Trauma Management

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- Injuries and violence affect everyone, regardless of age, race, or economic status
- About a quarter of all the emergency department visits are due to injuries.
- Young males are the highest risk groups, due to the propensity to engage in high-risk activities.
- Factors that increase risk taking and impair judgment (e.g., alcohol, drugs, crime, conflicts) further increase the chances to get injured.

Head Trauma

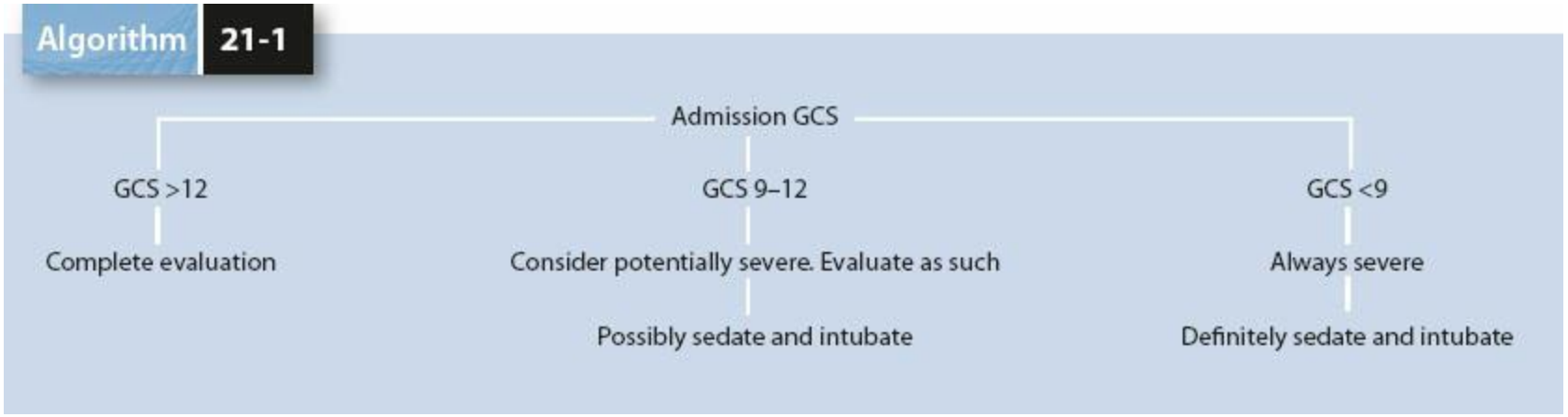
- In the field of trauma, other than for exsanguinating injuries, traumatic brain injury (TBI) is the injury most commonly responsible for mortality, accounting for about half of deaths at the scene.
- Traumatic injury to the brain involves a primary brain injury that occurs at impact and leads to disruption of brain substance and blood vessels. In addition, secondary brain injury may result from hypoxia, hypotension, hyperventilation, pyrexia, the effects of increased intracranial pressure (ICP), and altered cellular biochemical processes that are often ongoing long after the primary insult.

Management

- It includes establishing adequate oxygenation, ventilation, and circulatory stability and evaluating the extent of brain injury while treating ICP elevations.
- Although some evidence indicates that **systemic hypotension** may infrequently be the result of a head injury, always initially presume that hypotension in a trauma patient is the result **of hypovolemia**.
- It should be presumed that any change in mental status or the neurologic examination in general, or any evidence of herniation (e.g., anisocoria), suggests **an expanding intracranial mass lesion**. Under such circumstances, **therapeutic ICP reduction** becomes the **first priority** and diagnostic imaging or surgical decompression must be accomplished emergently.
- Do not assume that apparent neurologic unresponsiveness represents a lack of sensitivity to pain. Noxious stimuli, such as placement of urinary drainage catheters, nasogastric tubes, or IV catheters, can precipitate ICP peaks during resuscitation. These procedures should be done quickly and efficiently, optimally after sedation.

- The key parameters in assessment are level of consciousness, pupillary reflexes and size, and the motor examination.
- Glasgow Coma Scale

The single most important assessment for a patient with head injury is to evaluate the level of consciousness.



Pupils

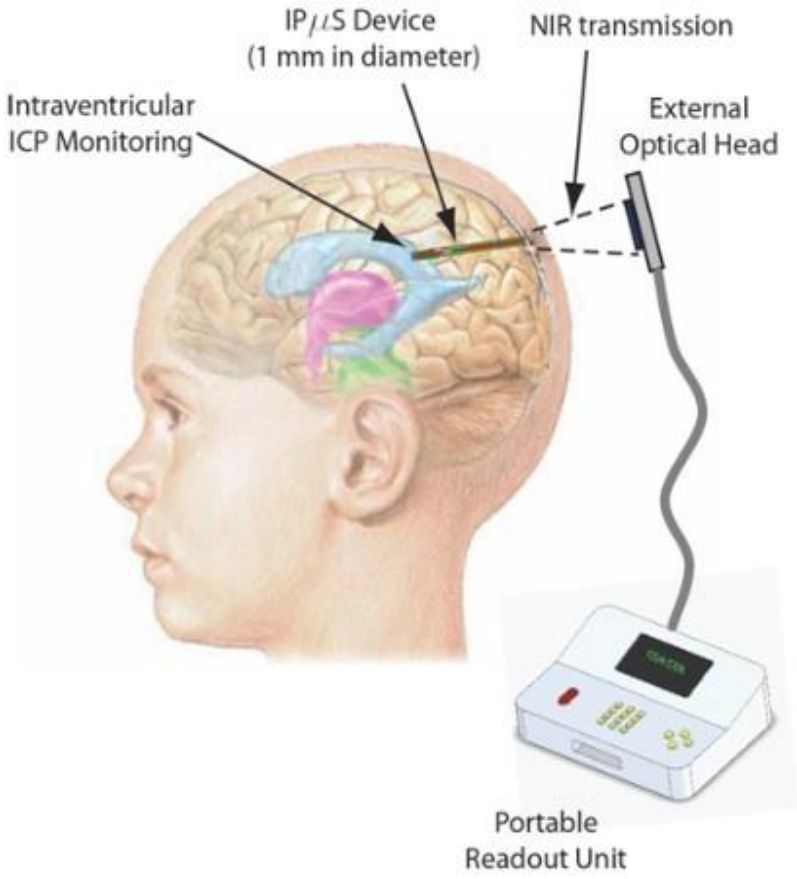
- Pupillary asymmetry, dilation, or loss of light reflex in an unconscious patient usually reflects herniation because of the mass effect from intracranial hemorrhage ipsilateral to the dilated pupil so in these cases rapid lowering of ICP is essintial.

Motor examination

- The motor system is examined for **asymmetry**, **abnormal posturing, or lack of movement**. Hemiparesis, paraparesis, or quadriparesis suggests a cervical or thoracolumbar spine fracture with spinal cord injury. Hemiparesis secondary to brainstem herniation from the mass effect may be either ipsilateral or contralateral to the side of the dilated pupil or an intracranial mass lesion. Hemiparesis may also result from significant brain contusion.
- In the unconscious patient, a painful stimulus should be used to evaluate motor function. All four extremities should be examined and the results noted, because only the response of the best limb will be reflected in the GCS score.

ICP Monitoring

- All patients with survivable, severe brain injuries and a significant percentage of those with moderate injuries require continuous ICP monitoring
- Although many techniques are available, the most common involve **small fiberoptic** or **strain gauge catheter** tip pressure sensors placed several millimeters into the brain or fluid-coupled catheters placed into the lateral ventricles
- Monitoring ICP not only provides early warning of **herniation** but also, by allowing **calculation of CPP**(Cerebral perfusion pressure), it opens up the possibility of more precisely *optimizing cerbral blood flow* and *preventing ischemic secondary brain injury*
- In hospital settings where ICP monitoring is not possible, recent evidence suggests that **hourly neurologic examination** by a physician may serve as a proxy for ICP monitoring
- it's reccomended that CPP should be kept in a physiologically normal range of 50 to 70 mm Hg , a CPP less than 50 mm Hg should be avoided.
- since CPP is calculated from MAP – ICP, a low CPP may be a result of *low MAP* and/or *elevated ICP*. Interventions taken to address low CPP must therefore be targeted at the relevant component : *blood pressure support in case of low MAP, and ICP reduction for elevated ICP*.



Radiology

- Prompt radiographic evaluation is essential and **CT scanning** is the imaging modality of choice for virtually all acute neurologic conditions.
- **Hemodynamically stable patients** with significant neurologic deterioration should go to the CT scanner immediately following ATLS resuscitation.
- **In hemodynamically unstable patients who** require immediate surgical intervention to sustain intravascular volume, lifesaving exploratory thoracotomy or laparotomy must take precedence. In such cases, it is a mistake to delay further investigation of the intracranial compartment pending the end of the case and transport to the CT scanner.
- Plain radiography is not useful.

- The **CT finding** that correlates most highly with intracranial hypertension is *compression or obliteration of the basilar cisterns*
- also the **primary predictor** of outcome in patients with this CT picture is the peak level of *intracranial hypertension occurring during the first 72 hours*.
- When cisternal compression is paired with a **midline shift of more than 5 mm**, the prognosis is even more ominous. **ICP monitoring** should be **immediately initiated** in any patient with cisternal compression and **intracranial hypertension** should be vigorously treated.
- Such patients, particularly those with **minimal evidence of contusions**, die primarily from *secondary brain insults*, which implies that they are potentially salvageable.

CT head immediately

- GCS < 13 on initial assessment
- GCS < 15 at 2 hours post-injury
- Suspected open or depressed skull fracture
- Any sign of basal skull fracture (haemotympanum, 'panda' eyes, cerebrospinal fluid leakage from the ear or nose, Battle's sign)
- Post-traumatic seizure
- Focal neurological deficit
- More than 1 episode of vomiting

CT head scan within 8 hours of the head injury

For adults with any of the following risk factors and who have experienced some loss of consciousness or amnesia since the injury:

- Age 65 years or older
- Any history of bleeding or clotting disorders
- Dangerous mechanism of injury (a pedestrian or cyclist struck by a motor vehicle, an occupant ejected from a motor vehicle or a fall from a height of greater than 1 metre or 5 stairs)
- More than 30 minutes' retrograde amnesia of events immediately before the head injury

Note : If a patient is on warfarin and has sustained a head injury with no other indications for a CT head scan, then perform a CT head scan within 8 hours of the injury.

Table 25.2 Discharge criteria in minor and mild head injury.

GCS 15/15 with no focal deficits
Normal CT brain if indicated (see below)
Patient not under the influence of alcohol or drugs
Patient accompanied by a responsible adult
Verbal and written head injury advice: seek medical attention if:
• Persistent/worsening headache despite analgesia
• Persistent vomiting
• Drowsiness
• Visual disturbance
• Limb weakness or numbness

CT, computed tomography; GCS, Glasgow Coma Scale.

Skull Fractures

- Skull fractures are a common result of head trauma and, when closed and not displaced, rarely require treatment.
- *Closed depressed* skull fractures that are *comminuted* and those with a *fragmented outer margin displaced* beneath the inner table have characteristically been treated surgically. *Open fractures* are also generally treated surgically.
- When surgery is indicated, the *primary goal is to avoid infection* by containing CSF, and *closing the wound in a manner to ensure healing*. Cosmesis is a secondary consideration.
- Once a fracture has been determined to be operative, early **operation is recommend to reduce the incidence of infection**.
- All management strategies for open (compound), depressed fractures should include **antibiotics regardless of whether surgery is undertaken.**
- The general tendency is the use of broad-spectrum antibiotics for 5 days if soft tissue coverage is achieved.

- **Basilar skull fractures** are usually diagnosed with CT imaging or on clinical evidence, as they are poorly visualized on plain films
- Clinical signs include otorrhea or rhinorrhea, subcutaneous ecchymoses overlying the mastoid region (Battle sign), bilateral periorbital ecchymoses (raccoon eyes), or hemotympanum and it may involve the paranasal sinuses, piriform sinus, petrous bone, sphenoid sinus, or sella turcica.
- In the acute CSF leak, no specific therapy is indicated
- *Antibiotics should not be administered* solely for prophylaxis of meningitis. Most CSF leaks stop spontaneously with minimal treatment (e.g., elevating the head of the bed)

Epidural Hematoma

- Results from rupture of an artery, vein or venous sinus, in association with a skull fracture. *Typically, it is damage to the middle meningeal artery under the thin temporal bone.*
- *A low energy injury mechanism, perhaps with brief loss of consciousness, is sufficient to start the extradural bleeding.*
- The patient may then present in the subsequent *lucid interval* with *headache*, but *without any neurological deficit.* At this stage, the increase in the intracranial volume is not yet causing a significant rise in intracranial pressure because compensation is occurring. However, once the limits of compensation have been reached after as long as some hours rapid deterioration follows.
- There is *contralateral hemiparesis*, *reduced conscious level* and *ipsilateral pupillary dilatation*, the cardinal signs of brain compression and herniation.
- Although this classical presentation occurs in only one third of cases, it emphasises the potential for rapid avoidable secondary brain injury in patients with minimal primary injury.

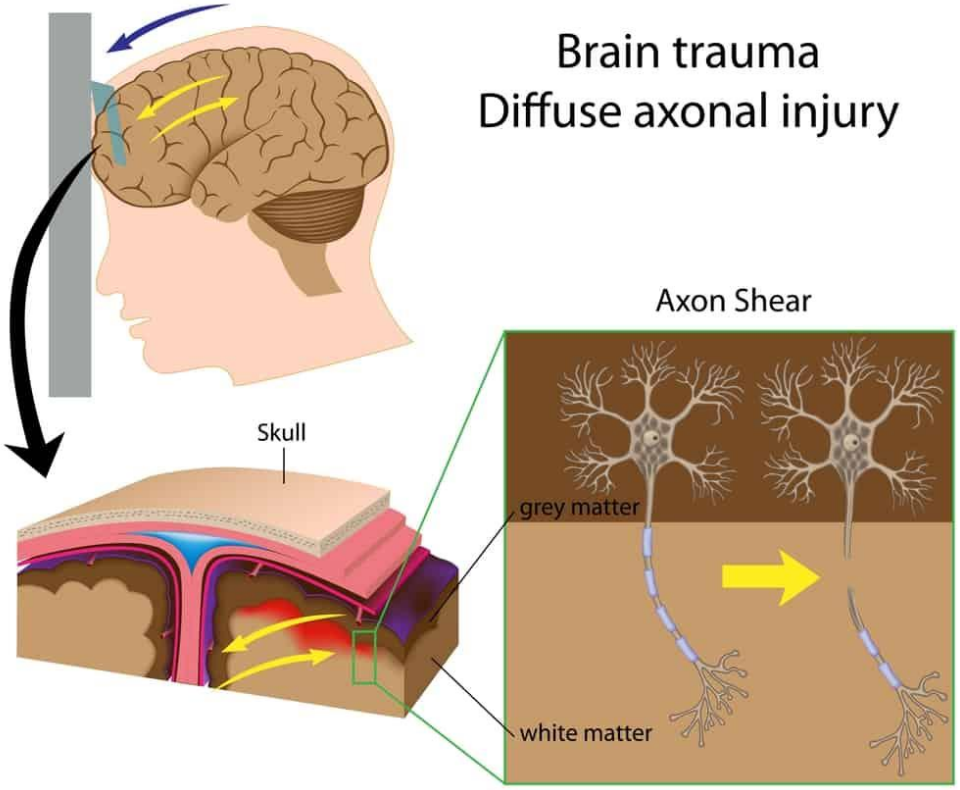
- On CT, extradural haematomas appear as a *lentiform (lens shaped or biconvex) hyperdense lesion* between skull and brain, constrained by the adherence of the dura to the skull.
- Mass effect may be evident, with compression of surrounding brain and midline shift.
- Areas of mixed density suggest active bleeding. A skull fracture will usually be evident.
- Extradural haematoma requires immediate transfer to the most accessible neurosurgical facility, for immediate evacuation in deteriorating or comatose patients or those with large bleeds, and for close observation with serial imaging in all cases.
- Overall mortality is around 10–20 per cent, but is considerably lower in isolated extradural haematoma.

Subdural hematoma

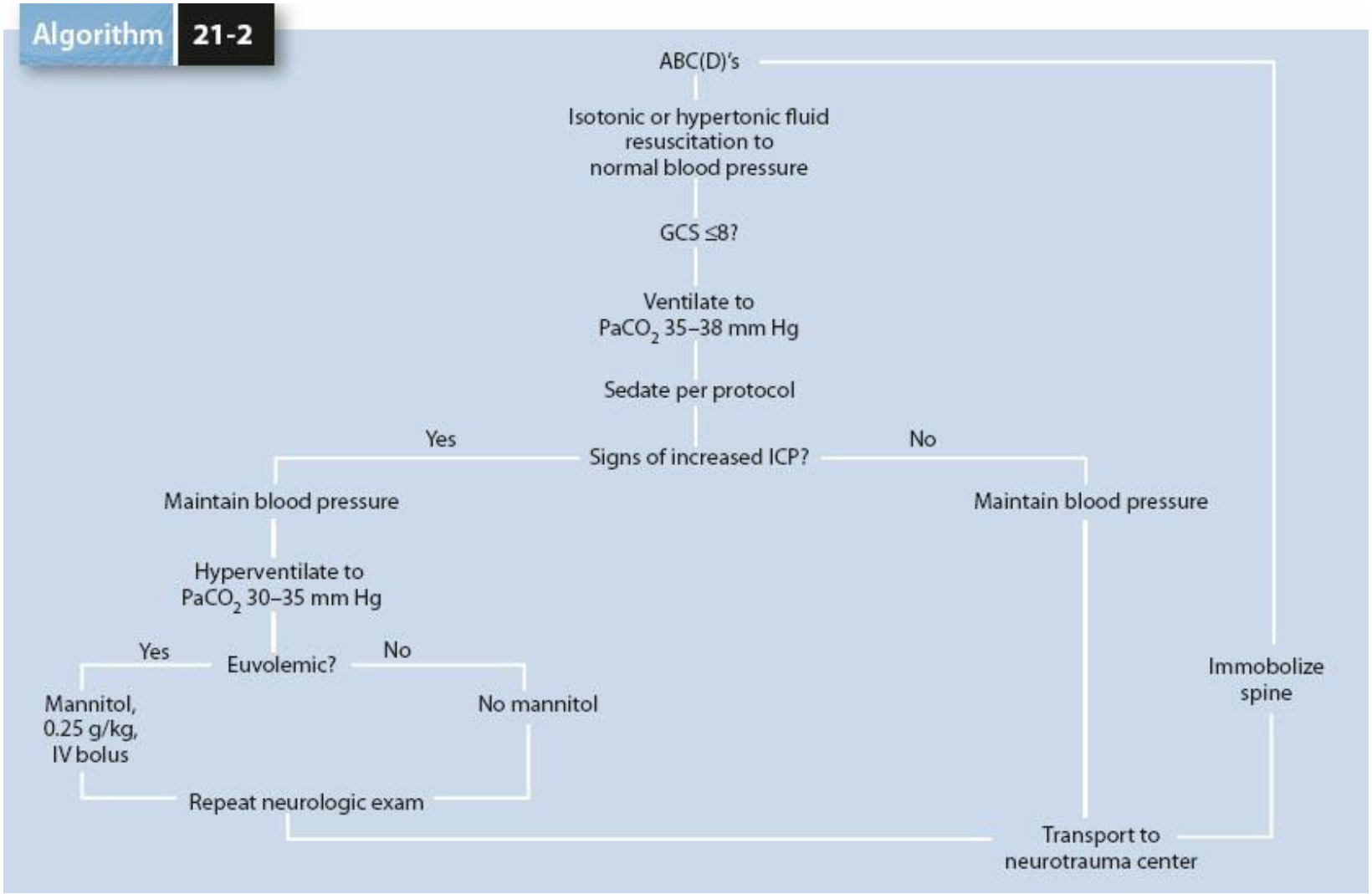
- Results from tears in bridging veins that cross the subdural space
- Relatively severe trauma
- No lucid interval
- Diffuse concave lesion on computed tomography
- Require immediate transfer to a neurosurgical unit for decision on evacuation
- 50% mortality

Diffuse axonal injury DAI

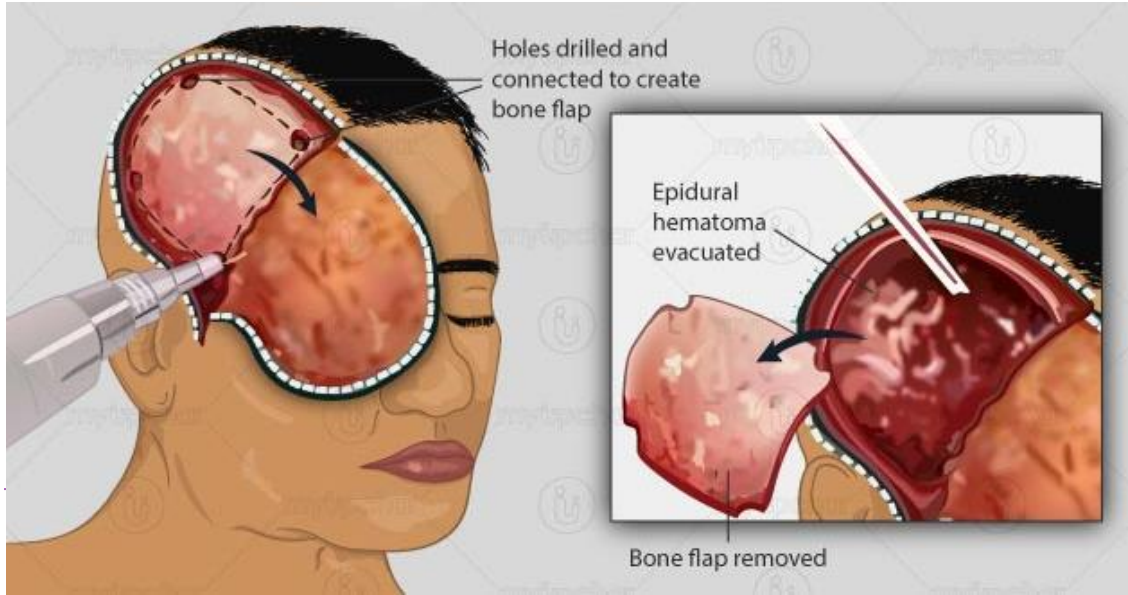
- A form of traumatic brain injury.
- It happens when the brain rapidly shifts inside the skull as an injury is occurring.
- Axons are sheared as the brain rapidly accelerates and decelerates inside the skull.
- DAI typically causes injury to many part of the brain, and people who suffer a DAI are usually left in a coma.
- The changes in the brain are often very tiny and can be difficult to detect using CT or MRI scans.



Management


Algorithm 21-2
ABC(D)'s
Isotonic or hypertonic fluid resuscitation to normal blood pressure
GCS ≤8?
Ventilate to $PaCO_2$ 35–38 mm Hg
Sedate per protocol
Signs of increased ICP?
Yes
No
Maintain blood pressure
Maintain blood pressure
Hyperventilate to $PaCO_2$ 30–35 mm Hg
Euvolemic?
Yes
No
Mannitol, 0.25 g/kg, IV bolus
No mannitol
Repeat neurologic exam
Immobolize spine
Transport to neurotrauma center

- When ICP control does not respond to medical management steps, surgical management must be considered. Indeed, with each escalation in medical therapy, surgical intervention should be considered: large mass lesions, for example, or widespread cerebral contusions will often require eventual surgical decompression, so it is preferable to operate before all medical options are exhausted.
- In the eventuality that lower-tier interventions have been unsuccessful at controlling intracranial hypertension, decompressive hemicraniectomy should be considered. By effectively expanding the intracranial volume, decompressive hemicraniectomy allows the swollen brain additional room to expand and can improve ICP.

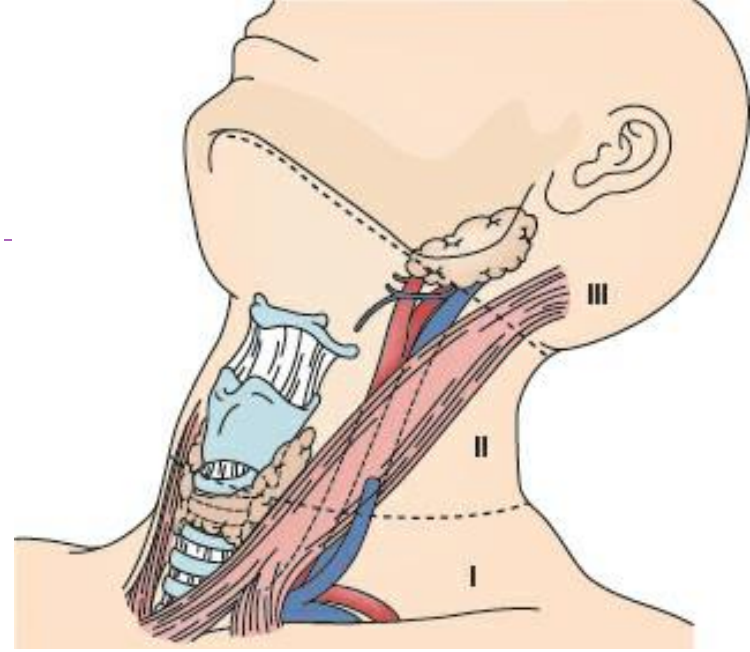


Neck Trauma

Anatomy

Neck zones

- The zones of the neck are important as the **approach to injury within each zone is different.**
- All major vascular structures in **zone II** can be readily accessed via a standard **sternocleidomastoid neck incision**. Via a single incision, proximal and distal vascular control can both be obtained within zone II and injuries repaired
- **proximal control for zone I injuries** requires control within the chest. A variety of incisions can be used depending on the location of the injury
- **Proximal control for zone III injuries** can be obtained in zone II without much difficulty. However, **distal control** may be very difficult as the mandible and skull base prevent wide exposure



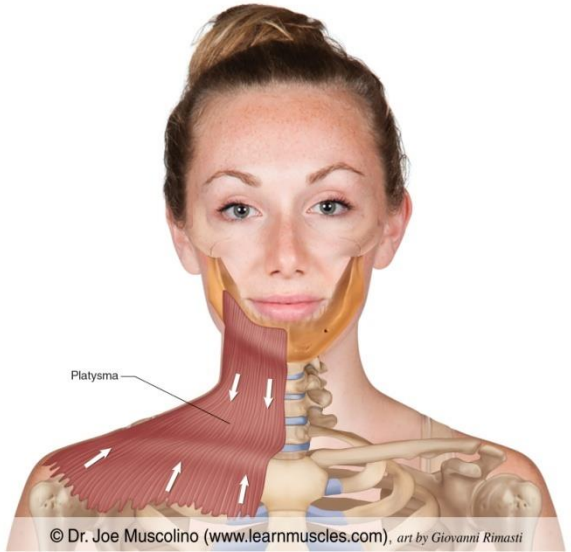
Zone I : Injuries here carry the highest mortality rate because of the risk of major vascular and intrathoracic injury.

Zone II :injuries are most common but carry a lower mortality rate than either zone I or III injuries, because injury is usually apparent and exposure of vital structures is readily accomplished.

Zone III: the risk of injury to the distal carotid artery, salivary glands, and pharynx is greatest in this zone. Exposure in this region can be particularly difficult.

Platysma

- The other major anatomic landmark in the neck is the platysma muscle. This **thin, broad muscle lies just beneath the skin and covers the entire anterior triangle and antero-inferior aspect of the posterior triangle**. Wounds that fail to penetrate the platysma are considered superficial and do not warrant extensive evaluation. Wounds that penetrate the platysma must be considered a serious surgical problem that mandates hospital admission and further evaluation.



Management

- Initial priority is given to securing the **patient's airway**. Every patient with a neck injury should be considered for early airway control.
- Even in seemingly stable and hemostatic patients, rebleeding can produce sudden and disastrous symptoms and sequlae. An airway that had previously been straightforward to control is now much more complicated and may require advanced techniques.
- Obvious injury to the neck, with the presence of an **expanding hematoma or other hard signs of vascular injury**, should lead the provider to obtain *definitive endotracheal access as the first step* in the resuscitation. Similarly, **air bubbling through the wound, hoarseness, or an obviously transected trachea,** should guide the treatment team toward immediate and definitive airway control.
- In the event that orotracheal intubation cannot proceed (rapidly expanding hematoma, destructive laryngeal trauma, patient habitus, excessive debris within the oropharynx, etc.); an emergent surgical airway should be expeditiously obtained. Cricothyroidotomy and emergency tracheostom remain the safest and most reliable methods of emergent surgical control of the airway.

- Concurrent with airway control is awareness of potential cervical spine injury, particularly in unconscious patients who have sustained blunt head and neck trauma. **The head and neck should be supported in the neutral position until this possibility is excluded radiographically and by physical examination.**
- In the emergency room, support of the head and neck during manipulation or procedures is best accomplished by a strong, steady assistant rather than by collars, sandbags, or tape. The lateral cervical spine film is an essential component of the initial evaluation of patients with either blunt or penetrating neck trauma, both to assess the bony cervical spine and to evaluate soft tissues for edema or malplaced air.
- Penetrating injuries to the neck, with hard signs of injury (**pulsatile hemorrhage, expanding hematoma, shock, air emanating from the wound, massive hemoptysis**), *mandate immediate surgical exploration.*
- In the absence of these hard signs of injury, most favor a *selective approach with clinical examination and diagnostic radiographs*.

Radiology

- **computed tomography (CT)** has become much more widely used to evaluate the possibility of neck injury
- CT is extremely attractive as it is a single study that is rapidly available in virtually every center and provides a three-dimensional evaluation of the neck.
- In patients with injury patterns that put the *upper mediastinal structures at risk as well*, CT can evaluate both areas for potential injury, simultaneously. CT may be very effective at excluding injuries in some cases.

- Unstable Patient:

Immediate surgical exploration in the OR for patients who present with signs and symptoms of shock and continuous hemorrhage from the neck wound. Surgical management varies by zone; zone I and zone III are difficult to expose making vascular control problematic, leading to higher mortality in zone I and III.

- Stable Patient:

The laceration should never be probed or locally explored in the emergency department if platysma is violated. This could dislodge a clot and initiate hemorrhage. If no significant injuries requiring surgery are present, surgery is not indicated and the patient should be observed.

Neck-zone I

- **Stable & Symptomatic:** Four-vessel cerebral angiography is indicated and OR for surgical exploration angiography remains the standard for assessing for arterial anatomy and injury
  - CTA possible alternative in these patients
- St**able & Asymptomatic:**
  Angiography, esophagiscopy or esophagram
  - CT considered as replacement

Neck-zone II

- Stable & Symptomatic: OR for exploration

- Stable & Asymptomatic: Observe

CT evaluation considered as adjunct.

Neck-zone III

- **Stable & Symptomatic:** Four-vessel cerebral angiography is indicated and OR for exploration Angiography remains the standard for assessing for arterial anatomy and injury CTA possible alternative in these patients.

- **Stable & Asymptomatic:** Observation
  CT considered as adjunct

- Ferguson et al. suggested angiography is not necessary if no hard vascular signs in zone.

Thoracic Trauma

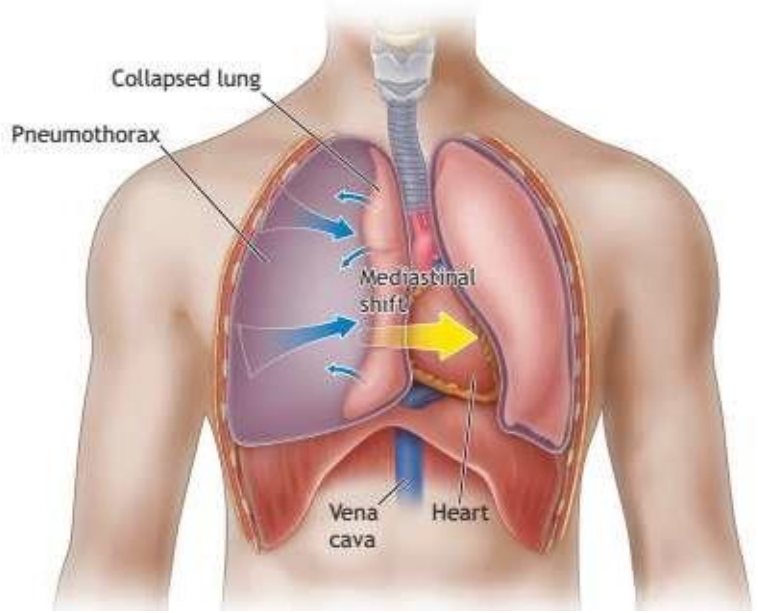
- Thoracic trauma is a common occurrence with an incidence of approximately 25% of all traumas.
- The most common thoracic injury is rib fracture and mortality/morbidity increases as the number of ribs fractured increases.
- Major thoracic injuries can be grouped together as the "fatal 14".
- The lethal six (airway obstruction, tension pneumothorax, open pneumothorax, flail chest with pulmonary contusion, massive hemothorax, and cardiac tamponade) are immediate life-threatening injuries that should be corrected as they are being identified during the primary survey.
- The hidden eight (simple pneumothorax, hemothorax, pulmonary contusion, tracheobronchial tree injury, blunt cardiac injury, traumatic aortic disruption, traumatic diaphragmatic tear, and esophageal rupture) are potentially life-threatening injuries that should be detected during the secondary survey with subsequent definitive treatment.

Manegement

- Airway patency and air exchange should be assessed by listening for air movement at the patient's nose, mouth, and lung fields; inspecting the oropharynx for airway obstruction; and observing for intercostal and supraclavicular muscle retractions. Orotracheal intubation with appropriate cervical spine immobilization and direct laryngoscopy is the most common important first step in establishing a secure airway.
- Breathing complete exposure of the patient's chest and neck allows for assessment of breathing and the neck veins. Signs of chest injury or hypoxia include increased respiratory rate or change in breathing pattern.

Tension Pneumothorax

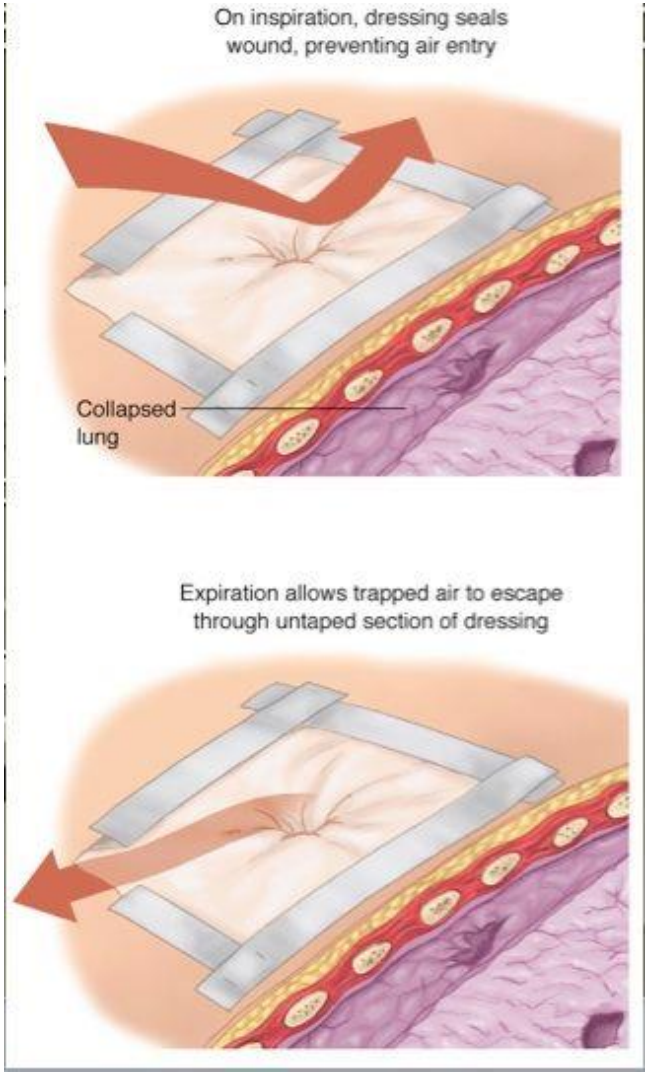
- Tension pneumothorax develops secondary to a bronchopleural fistula (BPF) acting as a one-way valve, allowing for air entry into the pleural space from a defect in the lung parenchyma or airway.
- As a result of the sudden increase of air in the pleural space, **the ipsilateral lung collapses**, and **the mediastinum shifts** to the opposite side. This interferes with **expansion of the contralateral lung and causes accompanying compromise of venous return to the heart.** The associated hypotension is due to impaired filling pressures of the myocardium.
- The most common cause of tension pneumothorax **is positive pressure mechanical ventilation** in patients with visceral pleural injury. It can also occur as a complication of a simple **after penetrating or blunt chest trauma** when the lung parenchyma fails to seal.
- A tension pneumothorax is a clinical diagnosis reflecting air under pressure in the pleural space. In the setting of clinical suspicion and physical signs, treatment should be immediate and not be delayed for a chest radiograph.

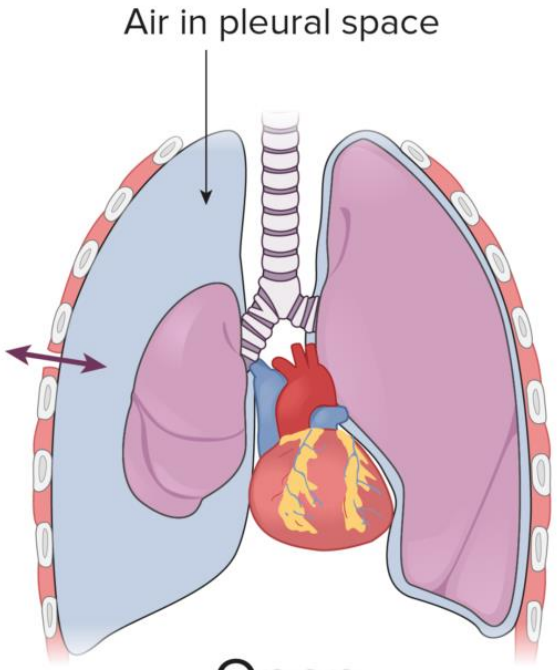


- Signs and symptoms of tension pneumothorax include **chest pain, respiratory distress, tachycardia, hypotension, tracheal deviation, unilateral absence of breath sounds, and neck vein distention.** As these signs are similar to cardiac tamponade, differentiation should be made *by hyperresonance on percussion and absence of breath sounds on the affected side*. Both tension pneumo thorax and massive hemothorax are associated with decreased breath sounds on auscultation. Differentiation on physical examination is made by percussion; hyperresonance confirm a pneumothorax, whereas dullness is present with a massive hemothorax.
- Immediate treatment includes emergency **needle decompression and aspiration,** followed **by chest tube placement**. A standard large-bore intravenous catheter is inserted into the second intercostal space in the midclavicular line of the affected hemithorax. This maneuver converts the injury to a simple pneumothorax. Definitive therapy soon follows in the form of insertion of a chest tube, usually in the fifth intercostal space just anterior to the midaxillary line.

Open Pneumothorax

- **('sucking chest wound')** *this is due to a large open defect in the chest (>3 cm), leading to equilibration between intrathoracic and atmospheric pressure.* Air accumulates in the hemithorax (rather than in the lung) with each inspiration, leading to **profound hypoventilation** on the affected side and **hypoxia**. Signs and symptoms are usually proportionate to the size of the defect. If there is a valvular effect, increasing amounts of air in the pleura will result in a tension pneumothorax
- Initial management consists of promptly closing the defect with a sterile occlusive plastic dressing (e.g. Opsite), taped on three sides to act as a flutter-type valve. A chest tube is inserted as soon as possible in a site remote from the injury site. **Definitive treatment may warrant formal debridement and closure, and early referral**.

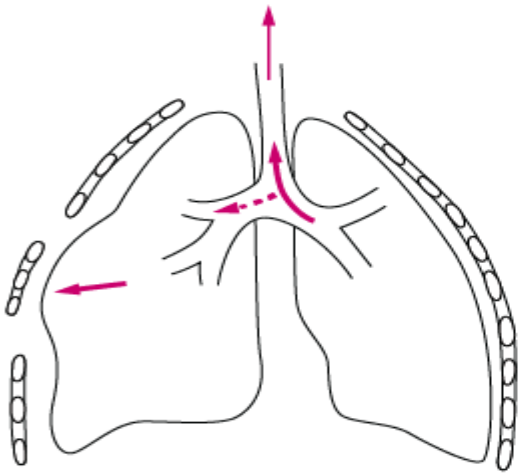




Open pneumothorax

Flail Chest

- This condition usually results from **blunt trauma associated with multiple rib fractures**, and is defined Flapping chest wall; condition in which three or more consecutive ribs on the same side of the chest have been fractured in at least two places, with resulting instability of the chest wall, paradoxic respiratory movements of the injured segment, and loss of respiratory efficiency.The blunt force required to disrupt the integrity of the thoracic cage typically produces an underlying pulmonary contusion as well. The diagnosis is made clinically, not by radiography. On inspiration, the loose segment of the chest wall is displaced inwards and therefore less air moves into the lungs. To confirm the diagnosis, the chest wall can be observed for paradoxical motion of a chest wall segment during respiration and during coughing. Voluntary splinting of the chest wall occurs as a result of pain, so mechanically impaired chest wall movement and the associated lung contusion all contribute to the hypoxia.



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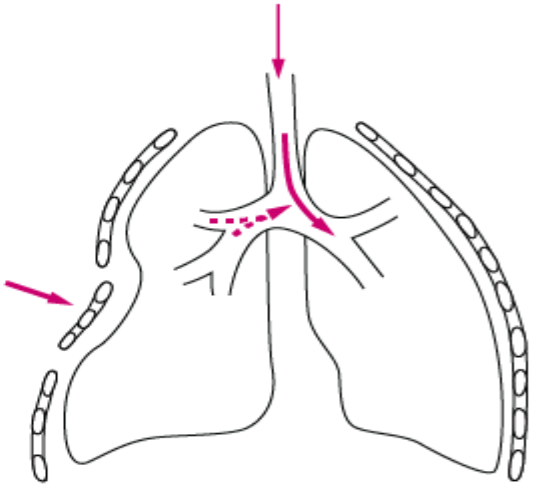
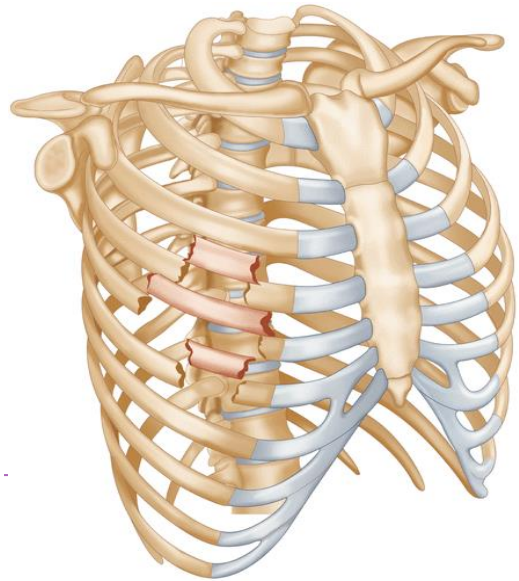
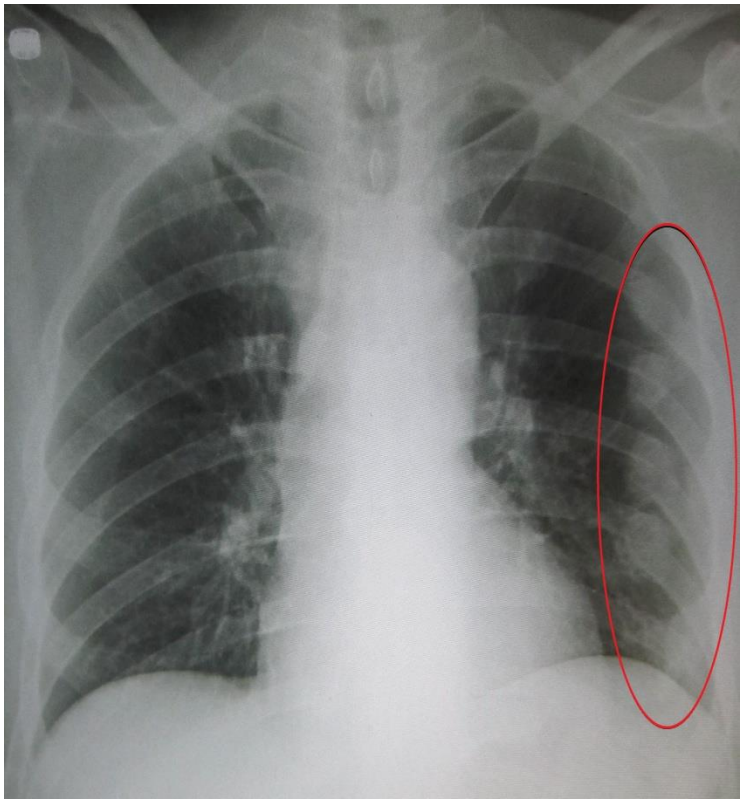


Inspiration



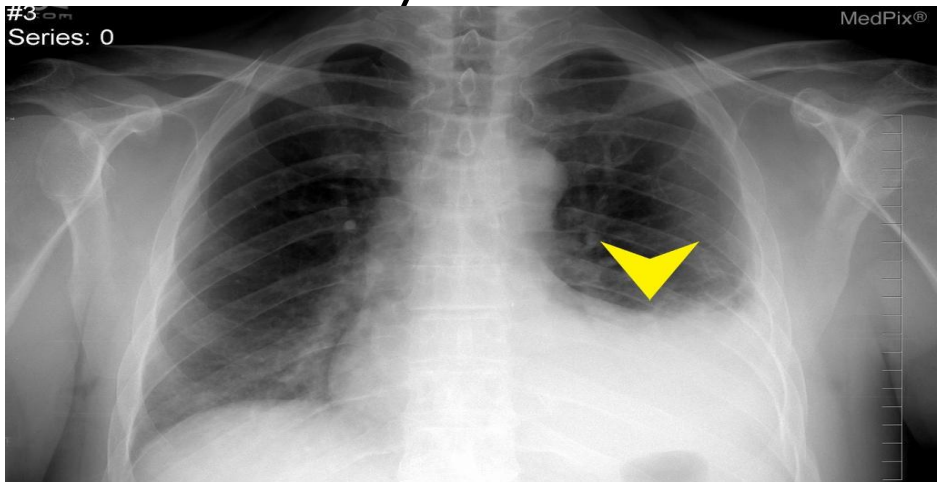
- There is a high risk of developing a pneumothorax or haemothorax. Traditionally, **mechanical ventilation** was used to 'internally splint' the chest, but had a price in terms of intensive care unit resources and ventilation-dependent morbidity. Currently, treatment consists of **oxygen administration, adequate analgesia (including opiates) and physiotherapy.** If a chest tube is in situ, intrapleural local analgesia can be used as well. Ventilation is reserved for cases developing respiratory failure despite adequate analgesia and oxygen. Surgery to stabilise the flail chest may be useful in a selected group of patients with isolated or severe chest injury and pulmonary contusion.



Massive Hemothorax

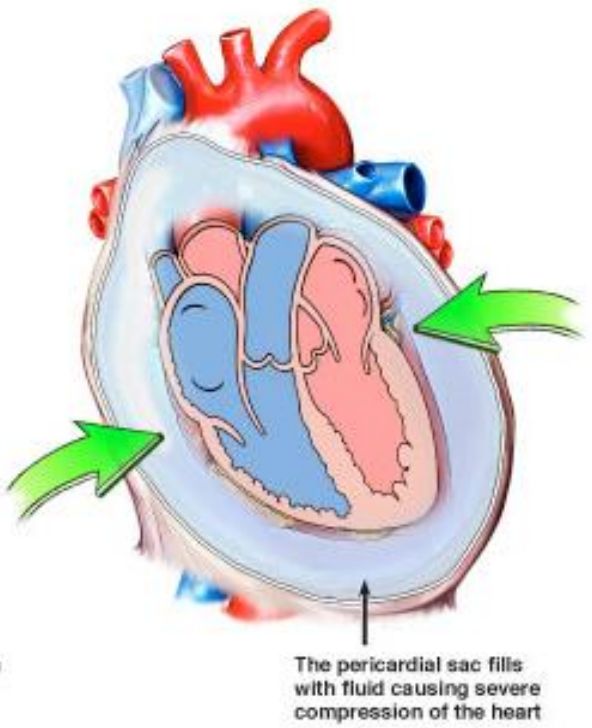
- **Massive hemothorax results from the collection of more than 1,500 mL of blood (30% to 40% of total blood volume) rapidly in the chest.** This occurs most often with a *penetrating wound with a systemic or hilar vessel injury, though it can also occur with blunt trauma*. Penetrating anterior chest wounds medial to the nipple line and posterior wounds medial to the scapula should alert to the likelihood of an injury to the great vessels, hilar structures, and the heart. A massive hemothorax is suspected when shock accompanies *absence of breathsounds and dullness to percussion on one side of the chest*.

- Blood loss is complicated by **hypoxia,** as the significant rapid accumulation of blood in the chest compromises respiratory efforts by mechanically compressing the lung and preventing adequate ventilation. Initial management includes **simultaneous restoration of blood volume along with decompression of the chest cavity with a chest tube to evacuate the blood**. If greater than 1,000 mL of blood is drained by the initial chest tube, an additional tube should be placed to ensure better evacuation and hemostasis and to avoid potential problems from clot formation and occlusion of the initial tube. *Traditional criteria for taking the patient to the operating room (OR) for a thoracotomy are initial output of more than 1,500 mL of blood or continuing blood loss of 200 mL/h for 2 to 4 hours*. *Need for blood transfusions to maintain blood pressure represents hemorrhagic shock and is an indication for thoracotomy*.
- In the OR, evacuated blood can ideally be collected in a device capable of auto-transfusion.



Cardiac Tamponade

- All patients with penetrating injury anywhere near the heart plus shock must be considered to have a cardiac injury until proven otherwise.
- Classically, the presentation consists of *venous pressure elevation, decline in arterial pressure* with *tachycardia, and muffled heart sounds* (Beck Triad).
- The presentation is similar to a tension pneumothorax: *deteriorating cyanosis tachycardia and agitation*
- Ultrasound is diagnostic
- The central venous pressure may not be elevated if the circulating volume is depleted, e.g. because of other injuries
- **Pericardiocentesis is a temporising measure only with a high complication rate** and is not a substitute for immediate operative intervention.
- The correct immediate treatment of tamponade is operative *(sternotomy or left thoracotomy),* with repair of the heart in the operating theatre if time allows or other wise in the emergency room.



Abdominal Trauma

- Unlike the extremity or neck for example, where bleeding occurs externally, for the abdomen, significant bleeding and enteric spillage can occur with minimal symptoms until late.
- Two types of injury:

Blunt injury: A sudden and pronounced rise in intra-abdominal pressure created by outward forces.

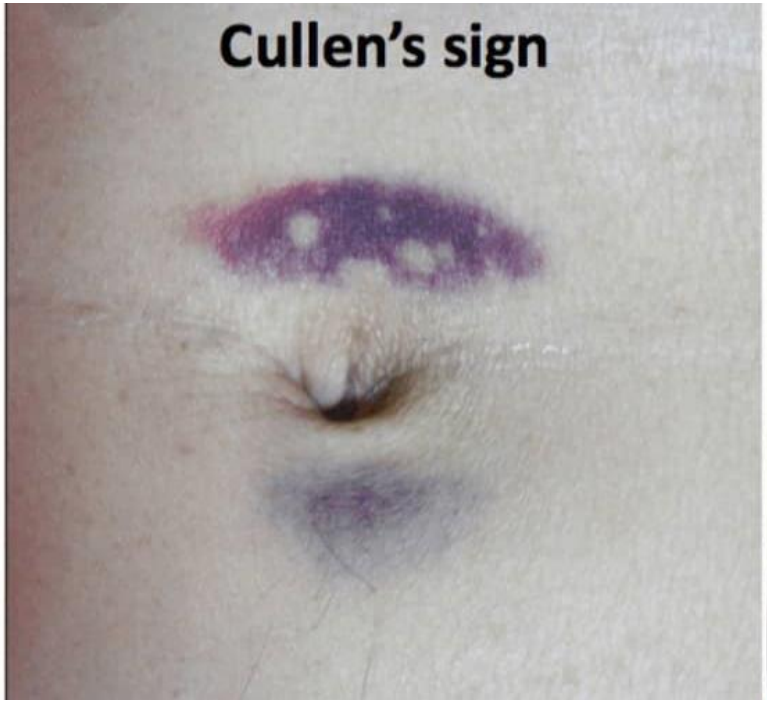
Penetrating injury: an injury caused by a foreign object piercing the skin, which damages the underlying tissues and results in an open wound

Blunt Injury
Physical Examination

- The spleen and liver are the most commonly injured solid organs

- Absence of abdominal pain or tenderness on physical examination does NOT rule out the presence of significant intra-abdominal injury.

- Physical Examination Findings
  - Seatbelt sign
  - Rebound tenderness
  - Hypotension
  - Abdominal distension
  - Abdominal guarding
  - Concomitant femur fracture

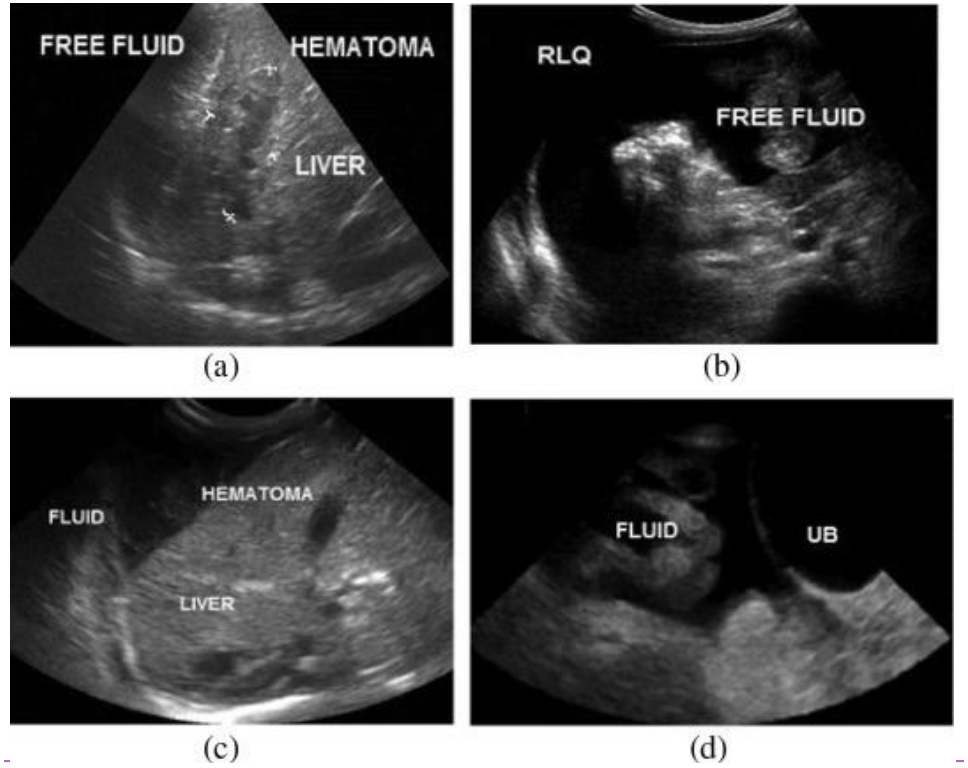

Cullen's sign

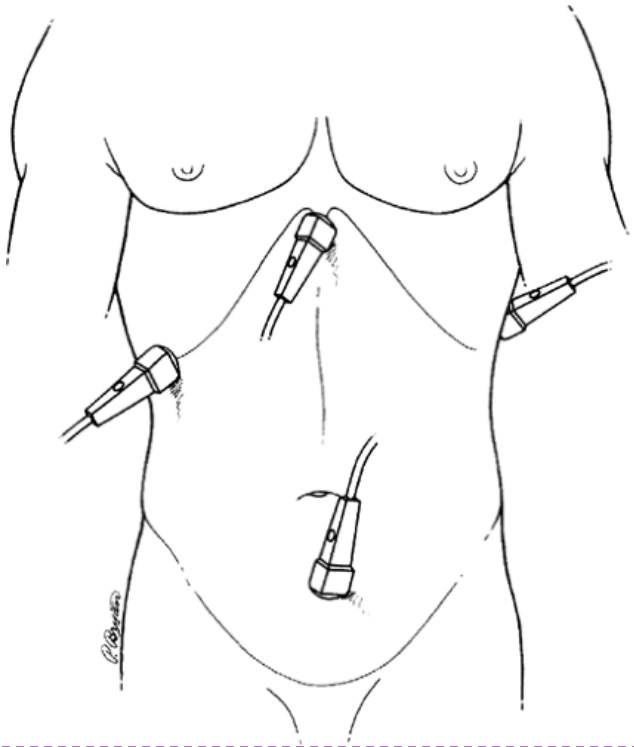

Grey Turner's sign


OLD NAVY
OLD NAVY
OLD NAVY
A

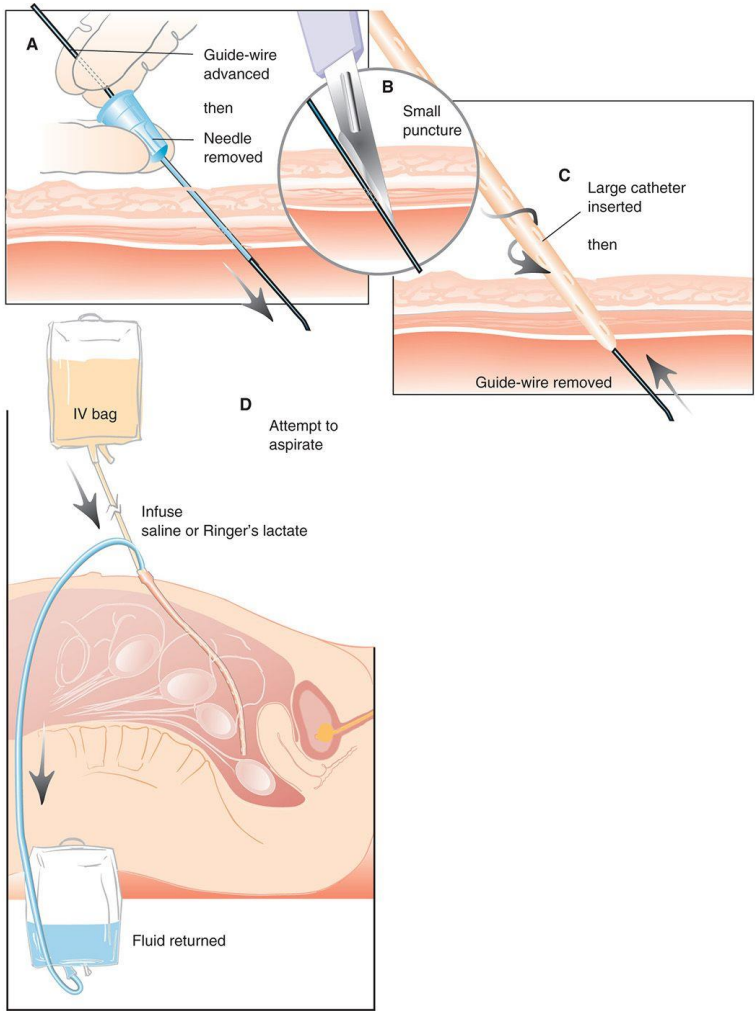
Management

- Unstable Patients :
- Focused assessment with sonography in trauma (FAST)
  - FAST is positive → emergent laparotomy





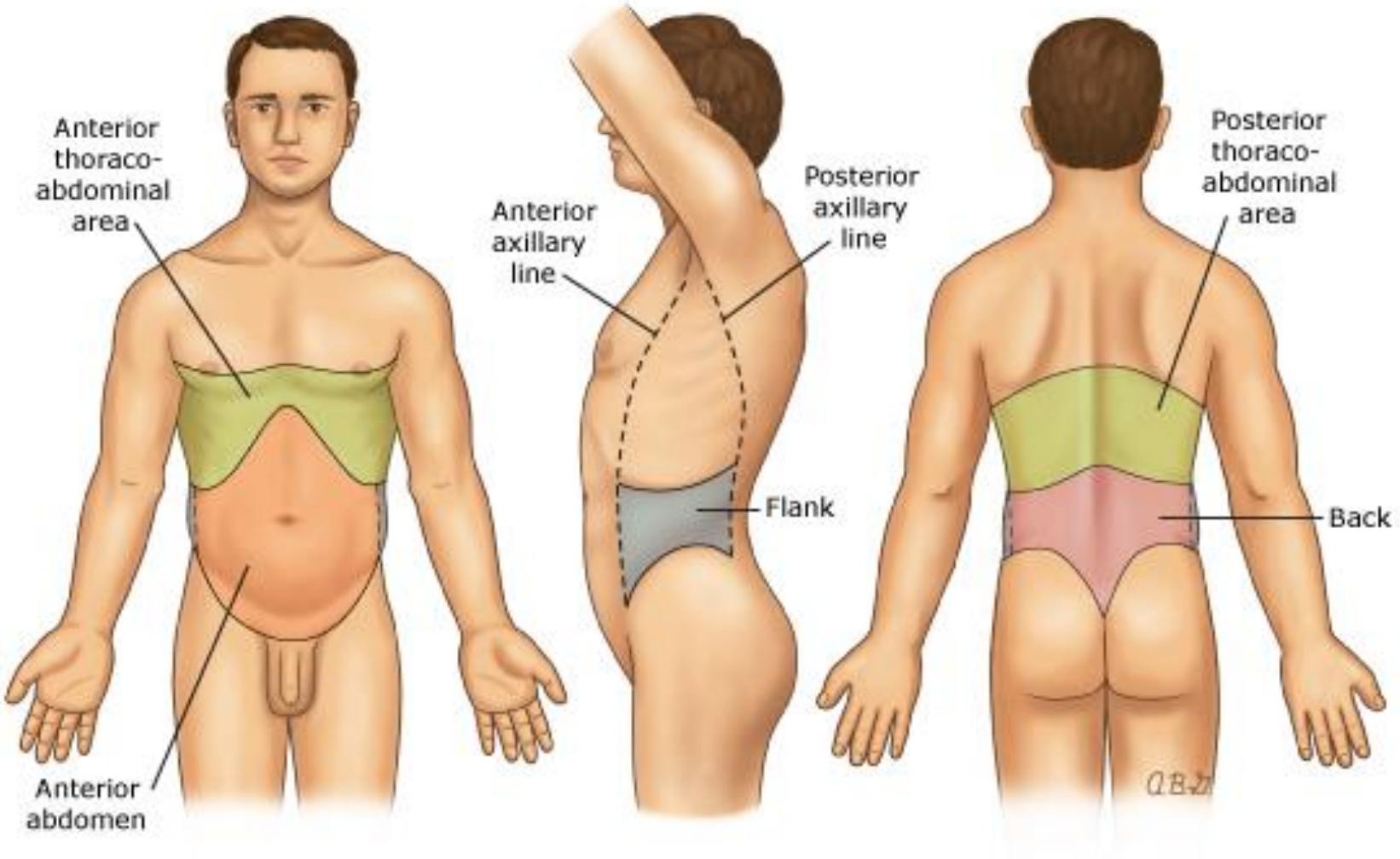
- Diagnostic peritoneal lavage (DPL)
- Replaced by the combination of US and CT
- Used When unstable → can't send him to CT & FAST is negative
- Aspiration of 10 mL of gross blood confirms the presence of a significant intra-abdominal wound.
  - DPA is positive → laparotomy.
  - DPA is negative → alternative sources for the hemorrhage are sought



- Stable patients :

- 9 hours of observation is sufficient to identify occult intra-abdominal injury
  - serial vital signs
  - abdominal examinations
- laboratory findings → CT is the preferred modality

Penetrating Injury
Anatomy of the abdomen



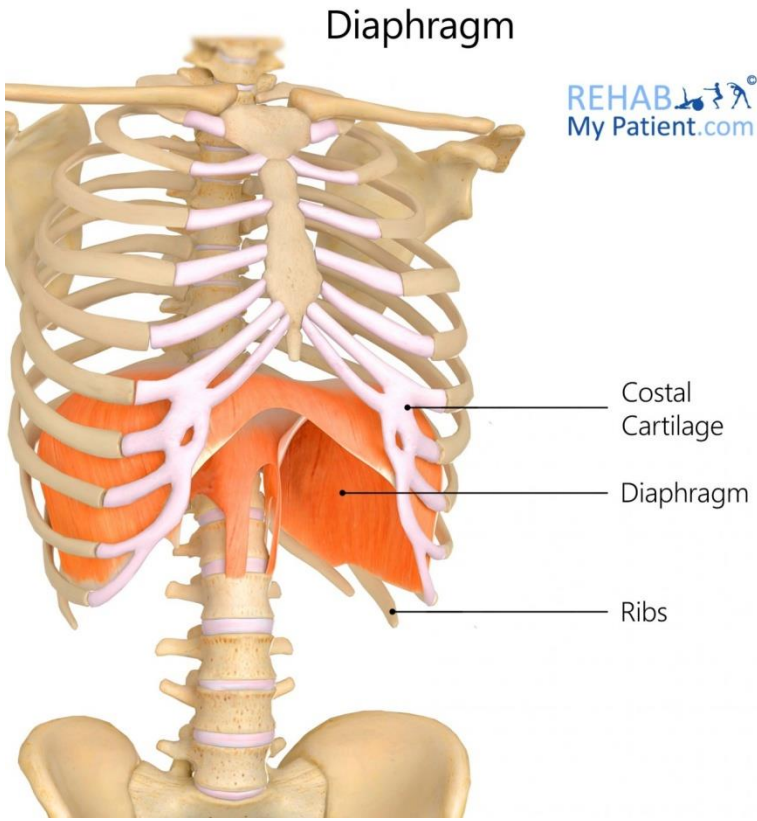
- External wounds do not always correspond to internal injury

- IMMEDIATE OPERATION:
  - ✓ Extremis
  - ✓ Hemodynamic Instability
  - ✓ Peritonitis
  - ✓ Unevaluable

- Hemodynamically stable evaluable patients without peritonitis → a detailed evaluation of the external wounds and retained fragments using plain radiographs

The Diaphragm

- Diaphragmatic injury is uncommon, representing less than 1 percent of all traumatic injuries
- The National Trauma Data Bank (NTDB) reports an overall mortality of 25 percent for patients with diaphragmatic injury
- A high index of suspicion needs to be maintained because delayed diagnosis is associated with an increased risk for herniation and strangulation of abdominal organs, which can be life threatening



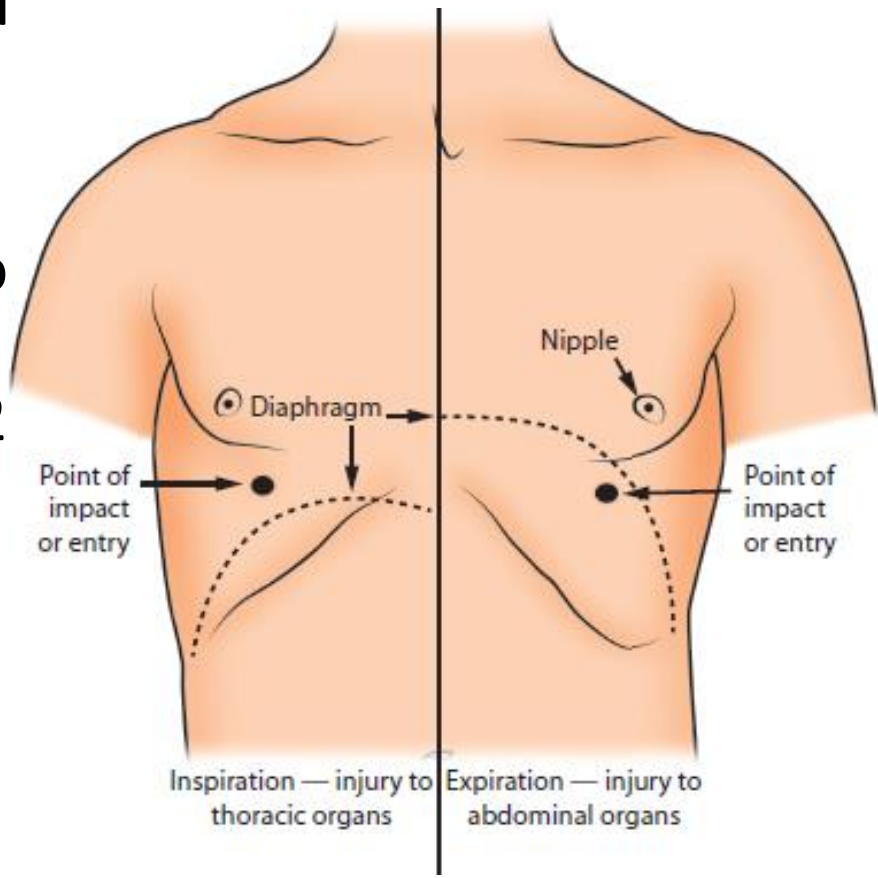
Presentation

- The left posterolateral region is the most common site

- Acute herniation of abdominal contents:
  - The classic signs and symptoms:
    - Shortness of breath,
    - Bowel sounds in the chest,
    - Gi obstruction, or Ischemia,

- Isolated and uncomplicated diaphragmatic injuries:
  - difficult to diagnose
  - asymptomatic
  - Or minor, nonspecific abdominal signs.

- Exhalation →the diaphragm rises to the level of the nipples at the fourth to fifth intercostal space → Penetrating injuries of the lower chest or insertion of a thoracostomy tube below the nipple →potential injury to the diaphragm
- penetrating trauma tears are 2 to 3 cm.→ more occult
- Any left thoraco-abdominal area wound
- → Evaluate for diaphragm injury

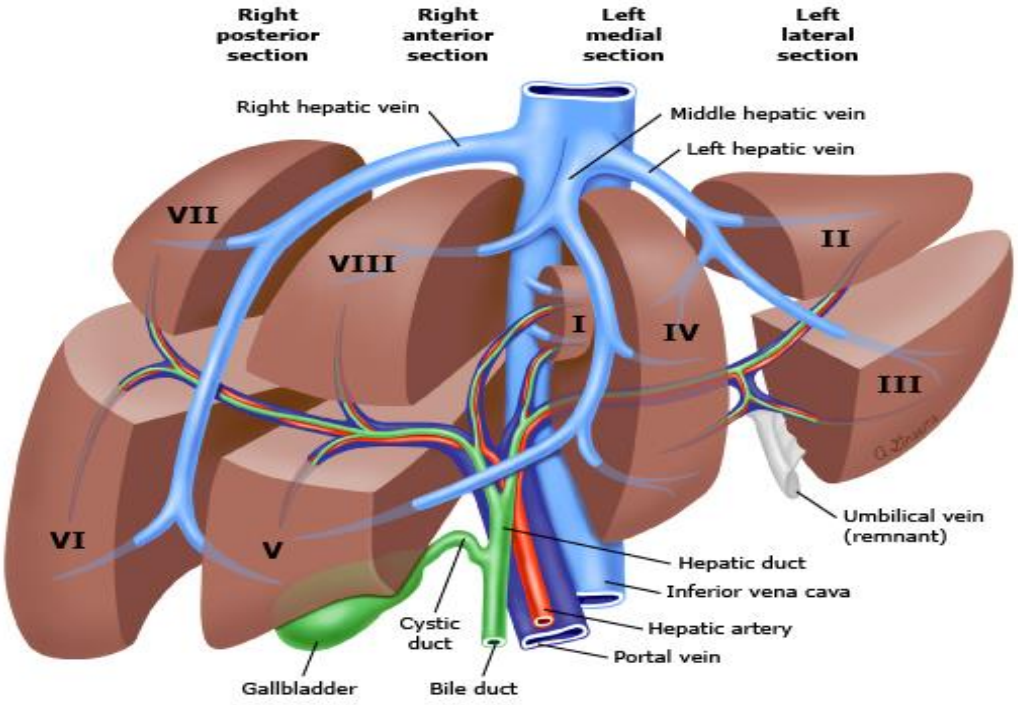


- Blunt tears are usually 7 to 10 cm.
- Imaging can be more useful.
- Once GI tract herniation , chest x-ray and CT have higher sensitivity.
- **CT scan is the highest-yield investigation**

Treatment

- All diaphragm injuries → contents reduced and defects repaired
  - Acute → approached through a laparotomy
  - Chronic, elective cases → thoracotomy.
- Contamination of the pleural cavity:
  - → Extend incision and wash the cavity out prior to closure
- Tube thoracostomy considered in most cases.

Liver and biliary tract



- The liver is the most frequently injured abdominal organ. Most hepatic injuries are relatively minor and heal spontaneously with nonoperative management, which consists of observation and possibly arteriography and embolization
- The most common in blunt abdominal trauma
- The second most commonly in penetrating abdominal trauma
- The posterior portion of the right lobe is the most common site

- History and physical examination — A history of trauma to the right upper quadrant, right rib cage, or right flank should increase the suspicion for liver injury. The patient may complain of pain in the right upper abdomen, right chest wall, or right shoulder due to diaphragmatic irritation.

- Abdominal tenderness and peritoneal signs are the most common findings indicative of intra-abdominal injury; however, these are not sensitive or specific for liver injury.
- Associated injuries — Other injuries are present in approximately 80 percent of patients with hepatic injury

- chest injury was the most commonly associated injury overall, and the spleen was the most commonly injured intra-abdominal organ
- Laboratory studies — There are no specific laboratory tests diagnostic for hepatic injury

Diagnosis

- A diagnosis of liver injury may be suspected in the *hemodynamically stable* patient based upon mechanism of injury, physical examination, or laboratory findings. However, imaging using intravenous contrast-enhanced computed tomography (CT) of the abdomen definitively confirms the injury and defines the injury grade. Pooling of intravenous contrast in or around the liver implies ongoing bleeding and the need for intervention. CT scanning also identifies associated intra-abdominal and chest injuries. **CT scan with IV contrast** is the most widely used and highest-yield modality

- The Focused Assessment with Sonography in Trauma (FAST) exam (signs of liver injury include findings of a hypoechoic (ie, black) rim of subcapsular fluid, intraperitoneal fluid around the liver, or fluid in Morrison's pouch) is more commonly used in hemodynamically unstable patients. However, a negative FAST examination is **not** adequate to exclude liver injury, particularly intraparenchymal injury.

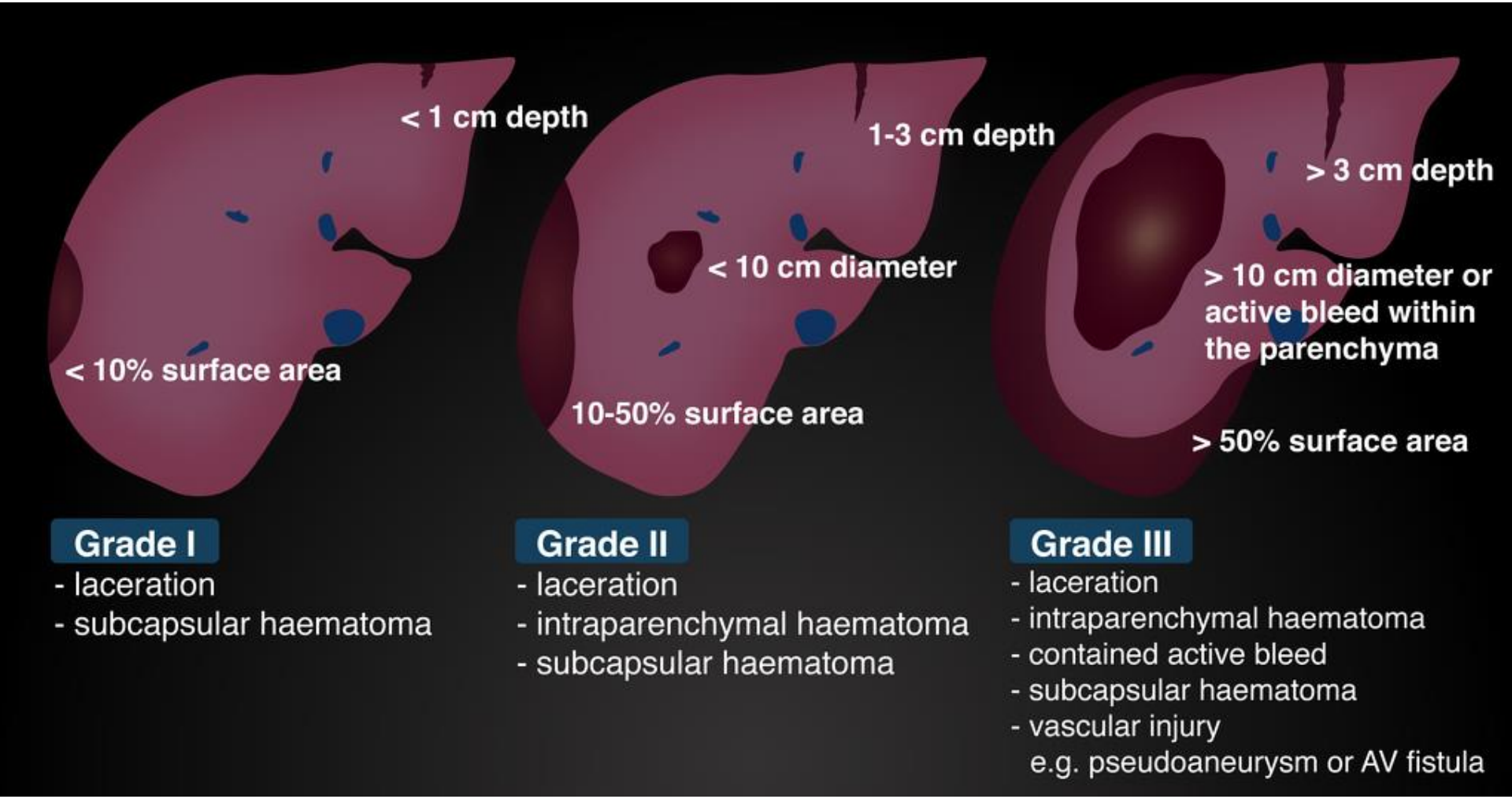
- Organ-based ultrasound imaging and magnetic resonance imaging (MRI) are of limited value in the initial diagnosis of liver injury.

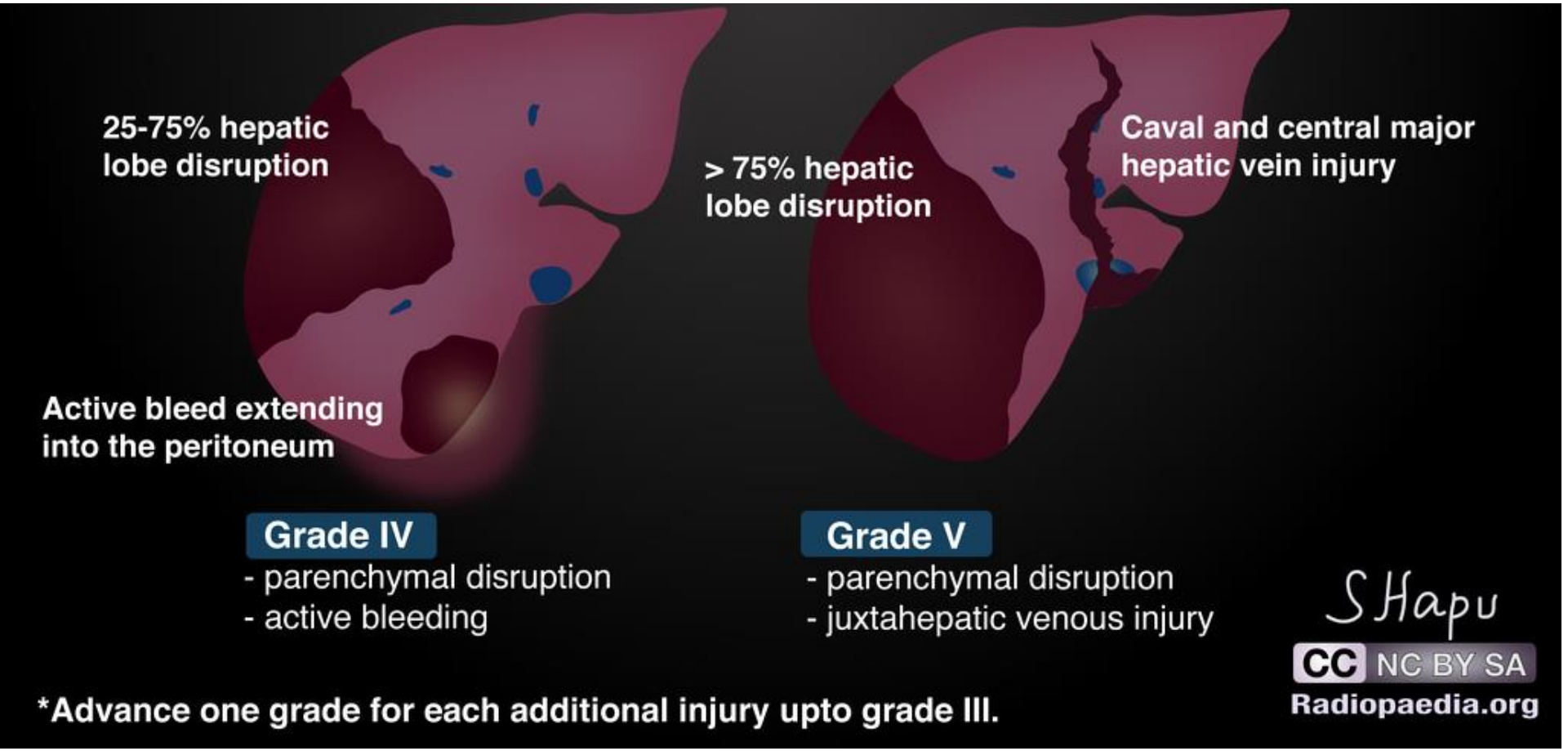
- Arteriography is generally reserved for patients who have indications for hepatic embolization to manage intrahepatic arterial hemorrhage

The AAST grading system is useful for predicting the likelihood of success with non-operative management

OIS-AAST Grading Scale for the Liver

Grade[a]	Type	Injury Description
I	Hematoma Laceration	Subcapsular, <10% surface area Capsular tear, <1 cm parenchymal depth
II	Hematoma Laceration	Subcapsular, 10–50% surface area; intraparenchymal, <10 cm in diameter 1–3 cm parenchymal depth, <10 cm in length
III	Hematoma Laceration	Subcapsular, >50% surface area or expanding; ruptured subcapsular or parenchymal hematoma; intraparenchymal hematoma, >10 cm or expanding >3 cm parenchymal depth
IV	Laceration	Parenchymal disruption involving 25–75% of hepatic lobe or 1–3 Couinaud segments within a single lobe
V	Laceration Vascular	Parenchymal disruption involving >75% of hepatic lobe or >3 Couinaud segments within a single lobe Juxtahepatic venous injuries; that is, retrohepatic vena cava/ central major hepatic veins
VI	Vascular	Hepatic avulsion


< 1 cm depth
< 10% surface area
1-3 cm depth
< 10 cm diameter
10-50% surface area
> 3 cm depth
> 10 cm diameter or active bleed within the parenchyma
> 50% surface area
Grade I
- laceration
- subcapsular haematoma
Grade II
- laceration
- intraparenchymal haematoma
- subcapsular haematoma
Grade III
- laceration
- intraparenchymal haematoma
- contained active bleed
- subcapsular haematoma
- vascular injury
e.g. pseudoaneurysm or AV fistula


25-75% hepatic lobe disruption
> 75% hepatic lobe disruption
Caval and central major hepatic vein injury
Active bleed extending into the peritoneum
Grade IV
- parenchymal disruption
- active bleeding
Grade V
- parenchymal disruption
- juxtahepatic venous injury
S Hapu
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*Advance one grade for each additional injury upto grade III.

- A FAST : free intraperitoneal bleeding
- CT scan for a Gunshot injury to the liver managed non operatively

Management

- The management strategy (operative or nonoperative) depends upon the hemodynamic status of the patient, grade of liver injury, and presence of other injuries and medical comorbidities.

- The hemodynamically unstable trauma patient with a positive Focused Assessment with Sonography for Trauma (FAST) scan or positive diagnostic peritoneal lavage or aspirate (DPA/DPL) requires emergent abdominal exploration to determine the source of intraperitoneal hemorrhage.
- Patients with blunt liver injury who are hemodynamically stable and who do **not** have other indications for abdominal exploration can be observed
- Surgical exploration is indicated in nonoperatively managed patients who continue to bleed (ongoing blood transfusion, hemodynamic instability), and in some patients who manifest a persistent systemic inflammatory response (ileus, fever, tachycardia, oliguria). The management of grade III injuries and higher often requires a combined angiographic and surgical approach

- **NONOPERATIVE MANAGEMENT**
- Nonoperative management is the treatment of choice for hemodynamically stable patients with hepatic injury, regardless of injury grade, and consists of observation and supportive care with the adjunctive use of arteriography and hepatic embolization

- Successful nonoperative management requires appropriate patient selection and the availability of resources, including availability of intensive care unit beds, blood bank support, immediate operating room availability, and surgeons and interventional angiographers experienced in managing hepatic injury.

- Contraindications to nonoperative management of liver injury include the following :

Hemodynamic instability after initial resuscitation.

Other indication for abdominal surgery (eg, peritonitis).

Gunshot injury (relative contraindication if extrahepatic injury is suspected).

Absence of an appropriate clinical environment to provide monitoring, serial clinical evaluation, or availability of facilities and personnel for hepatic embolization or urgent abdominal exploration should the need arise.

- **Observation** — Nonoperatively managed patients should be admitted to a monitored unit and initially placed on bed rest

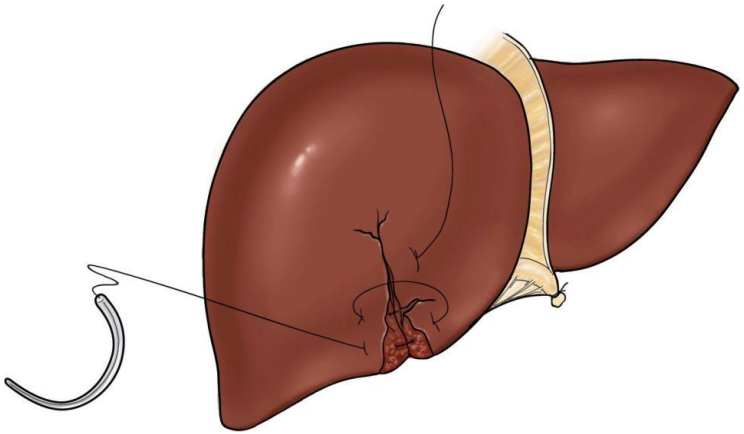
- **Hepatic embolization** — Hepatic embolization may be necessary as an adjunct to improve rates of nonoperative management.

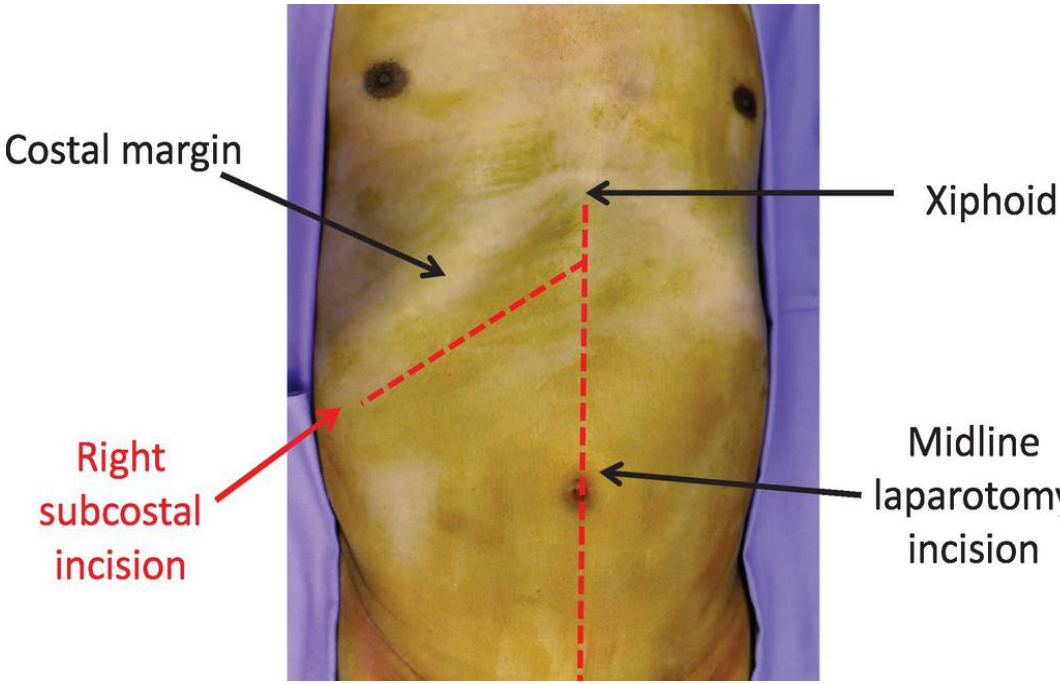
- **The operative management** of liver injuries that require surgical intervention can be a challenge even for experienced surgeons due to the complex nature of the liver, its size, vascularity, dual blood supply (portal, hepatic arterial), and its rich and difficult-to-access venous drainage. In hemodynamically unstable patients, damage control techniques provide temporary control of bleeding and allow anesthesia staff to resuscitate the patient. Definitive management of bleeding from the liver is accomplished using a variety of techniques.

Operative Management:

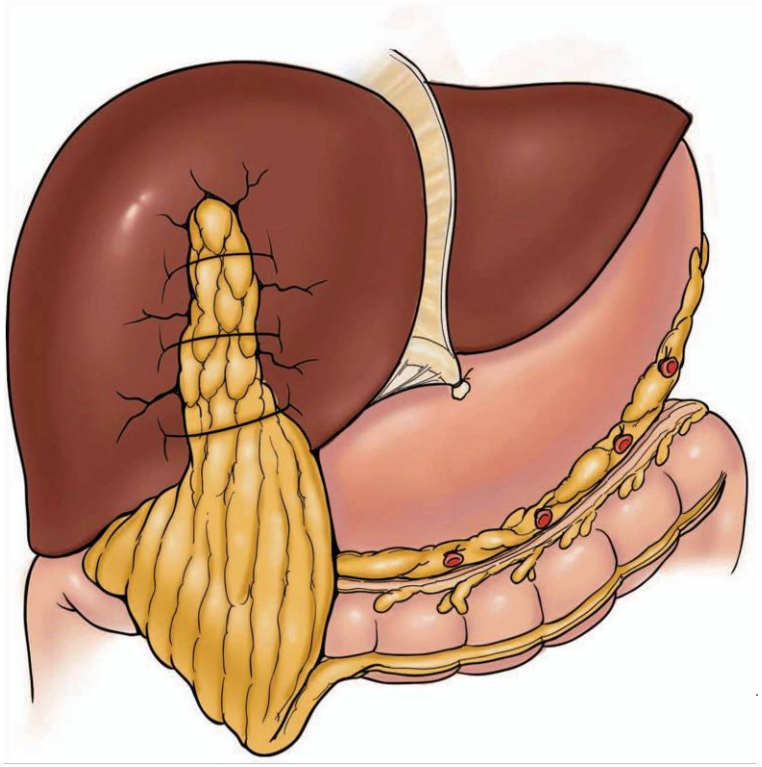
- **Incision**: a midline laparotomy
- posterolateral liver injuries : a right subcostal incision

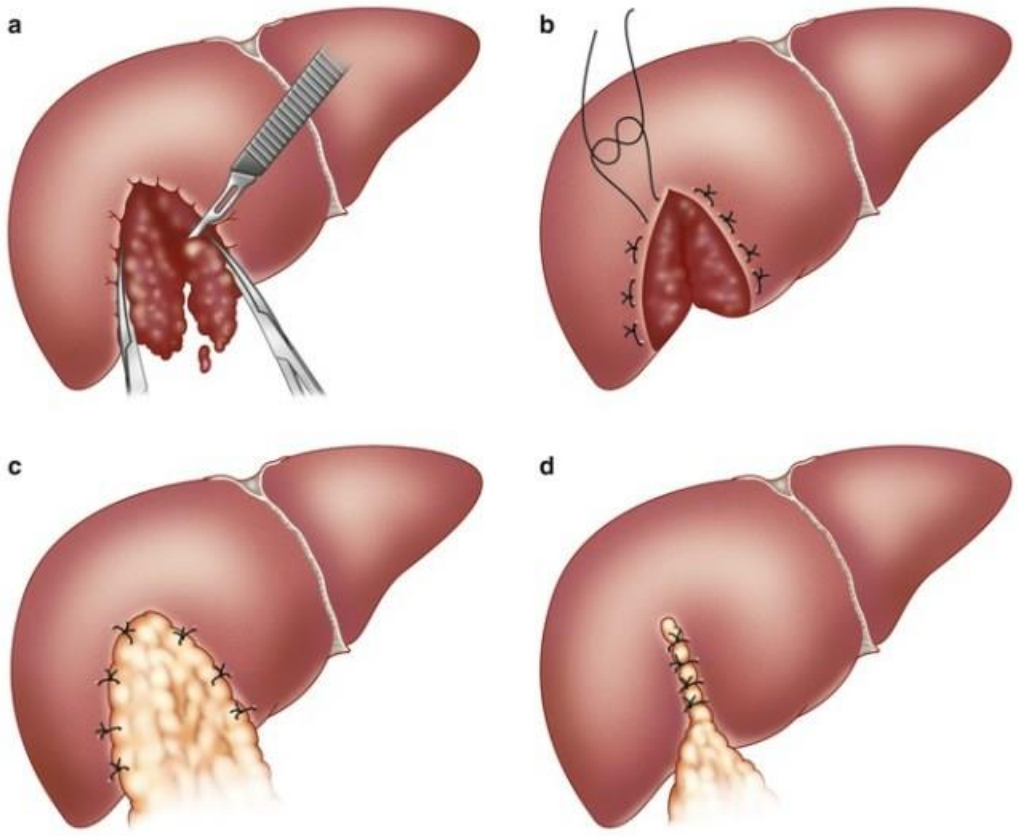
- In approximately 80% to 85% → the liver injury can be managed by relatively simple surgical techniques,
  - local hemostatic agents,
  - Electrocoagulation
  - superficial suturing.



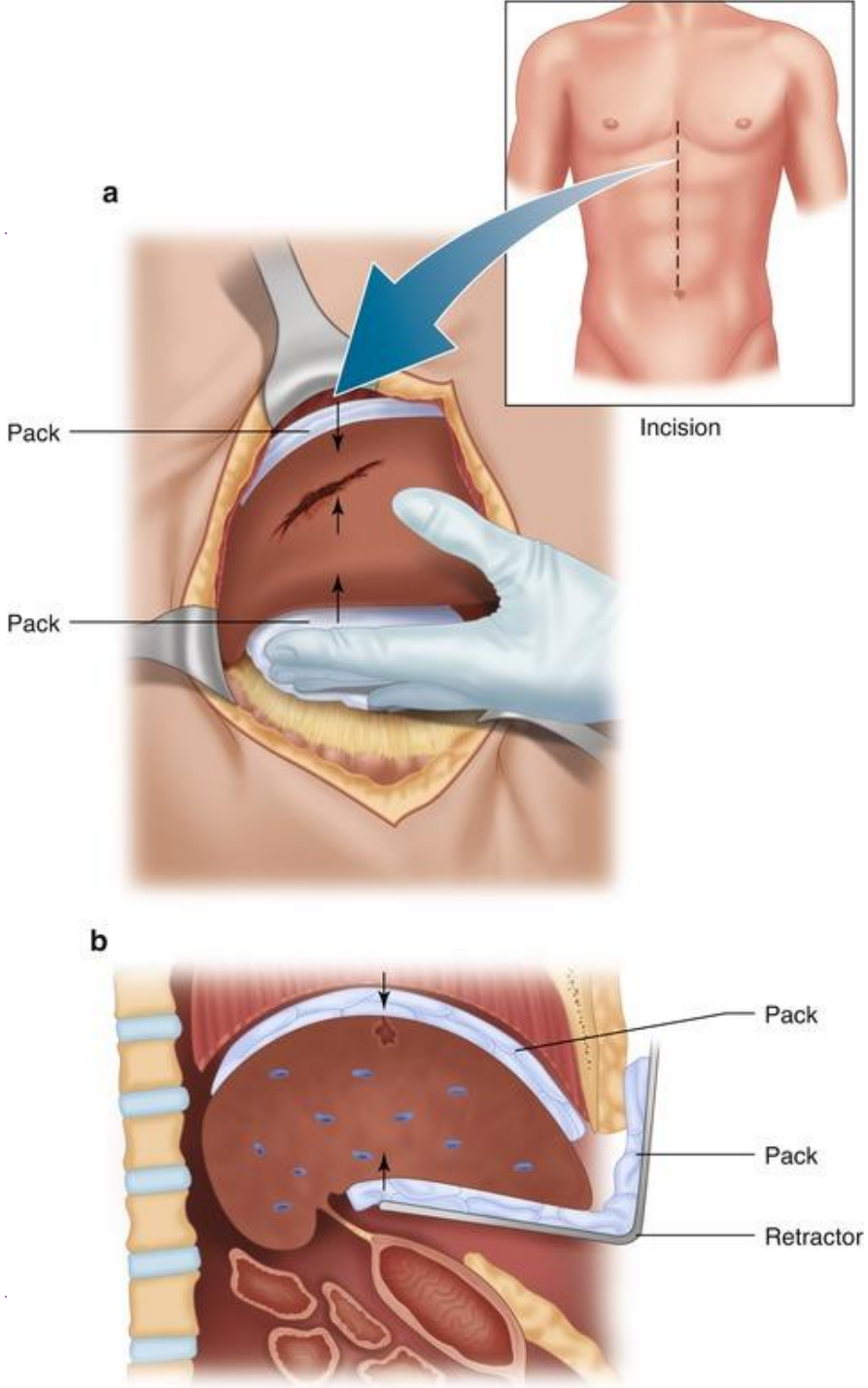

Costal margin
Xiphoid
Right subcostal incision
Midline laparotomy incision

- Bleeding from deep liver lacerations can be controlled by clipping or suture ligation of any major vessels, followed by deep, figure-of-eight sutures, on a large blunt liver needle.
- Omental packing of large liver defects is useful in eliminating any dead space.





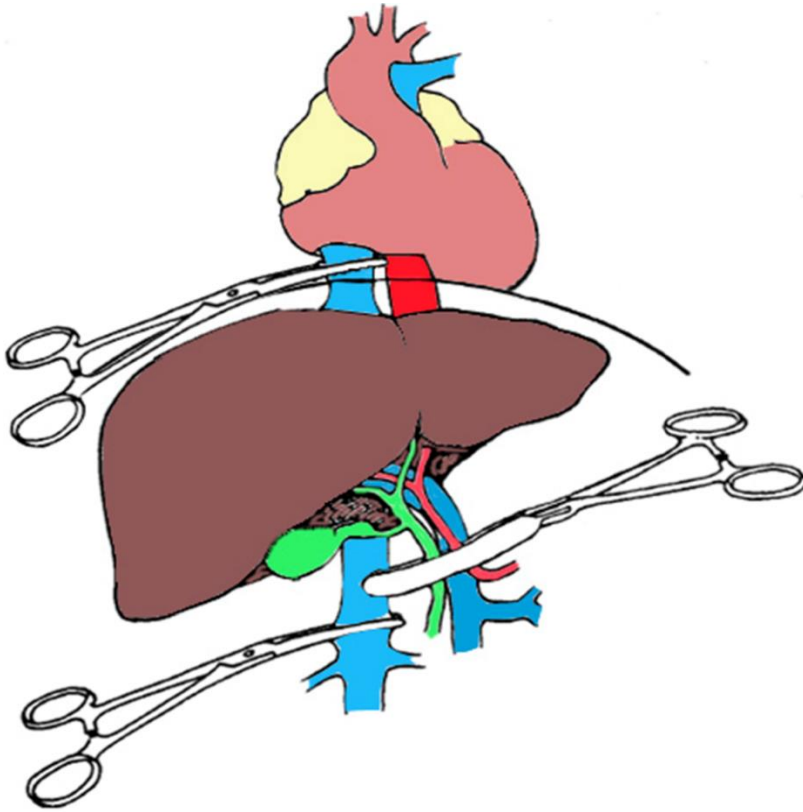
- Severe blunt trauma or high-velocity GSWs associated with extensive parenchymal damage are not amendable to deep suturing.
- Bleeding control in these cases may be achieved with perihepatic packing, with or without liver resection

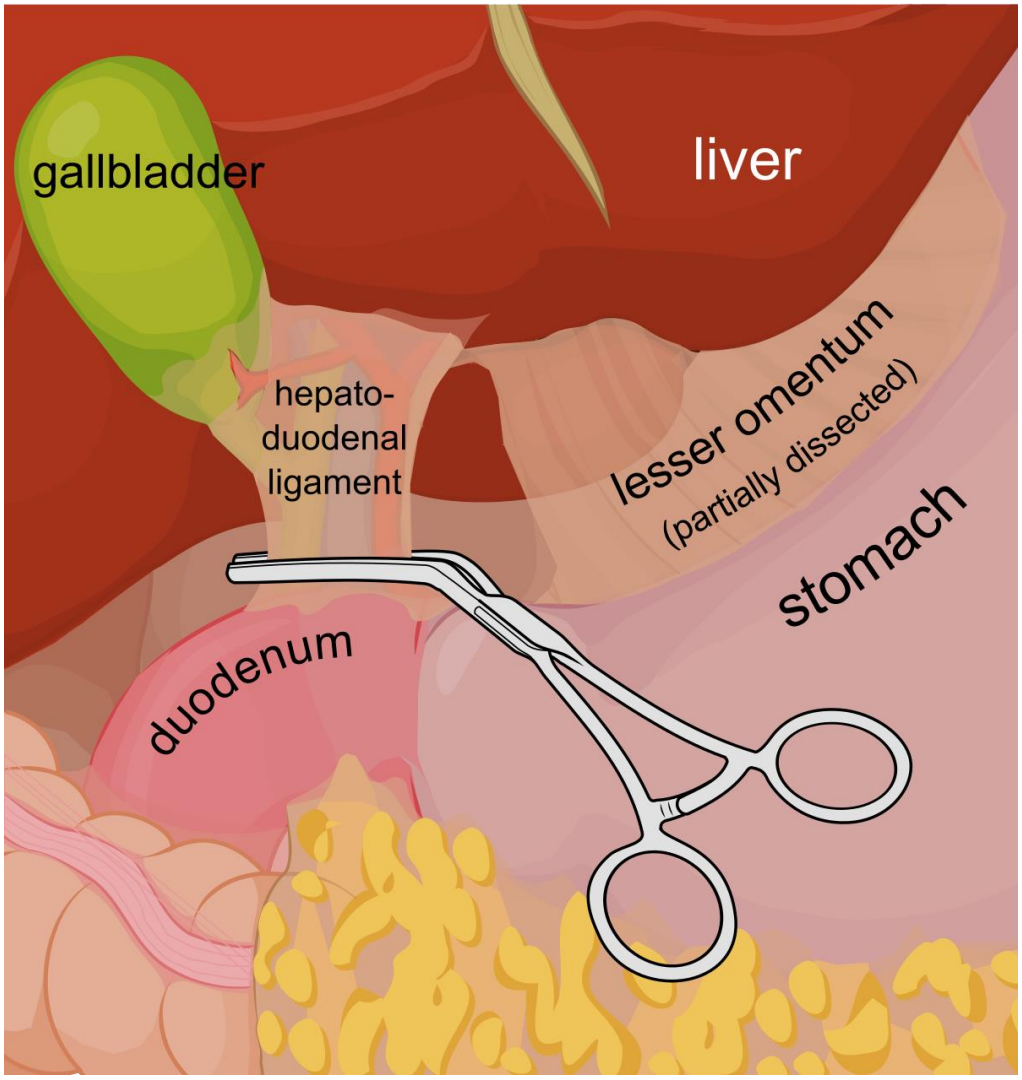


- In the rare situation where perihepatic packing is not effective

→ often due to major retrohepatic venous injuries,

- Total Vascular Isolation Of The Liver :
  - temporary bleeding control,
  - identification and ligation of the injured vessels.
- <u>Cross-clamping Of :</u>
- Infra-diaphragmatic Aorta
- Supra-hepatic IVC
- Infra-hepatic IVC
- The Porta Hepatis
- (pringles maneuver)




gallbladder
liver
hepato-
duodenal
ligament
lesser omentum
(partially dissected)
stomach
duodenum

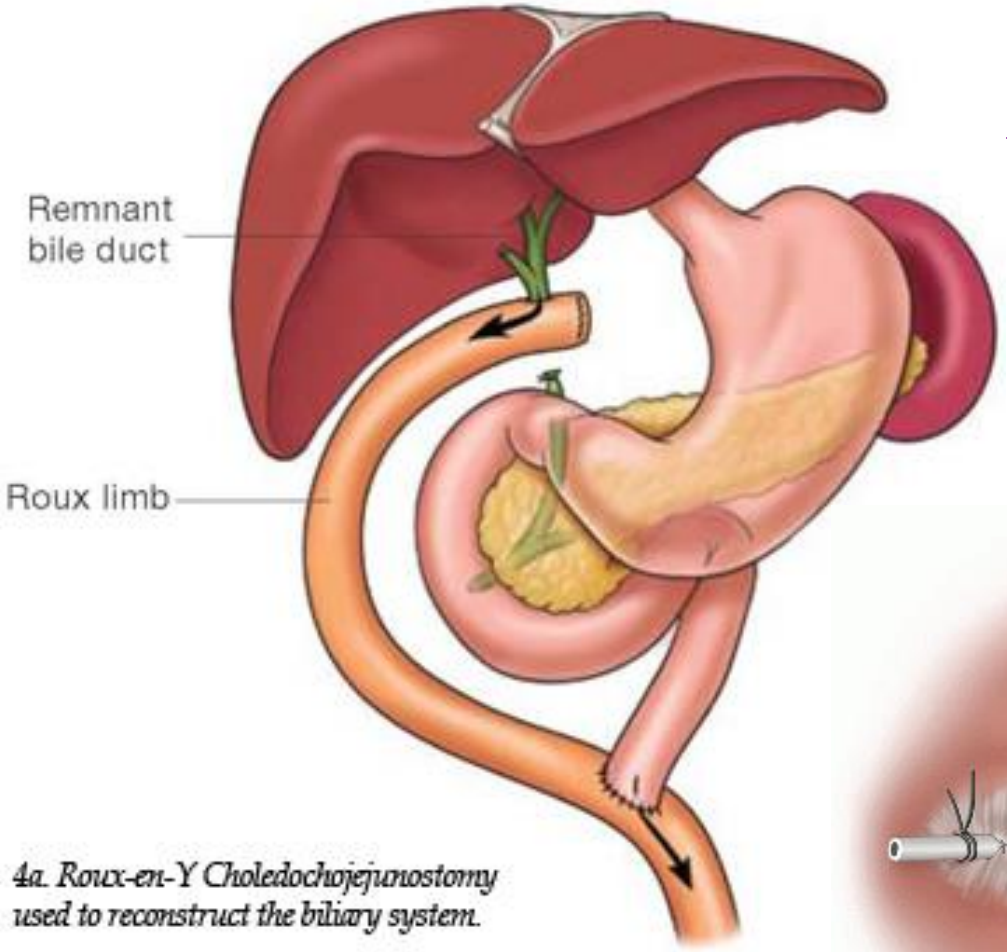
Extrahepatic Biliary Tract Injury

- Rare , usually a penetrating mechanism.

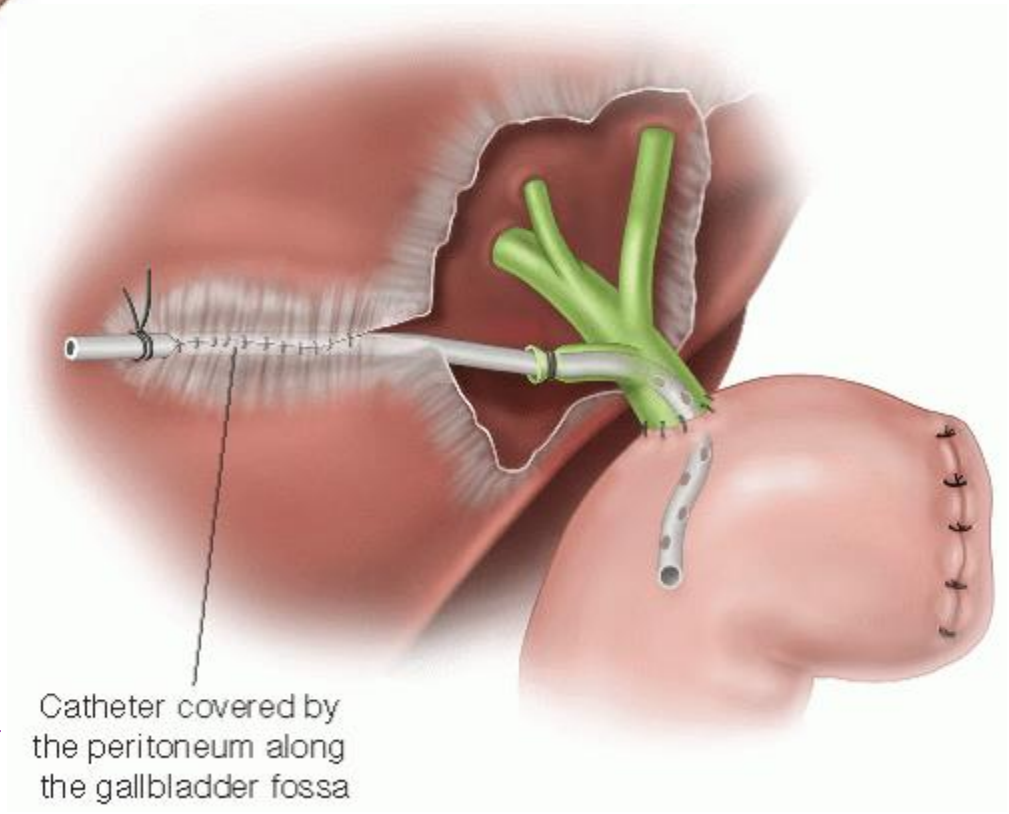
- **Diagnosis** : during laparotomy

- **Management:**
  - Complete transections → roux-en-y biliary-enteric anastomosis
  - Incomplete injuries :
    - Less than 50% of the duct circumference → primary repair
    - More than 50% of the duct circumference→ as complete

- All repairs should be drained externally with **closed suction drains**.



4a. Roux-en-Y Choledochojejunostomy used to reconstruct the biliary system.

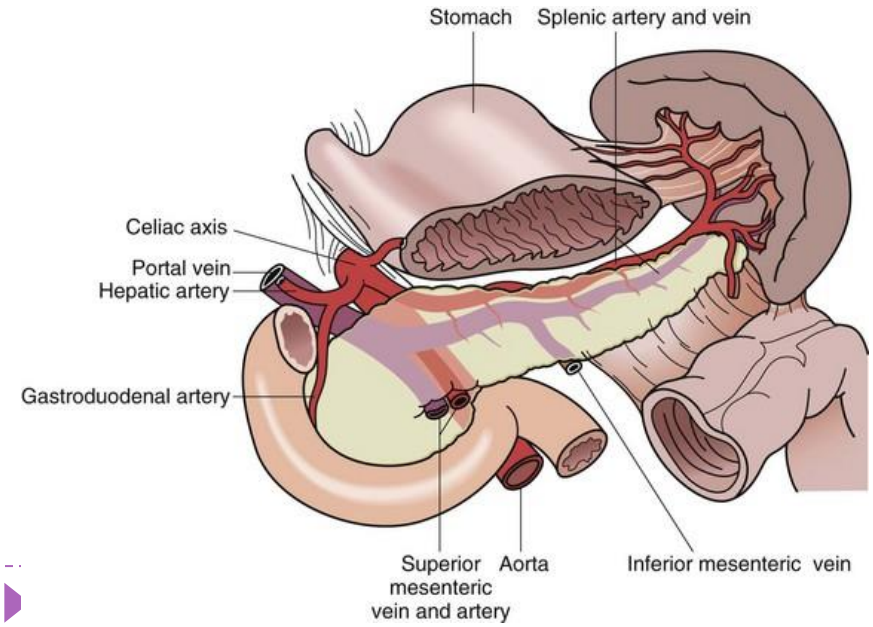


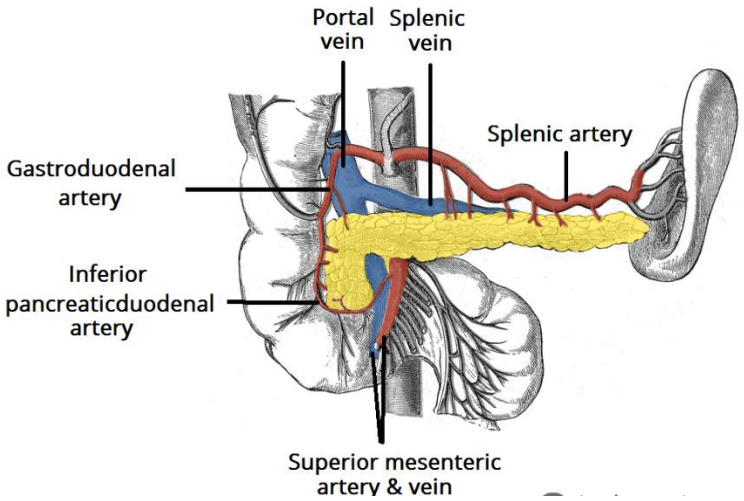
Spleen

- One of the most commonly injured intra-abdominal organs
- Blunt > Penetrating
- prompt management of potentially life-threatening hemorrhage is the primary goal.
- The preservation of functional splenic tissue is secondary
- **Emergent and urgent splenectomy** remains a life-saving measure for many patients.

Anatomy

- The spleen is held in place by four ligaments which include the splenogastric ligament medially, the splenocolic ligament inferiorly, and the splenophrenic and splenorenal ligaments posterolaterally. The splenogastric ligament is the only vascular ligament and contains five to seven short gastric vessels, which originate from the distal splenic artery. The tail of the pancreas is in close proximity to the splenic hilum and is at risk of injury during splenectomy or hilar clamping.





- The spleen is a commonly injured intra-abdominal organ following blunt trauma and the second most commonly injured solid organ after penetrating trauma. The severity of splenic injury is graded by the OIS-AAST spleen injury scale, which is based on CT, as well as operative findings (Table 25-2). Generally, grades I and II are considered minor injuries, grade III a moderate injury, and grades IV and V are severe injuries

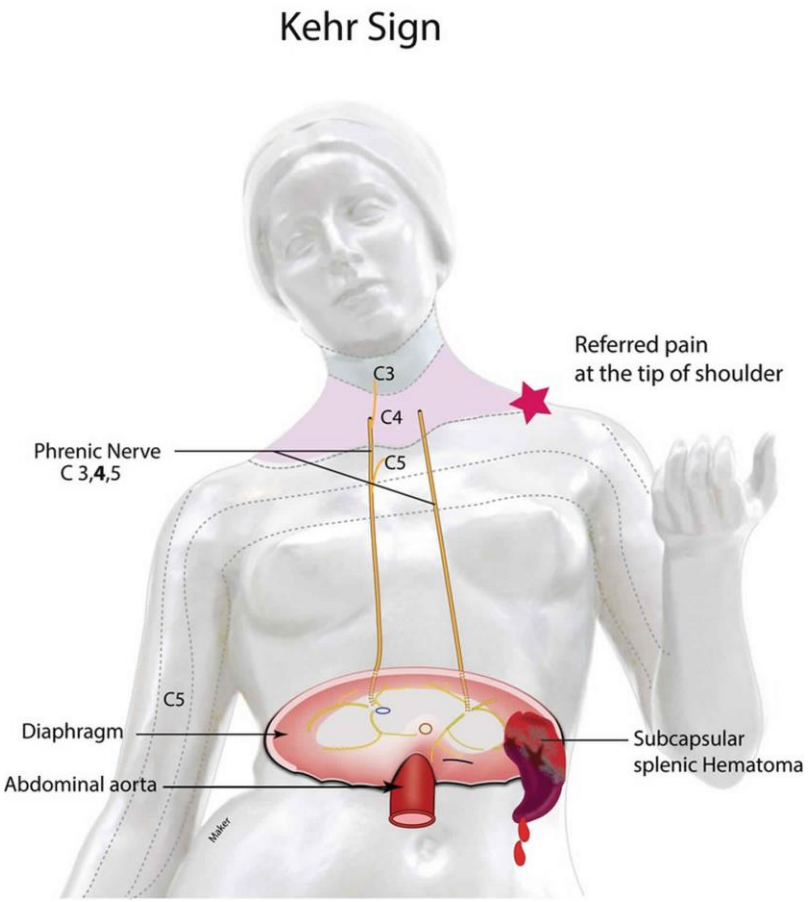
Table 25-2 OIS-AAST Grading Scale for the Spleen

Grade[a]	Type	Injury Description
I	Hematoma Laceration	Subcapsular, <10% surface area Capsular tear, <1 cm parenchymal depth
II	Hematoma Laceration	Subcapsular, 10–50% surface area, <5 cm in diameter 1–3 cm parenchymal depth not involving a trabecular vessel
III	Hematoma Laceration	Subcapsular, >50% surface area or expanding; ruptured subcapsular or parenchymal hematoma; intraparenchymal hematoma, ≥5 cm or expanding >3 cm parenchymal depth or involving trabecular vessels
IV	Laceration	Laceration involving segmental or hilar vessels producing major devascularization (>25% of the spleen)
V	Laceration Vascular	Shattered spleen Hilar vascular injury with devascularized spleen

[a]Advance one grade for multiple injuries, up to grade III.
Moore EE, Cogbill TH, Jurkovich GJ, et al. Organ injury scaling: spleen and liver (1994 revision). *J Trauma* 1995;38:323–324.

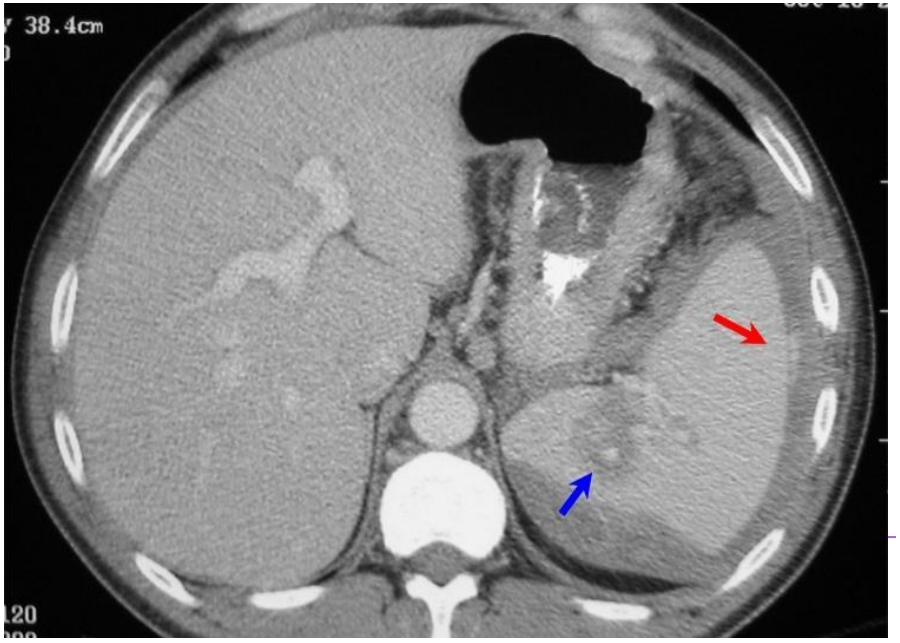
Diagnosis

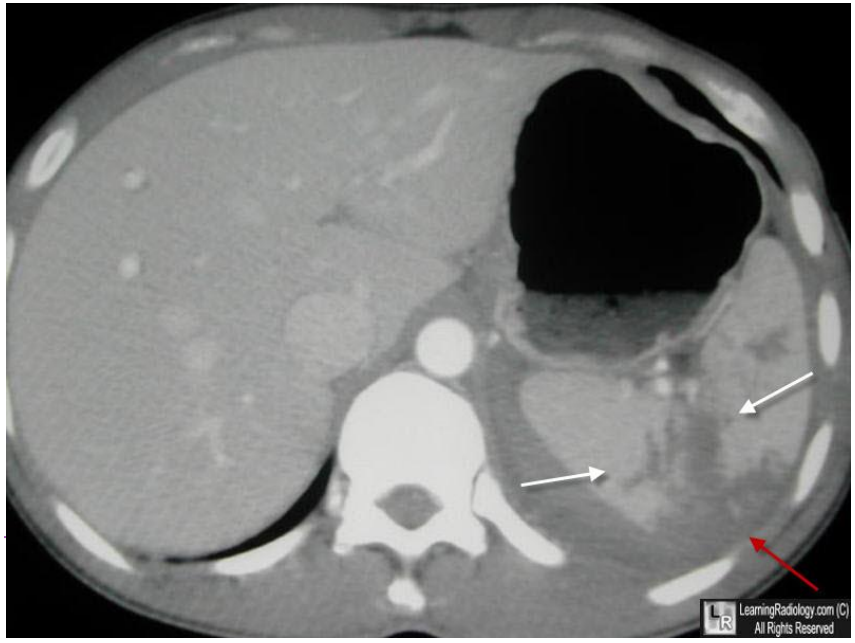
- Presentation depends on the volume of blood loss and the presence of associated injuries:
- 1. Asymptomatic Or Minor Local Tenderness
- → low-grade splenic injuries
- 2. Tachycardia And Hypotension
- → significant blood loss
- 3. Pain In The Left Upper Quadrant, radiating to the left shoulder (Kehr sign), especially when placed in the Trendelenburg position
- →large splenic hematomas

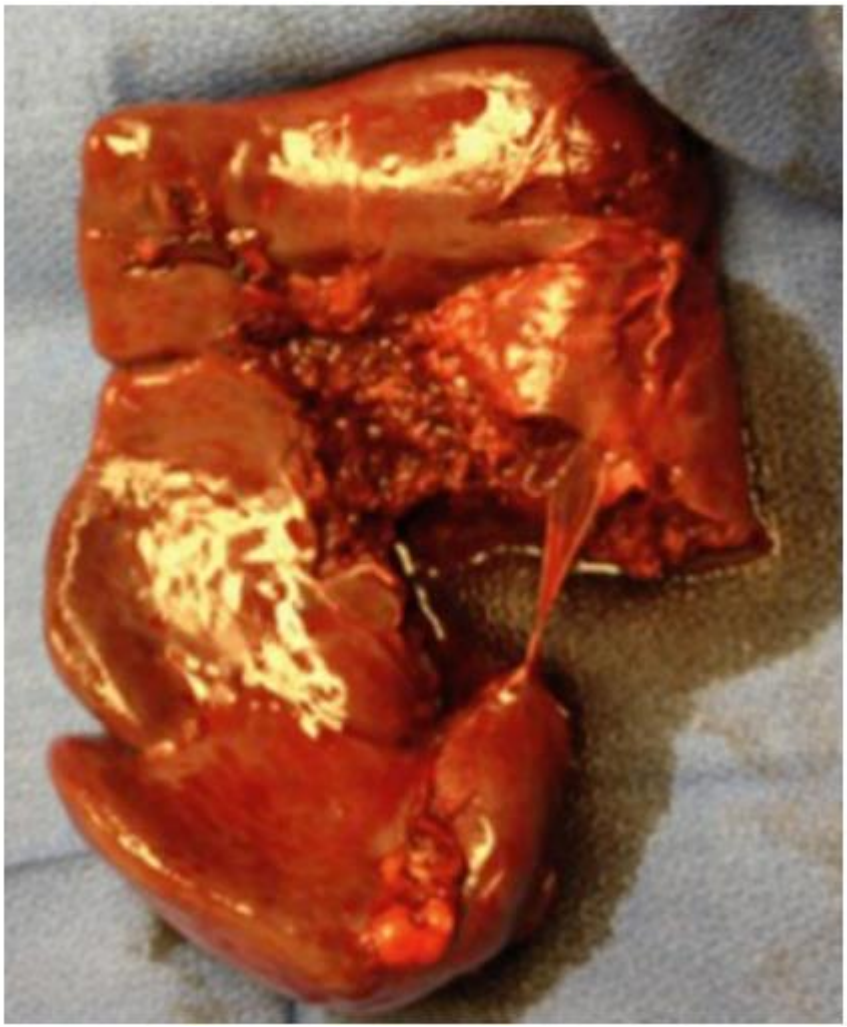


IMAGING :

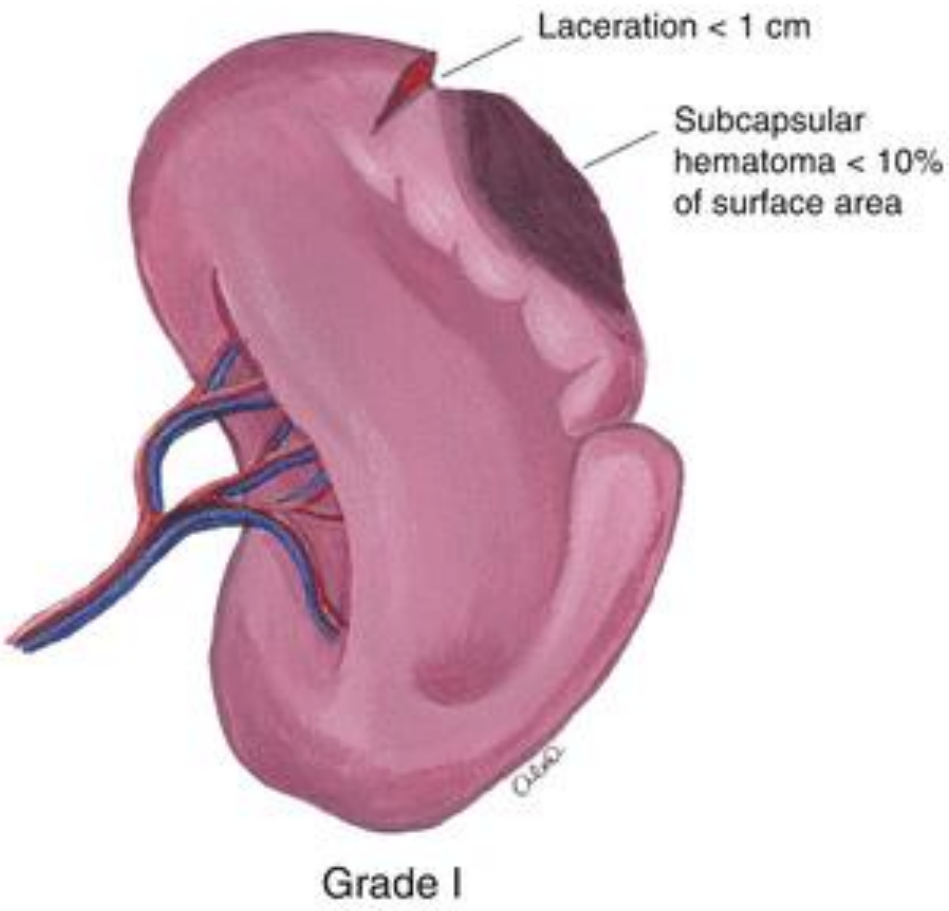
1. **Chest x-rays :** not diagnostic
2. **The FAST :** free fluid around the spleen.
3. **Abdominal CT scan with intravenous contrast :** is the most widely used and highest yield investigation



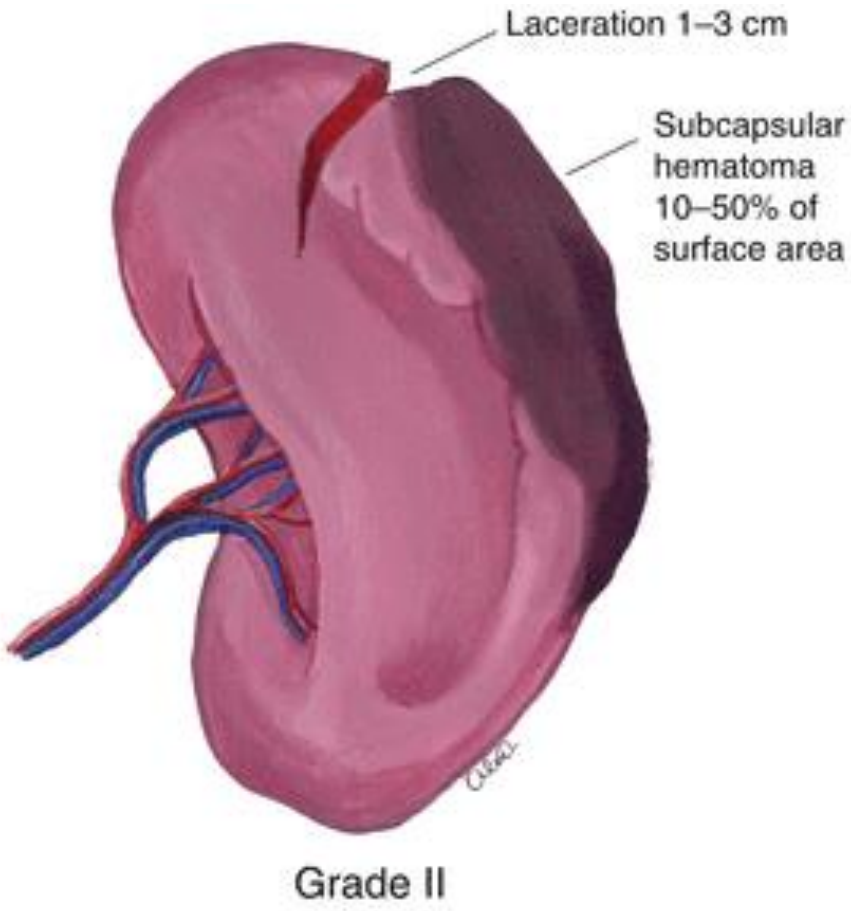




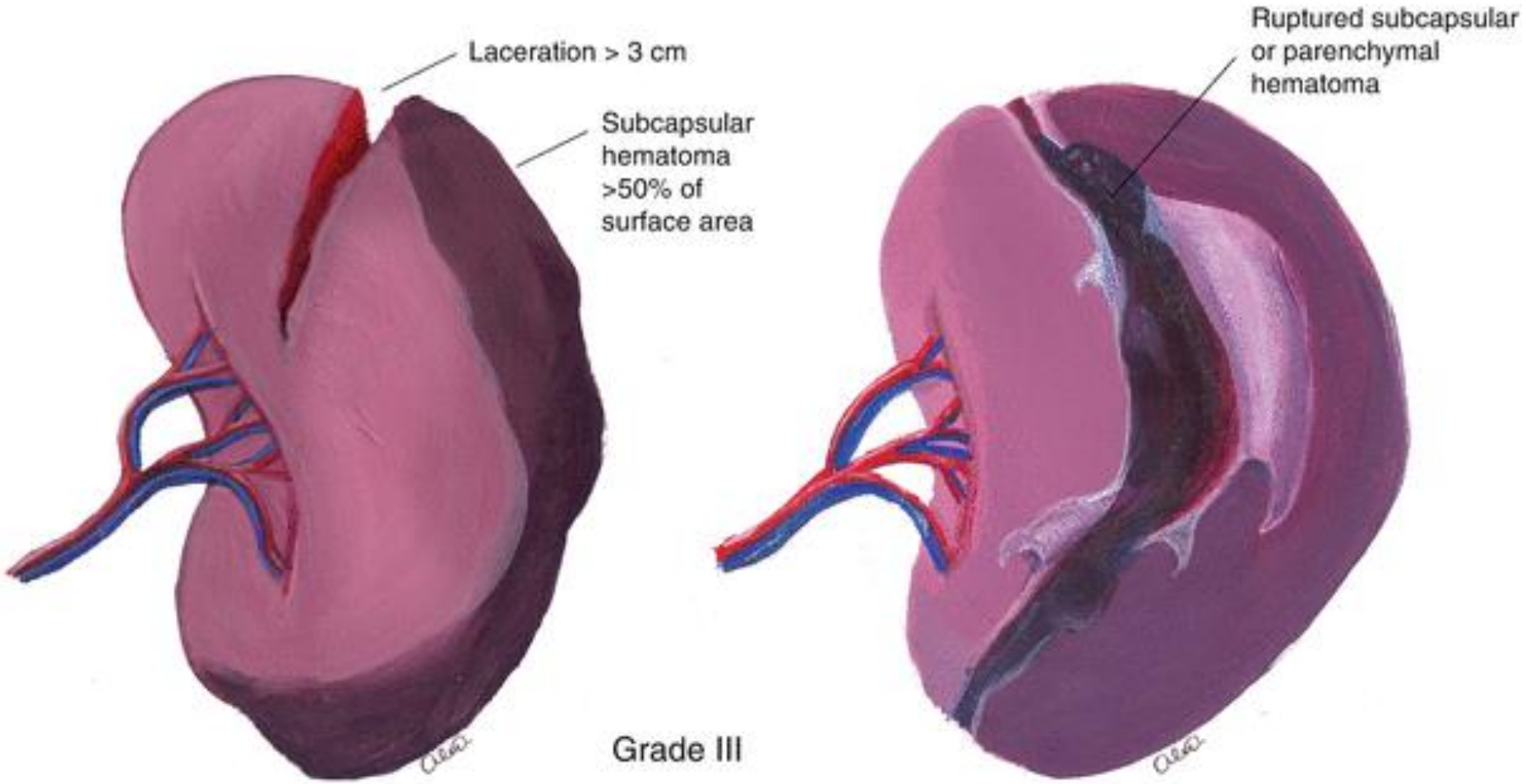
Spleen after removal as seen on CT

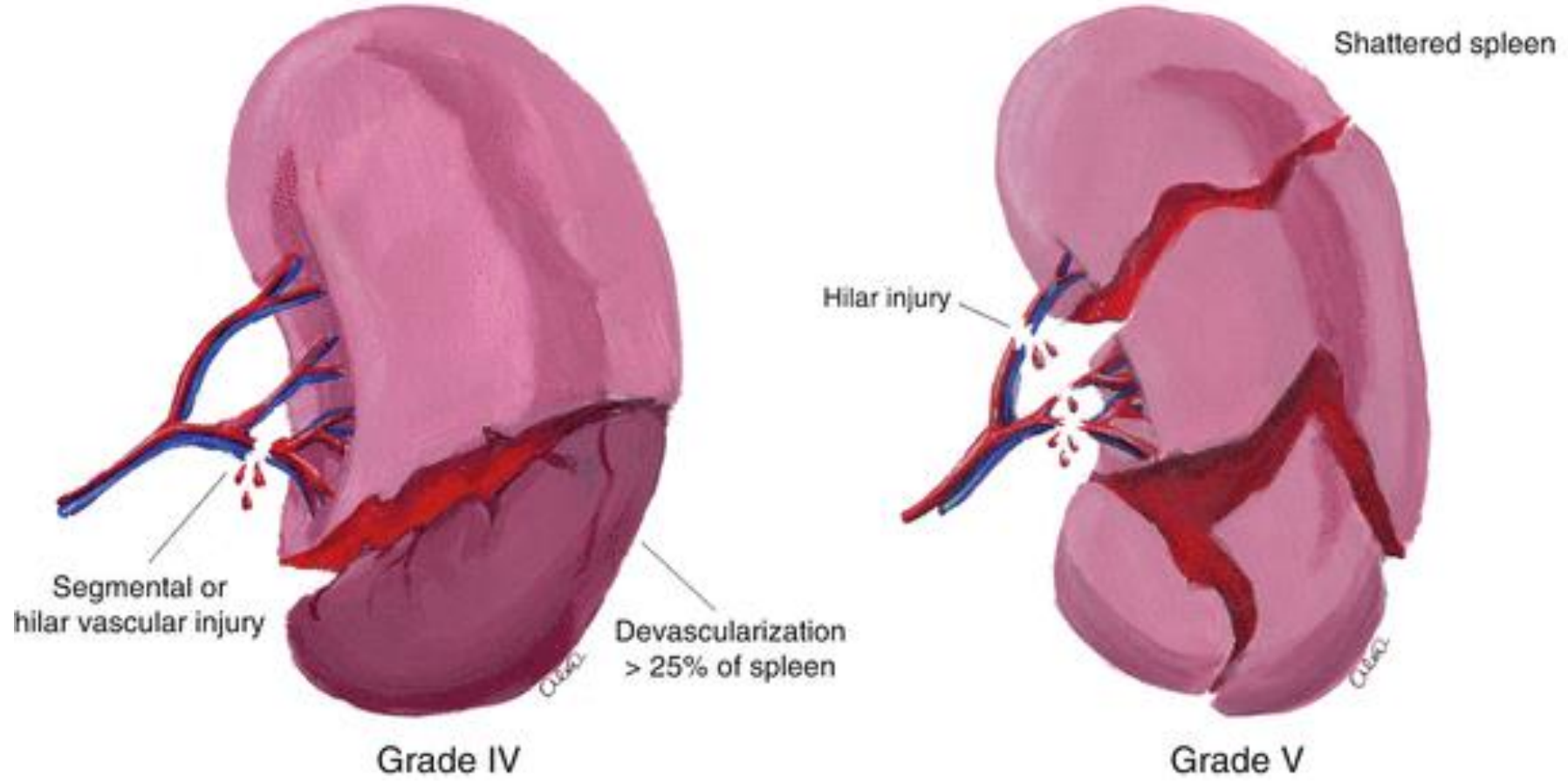


Grade I



Grade II


Laceration > 3 cm
Subcapsular hematoma >50% of surface area
Ruptured subcapsular or parenchymal hematoma
Grade III


Segmental or
hilar vascular injury
Devascularization
> 25% of spleen
Grade IV
Hilar injury
Shattered spleen
Grade V

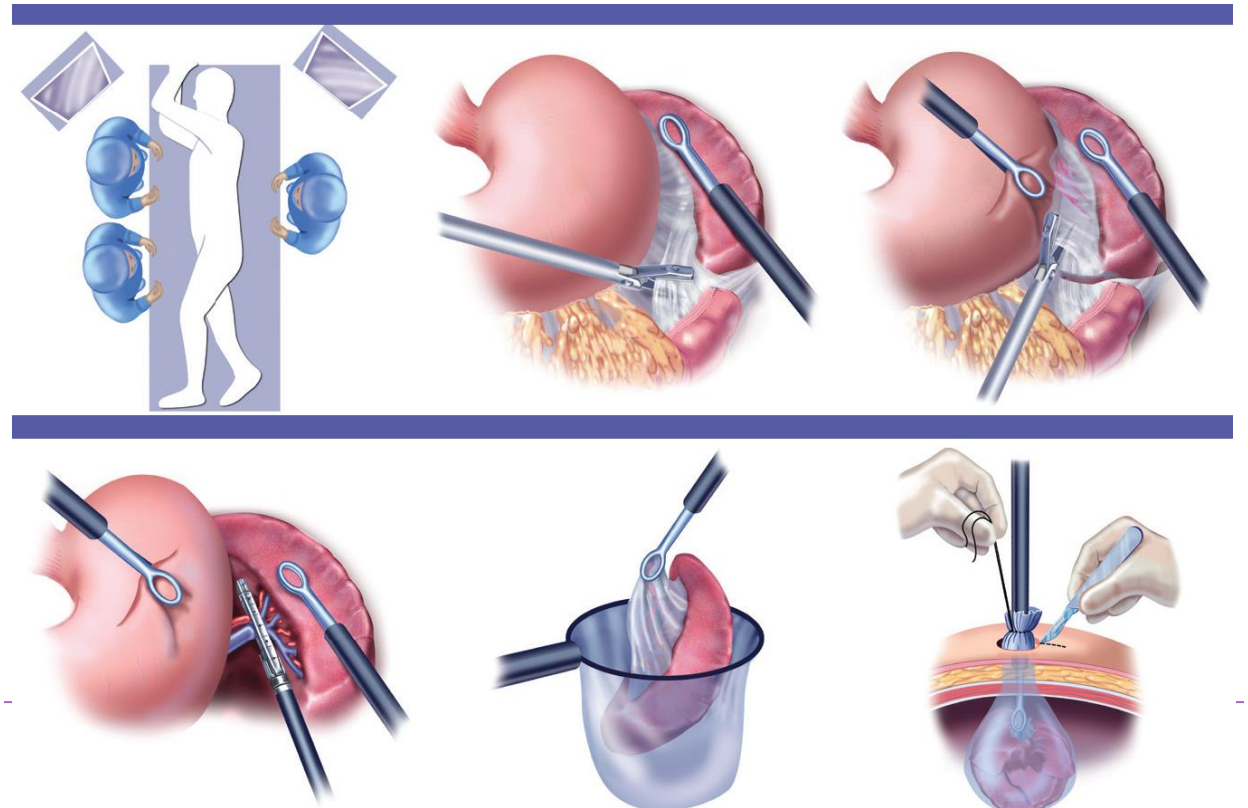
Management

Non-operatively

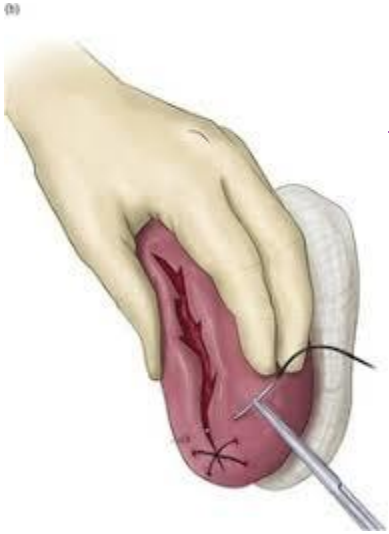
- Approximately 80% in adults and 90% to 95% in children
- Delayed bleeding may occur **days to weeks** after the injury
- The duration of avoidance of vigorous physical activities and contact sports should be individualized , **approximately 4 to 6 weeks.**
- Development of hemodynamic instability, peritonitis or the need for blood transfusion should trigger operative exploration.

Operative

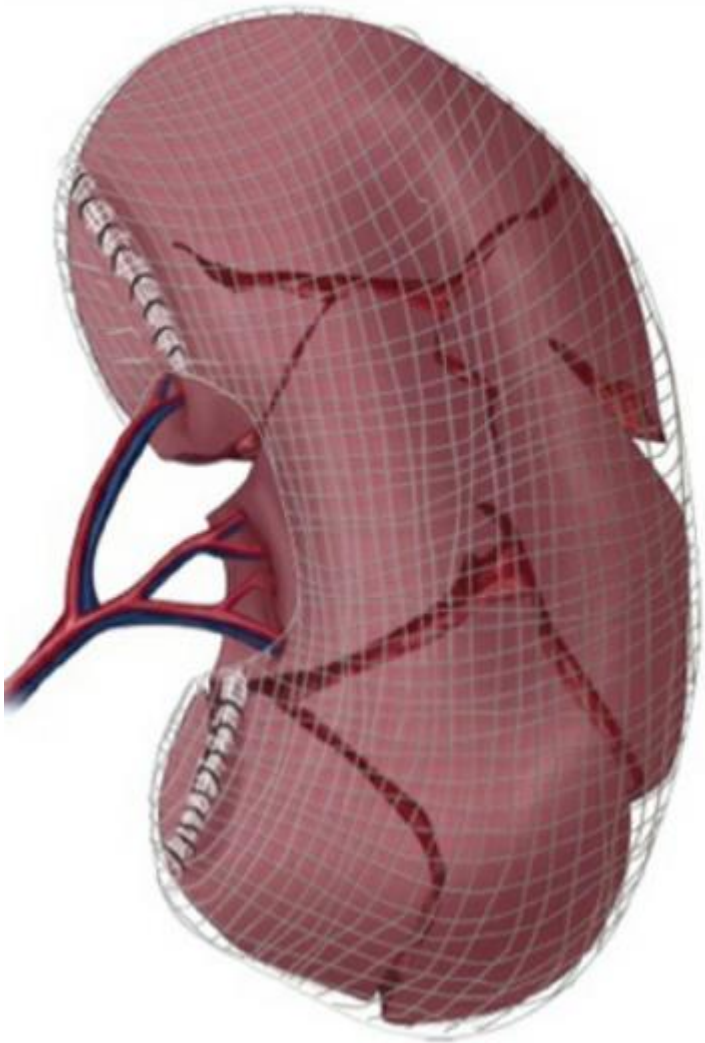
- Midline laparotomy incision
- Any free blood is evacuated
- Packing & rapid evaluation of any other major injuries
- Assessment & determine if the spleen is salvageable
- **IF Not → Splenectomy**



Preservation of the spleen



Lacerations suture



Early local post-splenectomy complications

1. Recurrent bleeding,
2. Pancreatic complications (pancreatitis, pseudocyst, and pancreatic fistula),
3. Gastric complications (gastroparesis, necrosis of the greater curvature),
4. Subdiaphragmatic abscess,
5. Splenic vein thrombosis,
6. Splenic arteriovenous fistula,
7. Left lower lobe atelectasis, or pleural effusion.
8. Overwhelming postsplenectomy infection (OPSI)

Overwhelming postsplenectomy sepsis is caused by encapsulated bacteria (S. pneumonia, H. influenzae, N. meningitidis).

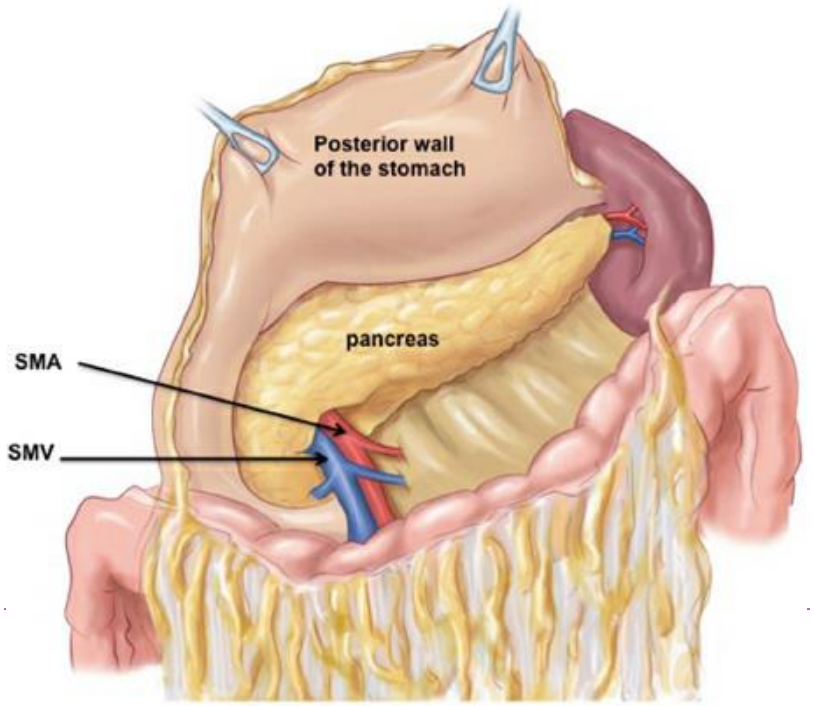
A rare but often fatal complication.

Prophylaxis against these bacteria is provided via vaccines administered optimally at 14 days.

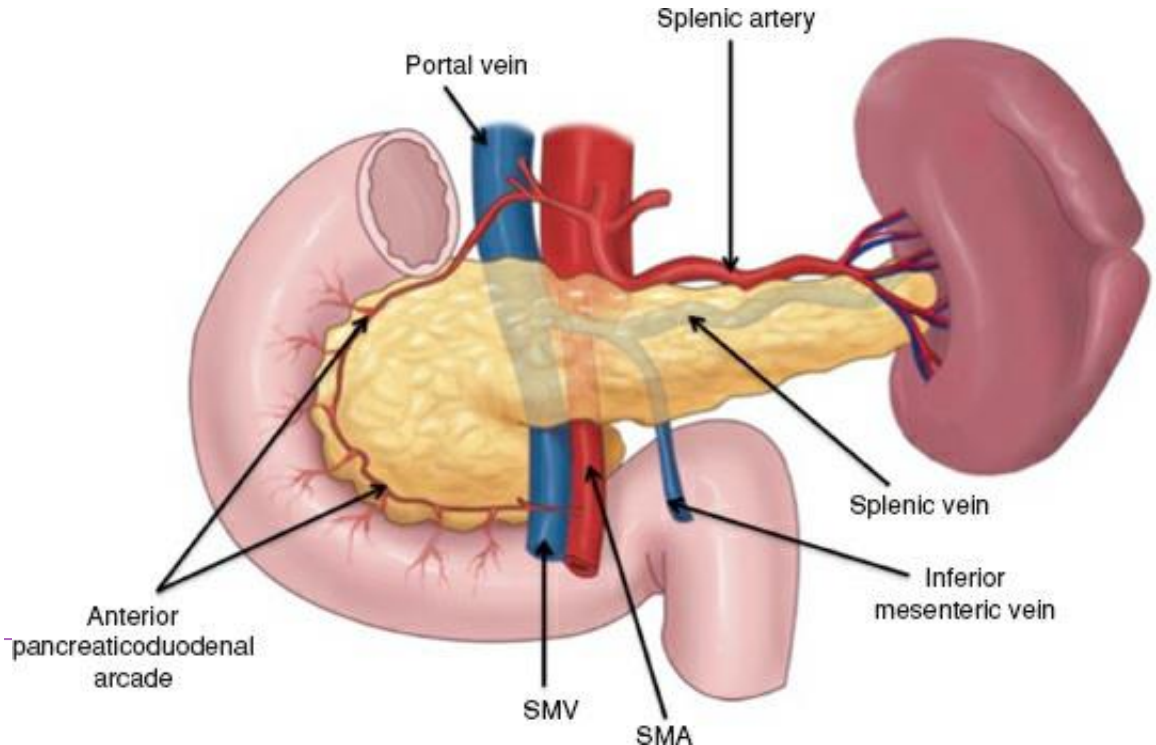
Pancreas

Anatomy

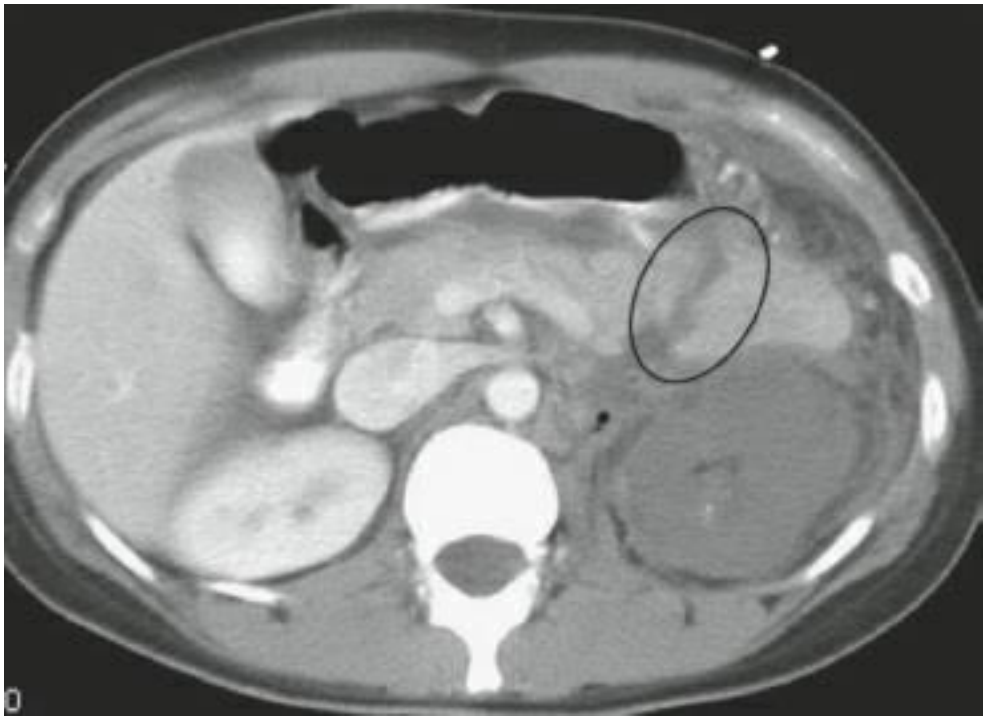
- The pancreas is a retroperitoneal organ with its head directly situated over the inferior vena cava and its neck over the superior mesenteric vessels and the proximal portal vein. The body extends over the suprarenal aorta and the left renal vessels, closely related to the splenic artery and vein. The uncinate process wraps around the superior mesenteric vessels.



- drains into the duodenum, approximately 2 to 3 cm proximal to the ampulla of Vater. The pancreatic head and the proximal duodenum receive their blood supply from the anterior and posterior pancreaticoduodenal arcades. Because these arcades lie on the surface of the pancreas, close to the duodenal loop, separating these can result in ischemic damage to the duodenum.



- 0.2% of blunt trauma and 1% of penetrating trauma
- Difficult to diagnose (retroperitoneal organ)
- Contrast-enhanced CT scan is the investigation of choice

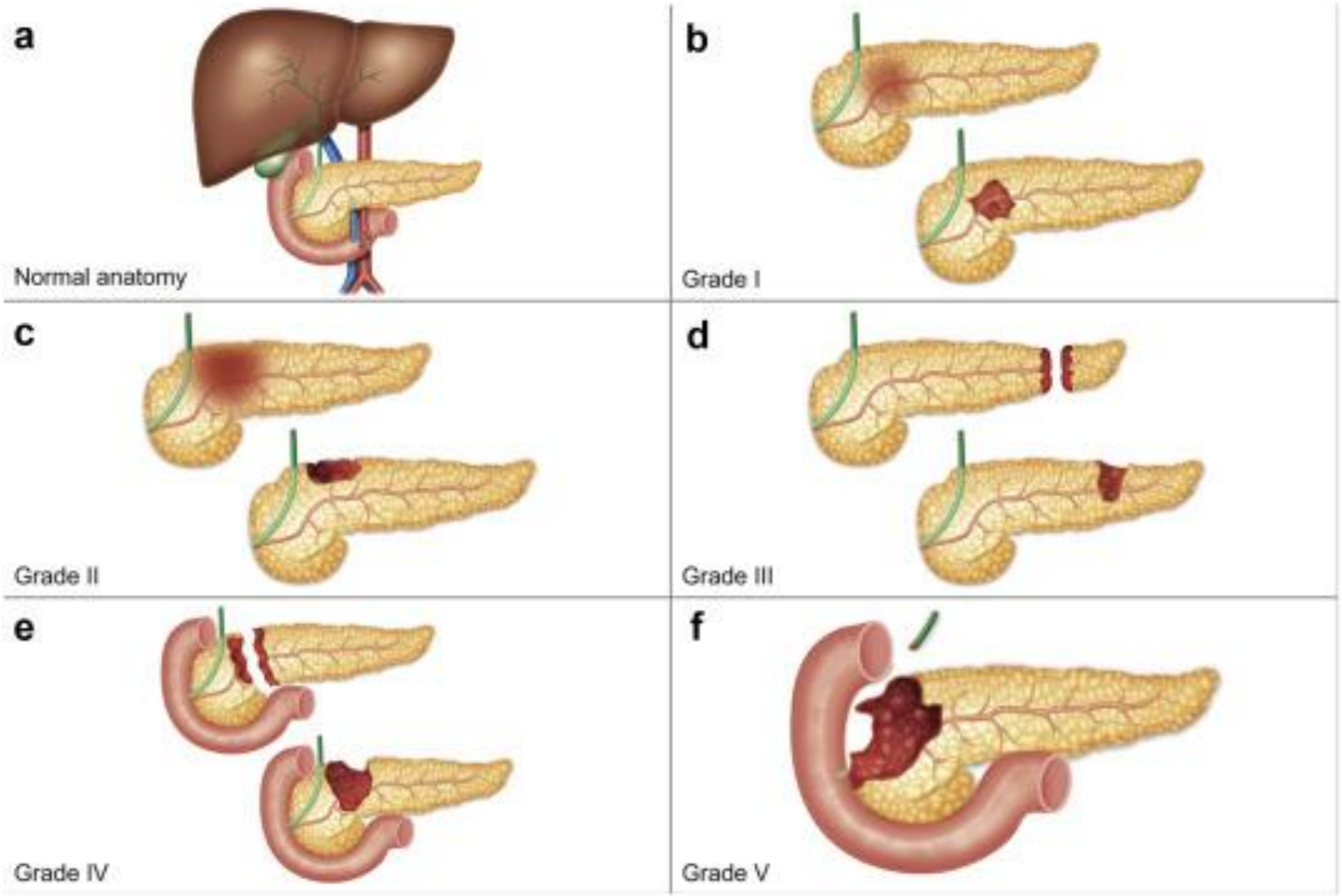


OIS-AAST Grading Scale for the Pancreas

Grade[a]	Type	Injury Description
I	Hematoma	Minor contusion without duct injury
	Laceration	Superficial laceration without duct injury
II	Hematoma	Major contusion without duct injury or tissue loss
	Laceration	Major laceration without duct injury or tissue loss
III	Laceration	Distal transection or parenchymal injury with duct injury
IV	Laceration	Proximal transection or parenchymal injury involving ampulla
V	Laceration	Massive disruption of pancreatic head

[a]Advance one grade for multiple injuries to the same organ.

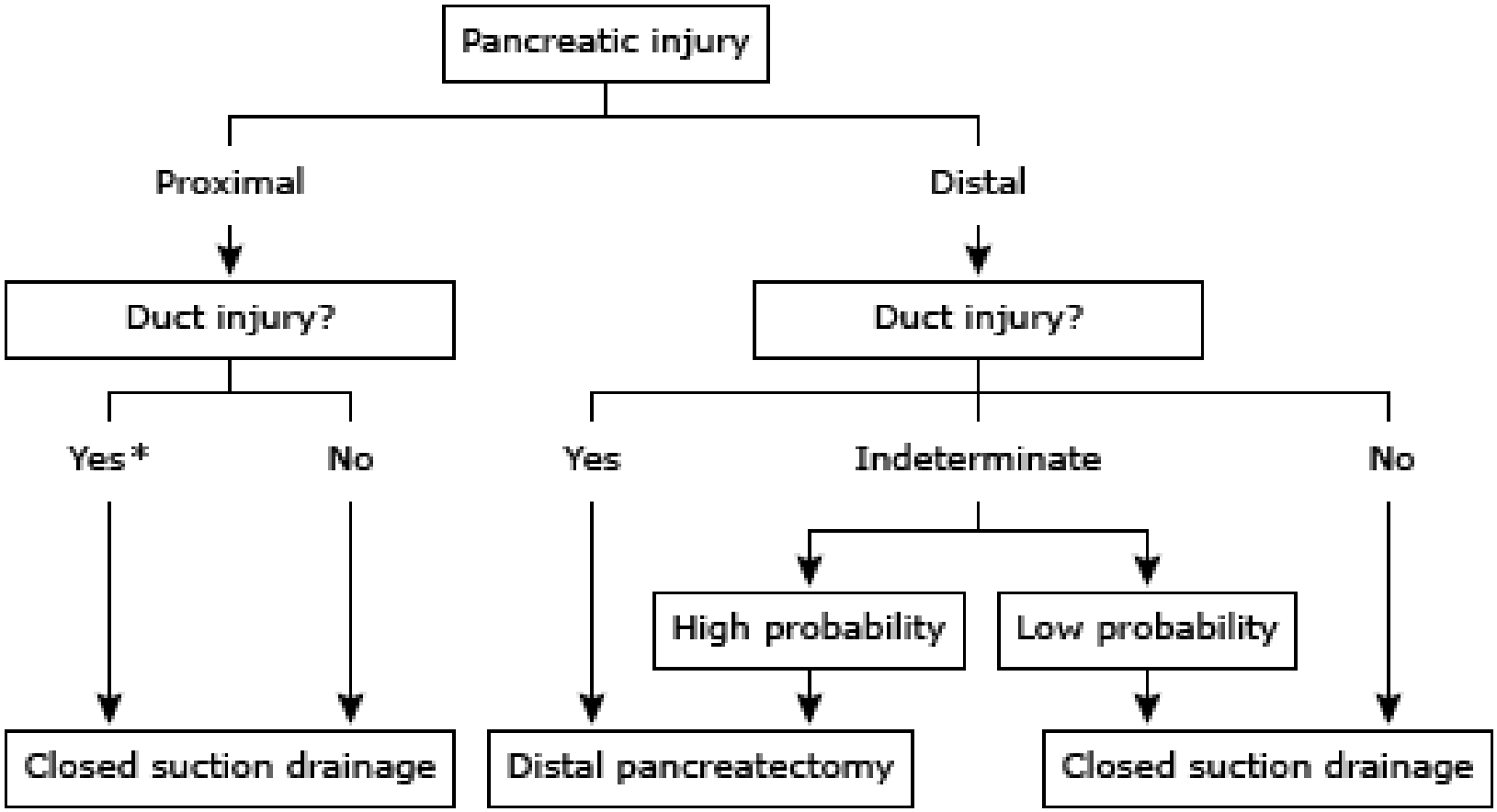
Moore EE, Cogbill TH, Malangoni MA, et al. Organ injury scaling, II: pancreas, duodenum, small bowel, colon, and rectum. *J Trauma* 1990;30: 1427–1429.


a
Normal anatomy
b
Grade I
c
Grade II
d
Grade III
e
Grade IV
f
Grade V

Management

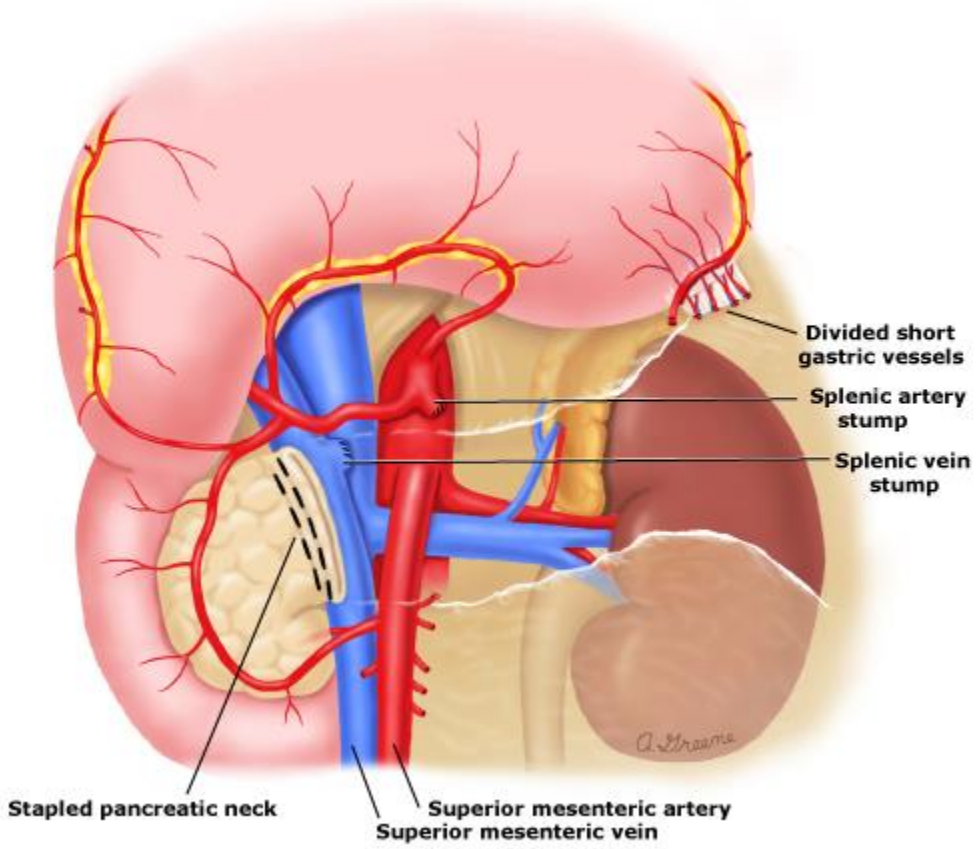
- The management of pancreatic trauma is determined by the mechanism of injury and the presence or absence of pancreatic duct injury. All penetrating injuries require operative management. However, most patients with isolated blunt trauma to the pancreas with an intact pancreatic duct can safely be managed non-operatively.
- Nonoperative management is safe for patients with **blunt** Grade I or Grade II injuries (contusion, superficial laceration) and it has been reported for management of higher-grade injuries in children. (most pancreatic injuries are grade I and II)
- Surgery is generally recommended for patients who have ductal injury identified on computed tomography or cholangiopancreatography.

When injury to the pancreas is identified during abdominal exploration, the integrity of the main pancreatic duct should be evaluated and the location of the injury



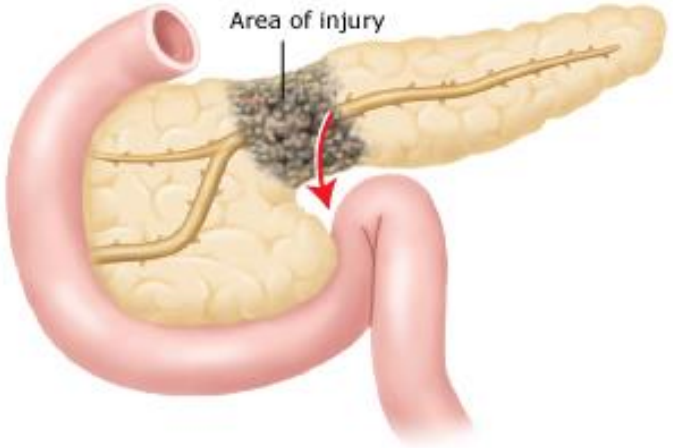
* Patients with significant injury to the head of the pancreas involving the proximal ducts may require debridement, or, rarely, more extensive surgery such as pancreaticoduodenectomy or pyloric exclusion.

Distal pancreatectomy specimen with splenectomy specimen after blunt trauma →

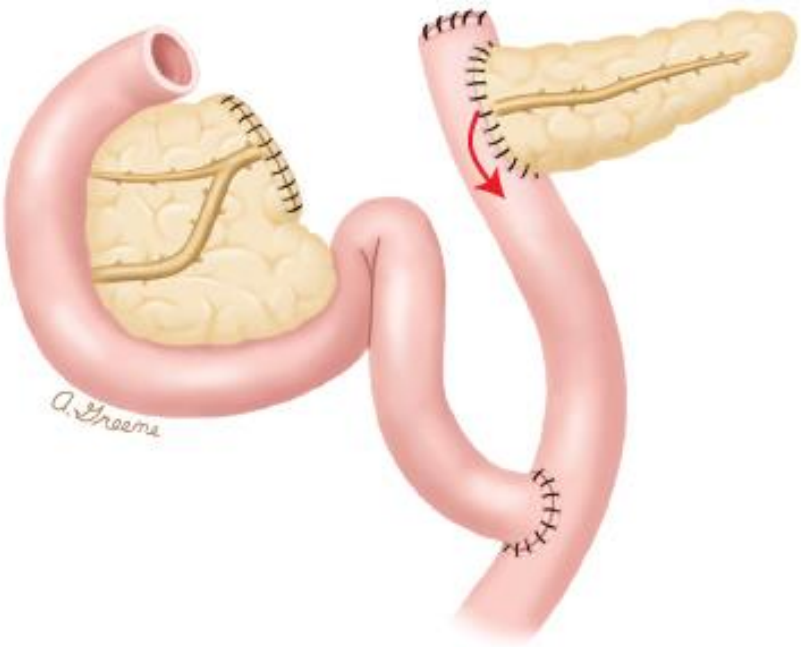


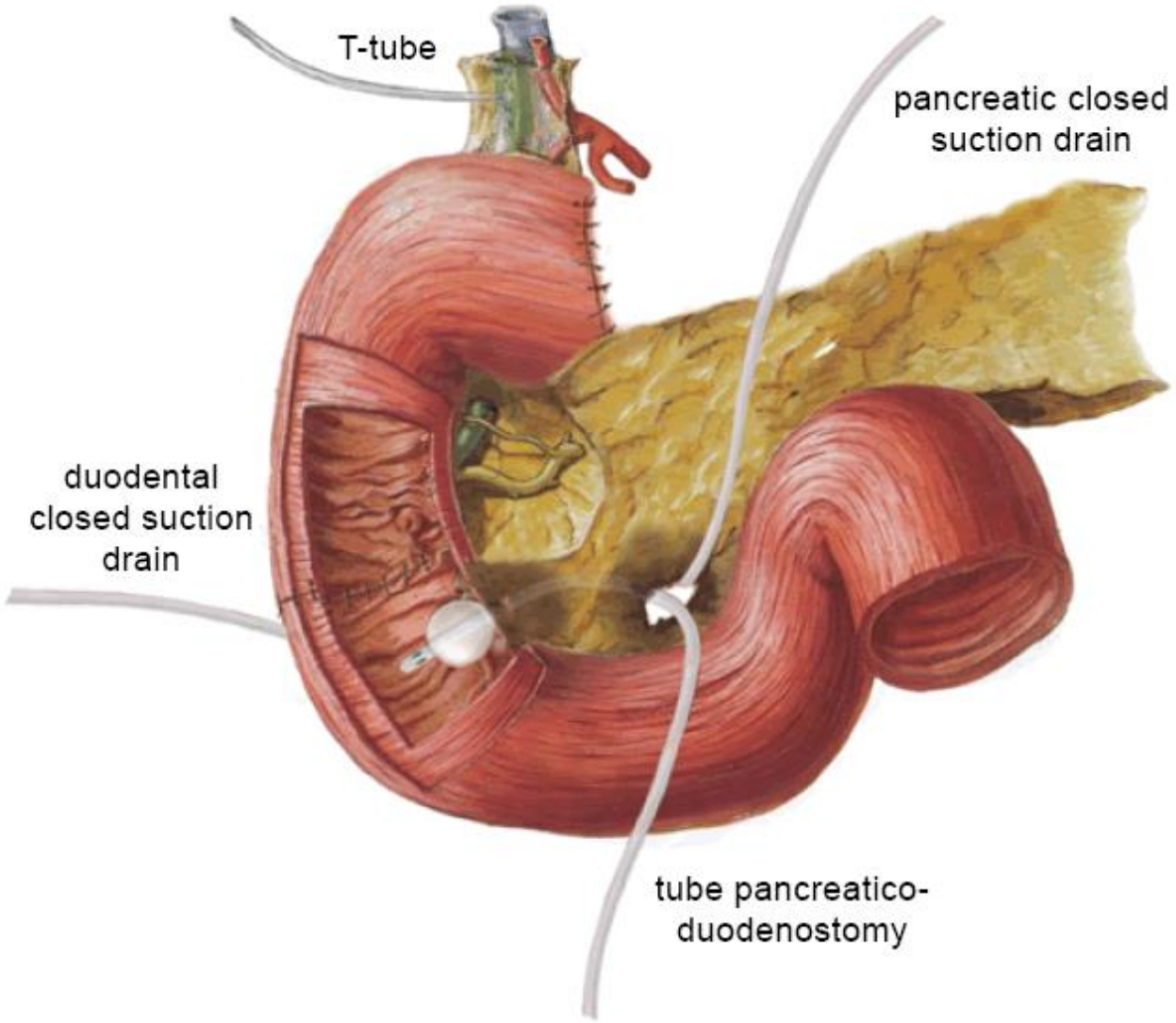
Distal pancreatectomy with splenectomy ←

A **Central pancreatic injury**

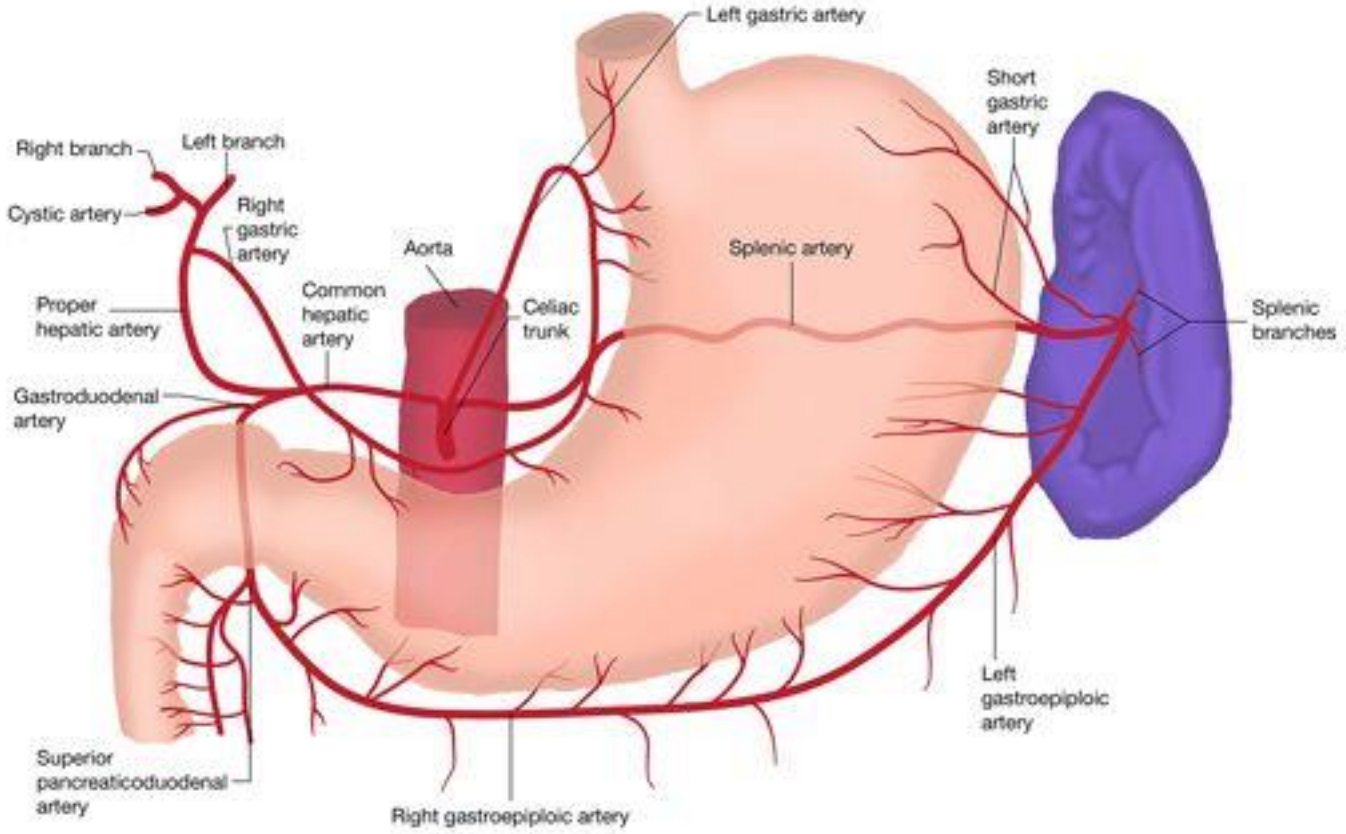


B **Repair with Roux-en-Y pancreaticojejunostomy**




T-tube
pancreatic closed suction drain
duodental closed suction drain
tube pancreatico-duodenostomy

Stomach


Left gastric artery
Short gastric artery
Right branch
Left branch
Cystic artery
Right gastric artery
Aorta
Splenic artery
Common hepatic artery
Celiac trunk
Proper hepatic artery
Splenic branches
Gastroduodenal artery
Left gastroepiploic artery
Superior pancreaticoduodenal artery
Right gastroepiploic artery

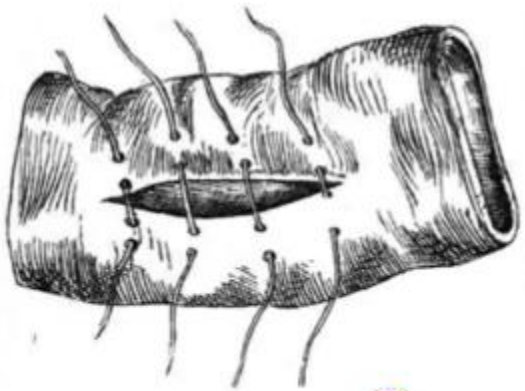
Diagnosis

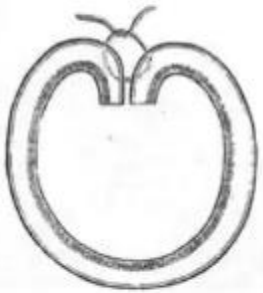
- Most of stomach injuries are due to penetrating trauma.
- Presence of blood upon placement of an NG tube is concerning for gastric injury. The majority of patients with full-thickness gastric injury after trauma will present with spillage of gastric contents and peritonitis resulting in direct transfer to the operating room.
- Blunt injury to the stomach can cause local contusion with gastric wall hematoma or hollow viscus rupture, similar to bladder rupture, with a large full-thickness defect.
- After blunt or penetrating trauma, in the absence of peritonitis or hemodynamic instability, additional diagnostic workup with CT imaging is appropriate.
- CT scan findings concerning gastric injury include extraluminal contrast, air, blood, or fluid, or localized thickening, or enhancement and discontinuity of the gastric wall.

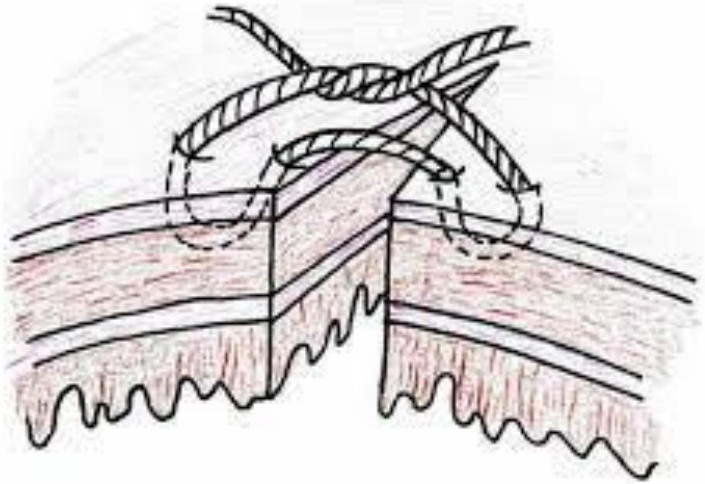
Manegement

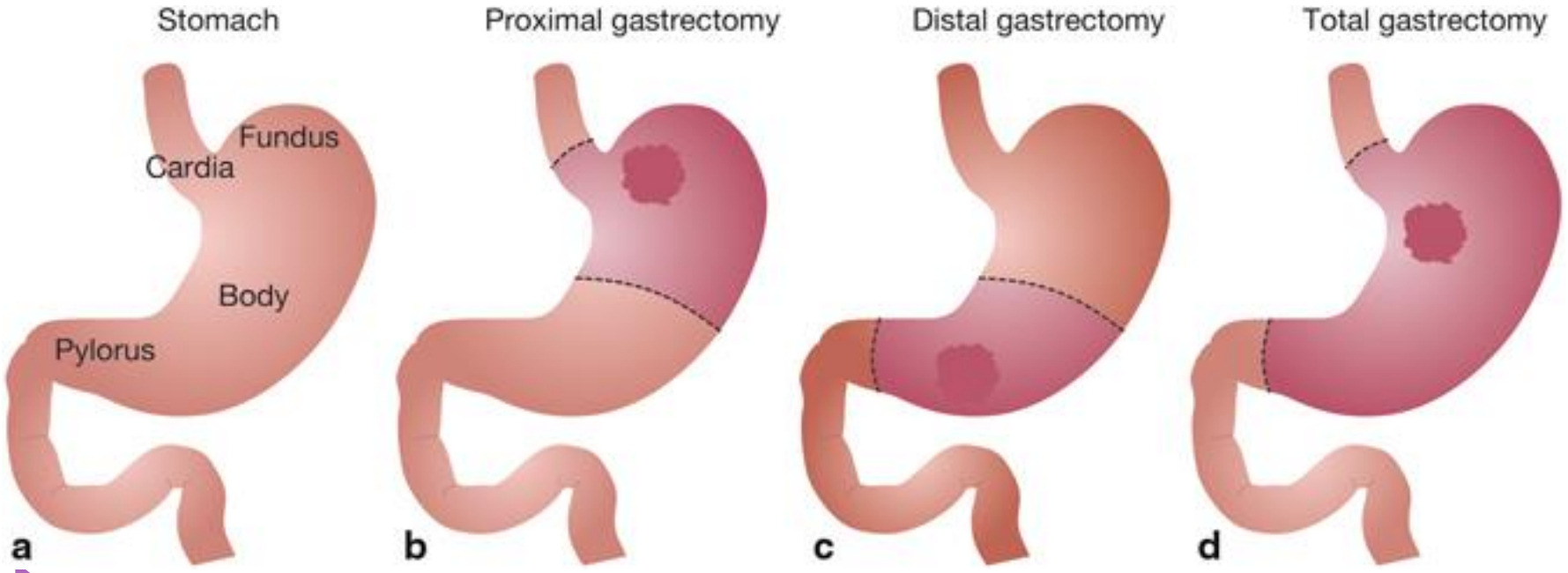
- After penetrating injury, if a single gastric injury is identified, the operating surgeon must assume there is an additional injury corresponding to the entry or exit site.
- Low-grade injuries including hematomas and contusions should be evaluated and evacuated as appropriate. After hematoma evacuation and hemostasis is achieved, the area may be reinforced with Lembert sutures. Full-thickness injuries can be repaired in one or two layers. A two-layered repair includes an inner layer of running absorbable suture and an outer layer of Lembert sutures.
- Significant destructive injuries or those involving the GE junction or pylorus may require a proximal or distal gastrectomy with reconstruction.

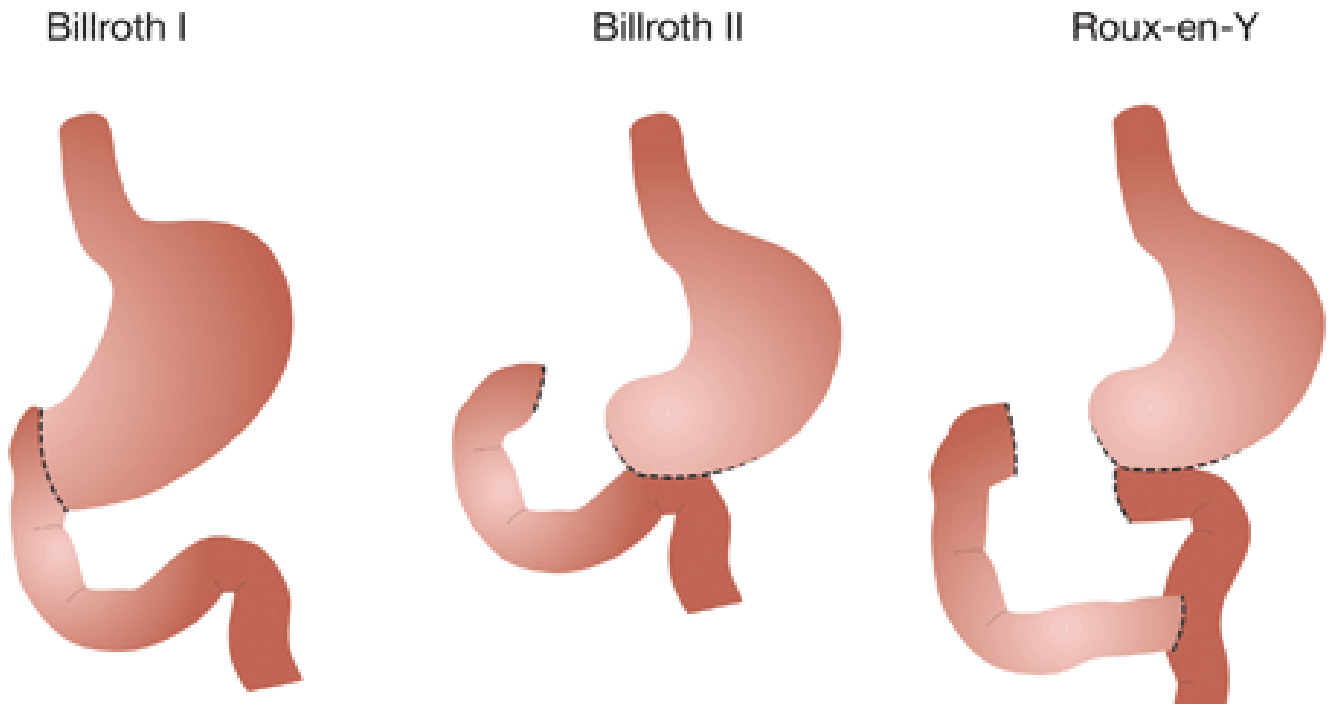
Lembert Suture





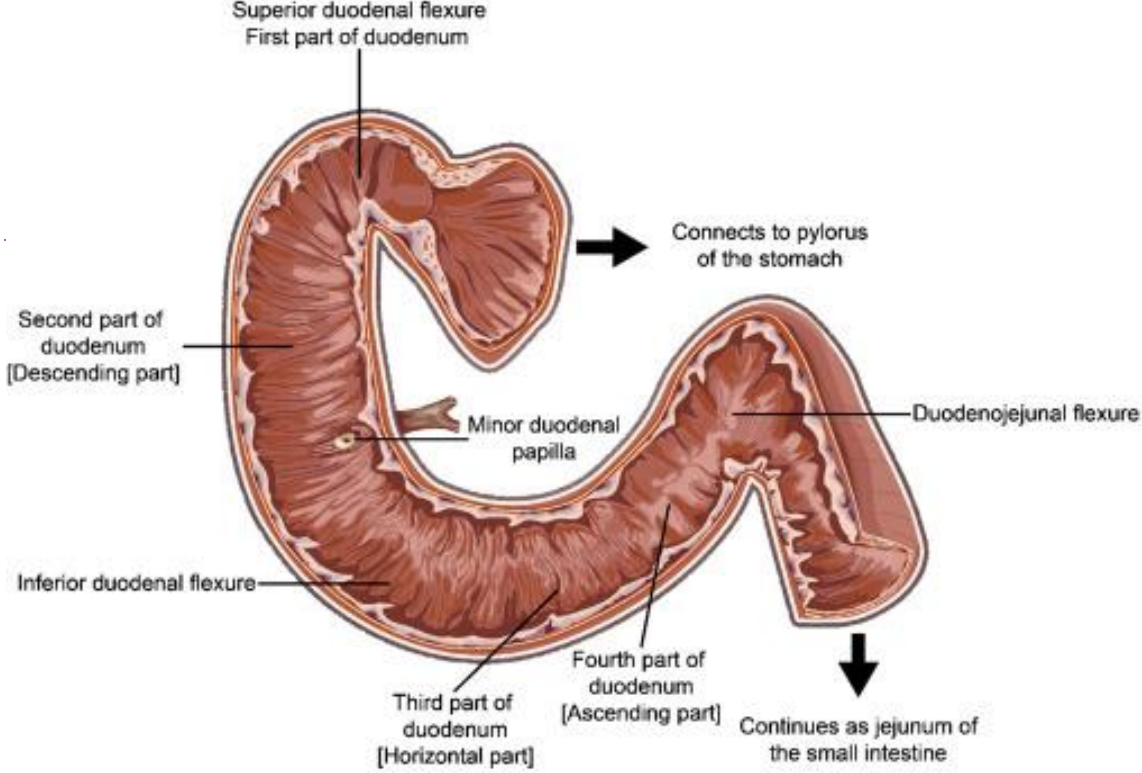




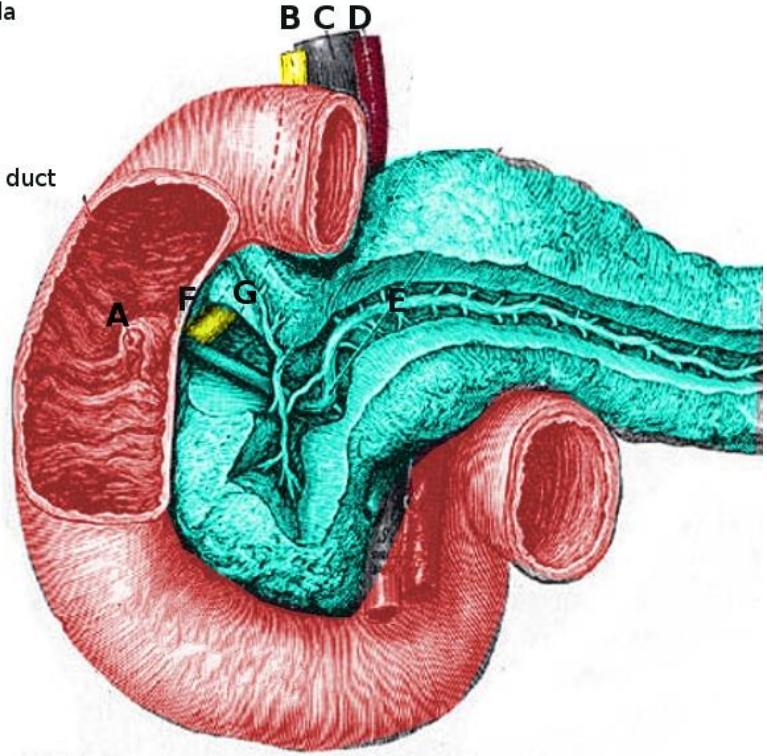

Billroth I
Billroth II
Roux-en-Y

Duodenum

Anatomy



A- Major duodenal papilla
B- CBD
C- Portal vein
D- Hepatic artery
E- Pancreatic duct
F: CBD
G- Accessory pancreatic duct



- Duodenal trauma is rare, occurring in less than 5% of all trauma patients, and is associated with a high morbidity and mortality.
- The majority of duodenal trauma is secondary to penetrating injury and is identified during operative exploration.
- Diagnosis made by imaging studies, typically computed tomography (CT) of the abdomen or exploratory laparotomy, as indicated by the clinical scenario (stable or unstable).
- CT findings are duodenal wall thickening, periduodenal fluid, fluid in the right anterior pararenal space, diminished enhancement of the injured duodenal wall segment, and the "sentinel clot" sign, which is a highly attenuating,heterogeneous fluid (clot) accumulation near the site of injury.
- Also findings of extraluminal air or extraluminal contrast indicate duodenal perforation.

Management

- Most low-grade duodenal hematomas secondary to blunt trauma without perforation can be managed conservatively with NG tube decompression and supplemental nutrition.
- Lacerations need primary repair after debridement of dead tissue.
- Destructive injuries or multiple penetrating injuries need segmental resection followed by end-to end anastomosis

Colon and rectum

- Relatively uncommon
- Definitive diagnosis is almost always **intraoperatively**

- Non-destructive colon and intraperitoneal rectal injuries:

Primary closure

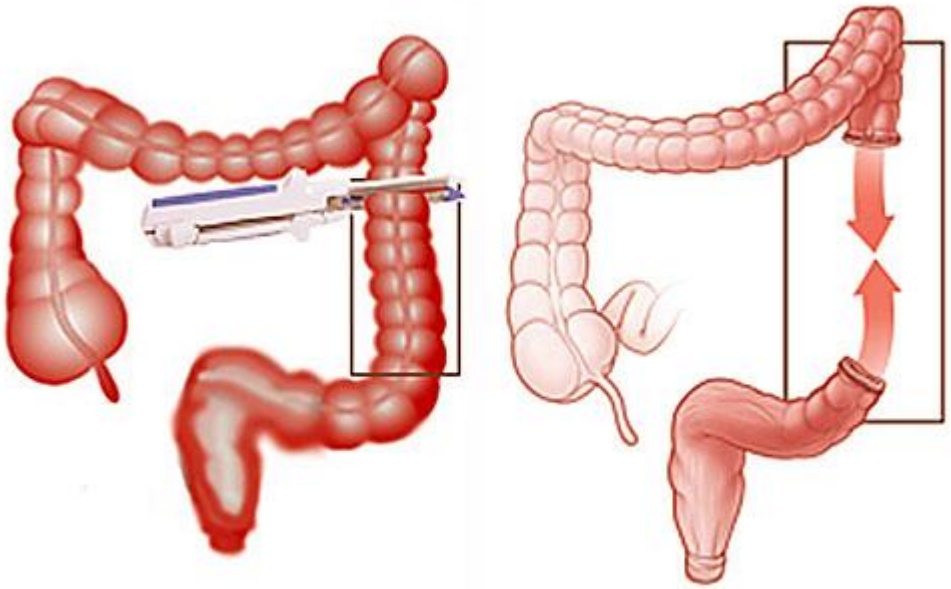
- Extra-peritoneal rectal injuries:

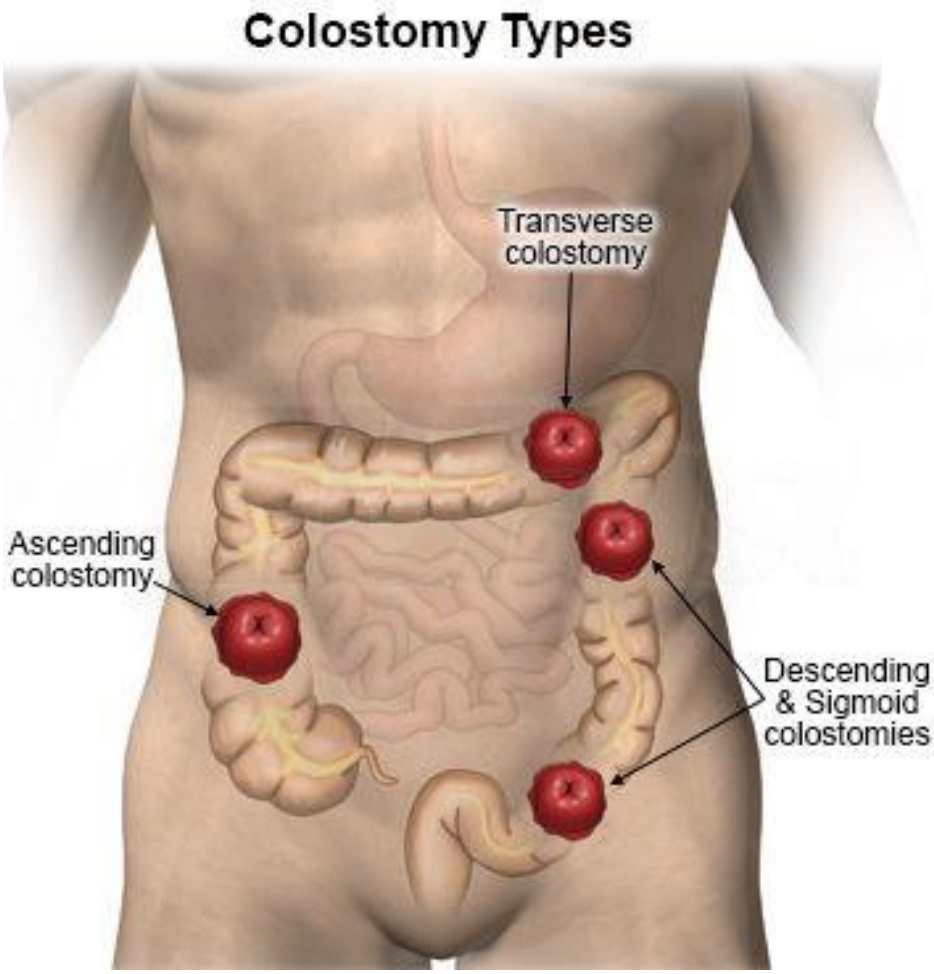
Diverting colostomy alone may be adequate

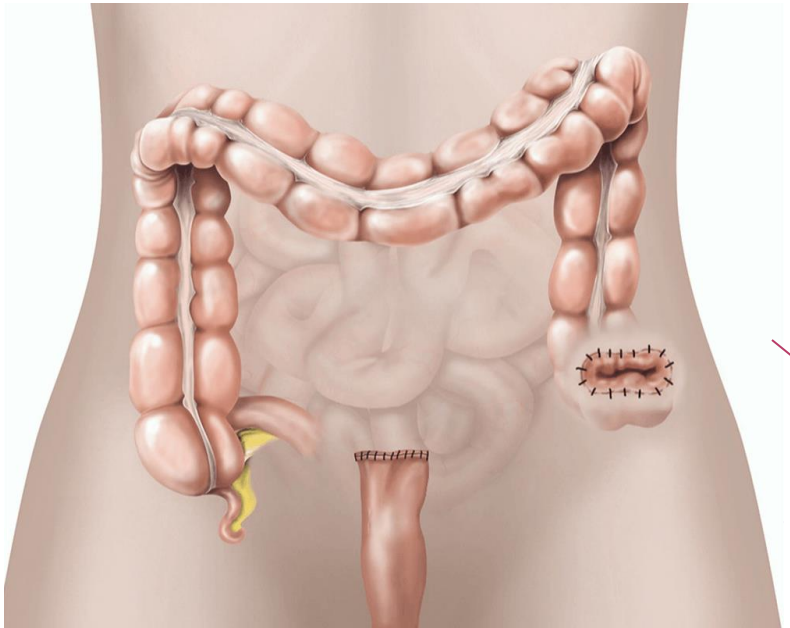
- Colon injuries not amenable to primary repair:

colon resection with primary anastomosis

colon resection with primary anastomosis







Hartmann Procedure

- References:

Greenfield's Surgery Textbook 6th Edition

Uptodate 2021 data

The End