Trauma: Abdomen, Extremities, Spine

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Basic Science

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36 year old man, restrained driver in rollover motor vehicle crash. Blood pressure on arrival is 83/57 and HR 102. Hypotension unresponsive to resuscitation. Tender abdomen. Abdominal ultrasound obtained.

Next step?

a. Exploratory laparotomy
b. Diagnostic peritoneal lavage
c. Abdominal CT scan
d. Serial observation

28 y/o woman, unrestrained driver in a motor vehicle crash. Stable vital signs and LUQ tenderness, but no signs of peritonitis. Next step?

a. Exploratory laparotomy
b. Diagnostic peritoneal lavage
c. Serial observation
d. Abdominal CT scan
e. Abdominal ultrasonography

Abdomen

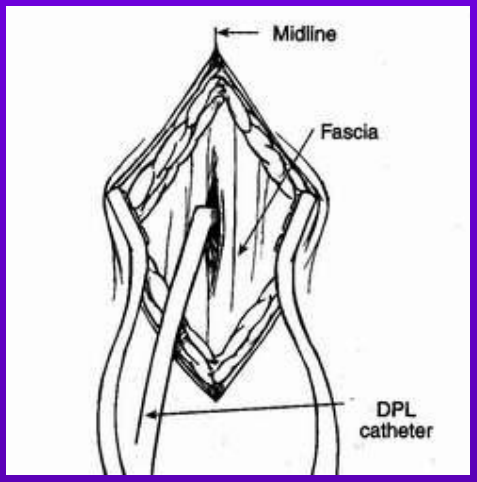
- 25% of all trauma patients require ex lap.
- Physical exam can be unreliable
  - AMS, compensated hemoperitoneum, retroperitoneal, pelvic injuries
- Diagnostic tools:
  - Diagnostic peritoneal lavage (DPL)
  - Ultrasound
  - CT
  - Laparoscopy

Diagnosis

- Test of choice dependent on hemodynamic stability and severity of associated injuries.
- Stable blunt trauma → FAST or CT
- Unstable blunt trauma → FAST or DPL
- Stab wounds without peritoneal signs, evisceration, or hypotension → wound exploration or DPL.
- Gun shot wounds → surgical exploration.

DPL

- Standard criteria
  - 10cc gross blood
  - RBC>100,000/mm^2 (5% miss)
  - WBC>500/mm^2
  - Amylase>175 IU/dL
  - Bile, bacteria, or food
- Contraindications
  - Clear indication for ex lap
  - Prior abdominal surgeries
  - Pregnancy
  - Obesity

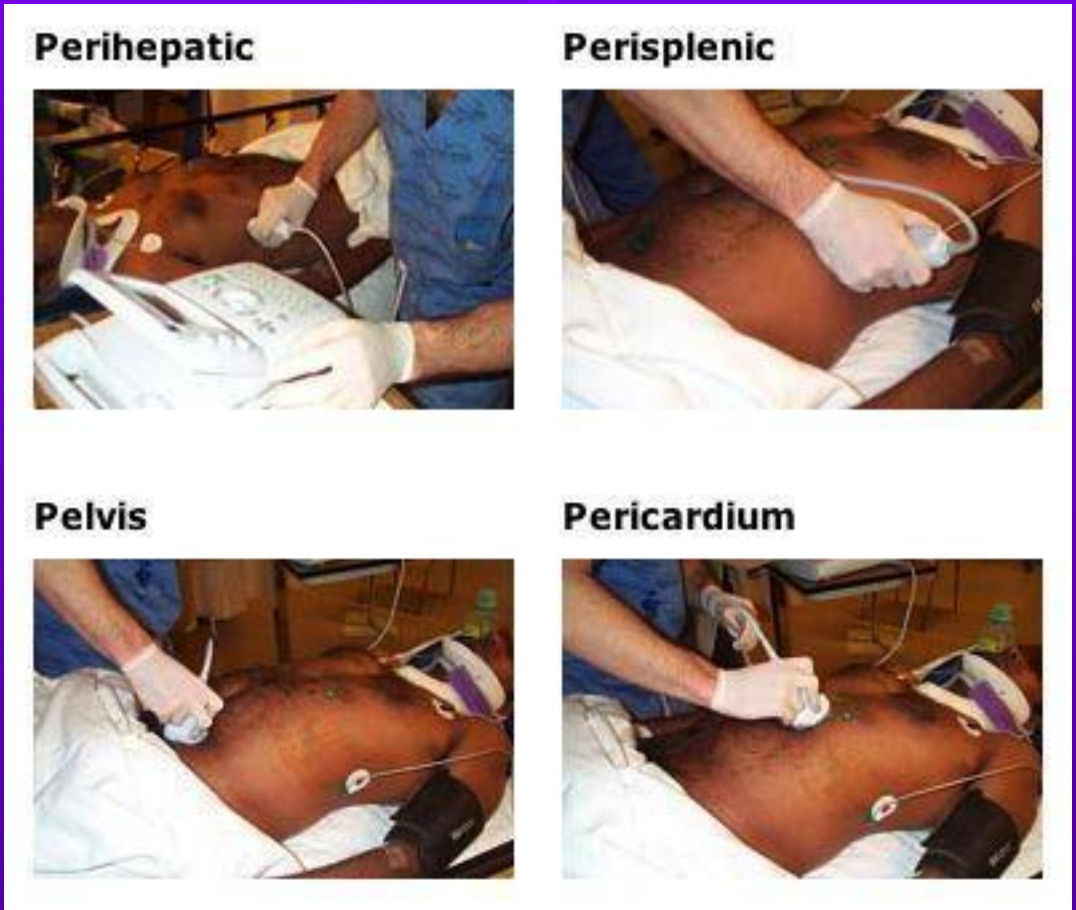


*NGT, foley

DPL

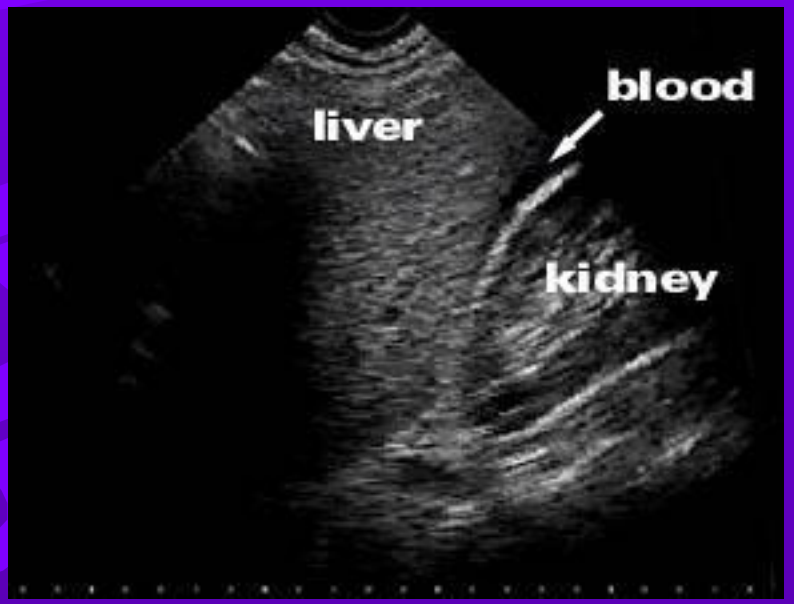
- Highly sensitive to intraperitoneal blood, but low specificity → nontherapeutic explorations.
- Supraumbilical if pelvic fracture present
- Significant injuries may be missed
  - Diaphragm
  - Retroperitoneal hematomas
  - Renal, pancreatic, duodenal
  - Minor intestinal
  - Extraperitoneal bladder injuries

Focused Assessment with Sonography for Trauma (FAST)



FAST

- Pros
  - Noninvasive
  - Fast
  - Low cost
- Cons
  - User dependent
  - Obesity, gas interposition
  - Misses retroperitoneal/hollow viscus injury
  - May not detect free fluid <50-80 cc



CT Scan

- Hemodynamically stable patient
- Pros
  - Retroperitoneal assessment
  - Nonoperative management of solid organ injury
  - High specificity
- Cons
  - Hardware, cost, radiation
  - Hollow viscus injuries, diaphragm injury

Laparoscopy

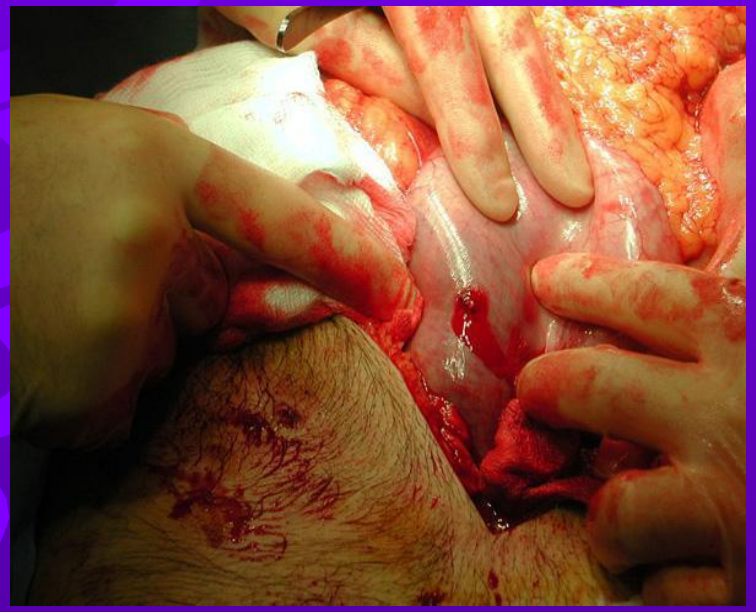
- Role still being defined
- Good for diaphragm injury evaluation
- Cons
  - Invasive
  - Expensive
  - Missed small bowel, splenic, retroperitoneal injuries

Gastric Injury

- Mostly penetrating trauma.
- <1% from blunt trauma
  - Including iatrogenic injury from CPR
- NGT + aspirate for blood
- Intraop evaluation includes complete visualization of posterior wall
- Most penetrating wounds treated by debridement and primary closure in layers.
- Evacuation of hematomas.
- Major tissue loss may necessitate resection.

Gastric Injury

- Post-op complications
  - Bleeding, abscesses, gastric fistula, empyema
- Recent meal → neutralization of gastric acidity → increased lower GI tract bacteria (*Bacteroides, E. coli, Strep faecalis*) → increased infection

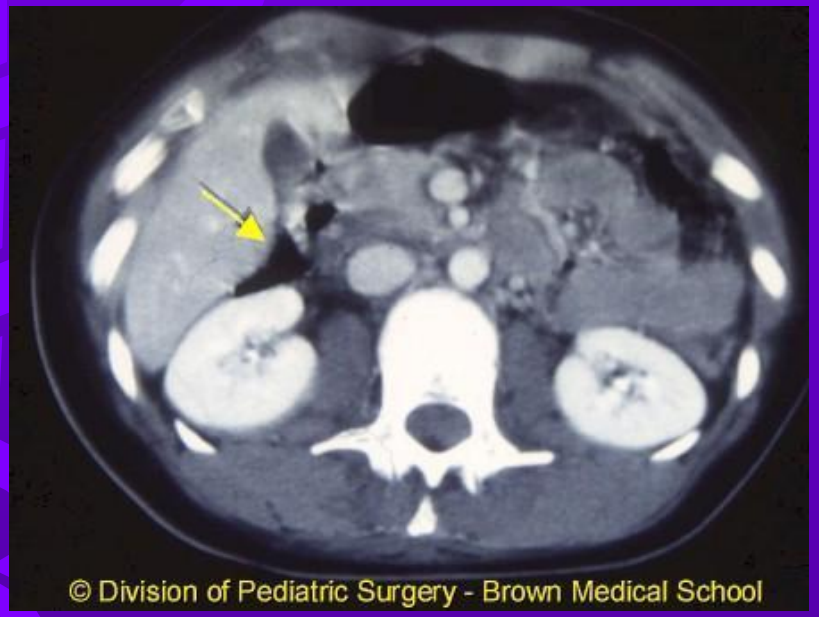


Duodenal Injury

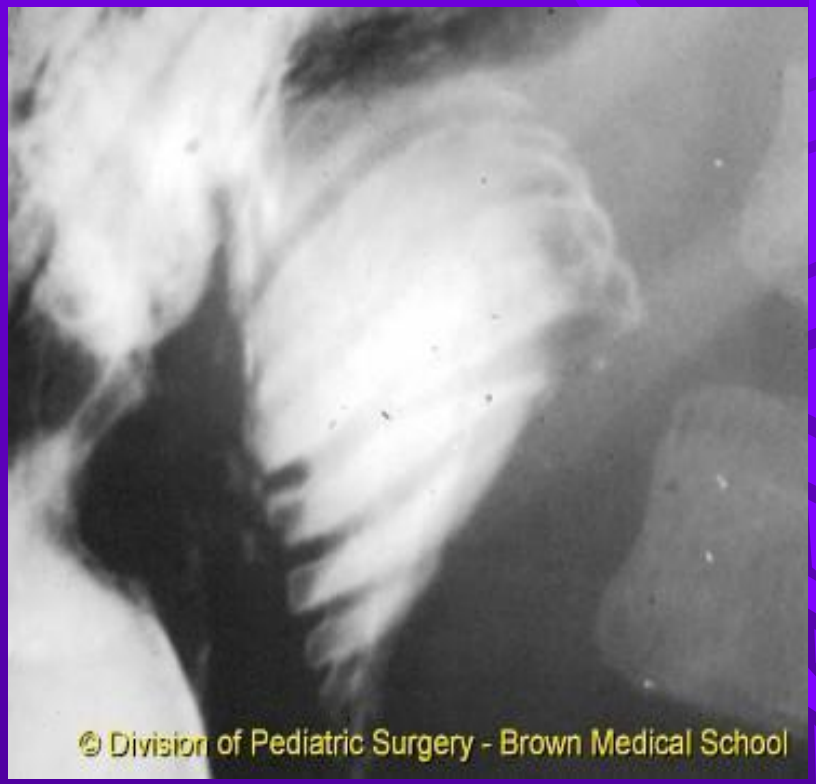
- Majority due to penetrating trauma.
- Blunt injury usually secondary to steering wheel blow to the epigastrium
- Retroperitoneal location is protective, but also prevents early diagnosis.
- Isolated injury to the duodenum is rare
- Hyperamylasemia in 50% with blunt injury.

Duodenal Injury

- Gastrograffin UGI or CT w/ contrast
- Extravasation of contrast → OR
- If CT eqivocal –dilute barium UGI
- May see retro-peritoneal air on CT
- DPL unreliable but may be positive from an associated injury



You suspect a duodenal injury and get an UGI w/ following result. Which of the following are true?



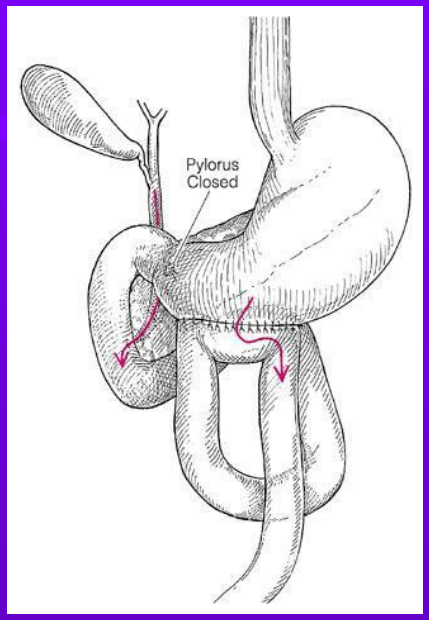
1. This patient needs a laparotomy
2. This patient may be managed non operatively
3. This is the stacked coin sign and indicates a duodenal rupture
4. Usually resolves in 2 weeks

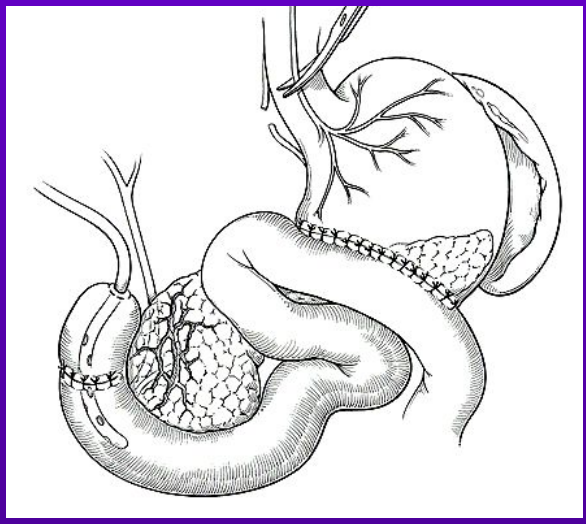
Duodenal Hematoma

- NGT until peristalsis resumes.
- Slow introduction of food.
- OR if obstruction persists > 10 –15 days.

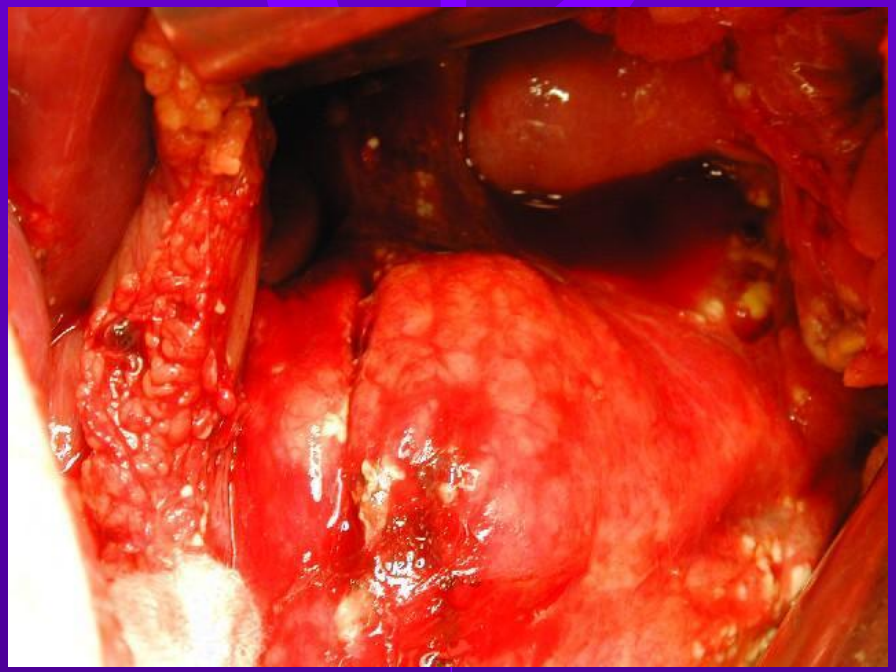
Duodenal Injury

- Appropriate repair depends on injury severity and elapsed time
- 80-85% can be primarily repaired.
- Duodenal decompression advisable if injury >6 hours old.



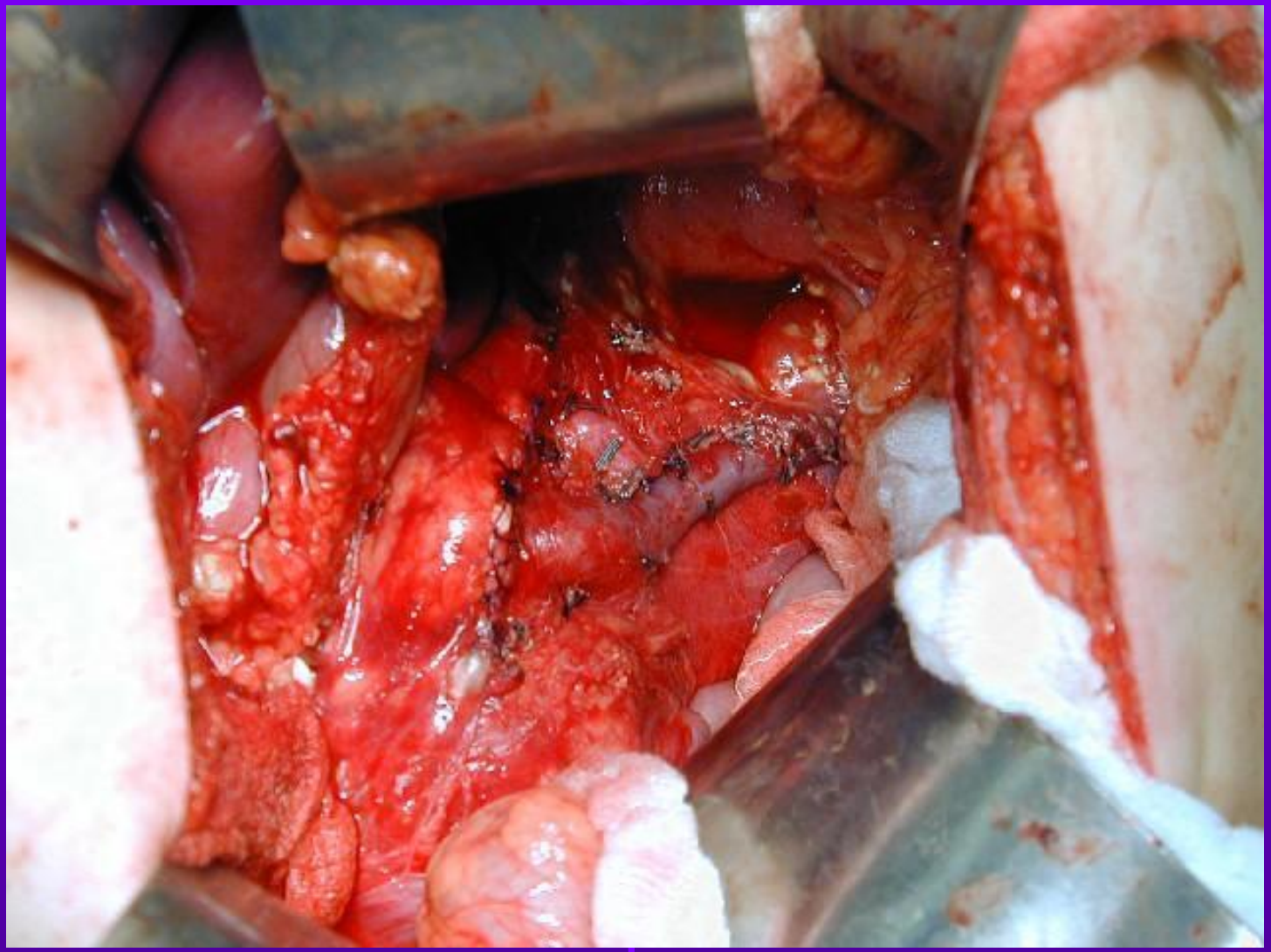


The upper abdomen of a 42 y/o male strikes the steering wheel during a MVA. After a positive DPL, he undergoes an ex lap, at which time transection of the pancreas at the neck is found. Next step?



Next step?

a. Distal pancreatectomy with oversewing and drainage of proximal stump.
b. Primary repair and drainage of the pancreatic duct.
c. Roux-en-Y pancreaticojejunostomy to the distal pancreas with oversewing and drainge of the proximal stump.
d. Total pancreatectomy

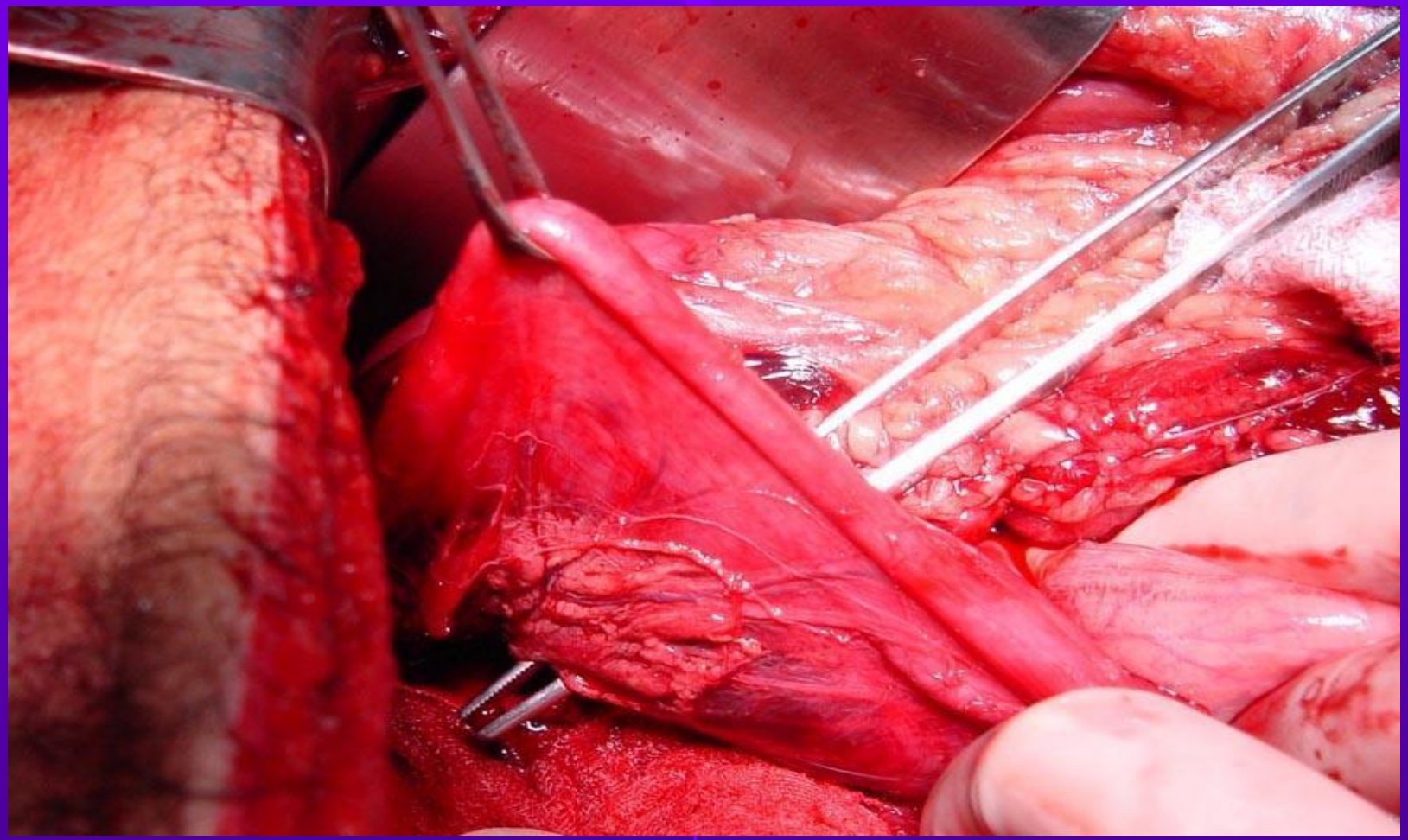


Pancreatic Injury

- Rare 10-12% of abdominal injuries, but mortality 10-25%, mostly from associated intra-abd injury
- Most caused by penetrating trauma - 75% associated with major vascular injury
- Blunt trauma → compression of pancreas against vertebral column
- Retroperitoneal location delays diagnosis.
- Elevated amylase/lipase
- Role of CT improving
- Pancreatic duct injury key factor in morbidity.

Pancreatic Injury

GSW to Pancreatic Head



Pancreatic Injury

- Divided into proximal or distal according to location on the R or L of SMV
- Contusions (Grade I-II) should be drained.
- Distal duct injury (Grade III) → distal resection with splenic preservation
- Proximal injury (Grade IV)
  - Oversewing and distal resection or pancreaticojejunostomy in diabetic patients.
- Extensive pancreatic head injuries (Grade V)
  - 40% pancreatic fistula development
  - Simple external wide drainage

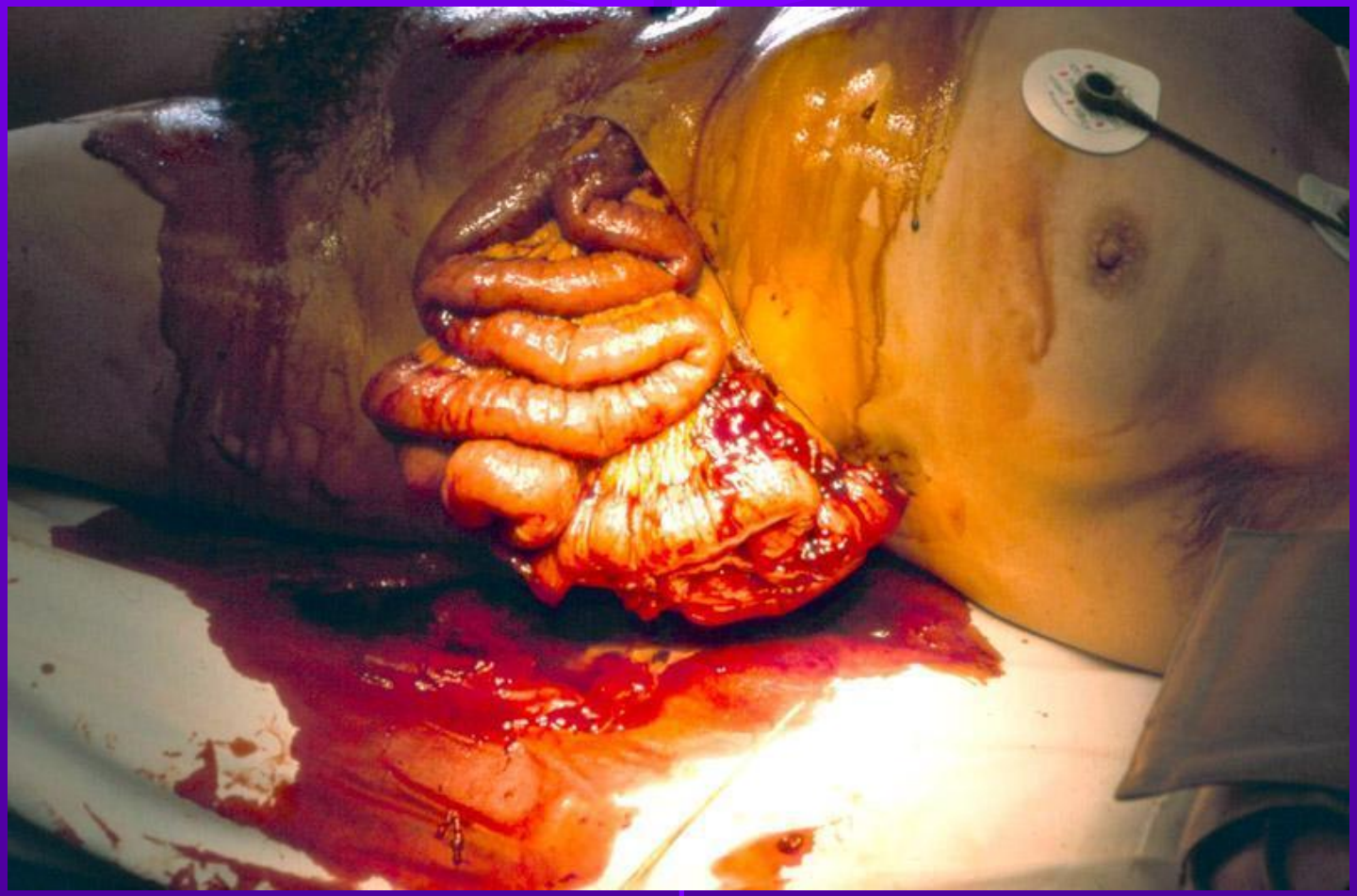
Complications after Pancreatic Trauma

- High complication rate 35-40%
- Most common are pancreatic fistulas & abscesses
- Most fistulas close spontaneously if well drained
- Somatostatin to expedite healing
- Abscesses - surgical debridement & drainage
- Incidence of pancreatitis 8-18%
- Pseudocysts are infrequent

Small Intestine Injury

- Most common organ injured after penetrating trauma
- Blunt trauma
  - Crushing injury against vertebral bodies
  - Shearing at fixed points
  - Closed loop rupture
- Seat-belt sign should raise suspicion.
- DPL/CT not reliable

Small Intestine Injury



Small Intestine Injury

- 13% w/ perforated small bowel have a normal CT scan
- Suggestive findings include free air, free fluid w/o solid organ injury, thickening of small bowel wall or mesentery

Operative management

- Bleeding initially controlled/leakage clamped
- Penetrating injuries by firearms should be debrided.
- Small tears closed primarily.
- Adjacent holes connected and closed transversely.
- Extensive lacerations and devascularization require resection and reanasatomosis.
- Explore all mesenteric hematomas

Colon Injury

- Second most frequent injured organ, usually from penetrating trauma
- Repair within 2 hours dramatically reduces infectious complications.
- Pre-operative antibiotics important adjunct.
- PE blood per rectum, stab to flanks or back
- CT w/rectal contrast, XR- pneumoperitoneum
- WWI primary repair led to 60% mortality.
- WWII colostomy led to 35% mortality.

Colon Injury

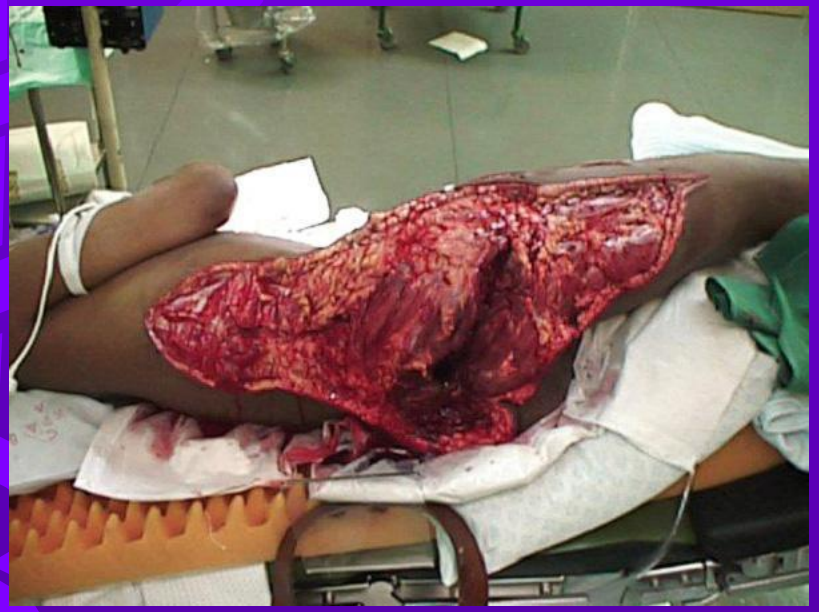
- Primary repair criteria
  - Early diagnosis (within 4-6 hours)
  - Absence of prolonged shock/hypotension
  - Absence of gross contamination
  - Absence of associated colonic vascular injury
  - Less than 6 units blood transfusion
  - No requirement for use of mesh for closure
- Extensive wounds
  - Right colon → hemicolectomy +/- ileostomy
  - Left colon → resection + colostomy

Rectal Injury

- Most from GSW
- Other causes - foreign body, impalement, pelvic fractures, and iatrogenic
- Lower abdomen/buttock penetrating injury should raise suspicion.
- May be intra- or extraperitoneal
- Rectal exam may reveal blood or laceration
- Work-up includes anoscopy and rigid sigmoidoscopy.

Rectal Injury

- Extraperitoneal injury
  - Primary closure
  - Diverting colostomy
  - Washout of rectal stump
  - Wide presacral drainage
- Intraperitoneal injury
  - Primary closure
  - Diverting colostomy



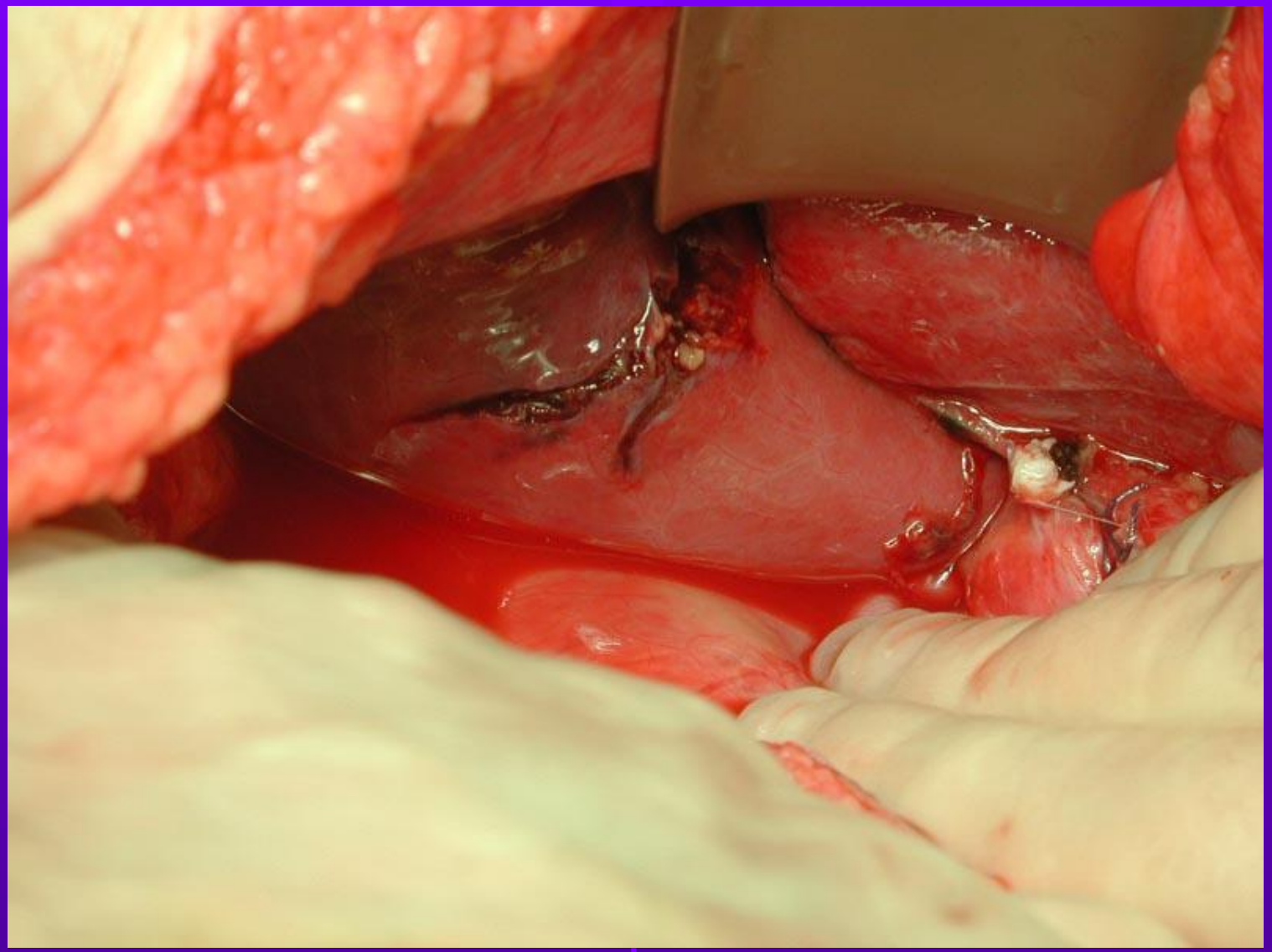
Liver Trauma

- Frequently injured in both blunt & penetrating trauma.
- Control of profuse bleeding from deep lacerations a formidable challenge.
  - Simple suture, mattress sutures, packing, debridement, resection, mesh hepatorrhaphy
- Nonoperative treatment (blunt trauma)
  - Stable without peritoneal signs → U/S → CT
  - Low-grade liver lesions (1-3, 95% success)
  - ICU monitoring

Liver Trauma

Grade	Injury Description	
I	Haematoma	Subcapsular, <10% surface area
	Laceration	Capsular tear, <1cm parenchymal depth
II	Haematoma	Subcapsular, 10-50% surface area
		Intraparenchymal, <10cm diameter
	Laceration	1-3cm parenchymal depth, <10cm length
III	Haematoma	Subcapsular, >50% surface area or expanding. Ruptured subcapsular or parenchymal haematoma
		Intraparencymal haematoma >10cm or expanding
	Laceration	>3cm parenchymal depth
IV	Laceration	Parenchymal disruption involving 25-75% of hepatic lobe or 1-3 Coinaud's segments in a single lobe
V	Laceration	Parenchymal disruption involving >75% of hepatic lobe or >3 Coinaud's segments within a single lobe
	Vascular	Juxtahepatic venous injuries ie. retrohepatic vena cava/central major hepatic veins
VI	Vascular	Hepatic Avulsion

Advance one grade for multiple injuries to same organ up to Grade III.



In the event of continued bleeding a vascular clamp can be placed around porta hepatis Pringle Maneuver

If bleeding continues…

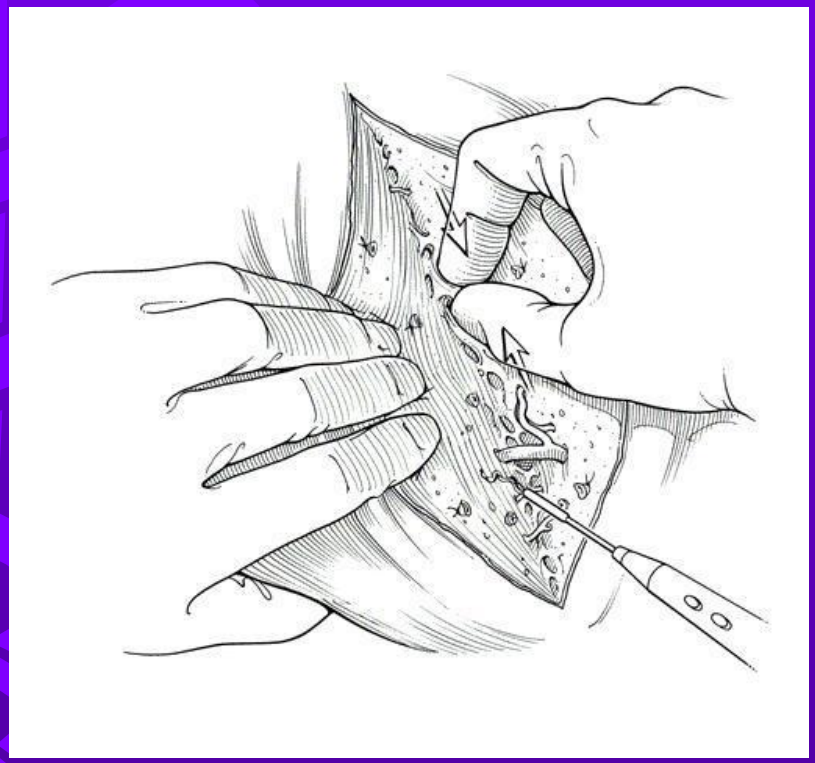
A. It is coming from the portal vein or hepatic artery

OR

B. It is coming from the retrohepatic vena cava or hepatic veins

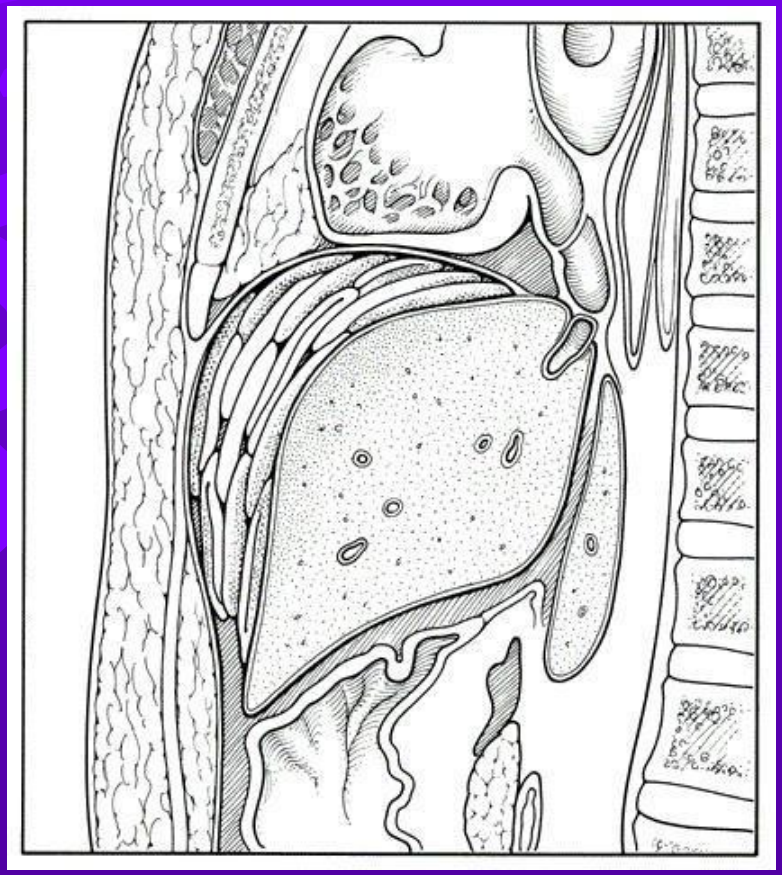
Finger Fracture Hepatotomy

- Alternative approach for deep lacerations
- Extend laceration along non anatomical plains to expose and directly ligate bleeding vessels
- Low mortality 10.7%
- Large defect in liver parenchyma
- Should only be performed by experienced surgeons



Packing

- Used when other techniques fail in controlling hemorrhage
- Use in patients that are hypothermic, acidotic, coagulopathic
- ICU for rewarming
- Re-explore 48-72 hours
- Intra-abd abscesses <15%
- Arteriography/embolization useful adjunct



Of the following hemodynamically stable patients, who is most likely to fail non-operative management.

A. 8 y/o girl s/p left lateral abdominal blow playing soccer. CT with 3cm laceration with blood around spleen and liver.
B. 22 y/o male restrained low speed MVA with left lower rib fractures. CT with 3cm laceration with blood around spleen and liver.
C. 15 y/o boy tackled playing football. CT with 3 splenic lacerations, blood around spleen, liver, and in pelvis.
D. 21 y/o intoxicated restrained high speed MVA. CT with deep splenic laceration, upper pole contusion, and perisplenic blood.
E. 25 y/o male pinned under car when it feel from its lumberjack and landed on his upper chest. CT with deep splenic laceration, blush of intravenous contrast by laceration, and perisplenic blood.

Splenic Injury

- Most frequently injured intra-abdominal organ in blunt trauma.
- Splenic preservation when possible
  - OPSI (0.6% in children, 0.3% in adults)
- More than 70% can be treated non-operatively

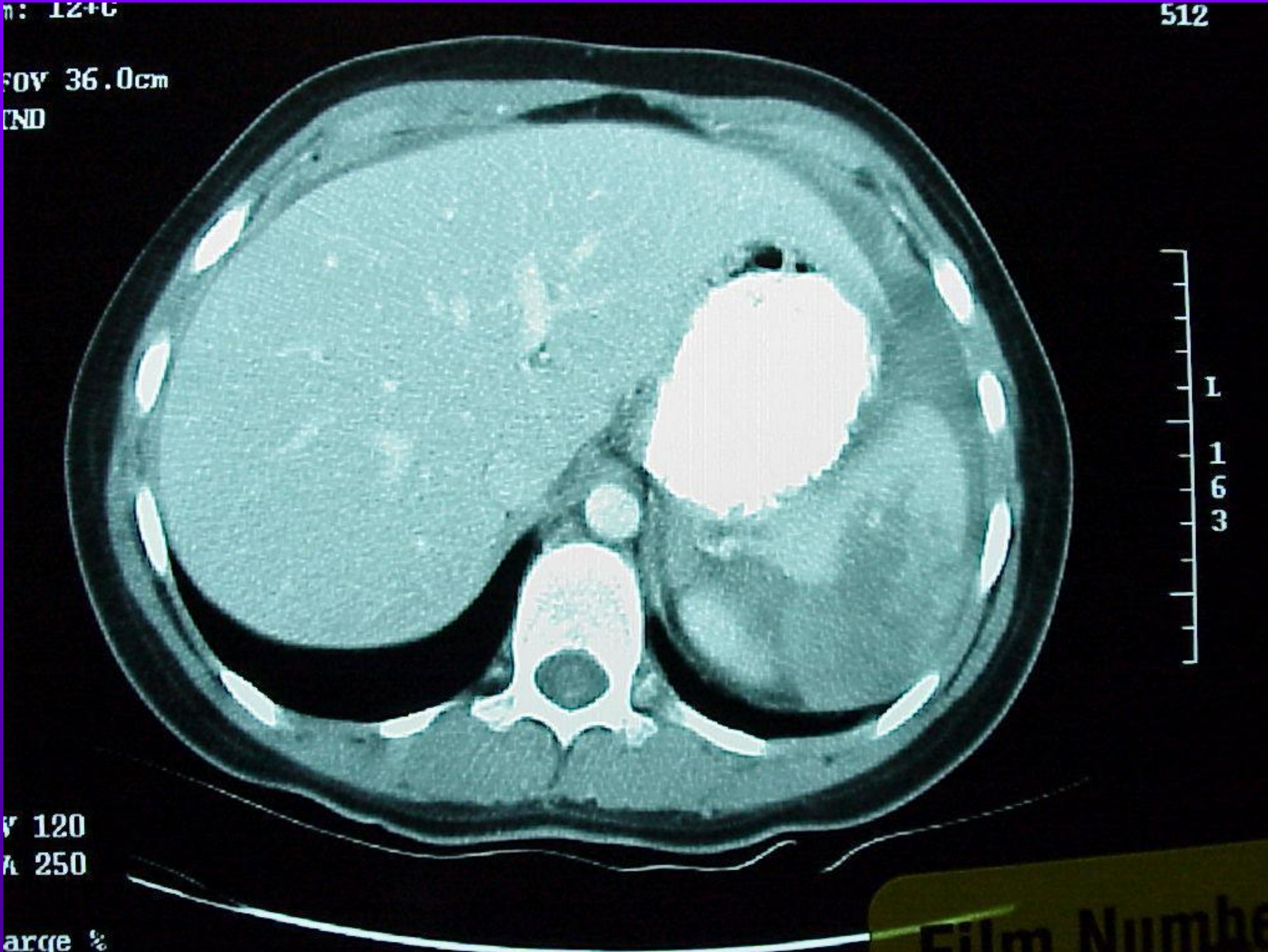
Splenic Injury

- Nonoperative criteria
  - Hemodynamic stability
  - Negative abdominal examination
  - Absence of contrast extravasation
    - Angiography/embolization an option
  - No other clear indications for ex lap
  - No coagulopathy
  - Low grade injuries (1-3)

Splenic Injury

Grade	Injury Description	
I	Haematoma	Subcapsular, <10% surface area
	Laceration	Capsular tear, <1cm parenchymal depth
II	Haematoma	Subcapsular, 10-50% surface area Intraparenchymal, <5cm diameter
	Laceration	1-3cm parenchymal depth not involving a parenchymal vessel
III	Haematoma	Subcapsular, >50% surface area or expanding. Ruptured subcapsular or parenchymal haematoma. Intraparencymal haematoma >5cm
	Laceration	>3cm parenchymal depth or involving trabecular vessels
IV	Laceration	Laceration of segmental or hilar vessels producing major devascularization (>25% of spleen)
V	Laceration	Completely shattered spleen
	Vascular	Hilar vascular injury which devascularized spleen

Advance one grade for multiple injuries to same organ up to Grade III.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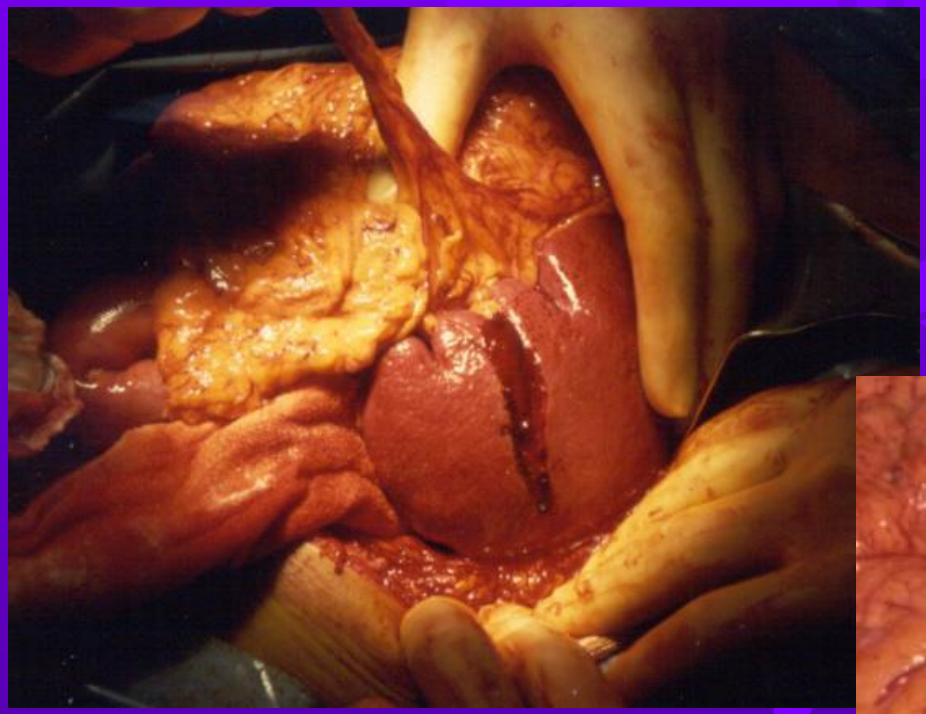
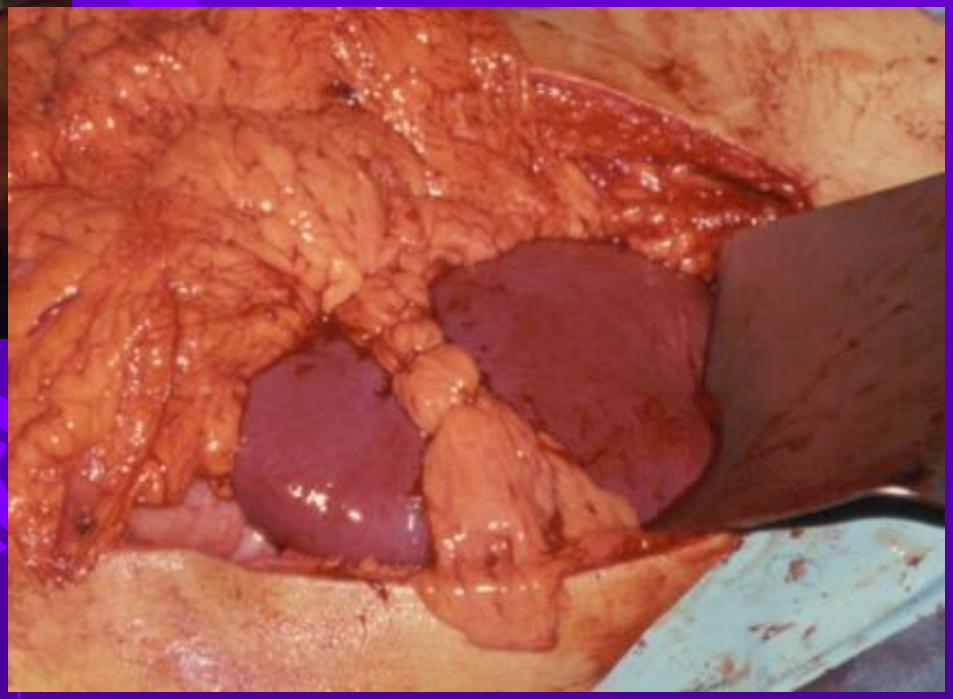
Splenic Injury

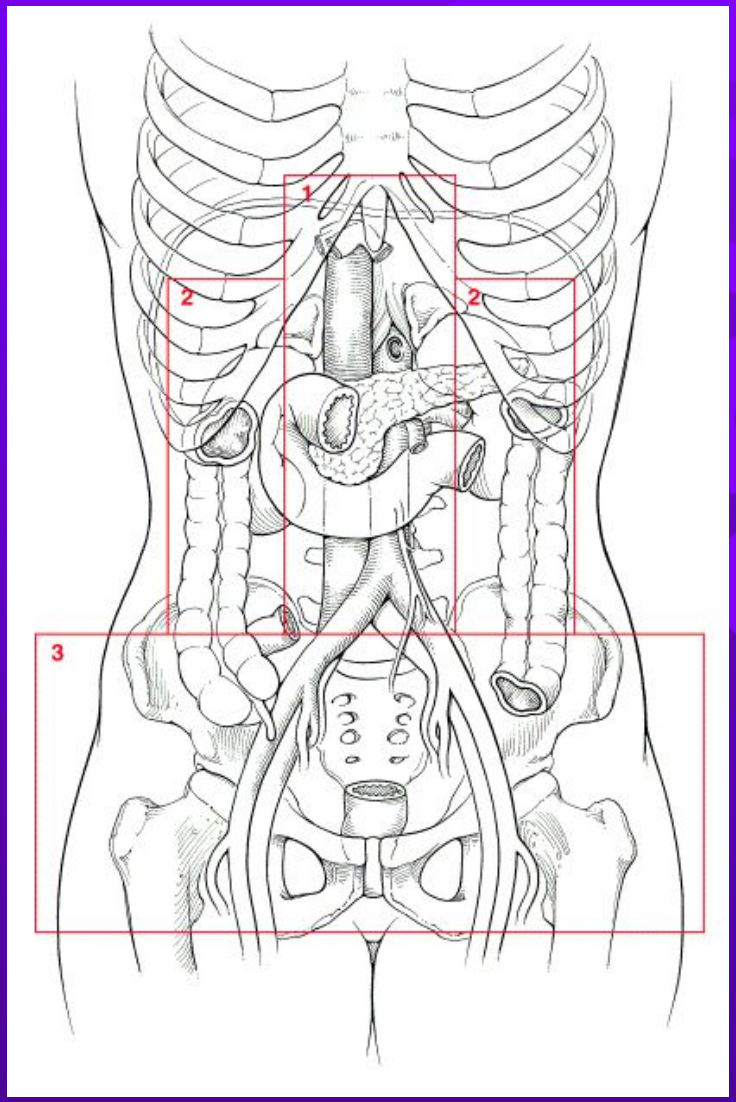




30 year-old man ejected from automobile after head-on collision at high speed. Sustained pelvic fracture. Grossly positive supra-umbilical DPL. On exploration, a pelvic hematoma and an expanding central hematoma are noted. Next step?

a. Observation of both hematomas.
b. Exploration of both hematomas.
c. Exploration of central hematoma after obtaining proximal and distal vascular control; observation of the pelvic hematoma.
d. Observation of central hematoma, and exploration of the pelvic hematoma after application of external fixators.

Retroperitoneal hematoma



- Zone 1
  - Explore regardless of mechanism.
- Zone 2
  - Explore penetrating trauma.
  - Observe blunt trauma (nonexpanding, nonpulsatile, no urologic indications)
- Zone 3
  - Explore penetrating.
  - Observe blunt.

Damage Control

- Abbreviated laparotomy and temporary packing
- Effort to blunt physiologic response to shock and hemorrhage
  - Severe metabolic acidosis, coagulopathy, and hypothermia
- ICU resuscitation
- Return to OR in 48-72 hours

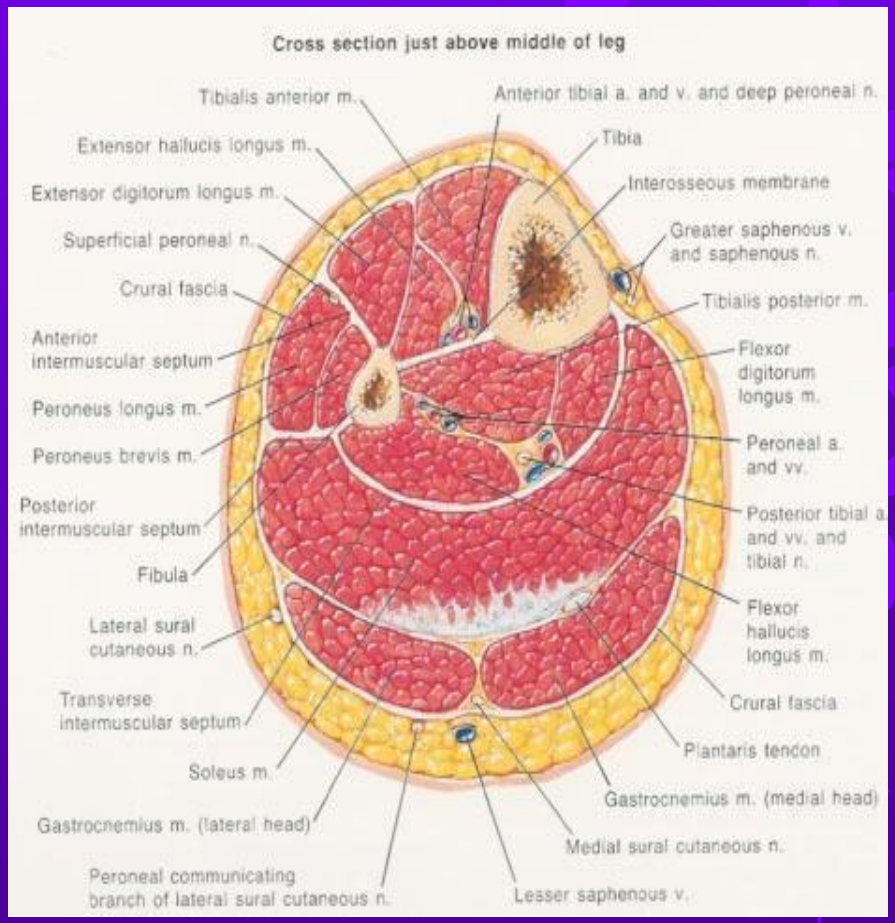
30 y/o woman sustained crushing injury to right lower leg. Arrived at hospital 12 hours later. PE reveals tense calf and closed tibia-fibula fracture. Unable to dorsiflex foot, absent pedal pulses. Next step?

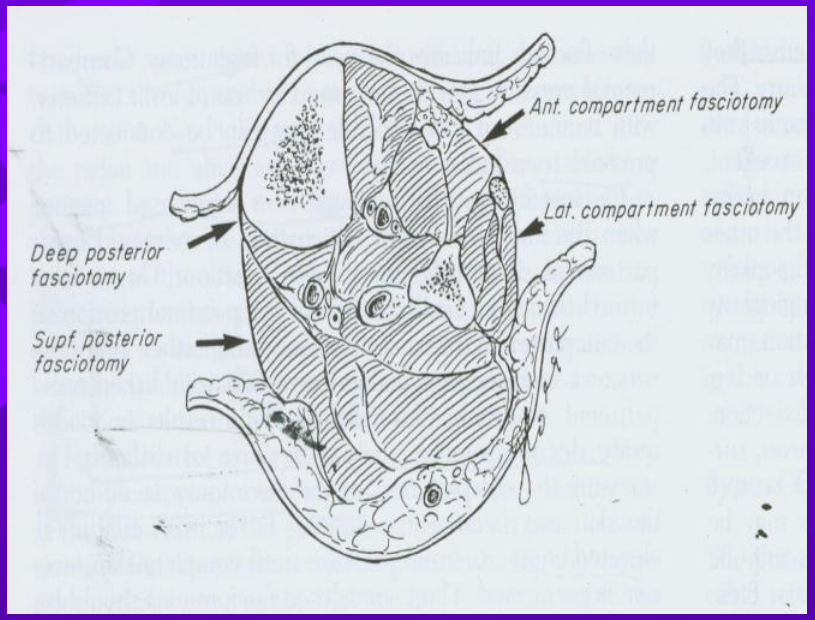
a. Angiography
b. Below knee amputation
c. Four compartment fasciotomy
d. Surgical exploration of popliteal artery
e. Internal fixation of tibial fracture

Compartment Syndrome

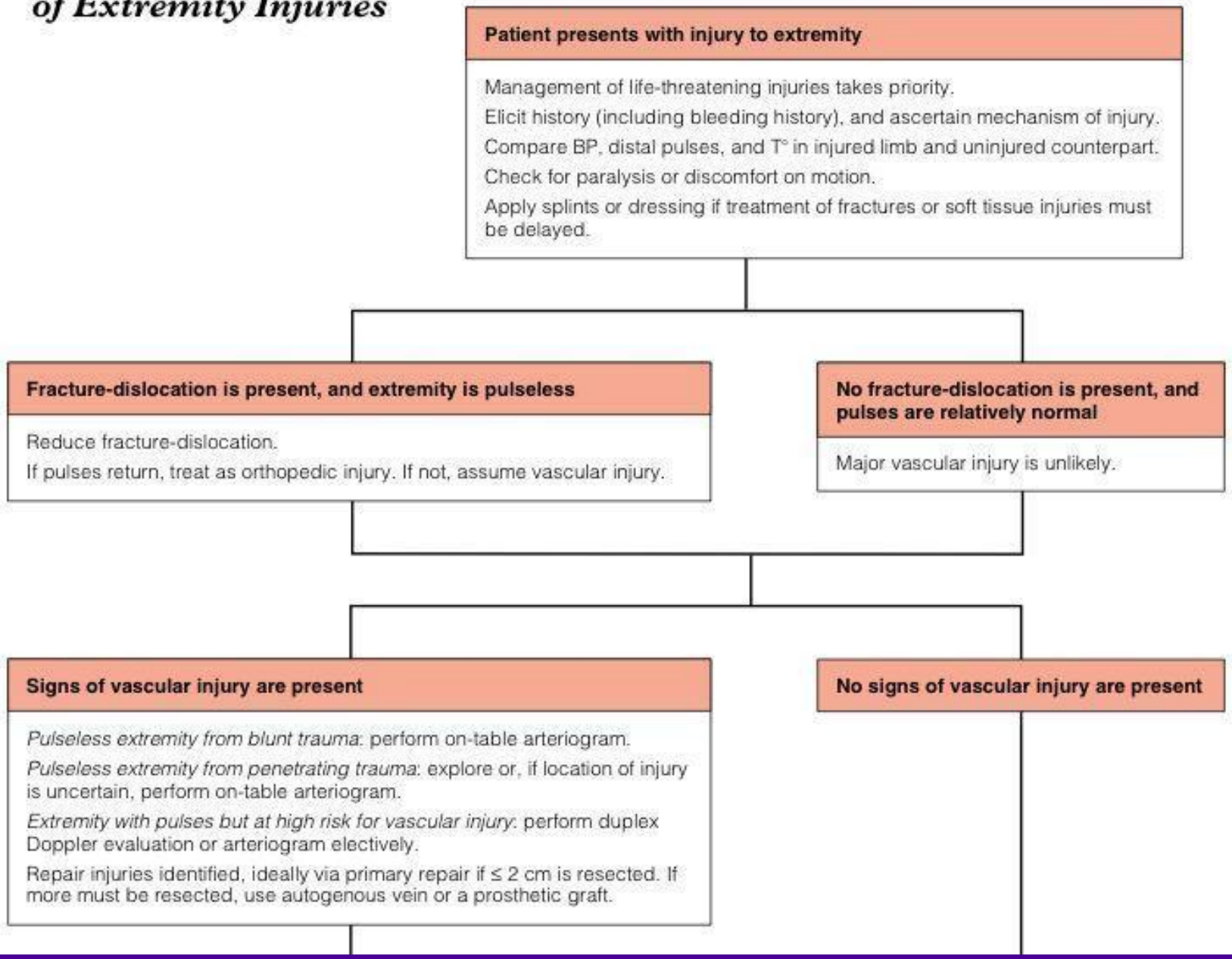
- Common in forearm and lower leg secondary to defined fascial boundaries.
- Four Ps: pressure, pain, paresthesia, and intact pulses
- Compartment pressure measurement
  - Critical pressure? (20-30mm Hg)
  - MAP - compartment pressure < 40mm Hg

Compartment Syndrome





Assessment and Management of Extremity Injuries



With regard to cervical spine injury, which of the following is/are true?

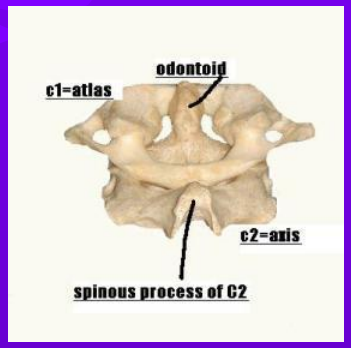
a. Jefferson fractures (C1) are usually caused by axial load and involve blowout of the ring.
b. Hangman's fractures are unstable and are best treated by operative spinal fusion.
c. Type II odontoid fractures are considered stable.

Spine Trauma

- C1 burst fractures (Jefferson's)
  - Axial loading force
  - Considered stable
  - Treat with rigid cervical collar
- Hangman's fracture
  - Extension and distraction force
  - Posterior C2 elements
  - Unstable fracture
  - Traction → halo vest

Odontoid Fractures

- Type I
  - Above base
  - Stable
  - Cervical collar or halo jacket
- Type II
  - At base
  - Usually unstable
  - <5mm displacement → halo jacket
  - >5mm displacement → surgical tx
- Type III
  - Extension into vertebral body
  - Halo jacket
  - >5mm displacement → surgical tx



Spine Trauma

- Strict immobilization during ABCDEs
- Neurogenic shock
  - High spine injuries
  - Loss of sympathetic tone
  - Hypotension, bradycardia, and good peripheral perfusion
- Cervical spine films
  - Must visualize all 7 vertebrae including articulation with T1
  - Lateral, AP, open-mouth odontoid

Spinal Cord Injury

- Preservation of remaining function
- Optimize perfusion and prevent ischemic secondary injury
- High-dose corticosteroids for first 24 hours
- Surgical therapy
  - Restoration of anatomy, removal of foreign bodies, and removal of bone, disc, hematoma
- Traction devices

Motor Function of spinal roots

	Nerve Root	Muscle	Motor Examination
Upper Extremity	C5	Deltoid	Shoulder abduction
	C6	Biceps	Elbow flexion
	C7	Triceps	Elbow extension
	C8	Flexor carpi ulnaris	Wrist flexion
	T1	Lumbricales	Finger abduction
Lower Extremity	L2	Iliopsoas	Hip flexion
	L3	Quadriceps	Knee extension
	L4	Tibialis anterior	Ankle dorsiflexion
	L5-S1	Extensor hallucis longus	Great toe extension
	S1	Gastrocnemius	Ankle plantarflexion

Score	Functional Ability
0	No contraction of muscle
1	Palpable muscle contraction, no limb movement
2	Able to move in gravity-neutral plane
3	Able to move against gravity
4	Diminished strength
5	Normal strength