is your diagnosis ?**

A. Acute hemorrhagic contusion
B. Non-hemorrhagic contusion



❖**What is the diagnosis according to these CT scan ?**

- Coup counter-coup hemorrhagic contusion

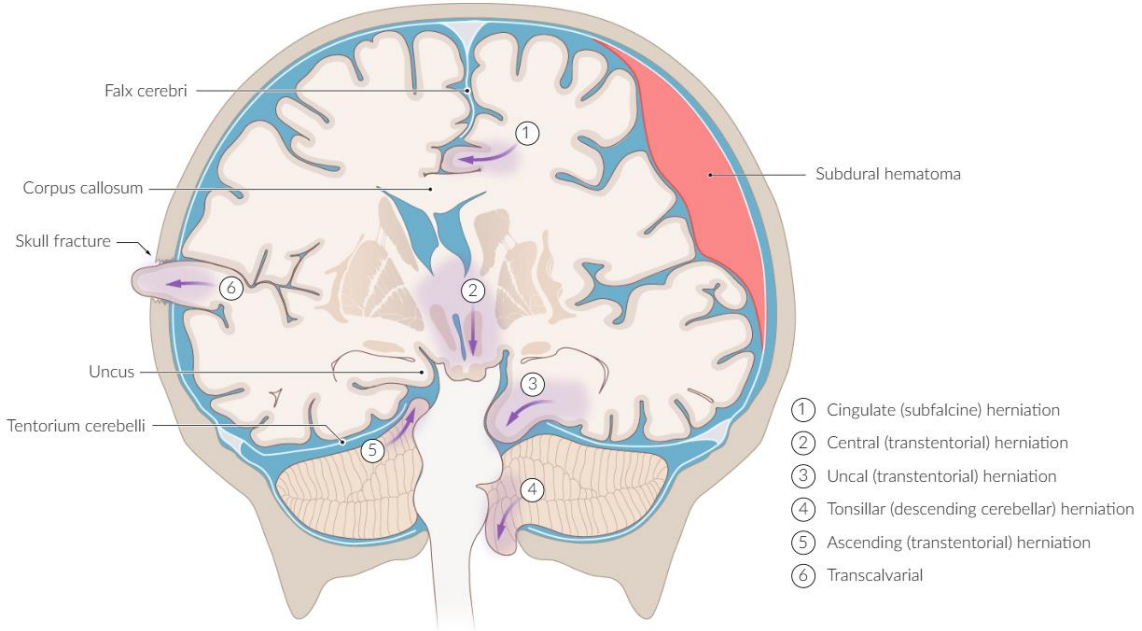


Diffuse primary brain injury

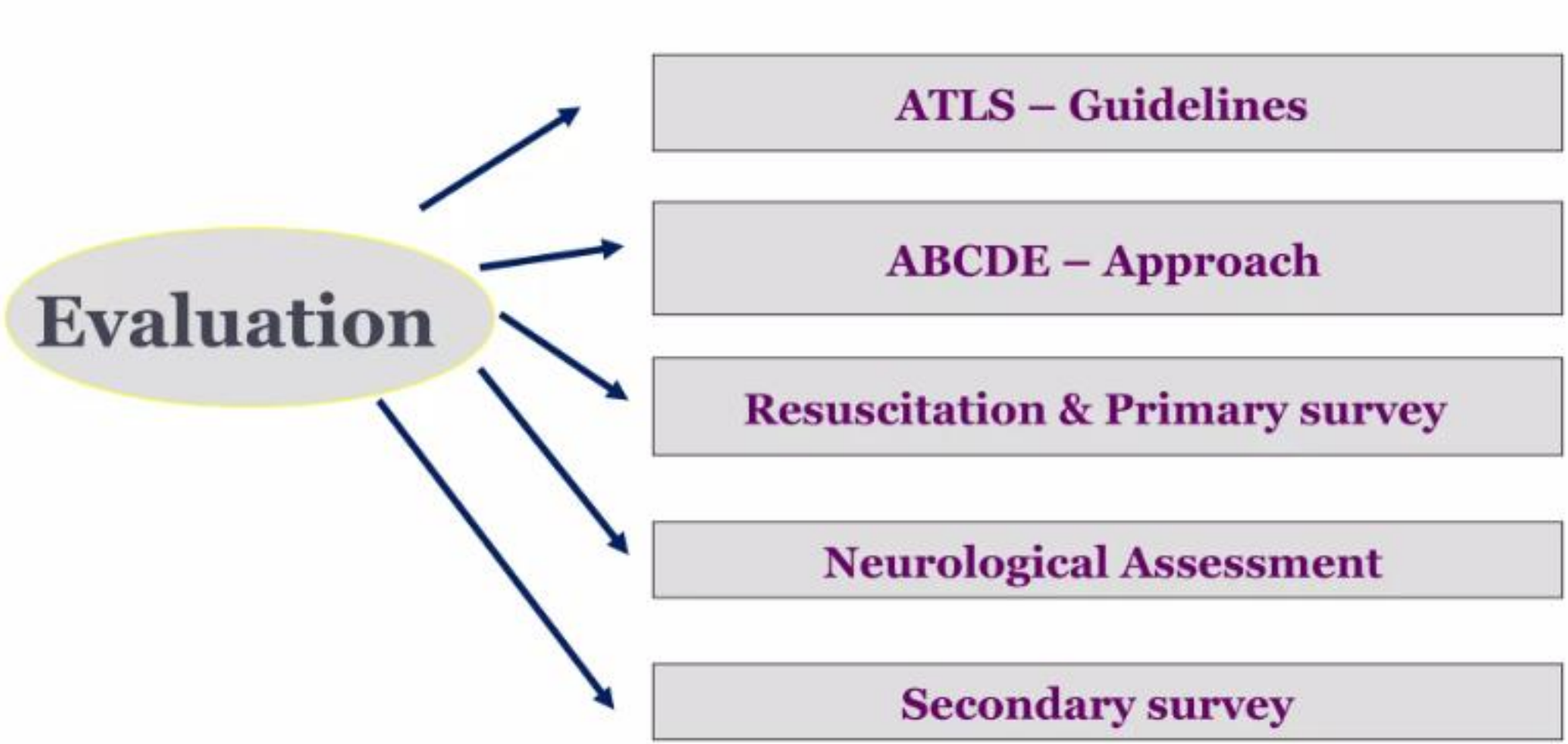
- **Mild traumatic brain injury (concussion)**
  - A trauma-induced disruption of brain function associated with a GCS ≥ 13-15 at least 30 minutes post-injury and ≥ 1 of the following: altered mental state at the time of the injury, loss of consciousness < 30 minutes, posttraumatic amnesia < 24 hours, or minor neurological abnormalities not requiring surgical intervention.
- **Cerebral edema**: early vasogenic then lately cytogenic
- **Diffuse axonal injury (DAI)**
  - Multifocal shearing tears and disruption of the axons of the brain due to rotational acceleration-deceleration trauma of the head; typically seen in high-impact road traffic accidents. (لما السيارة تقلب أكثر من مرة)
  - Commonly results in severe neurological injury (e.g., coma, persistent vegetative state)

Coning

- Its due to increase ICP causing either herniation of content of supratentorial compartment through the tentorial hiatus, or herniation of the content of infratentorial compartment through the foramen magnum.
- In supratentorial herniation there is compression of ipsilateral CN3 and midbrain
- In infratentorial herniation there is obstruction of cerebral aqueduct with damage to brain function.



Clinical approach to head injuries

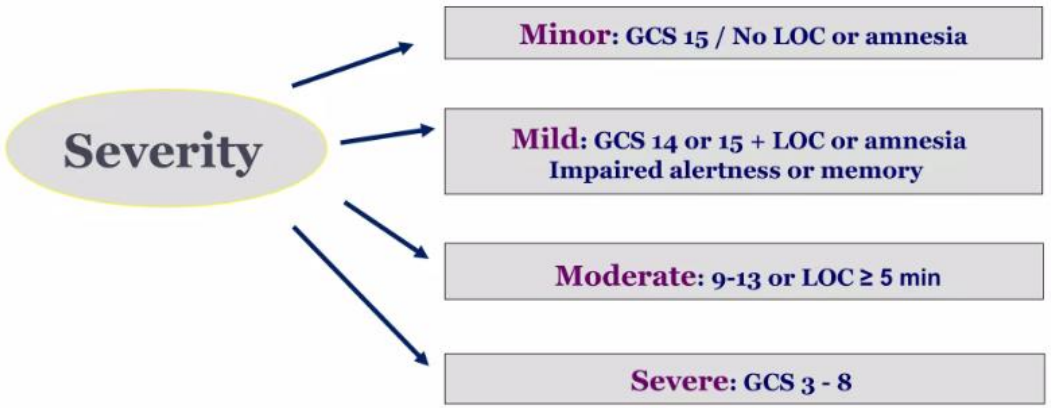


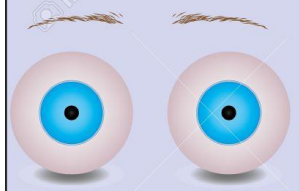
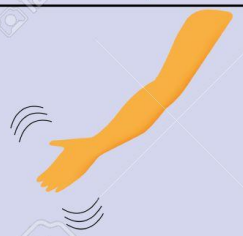
Clinical approach to head injuries

- **History**
  - Mechanism of injury
  - LOC or amnesia
  - Level of consciousness at the scene and on transfer
  - Current symptoms - evidence of seizure
  - Hypotension or signs of hypoxia
  - Pre- existing medical conditions
  - Medication (especially anticoagulants) - allergies
- **Physical examination**
  - **Neurological Assessment**: Glasgow coma scale, Pupillary reaction to light and size, Reflexes and Limb movements
  - **Secondary survey**: General assessment and other injuries

Glasgow coma scale

- 14-15 → mild
- 9-13 → moderate
  - Next step: urgent CT head
- 3-8 → severe
  - Next step: intubate
- In case of tracheostomy, we add +T



Behaviour	Response
 Eye Opening Response	4. Spontaneously 3. To speech 2. To pain 1. No response
 Verbal Response	5. Oriented to time, person and place 4. Confused 3. Inappropriate words 2. Incomprehensible sounds 1. No response
 Motor Response	6. Obeys command 5. Moves to localised pain 4. Flex to withdraw from pain 3. Abnormal flexion 2. Abnormal extension 1. No response

Calculate the GCS and determine the severity

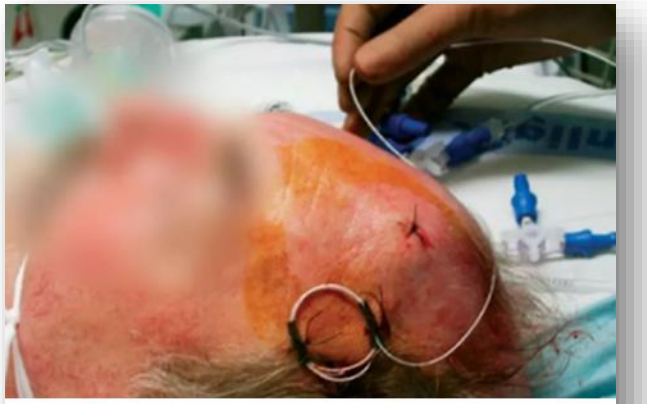
1. **Patient open eye to painful stimuli, inappropriate words, and decerebrate on both side**
   - 7/15, severe, management: intubation
2. **Patient open only his left eye to painful stimuli, incomprehensible sounds, and localizes pain**
   - 9/15, moderate
3. **Patient right eye is fixed dilated and don’t respond to light and the other eye response to pain, inappropriate words, and decerebrate on both side**
   - 7/15, severe, management: intubation
4. **Patient open eyes to pain, incomprehensive sound, decerebrate right side, decorticate left side**
   - 7/15, severe, management: intubation

Calculate the GCS and determine the severity

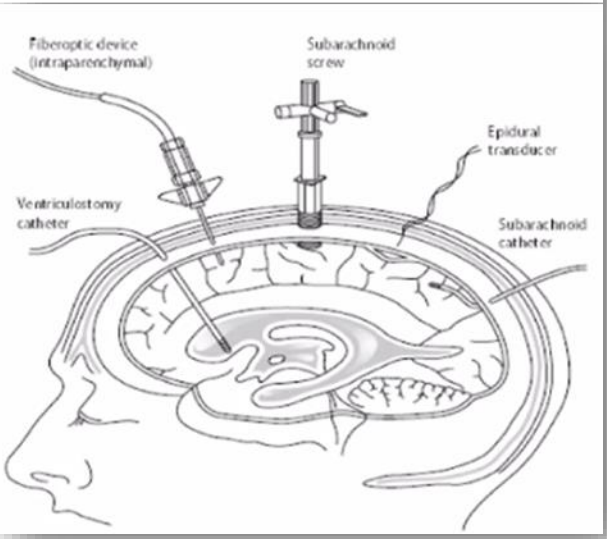
5. **Patient open eyes to speech, localize to pain, confused verbal response**
   - 12/15, moderate
6. **Patient open his eyes to pain, localized to pain, confused and disoriented**
   - 11/15, moderate
7. **Patient is permanent intubated, eyes open to pain, decerebrate, no verbal response**
   - 5/15+T, severe
8. **Patient opens his eye to pain, inappropriate words, decorticate**
   - 8/15, severe, management: intubation
9. **Patient opens his eye to pain, inappropriate words, decerebrate**
   - 7/15, severe, management: intubation

Investigations

- Basic labs
- X-rays skull : to look for fracture
- CT scan : plain (no contrast) to look for cerebral oedema, hematoma, midline shifts, fractures, ventricles, brainstem injury.
- Carotid arteriography - MRI scan
- Investigations for other injuries like U/S abdomen
- Monitoring of intracranial pressure.



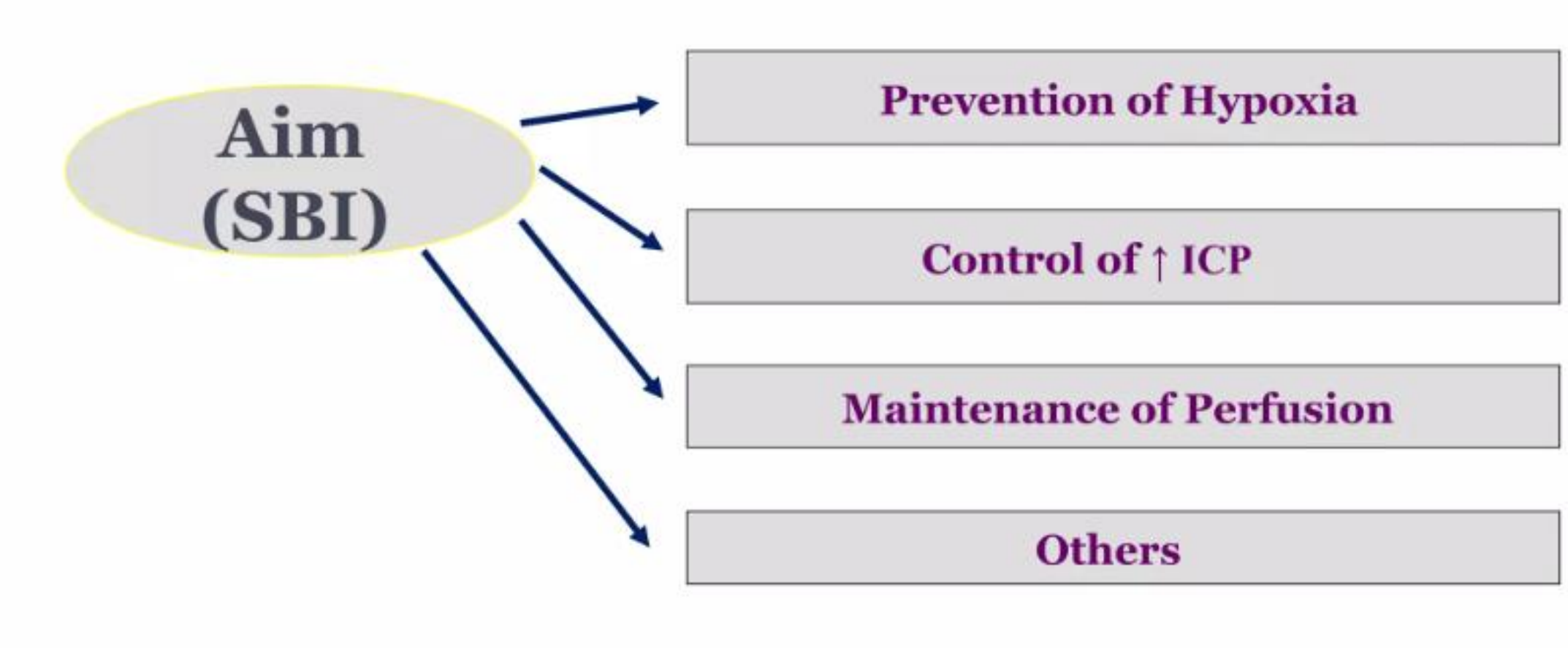
ICP - monitoring



Criteria

- **Hospitalization criteria**
  - Any altered level of consciousness.
  - Skull fracture.
  - Focal neurological features.
  - Persistent headache, vomiting, systolic hypertension, bradycardia.
  - No CT scan available or abnormal CT head.
  - Alcohol intoxication.
  - Bleeding from ear or nose.
  - Associated injuries.
- **NICE Guideline (CT scan criteria)**
  - GCS < 13 at any point.
  - GSC 13 or 14 at 2 hr.
  - Focal neurological deficit.
  - Suspected open, depressed or basal skull fracture.
  - Seizure.
  - Vomiting > 1 episode.
- **Discharge Criteria**
  - GCS 15\15.
  - No focal neurological deficit.
  - Follow up.

Treatment - Moderate to Severe Injury



Control of ICP

Medical

- Normal ICP = 8-12 mm hg
- Position head up 30 degree.
- Avoid obstruction of venous drainage of the head.
- Sedation, muscle relaxant.
- Normocapnia 4.5-5 kPa.
- Diuretics : furosemide, mannitol.
- Seizure control.
- Normothermia.
- Sodium balance.
- Barbiturates.

Surgical

- Early evacuation of focal hematoma: EDH, ASDH (burr-hole - craniotomy).
- Cerebrospinal fluid drainage via ventriculostomy.
- Delayed evacuation of swelling contusions.
- Decompressive craniectomy.

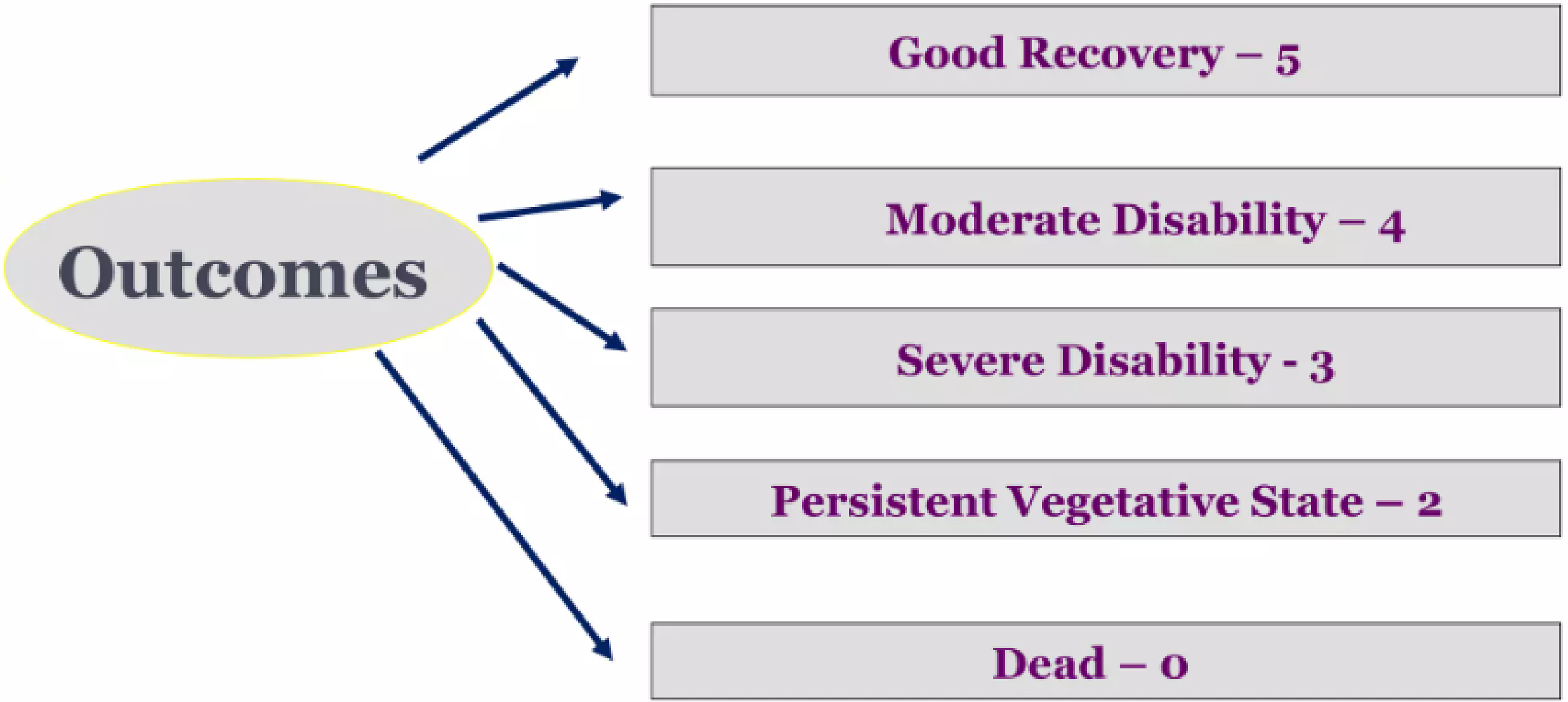
Complications

Early

- Brainstem injury due to coning.
- Compression over cerebellum and medulla.
- CSF leak (e.g., CSF rhinorrhea).

Late

- Chronic subdural hematoma.
- Early post-traumatic epilepsy, they need anticonvulsants for 3 years.
- Late post-traumatic epilepsy is due to scarring and gliosis of cerebrum.
- Post-traumatic amnesia.
- Post-traumatic hydrocephalus.
- Post-traumatic headache.


Outcomes
Good Recovery – 5
Moderate Disability – 4
Severe Disability - 3
Persistent Vegetative State – 2
Dead – 0

Neck Injury

Source: National Library of Medicine

Introduction

❖Epidemiology

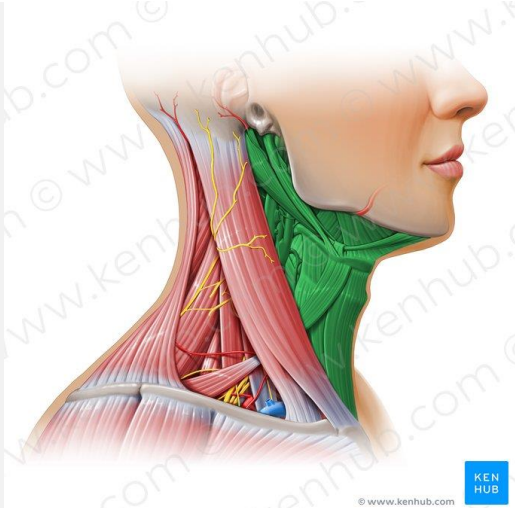
- The mortality rate for penetrating neck injuries is as high as 10%.
- The most common cause of death from penetrating neck trauma is a vascular injury.
- The most injured area is zone 2, which can easily be accessed surgically.
- The area of highest risk is injuries at the base of the neck, in zone 1.
- The leading causes of delayed mortality are due to esophageal injuries, which may not be apparent on initial presentation.

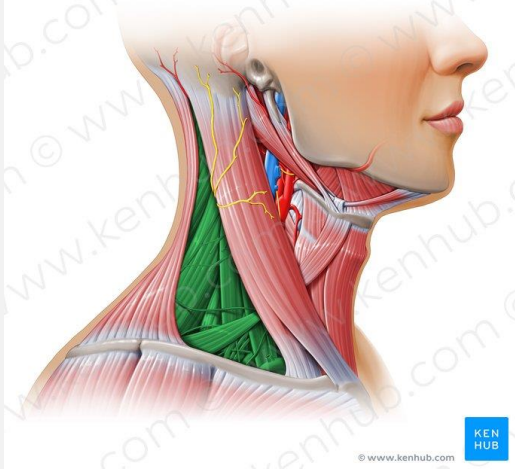
❖Neck anatomy

- Surgically, the neck is divided into three zones instead of the usual anatomical triangles system. Especially in penetrating trauma, zone designations have anatomical, diagnostic, and management implications.
- Although, the next slide will talk briefly about the neck triangles ☺

Neck anatomy

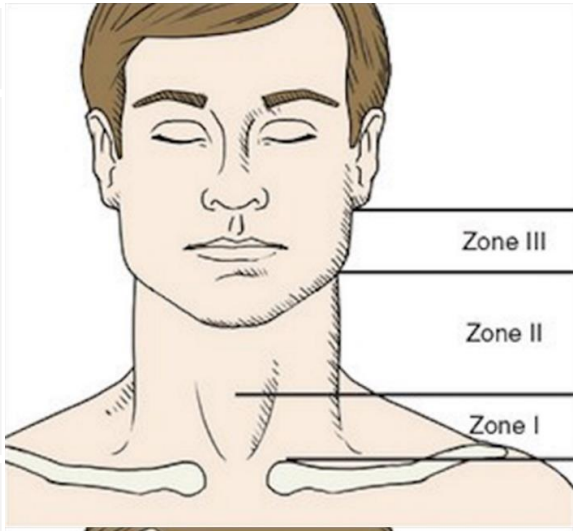
Anterior triangle	**Borders**: - Superior - inferior border of mandible - Medial - midline of neck - Lateral - anterior border of sternocleidomastoid muscle **Subdivisions**: - Muscular (omotracheal) triangle - Carotid triangle - Submandibular triangle - Submental triangle
Posterior triangle	**Borders**: - Anterior - posterior margin of sternocleidomastoid muscle - Posterior - anterior margin of trapezius muscle - Inferior - middle one-third of clavicle **Subdivisions**: - Occipital triangle - Supraclavicular (omoclavicular) triangle

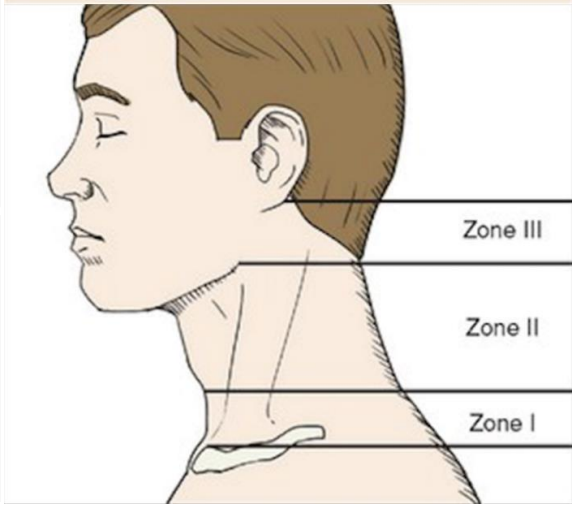




Neck zones

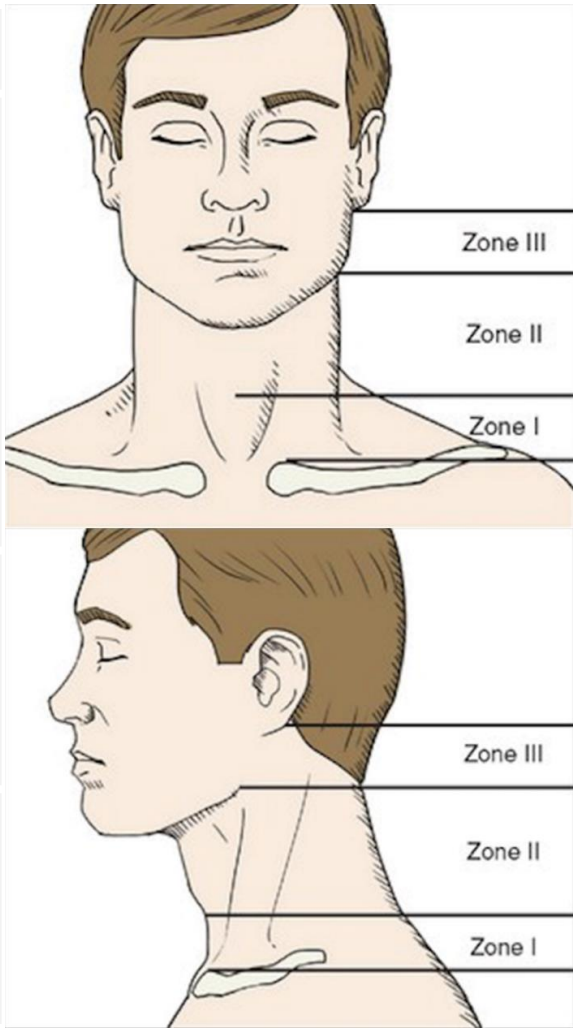
Zones	Boarders	Protection	Access
Zone I	This is the area between the clavicles and the cricoid cartilage	Considered to be well protected	Surgical exposure and access can be difficult in this zone, because of the presence of the clavicle and bony structures of the thoracic inlet.
Zone II	This is the area between the cricoid cartilage and the angle of the mandible	Considered to be least protected, very superficial	This zone has comparatively easy access for clinical examination and surgical exploration. It is the largest and the most injured zone.
Zone III	This is the area between the angle of the mandible and the base of the skull	Very confined, protected area	Since it is very close to the base of the skull, this area is less amenable to physical examination and difficult to explore during surgical evaluation.





Neck zones

Zones	Content
Zone I	• **Blood vessels**: aortic arch, subclavian, and innominate (brachiocephalic) vessels • **Nerves**: brachial plexus, left recurrent laryngeal nerve, spinal cord, sympathetic trunks • **Respiratory**: trachea, apex of the lung • **Digestive**: esophagus • **Lymphatic**: thoracic duct on the left • **Thyroid gland**.
Zone II	• **Blood vessels**: carotid vessels, internal jugular vein • **Nerves**: vagus, recurrent laryngeal, phrenic nerve • **Respiratory**: Trachea, larynx • **Digestive**: esophagus
Zone III	• **Blood vessels**: carotid vessels, internal jugular vein • **Nerves**: cranial nerves VII-XII • **Respiratory/digestive**: pharynx • **Glands**: Parotid gland



Etiology

Three major mechanisms have been described in neck trauma:

1. **Blunt trauma**: This includes motor vehicle accidents and sports injuries. There may be delayed presentation of laryngeal, vascular, and digestive tract injuries if blunt trauma occurs. Also, beware that occult cervical spine injury may be present in patients with blunt neck trauma. In addition, a shoulder harness (seatbelt) may also be responsible for shearing trauma to the anterior neck.
2. **Penetrating trauma**: This comprises as much as 5% to 10% of all trauma injuries. Examples include gunshot wounds and stab wounds. It is the violation of the platysma that determines penetrating injury. Wounds that penetrate the platysma have the potential for severe injury. Consequently, it is wise to consider damage to the vital structures if the platysma is violated. Stab wounds involve low-energy penetration.
3. **Near-hanging or strangulation**: External neck pressure causes cerebral hypoxia due to venous and arterial obstruction.

Approach to blunt neck trauma

- Primary survey
  - Prepare for difficult airway management and secure the airway early
  - Immobilize the cervical spine with a cervical collar.
  - Consider neurogenic shock in hypotensive patients with no evidence of hemorrhagic or obstructive shock.
- Secondary survey
  - Perform neurovascular examination focusing on clinical and diagnostic features of BCVI.
  - Obtain urgent diagnostics for trauma patients.
    - Bedside assessment: CXR for all
    - Vascular injury: CTA head and neck
    - Laryngeal injury: CT neck with IV contrast
  - Consult specialists based on injured anatomical structures.

Laryngeal injuries in blunt neck trauma

- Common to all traumatic mechanisms is the direct transfer of severe forces to the larynx. These forces have the potential to produce many devastating injuries, including mucosal tears, dislocations, and fractures.
- Edema, hematoma, cartilage necrosis, voice alteration, cord paralysis, aspiration, and airway loss may accompany these injuries.
- Common signs of laryngeal injury include stridor, subcutaneous emphysema, hemoptysis, hematoma, ecchymosis, laryngeal tenderness, vocal cord immobility, loss of anatomical landmarks, and bony crepitus

Laryngeal injuries according to the anatomical location:

1. **Supraglottis**: Traumatic forces commonly cause horizontal fractures of the thyroid alae and disrupt the hyoepiglottic ligament, leading to superior and posterior displacement of the epiglottis.
2. **Glottis**: Traumatic force leads to cruciate fractures of the thyroid cartilage near the attachment of the true vocal cords.

Laryngeal injuries according to the anatomical location

3. **Subglottis**: Crushing forces to the cricoid cartilage can injure the cricothyroid joint, possibly resulting in bilateral vocal cord paralysis from recurrent laryngeal nerve damage.
4. **Hyoid bone**: More common in women, hyoid fractures tend to occur centrally because of the inherent strength of the cornua.
5. **Cricoarytenoid joint**: Traumatic forces may displace the thyroid alae medially or compress the larynx against the cervical vertebrae, leading to cricoarytenoid dislocation, usually unilateral.
6. **Cricothyroid joint**: Injury occurs when traumatic forces to the anterior neck displace the inferior cornu of the thyroid cartilage posterior to the cricoid cartilage, limiting cricothyroid muscle function and pitch control. Recurrent laryngeal nerve injury may also contribute to vocal cord paralysis.

Laryngeal injuries in blunt neck trauma

Group	Symptoms	Sign	Management
Group 1	Minor airway symptoms	• Minor hematomas • Small Lacerations • No detectable fractures	• Observation • Humidified air • Head of bed elevation
Group 2	Airway compromise	• Edema/hematoma • Minor mucosal disruption • No cartilage exposure	• Tracheostomy • Direct laryngoscopy • Esophagoscopy
Group 3	Airway compromise	• Massive edema • Mucosal tears • Exposed cartilage • Vocal cord immobility	• Tracheostomy • Direct laryngoscopy • Esophagoscopy • Exploration/repair • No stent necessary
Group 4	Airway compromise	• Massive edema • Mucosal tears • Exposed cartilage • Vocal cord immobility	• Tracheostomy • Direct laryngoscopy • Esophagoscopy • Stent required

Approach to penetrating neck trauma

- Primary survey
  - Prepare for difficult airway management and secure the airway.
    - If the airway is compromised, oral intubation should be attempted whenever possible.
    - If there is an obvious open injury to the airway, it is better to consider tracheostomy as soon as possible.
  - Consider C-spine immobilization if a C-spine fracture is suspected, e.g., focal neurological deficit, low GCS or intoxication, GSW.
  - A high-flow intravenous line should be set up. Intravenous lines should be avoided in the arm on the side of the neck wound.
  - Active external bleeding can be controlled by external digital pressure or by Foley catheter balloon tamponade that has been carefully inserted as deep as possible into the wound.
  - Assess for hard signs of penetrating neck injury requiring emergency surgery.
- Secondary survey
  - Examine neck wound without probing for violation of the platysma.
  - Perform neurological examination.
  - Obtain urgent diagnostics for trauma patients, including CTA neck, once stable

Clinical features of penetrating neck trauma

Signs	**Hard signs of penetrating injury**	**Soft signs of penetrating injury**
Next step	The presence of any of the following increases the likelihood of life-threatening injury requiring surgical intervention often bypassing CT:	The presence of any of the following increases the likelihood of serious injury and often requires a CTA neck for further evaluation:
Airway or esophageal injury	• Airway compromise • Wound bubbling • Extensive subcutaneous emphysema • Hoarseness and/or stridor	• Hemoptysis and/or hematemesis • Dysphonia • Dysphagia • Mild subcutaneous emphysema
Vascular injury	• Hemorrhagic shock • Pulsatile bleeding • Expanding hematoma • Carotid bruit • Unilateral pulse deficit • Signs of stroke	• Minor bleeding • Nonexpanding hematoma • Proximity wound

Penetrating neck trauma investigations

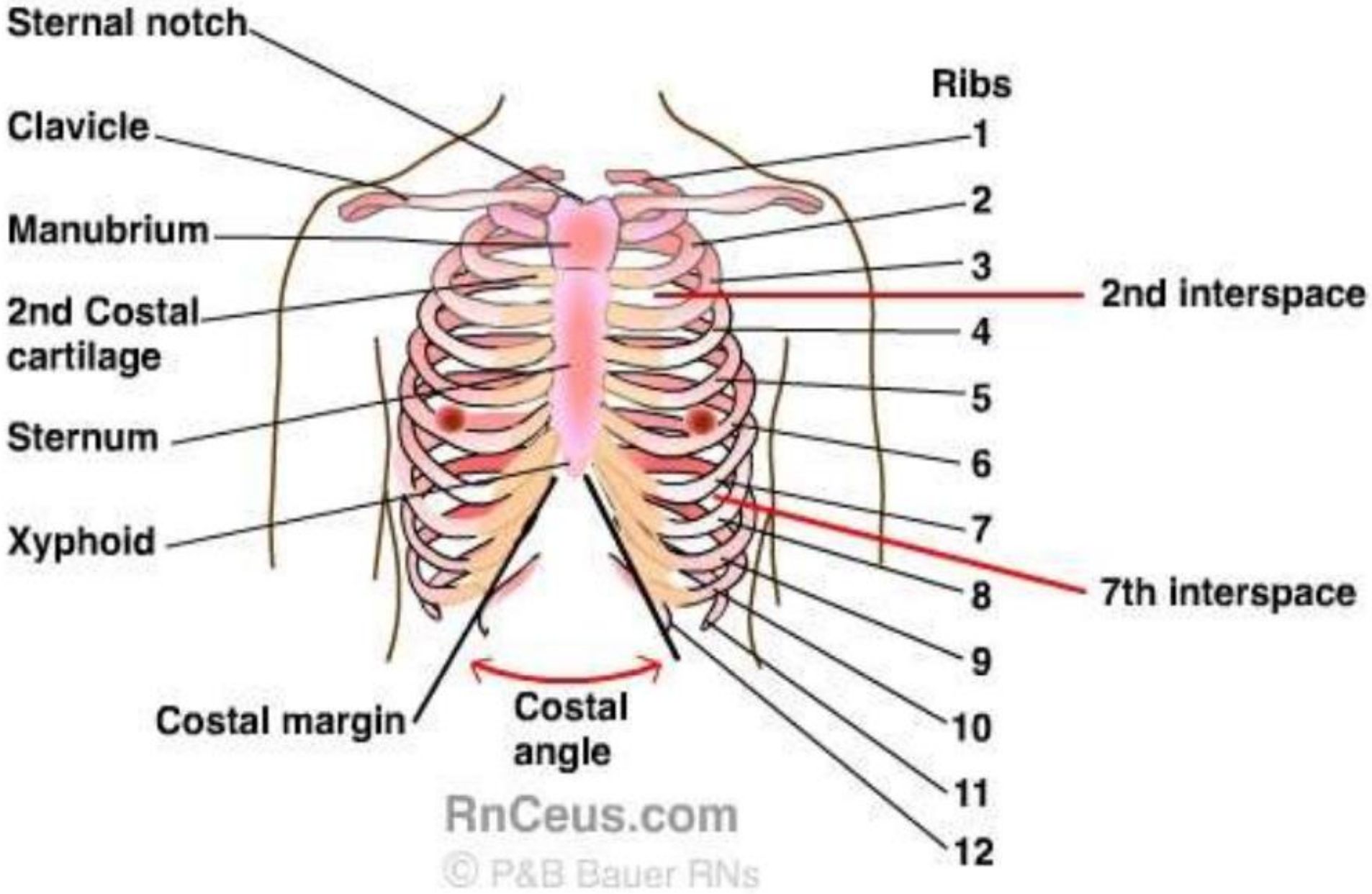
- **Chest X-ray**
  - Essential in all patients with neck injuries.
  - Do not sit patient up; if there is an open wound, it may cause a fatal air
  - embolism or complicate a cervical spine injury.
- **Cervical spine X-ray**
  - Look for the presence of fractures, foreign bodies, or air in soft tissues.
- **CT scan or CT angiography**
  - In the stable patient, a spiral CT scan (if available) with intravenous contrast will provide information on soft tissue, bony structures, wound trajectory, and vascular injuries.
  - Specifically look out for intimal injuries of the carotids.
  - Oral contrast can be given if required to identify leaks.
- **Color Flow Doppler (CFD)**
  - Color flow Doppler has been suggested as a reliable alternative to angiography in the evaluation of PNI.

Penetrating neck trauma management

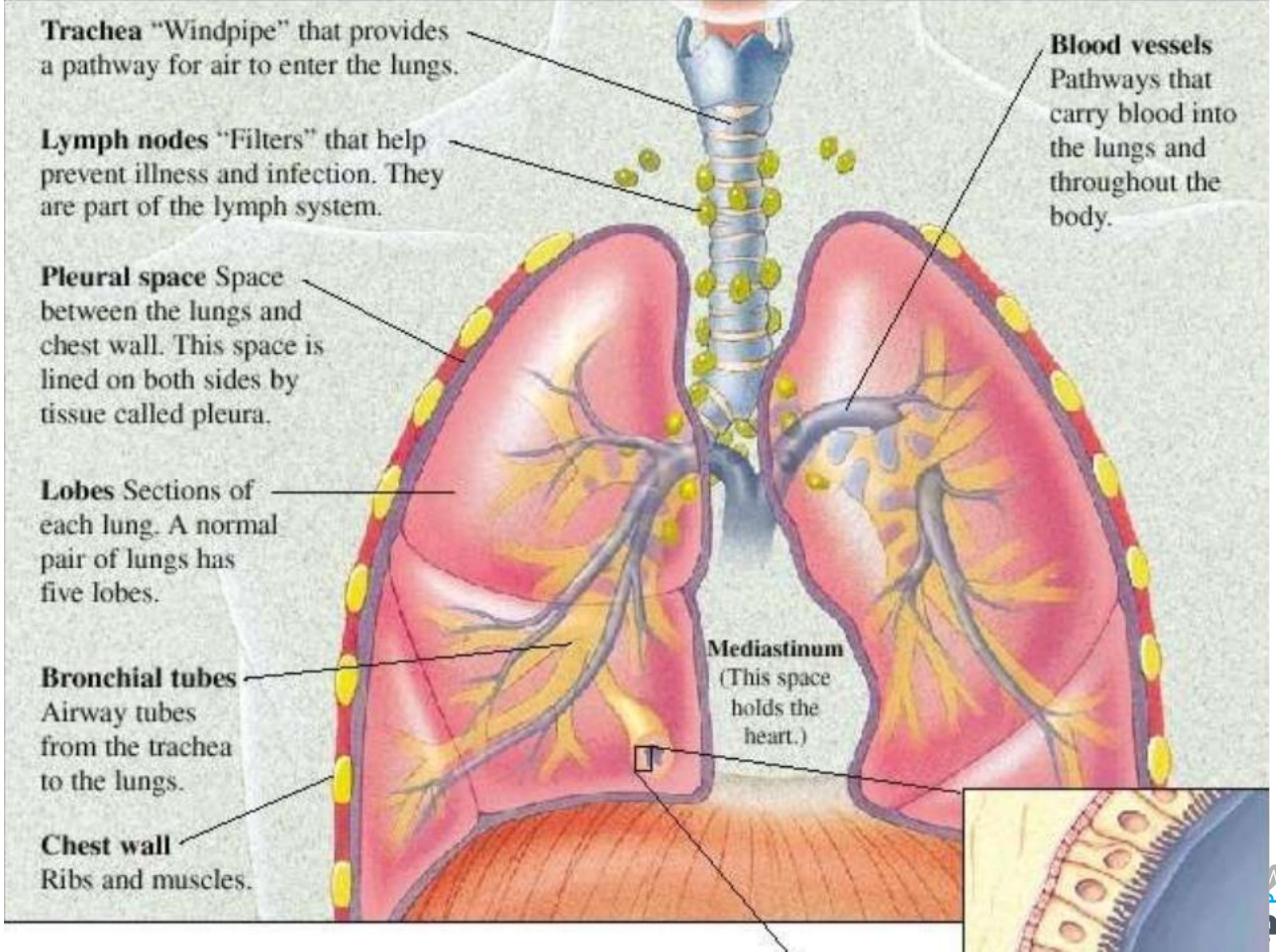
- Consider early intubation or surgical airway
- If all the investigations are normal, the patient may be observed over-night and discharged home if there is no deterioration.
- A hemothorax should be managed accordingly.
- If the patient is bleeding or airway compromised or investigations are abnormal, immediate surgical intervention is required.
- Small pharyngeal and tracheal injuries can be treated conservatively

Thoracic trauma

Thoracic wall Anatomy



Lungs Anatomy

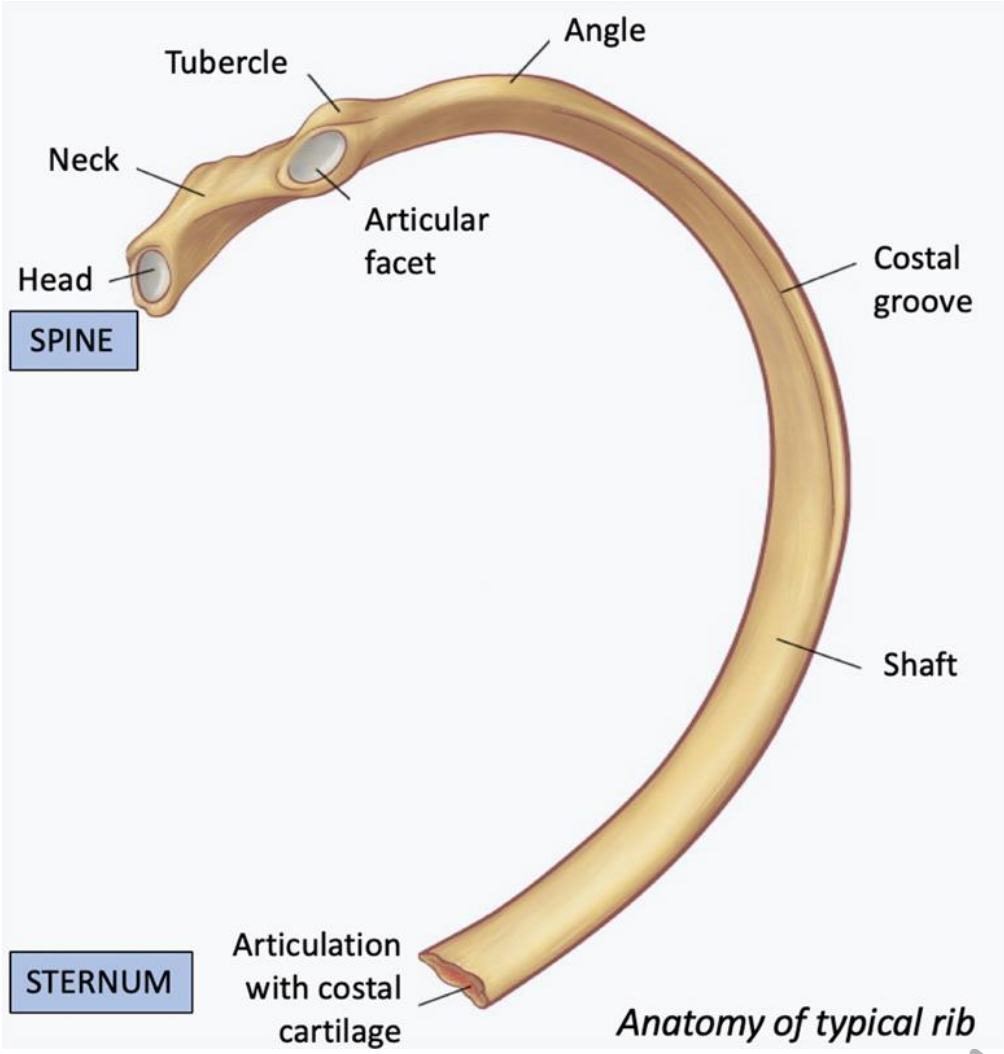


Thoracic injury

Epidemiology	• Represents 20% of trauma associated mortality • It is the commonest cause of death in cases of RTA • Up to 75% of patients have also other associated injuries
Classification	According to the chest wall status; thoracic injuries can be classified into open or closed
Complications and sequalae	• Parietal injuries: Soft tissues and Bone • Thoracic visceral injuries: Pleura, Lung, Heart, Tracheobronchial tree, Major vessels, Esophagus and diaphragm • Associated abdominal injuries
Clinical picture	• History of chest trauma followed by chest pain, dyspnea, cyanosis, cough or hemoptysis, +/- abdominal pain • Internal hemorrhage and hypovolemic shock

Rib fracture

Epidemiology	• Most common blunt thoracic injuries (35-40%) • Ribs 4-10 are most frequently involved • Ribs 8-12 should raise the suspicion of associated abdominal (splenic, hepatic) injuries
Etiology	• **Direct trauma**: Fracture occurs at the site of trauma • **Indirect trauma**: Fracture at the angle of the ribs • **Muscular violence**: Pathological fracture
Pathologically classification	**Isolated simple rib fracture** • One or more ribs are fractured in a single site **Double rib fractures** • **Flail chest**: Three or more successive ribs are fractured at two points • **Stove-in chest**: Rare type of flail chest where the flail part collapses into the chest



Anatomy of typical rib

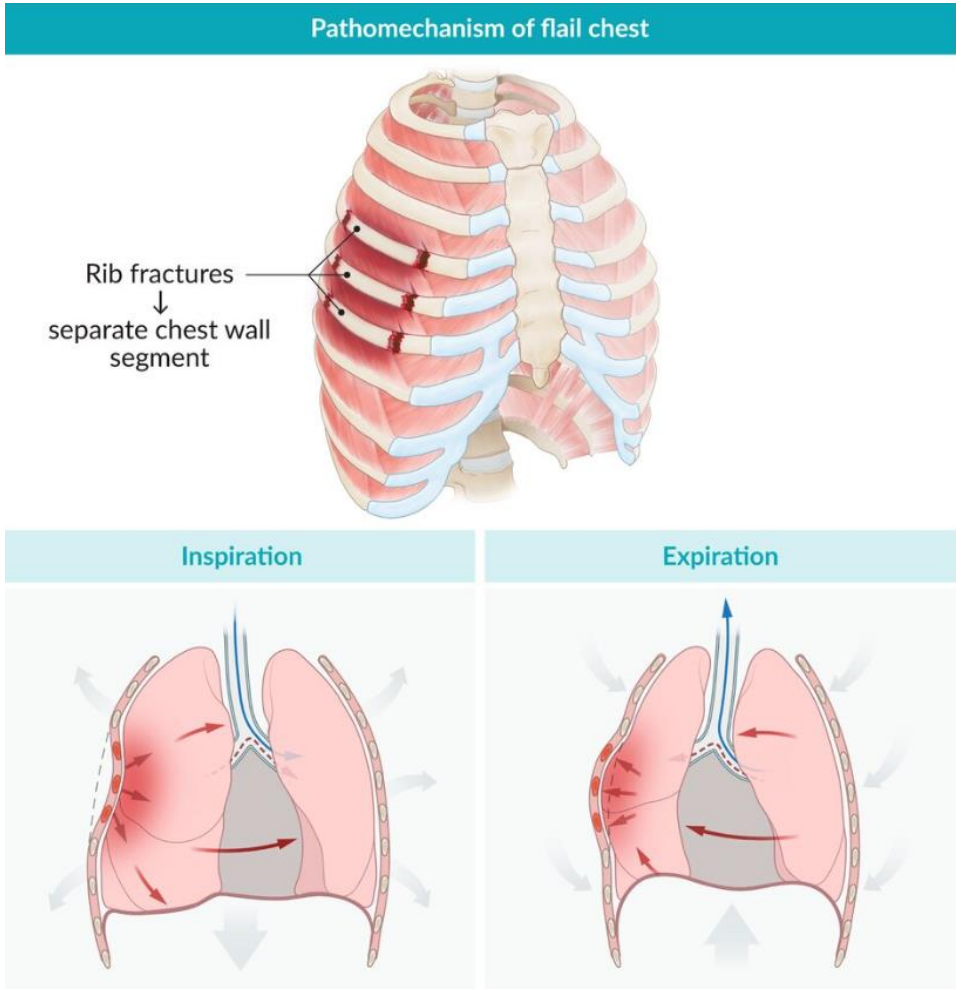
Rib fracture

Clinical features	• **Symptoms**: inspiratory chest pain and discomfort over the fractured rib or ribs • **Examination**: local tenderness, crepitus over site of the fracture and bruises
Diagnostics (X-ray)	• Confirm the diagnosis • Detects associated conditions (e.g., pneumothorax , hemothorax)
Prognostic factors	1. Number of ribs injured 2. Elderly with 3 or more rib fractures tend to have a 5-fold increased mortality rate and a 4-fold increased incidence of pneumonia 3. Underlying pulmonary status
Indications for admission	1. Unable to cough and clear secretions adequately. 2. Underlying pulmonary disease (COPD) 3. Age ≥ 65 years (high incidence of hypoventilation, hypercapnia, atelectasis, and pneumonia) 4. First and second rib fracture 5. 3 or more unilateral rib fractures 6. Associated with hemothorax, pneumothorax, or pulmonary contusion
Treatment of rib fracture	• Pain killer (oral or parenteral): cornerstone of medical therapy for patients with rib fractures • Intercostal nerve blocks (for those with severe pain who do not have numerous rib fractures) • Epidural analgesia (Patients with multiple rib fractures whose pain is difficult to control) • Early mobilization, pulmonary toilet

Pathomechanism of flail chest

Instability of the chest wall from unilateral or bilateral multiple rib fractures or from disruptions of the costochondral junctions

Paradoxic chest wall motion → reduction in vital capacity → ineffective ventilation + associated pulmonary contusion → ARDS

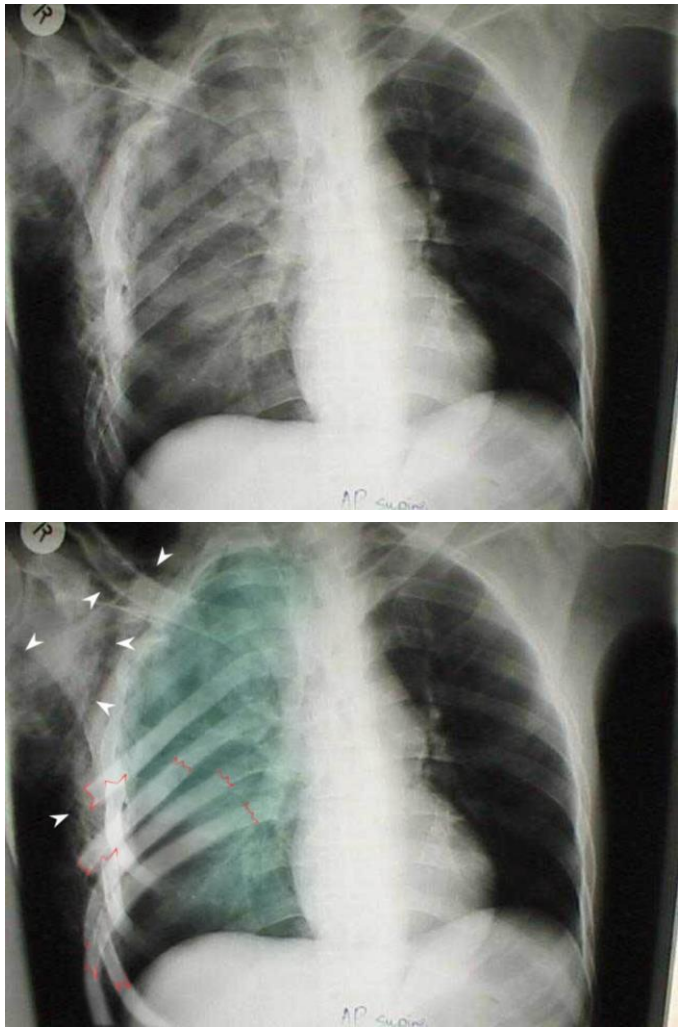


Flail chest

Effects of flail chest	Clinical picture	Treatment	Indications for endotracheal intubation
1. Paradoxical chest wall movement with respiration 2. Impaired respiratory movement of the affected lung 3. Pendulum breathing 4. Mediastinal flutter 5. Circulatory failure 6. Lung contusion and laceration	1. Sever pain and tenderness over the fracture site 2. Shallow rapid breathing 3. Crepitus 4. Evidence of other associated chest or abdominal injuries	1. Aggressive pulmonary physiotherapy 2. Incentive spirometry 3. Deep coughing 4. Bronchoscopy	1. Respiratory rate > 30/min (Seminar >35) 2. PaO2 < 60 3. PaCO2 > 45 (Seminar >50) 4. Age > 50 year

Flail chest

- X-ray chest (AP view; supine) of patient with a history of trauma
- Multiple right rib fractures (red lines) are present, some of which show marked displacement. There is extensive subcutaneous emphysema (examples indicated by arrowheads). The right lung is diffusely opaque (green overlay), likely reflective of pulmonary contusion in view of the trauma history.
- White overlay: ribs



Other fractures

Sternal fracture	• 4% of motor vehicle accidents • Typically, the fracture is transverse and located in the upper and middle portions of the body of the sternum. (M/C location) • Associated injuries (thoracic & head) occur in 55-70% • The most common associated injuries are rib fractures, long bone fractures, and closed head injuries • Blunt cardiac injuries are diagnosed in fewer than 20%
Scapula fractures	• 80-90% incidence of associated injuries • Due to significant force of impact
Clavicle fracture	• Approximately 75-80% of occur in the middle third • Nearly all clavicular fractures can be managed without surgery • Primary treatment consists of immobilization with a figure-of-eight dressing, clavicle strap, or sling.

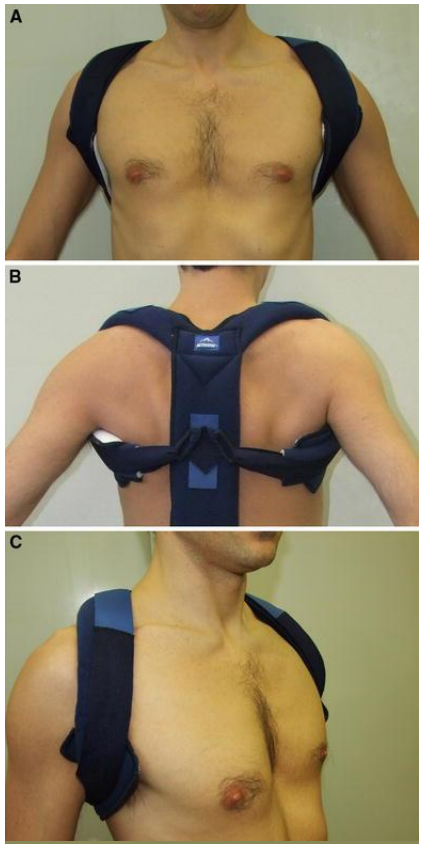
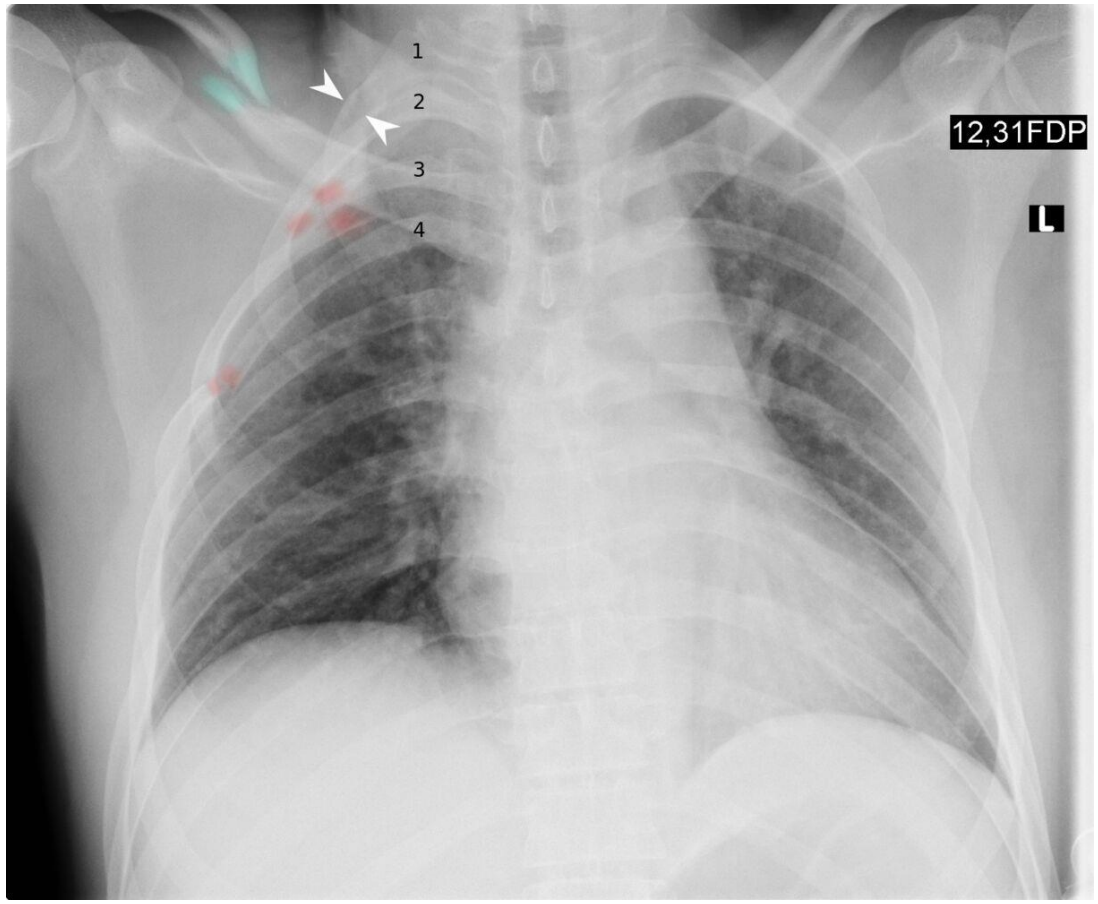


Figure-of-eight dressing

Clavicle and rib fractures

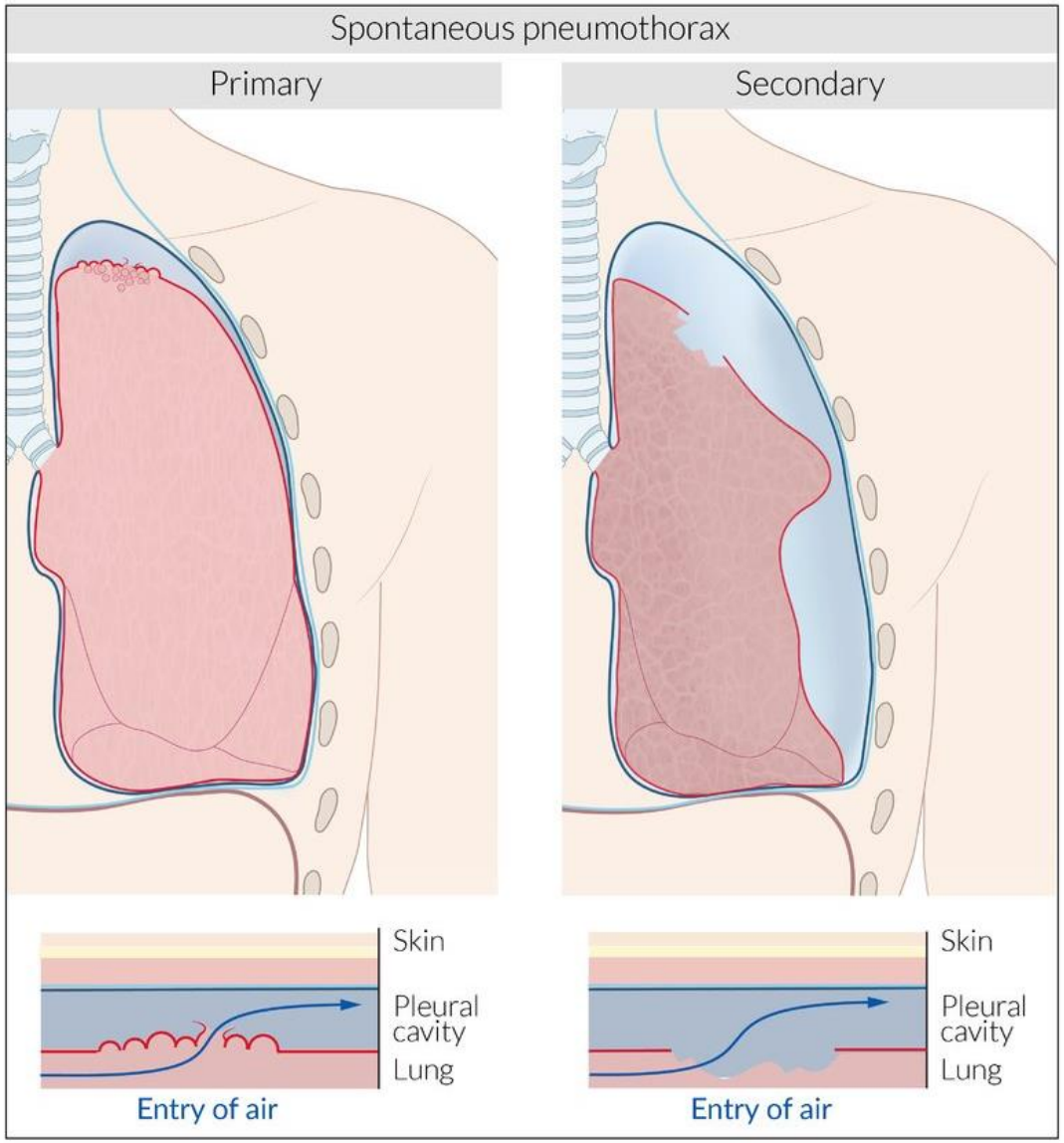
- X-ray chest (PA view) of a patient with polytrauma from a motor vehicle crash
- A displaced fracture (green overlay) of the mid-shaft of the right clavicle is accompanied by fractures of the third and fourth ribs (red overlay). Subtle buckling of the cortex of the first rib also suggests a fracture (arrowheads). A first rib fracture is a marker of severity in polytrauma, frequently associated with severe organ injury.

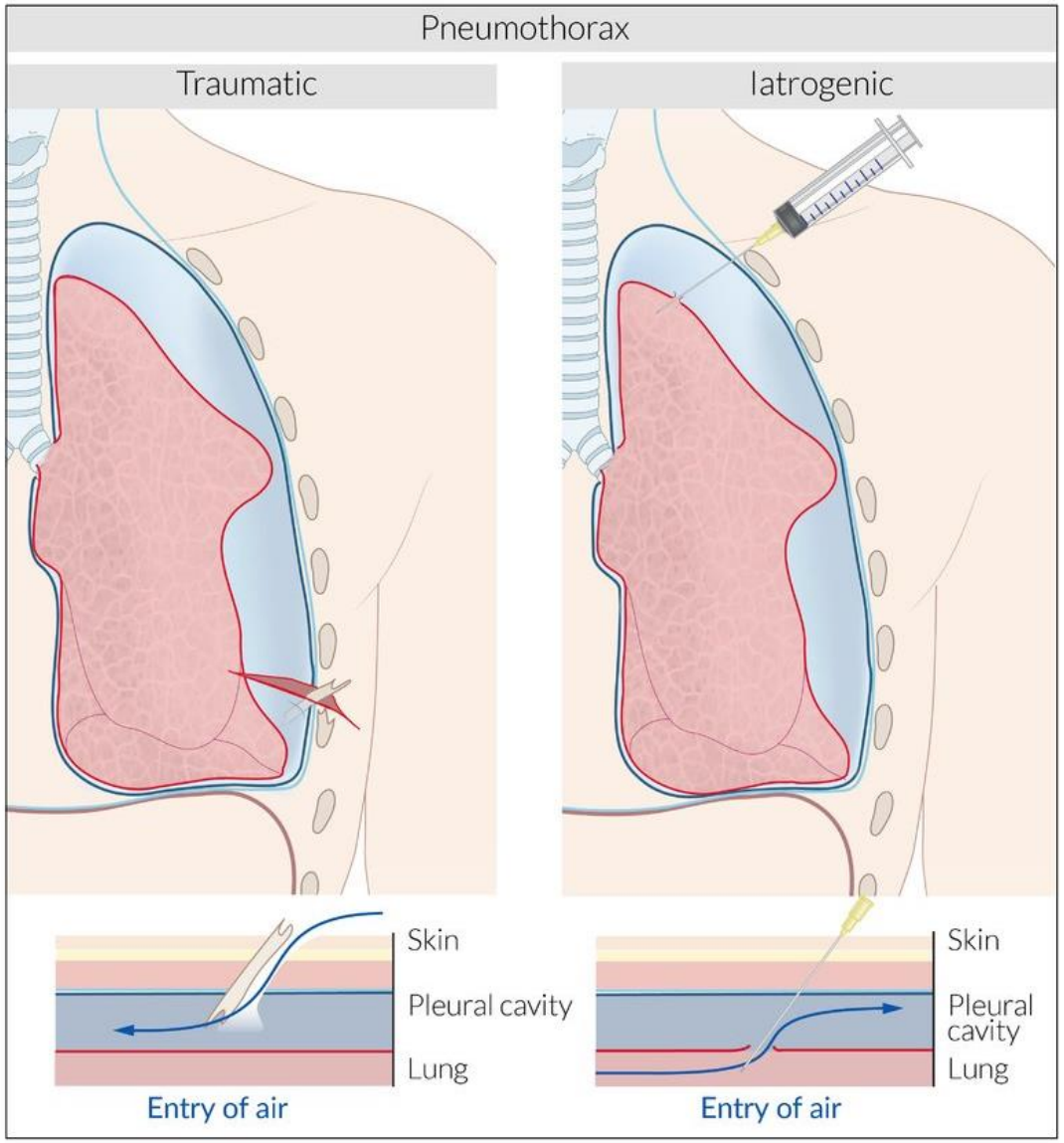


Pneumothorax

- **Pneumothorax**: a collection of air within the pleural space between the lung (visceral pleura) and the chest wall (parietal pleura) that can lead to partial or complete pulmonary collapse. **May be classified as**
- **Spontaneous pneumothorax**
  - **Primary spontaneous pneumothorax** occurs in patients without clinically apparent underlying lung disease
  - **Secondary spontaneous pneumothorax** occurs as a complication of underlying lung disease
  - **Recurrent pneumothorax**: a second episode of spontaneous pneumothorax, either ipsilateral or contralateral
- **Traumatic pneumothorax**: a type of pneumothorax caused by a trauma (e.g., penetrating injury, iatrogenic trauma)
- **Tension pneumothorax**: a life-threatening variant of pneumothorax characterized by progressively increasing pressure within the chest and cardiorespiratory compromise

Pneumothorax

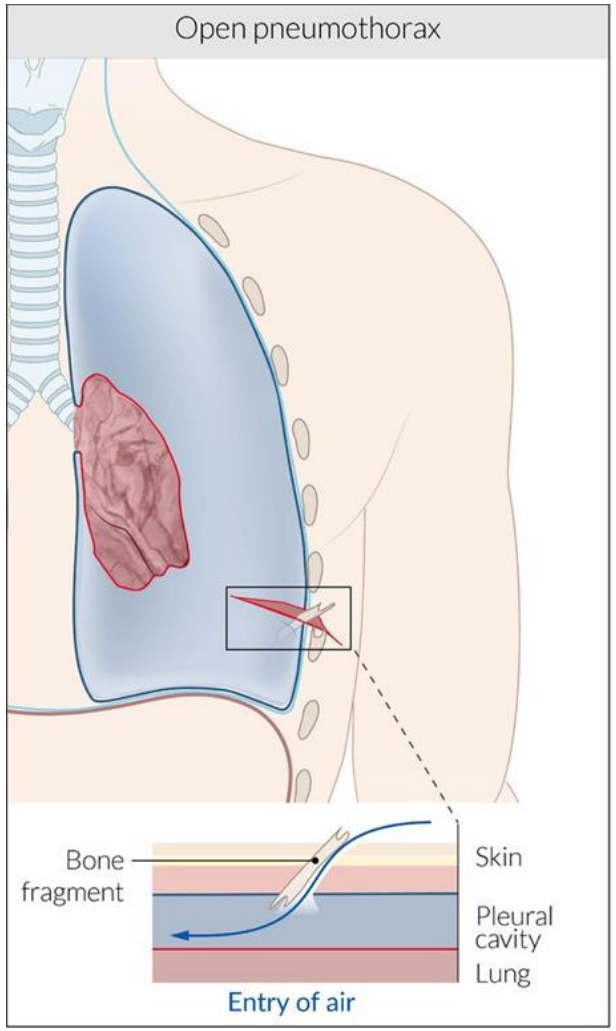


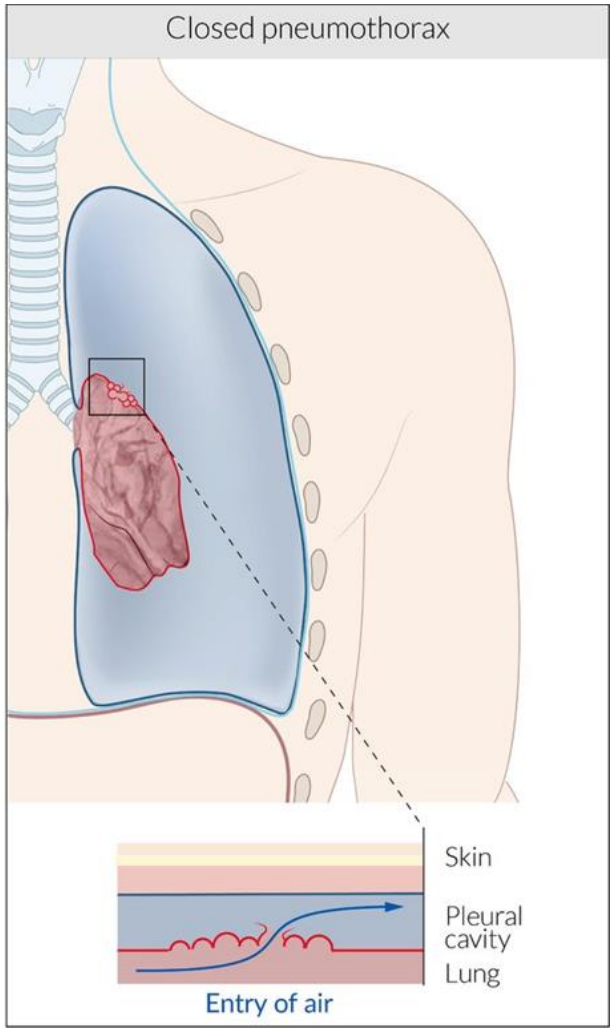


Types of traumatic pneumothorax

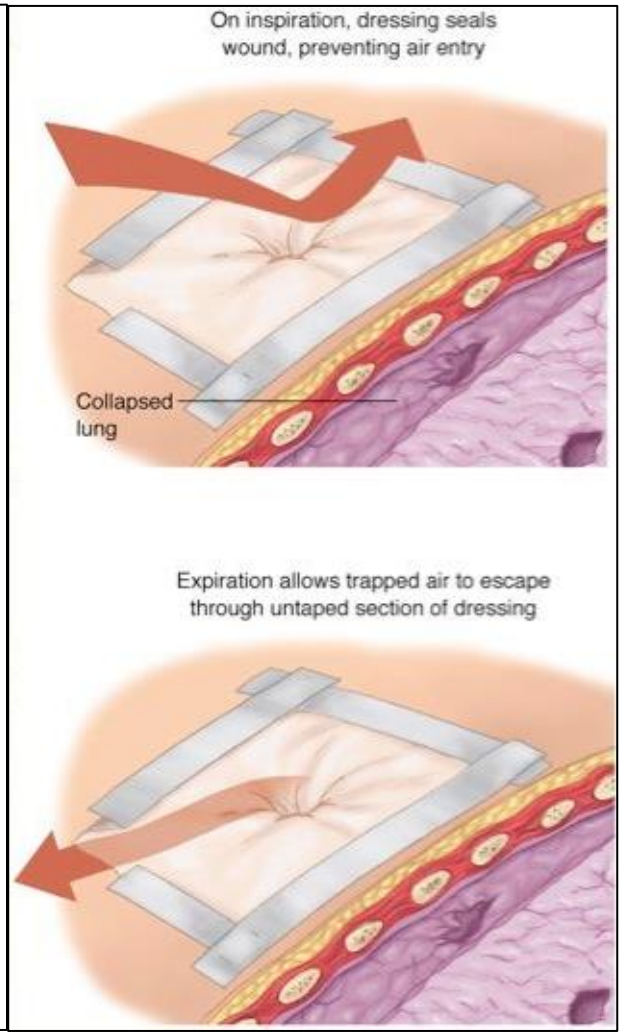
Type	Closed pneumothorax	Open pneumothorax	Tension pneumothorax
Characteristics	**AKA** simple pneumothorax	Characterized by the presence of a sucking wound	The most serious type, characterized by the presence of valvular wound
Effects on respiration & circulation		1. Paradoxical respiration 2. Pendulum respiration 3. Mediastinal flutter 4. Circulatory failure	1. Lung collapse 2. Mediastinal shifting 3. Circulatory failure 4. Acute right ventricular failure
Presentation	asymptomatic or mild chest pain and dyspnea	moderate dyspnea, chest pain and cyanosis	sever sharp stabbing chest pain with sever progressive dyspnea and cyanosis
On physical examination	1. Diminished air entry and resonance on percussion 2. No tracheal or mediastinal shifting	1. Same as closed type 2. Sound of air passing the wound (both sucking and wheezing sounds)	1. Sound of air passing the wound (sucking sound only) 2. Diminished chest movement and air entry with hyper-resonance percussion tone 3. Tracheal and mediastinal shifting 4. Congested neck veins
Chest X-ray	1. Translucency 2. Loss of lung marking 3. Visible collapsed lung edges	Same as closed type	1. Translucency 2. Loss of lung marking 3. Visible collapsed lung edges 4. Mediastinal shifting 5. Depression of diaphragm
Treatment	1. Minimal amount of air without dyspnea may resolve spontaneously 2. Chest tube connected to underwater seal	1. 3-way dressing 2. Chest tube connected to underwater seal	1. Needle decompression 2. Chest tube connected to underwater seal 3. thoracotomy

Types of traumatic pneumothorax

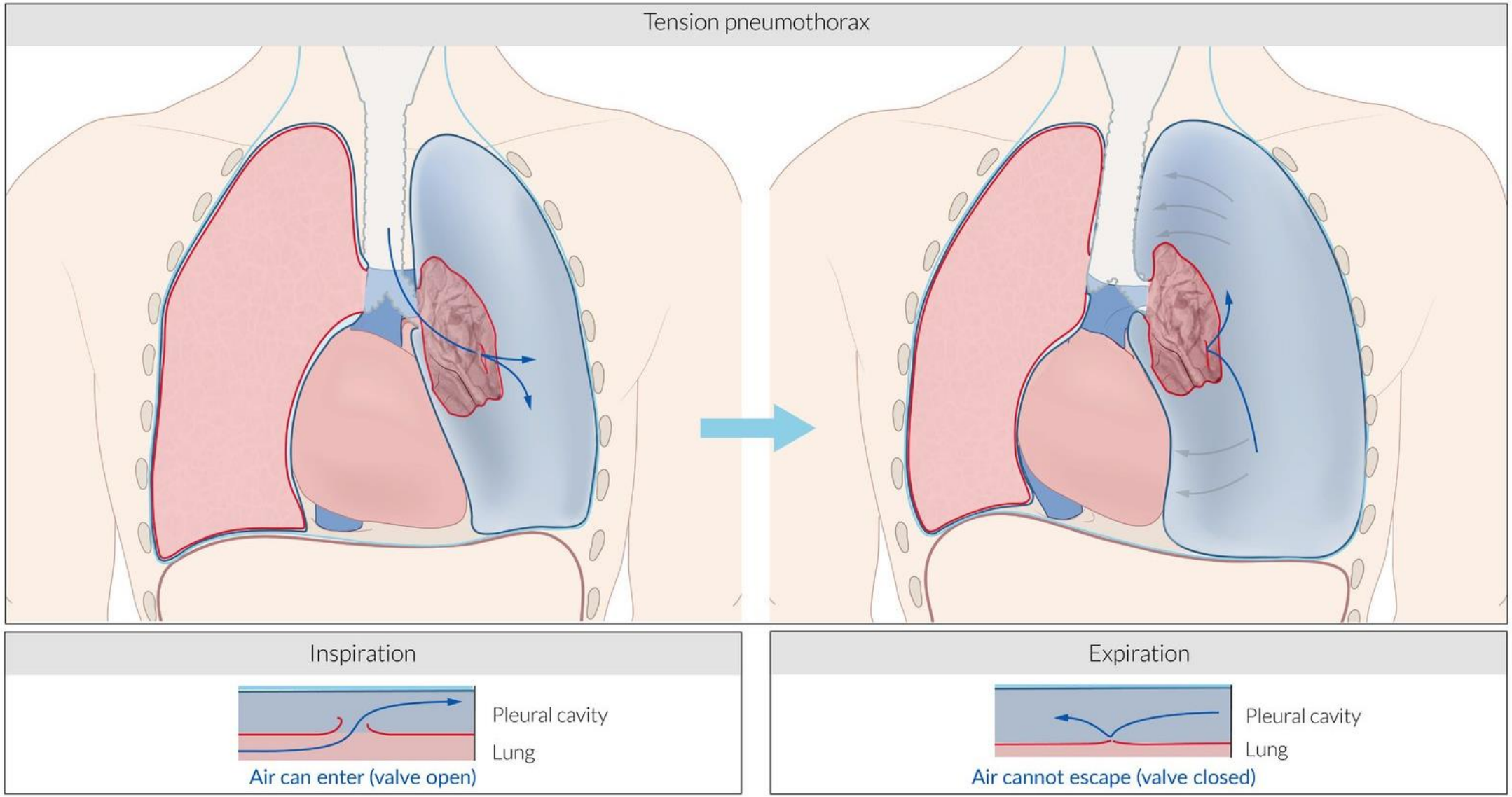




3-way dressing

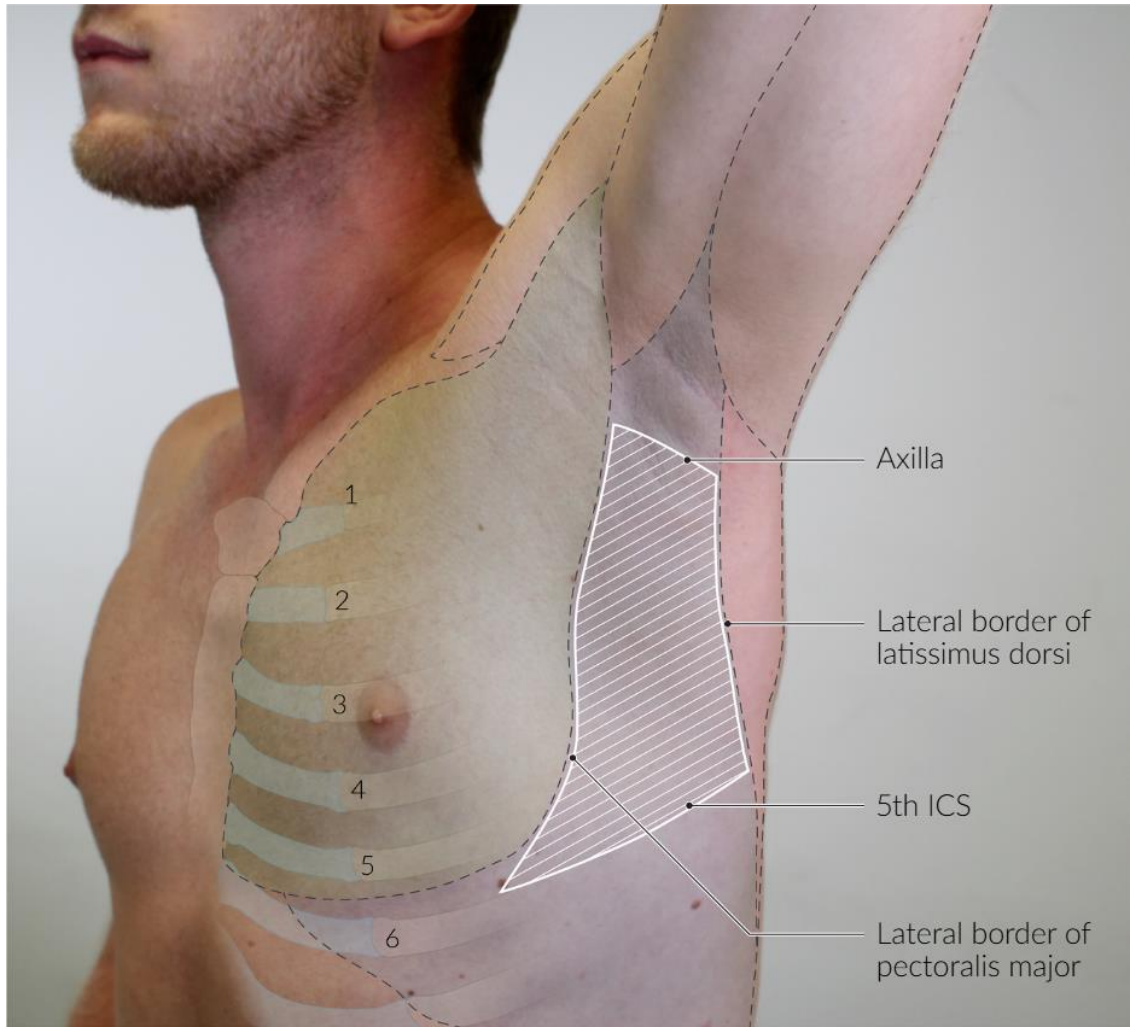


Types of traumatic pneumothorax



Chest tube placement procedure

- Most commonly in the 4th–5th intercostal space (nipple line), between the anterior and midaxillary line (safe triangle)
- **The safe triangle** is a term used to describe the anatomical landmarks used during chest drain insertion. The axilla forms the apex and the triangle is formed by the lateral border of pectoralis major and the lateral border of latissimus dorsi.
- The chest drainage system may be used with or without suction.
- Always check CXR after the procedure is complete

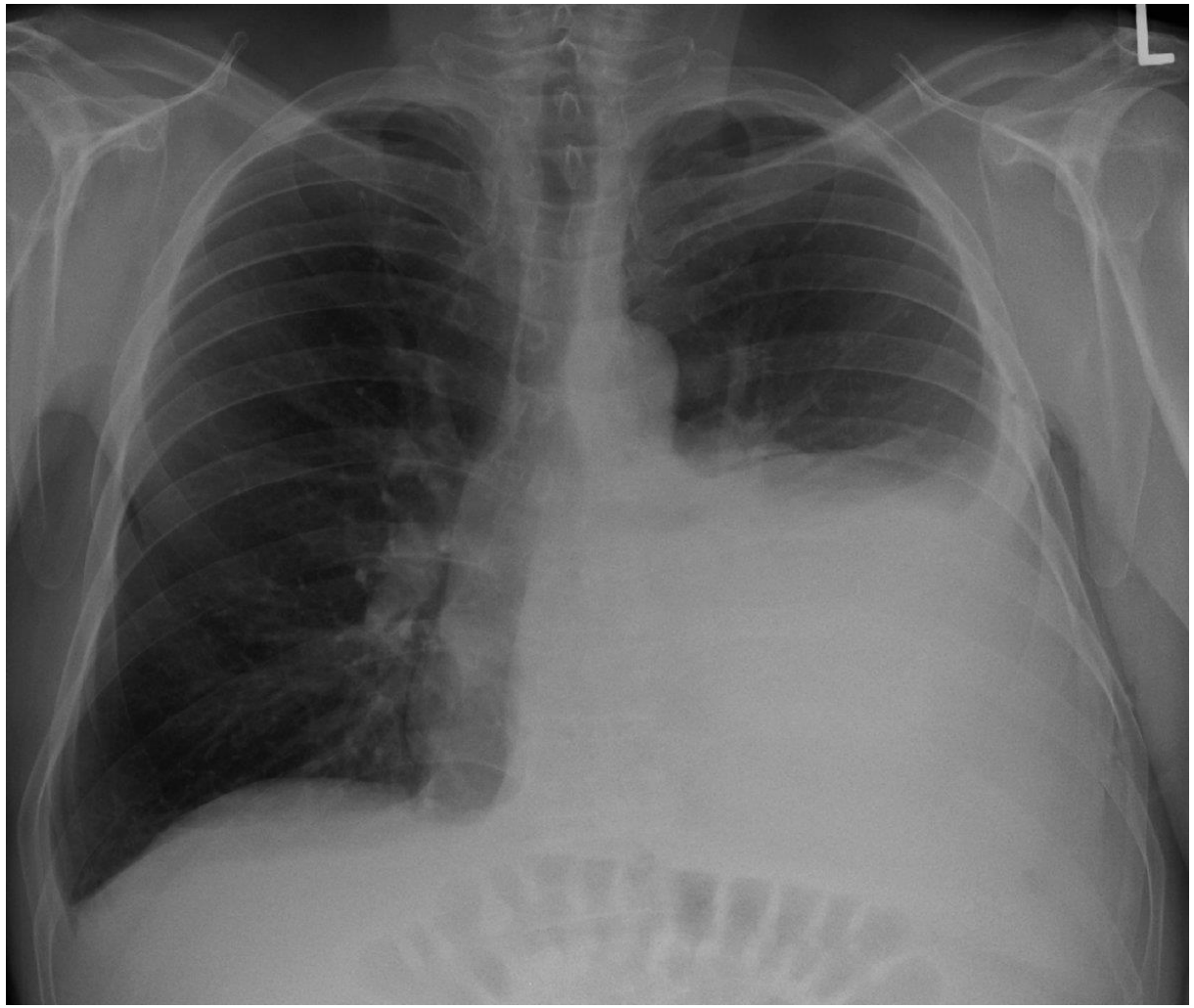


Hemothorax

Etiology	• **Causes**: Traumatic, Iatrogenic, Spontaneous • May be associated with pneumothorax
Complications & sequelae	1. Blood remain liquid for many days due to defibrination 2. Clot formation 3. Fibrosis of parietal and visceral plura 4. Empyema
Clinical picture	1. Hx of chest trauma 2. Manifestations of hypovolemic shock 3. Diminished chest wall movement with dull percussion tone 4. Tracheal and mediastinal shifting
Sources of bleeding	1. Intercostal vessels 2. Internal mammary artery 3. Pulmonary parenchymal injuries 4. Major pulmonary vessels 5. Injury to the heart or great vessels

Hemothorax – Investigations (Chest X-ray)

1. Obliteration of costovertebral angle
2. Opacity raised to the axilla
3. Air-fluid level
4. Lung collapse
5. Mediastinal shifting



Hemothorax – Treatment

1. IVF, prophylactic antibiotic and analgesia
2. Chest tube connected to underwater seal
3. Video assisted thoracoscopy
4. Interventional radiologic arterial embolization
5. Thoracotomy
   - **Early indications**
     a. Complete opacification of hemithorax
     b. Output > 200ml/hour for 3 successive hours
     c. Output > 1500 ml in 24 hours
     d. Associated injury requiring surgery
   - **Late indications**
     a. Clotted hemothorax
     b. Fibrothorax

Lung injuries

- **Types**: Hematoma, Contusion, Laceration, Blast injury

Pulmonary contusion

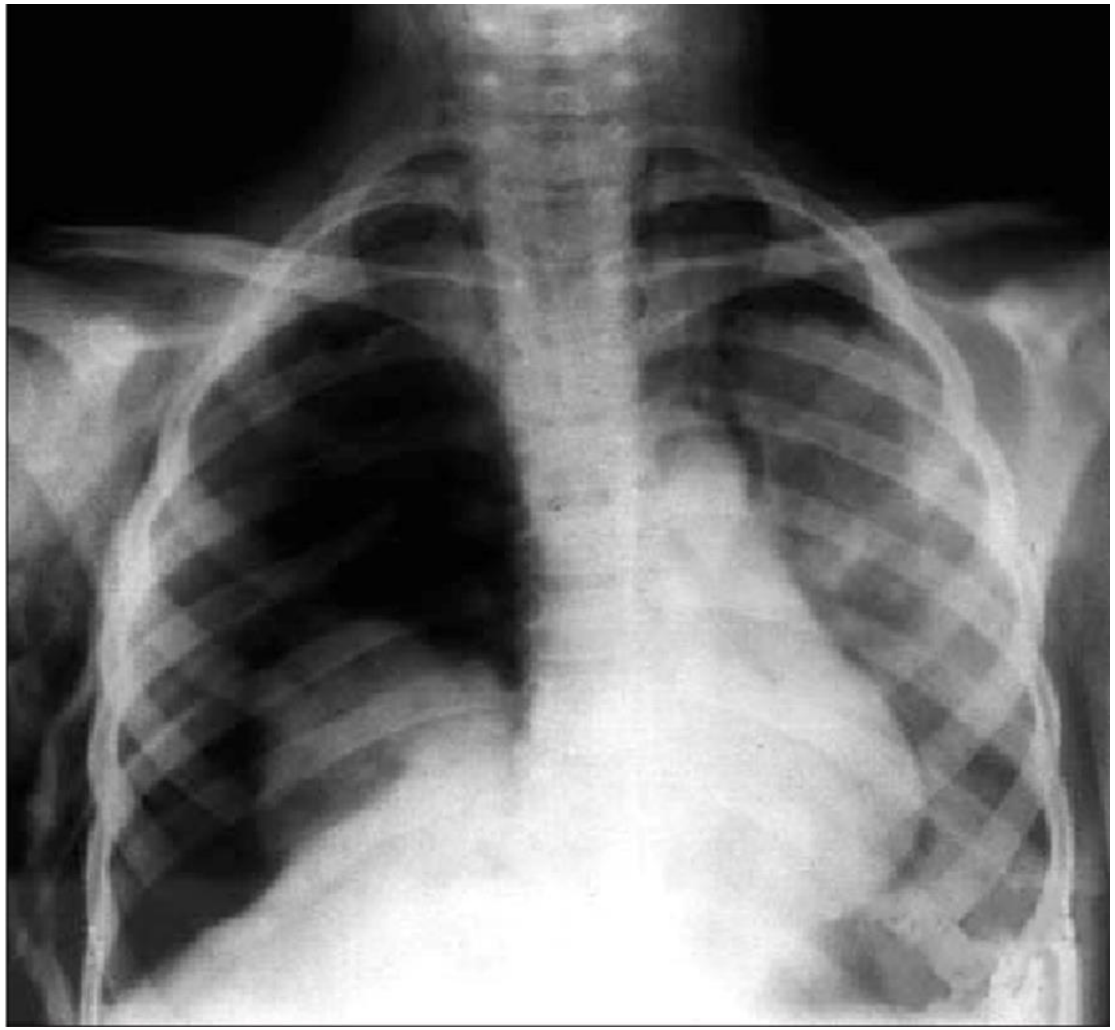
- **Definition**: a lung injury from blunt trauma resulting in alveolar edema and hemorrhage
- **Clinical features**
  - Dyspnea, Tachypnea, Hypoxia, Tachycardia, Chest pain
- **Diagnostics**: CXR
- **Management**
  - Provide respiratory support (e.g., oxygen, positive pressure ventilation).
  - Maintain euvolemia and avoid excessive IVF resuscitation.
  - Monitor for respiratory insufficiency, e.g., with repeated ABGs
- **Complications**: ARDS

Tracheobronchial injuries

Definition	A tear in the tracheobronchial tree resulting from high-energy impact, decelerating forces, or a penetrating chest wall injury
Etiology	1. Linear rupture 2. Disruption at sites of fixation 3. Laceration or transection
Clinical features	1. Dyspnea 2. Dysphonia 3. Hemoptysis 4. Sternal tenderness 5. Subcutaneous emphysema 6. Clinical features of pneumothorax 7. Hamman sign
Diagnostics	• CXR: subcutaneous emphysema, pneumomediastinum, pneumothorax • Bronchoscopy
Complications	1. Empyema 2. Clotted Hemothorax 3. Bronchopleural fistula 4. Bronchial stenosis 5. Chylothorax

Tracheobronchial injuries – Fallen lung sign

The fallen lung sign (also known as CT fallen lung sign) describes the appearance of collapsed lung away from the mediastinum encountered with tracheobronchial injury (in particular those >2 cm away from the carina). It is helpful to look for this rare but specific sign, in cases of unexplained persistent pneumothorax. It can be seen on both plain radiographs and CT.



Cardiac injuries

❖ Etiology

- Penetrating injury
- Blunt injury to sternum

❖ Complications and sequels

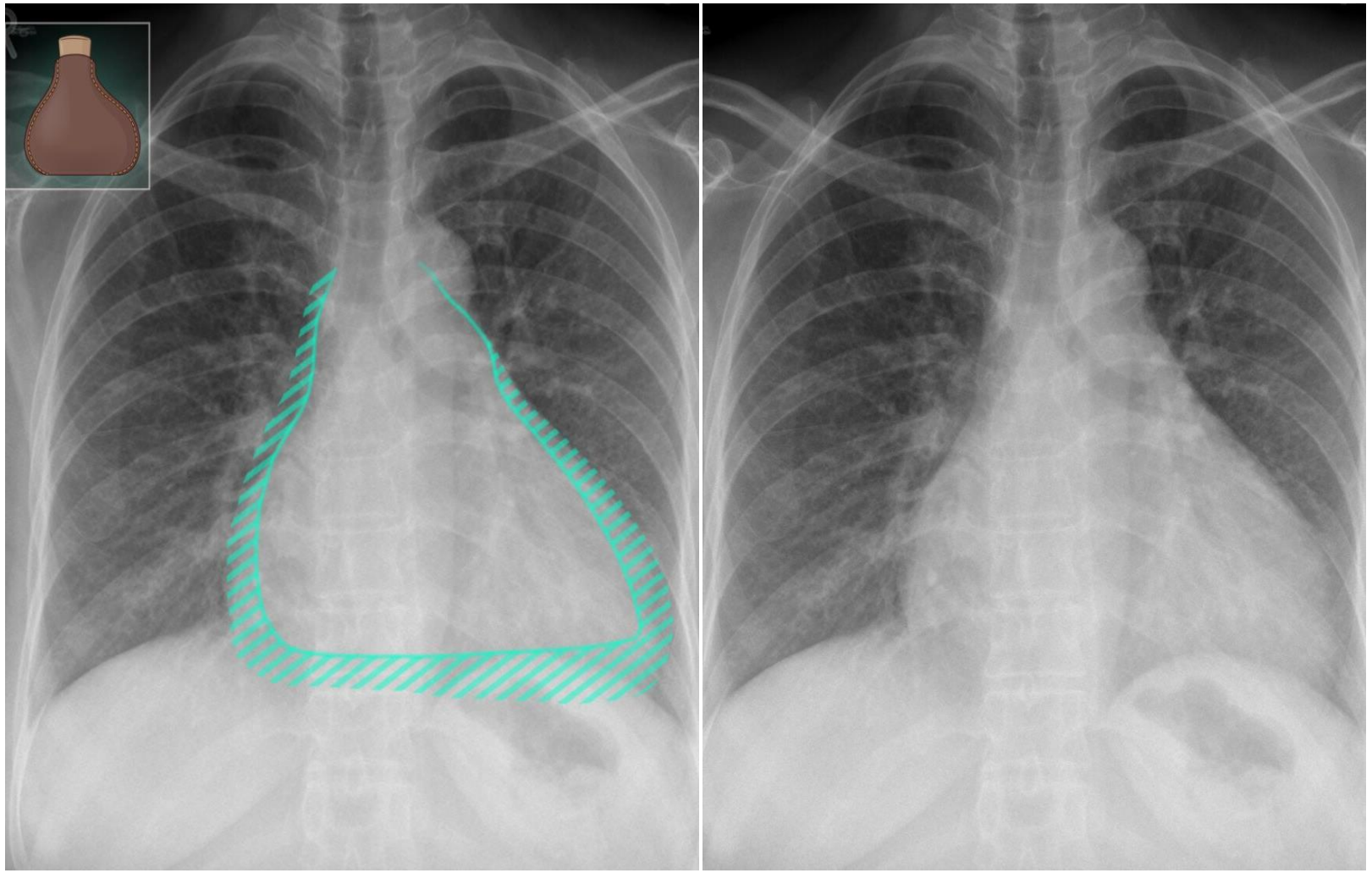
1. Mural thrombosis
2. Myocardial fibrosis and aneurysm
3. Hemopericardium and cardiac tamponade
4. Cardiac arrest
5. Cardiac rupture

Cardiac tamponade

Definition	• Cardiac compression by hemopericardium which decreases the cardiac output due to impaired cardiac filling • Rate of accumulation is more important than the amount itself
Clinical picture	Massive rapid hemopericardium → Lead to sudden death Survivors will show 1. Dyspnea and cyanosis 2. Beck's triad (persistent hypotension, congested neck veins & weak heart sounds) 3. Manifestations of hypovolemic shock 4. High venous pressure 5. Weak apex beat
Investigations	ECG, Chest X-ray, Echocardiography, EFAST
Treatment	Temporary relief of cardiac compression 1. Pericardiocentesis 2. Subxiphoid pericardiotomy Thoracotomy and pericardiotomy

Chest x-ray of cardiac tamponade

- Enlarged cardiac silhouette
- Chest X-ray (PA view) of a patient with a history of pericarditis and clinical findings of tamponade
- The cardiac silhouette is enlarged (globular water bottle-shape; enlargement highlighted by green-hatched overlay) due to pericardial effusion.



Esophageal injuries

Etiology	1. Iatrogenic 2. Swallowing of corrosive agent or foreign body 3. Penetrating or blunt chest or neck trauma
Clinical picture	1. Sudden onset of pain at the site of trauma followed by fever, tachycardia and hypotension 2. Mediastinal emphysema 3. Manifestations pneumothorax and plural effusion
Complications	1. Mediastinitis 2. Septic shock
Investigations	1. Plain chest X-ray 2. Contrast media study

Esophageal injuries – Treatment

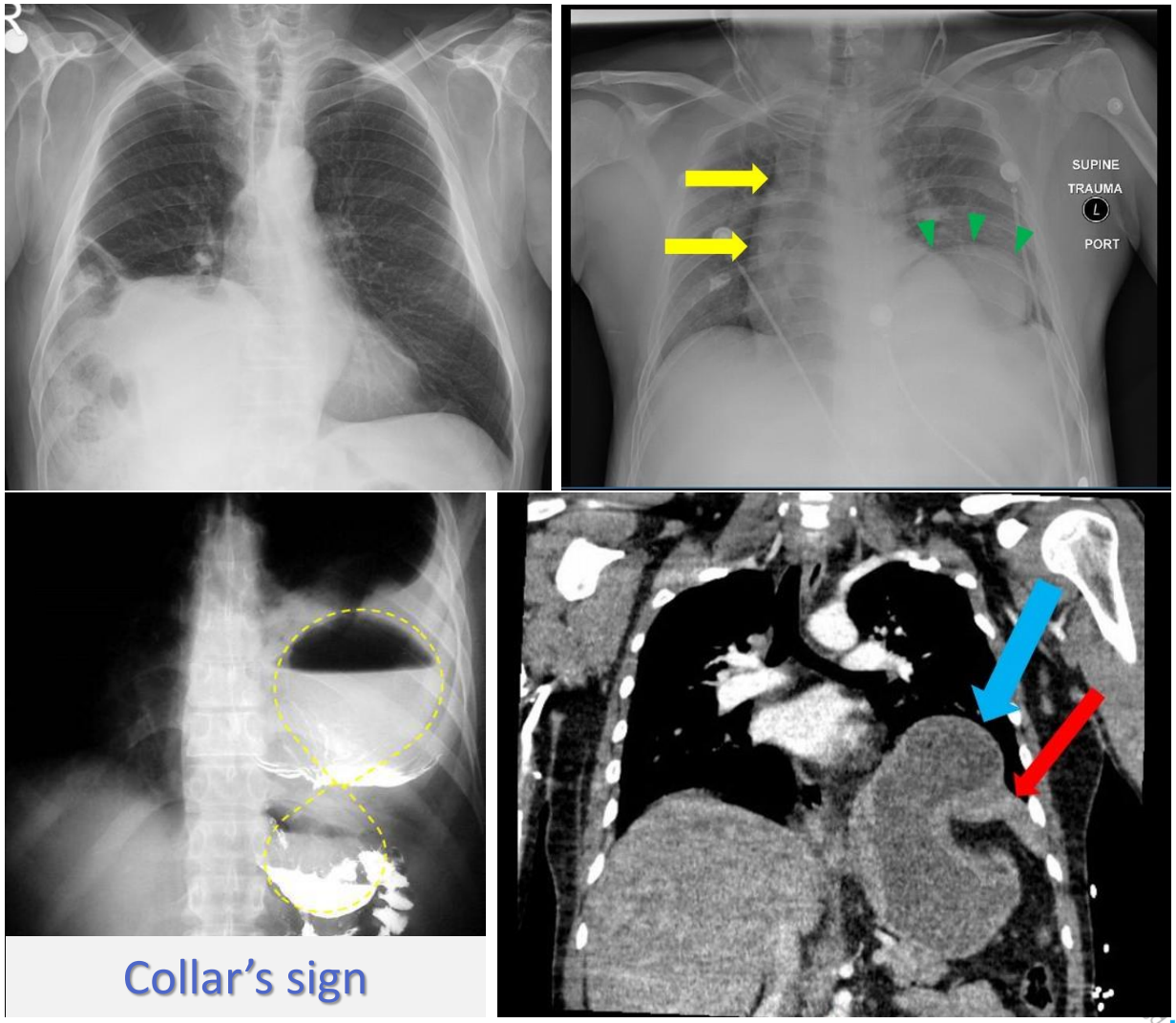
- NPO, IVF, IVA and never try to pass a NG tube
- **Depends on site of perforation and time of detection**
  1. Early detected cervical and thoracic perforation
     - Surgical closure and drainage
  2. Late detected cervical perforation
     - External drainage with parenteral feeding
  3. Late detected thoracic perforation
     - Drainage with feeding jejunostomy
  4. Abdominal perforation
     - Surgical repair

Diaphragmatic injury

Epidemiology	• The left hemidiaphragm is involved in 65-80% of cases • Blunt trauma cause > Penetrating trauma
Etiology	1. Rapid deceleration or direct crush to the upper abdomen 2. Severe chest trauma, lower rib fractures 3. Penetrating injuries to the chest and upper abdomen
Diagnostics	Diagnosis can be difficult; therefore, have a high index of suspicion based on mechanism 1. CXR is diagnostic in only 25% to 50% of cases of blunt trauma 2. CT scan may miss diaphragmatic injury in the absence of gross hollow visceral herniation 3. Direct visualization of the injury by laparotomy, laparoscopy, or thoracoscopy remains the gold standard for diagnosis
Treatment	These injuries do not heal spontaneously and can produce herniation, so need operative repair when diagnosed

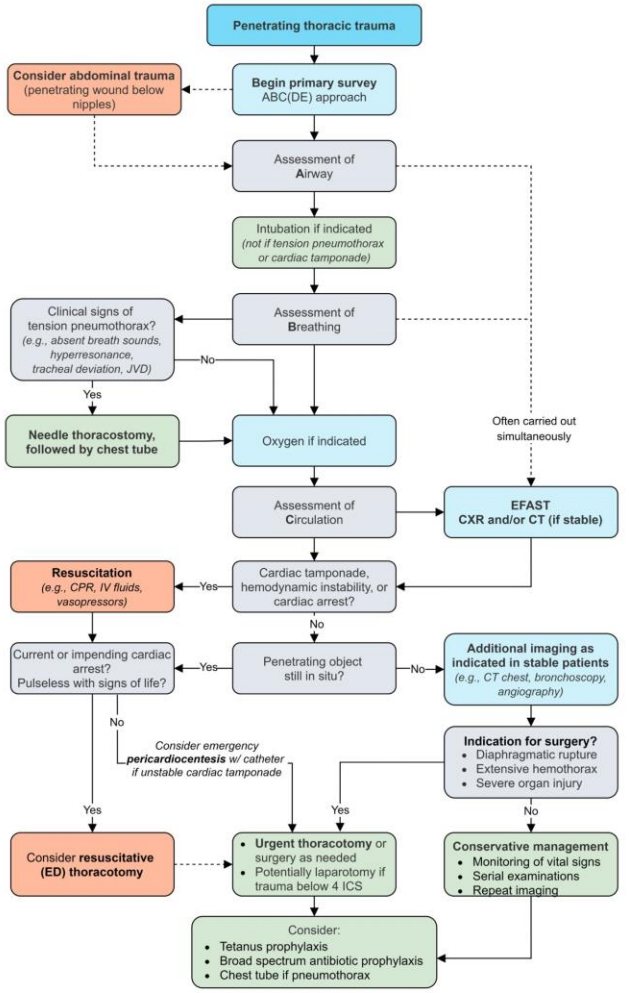
Diaphragmatic injury – Possible findings on imaging

- **On Chest X-ray**
  - Hemi diaphragmatic elevation
  - Stomach, colon, or small bowel in chest
  - Collar's sign
- **On CT scan**
  - Bowel herniation
  - Diaphragmatic tear
  - Collar's sign



Approach to penetrating chest trauma

- Primary survey
  - Identify and treat respiratory failure and shock, tension pneumothorax, open pneumothorax, massive hemothorax, and cardiac tamponade.
  - If at a non-trauma center, initiate transfer to trauma center; penetrating injury to the torso is an indication for trauma team activation.
  - Perform resuscitative thoracotomy if indicated.
- Secondary survey
  - Examine axillae, back, and flank for wounds that could enter the thoracic cavity.
  - Evaluate for penetrating thoracoabdominal and flank injuries.
  - Obtain urgent diagnostics for trauma patients, including CT chest, once stable.
  - Assess for indications for urgent thoracotomy.



Bedside interventions for penetrating chest trauma

Perform the following during the primary survey:

- Respiratory failure: RSI and mechanical ventilation
- Tension pneumothorax: Perform emergency chest decompression.
- Open pneumothorax: Place 3-sided occlusive dressing.
- Traumatic hemothorax: Place chest tube.
- Cardiac tamponade: Perform pericardiocentesis followed by pericardial window, or resuscitative thoracotomy.
- Loss of vital signs due to penetrating chest trauma: Perform resuscitative thoracotomy.

Urgent thoracotomy

- **Definition**: a surgical procedure performed in the operating room to obtain access to the thoracic cavity to treat acute injuries to thoracic organs (e.g., heart, lungs, esophagus)
- **Indications**
  1. Progressive opacification of CXR
  2. Hemorrhagic shock (e.g., hypotension, tachycardia)
  3. Massive hemothorax; any of the following:
     a. Hemorrhagic shock, e.g., need for multiple blood transfusions
     b. Chest tube output ≥ 1500 mL immediately upon placement
     c. Chest tube output ≥ 200 mL/hour for 2–4 hours
  4. Impaled penetrating object
  5. Cardiac tamponade
  6. Open pneumothorax
  7. Tracheobronchial tree injury (e.g., persistent air leak)
  8. Esophageal injury

Abdominal trauma

Abdominal trauma

❖ Epidemiology

- Road traffic accidents is the main cause of abdominal trauma in the civilian population
- Abdominal injuries rank third as a cause of traumatic death after head and chest injuries
- The primary cause of death in abdominal trauma is hemorrhage and sepsis after 48 hours

❖ Etiology

- Blunt abdominal trauma which is the most common cause usually due to RTA, direct blow to the abdomen or falling down
- Penetrating abdominal trauma may be due to missile injuries or stab wounds
- Combined Penetrating & Blunt traumas can occur in explosive devices due to penetrating fragments wounds in addition to the patient being thrown or struck

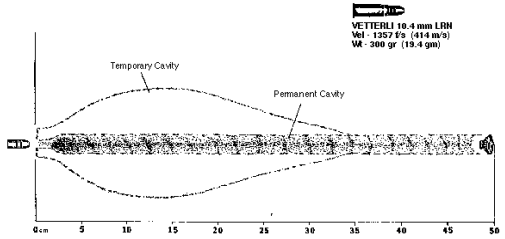
Abdominal trauma

❖Mechanism of injury in blunt abdominal trauma

- Sudden deceleration can lead to differential movement among adjacent structures especially at fixed points of attachment such as (ligament of Treitz, ileocecal valve, phrenocolic ligament and ligamentum teres)
- Compression with crush: intraabdominal contents are crushed between anterior abdominal wall and the vertebral column.
- Compression with rupture: it affects hollow viscus organs due to sudden rise in intraabdominal pressure.

❖Mechanism of injury in penetrating abdominal trauma

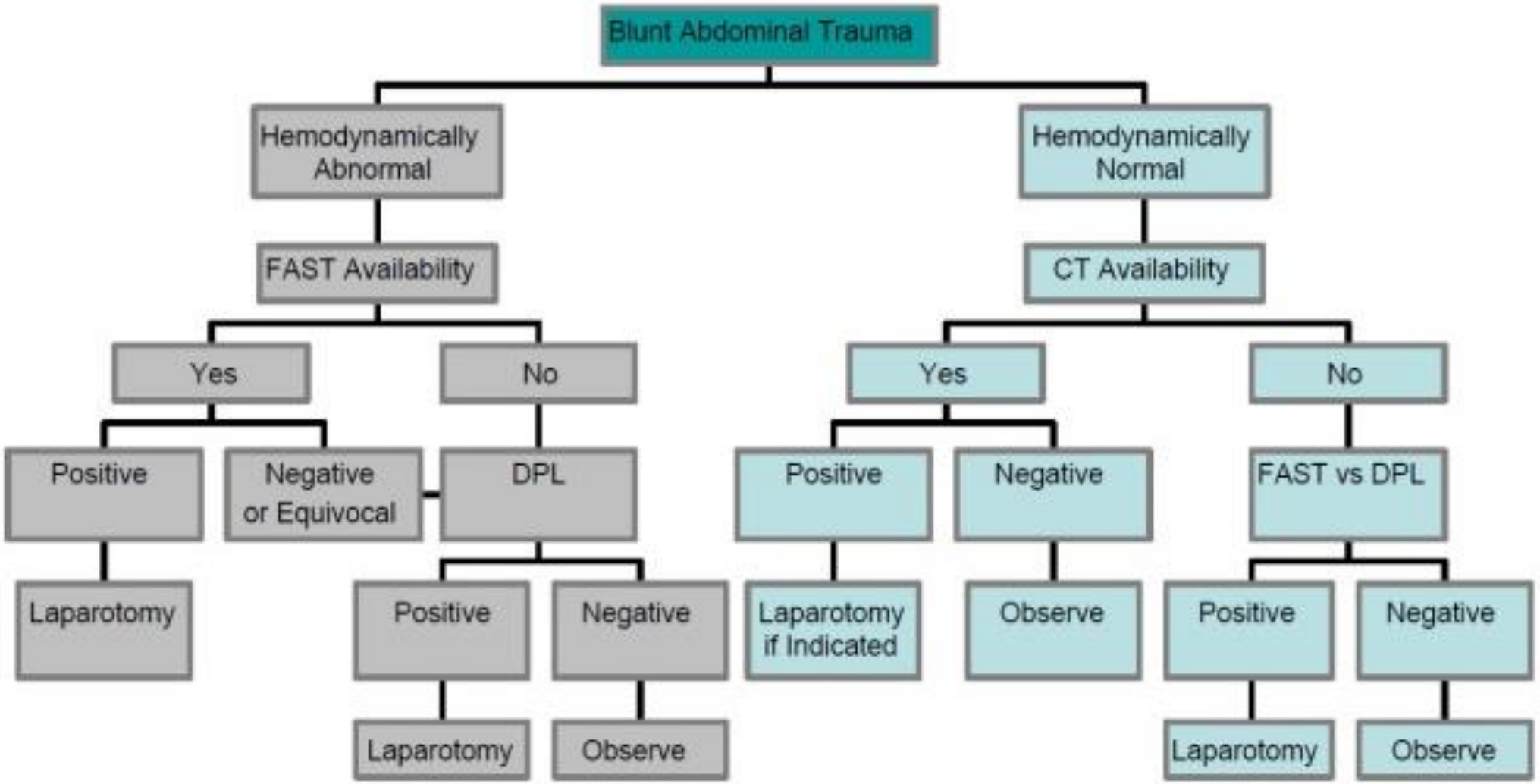
- Mechanical disruption of the tissues along the pathway of the bullet or the stab.
- Cavitation injuries occurs when velocities exceed 500-600 m/s which is a temporary space torn in tissues at right angles to the direction of travel. It depends on the tissue involved and its elasticity. Usually, it occur in a hollow viscus organ as if it occurs in solid organs, it will cause shattering of the organ. (cavitation injury require high speed and more elastic tissue)



Approach to abdominal trauma patient

- Resuscitation of all injuries to the abdomen should follow traditional Advanced Trauma Life Support (ATLS) principles i.e., Primary Survey (ABCDE)
- After initial resuscitation, abdominal trauma patients can generally be classified into the following categories based on their physiological condition into:
  - Hemodynamically stable: Assessment & investigation is more limited aiming at establishing whether the patient can be managed non-operatively, whether angioembolization can be used, or whether surgery is required
  - Hemodynamically unstable: investigations need to be suspended as immediate surgical correction of the bleeding is required.

Approach to blunt abdominal trauma



FAST: Focused assessment with sonography for trauma; **DPL**: diagnostic peritoneal lavage

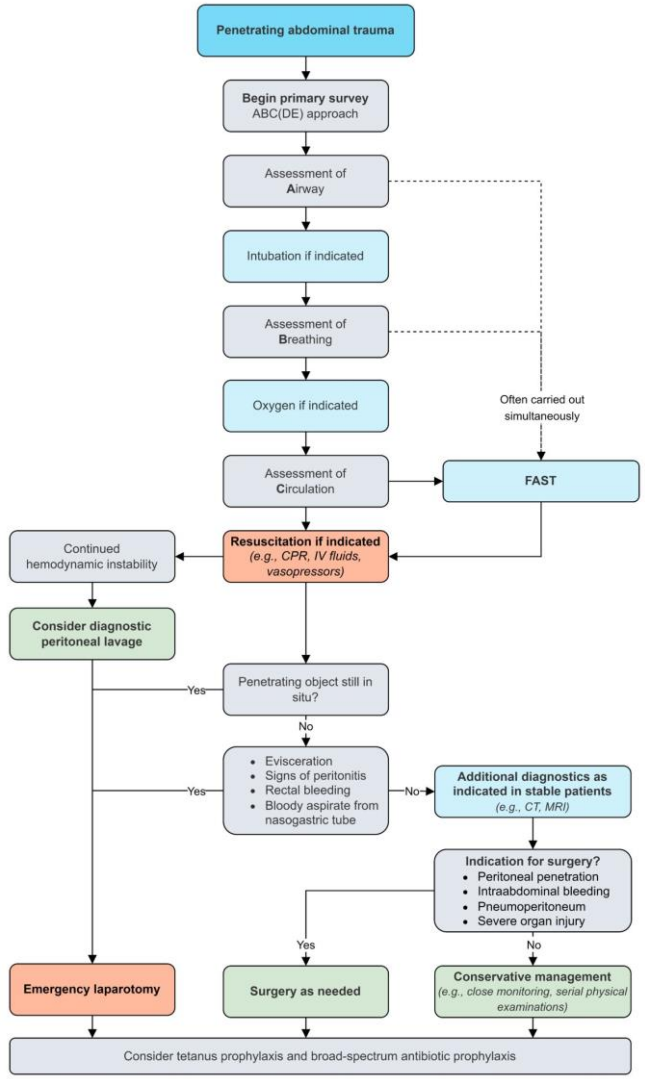
Approach to penetrating abdominal trauma

❖Primary survey

- Perform FAST exam and portable CXR.
- Treat hemorrhagic shock with emergency transfusion and immediate hemodynamic support.
- Identify obvious indications for exploratory laparotomy, e.g., hypotension, evisceration, peritoneal signs, subdiaphragmatic air on CXR.

❖Secondary survey

- Examine flank, back, and groin for wounds that could end the abdominal cavity.
- Locally explore wounds for evidence of violation of the abdominal fascia.
- Evaluate for penetrating thoracoabdominal and flank injuries.
- Obtain urgent diagnostics for trauma patients, including contrast CT abdomen and pelvis, once stable.
- Identify other radiological indications for exploratory laparotomy.



Assessment of blunt abdominal trauma

- **History**
  - In RTA: The type of collision, The extent of vehicle damage, The patient position in the vehicle, The extraction time, The status of other passengers.
  - In Falling Down patients the most important question is to ask about the height of FD and in direct blow patients you have to ask about the site of blow.
- **Examination**
  - There are some signs that indicate an intra abdominal injury such as abdominal distention, seat belt mark, abrasions and ecchymosis.
  - The most reliable signs and symptoms in alert patients are pain, tenderness, gastrointestinal hemorrhage, hypovolemia, and evidence of peritoneal irritation.

Assessment of penetrating injuries

- **History**
  - Generally, we have to ask about the time between injury and reaching hospital and the type of weapon and the site of injury.
  - If it is knife, we have to ask about how many times and its length.
  - If it is gunshot, we have to ask about the type and how many bullets.
- **Examination**
  - Assessment should be done when the patient is stable
- **Site**
  - Any wound in the boundaries of the abdomen is a potential abdominal injury
  - If the wound in the retroperitoneum we consider it in the ascending or descending colon

Assessment of abdominal injuries

- **Full Examination**
  - The patient must be fully undressed.
  - Inspection
    - The anterior and posterior abdomen, as well as the lower chest and perineum, should be inspected for abrasions, contusions from restraint devices, lacerations, penetrating wounds, abdominal distension and impaled foreign bodies
    - Log roll the patient for complete examination
  - Palpation
    - Distinguish superficial (abdominal wall) and deep tenderness.
    - Signs of peritoneal irritation: gaurdining, rigidity and rebound tenderness.
    - Crepitus at lower thoracic cage.
    - The presence of a pregnant uterus.
  - Auscultation: Used to confirm the presence or absence of bowel sounds

Assessment of abdominal injuries

- **Full Examination**
  - Look for evidence of urethral injury:
    - Blood at the urethral meatus
    - Scrotal ecchymosis or hematoma
  - Rectal examination, look for:
    - Assess sphincter tone and rectal mucosal integrity.
    - Determine the position of the prostate.
    - Identify any fractures of the pelvic bones.
    - Gross blood from bowel perforation.
  - Lastly, Vaginal examination is done if severe perineal injuries, pelvic fracture or trans-pelvic gunshot are present.
  - Gluteal examination: Penetrating injuries to this area are associated with up to a 50% incidence of significant intra-abdominal injuries.
  - At the conclusion of the rapid physical exam, the patient should be covered with warmed blankets to help prevent hypothermia.
  - Repeated Physical examinations are encouraged to detect signs of bleeding or peritonitis developing over time.

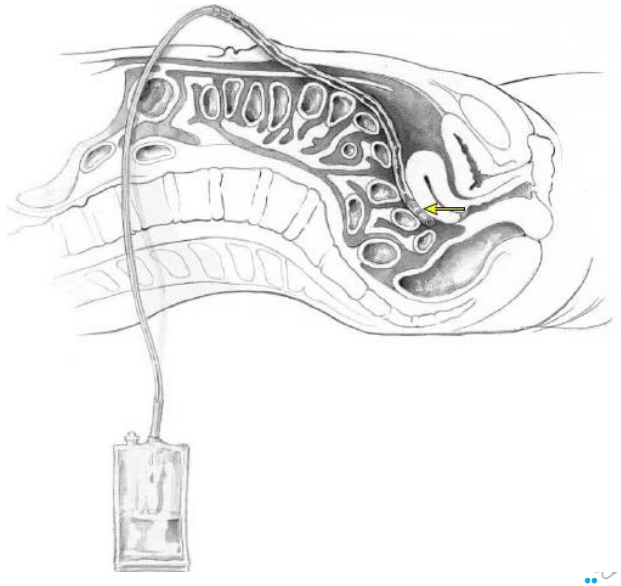
Diagnostics

- **Local wound exploration**
  - It is done for penetrating injuries if it is stab-wound, we dilate the wound and we put a probe to explore the wound when the probe stops it indicates the depth of the wound. If the probe passes the peritoneum, then we have to do laparotomy.
  - If the cause is gunshot, then radiological studies are used to determine the depth of injury.
- **Focused abdominal sonar for trauma**
  - it is used to indicate the presence of blood in the abdominal cavity mainly (Morison (hepatorenal recess) pouch, paracolic gutter, splenorenal recess and pouch of Douglas). If it is present, it is an indication of laparotomy. It can be done in unstable patients.
  - Accurate in detecting more than 100 ml of fluid in the abdomen.
  - Should be repeated in 30 minutes for detection of progressive hemoperitoneum.
- **CT scan**
  - It is used in stable patients to identify injured organs(solid and retroperitoneal)
  - We can determine bowel perforation, diaphragmatic rupture, retroperitoneal blood and pelvic and spinal fractures

Diagnostics

❖Diagnostic peritoneal lavage (DPL)

- It is used to assess the presence of blood in the abdomen
- Indications: may be performed after the primary survey for suspected hemoperitoneum with equivocal or unavailable FAST
- Procedure: A catheter is placed into the abdomen and contents are aspirated to assess for the presence of blood or fecal matter. If neither is observed, a liter of warm saline is instilled and then collected for cytological analysis.
- **Positive signs in DPL**
  - > 5mls of blood aspirated before fluid is infused.
  - Bloody irrigated fluid
  - the presence of bile,
  - enteric contents.
  - Hematological & biochemical tests for the aspirated fluid:
    - RBC > 100,000/cmm
    - WBC > 500 /cmm
    - Amylase > 175 units

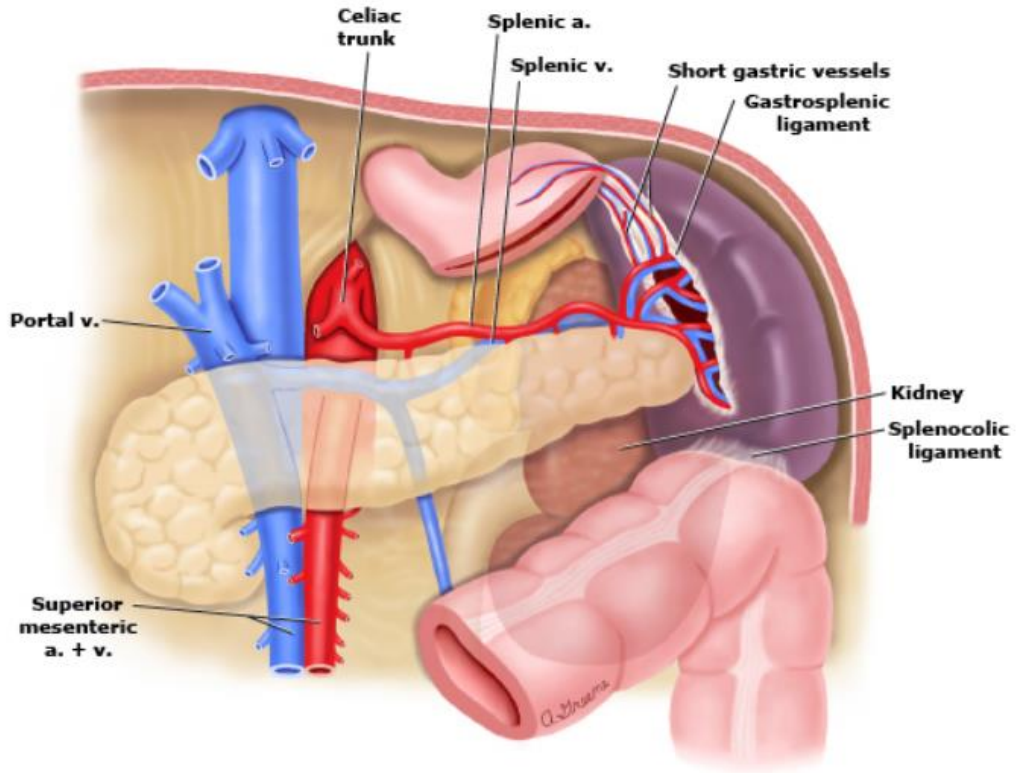


Diagnostics – Comparison

	DPL	FAST	CT SCAN
Advantages	• Early diagnosis • Performed rapidly • 98% sensitive • Detects bowel injury • Transport: No	• Early diagnosis • Noninvasive • Performed rapidly • Repeatable • 86%–97% sensitive • Transport: No	• Most specific for injury • 92%–98% sensitive • Non-invasive
Disadvantages	• Invasive • Specificity: Low • Misses injuries to diaphragm and retroperitoneum	• Operator-dependent • Bowel gas and subcutaneous air distortion • Misses diaphragm, bowel, and pancreatic injuries	• Cost and time • Misses diaphragm, bowel, and some pancreatic injuries • Transport: Required
Indications	• Unstable blunt trauma • Penetrating trauma	• Unstable blunt trauma	• Stable blunt trauma • Penetrating back/flank trauma

Splenic injury – Spleen anatomy

- The spleen, situated in the left upper abdomen, adjacent to the left hemidiaphragm and the greater curvature of the stomach, is encased in a fibrous capsule made of collagen, elastin, and smooth muscle. Its key function involves opsonization of encapsulated organisms.
- Blood supply primarily comes from the splenic artery, a branch of the celiac trunk, with additional support from the short gastric arteries, potentially receiving input from the left gastric and left gastroepiploic artery. This tortuous splenic artery courses along the superior margin of the pancreas, providing branches to it before reaching the spleen.



Splenic injury

❖Mechanism of trauma

- Splenic injury often results from blunt trauma, typically in motor vehicle collisions but also from falls, sports, or assaults. Penetrating trauma is less common and usually involves assaults or inadvertent impalement rather than gunshot or shotgun wounds due to the spleen's protected location. Intra-abdominal injuries most frequently affect the spleen and liver after blunt trauma, with the spleen being the sole organ injured in around 60% of cases.

❖Clinical features

- Symptoms:
  - May be painless, or LUQ/diffuse abdominal pain.
  - Referred L shoulder pain in splenic laceration: Kehr’s sign.
  - Syncope due to hypotension
- Signs:
  - Physical examination is insensitive and non-specific.
  - Pt may have signs of lt upper quadrant tenderness or signs of generalized peritoneal irritation.
  - May present with tachycardia ,tachypnea, hypotension or shock.

Diagnostic evaluation

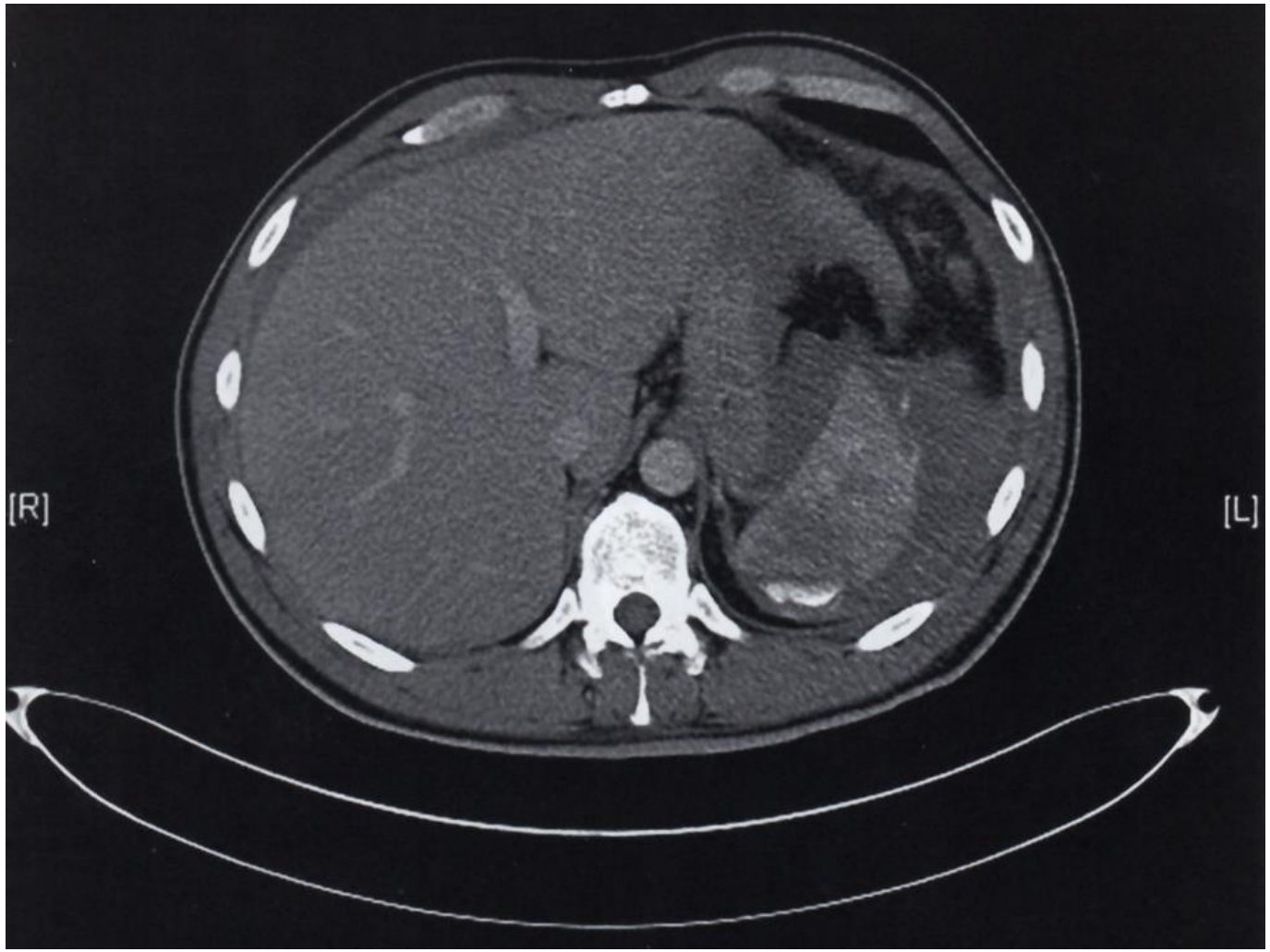
- Plain radiographic findings in splenic injury
  - Left lower rib fracture
  - Left hemidiaphragm elevation
  - Left lower lobe atelectasis,
  - Left pleural effusion
  - Medial displacement of the gastric bubble
  - Inferior displacement of the splenic flexure gas pattern.

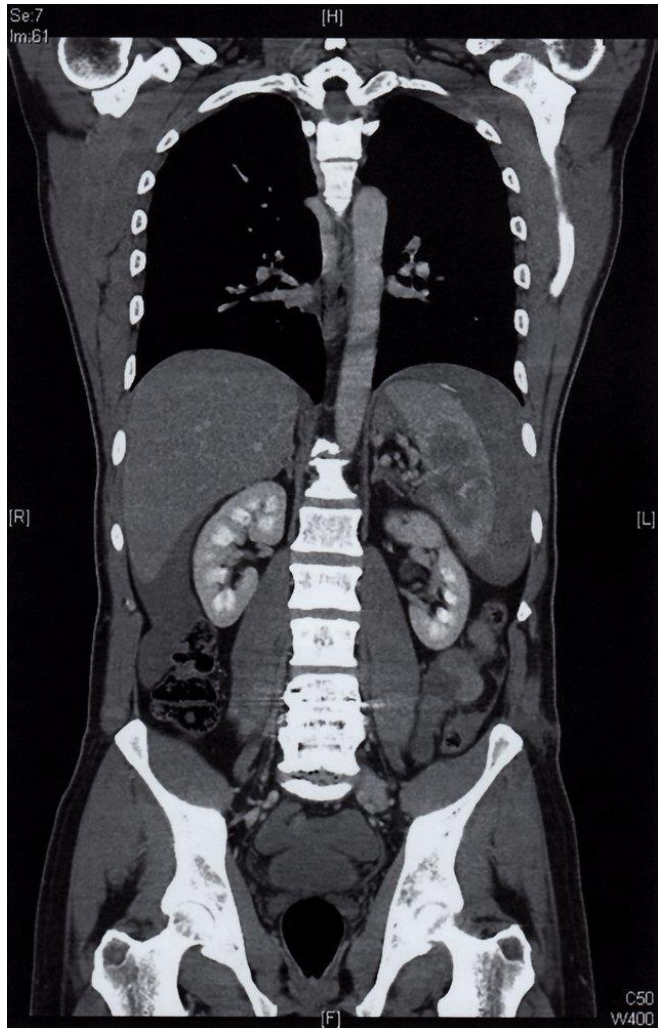
Diagnostic evaluation

- **FAST**
  - **Findings**: signs of splenic injury observed with FAST examination include a finding of hypoechoic (i.e., black) rim around the spleen, which may represent subcapsular fluid or intraperitoneal perisplenic fluid, or fluid in Morison's pouch (hepatorenal space).
- **CT scan with IV contrast**: grade splenic injury (The AAST imaging criteria for splenic injury are as follows)

Grade 1	Subcapsular hematoma <10 percent surface area. Parenchymal laceration <1 cm in depth
Grade 2	Subcapsular hematoma 10 to 50 percent surface area; intraparenchymal hematoma <5 cm. Parenchymal laceration 1 to 3 cm in depth
Grade 3	Subcapsular hematoma >50 percent of surface area; ruptured subcapsular or intraparenchymal hematoma ≥5 cm. Parenchymal laceration >3 cm in depth
Grade 4	Any injury in the presence of a splenic vascular injury or active bleeding confined within splenic capsule. Parenchymal laceration involving segmental or hilar vessels producing >25 percent of devascularization
Grade 5	Any injury in the presence of splenic vascular injury with active bleeding extending beyond the spleen into the peritoneum. Shattered spleen.

CT scan with IV contrast showing splenic injury





Management of splenic injury

- **Conservative (Observation)**
  - Indication: Hemodynamically stable patients with low-grade (I to III) blunt or penetrating splenic injuries without any evidence for other intra-abdominal injuries
  - May be followed by a selective splenic artery embolization
  - Nonoperative management is not appropriate in patients with hemodynamic instability, generalized peritonitis, or for patients with other intra-abdominal injuries requiring surgical exploration
- **Surgery**
  - **Options**: Splenic preservation (splenorraphy and partial splenectomy) or splenectomy
- **Immunocompetence after splenic injury**
  - Immunization is recommended for asplenic patients since splenectomy impairs opsonization of encapsulated organisms
  - Ideally, vaccines are administered either 14 days prior to or 14 days following splenectomy for maximal immunologic benefit

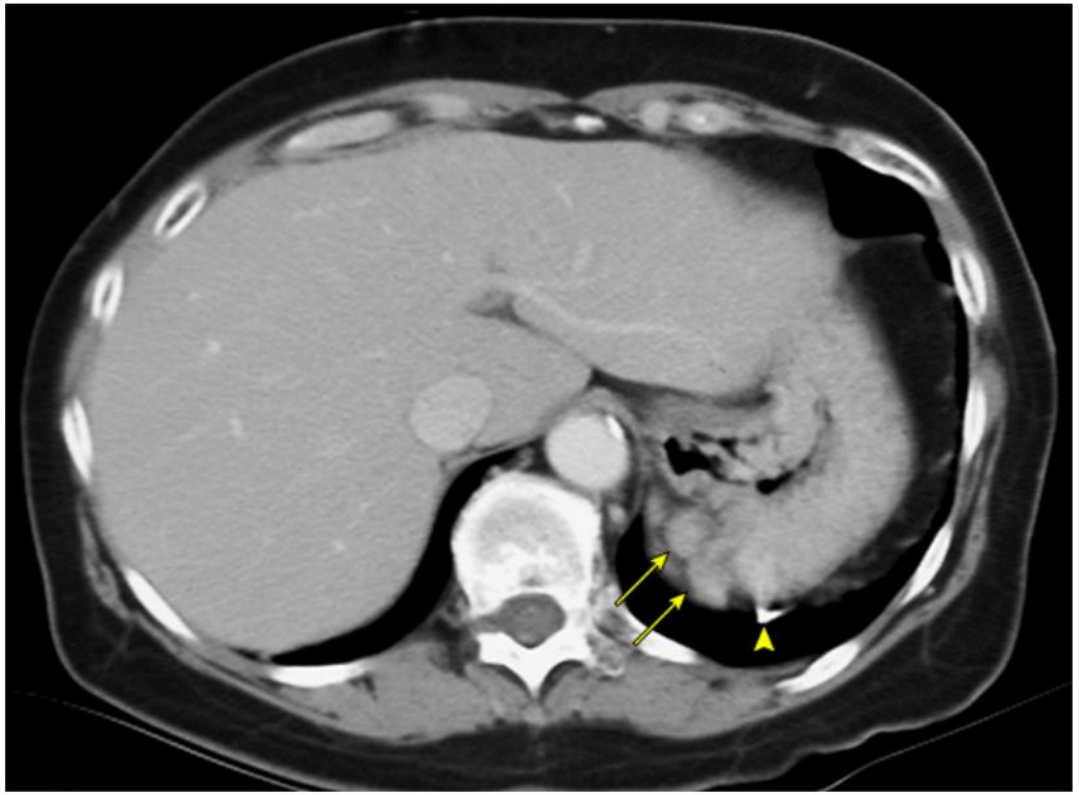
Atraumatic rupture

- Splenic rupture in the absence of trauma is uncommon but may be life threatening
- A systematic review of 845 cases from the literature identified the following causes
  - Neoplasm (eg, leukemia, lymphoma)
  - Infection (eg, infectious mononucleosis, cytomegalovirus [CMV], HIV, endocarditis, malaria)
  - Inflammatory disease/non-infectious disorders (eg, acute and chronic pancreatitis)
  - Drug and treatment related (eg, anticoagulation, granulocyte colony-stimulating factor [G-CSF], thrombolytic therapy, dialysis
  - Mechanical causes (eg, pregnancy related, congestive splenomegaly)
  - Idiopathic (normal spleen)

Splenosis

- Splenosis refers to implants of splenic tissue resulting from spillage of cells following abdominal trauma or surgery.
- There are often multiple implants, and they can be located anywhere in the peritoneal cavity. Common sites include the left upper quadrant of the abdomen

Splenosis on CT scan



This 55 year-old woman had a total splenectomy for traumatic splenic rupture. A CT scan taken a number of years later for unrelated purposes showed two foci of splenosis (arrows) and a surgical clip (arrowhead).

Liver injury

❖Symptoms of a liver injury

- Right upper quadrant pain, increase with deep breathing.
- Nausea or vomiting, tachycardia and fainting,

❖Physical examination

- Tenderness to palpation in the right upper quadrant of the abdomen.
- Abnormalities of blood pressure and pulse will be noted (low blood pressure and pulse over 100).

❖Liver injury scale

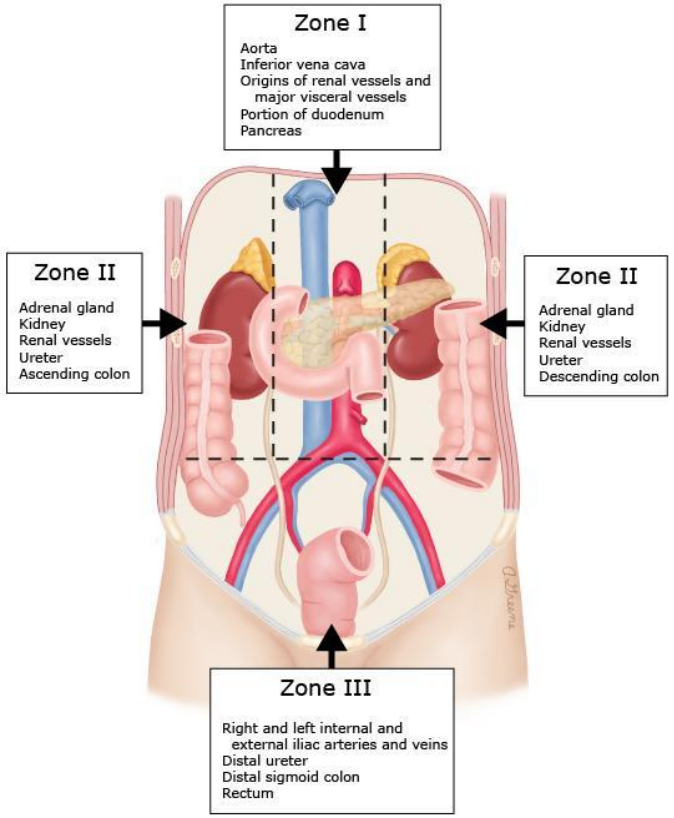
Grade 1	• Sub capsular hematoma < 10%of surface area, non-expanding. • Parenchymal laceration < 1cm parenchymal depth, non-bleeding.
Grade 2	• Sub capsular hematoma 10-50%. • Parenchymal laceration 1-3 in depth ,<10 cm in length.
Grade 3	• Sub capsular hematoma >50 %. • Parenchymal laceration 3 cm in depth
Grade 4	• Ruptured intra parenchymal hematoma with active bleeding. • Parenchymal disruption involving 25-50%of hepatic lobe.
Grade 5	• Parenchymal disruption >50%of hepatic lobe. • Vascular injuries: hepatic veins, inf. Vena cava.

Treatment of liver injury

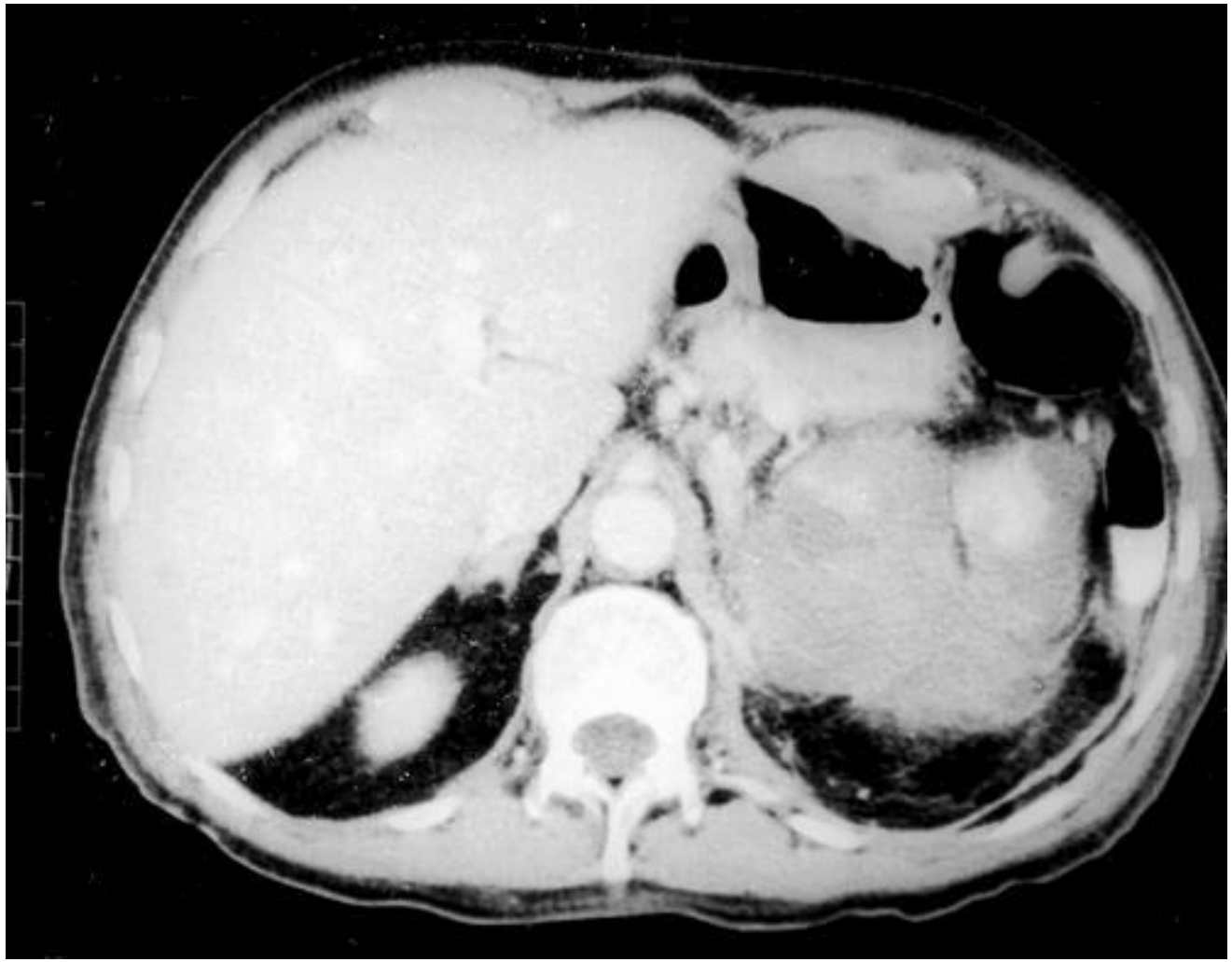
- **Nonoperative management**
  - Safe, effective, and clearly the treatment modality of choice in hemodynamically stable patients.
  - The weakness in this treatment is the possibility of missing an associated intra abdominal injury
- **Operative management options**
  - Simple suture techniques
  - Resectional debridement to control hemorrhage.
  - Anatomic resection
  - hepatic artery ligation
  - Mesh wrapping or perihepatic packing,
  - fibrin glue application

Retroperitoneal hematoma

	Occupy	Include	Tx of blunt	Tx of penetrating
Zone I	Occupy the centro-medial portion of the retro peritoneum	duodenum & pancreases and major blood vessels	Explore	Explore
Zone II	Is lateral to zone I	kidney & retro peritoneal portion of colon	Observe	Explore
Zone III	Include entire pelvis		Observe	Explore

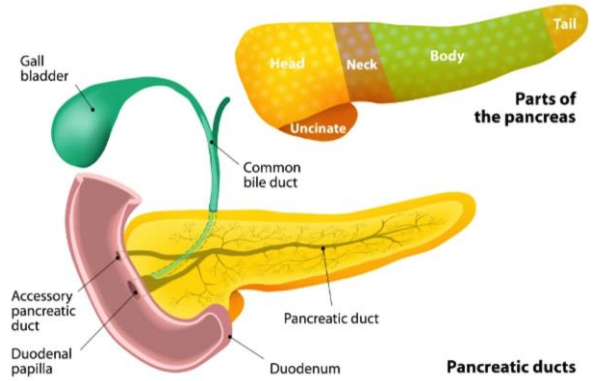


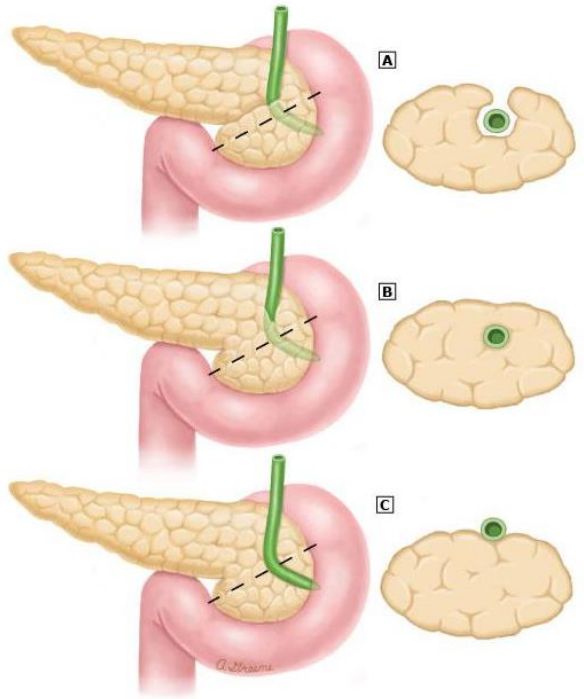
Retroperitoneal hematoma, CT scan



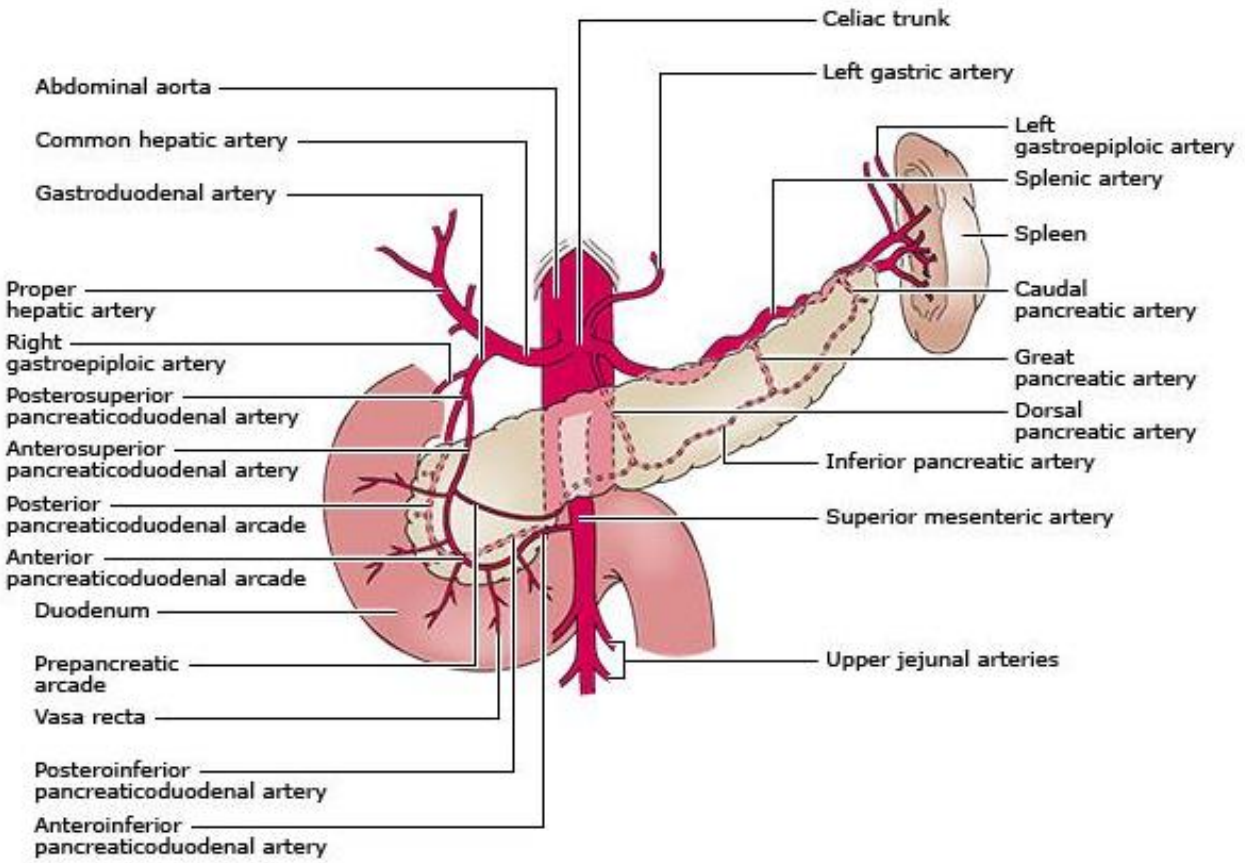
Pancreatic trauma – Pancreas anatomy

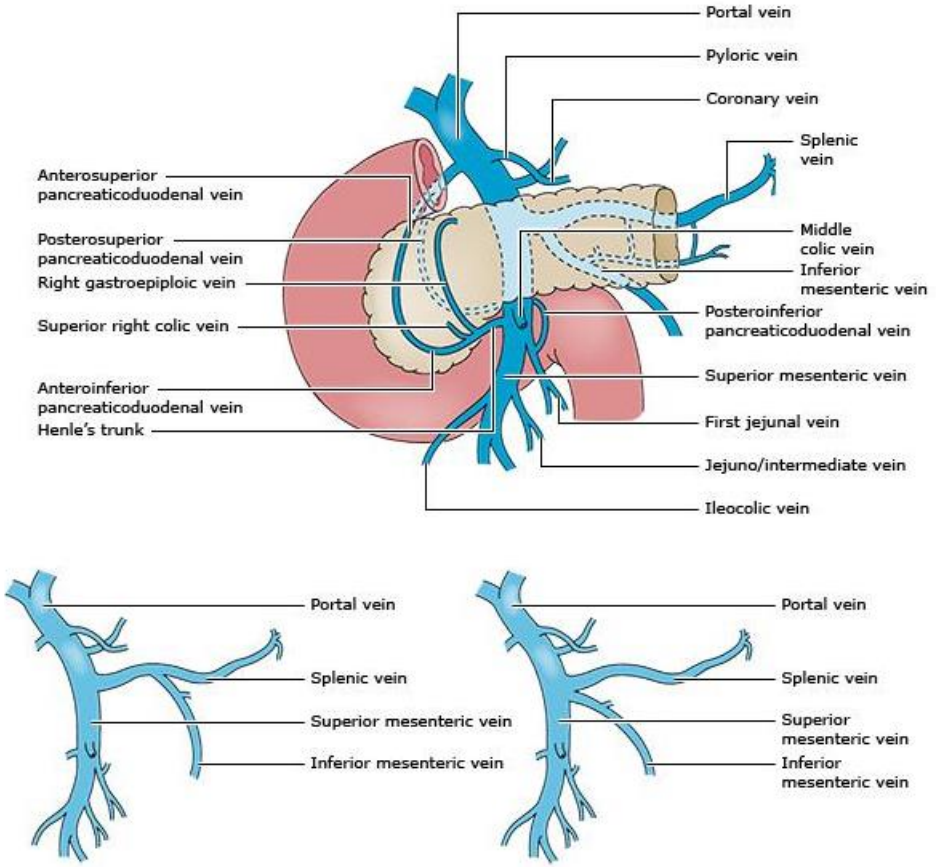
- Positioned in the retroperitoneum, it comprises distinct anatomical regions: the head, uncinate process, neck, body, and tail.
- Interestingly, the removal of 90% of its mass typically doesn't impair its functions significantly.
- Variations in duct anatomy, especially regarding drainage into the duodenum, are common, impacting digestive processes.
- Blood supply originates from the celiac and superior mesenteric arteries, while innervation involves sympathetic and parasympathetic fibers, modulating both exocrine and endocrine activities.





Pancreatic trauma – Pancreas anatomy





Pancreatic trauma

❖ Epidemiology

- Pancreatic injuries are rare, occurring in less than 1% of trauma admissions, with blunt trauma being more common than penetrating trauma, often from motor vehicle collisions.

❖ Diagnostics (Pancreatic injury diagnosis relies on imaging)

- **FAST is not reliable for pancreatic injury screening.**
- **CT imaging**
  - Preferred for hemodynamically stable patients with suspected pancreatic injury.
  - May not initially show injuries but could become evident on subsequent scans
  - Findings include direct signs like swelling, laceration, or hematoma, and indirect signs like peripancreatic fluid.
- **ERCP**: **Indication**: equivocal findings on CT imaging

Pancreatic trauma grading

Grade 1	Minor contusion without duct injury or superficial laceration without duct injury.
Grade 2	Major contusion without duct injury or tissue loss, or major laceration without duct injury or tissue loss.
Grade 3	Distal transection (through-and-through laceration) or deep parenchymal injury with ductal injury.
Grade 4	Proximal pancreatic transection (through-and-through laceration) or deep parenchymal injury involving ampulla.
Grade 5	Massive disruption of the pancreatic head.

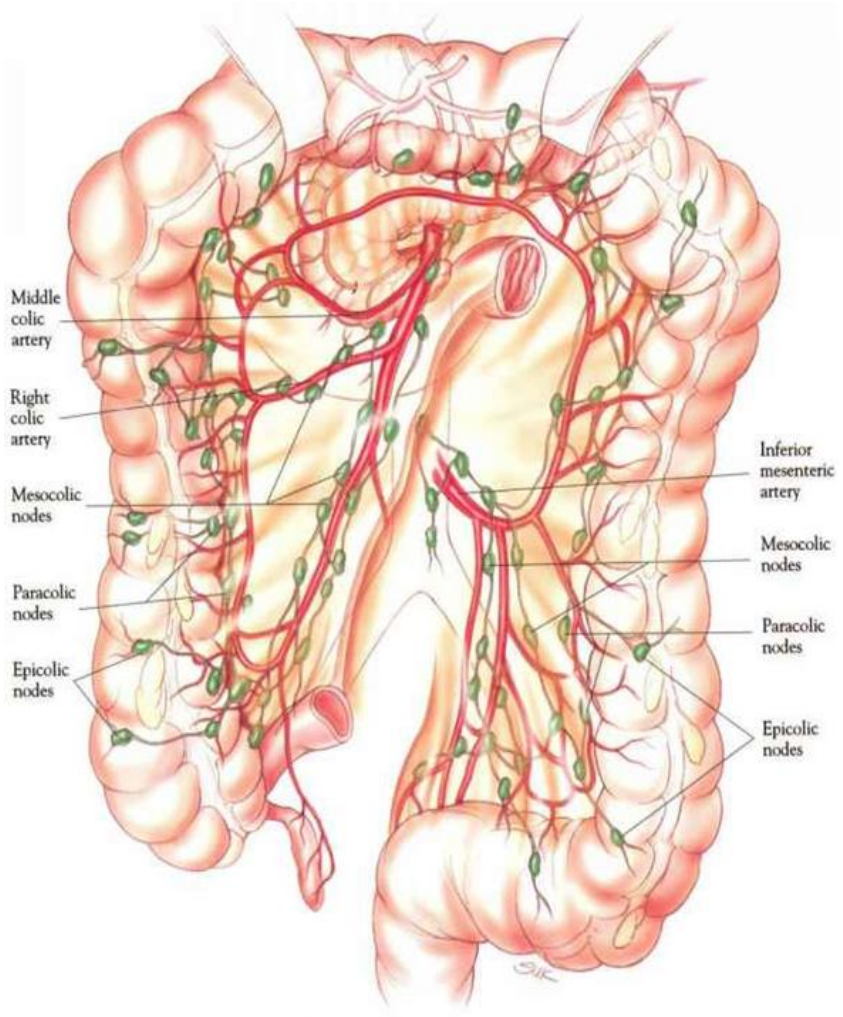
Pancreatic trauma management

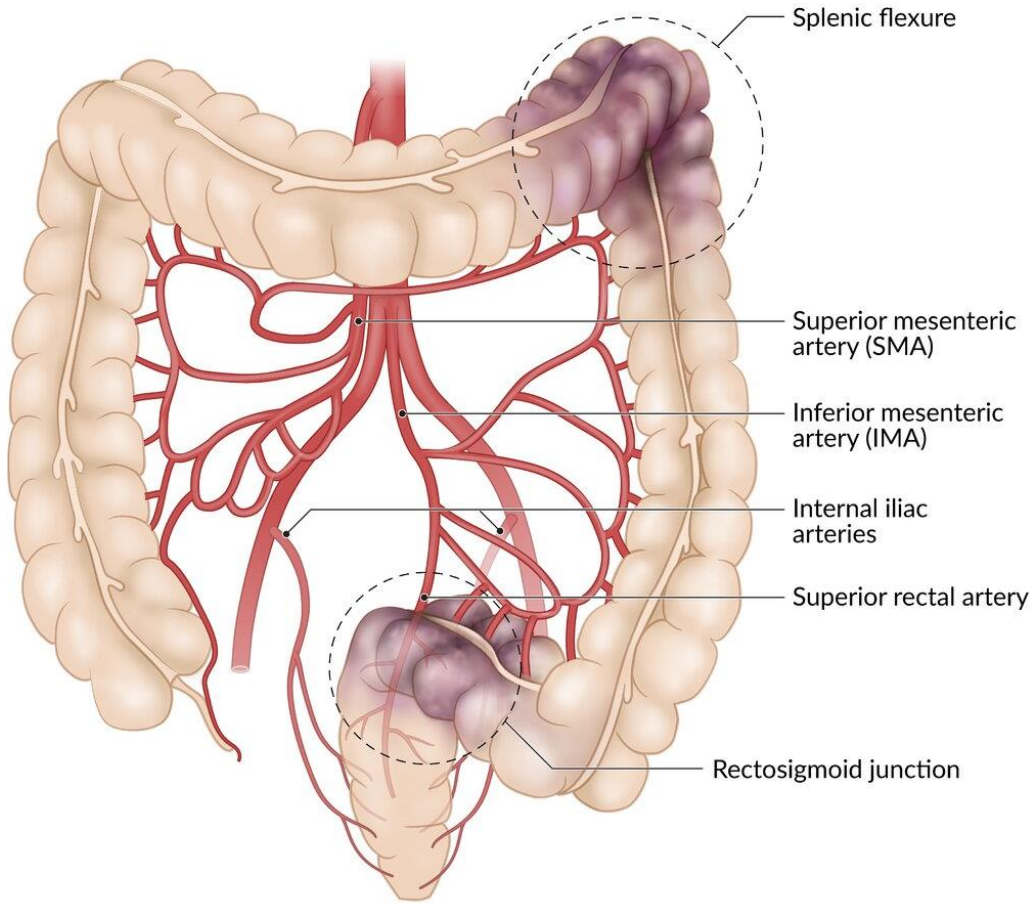
- Conservative management can be safe for low-grade blunt pancreatic injuries, especially if determined by imaging and if the patient is stable. Close monitoring for worsening symptoms or complications is crucial.
- Penetrating injuries usually require surgical intervention.
- Operative management principles include controlling bleeding, wide drainage, and avoiding pancreaticoenteric anastomoses. Distal pancreatectomy is preferred for injuries to the left of the superior mesenteric vein, while selective debridement or pancreaticoduodenectomy may be needed for injuries to the right. The choice depends on factors like tissue devitalization and associated injuries.
- During exploratory laparotomy for other indications, pancreatic injuries should be actively sought. Techniques like the Kocher maneuver and duodenal mobilization are employed to examine the pancreas thoroughly.
- Nutrition support, preferably enteral, is vital for patient recovery.

Colon Anatomy

- Connects the cecum proximally and the rectum distally
- **Ascending colon**
  - Retroperitoneal
  - Ascends along the right posterolateral abdominal wall from the cecum up to the right subcostal region, where it makes a 90° turn to the left (hepatic flexure)
- **Transverse colon**
  - Intraperitoneal
  - Extends from the hepatic flexure to the splenic hilum, where it makes a 90° turn caudally (splenic flexure)
- **Descending colon**
  - Retroperitoneal
  - Descends along the left posterolateral abdominal wall from the splenic flexure to the left iliac fossa
- **Sigmoid colon**
  - Intraperitoneal
  - The S-shaped terminal portion of the descending colon located in the left iliac fossa
  - Extends up to the S3 vertebra

Colon Anatomy – Blood supply & Lymphatics





Watershed areas in colon ischemia

Rectal Anatomy – Blood supply & Lymphatics

Upper and middle rectum

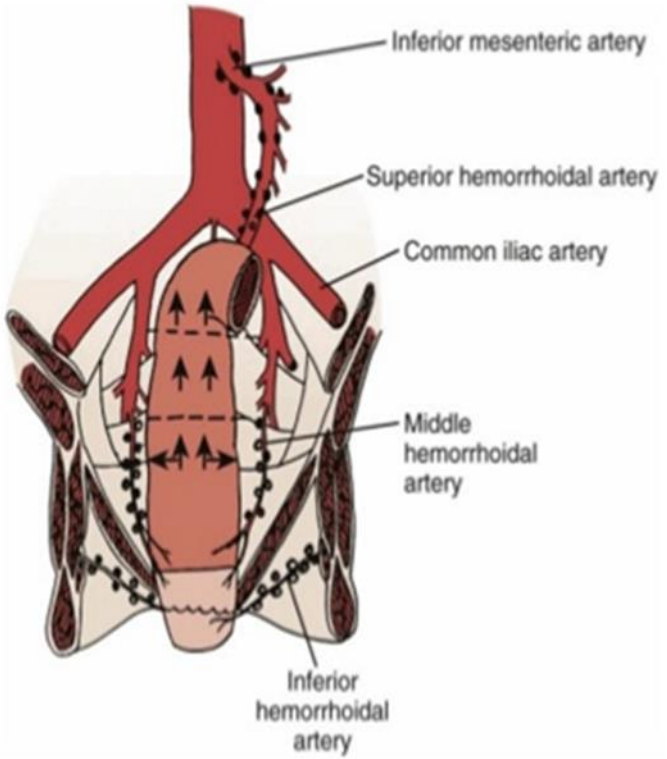
- Pararectal lymph nodes, located directly on the muscle layer of the rectum

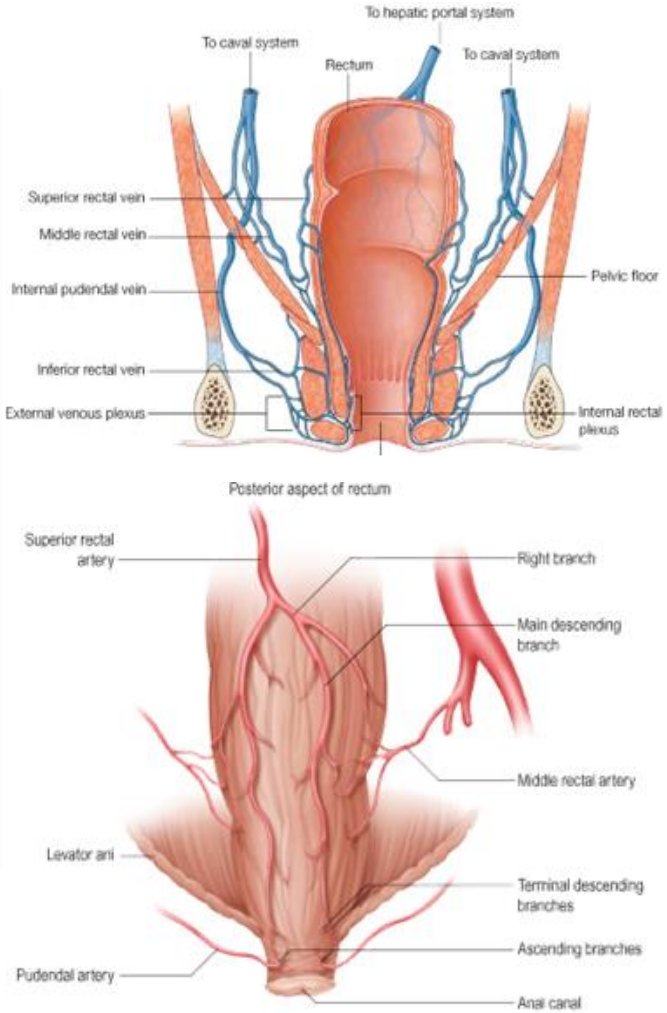
Lower rectum

- Sacral group of the lymph nodes or internal iliac lymph nodes

Below the dentate line

- Inguinal nodes and external iliac chain





Colorectal Injury

❖ Etiology

- **Penetrating trauma**, the most common type of trauma seen and is usually due to:
  - High velocity missiles.
  - Rectal impalement injuries result when a patient falls on a penetrating object.
  - Iatrogenic injuries due to uterine perforation during curettage of the uterus, use of endoscopies or with rectal instrumentations.
  - During surgical operations for urologic or gynecologic operations.
- **Blunt trauma**
  - This is rare due to the protected situation of the anus and rectum and it is usually associated with fracture pelvis. The commonest cause is motor vehicle accidents followed by falls and crush injuries.

How to suspect large bowel injuries

- Intra-abdominal injuries are diagnosed as any abdominal trauma by the presence of manifestations of peritoneal irritation, free intraperitoneal fluid or air, and/or by assuring the presence of penetration into the peritoneal cavity.
- Rectal, anal canal and perineal trauma are diagnosed by proper inspection and per rectal examination of the patient.
- The presence of bleeding per rectum is a very important sign.
- The presence of different types of ureteral injuries as well as different types of fracture pelvis should stimulate the surgeon to properly examine and even sigmoidoscope the rectum and the pelvic colon.

Colon Injury Scale

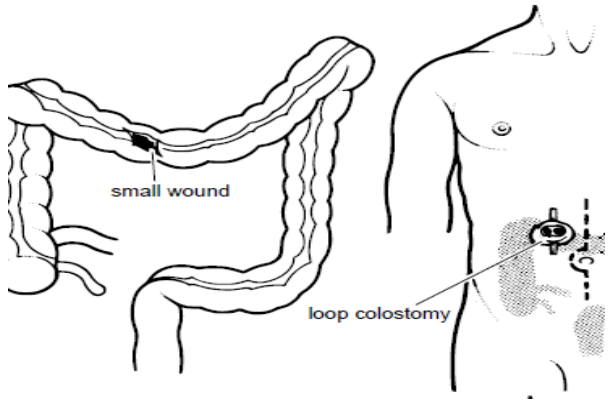
Grade	Type of injury	Description	AIS-90
I	Hematoma	Contusion or hematoma	2
	Laceration	Without devascularization	2
	Laceration	Partial thickness, no perforation	2
II	Laceration	Laceration <50% of circumference	3
III	Laceration	Laceration >50% of circumference	3
		Without transection	
IV	Laceration	Transection of the colon	4
V	Laceration	Transection of the colon with	4
	Vascular	Devascularized segment	

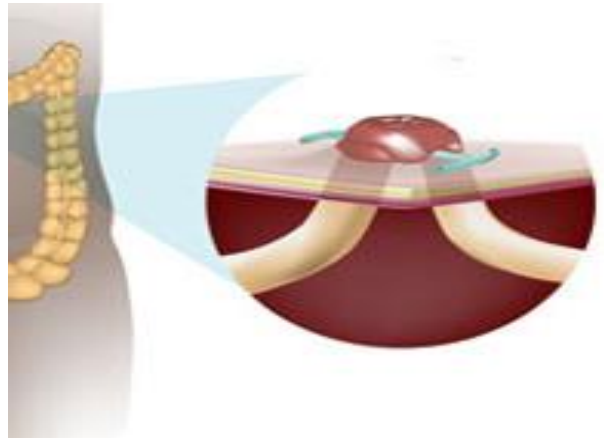
Colon Injury Treatment – Primary repair

- Include lateral suture of perforations and resection of the damaged colon with reconstruction by ileocolostomy or colocolostomy.
- **Advantage** of primary repairs is that definitive treatment is carried out at the initial operation.
- **Disadvantage** is that suture lines are created in suboptimal conditions, and leakage may occur.
- **Necessitates the presence of the following conditions**
  1. Small tear less than 2 cm
  2. Little contamination and minimal fecal spillage
  3. Interference in a time less than 8 hours from wound inflection
  4. No other large bowel injuries
  5. No other organ injuries
  6. No hemodynamic shock

Colon Injury Treatment – Colostomy

- **Advantage** of colostomy is that it avoids an unprotected suture line in the abdomen.
- **Disadvantage** is that a second operation is required to close the colostomy.
- **Types of colostomies**
  1. **Loop Colostomy**
     - Suitable for wounds involving part of the circumference of the gut.
     - Easier to perform in the transverse or sigmoid colon.
     - Can be used anywhere at or beyond the hepatic flexure with proper mobilization of the colon.
     - The loop must lie easily on the abdominal wall without tension to prevent retraction and abdominal wall abscesses.

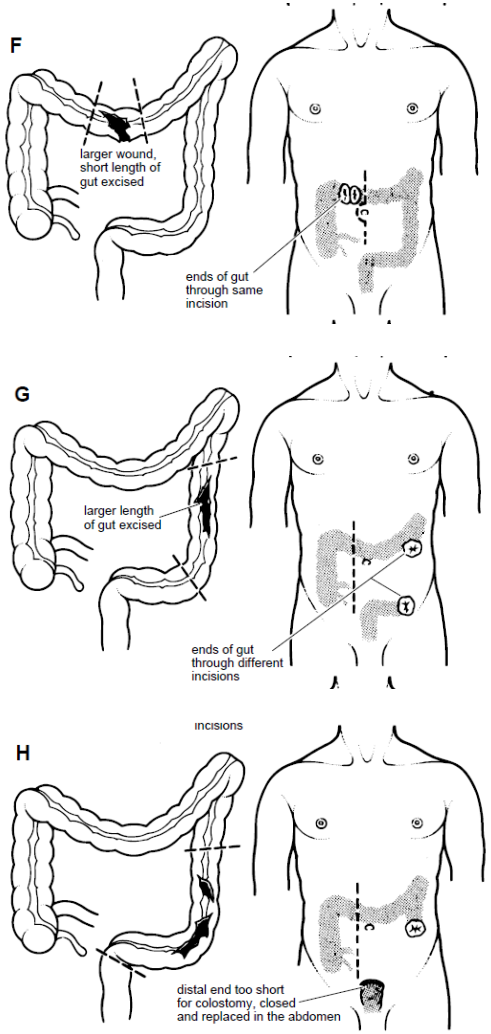




Colon Injury Treatment – Colostomy

❖**Types of colostomies** cont.

2. **Double-barrel Colostomy**
   - Used when resecting a short (5cm) length of the gut.
   - Both cut ends can be brought out through the same incision.
3. **Separate Incisions Colostomy**
   - Necessary if resecting a longer length of the gut (>5cm)
   - The cut ends cannot be brought out through the same incision and must be brought out through separate incisions as fecal and mucous colostomies.
4. **Hartmann's Procedure**
   - Required if the lower end of the gut is too short to bring out to the surface



Colon Injury Treatment – Exteriorized repair

- Exteriorized repairs are created by the suspending of a repaired perforation or anastomosis on the abdominal wall with an appliance after the fashion of a loop colostomy.
- If after 10 days the suture line does not leak, it can be returned to the abdominal cavity under local anesthesia without subsequent risk of leakage.
- If the repair breaks down before 10 days, it is treated as a loop colostomy. Healing is successful in 50 to 60 percent of cases.
- **Advantage** is avoidance of an intraperitoneal suture line when it is at risk of leakage.
- **Disadvantage** is that 40-50% of patients require colostomy closure.

Complications

Complications related to the colonic injury and its treatment may include

1. Intraabdominal abscess
2. Fecal fistula
3. Wound infection
4. Stomal complications

Rectal injury

- **Etiology**: several ways, all uncommon:
  - by falling in a sitting posture onto pointed object
  - by penetrating injury (including gunshots) to the buttocks
  - by sexual assault or sexual activity involving anal penetration
  - by The fetal head during childbirth, especially forceps-assisted

TABLE 33-5 AAST Rectal Organ Injury Scale

Grade	Injury Description
I	(a) Contusion or hematoma without devascularization
	(b) Partial thickness laceration
II	Laceration ≤50% of circumference
III	Laceration >50% of circumference
IV	Full-thickness laceration with extension into the perineum
V	Devascularized segment

The American Association for the Surgery of Trauma (AAST)

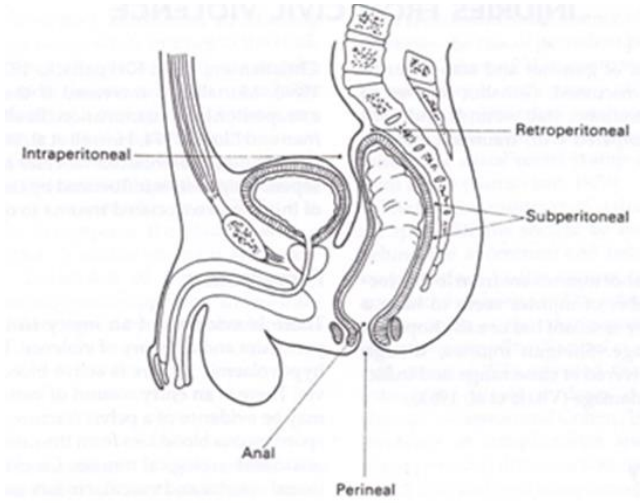


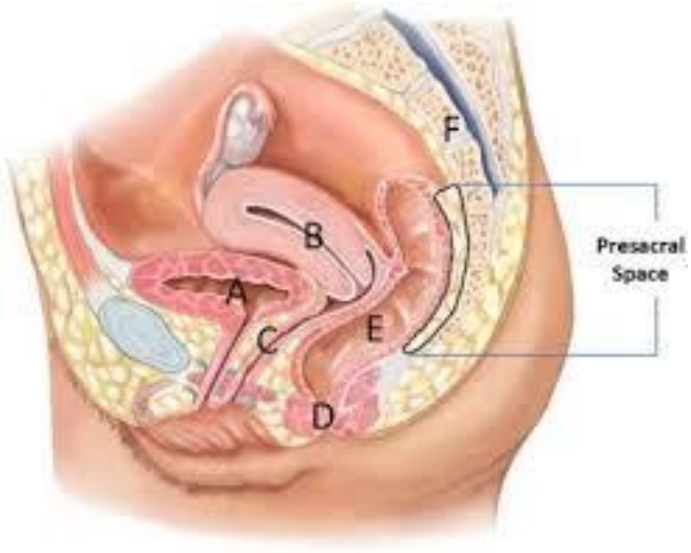
Fig. Sites of injuries to the rectum

Principles of management of rectal injuries

- The injury in the rectum is detected by a thorough endoscopic examination, preferably done with a rigid sigmoidoscope in the left lateral or lithotomy position, to determine if the injury is in the intraperitoneal or extraperitoneal segment.
- The extraperitoneal space of the rectum is divided into retroperitoneal (high in the abdomen) and subperitoneal (low in the presacral space). The scope is also used to remove retained feces with irrigation.
- Direct per rectal repair is performed for low injuries (subperitoneal spaces) with possible drainage of the presacral space through an incision between the coccyx and the anus, especially for posterior injuries.

Principles of management of rectal injuries

- Direct repair through abdominal exploration is done for injuries in the intraperitoneal or retroperitoneal segments, with possible suction drainage of the presacral space for posterior injuries and drainage of the Douglas pouch for anterior injuries.
- A proximal complete fecal diversion is necessary in all cases.
- Ensure removal of all retained feces by irrigation through either the distal limb of the colostomy or preferably through the rectum.



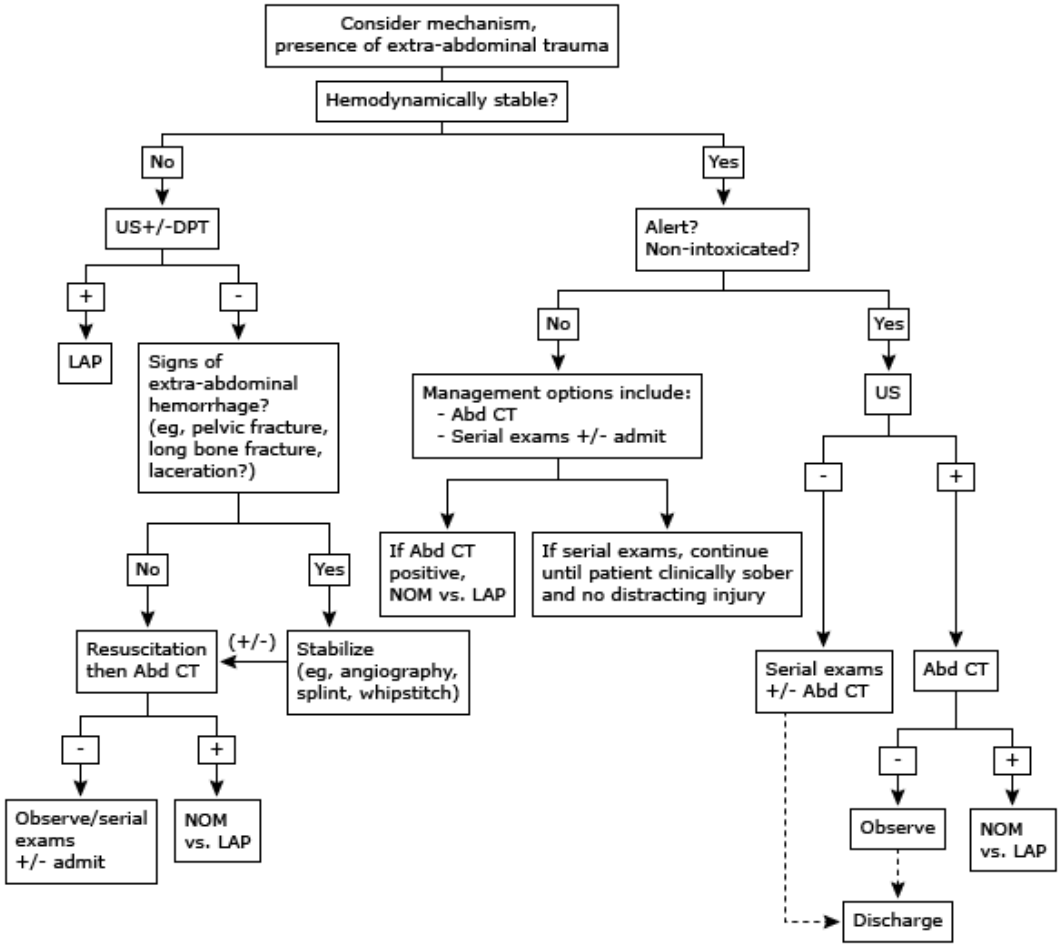
Perianal and anal canal injuries

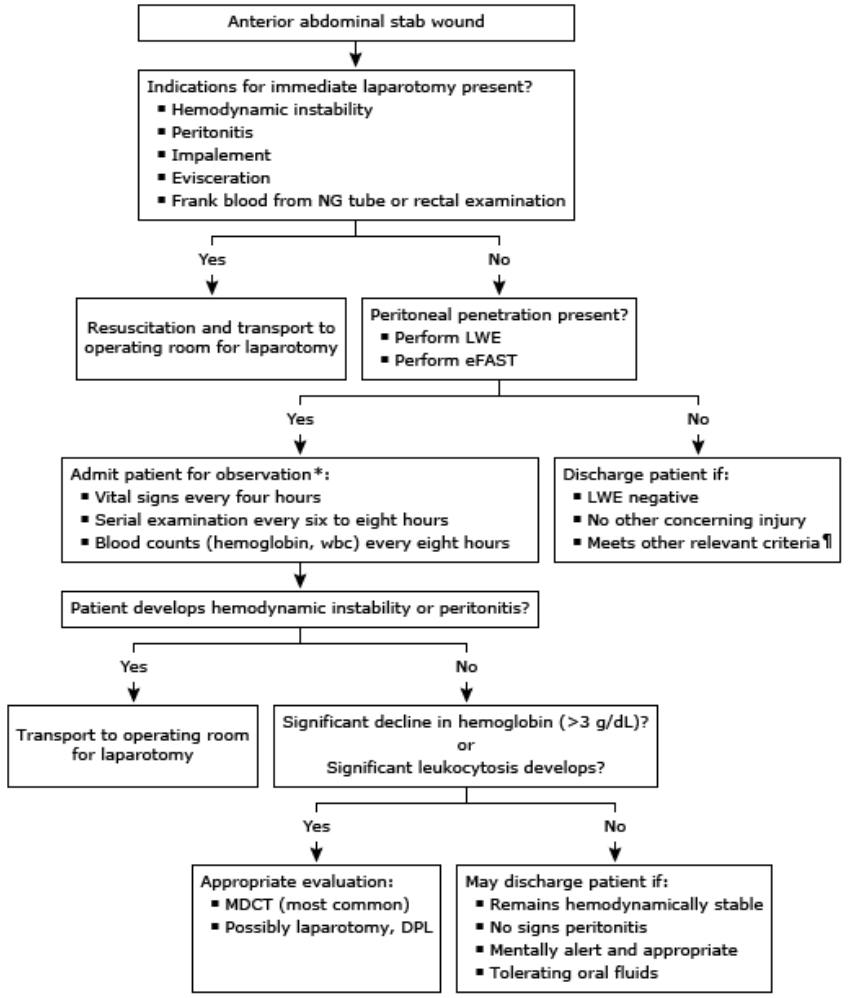
- In perineal and anal canal injuries, no attempt should be done for primary sphincteric or tissue repair, only debridement and hemostasis are done.
- It is however, mandatory to divert the fecal stream totally from the wound in the perineum if the lesion is even moderately extensive and specially if involving the sphincteric complex of the anal canal.
- After healing of the wound and before any colostomy closure, sphincteric repairs can be done under cover of the diversion usually with satisfactory results.
- **Treatment**: debridement, diversion, drainage, distal washout

Multiple trauma patients

- Multiple trauma patients are more likely to die from their intra-operative metabolic failure that from a failure to complete operative repairs.
- The patients die from a triad of coagulopathy, hypothermia and metabolic acidosis
- The principles of the first 'damage control' procedure are control of hemorrhage, prevention of contamination and protection from further injury.

Flowcharts


Consider mechanism, presence of extra-abdominal trauma
Hemodynamically stable?
No
Yes
US+/-DPT
Alert? Non-intoxicated?
+
-
LAP
Signs of extra-abdominal hemorrhage? (eg, pelvic fracture, long bone fracture, laceration?)
No
Yes
Resuscitation then Abd CT
(+/-)
Stabilize (eg, angiography, splint, whipstitch)
-
+
Observe/serial exams +/- admit
NOM vs. LAP
No
Yes
Management options include: - Abd CT - Serial exams +/- admit
If Abd CT positive, NOM vs. LAP
If serial exams, continue until patient clinically sober and no distracting injury
US
-
+
Serial exams +/- Abd CT
Abd CT
-
+
Observe
NOM vs. LAP
Discharge


Anterior abdominal stab wound
Indications for immediate laparotomy present?
▪ Hemodynamic instability
▪ Peritonitis
▪ Impalement
▪ Evisceration
▪ Frank blood from NG tube or rectal examination
Yes
No
Resuscitation and transport to operating room for laparotomy
Peritoneal penetration present?
▪ Perform LWE
▪ Perform eFAST
Yes
No
Admit patient for observation*:
▪ Vital signs every four hours
▪ Serial examination every six to eight hours
▪ Blood counts (hemoglobin, wbc) every eight hours
Discharge patient if:
▪ LWE negative
▪ No other concerning injury
▪ Meets other relevant criteria¶
Patient develops hemodynamic instability or peritonitis?
Yes
No
Transport to operating room for laparotomy
Significant decline in hemoglobin (>3 g/dL)? or Significant leukocytosis develops?
Yes
No
Appropriate evaluation:
▪ MDCT (most common)
▪ Possibly laparotomy, DPL
May discharge patient if:
▪ Remains hemodynamically stable
▪ No signs peritonitis
▪ Mentally alert and appropriate
▪ Tolerating oral fluids

Burn

Burns

Etiology

- **Thermal burns (most common)**
  - Flame burns: fire
  - Contact burns: hot surfaces
  - Scalding: hot liquids or steam
- **Nonthermal burns**
  - Chemical burns
  - Electrical burns
  - Radiation burns
  - Friction burns

Classification

- **Depth of burns**
- **Total body surface area**

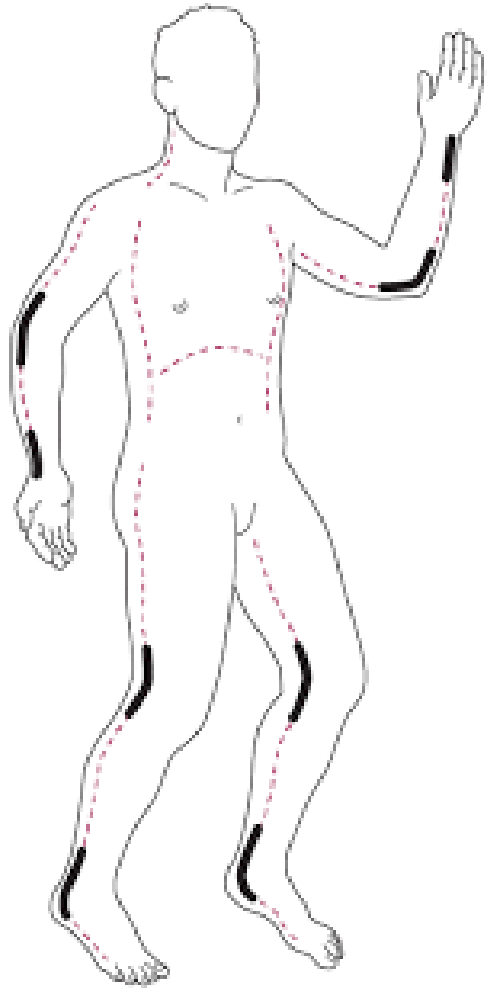
  Total body surface area (TBSA) is the total area of skin involved in an injury (e.g., burn) or disease (e.g., psoriasis).
- **Burn severity**
  - Minor burn
  - Moderate burn
  - Major burn

Pathophysiology of thermal burns

- **Local effects**
  - **Local changes at the burn site (Jackson model of the burn wound)**
    - Zone of coagulation: a central zone of irreversible, coagulative necrosis
    - Zone of stasis: surrounds the central zone of coagulation and is comprised of damaged but viable tissue with decreased perfusion
    - Zone of hyperemia: surrounds the zone of stasis and is characterized by inflammation and increased blood flow
  - **Bacterial colonization of the burn site**
    - Almost all burn wounds are colonized by bacteria.
    - Common pathogens that infect burn wounds include MRSA, Pseudomonas, Klebsiella, Acinetobacter, and Candida.
  - **Eschars: a skin lesion characterized by dried, necrotic skin tissue**
    - Can cause constrictive effects
    - Circumferential eschars (burns that fully encircle the chest, neck, abdomen, and/or an extremity) → loss of skin elasticity → impaired blood flow and/or compartment syndrome (caused by an accumulation of fluids) → acute ischemia distal to the eschar

Pathophysiology of thermal burns

- **Local effects**
  - **Eschars: a skin lesion characterized by dried, necrotic skin tissue**
    - Significant eschar on chest or neck → restriction of chest excursion → asphyxia
    - Significant eschar on abdomen → abdominal compartment syndrome (Bladder pressure is a good estimate of intra-abdominal pressure and can be measured via the foley catheter)
    - Escharotomy : is an incision of burned skin to relieve constriction
      - Arms and legs Can be decompressed with axially oriented medial and lateral incisions. Digital escharotomies are not typically needed
      - Chest and upper abdomen Can be decompressed with bilateral midaxillary releases. These can be connected with one or multiple horizontal incision toform an “H”



Pathophysiology of thermal burns

❖ Systemic effects

Burns involving > 30% of the body surface area and third- or fourth-degree burns are likely to have systemic effects.

- Release of cytokines and other inflammatory mediators → systemic inflammatory response syndrome
  - Increased vascular permeability → extravasation of protein and fluid from the intravascular compartment into interstitial tissue → generalized edema, acute respiratory distress syndrome, and hypovolemic shock with paralytic ileus
  - Disseminated intravascular coagulation (DIC)
- Evaporative fluid loss → hypothermia, dehydration
- Hemolysis, muscle damage → hemoglobinuria and/or myoglobinuria → acute tubular necrosis
- Immunosuppression

Pathophysiology of thermal burns

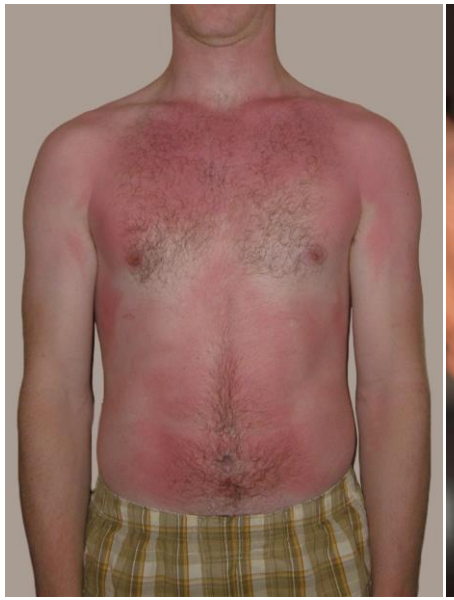
- **Postburn Hypermetabolic state**
  - Initial response: Decreased cardiac output, decreased metabolic rate
  - 24 to 48 hour after injury: Increased cardiac output (2 times normal), increased metabolic rate (2 times normal).
  - Hypothalamic function altered: Increased glucagon / cortisol / Catecholamines
  - GI barrier function breaks down, leads to bacterial translocation
  - Nutritional needs dramatically increase (2 to 3 times normal)

Degree of burns		Affected tissue layers	Clinical features			Prognosis
			Pain	Wound blanching on pressure	Appearance	

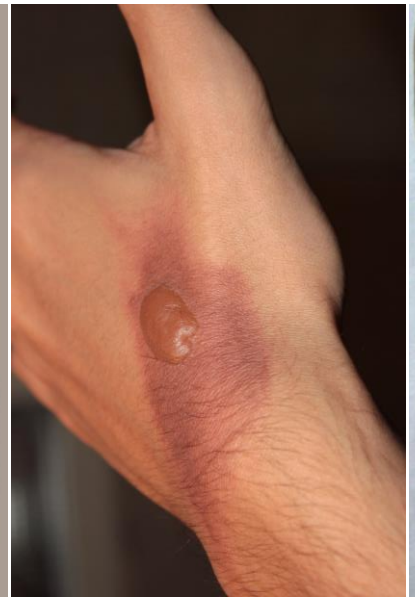
Superficial burn (1st-degree)		Superficial layers of the epidermis	Yes (localized pain)	• Yes
				• Rapid refill
					• Like sunburn
					• Localized features include:
					  • Erythema
					  • Swelling
					  • Skin appears dry
					  • No blistering
						• Healing within 3–6 days
						• No scarring

Partial thickness burn (2nd-degree)	Superficial partial thickness burn (2a)	Epidermis and upper layers of the dermis (papillary dermis)	Yes (especially with the movement of air or changes in temperature in the area surrounding the wound)	• Yes • Slow refill	• Erythema • Swelling • Increased temperature of affected skin • Vesicles/bullae	• Healing within 1–3 weeks • Temporary hypopigmentation/ hyperpigmentation • No scarring
	Deep partial thickness burn (2b)	Deeper layers of the dermis (papillary and reticular dermis)	Yes (pain is typically felt on applying pressure)	No Very slow refill	• Vesicles/bullae: fragile (rupture easily) • Mottled coloration of the skin with red and/or white patches	• Healing takes 3 weeks or longer. • Scar formation
Full thickness burn (3rd-degree)		Epidermis, dermis, and subcutaneous tissue	No (perception of deep pressure is intact)	No	• Tissue necrosis with black, waxy-white, or gray leather-like skin (eschar) • Skin appears dry and inelastic	The burn does not heal by itself.
deeper injury burn (4th-degree)		Epidermis, dermis, and deeper structures	No (minimal perception of deep pressure)	No		The tissue is dead and requires amputation.

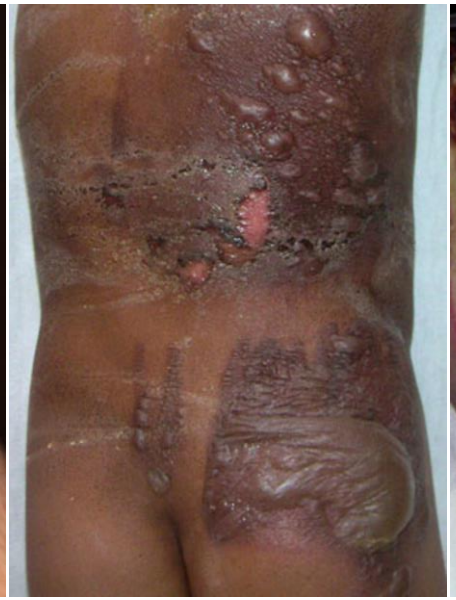
Classification – Depth of burns



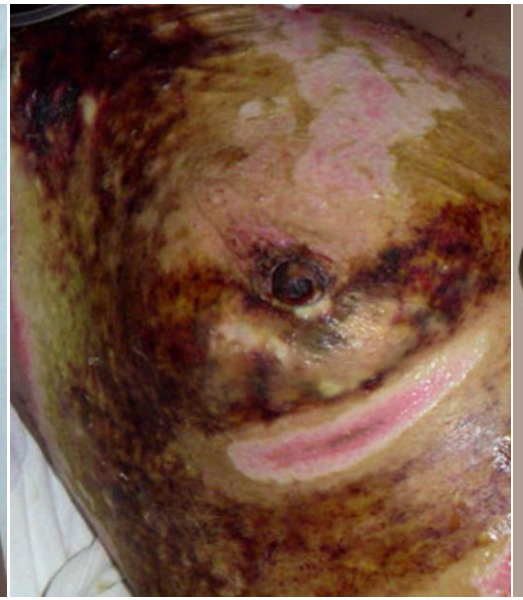
Superficial burn (1st-degree)



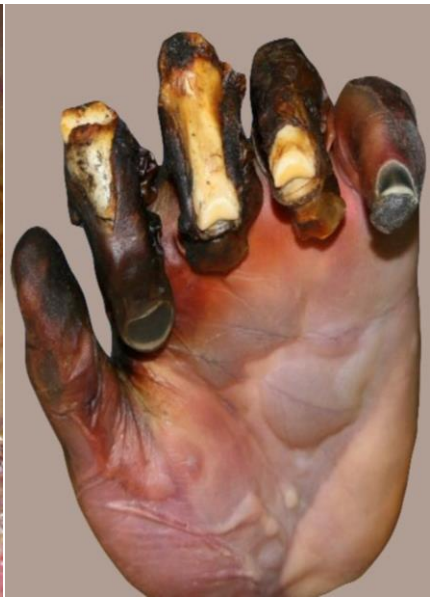
Superficial partial thickness (2a)



Deep partial thickness burn (2b)



Full thickness burn (3rd-degree)



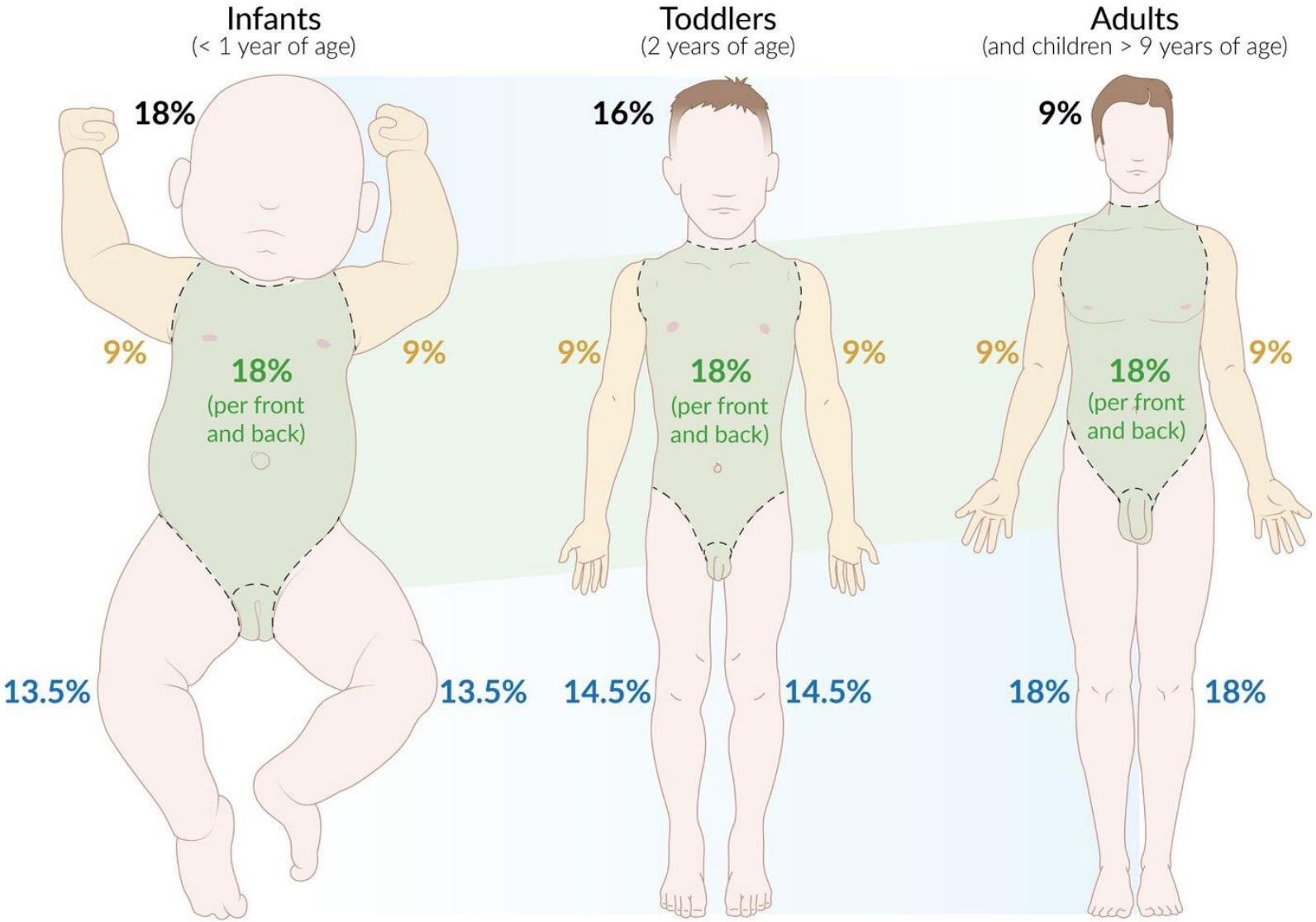
Deeper injury burn (4th-degree)

Assessment of burn surface area involvement

TBSA is calculated using tools such as the Lund-Browder chart and the rule of nines to assess the severity of the skin condition

- **Rule of nines**
  - A clinical tool used to rapidly assess the extent of body surface area affected by burns in adults
  - Divides the adult body's surface into 11 regions (head/neck, 2x anterior trunk, 2x posterior trunk, each arm, 2x each leg), each of which comprises ~ 9% of the total body surface. or plus 1% for the genital/perineal region
  - The rule of nines does not accurately account for pediatric proportions in children.
- **Lund-Browder chart**
  - A set of charts that take into account the different proportions of children and adults (children have proportionally up to 20% larger heads and up to 13% smaller legs) to more precisely estimate the burn surface area involved.
  - Most accurate method for both adults and children
- **Palmar method**
  - A method of calculating TBSA using the palm as a unit of measurement to account for different proportions. (A person's palm represents approx. 1% of the total body surface area)
  - Least reliable method

Rule of nines



Burn severity is assessed based on burn depth, TBSA, location, and cause.

	Criteria	Management
Minor burn	• Partial thickness burns < 10% TBSA in adults • Partial thickness burns < 5% TBSA in children or older adults • Full thickness burns < 2% TBSA in any patient without other injuries	Outpatient care

Moderate burn	• Partial thickness burns 10–20% TBSA in adults
	• Partial thickness burns 5–10% TBSA in children or older adults
	• Full thickness burns 2–5% TBSA
	• Any of the following:
	  • Low-voltage electrical burn
	  • Suspected inhalation injury
	  • Circumferential burn
	  • Comorbidities that increase infection risk (e.g., diabetes mellitus)
		Hospitalization admission

Major burn	• Partial thickness burns > 20% TBSA in adults
	• Partial thickness burns > 10% TBSA in children and older adults
	• Full thickness burns > 5% TBSA
	• Any of the following:
	  • High-voltage electrical injury
	  • Chemical burns
	  • Inhalation injury
	  • Burn to the face, eyes, ears, hand, feet, genitalia, or perineum
	  • Burns around major joints
	  • Other concomitant significant trauma (e.g., fractures)
		Burn center

Inhalation injury

- **Definition**: damage to the respiratory tract that occurs due to the inhalation of hot smoke and/or noxious gases
- **Epidemiology**
  - Occurs in ~10% of burn patients
  - Present in ~70% of patients who die of their burn injury
- **Etiology**: inhalation of hot smoke, particles (< 1 µm diameter in size), and/or irritant/noxious gases (e.g., ammonia, chlorine)
- **Inhalation injury can be divided into three categories**
  - **Injury above the glottis**: from inhalation of superheated air
  - **Injury below the glottis** : smoke particles damaging large airway epithelium
  - **Carbon monoxide CO poisoning**: CO will shift oxygen disassociation curve to the left and create tissue hypoxia, occurs because CO has 200 times affinity for hemoglobin compared to O2

Inhalation injury

- **Diagnostics**
  - **Inhalation injury should be suspected when any of the following are present:**
    - History of being in a confined space
    - Facial burns, singed eyebrows and/or nose hair, evidence of soot on the face or in the airway
    - Stridor, dysphonia
    - Extensive burns
  - **In suspected inhalation injury, the following tests should be performed:**
    - Bedside respiratory function tests to rule out airway obstruction
    - Chest x-ray to rule out ARDS
    - Carboxyhemoglobin levels
    - End-tidal CO2 (ETCO2), serum lactate
    - Fluorescein eye examination is mandatory for patients with facial burns
    - **Definitive diagnosis**: Flexible fiberoptic laryngoscopy & bronchoscopy: may show mucosal erythema and edema, blistering, ulceration, and/or soot deposition
- **Treatment**: intubation and high-flow (100%) oxygen therapy; because CO half life is 4 hours on room air versus 1 hour on 100% FiO2

Special burn areas

❖ Face

- The central face has deeper skin appendages and excellent blood supply, resulting in a greater healing capacity
- Assessed using the subunit principle: When greater than 50% of a subunit requires grafting, use unmeshed sheet grafts
- Thicker grafts are preferable on the face
- Full thickness graft is the choice
- Facial grafting should be performed less than 2 weeks from the time of injury to decrease scarring

❖ Eyes

- Lid edema usually protects the eyes in the early stages.
- Patients are at risk of corneal exposure and corneal abrasion as edema subsides.
- Fluorescent staining often indicated to assess for corneal abrasions.
- Electrical burn could make glaucoma so consultation is a must.
- Goals: Restore the lid to the proper functional position.
- Covering the inferior margin of the corneoscleral limbus in neutral gaze
- Don’t forget: Ophthalmology consult, Eye lubrication, Tarsorrhaphy, and Definitive surgical correction

Special burn areas

❖Ears

- If no cartilage exposure → split-thickness skin grafting and a bolster are appropriate
- Small amounts of exposed cartilage → debrided to allow primary wound closure
- Large amounts of exposed cartilage→ necessitate vascularized coverage prior to grafting (An ipsilateral temporal-parietal fascia flap is ideal)

❖Hands & feet

- After 5 days of immobilization, ROM exercises should be restarted
- Burns of the feet are managed similarly to hand burns

❖Genital area

- Place burned foreskin into its normal position to prevent paraphimosis.
- Topical antibiotic for several weeks as needed.
- Any remaining open wounds should then be sheet-grafted.
- Early urologist consultation is recommended.

Management of minor burns

- **Management of the burn area**
  - Remove clothing, dirt, and debris.
  - Cool with room-temperature or cool running water.
- **Wound care**
  - Irrigation: cleaning the wound with mild soap and water
  - Topical moisturizers (e.g., calamine lotion, aloe vera-based gels): symptom relief for 1st-degree burns
  - Consider antiseptic ointments (e.g, silver sulfadiazine) or topical antibiotics (e.g., bacitracin) for 2nd-degree burns.
- **Wound dressing**: indicated in 2nd-degree burns
  - Types of dressings (e.g., paraffin-impregnated gauze, hydrocolloid dressings, biosynthetic dressings)
  - Wet-to-dry dressing: for infected wounds or wounds with devitalized tissue
- **Pain management**: oral NSAIDs, acetaminophen
- **Prophylaxis**: tetanus vaccination

Management of moderate and major burns

1. **Initial management (ABCDE approach)**
   - **Airway**: Intubation is indicated if an inhalation injury is suspected or if burns involve > 30% TBSA
   - **Breathing**: Administer 100% oxygen, if carbon monoxide poisoning is suspected
   - **Circulation**: Fluid resuscitation with crystalloids is indicated to ensure sufficient perfusion in patients with major burns
     - Lactated Ringer solution (LR) is preferred over hypertonic saline (HTS) because HTS may cause hyperchloremic metabolic acidosis
     - The volume for 24 hours of initial fluid therapy with LR is calculated using the Parkland formula: 4 mL x [% of TBSA affected by 2nd- and 3rd-degree burns] x weight (in kg).
     - After initial stabilization, patients who require aggressive fluid resuscitation should undergo urethral catheterization to monitor urine output and adjust fluids accordingly
       - Target rate: urine output of 0.5 mL/kg/h in adults and 1 mL/kg/h in children < 30 kg.
     - Because fluid resuscitation can worsen laryngeal edema, intubation should be performed as early as possible, if necessary.

Fluid resuscitation

- Because of the risk of serious complications from over resuscitation (e.g., pleural effusion and compartment syndrome), recommend adjusting the Parkland formula as follows:
  - Individuals ≥ 14 years of age: half the volume calculated using the Parkland formula
  - Individuals < 14 years of age who are ≥ 30 kg: initial fluid therapy with LR for a 24-hour period using 3 mL x [% of TBSA affected by 2nd- and 3rd-degree burns] × weight (in kg)
  - Children < 30 kg: 24 hours of initial fluid therapy followed by 24 hours of maintenance fluid therapy with a glucose-containing solution is required
- Half of the recommended fluid volume should be administered within the first 8 hours and the remaining half over the course of the next 16 hours.

Management of moderate and major burns

2. Subsequent management
   - Wound care
     - Early debridement of necrotic tissue
       - Initial debridement of blisters should be performed at the bedside prior to initial wound dressing
       - Formal debridement and grafting in the operating room is performed after adequate resuscitation and when the patient is hemodynamically stable
       - Early debridement can prevent burn wound infection; the first debridement (formal) is often within 2 to 4 days of injury
       - For large burns, sequential debridement and grafting is appropriate
       - Ideally, all burn wounds would be grafted by 3 weeks to prevent hypertrophic scar formation that led to form fibrotic bands that lead to contractures, however, in very large burns, it is important to perform early escharotomies to remove the large bioburden of dead tissue
       - Tangential excision allows sequential excision of thin layers of nonviable tissue until bleeding, healthy tissue is reached

Management of moderate and major burns

2. Subsequent management
   - Wound care
     - Topical antibiotics
       - Silvadene (1% silver sulfadiazine)
       - Sulfamylon: 10% mafenide acetate (a carbonic anhydrase inhibitor)
       - Silver nitrate (0.5%)
       - Acticoat a silver impregnated
       - Bacitracin zinc
     - Wound dressing depends on specific burn characteristics. Options include:
       - Free-skin grafts (split thickness or full thickness)
         - Autograft: It is tissue transfer from one location to another on the same patient
         - Isograft: Tissue transfer between two genetically identical individuals: monozygotic twins
         - Allograft (Homograft): Tissue transfer between two genetically different members
         - Xenograft (Heterograft): The donor and recipient are of different species
       - Flap reconstruction with free or pedicled flaps

Grafting

	Definition	Advantages	Disadvantages
Partial Thickness Graft	It is removal of full epidermis plus part of dermis from the donor area, leaving some skin appendages in the remaining dermis.	• It is technically easier • Graft take up is better • Donor area heals on its own	• Infection • Contracture • Loss of hair growth • hematoma formation will prevent graft take up
Full Thickness Graft	A full-thickness skin graft (FTSGs) removes epidermis and the entire thickness of the dermis and leaves a donor defect (which needs to be sutured or grafted)	• Color match is good • Sensation and function of sebaceous gland, hair follicles retained better	• Used only for small areas • Wider donor area has to be covered with SSG

Grafting

- **Meshing**
  - Is typically performed at a 1:1.5 ratio to increase surface area and decrease fluid collection beneath the graft
  - Meshing decrease hematoma and seroma
  - Higher mesh ratios (e.g., 1:2, 1:3, or 1:4) can be used but prolong healing
- **Graft failure**
  - Inadequate wound debridement prior to graft application is the primary cause
  - Quantitative cultures showing more than 105 cells will result in graft loss. (infection)
  - Fluid collection beneath the graft, including hematoma (most common) or seroma.
  - Shear force to graft from inadequate immobilization and compression.
  - Poor nutrition or overall physiologic status

Differences between grafts and flaps

Grafts	Flaps
Depends on recipient site for nutrition	Has own blood supply
Cosmetic may discolor or contract	Better color take, less likely to contract
Less adaptable to weight bearing	More adaptable to weight bearing
Less able to survive on a bed with questionable nutrition	Can be used on a bed with questionable nutrition
Requires pressure dressing	Requires no pressure dressing

Management of moderate and major burns

2. Subsequent management
   - Nutritional support
     - Enteral feeding via a nasogastric or nasoduodenal feeding tube is preferred over parenteral.
     - Early initiation of nutritional support helps to control the hypermetabolic response.
       a. The metabolic rate is proportional to the size of the burn, up to 60% TBSA, and remains constant thereafter.
       b. This response begins soon after injury, reaching a plateau by the end of the first week.
       c. Most burns >30% TBSA require intensive nutritional support until wound healing is complete.
       d. Curreri formula for caloric requirements: 24-hour caloric requirement = (25 kcal × kg body weight) + (40 kcal × %TBSA).
       e. Protein requirements: 2.5 to 3 g/kg/day are recommended. In children, requirements are 3 to 4 g/kg/day

Management of moderate and major burns

2. Subsequent management
   - Pain management: NSAIDs, opioids
   - Anxiety management: benzodiazepines
   - Prophylaxis
     - Proton pump inhibitors or H2 antagonists: curling ulcer prophylaxis
     - Vaccination: tetanus prophylaxis
     - Antibiotic therapy: Routine prophylactic systemic antibiotic therapy is not recommended.
       - If infection or sepsis occur, treat empirically (e.g., with vancomycin) until MRSA can be ruled out.
       - Treat for Pseudomonas (e.g. with cefepime) if suspected.
   - Supportive measures: physical therapy