

# Imaging in abdominal trauma

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# Imaging in polytrauma

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- Injury to several ( $>1$ ) physical regions or organ systems, where at least one injury or the combination of several injuries is life threatening with the severity of injury being  $> 16$  on the scale of the Injury Severity Score (ISS)
- To be differentiated from multiple injuries, which are not life threatening, or from a severe, life-threatening single injury

# Injury Severity Score ISS

Anatomical scoring system to assess trauma severity

Each injury is assigned a severity score from 1 to 6  
**Abbreviated Injury Scale (AIS)** and it is allocated to one of the six body regions (Head&Neck, Face, Chest, Abdomen, Extremities&Pelvic girdle , External)

Only the highest AIS score in each body region is used. The 3 most severely injured body regions have their score squared and added together to produce the ISS score

Score from 1 to 75

Any AIS=6 gives automatically 75

The screenshot shows a web browser window titled "ISS Calculator - Microsoft Internet E...". The address bar displays "http://www.trauma.org/archive/scores/is...". The main content area has a light blue background and features the text "TRAUMA.ORG" in large, bold, purple letters. Below this, it says "INJURY SEVERITY SCORE CALCULATOR" in bold, black letters. Underneath, it reads "Abbreviated Injury Scale:". There are six input fields arranged in a 3x2 grid, each with a label above it: "Head", "Face", "Chest", "Abdomen", "Extremity", and "External". Below the input fields is a "Calculate" button. At the bottom, it says "ISS:" followed by a large empty box for the result. The browser's status bar at the bottom shows "Internet" and a zoom level of "100%".

**ISS > 15** is considered a polytrauma

(mortality 10%)

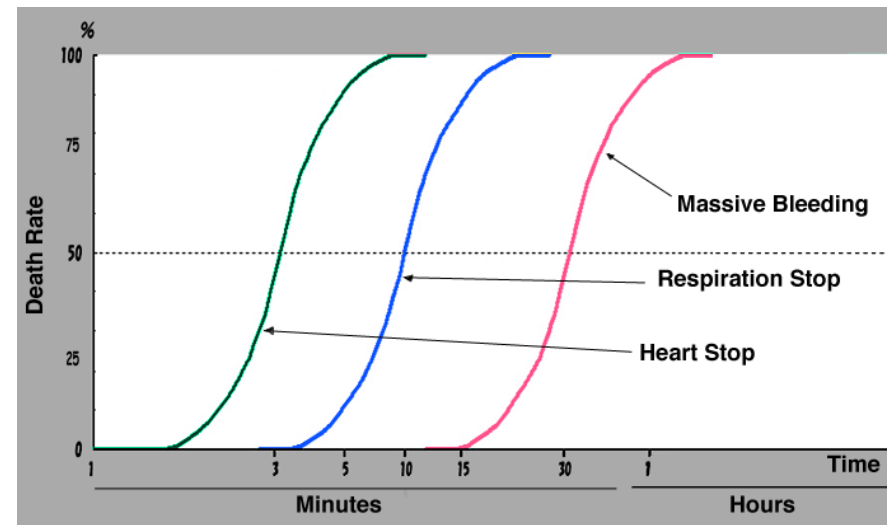
# TRIAGE RULE : Vittel criteria

Category I, mechanism of trauma	Category II, vital signs	Category III, clinical apparent injuries
Falls >5 m	Blood pressure <80 mm Hg	Flail chest
Traffic accident	Respiratory rate <10; others, >29	Open chest wound
1. High-speed crash		
2. Crash against a truck		
3. Pedestrian thrown or run over	Pulse oxymetry <90%	Open abdominal wound
Auto crash		
1. Patient trapped in the car		
2. Roll over		
3. Head-on collision		
4. Ejection from auto		
5. Death in same passenger compartment	Intubated patient with an initial GCS <9 on scene	Unstable pelvis
Explosion, buried person		≥2 Proximal long-bone fractures
		Amputation proximal to wrist or ankle

If just 1 parameter in 1 of the 3 categories is positive, serious injuries in one or more organ systems are suspected

Trimodal peak distribution of trauma mortality:

- 50% of deaths occur right after the traumatic event
- 2nd peak (30%) during 1 and 4 hours after injury - aka “**golden hour**” - commonest cause of death is hypovolemic shock
- 3rd peak (20%) several weeks later- patient dies of late complications and multiple organ failure



Primary survey: detect and treat life threatening injuries

*treat first what kills first*

- A Airway and c-spine protection
- B Breathing and ventilation
- C Circulation with hemorrhage control
- D Disability/Neurologic status
- E Exposure/Environmental control

C-spine Xray

Chest Xray

FAST + pelvic Xray

Secondary survey: head to toe examination

selective CT

## Focused Abdominal Sonography for Trauma

Standardised US examination looking for free fluid, regardless from its nature (blood, urine, bile, ascitis, , bowel content, lymphé...)

Replacing *peritoneal lavage*

Mean minimum volume detectable in  
Morrison pouch: 619 ml

Mean minimum volume detectable in  
Douglas pouch: 100 ml

Up to 50 ml in pelvis of childbearing age  
females is physiologic  
*No fluid expected in males*





## Focused Assessment Sonography for Trauma

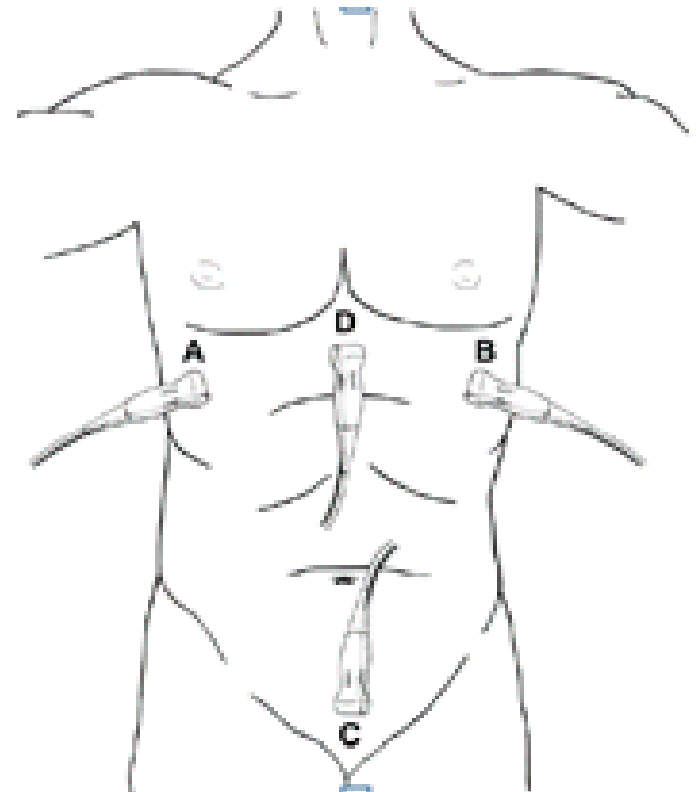
Standardised US examination looking for free fluid, regardless from its nature (blood, urine, bile, ascitis, , bowel content, lymph...

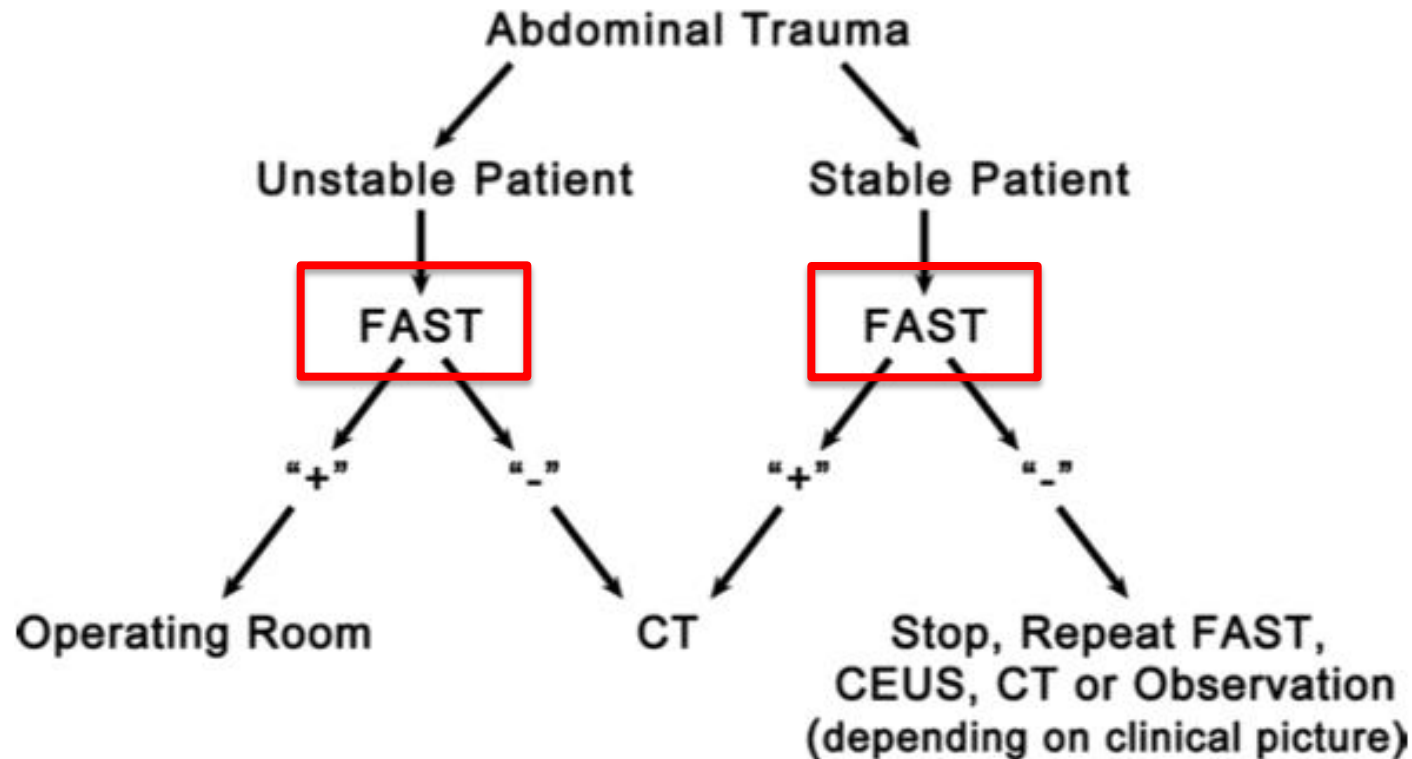
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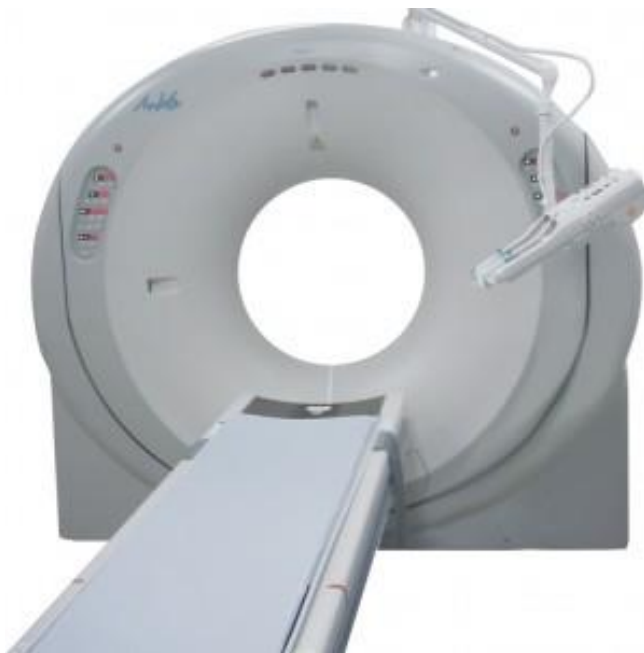




*Clinical suspicion, mechanism of injury and change in haemodynamic status should always be considered in decision to further imaging after an initial negative FAST*

The ATLS® handbook states that “CT is a time consuming procedure that should be used only in patients with no haemodynamic abnormalities”

Some surgeons initially referred to a CT scanner as the « doughnut of death »



- Trauma screening with WB MSCT is justified in patients with an injury severity score (ISS) of 16 or greater
- Identify patients with suspected serious injuries to justify the higher radiation dose
- Treat life-threatening conditions before starting whole-body MSCT

- *Overtriage* is the use of CT trauma protocol in patients with an ISS below 16 (30%)
- *Undertriage* is conventional trauma protocol used in patients with an ISS of 16 or greater (6%)
- 35% of overtriaged patients had significant injuries (pulmonary contusion and spine injury)

Sensitivity 96.7%

Specificity 55.9%

Positive predictive value 69.4%

Negative predictive value 94.3 %

**Table 5** Two-by-two table

	Triage with multiple trauma triage scheme		$\Sigma$
	CT trauma protocol	Conventional trauma protocol	
ISS $\geq 16$	59	2	61
ISS $< 16$	26	33	59
$\Sigma$	85	35	120



## The haemodynamically stable SIP

Clamp urinary catheter before patient leaves emergency department.

**Oral contrast:** Not required for standard protocol.

**Rectal contrast:** When there is penetrating trauma to the abdominal or pelvic cavity, there is a strong argument for using rectal and oral contrast to help detect bowel injury. Give 1000 ml 2% iodinated contrast delivered via a drip system and ballooned Foley catheter.

**Intravenous contrast:** 150 ml @ 3 ml/sec. Venous access whenever possible should be via an antecubital fossa vein. Avoid small peripheral lines on backs of hands, central lines etc. Ideally use a right arm injection and commence scanning at 25 seconds.

**Scan from C6 to groins:** Thorax should be in arterial phase (25 secs), abdominal and pelvic imaging should then follow aiming to commence scanning the liver and spleen at 60 to 65 seconds.

Modify times for the elderly.

In order

1. Standard head CT
2. Cervical spine  
Collimation: 1.25 mm  
Coverage: C<sub>6</sub>–bottom of T<sub>1</sub>  
Reformats: standard sagittal and coronal
3. Chest, abdomen, pelvis
4. Collimation 2.5 mm. In obese patient or if other technical problems, 5 mm may be a compromise option. Thin slice but noisy images are not helpful.

Reformats – reconstruct 2.5 mm sagittal and coronal reformats for dorsal spine and lumbar spine. If suspicion of pelvic trauma, reconstruct pelvic images at 2.5 mm then do coronal reformats. A coronal soft tissue reformat of chest, abdomen and pelvis often helpful, particularly when discussing findings with clinicians.

## The haemodynamically unstable SIP

This is aimed at a specific subset of patients where CT forms part of the ATLS primary survey, with the focus of the study aimed at detecting acute life-threatening injuries. This should be used where there is clinical evidence of bleeding or a high likelihood of vascular trauma.

The protocol is particularly aimed at the identification and characterisation of potential bleeding.

Clamp urinary catheter before leave emergency department

**Oral contrast:** not required.

**Rectal contrast:** not required.

**Reformats:** as per polytrauma protocol

1. Standard head CT
2. Cervical spine
  - Collimation: 1.25 mm
  - Coverage: C<sub>6</sub>–bottom of T<sub>1</sub>
  - Reformats: standard sagittal and coronal
3. Chest, abdomen, pelvis and extend to knees if possible.

Non-contrast-enhanced volume is of no value in trauma.

- a) Arterial phase volume.
  - Intravenous contrast: 150 ml @ 3 ml/sec. Use a right antecubital vein injection and commence scanning at 25 seconds. Scan from C6 to groin (see thoracic aortic protocols). Modify times for older patients etc.
  - Collimation: 1 mm. For obese patient or other technical problems, 2.5–5 mm.
- b) Portal venous phase. The abdomen and pelvis should be routinely rescanned in PV phase (not before 60–65 seconds, later for the elderly).
  - Collimation: 2.5 mm. Domes of diaphragm to below symphysis pubis
  - Reformats – reconstruct 2.5 mm for dorsal spine and lumbar spine. Sagittal and coronal reformats.
- c) Delayed phase. Abdomen and pelvis 60 seconds post-commencement portal venous phase.
  - Collimation: 2.5 mm. The initial images should be reviewed on the scanner console and delayed images through all areas suspicious for active bleeding or where solid organ injury detected.



### Example 3. Military protocol

- 1) Unenhanced spiral brain 1.25 mm (brain and bone algorithms); 5 mm reconstructions immediately available for review.
- 2) Circle of Willis to symphysis pubis (bone and soft tissue algorithms).
  - 150 ml biphasic contrast injection – initial 65 ml at 2 ml/sec then 85 ml at 3.5 ml/sec
  - Scan starts at 60 sec.

This gives both portal venous enhancement with good arterial contrast at the same time and the scan can be carried on down the legs if necessary. The cervical contrast has been very useful both for penetrating injury and for spinal injury/vertebral artery.

- 3) The use of delayed scans limited to specific cases at the request of radiologist.

- Unenhanced head scan
- Thin slices (0,5-3 mm) arterial scan (bolus tracking) from circle of willis to pelvic vessels
- Thick slices portal phase scan (3-5 mm)
- Low dose abdominal delayed phase (5-20 min) if suspicion of renal or urinary tract injuries
- Delayed CT cystogram in selected cases to detect bladder leak (retrograde filling with 300- 350 ml of diluted cm) in order to differentiate intraperitoneal (surgical) from extraperitoneal (conservative) rupture
- No oral contrast , in any case!
- Retrograde rectal filling in very selected cases

# MULTI-TRAUMA MDCT PROTOCOL: ERASME

- Thorax and abdominopelvic scan (+/- cervical spine)
- Unenhanced scan on abdomen and pelvis
- Split bolus scan: 120 ml iodine contrast injection splitted in two flow rates of 80ml at 2ml/min and 50 ml at 3,5 ml/min, plus saline flush at 3,5 ml/min

Start scan at 70 sec

	CT head + cervical spine		Iodine concentrate (mg/mL)	Split-bolus volume and rate					Scan delay (s)	Saline flush
	Non-contrast	Contrast		1st bolus volume (mL)	Rate (mL/s)	Inter-bolus delay (s)	2nd bolus volume (mL)	Rate (mL/s)		
Beenen [12]	X		350	80	4	20	40	5	60	X
Leung [7]	X	X	340	65	2	10	85	3.5	77	X
Loupatatzis [13]	X		300	70	3	8	75	4	50	
Stedman [14]		NS	370	70	3	20	70	4	75	
Stengel [8]	X	X	300	80	2.7	30	70	4	NS	
Yaniv [15]	X		350	80	3	13	50	4	75	X

NS not specified, N/A not applicable, HU Hounsfield units

- **Missed injuries**
- **Misinterpretation errors**
- **60%** of misdiagnoses are attributed to incomplete or **poor-quality** imaging
- up to **25%** of **contained vascular injuries**, pseudoaneurysms and arteriovenous fistulae, are not demonstrated on initial evaluation
- 40% of delayed diagnosis are because of clinical survey oversight: 15% during the primary survey, 25% on secondary survey, and 50% during tertiary survey or re-evaluation

**PRIMARY:** identify life threatening problems (**coronal images**)

**SECONDARY:** detailed catalogue of all injuries

**TERTIARY:** delayed (24h) full clinical examination of the patient  
Structured and taken by a doctor familiar with the case and a doctor  
with a « new pair of eyes » (senior)

8- 21 % injuries diagnosed after 24 h

0.2% require operative management

*Standard Reporting & Tertiary Survey Checklist*

## Appendix 3. CT primary assessment

Patient name:	
Date of scan:	
Reporting radiologist:	

*Purpose: To guide initial management only. Formal detailed report will follow on results server.*

AIRWAY			
ET placement	N/A	Satisfactory	Unsatisfactory
Airway obstruction		Yes	No

BREATHING			
Pneumothorax		Yes	No
Contusion		Yes	No
Laceration		Yes	No
Chest drain placement	N/A	Satisfactory	Unsatisfactory

CIRCULATION (BLEEDING)			
Thoracic		Yes	No
Abdominal		Yes	No
Pelvic		Yes	No
Soft tissue		Yes	No

DISABILITY			
	Intracranial bleed/oedema	Yes	No
	Major spinal injury	Yes	No

## Appendix 4. Secondary trauma report

Date:	Time:
Name:	DOB:
CT head:	

### ABDOMEN/PELVIS

Reformats reviewed

Free gas		
Bowel/mesentery		
Peritoneal fluid		Haemoperitoneum
Vascular injury		
Spleen		
Liver		
Pancreato-biliary		
Renal/adrenal		
Retroperitoneum		
Bladder		CT cystogram
Other findings		Other structures normal
Delayed imaging		
Rectal contrast		

Liver		
Pancreato-biliary		
Renal/adrenal		
Retroperitoneum		
Bladder		CT cystogram
Other findings		Other structures normal
Delayed imaging		
Rectal contrast		

CONCLUSION:

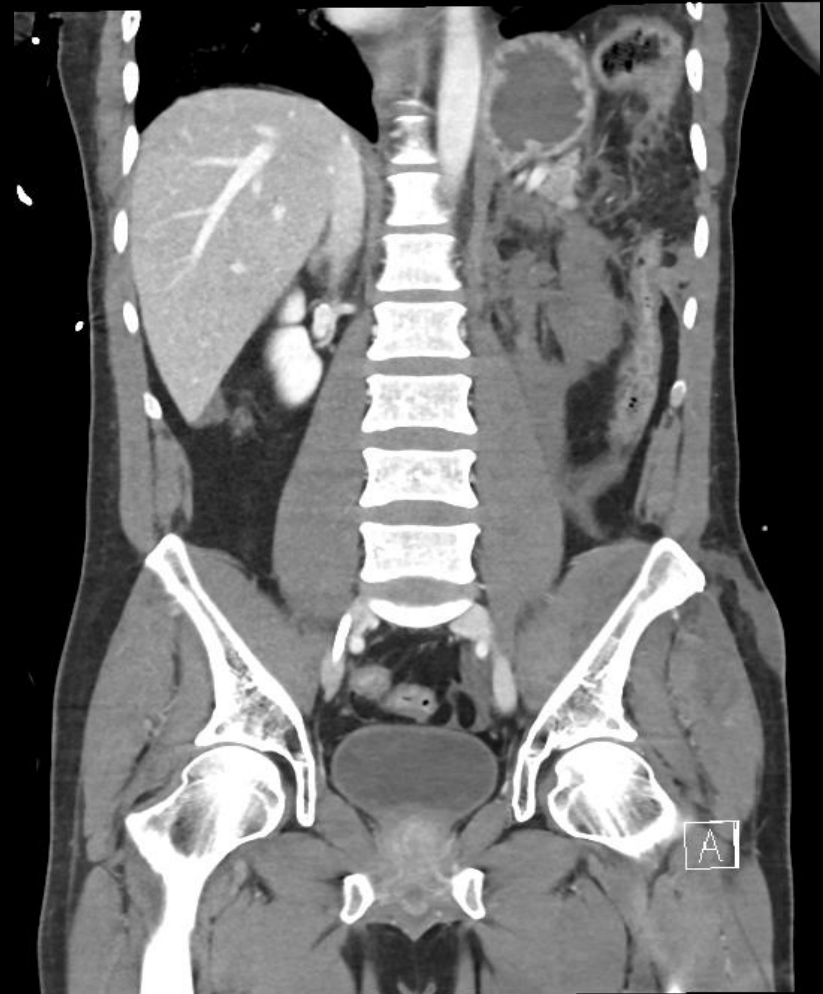
# Some cases





- Male 44yo
- motorvehicle accident, high velocity collision with a tree
- Hemorrhagic shock
- Gleason 15/15

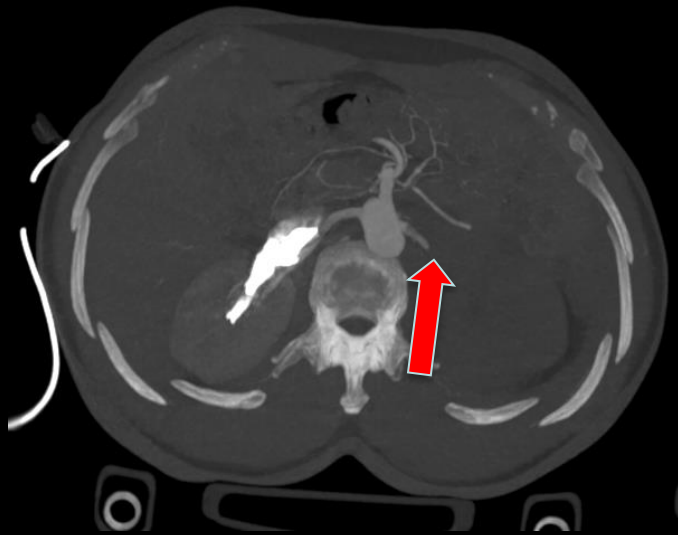
# Case 1



# Case 1

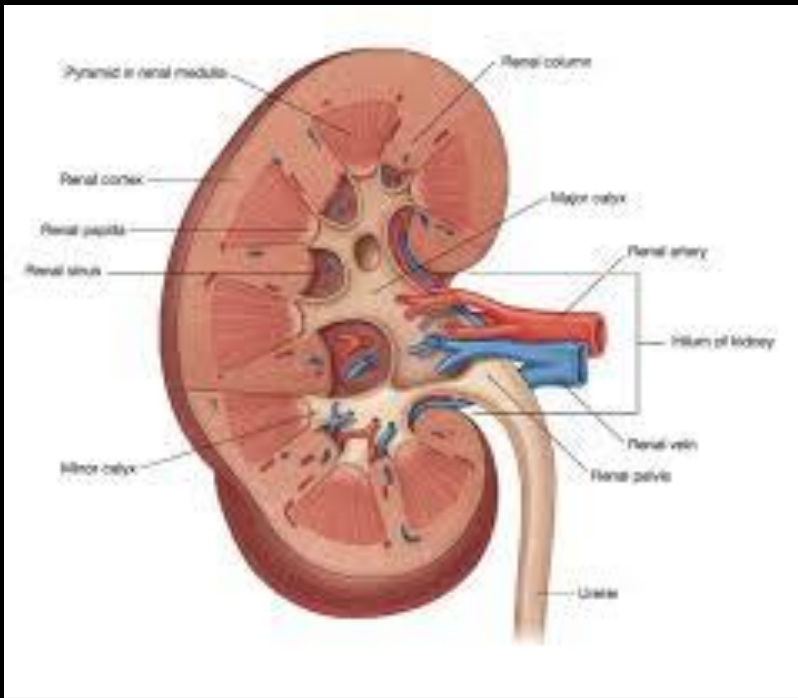


# Case 1



# Case 1

## Kidney injury



- Evaluation of the three structures of the pedicle
- Surgery vs NOM

*Absolute indication for surgery:*

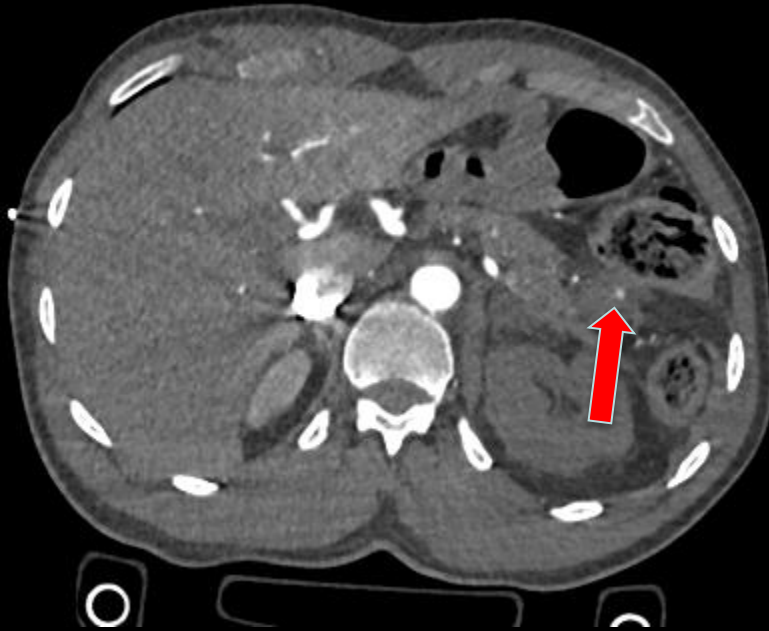
- *Life-threatening renal bleeding*

*Relative indications for surgery:*

- *Extensively devitalized tissue (>50%)*
- *Urinary extravasation that cannot be controlled with conservative means such as ureteral stent placement or nephrostomy*
- *Arterial thrombosis*



## Case 1... keep looking...



## Specific signs:

- Mesenteric Extravasation: 100% specific but low sensitivity (17%) , indication for surgery
- Termination of Mesenteric Vessels: high specificity intermed sensitivity (35%)
- Mesenteric Vascular Beading or Irregularity: good sensitivity (39%)

## Less specific signs:

- Mesenteric infiltration: sensitive but non specific (69%)
- Mesenteric hematoma: no indication for surgery
- Bowel features: wall thickening (49%) or abnormal enhancement (35%) indicate vascular compromise. Ischemia may not be evident on the initial scan!

## Case 1... still keep looking...



*Dependent viscera sign*



*Collar sign*



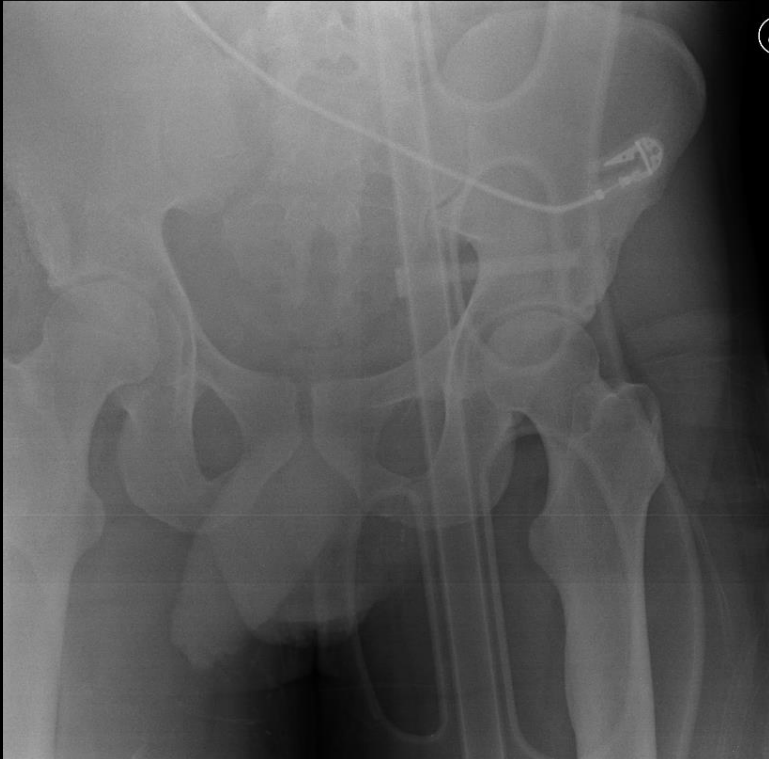
## Direct signs:

- Segmental Diaphragmatic Defect
- Dangling Diaphragm
- Absent Diaphragm

## Indirect signs related to herniation:

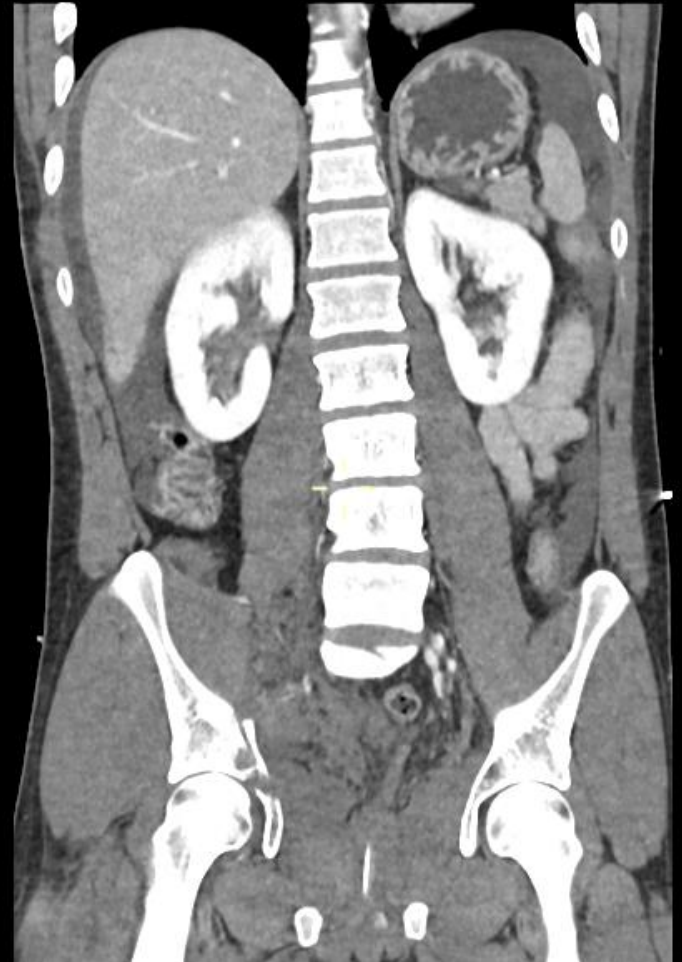
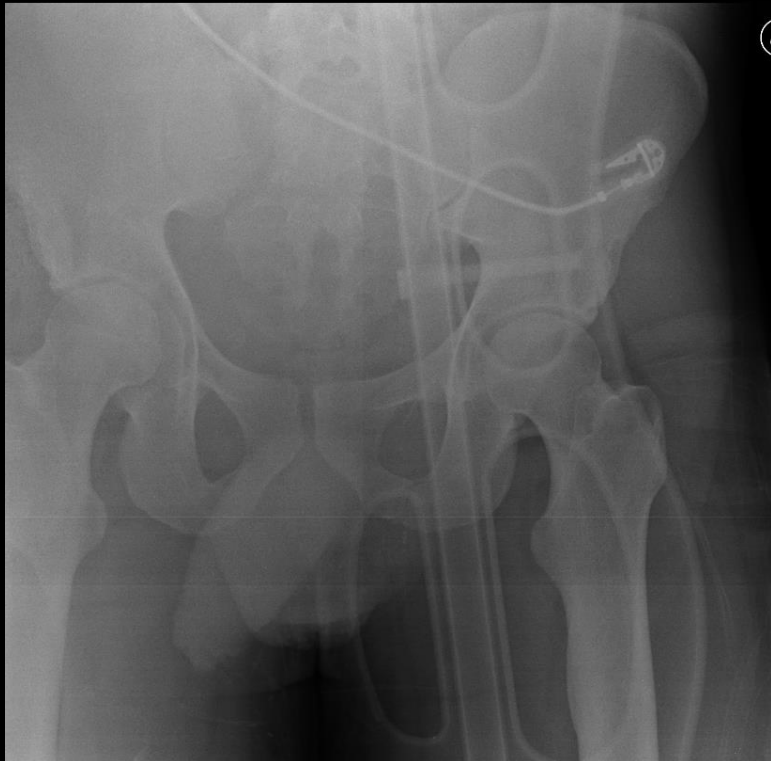
- Herniation through a defect
- Collar sign (left) or hump sign (right)
- Dependent viscera sign
- Elevated abdominal organs

- Male 24yo
- Pedestrian hit by a car
- Tachycardia (120 bpm)
- Gleason 7/15
- $\text{CH}_3\text{CH}_2\text{OH}$  +

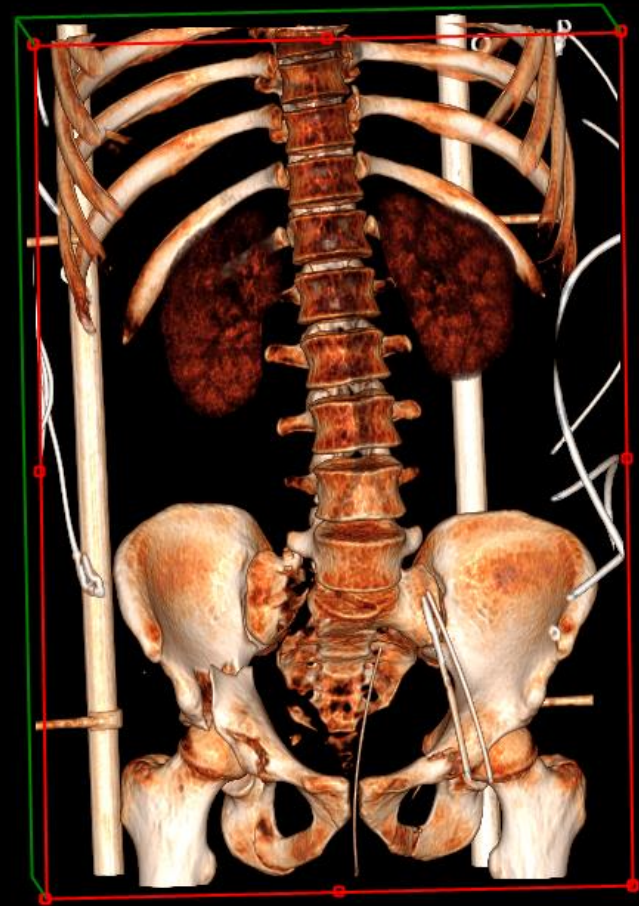
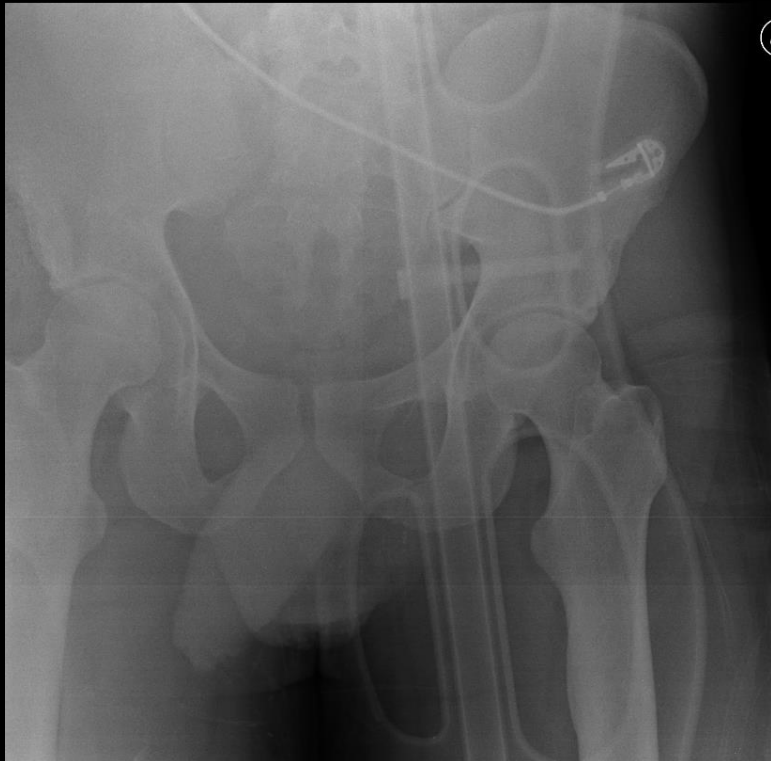


Pelvic Fracture  
Yes or No?

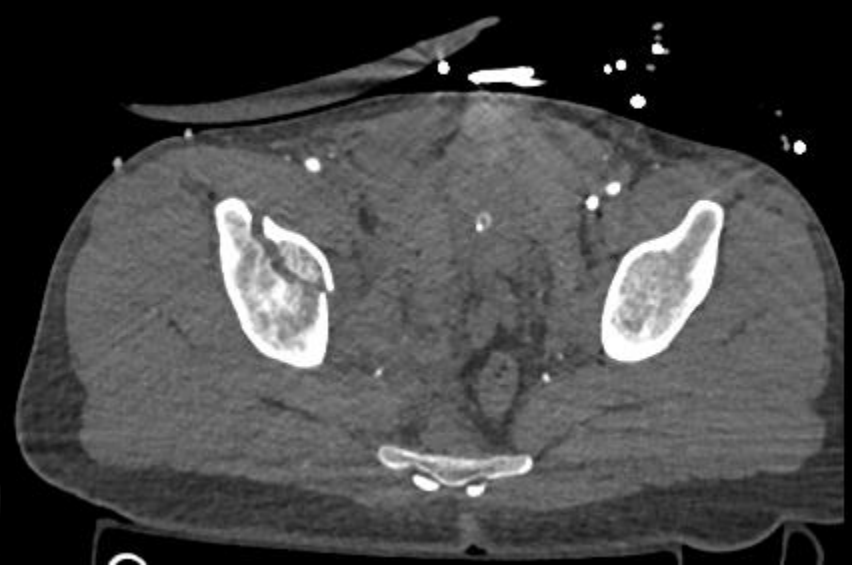
## Case 2



## Case 2



## Case 2 arterial phase





## Case 2 venous phase



11 HU



59 HU



## Case 2 delayed phase (clamp the foley!)

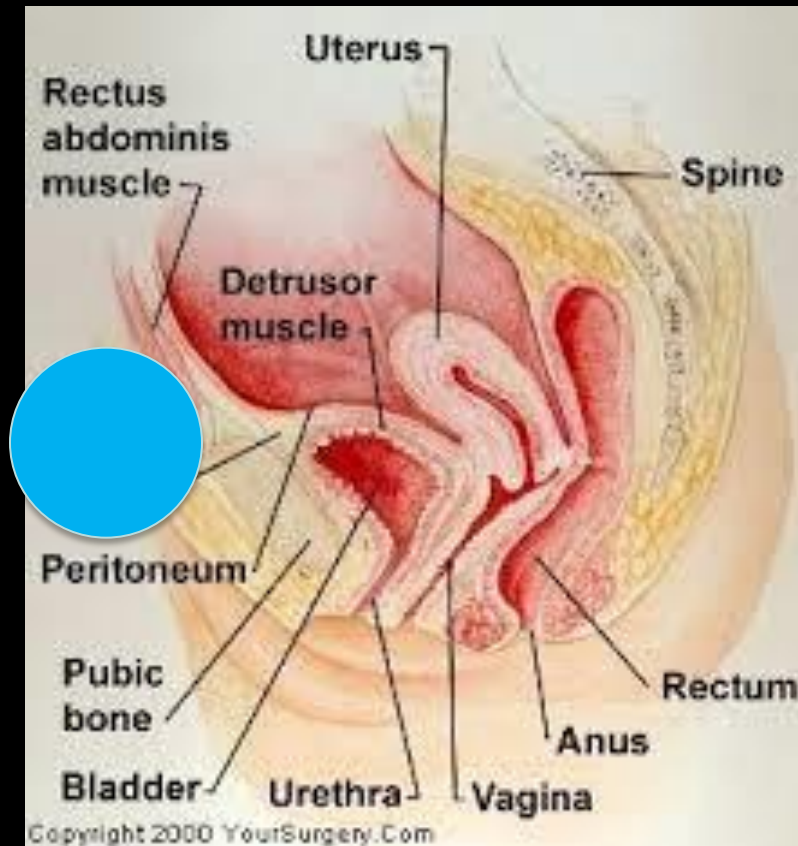




## Case 2

# Bladder rupture

The propensity for bladder injury is related to the degree of distention at the time of impact

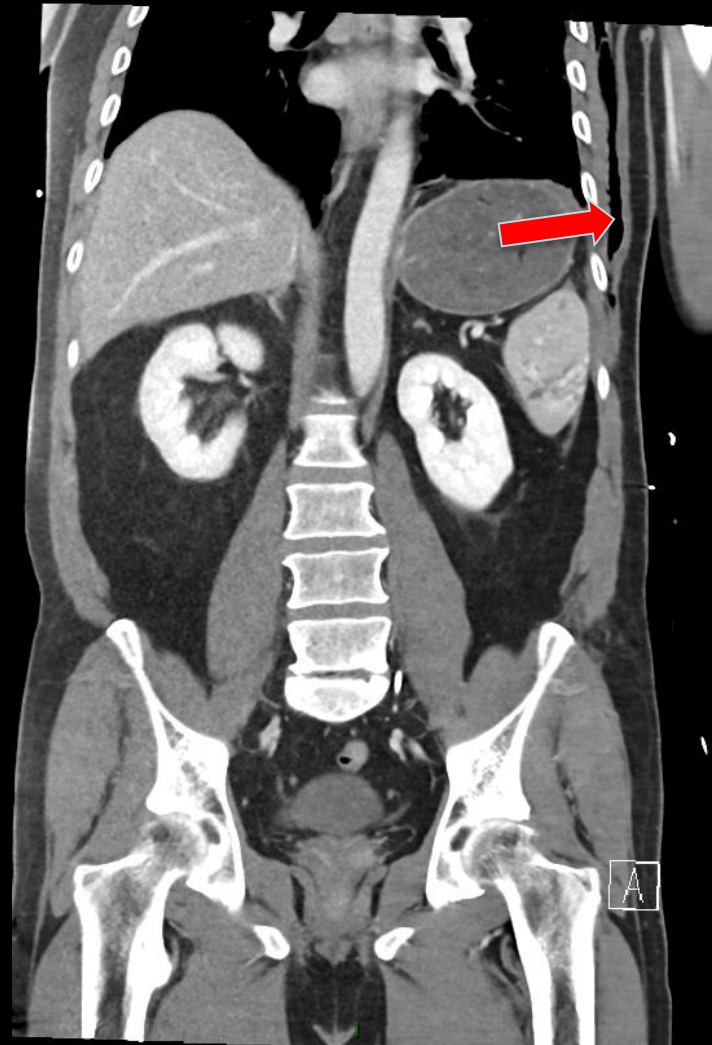


## Intraperitoneal vs extraperitoneal rupture

## Surgical vs Conservative

- Male 49yo
- Fallen from 8 mt
- No hemodynamic instability
- GCS 15/15

## Case 3



## Case 3

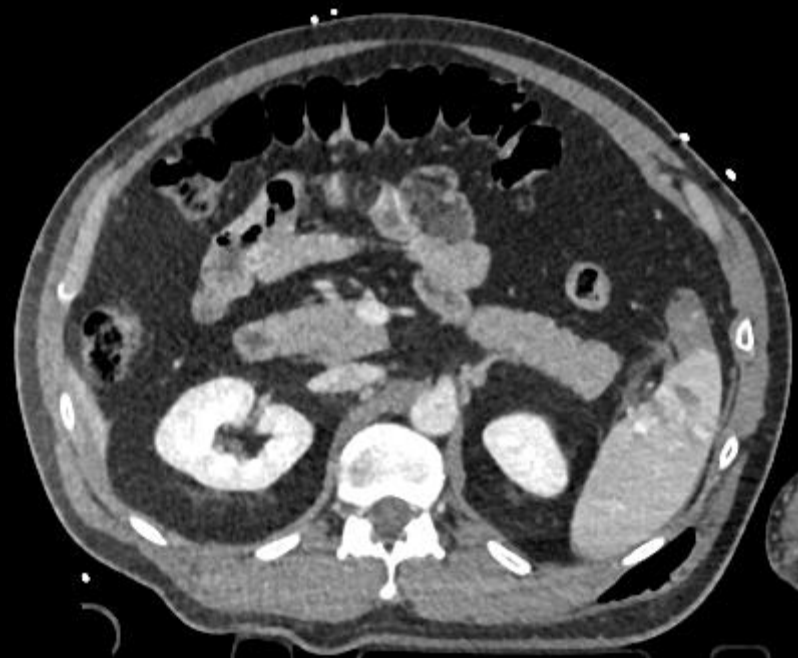


## Case 3

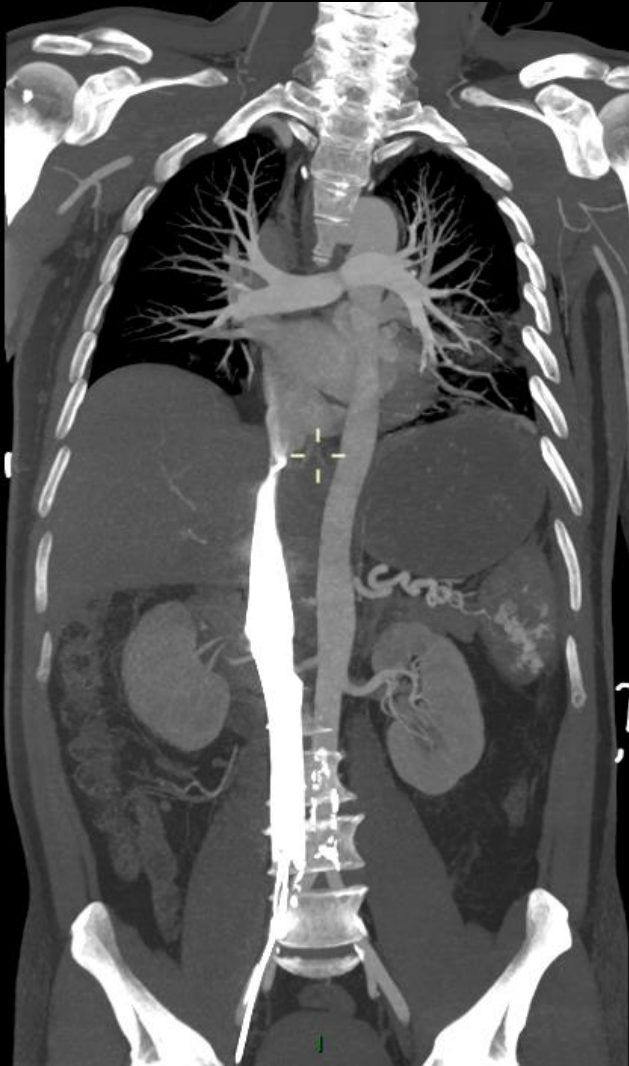




## Case 3

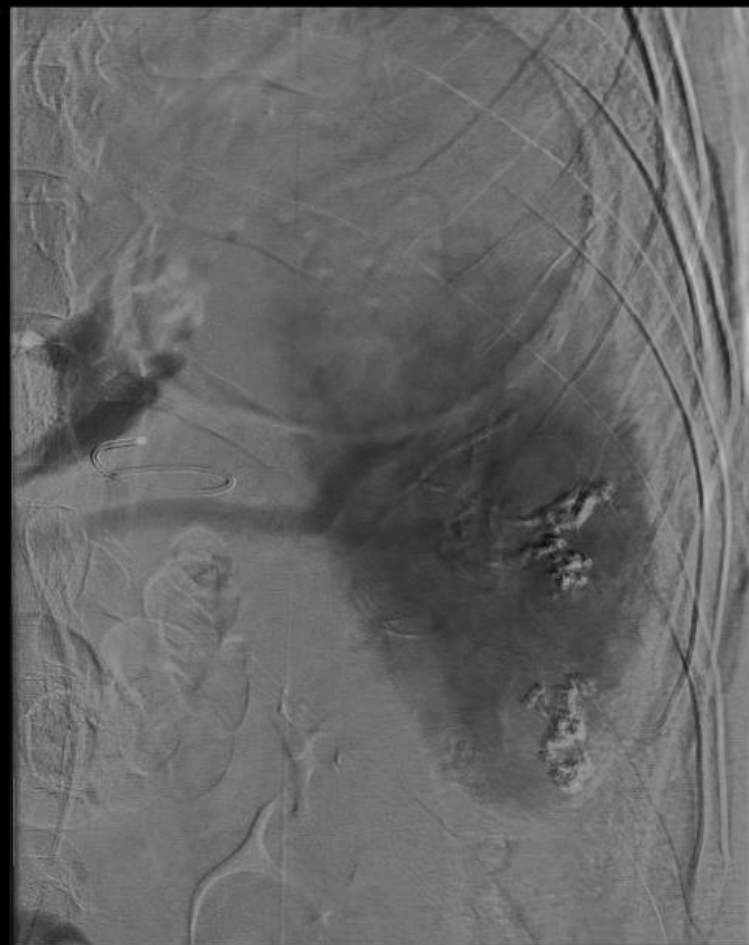
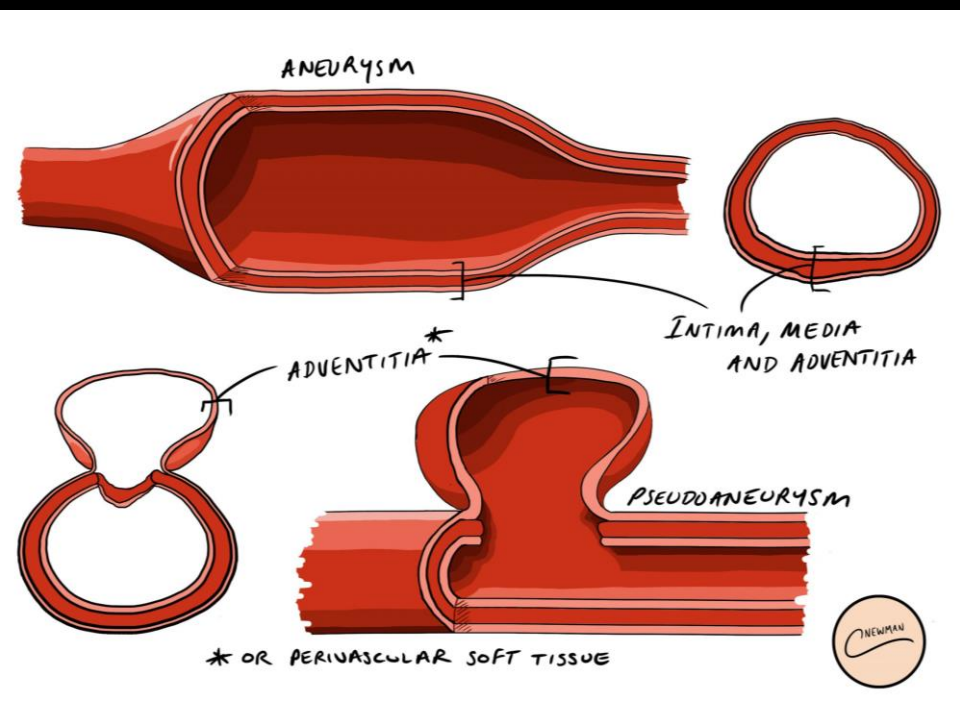


## Case 3



## Case 2

### Contained vascular injuries



Multiphasic imaging



## Trauma = Disease

- Systemic and evolutive illness
- Vascular lesions are killer n1
- Vector of trauma
- Be systematic
- MDCT the doughnut of life

### REVISED ATLS GUIDELINES

- **A**irway
- **B**reathing
- **C**T
- **D**iagnosis
- **E**mbolisation

# Q&A

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