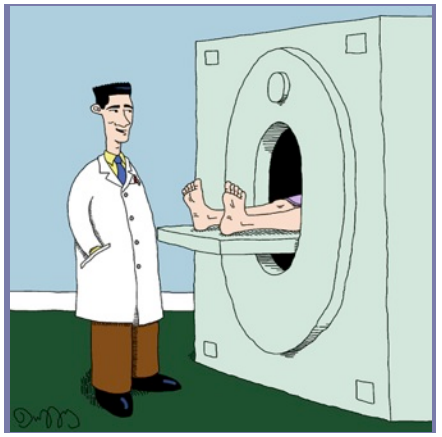


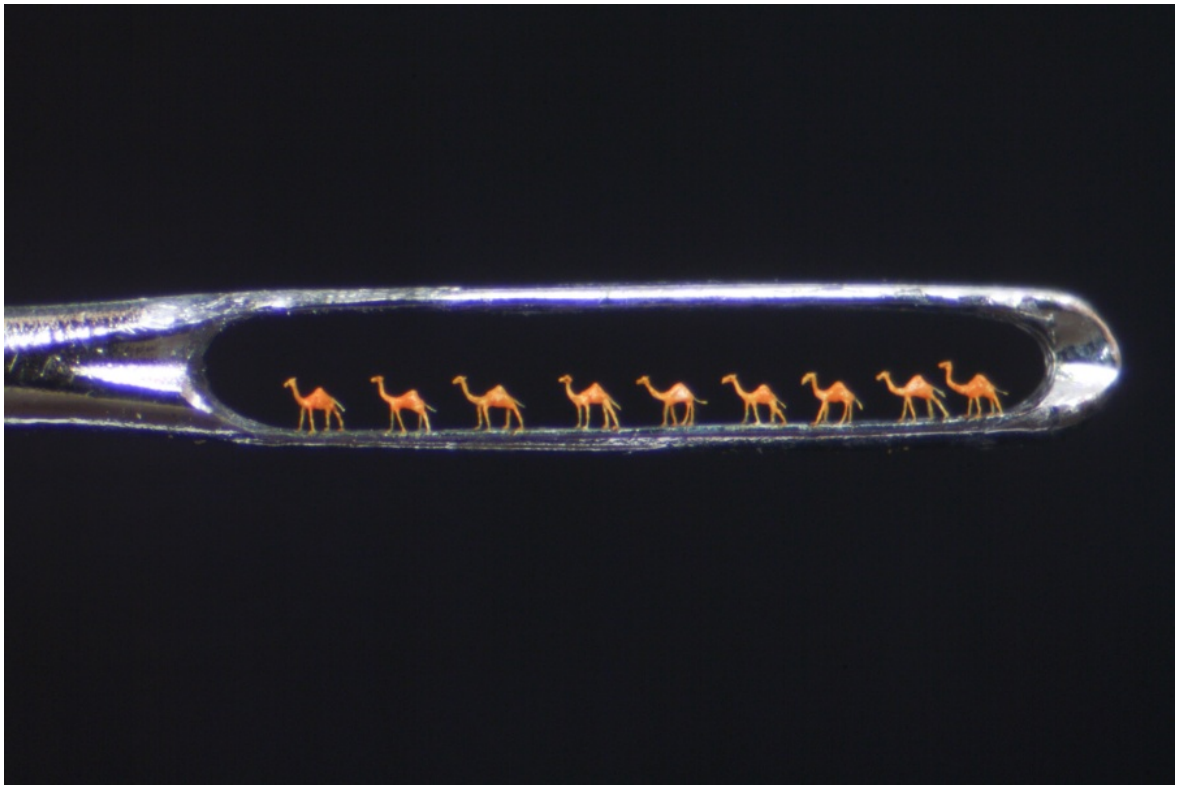
Imaging in Trauma

Dr Amir Ashrafi

Portable x-rays

- Plain radiographs play an important role in the primary evaluation of the unstable trauma patient.
- Prompt imaging of the lateral cervical spine, chest, and pelvis can detect life threatening injuries that might otherwise be missed.
- However, the sensitivity of the lateral cervical spine radiograph is only 70 to 80 percent and its is mainly replaced with C.Spine CT.
- some sacral and iliac fractures can be missed on plain pelvic radiographs.
- Fracture of the scapula belongs to the commonly overlooked injuries. It is usually caused by strong direct impact or the effect of large axial forces. In up to 40 % of cases, it is associated with pulmonary contusion, pneumothorax or hemothorax

Just because you can't see it, doesn't mean it's not there!



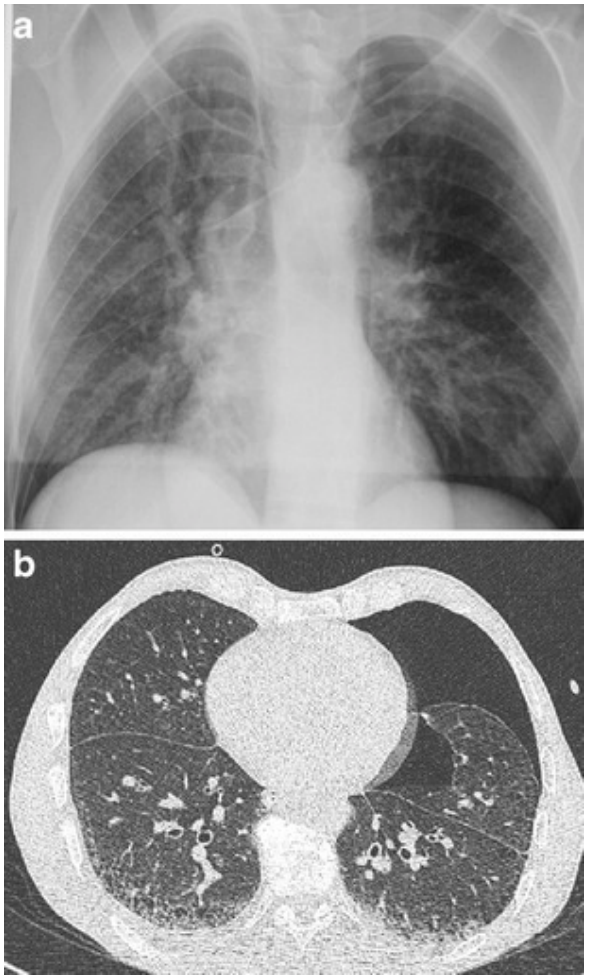
Limitation of CXR

- In supine chest X-ray, it is often manifested very discretely, and in 30–55 % of cases it cannot be seen at all

(*Sangster GP, González-Beicos A, Carbo AI, et al. Blunt traumatic injuries of the lung parenchyma, pleura, thoracic wall, and intrathoracic airways: multidetector computer tomography imaging findings. Emerg Radiol. 2007;14:297–31*)

- The clinical significance of pneumothorax depends not only on its size at the time of initial examination, but also on its development over time and on the overall condition of the patient. In a ventilated patient, a small overlooked pneumothorax can grow rapidly and cause a hemodynamic and ventilation instability

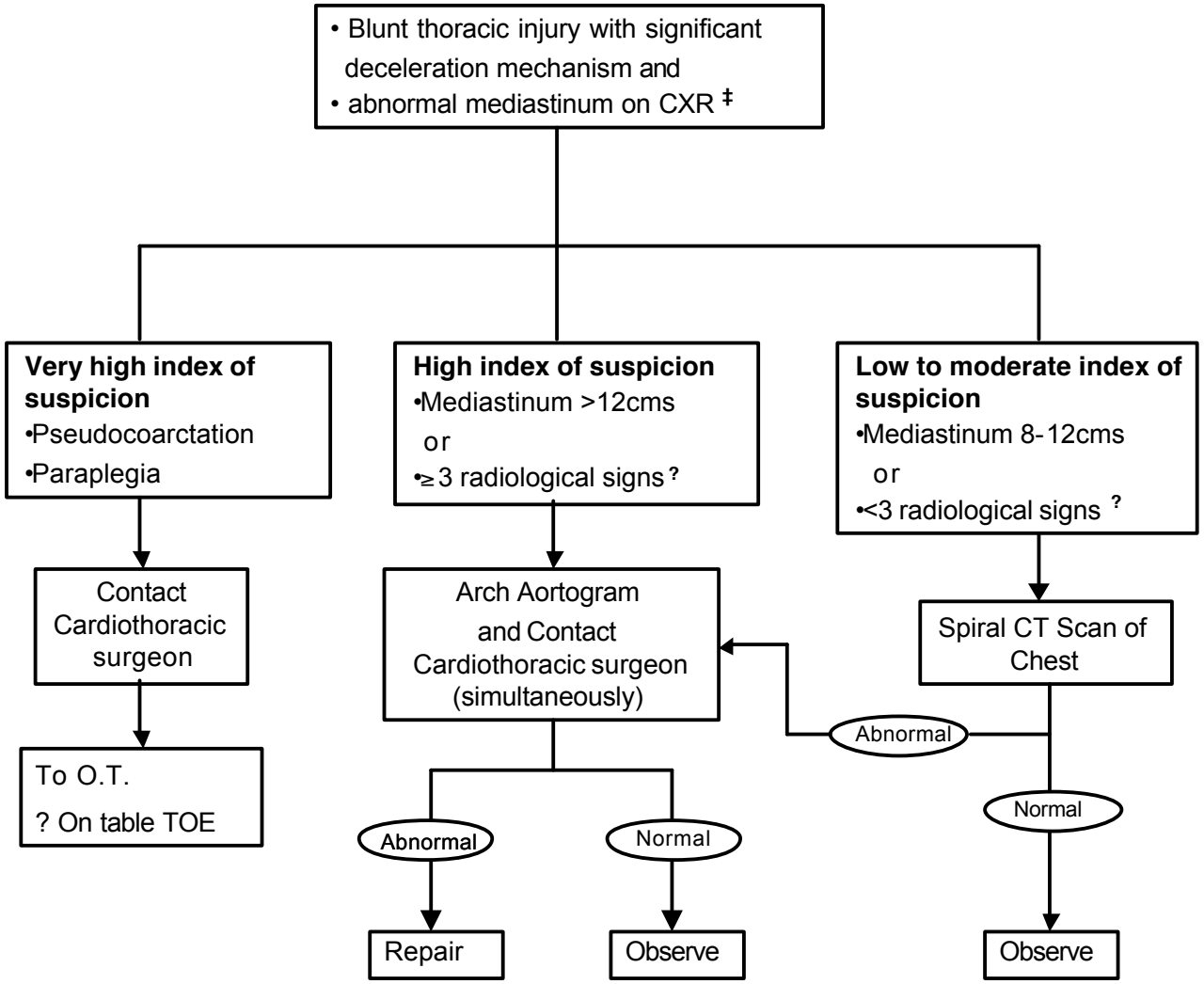
- Lung contusion can be detected on the X-ray image with up to a 6-h delay. Contusion achieves its maximum in the 24–48 h followed by absorption, which takes 1–2 weeks



Diaphragmatic rupture

- Sensitivity of the initial X-ray examination is low, 17 % and 27–60 % on the right and left side, respectively. CT reaches a sensitivity of 50–83 % and 78–100 % in the right and left side, respectively. (Kaewlai R, Avery LL, Asrani AV, Novelline RA. Multidetector CT of blunt thoracic trauma. RadioGraphics. 2008;28:1555–1570.
- Diaphragmatic injuries are often associated with injuries of the spleen, liver, lungs and rib fractures.

WIDENED MEDIASTINUM



2002: D'Amours

Motion artifact in scanning for ascending aorta injury

+

On the ascending aorta above the valve, motion artifacts can often be seen. In case of diagnostic uncertainty, it is possible to add a targeted examination with ECG synchronisation.

Cervical Spine Imaging

STABILITY: A Word or Two

- We talk about it, but what is it?
- A useful definition: An injury is STABLE if putting the spinal column through normal range of motion does not increase neurological or mechanical deficits.

Denis's Three Column Theory

- Spinal column divided into an ANTERIOR, MIDDLE and POSTERIOR column.

- Injury to one column is stable, two or three are unstable.

ANTERIOR COLUMN

- The anterior longitudinal ligament, anterior 2/3 of the body and disc.

MIDDLE COLUMN

- Posterior longitudinal ligament and posterior 1/3 of body and disc.

POSTERIOR COLUMN

- The posterior osseous arch and ligaments.

DOES IT WORK?

fractures involving the middle column or two or more columns are regarded as unstable: Works well for C3 to T1.

Does not work so well for C1-2, so consider most or all injuries here unstable.

C. Spine Imaging in Trauma

NEXSUS criteria:

One easy mnemonic for these criteria is NSAID:

- Neuro Deficit
- Spinal Tenderness (Midline)
- Altered Mental Status/Level of Consciousness
- Intoxication
- Distracting Injury

Hoffman JR, Wolfson AB, Todd K, Mower WR. Selective cervical spine radiography in blunt trauma: methodology of the National Emergency X-Radiography Utilization Study (NEXUS). Ann Emerg Med. 1998 Oct;32(4):461-9

Canadian C-Spine Rule

For alert (GCS=15) and stable trauma patients where cervical spine injury is a concern.

1. Any High-Risk Factor Which Mandates Radiography?

Age ≥ 65 years
or
Dangerous mechanism*
or
Paresthesias in extremities

Rule Not Applicable If:

- Non-trauma cases
- GCS < 15
- Unstable vital signs
- Age < 16 years
- Acute paralysis
- Known vertebral disease
- Previous C-spine surgery

No

Yes

2. Any Low-Risk Factor Which Allows Safe Assessment of Range of Motion?

Simple rearend MVC**
or
Sitting position in ED
or
Ambulatory at any time
or
Delayed onset of neck pain***
or
Absence of midline c-spine tenderness

No

Radiography

Yes

3. Able to Actively Rotate Neck?

45° left and right

Unable

Able

No Radiography

*** Dangerous Mechanism:**

- fall from elevation ≥ 3 feet / 5 stairs
- axial load to head, e.g. diving
- MVC high speed (>100km/hr), rollover, ejection
- motorized recreational vehicles
- bicycle struck or collision

**** Simple Rearend MVC Excludes:**

- pushed into oncoming traffic
- hit by bus / large truck
- rollover
- hit by high speed vehicle

***** Delayed:**

- i.e. not immediate onset of neck pain

Stiell IG, Clement CM, McKnight RD, Wells GA, Brison R, Schull M, Rowe B, Worthington J, Eisenhauer M, Cass D, Greenberg G, MacPhail I, Dreyer J, Lee J, Bandiera G, Reardon M, Holroyd B, Lesiuk H. Comparative Validation of the Canadian C-Spine Rule and the NEXUS Low-Risk Criteria in Alert and Stable Trauma Patients. New Engl J Med 2003; in press.

- Hemodynamically unstable trauma patients often proceed rapidly to the operating room. These patients are presumed to have an unstable cervical spine injury and spinal immobilization is maintained until radiographic evaluation, generally by computed tomography (CT), can be performed postoperatively.
- FIRST CT then ICU if stable post op
- For patients who have sustained major trauma and are undergoing CT imaging to assess for internal injury of the head, chest, or abdomen, we perform CT of the cervical spine
- In all cases of suspected spinal column injury, immobilization of the spine must be maintained until an unstable injury is ruled out.

C. Spine Imaging in unconscious trauma pts

- Blunt trauma coma functional survivor (independent living) rates are alarming. When a comprehensive CS computed tomography evaluation is negative and there is no apparent spinal deficit, CS instability is unlikely (2.5%).
- Secondary brain injury from the cervical collar or MRI is more probable than CS instability and jeopardizes cerebral recovery.
- Brain injury severity, probability of CS instability, cervical collar risk, and MRI risk assessments are essential when deciding whether CS MRI is appropriate and for determining the timing of cervical collar removal.

MRI for cervical spinal column injury

- neurologic deficits caused by extrinsic compression versus those caused by hemorrhage, edema, or injury to the cord itself.
- Diagnosing the causes of delayed and progressive neurologic deterioration in spinal injury.
- Detecting and predicting the outcome of "Spinal Cord Injury Without Radiographic Abnormalities" (SCIWORA). (4.2%)

The adult spinal cord injury without radiographic abnormalities syndrome: magnetic resonance imaging and clinical findings in adults with spinal cord injuries having normal radiographs and computed tomography studies. J Trauma. 2008;65(1):86.

Midline tenderness negative CT

In alert and neurologically intact pts with midline tenderness do MRI only:

- CT evidence of moderate-to-severe spinal degenerative disease
- fractures elsewhere in the spinal column.

Vascular Neck injury

The risk for vascular injury of the neck is increased in the following settings:

- Severe blunt force to the neck
- Significant hyperextension or hyperflexion injuries of the neck
- Unexplained neurologic deficits
- Fractures of the skull base
- Fractures of cervical vertebra adjacent to or involving vascular foramina
- Penetrating injuries adjacent to vascular structures
- Severe facial fractures

BOX 18-4 Indicators of High Risk for Blunt Cerebrovascular Injury

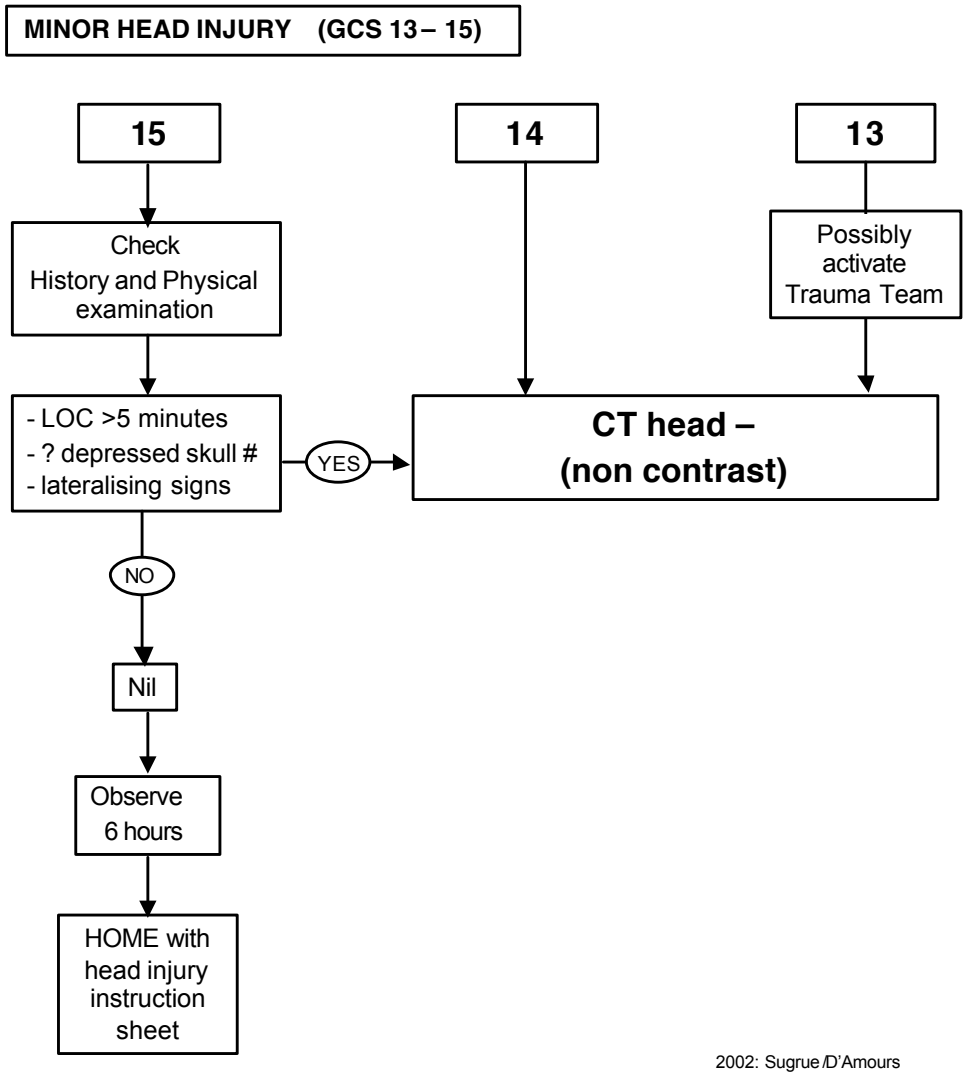
Signs and Symptoms

Expanding neck hematoma
Arterial hemorrhage from neck, nose, mouth
Focal neurologic deficit
Cervical bruit (patient age <50 yr)
Stroke on CT or MRI
Neurologic deficit unexplained by CT findings

Risk Factors

Severe midface fracture, Lefort II or III
Basilar skull fracture involving the carotid canal
Diffuse axonal injury and GCS ≤6
Significant cervical spine fracture or ligamentous injury
Significant soft tissue injury to anterior neck (e.g., seatbelt mark)
Near-hanging with anoxia

Imaging the BRAIN


MINOR HEAD INJURY (GCS 13 – 15)
15
14
13
Check
History and Physical examination
Possibly activate Trauma Team
- LOC >5 minutes
- ? depressed skull #
- lateralising signs
YES
CT head –
(non contrast)
NO
Nil
Observe
6 hours
HOME with head injury instruction sheet
2002: Sugrue /D'Amours

Canadian CT Head Rule

CT head is only required for minor head injury patients with any one of these findings:

High Risk (for Neurological Intervention)

1. GCS score < 15 at 2 hrs after injury
2. Suspected open or depressed skull fracture
3. Any sign of basal skull fracture*
4. Vomiting ≥ 2 episodes
5. Age ≥ 65 years

Medium Risk (for Brain Injury on CT)

6. Amnesia before impact ≥ 30 min
7. Dangerous mechanism ** *(pedestrian, occupant ejected, fall from elevation)*

***Signs of Basal Skull Fracture**

- hemotympanum, 'racoon' eyes, CSF otorrhea/ rhinorrhea, Battle's sign

**** Dangerous Mechanism**

- pedestrian struck by vehicle
- occupant ejected from motor vehicle
- fall from elevation ≥ 3 feet or 5 stairs

Rule Not Applicable If:

- Non-trauma cases
- GCS < 13
- Age < 16 years
- Coumadin or bleeding disorder
- Obvious open skull fracture

Stiell IG, et al. The Canadian CT Head Rule for Patients with Minor Head Injury. Lancet 2001;357:1391-96.

IMAGING THORACIC OR LUMBAR SPINE INJURY

- Focal pain or tenderness over the TL spine
- Signs of injury (eg, bruising, hematoma) along the TL spine
- Neurologic deficit consistent with TL injury
- Painful distracting injury, particularly when elements of the mechanism or clinical evaluation suggest increased risk for TL injury.
- Presence of another spine injury, particularly a known cervical fracture
- High-force mechanism

High-force mechanism includes

- Fall greater than 3 m (10 ft)
- Ejection from a vehicle
- Moderate or high-velocity motor vehicle collision
- Car versus pedestrian
- Forceful direct blow (eg, struck with bat)

MRI is necessary to assess the spinal cord of any trauma patient with neurologic deficits or symptoms that suggest spinal cord injury

Imaging in Penetrating Trauma

- The evaluation of patients with penetrating trauma often includes images of the region of penetration; even in stable patients, these Xrays can detect retained foreign bodies or fragments.
- A plain radiograph of the chest should be obtained in patients with penetrating injuries of the chest, back, or abdomen regardless of the need for CT. Plain films may reveal subdiaphragmatic free air, a foreign body, or a pneumothorax or hemothorax.
- Diagnostic laparoscopy may be useful in patients with penetrating injury and signs of peritoneal penetration despite negative CT imaging.

Echocardiography
(Cardiac Injury??)

ECG should be obtained for all patients injured by mechanisms with the potential for causing cardiac injury

Signs of blunt cardiac injury

- arrhythmias,
- significant conduction delays,
- ST segment changes.

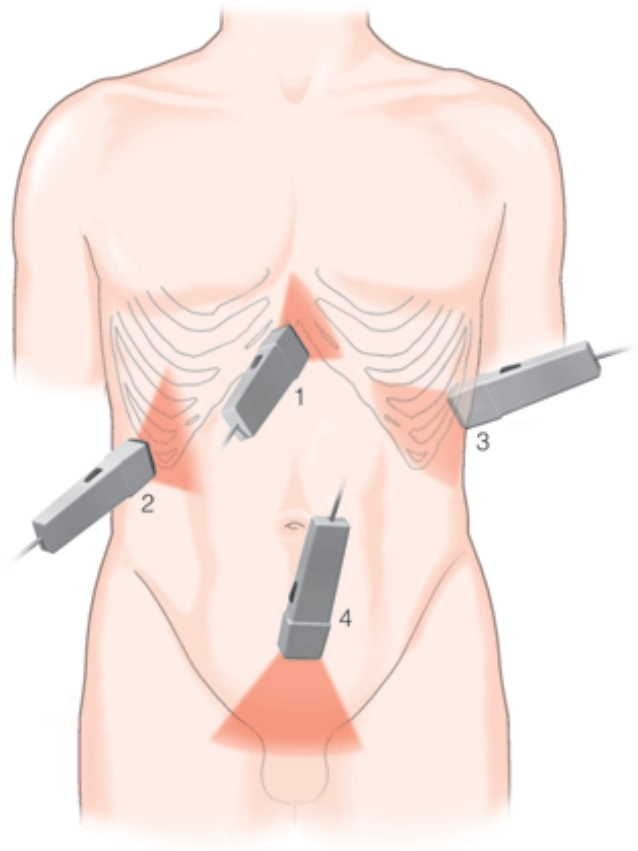
Findings consistent with pericardial tamponade :

- tachycardia,
- low voltage, and
- electrical alternans.

If ECG findings consistent with cardiac injury are present, formal echocardiography (in addition to the FAST examination) should be performed.

FAST

(Focused Assessment with Sonography for Trauma)



- Focused Abdominal Sonography for Trauma (FAST) is an essential part of the primary circulation survey for unstable patients, in whom it often determines management.
- FAST is used primarily to detect pericardial and intraperitoneal blood, and it is more accurate than any physical examination finding for detecting intra-abdominal injury.
- In hemodynamically stable patients, FAST can be delayed until the secondary survey and is ideally performed by a second operator while the remainder of the secondary survey is completed.

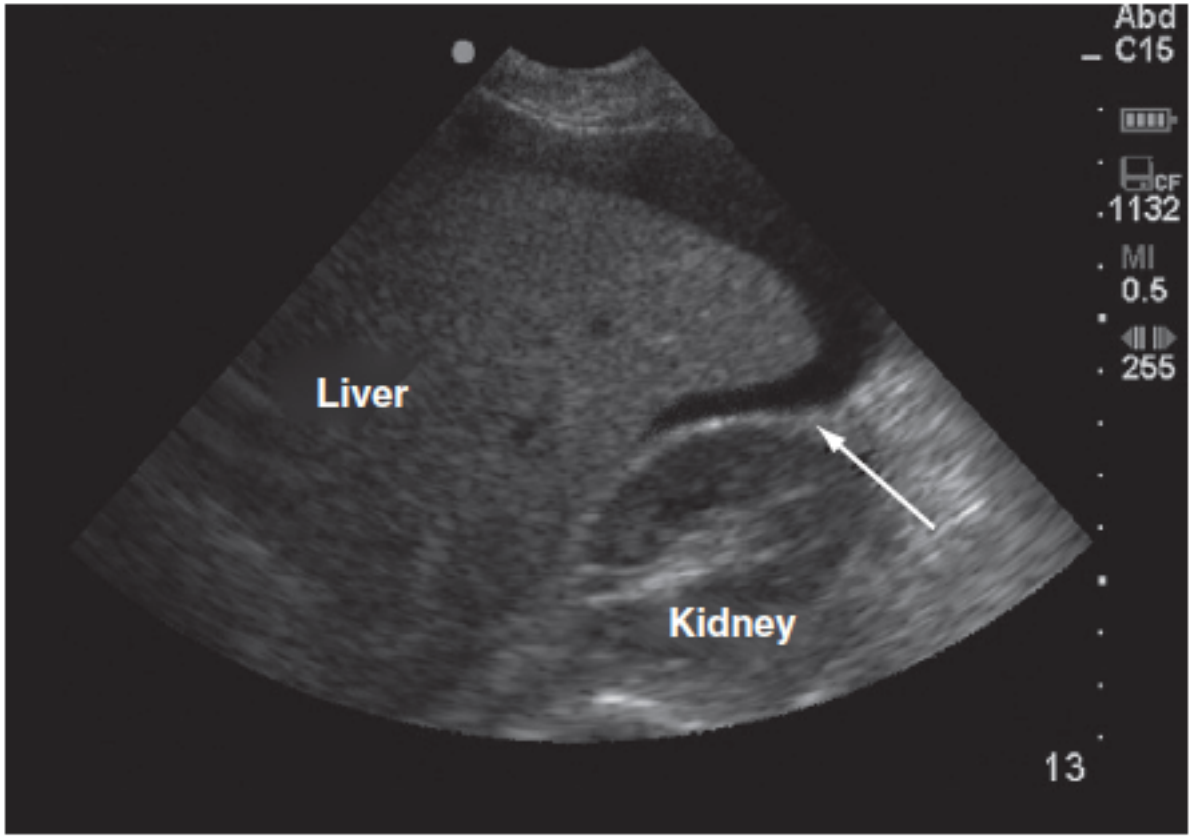
E-FAST

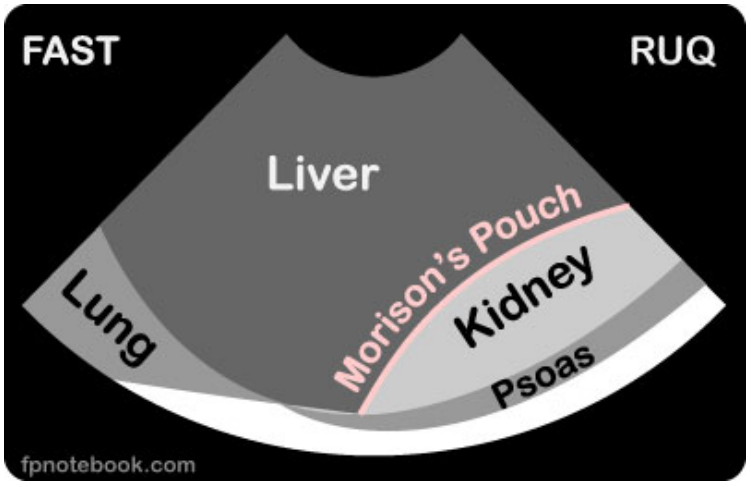
Essential part of the primary circulation survey for unstable patients

In hemodynamically stable patients, FAST can be delayed until the secondary survey

- Pericardial
- Right flank (hepatorenal view or "Morison's pouch")
- Left flank (perisplenic view)
- Pelvic (retrovesical views)
- Thoracic (pneumothorax evaluations)

- The Extended FAST (E-FAST) includes examinations of the thoracic cavity looking for pneumothoraces.
- Preliminary studies suggest the sensitivity of E-FAST is better than plain radiograph for this injury


Abd
C15
CF
1132
MI
0.5
255
Liver
Kidney
13


FAST
RUQ
Liver
Morison's Pouch
Kidney
Lung
Psoas
fpnotebook.com

What FAST negative means?

- In most studies, the sensitivity of the FAST examination for intraperitoneal hemorrhage ranges from 63 to 100 percent , However, sensitivities as low as 42 percent have been reported

The FAST examination cannot detect:

- diaphragm tears,
- pancreatic lesions
- bowel perforations,
- mesenteric trauma, and
- abdominal injuries that do not produce free fluid in amounts detectable by ultrasound (generally >200 mL)

Limitations of FAST

- Injury of the kidney and other retroperitoneal structures
- cannot distinguish between urine and blood, which contributes to its lower sensitivity and specificity in major pelvic trauma
- Fluid/Clot vs epicardial fat pad ?

The detection and location of intraperitoneal free fluid depends upon several factors including :

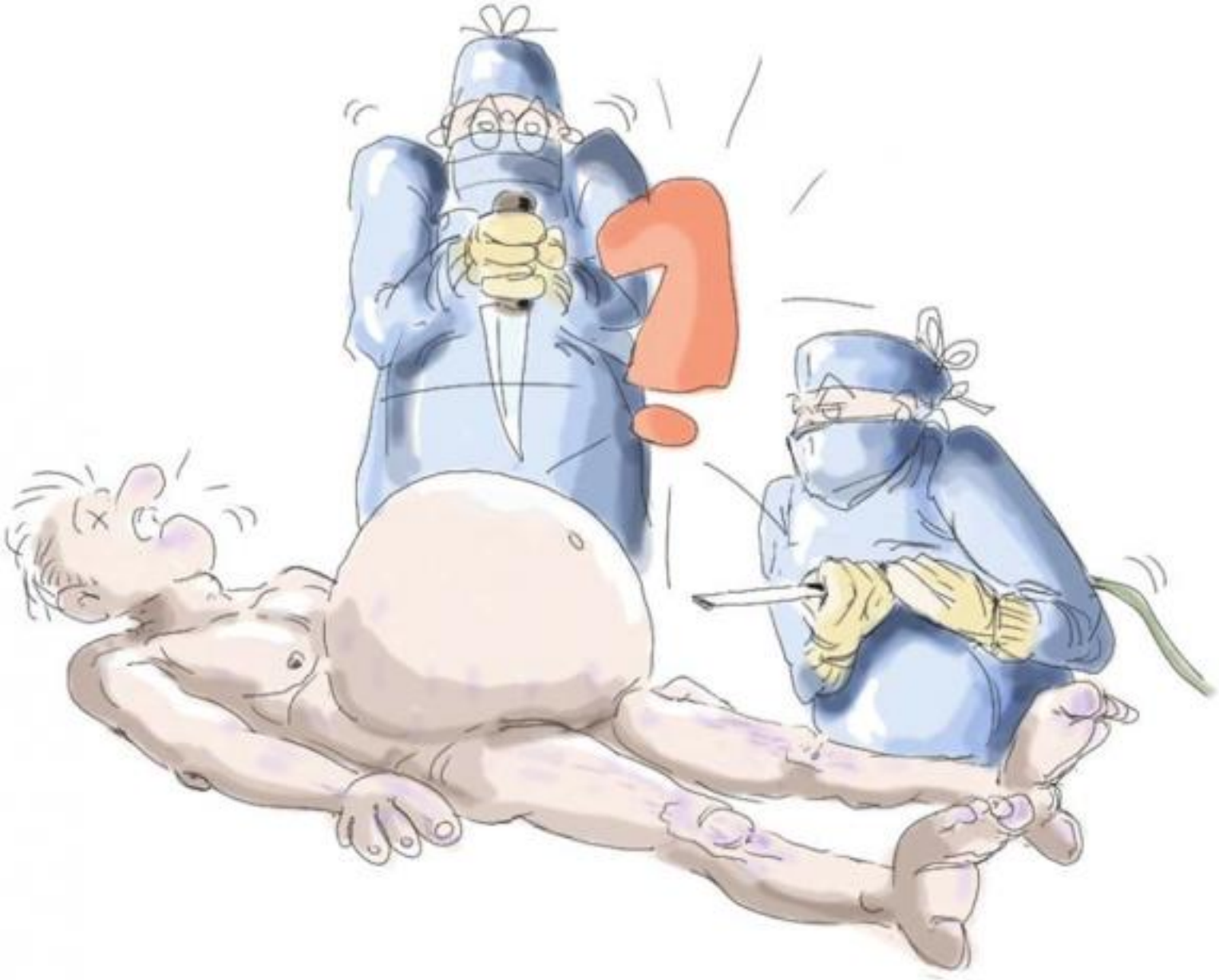
- Location of injury
- Time elapsed since the injury
- Presence of intraabdominal adhesions
- Bowel gas patterns
- Fluid volume
- Patient positioning
- Quality of the FAST examination

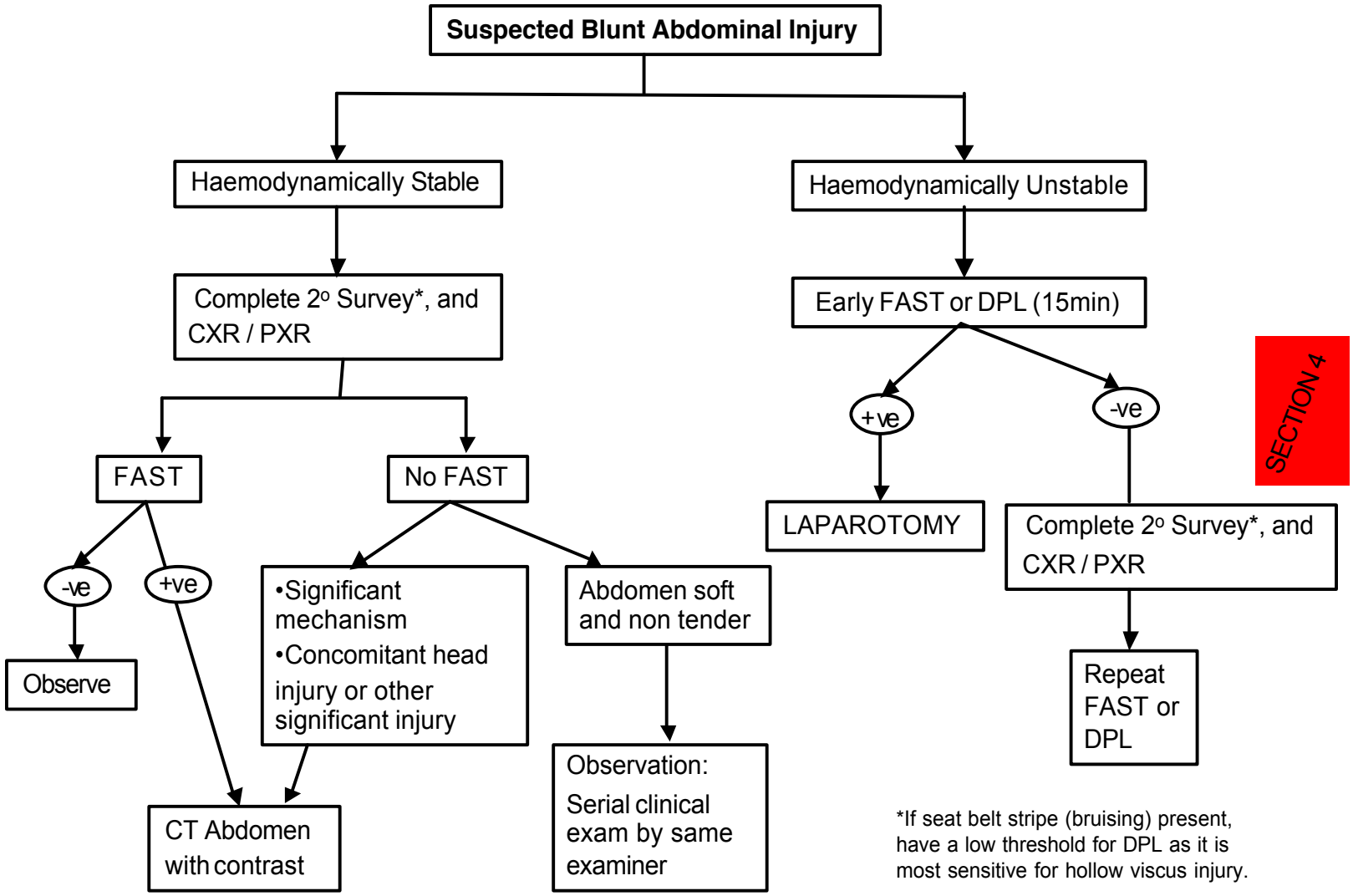
Diagnostic peritoneal lavage (DPL)

- Diagnostic peritoneal tap or lavage has a role similar to FAST in the unstable patient in whom a source of bleeding has not been found
- to determine the type of intraperitoneal fluid when it is important to do so (blood versus urine in the setting of a pelvic fracture)
- specially when the pt is in OT and still there is a doubt about intraabdominal injury/bleeding.
- aspiration of 10 mL or more of gross blood on DPL also suggests an intra-abdominal source of hemorrhage requiring emergent operation.
- more than 500 white blood cells/mm3, amylase, bilirubin, or particulate matter, have been found to be indicative of a hollow visceral injury.

TABLE 5-2 ■ Comparison of DPL, FAST, and CT in Blunt Abdominal Trauma

	DPL	FAST	CT SCAN
Advantages	• Early diagnosis • Performed rapidly • 98% sensitive • Detects bowel injury	• Early diagnosis • Noninvasive • Performed rapidly • Repeatable	• Most specific for injury • Sensitive: 92%–98% accurate
Disadvantages	• Invasive • Low specificity • Misses injuries to diaphragm and retroperitoneum	• Operator-dependent • Bowel gas and subcutaneous air distortion • Misses diaphragm, bowel, pancreatic, and solid organ injuries	• Cost and time • Misses diaphragm, bowel, and some pancreatic injuries • Transport required

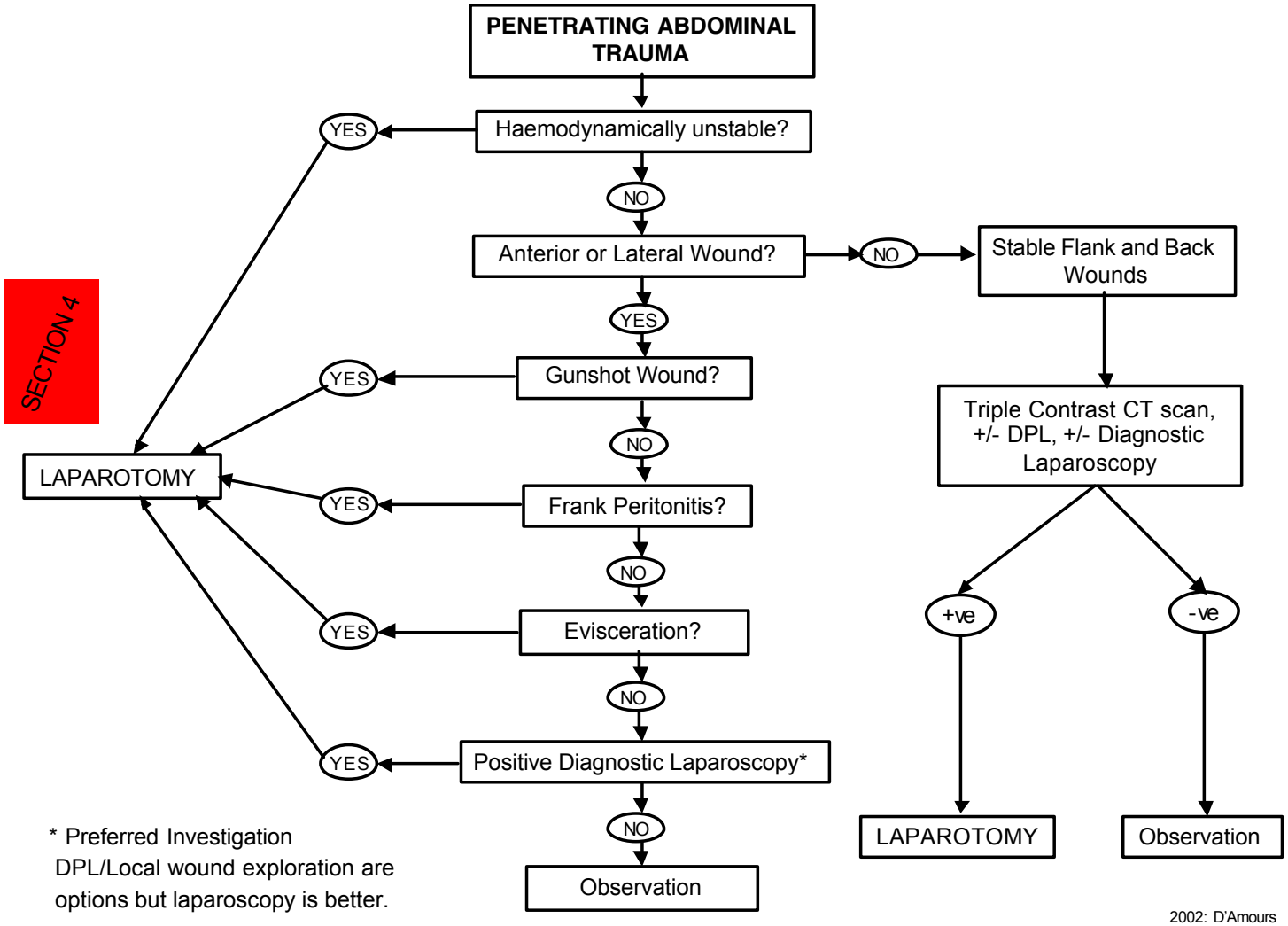




*If seat belt stripe (bruising) present, have a low threshold for DPL as it is most sensitive for hollow viscus injury.

S. D'Amours: 2002

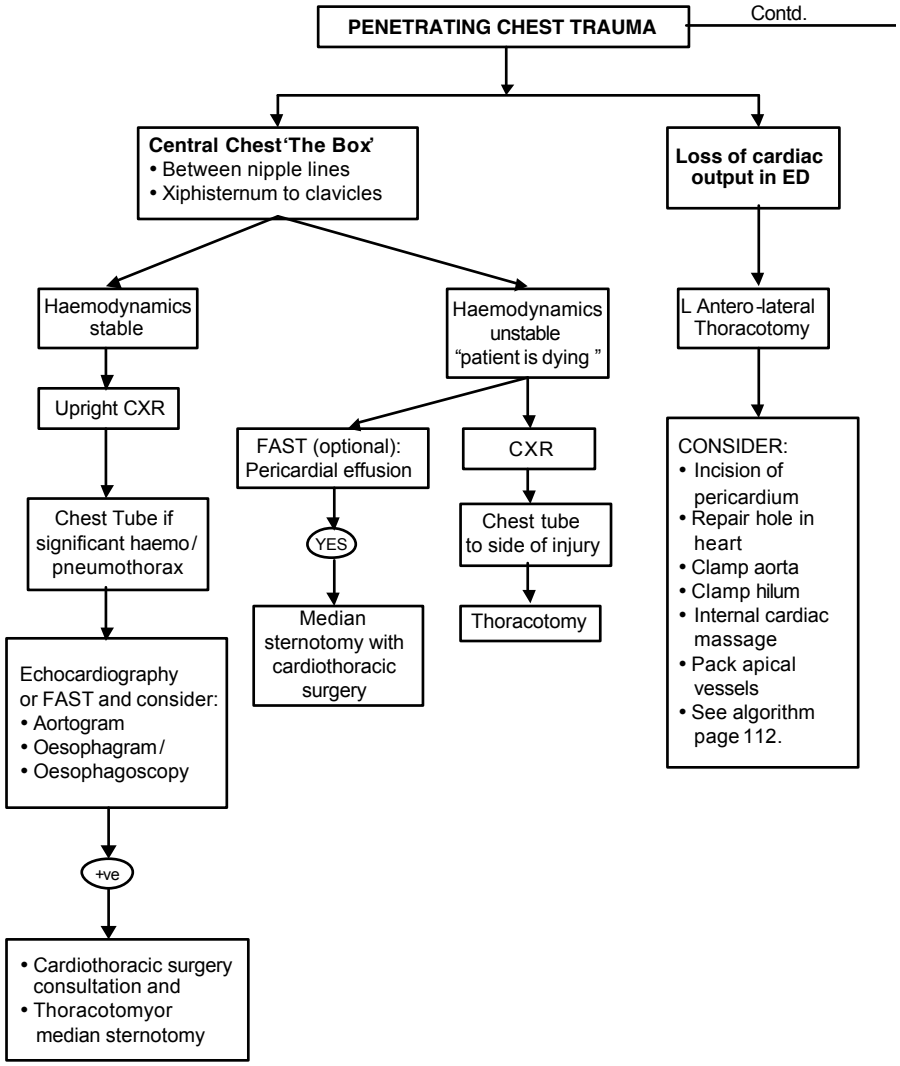
SECTION 4

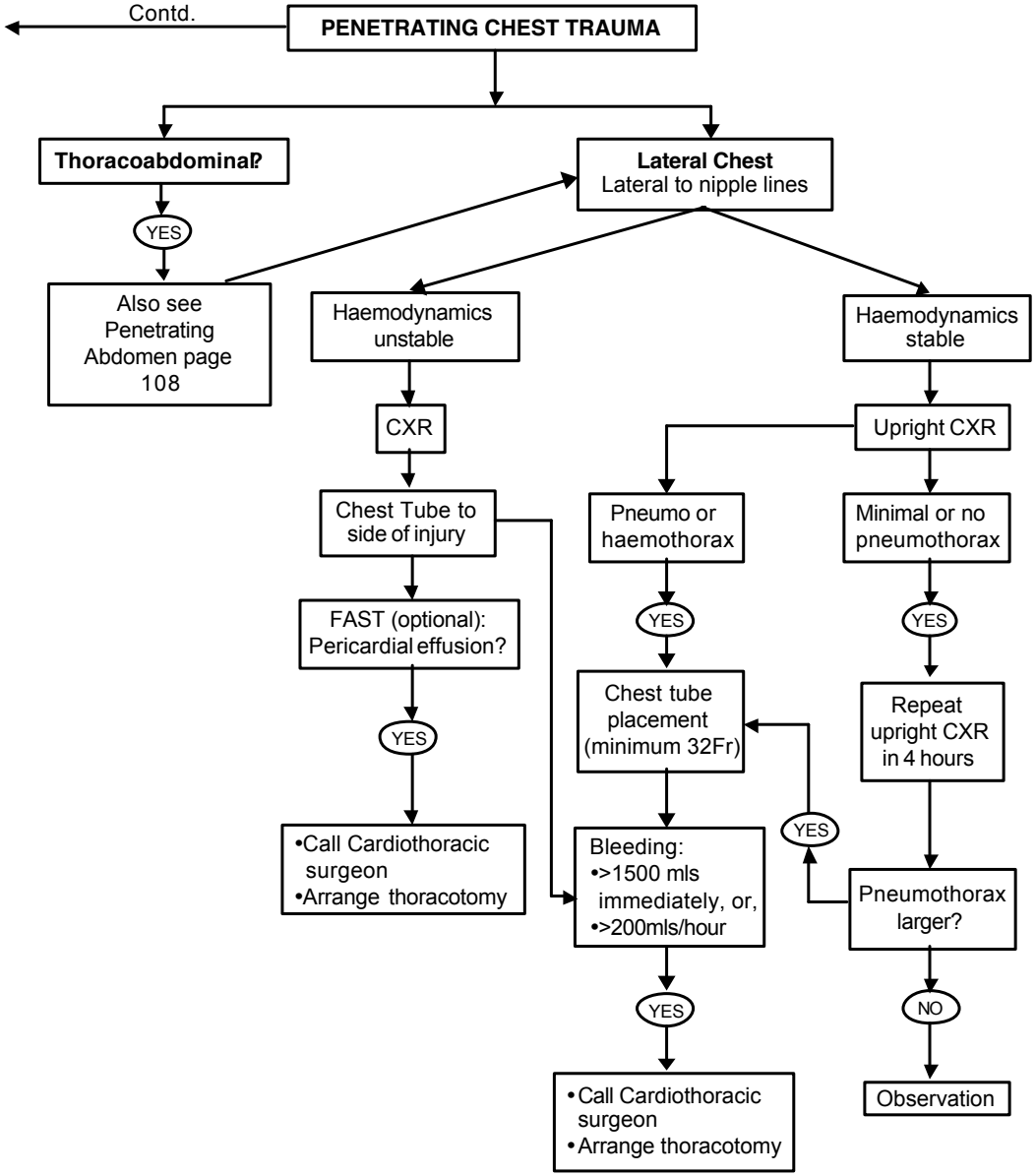


* Preferred Investigation
DPL/Local wound exploration are options but laparoscopy is better.

2002: D'Amours

PENETRATING CHEST




Contd.
PENETRATING CHEST TRAUMA
Thoracoabdominal?
YES
Also see Penetrating Abdomen page 108
Lateral Chest
Lateral to nipple lines
Haemodynamics unstable
CXR
Chest Tube to side of injury
FAST (optional): Pericardial effusion?
YES
•Call Cardiothoracic surgeon
•Arrange thoracotomy
Haemodynamics stable
Upright CXR
Pneumo or haemothorax
YES
Chest tube placement (minimum 32Fr)
Bleeding:
•>1500 mls immediately, or,
•>200mls/hour
YES
•Call Cardiothoracic surgeon
•Arrange thoracotomy
YES
Minimal or no pneumothorax
YES
Repeat upright CXR in 4 hours
Pneumothorax larger?
NO
Observation

Scan the whole body?

- In a retrospective database analysis of 5,208 patients in Japan with Glasgow Coma Score ranging from 3 to 12, decreased mortality was noted in patients who received whole body CT scans . (p = 0.0002)

Whole-body computed tomography is associated with decreased mortality in blunt trauma patients with moderate-to-severe consciousness disturbance: a multicenter, retrospective study. Kimura A, Tanaka , J Trauma Acute Care Surg. 2013 Aug;75(2):202-6