FAST

Focused Assessment with Sonography in Trauma

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OBJECTIVES

- Understand standard sonographic views of a FAST exam ; and E- FAST evaluation
- Understand limitations of the FAST exam
- Review Basic Concepts of Ultrasound Physics
- Recognize sonographic appearance of intra-abdominal echogenicities

BLUNT ABDOMINAL TRAUMA (BAT) or Penetrating Injuries : Common Reasons for Presentation at ER

- ALTERNATIVES FOR EVALUATION

DPL : Diagnostic Peritoneal Lavage

= historically used to detect bleeding or injury to hollow viscus
= invasive
= not used for serial assessments
= difficult in pregnant patients
= replaced by FAST and CT
= retains usefulness in the hemodynamically unstable trauma patient, with negative or equivocal FAST exam

BLUNT ABDOMINAL TRAUMA (BAT) or Penetrating Injuries : Common Reasons for Presentation at ER

- ALTERNATIVES FOR EVALUATION

Abdominal CT exam

= better than DPL for intraabdominal injury

(solid organ, bowel wall , mesentery , bladder)

= expensive ; radiation

= in the hemodynamically stable patient , CT follows a positive or equivocal FAST scan

BLUNT ABDOMINAL TRAUMA (BAT)
or Penetrating Injuries :
Common Reasons for Presentation at ER

- ALTERNATIVES FOR EVALUATION

FAST: focused sonography ** (widely used as initial exam)

= bedside sonography to DX hemoperitoneum and hemopericardium in abdominal trauma

= portable, low cost, high quality machines since 1990's

= non invasive ; no radiation ; rapidly performed

= serial exams can be done

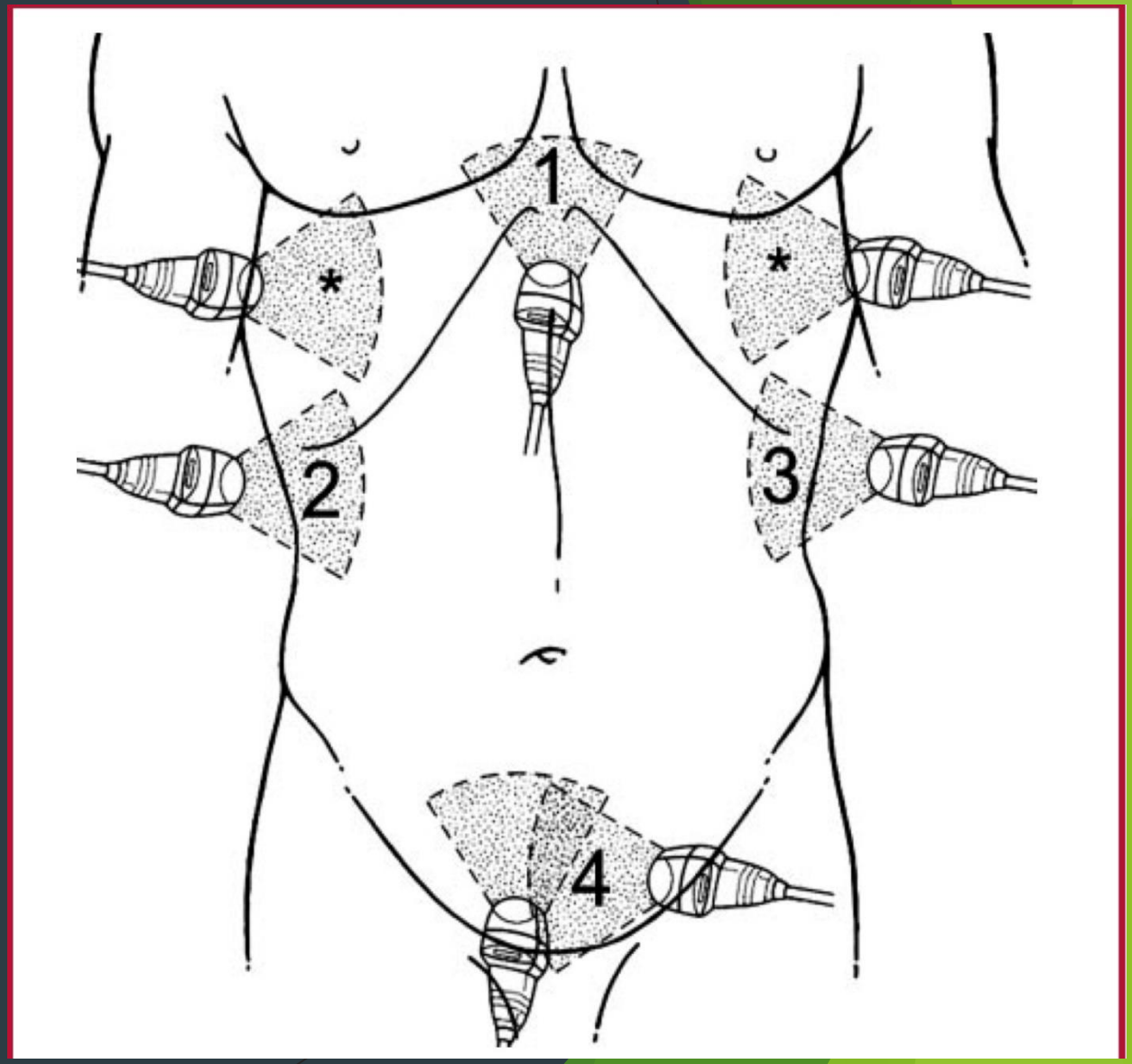
= safe in pregnant patients and children

Comparison parameters for DPL, FAST, and CT

	DPL	FAST	CT
TIME	10 – 15 min	2 – 4 min	Variable
REPEATABILITY	Possible, rarely done	Easy and frequently done	Yes
RELIABILITY	Not organ specific	Operator dependent	Obesity ; movement
SENSITIVITY	High	Medium	High
SPECIFICITY	Low	High	High
ADVANTAGES	Inexpensive; detects bowel injury	Noninvasive, rapid, portable; no radiation	Noninvasive ; highly accurate
DISADVANTAGES	Invasive ; misses retroperitoneal, diaphragm injuries	Limited by subcutaneous or intra-abdominal air, obesity. Operator dependent	Radiation ; expensive ; may miss diaphragm, small bowel, pancreatic injuries

FAST : Sonography Screening in Major Trauma Patients

- Quick evaluation of intraperitoneal cavity and pericardium
- Detects free fluid : indirect sign of acute hemorrhage and organ injury
- Supine patient ; convex 3.5 – 5 Mhz probe



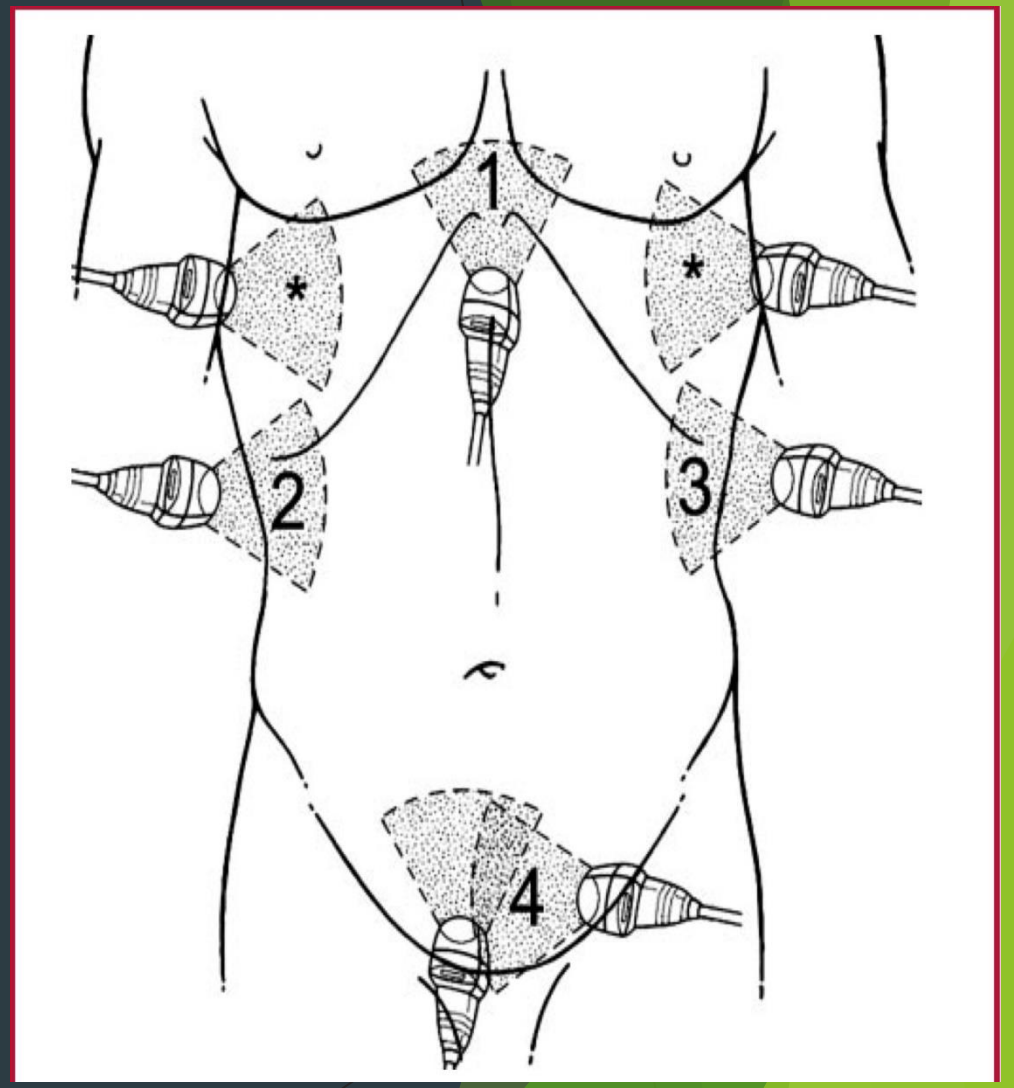
FAST : Standard Projections

(1) Subxiphoid /Subcostal region : transverse view for pericardial effusion and left liver lobe

(2) RUQ : longitudinal view to assess Morison's pouch: liver - right kidney space ; rt. pleural space *

(3) LUQ : longitudinal view to assess spleen – left kidney space; lt.pleural space *

(4) Suprapubic space : long and transverse views; to assess fluid in pouch of Douglas



FAST : FOCUSED ASSESSMENT with SONOGRAPHY in TRAUMA

- When performed correctly , evaluation is done in 2-4 minutes
- If difficulty arises performing the complete exam, the operator should not waste too much time with the FAST evaluation, if there is any suspicion of hemorrhage
- If there is intraabdominal bleeding, probability of death increases about 1% for every 3 minutes that elapses before treatment

FAST : FOCUSED ASSESSMENT with SONOGRAPHY in TRAUMA

- Detectability of free fluid is dependent on the volume of fluid present
- Trendelenburg positions have been used to assess fluid pockets

- FAST may detect minimum 100 – 250 ml of free fluid

(Variable reported sensitivity : 0.64 – 0.98 ; specificity : 0.86 – 1.00)

- "Rule of thumb" :
  - 5 mm rim of fluid at Morison's pouch : 500 ml free fluid **
  - 10 mm rim of fluid at same level : 1,000 ml free fluid **

Extended FAST : E- FAST

- BASIC FAST includes : detection of fluid in upper and lower peritoneal cavity ; pericardial space, pleural spaces (subxiphoid , RUQ, LUQ, pelvic views)

- Other sites incorporated :
  - = Sonographic evaluation at anterior 2nd or 3rd intercostal spaces : to assess for pneumothorax
  - = Right and Left Pericolic gutter views : free fluid adjacent to bowel along flanks
  - = Inferior Vena Cava views : intravascular volume status

KNOWLEDGE of
BASIC ULTRASOUND CONCEPTS

will aid in the performance and in the interpretation of the FAST exam

- GOOD CONTACT IS IMPORTANT, BETWEEN PATIENT'S SKIN AND PROBE, with ACOUSTIC GEL (to facilitate sound transmission)

- SELECT THE APPROPRIATE PROBE with proper frequency

  Curved probes for abdomen ; with penetration of sound up to 20 cm

  = adults : 3. 5 Mhz - 5 Mhz

  = children : 5 MHZ or higher frequency

  Curved or linear probes for pneumothorax evaluation

- KNOW THE NORMAL ANATOMY OF THE AREA BEING EXAMINED

NOTE : You will interpret exams best, when you can supervise images done ; or if you obtain images yourself **

** ULTRASOUND IS 100% OPERATOR DEPENDENT **

Ultrasound equipment

Ultrasound Transmission Gel

US transducers/probes

HOW DOES ULTRASOUND WORKS

1- Ultrasound transducer receives a short electrical impulse, and generates a pressure wave pulse

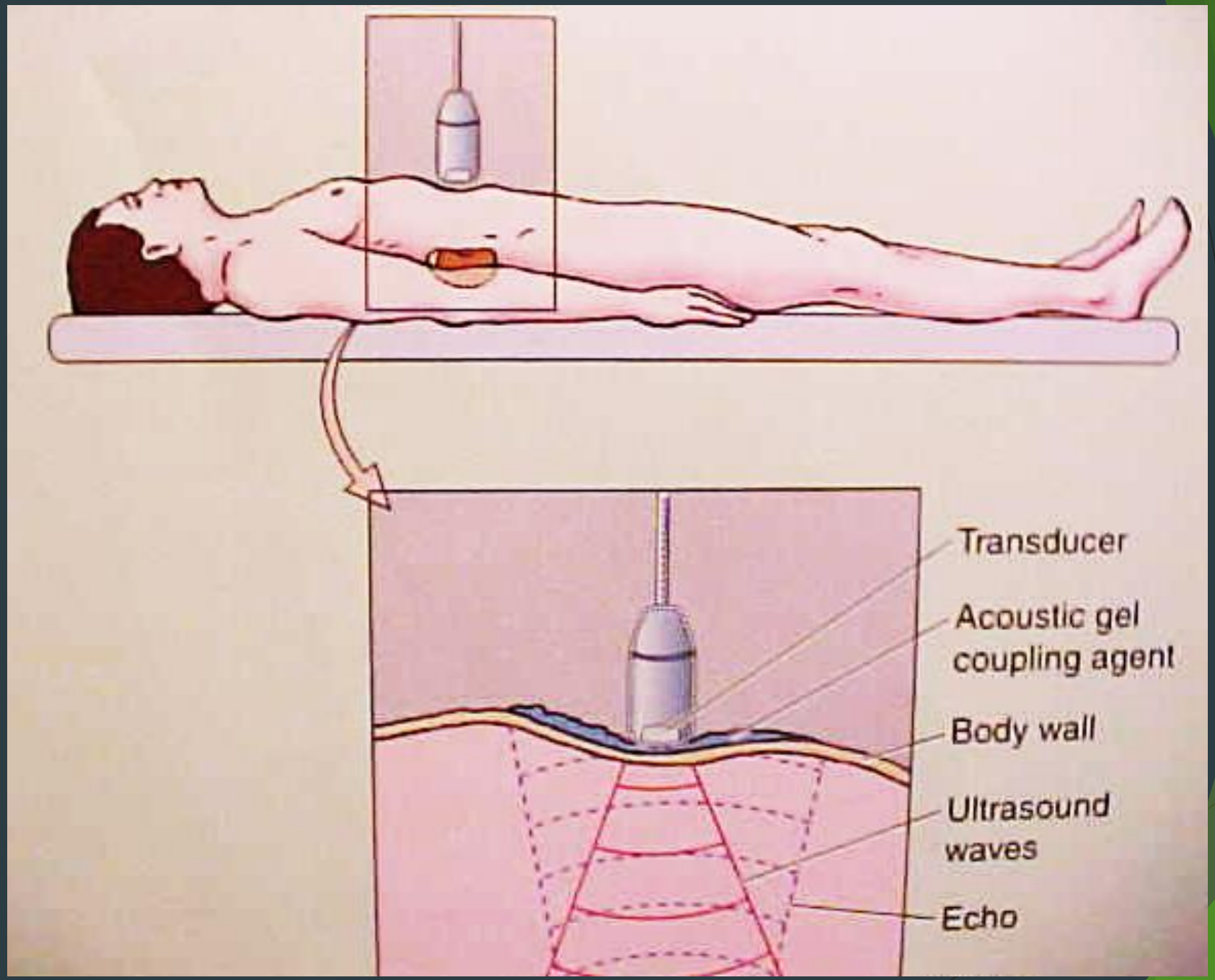
2- Pulsed wave propagates down through the tissue

3- Tissue absorbs , scatters, reflects and refracts the wave

4- Reflected waves (at 90 degrees, perpendicular to probe) return to the transducer **

5- Transducer switches to receive mode, and converts the received pressure waves into electrical pulses (seen in monitor as echoes)**

6- After a fixed period of time, the transducer stops receiving, and transmits the next pressure wave


Transducer
Acoustic gel coupling agent
Body wall
Ultrasound waves
Echo

ACOUSTIC FREQUENCY

- **Frequency represents cycles per second**

- **The unit of acoustic frequency is the hertz (Hz):**

  1 cycle / second = 1 Hz

  1000 cycles / second = 1 KHz

  1,000,000 cycles / second = 1 **MHz ****

- Sound frequencies used for diagnostic applications **typically range from 2 - 15 MHz**

- To produce an echo, a **reflecting interface** must be present
- At the junction of tissues with **different** physical properties, **acoustic interfaces** are present
- The **amount of reflection** is **determined by difference in acoustic impedances** of materials at interface
- Acoustic impedance is determined by properties of the **tissue**, and is **independent of the frequency**

RESOLUTION

Higher frequency : best resolution / lower penetration of sound waves

Lower frequency : better penetration of waves / lower resolution

- **Best image resolution is obtained by using highest frequency possible, although higher frequencies have limited ability to penetrate tissue ****
- **In order to assess deeper anatomic regions in the body, lower frequencies are used , although with some loss of resolution**

Velocity of propagation

Velocity of sound = frequency x wavelength

- The more closely packed the molecules of the tissues, the faster the speed of sound :

= lowest in gases **

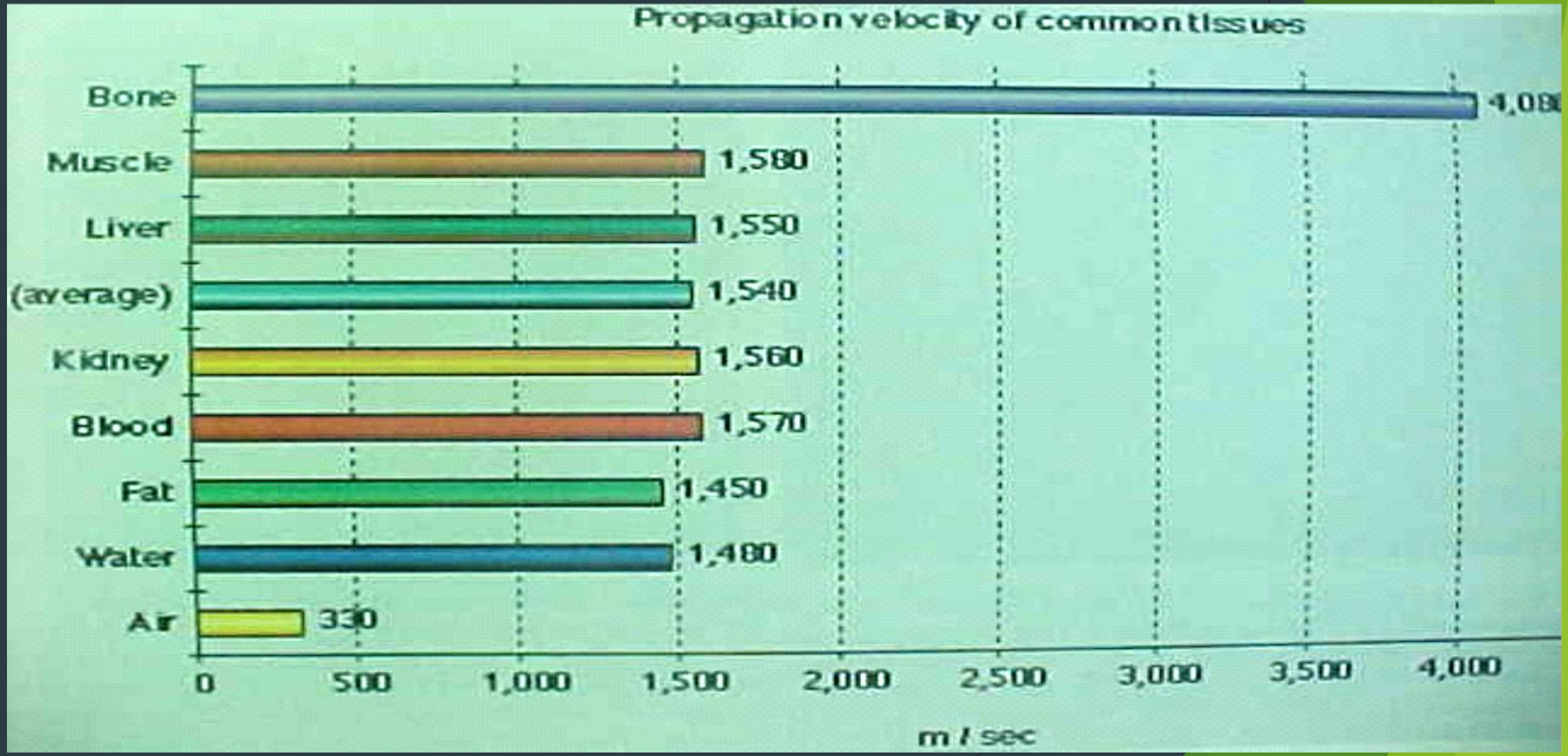
= faster in fluids

= faster yet in soft tissues

= fastest in bones **

The **average** propagation **velocity of sound** in soft tissues is 1,540 m/sec

BONE and AIR create the largest artifacts in sonography ***



ATTENUATION

- **Attenuation occurs** with the transfer of energy to the tissue (**heating , absorption**) ; as well as with the removal of energy by **reflection** and **scattering** ***
- As sound passes through tissue it **looses energy**, and the pressure waves decrease in amplitude as they travel further from the source
- **Attenuation depends on the insonating frequency**; higher frequencies are attenuated more rapidly than lower frequencies ***

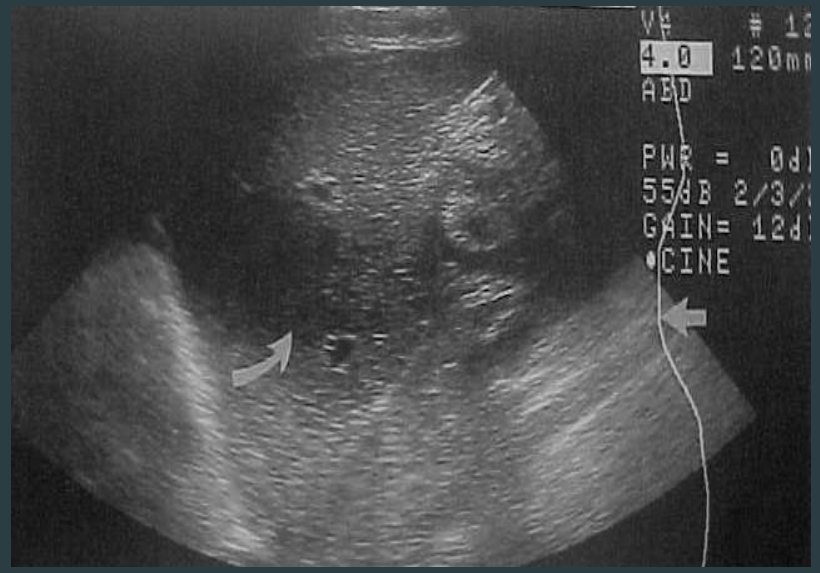
A technique used to compensate for attenuation is time gain compensation curve adjustment (TGC)

EXAMPLE :

- (A) Image through liver shows central band of dark echoes caused by faulty adjustment of TGC curve

- (B) Proper adjustment of TGC curve produces a uniform appearance : operator adjusts the curve ***

A



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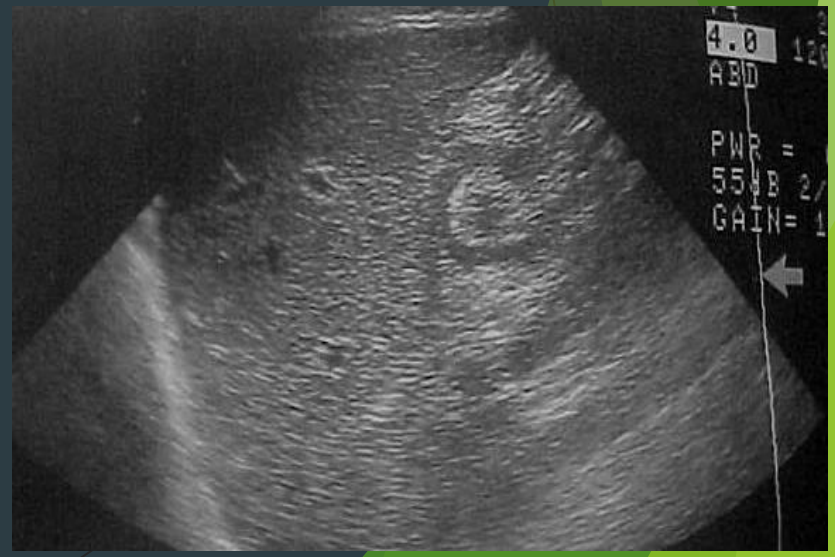


Ultrasound Terminology

- Echo - free fluid
- Particulate fluid

- Echogenic /solid tissue
  with acoustic interfaces : echoes

  = hypoechoic
  = hyperechoic
  = isoechoic

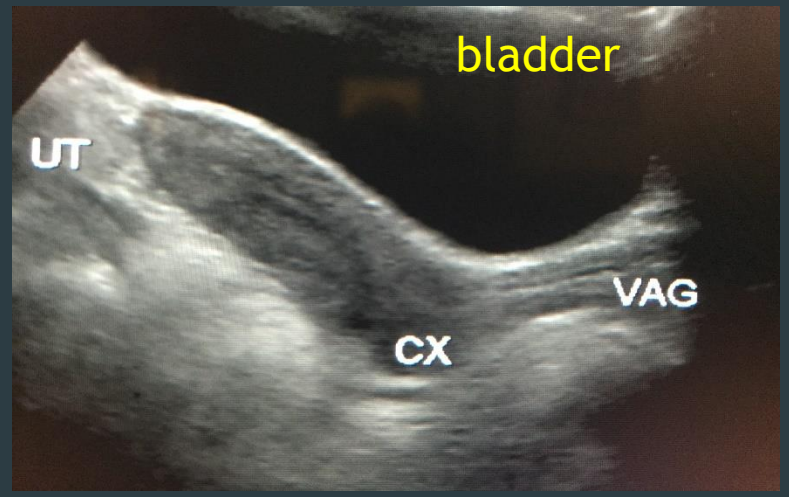
- Complex texture
  = fluid
  = plus solid material

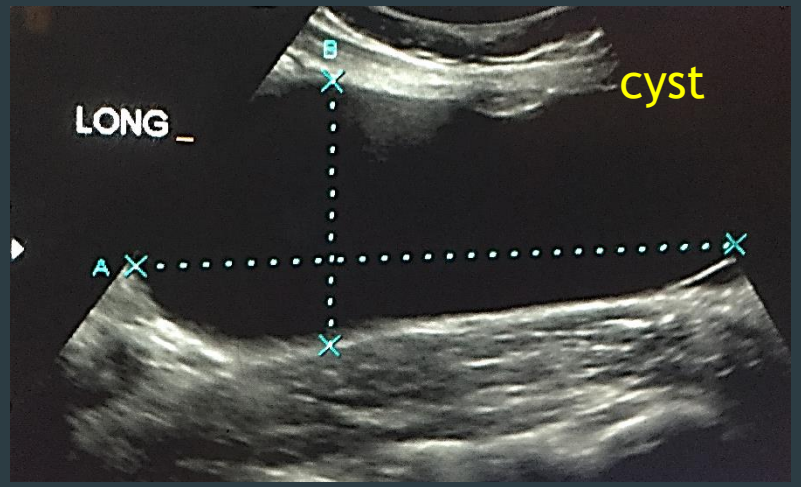
- Air / Gas artifacts (dirty shadow)

- Bone / calcium / calculi
  (sharp acoustic shadow)

FLUID

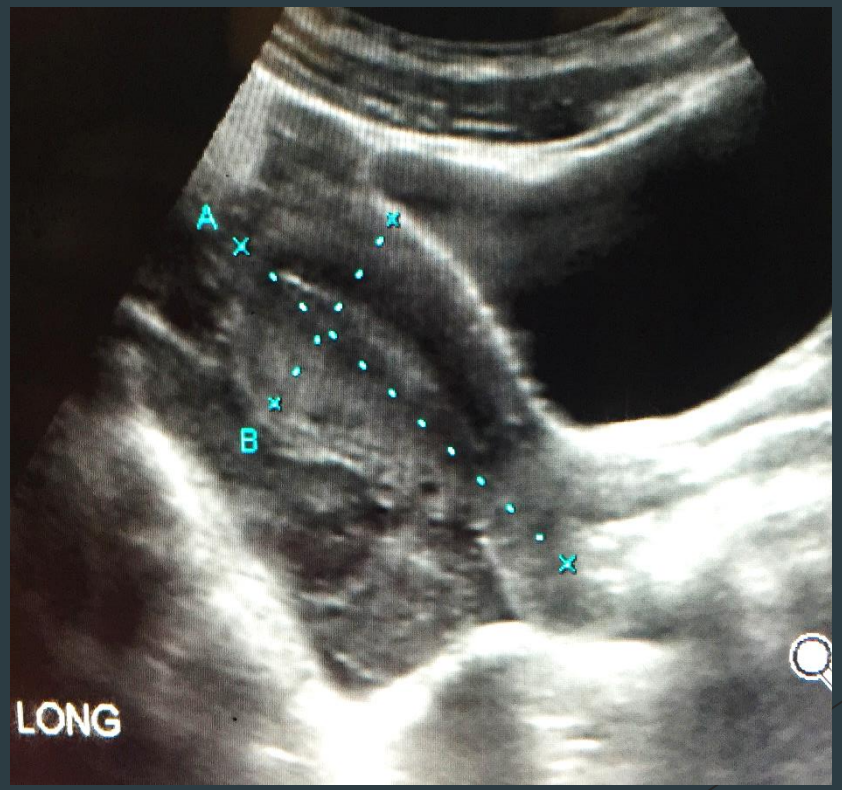
- **ECHO - FREE FLUID**



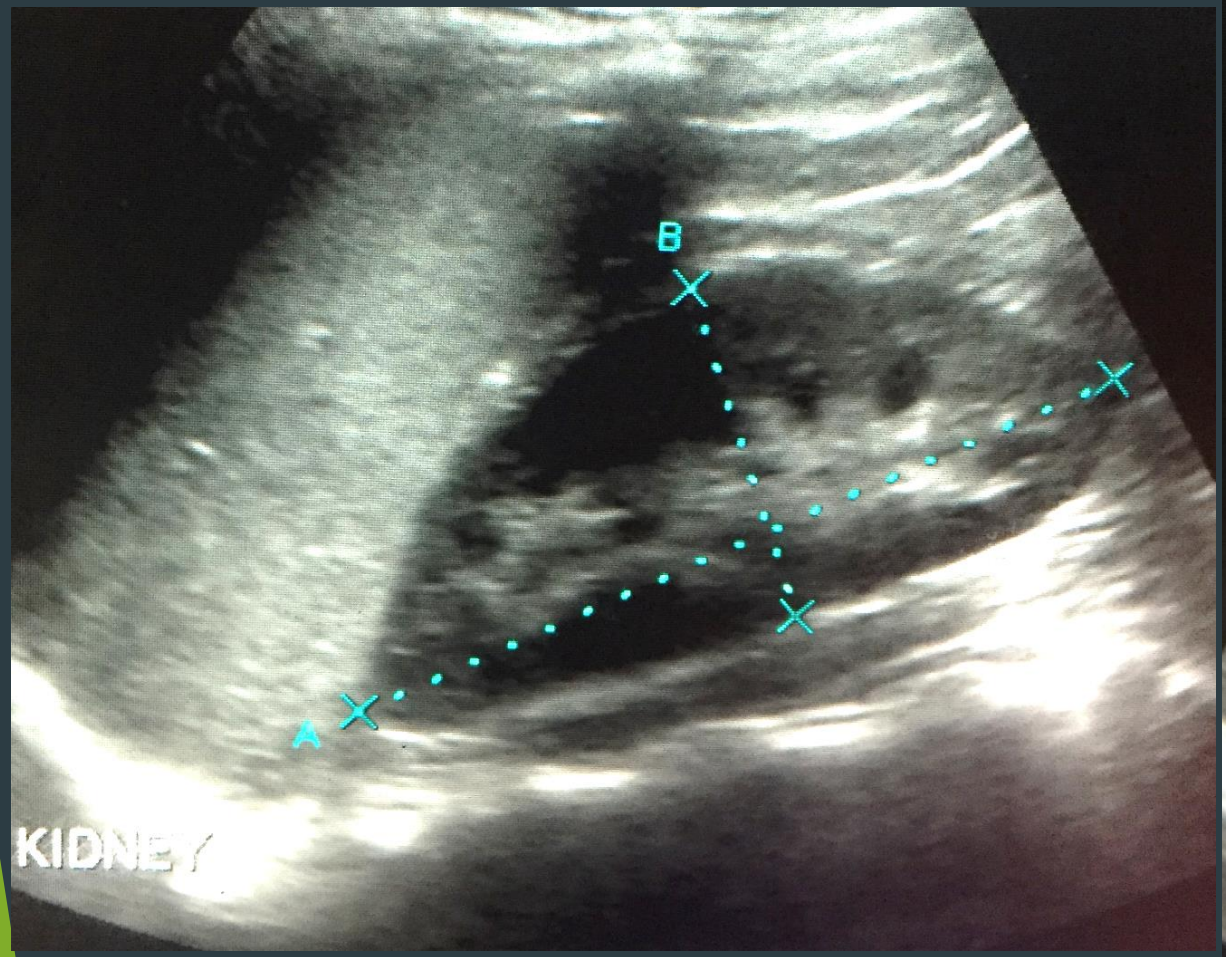


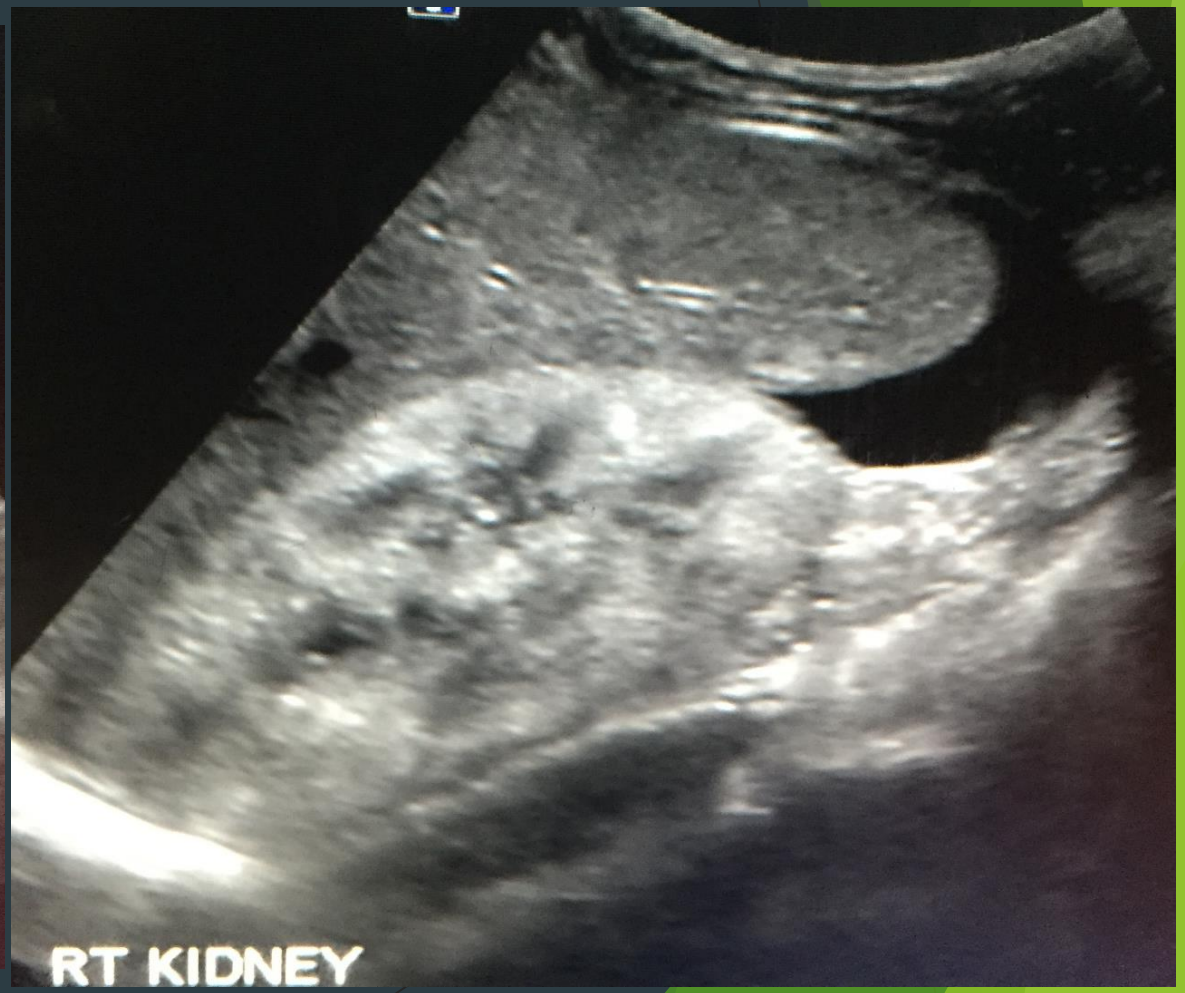
- **PARTICULATE FLUID**

(blood or infection)

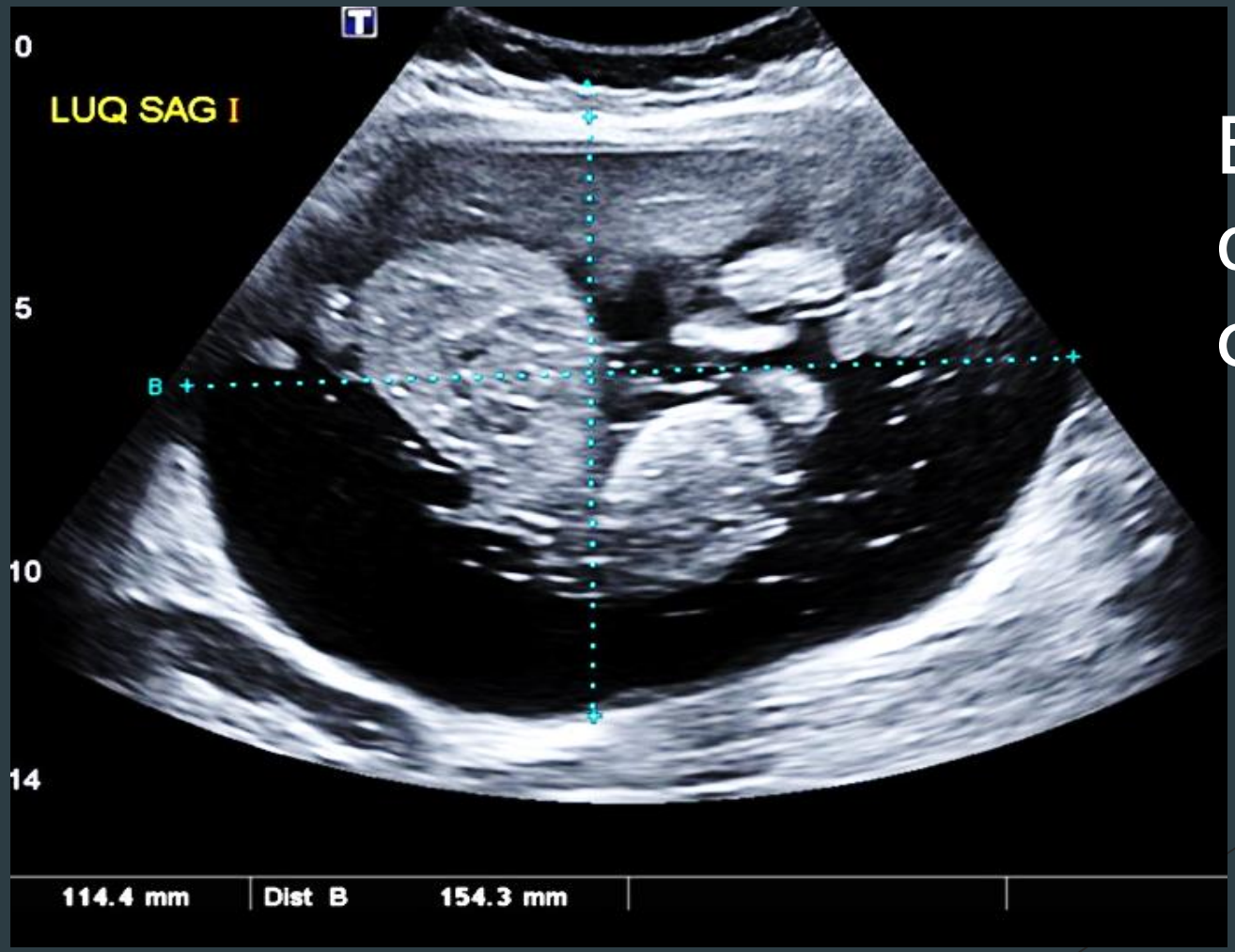


ECHOGENIC solid tissue : reflective echoes / acoustic interfaces
(hypoechoic ; hyperechoic ; isoechoic)



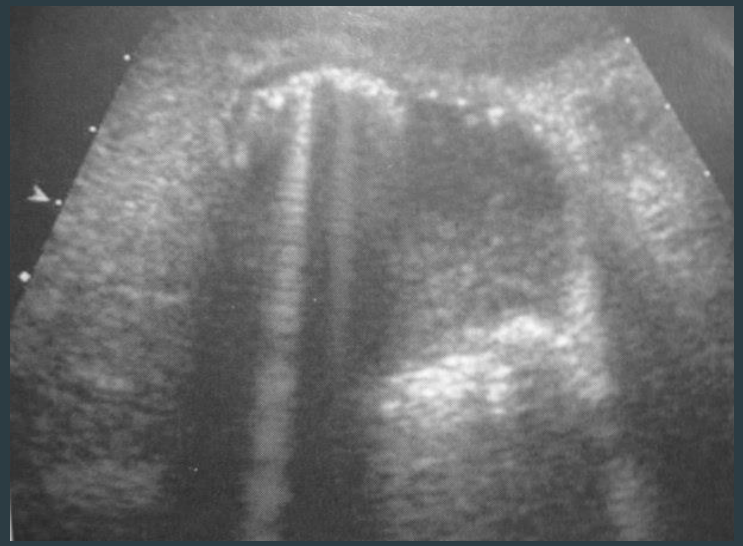


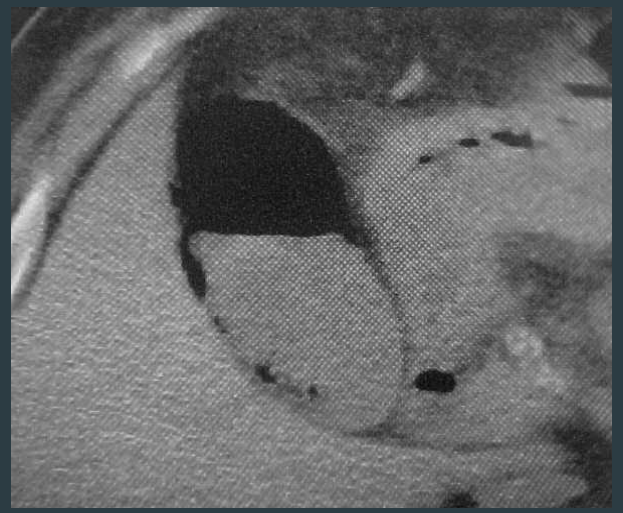
Complex texture : mixture of fluid plus echogenic tissue



Example : large ovarian dermoid cyst

AIR / DIRTY “ring down” SHADOW

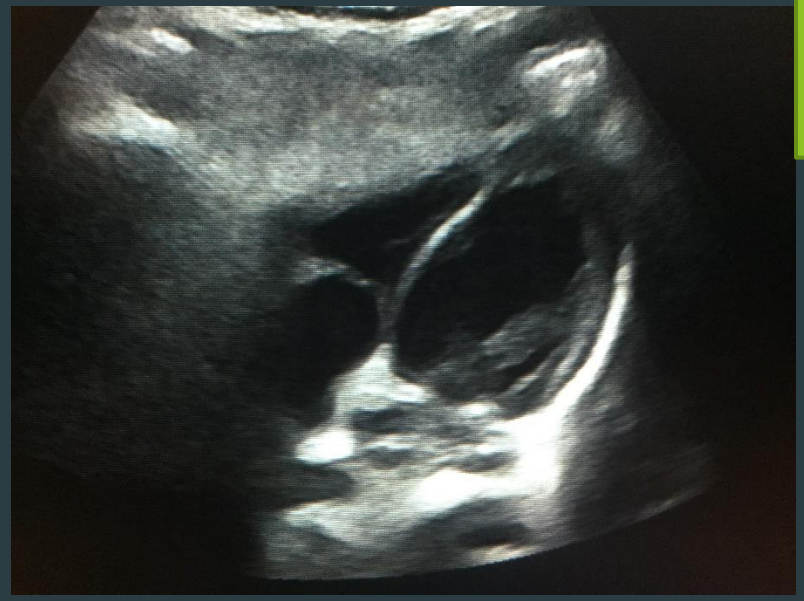


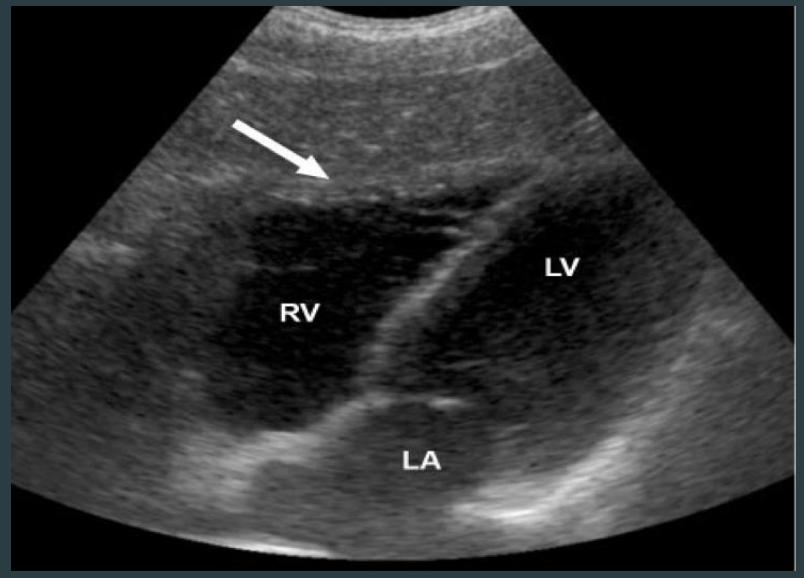


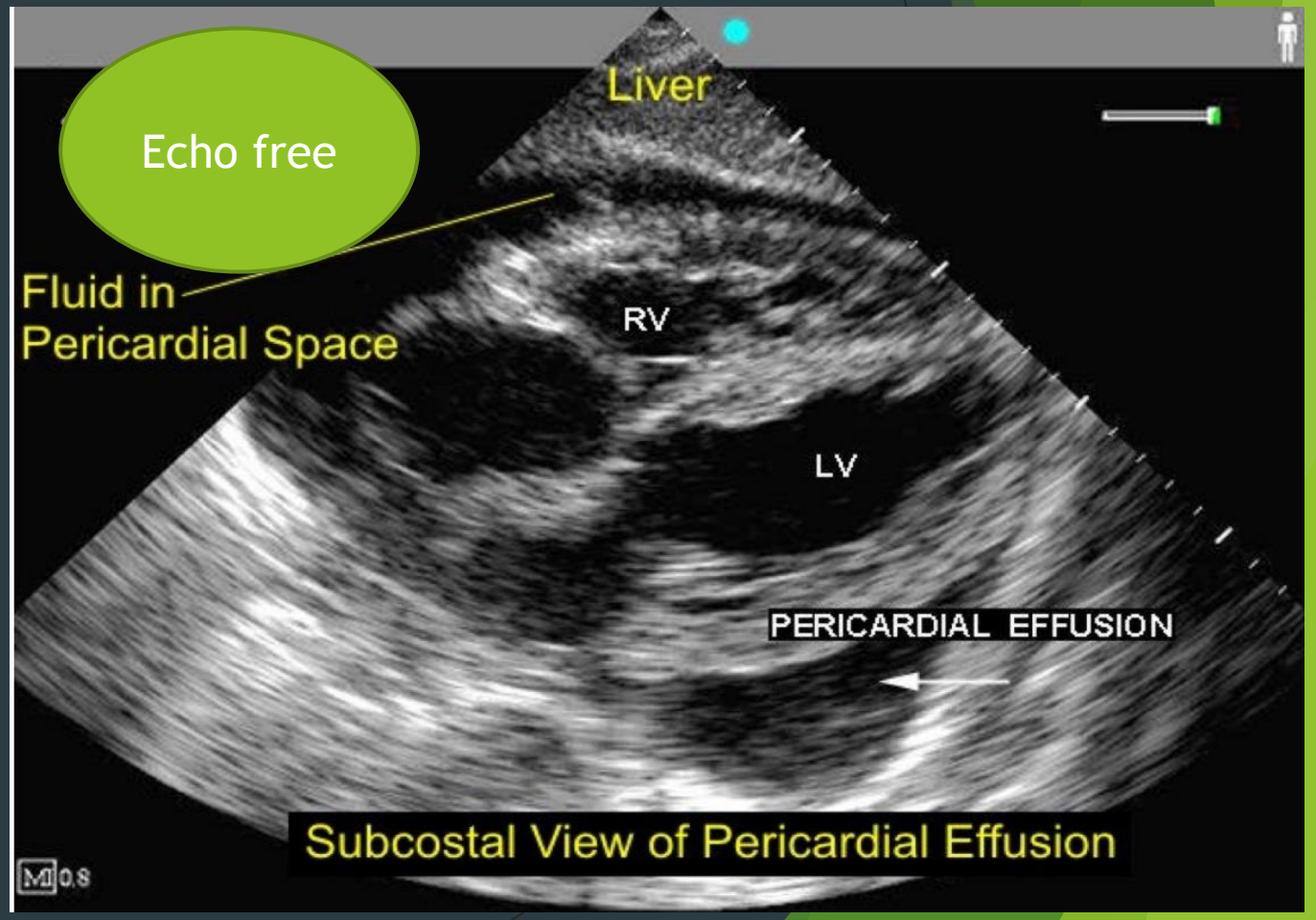
BONE / CALCULUS : SHARP ACOUSTIC SHADOW

FAST : Subxiphoid Subcostal view

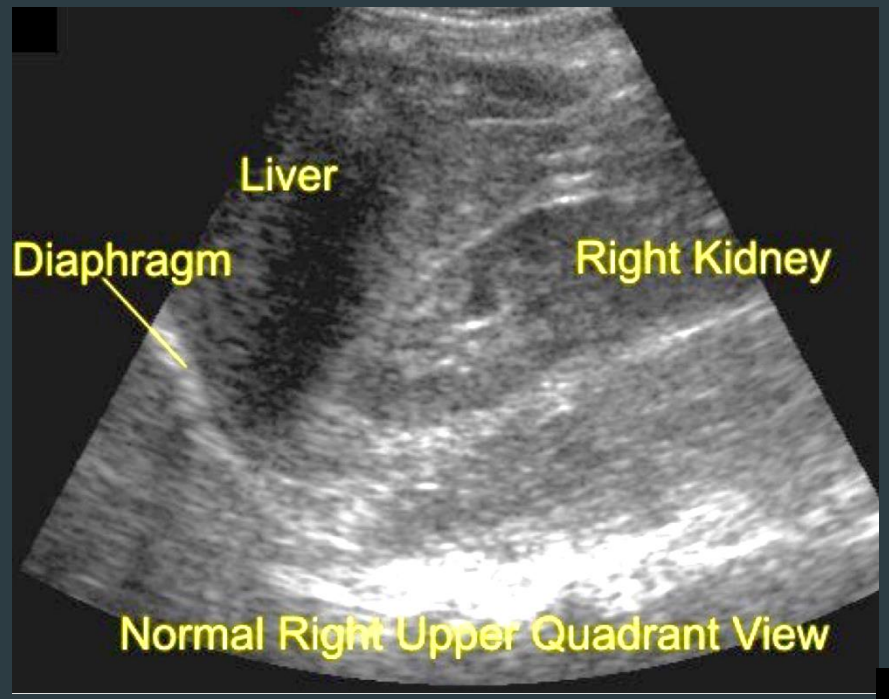
Normal

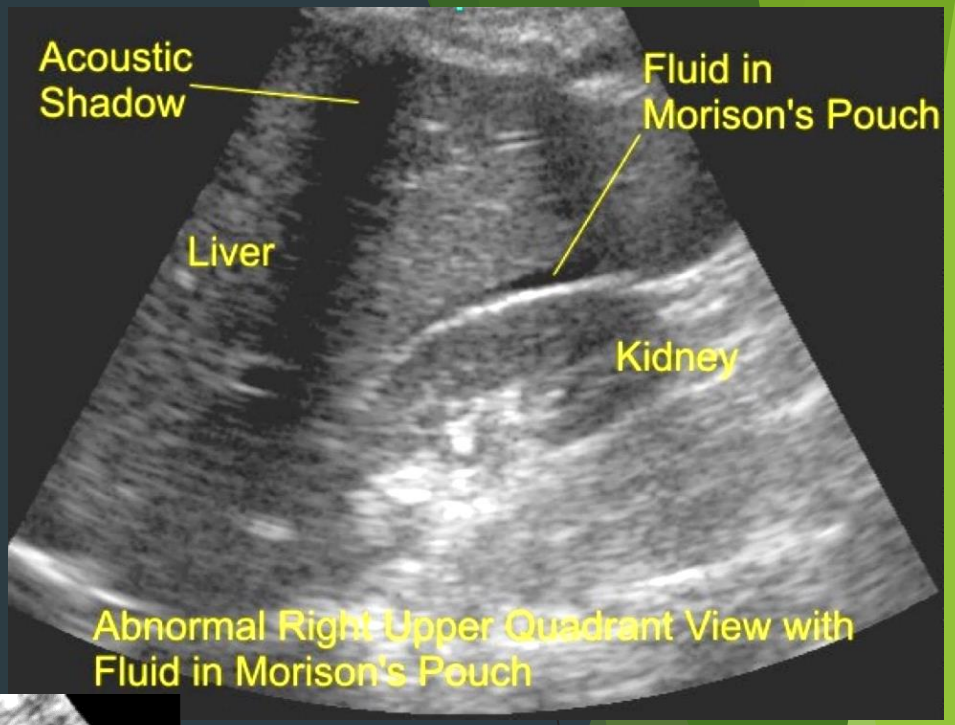


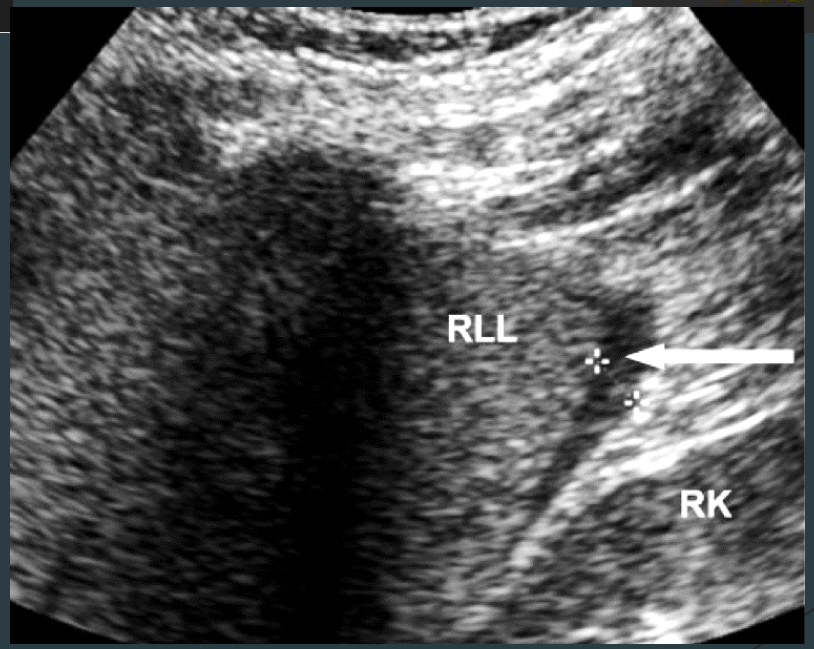




RUQ longitudinal view

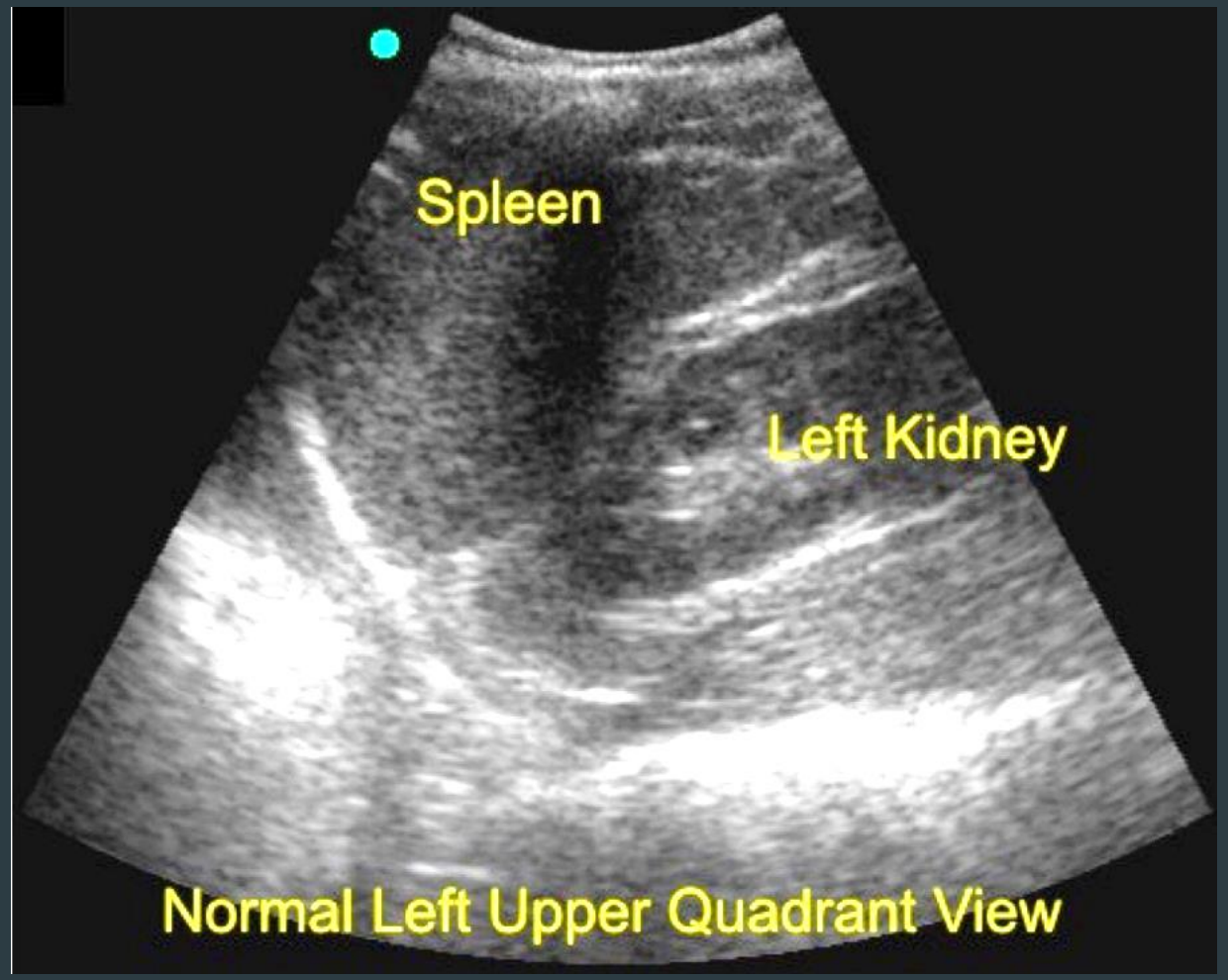


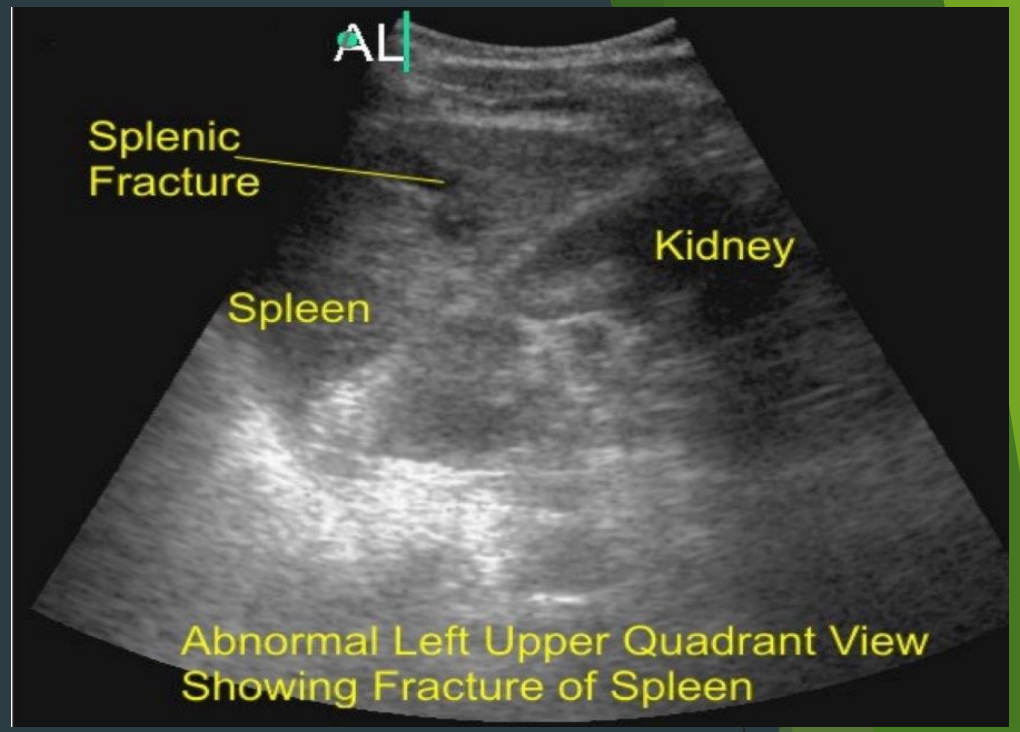


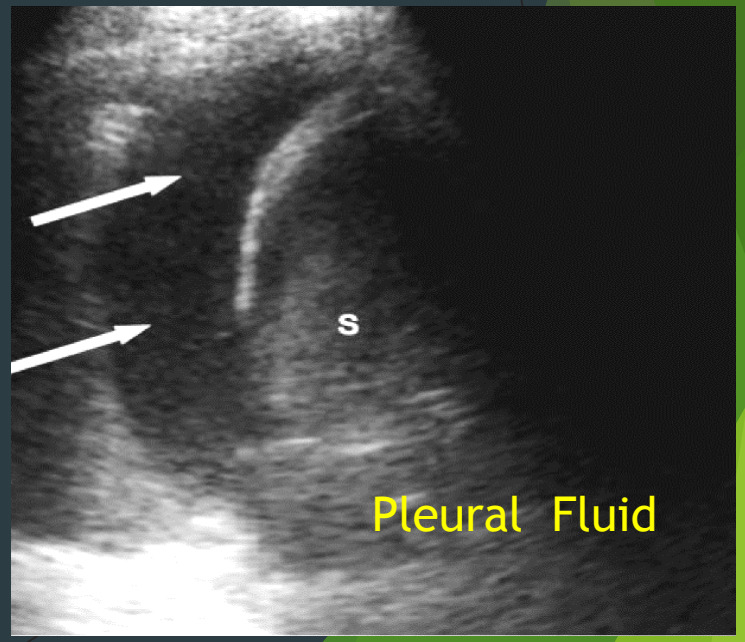


PERIHEPATIC PARTICULATE FLUID (CLOTTED BLOOD)

- Complex fluid collection with low level echoes and septations
- Most likely dx is hematoma in setting of trauma (D/D biloma ; abscess)
- Subcapsular location
- Infected hematoma or abscess if air present

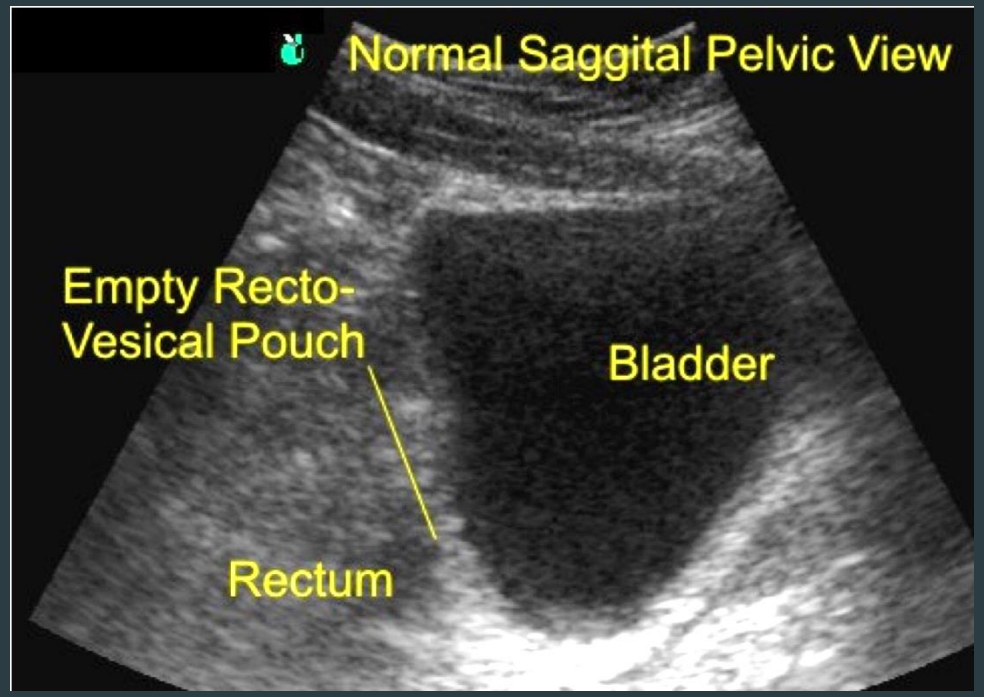


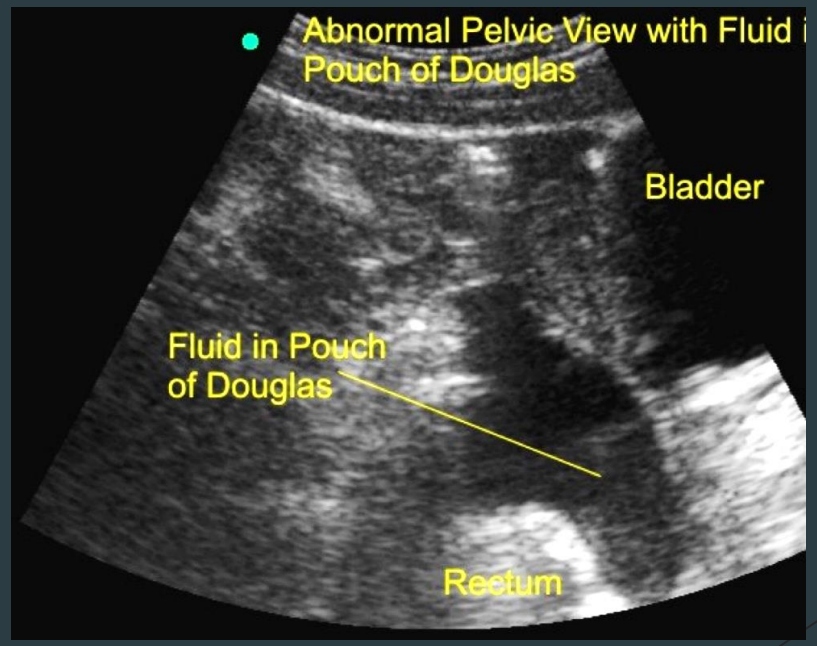


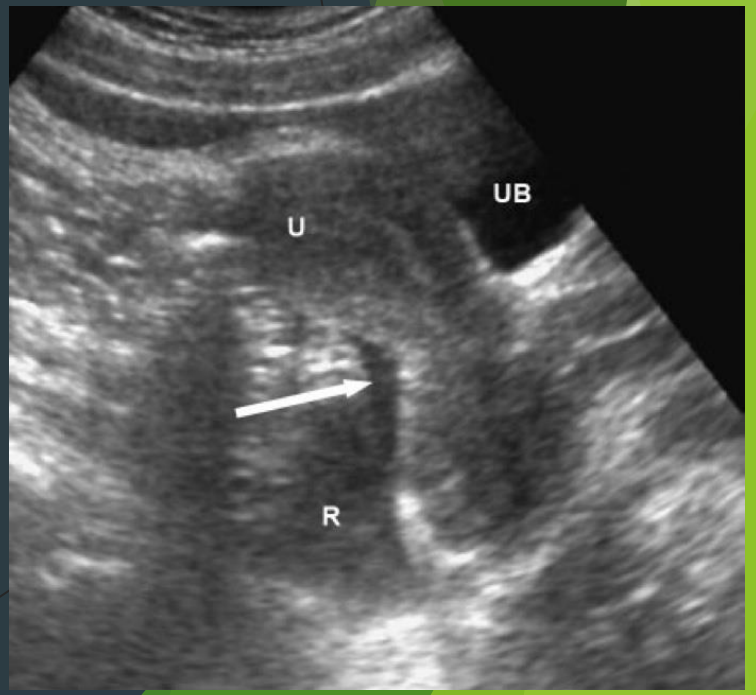


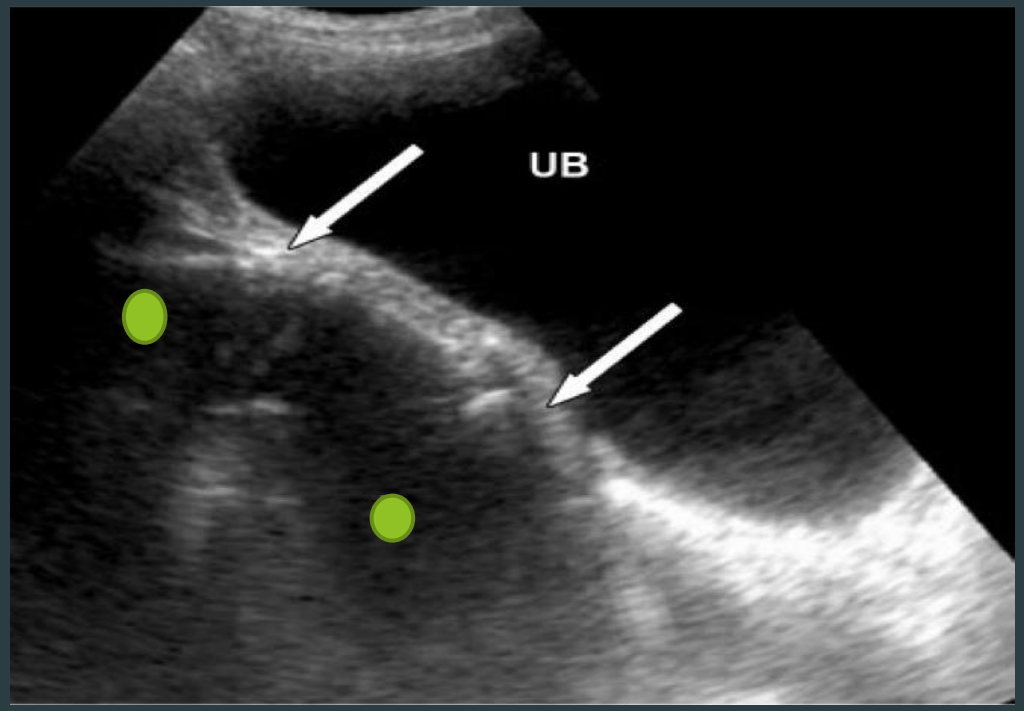
LUQ longitudinal view

PELVIS VIEWS
CUL DE SAC



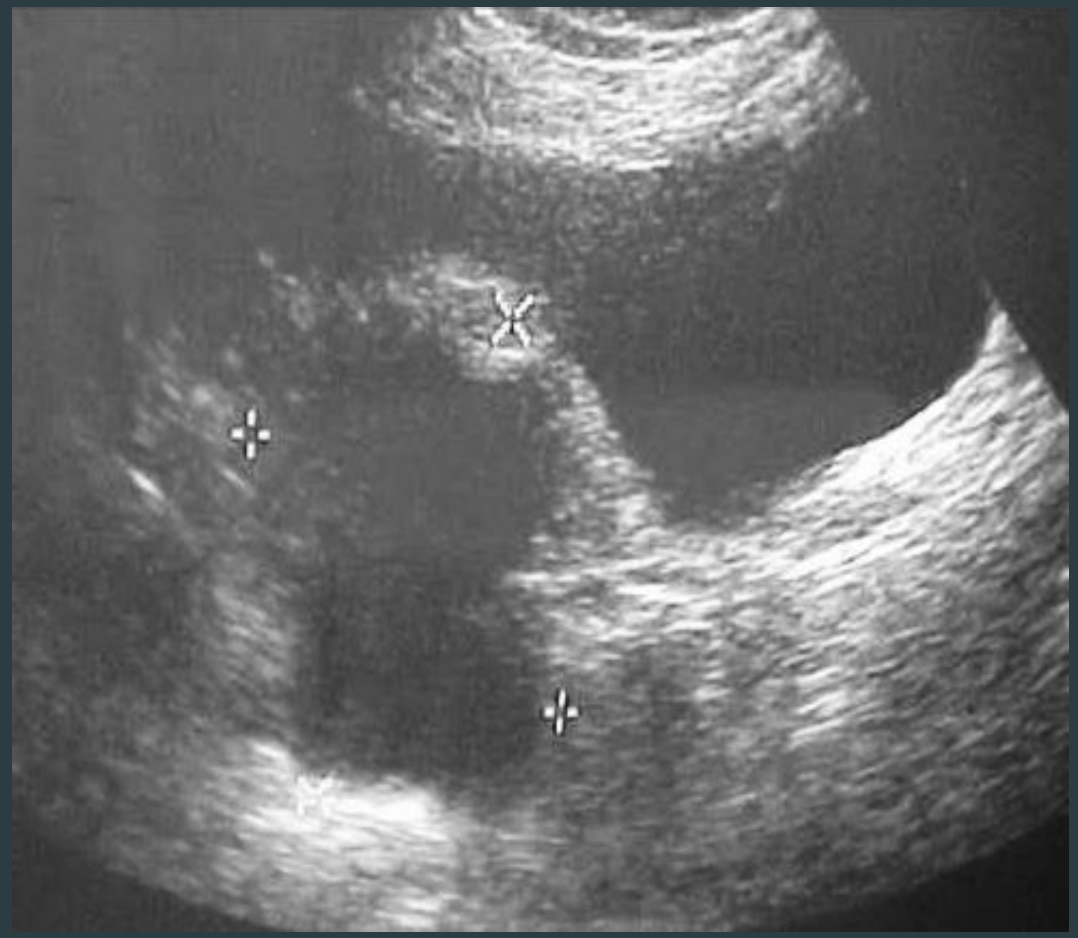






Do not confuse posterior sacral promontory and bone absorption, with free fluid

PELVIC “PSEUDOMASS” : REVERBERATION ARTIFACT MAY BE CONFUSED WITH FREE FLUID or CYST

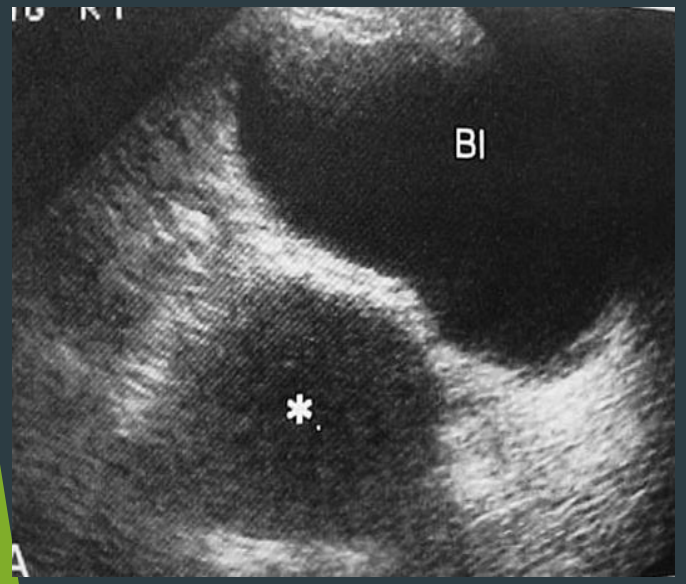


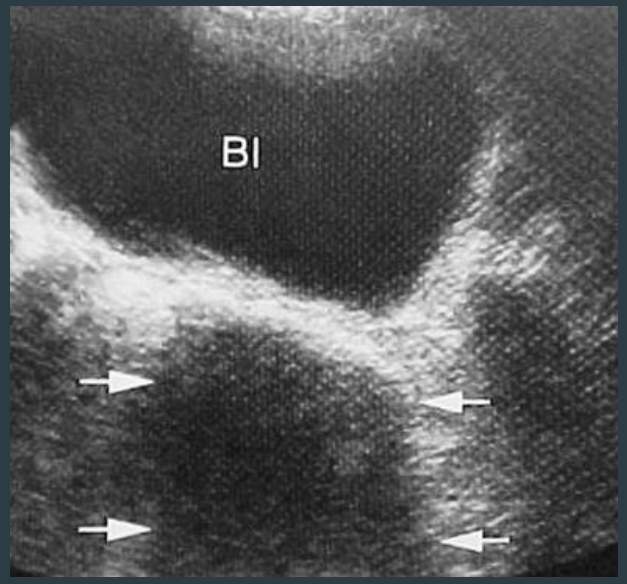
A) BOWEL GAS ARTIFACT : REVERBERATION ****

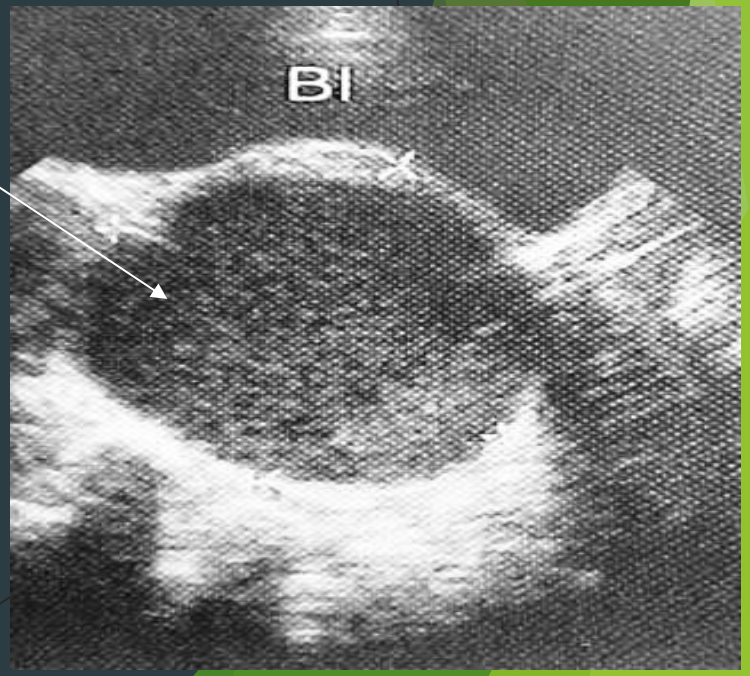
The strong reflection adjacent to the urinary bladder, and the “squared” appearance of the cul de sac hypoechoic region should make one suspicious of “pseudolesion” ; not a cyst , and not free fluid

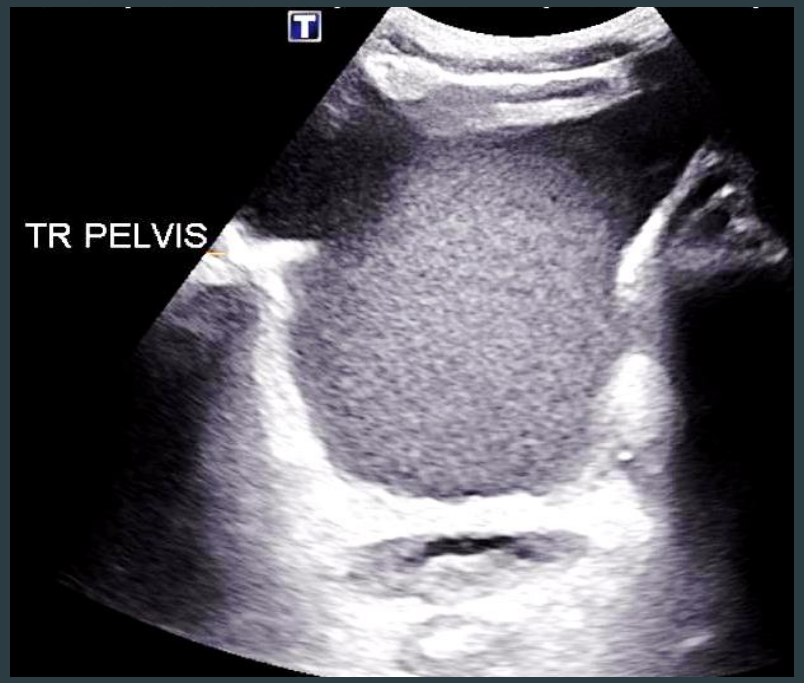
B) DO NOT CONFUSE PELVIC CYSTIC LESIONS WITH FREE FLUID

A true cyst has walls on every side









PARTICULATE

BLOODY

FREE FLUID

SOLID ORGAN INJURIES

Role of FAST in the diagnosis of injuries to solid organs is limited

- LIVER : Lacerations range from hypo to hyperechoic
  Extensive scanning to assess subtle changes would take too much time
  Sensitivity reported : 0.15 – 0.88

- SPLEEN : Lacerations have variable US appearance ; sensitivity 0.37-0.85

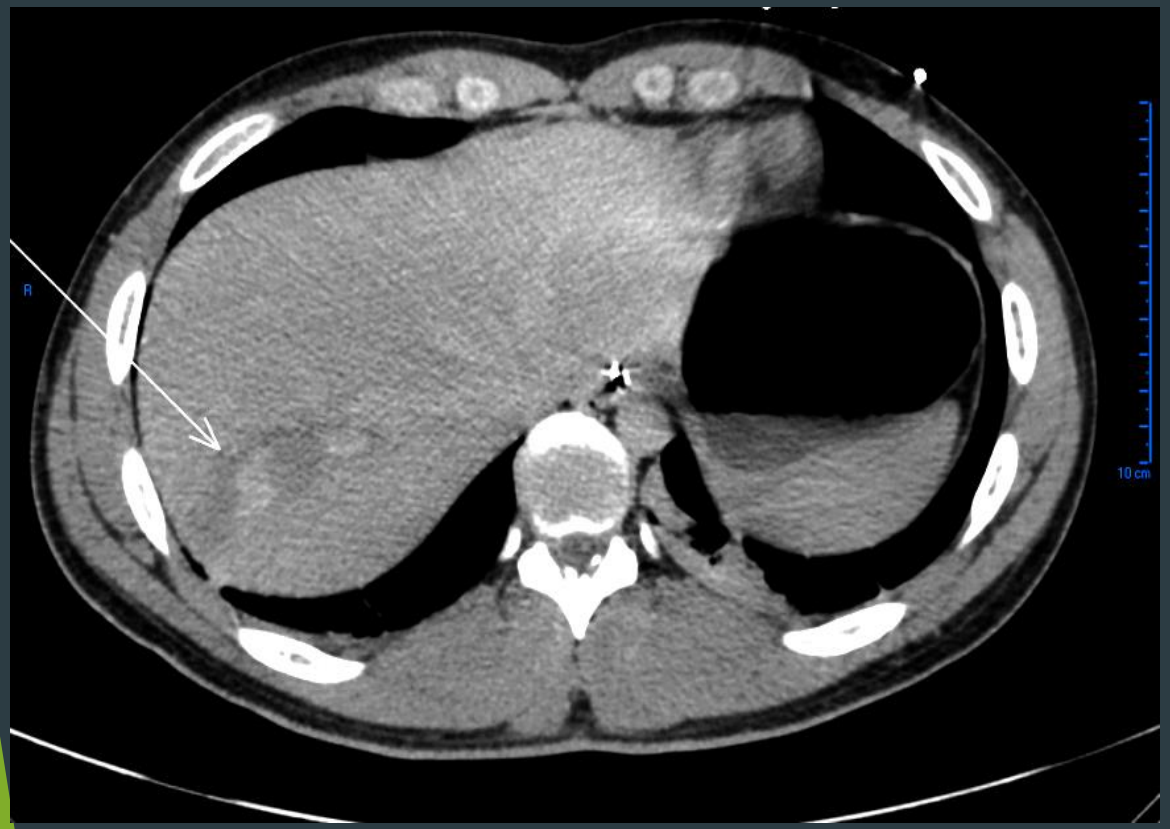
- KIDNEYS : Injuries not as common as in spleen and liver
  Cross sectional imaging needed to assess extent of injury, for treatment

SOLID ORGAN INJURIES

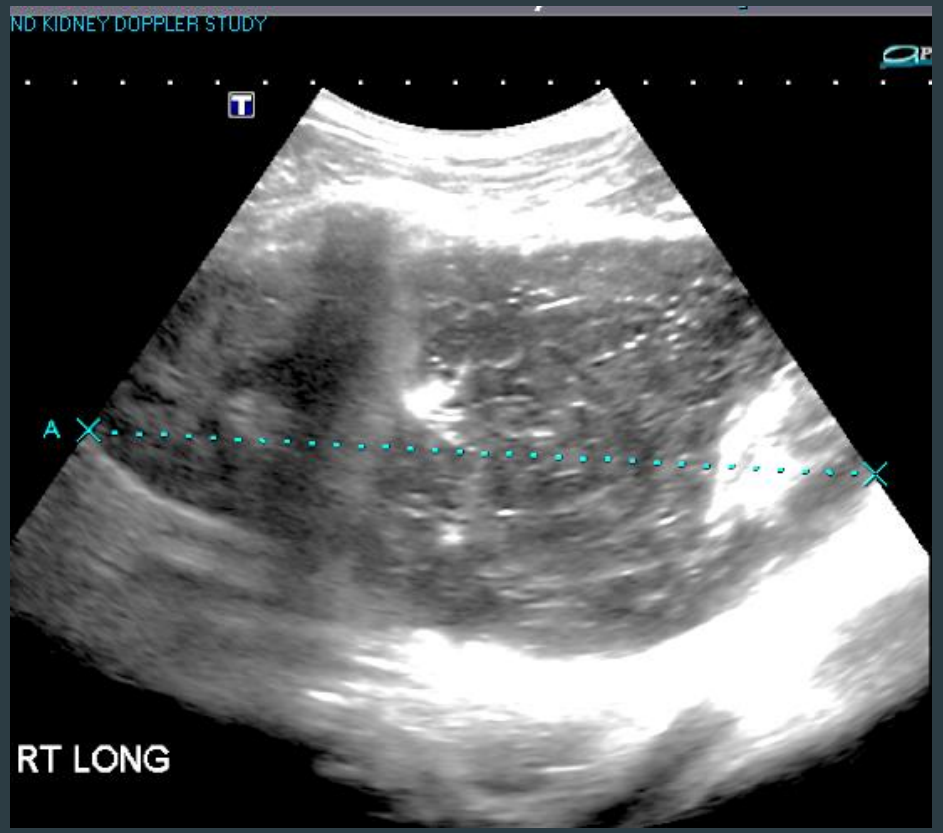
- PANCREAS : Injuries in less than 2% of abdominal trauma cases
  Subtle changes , best evaluated with CT

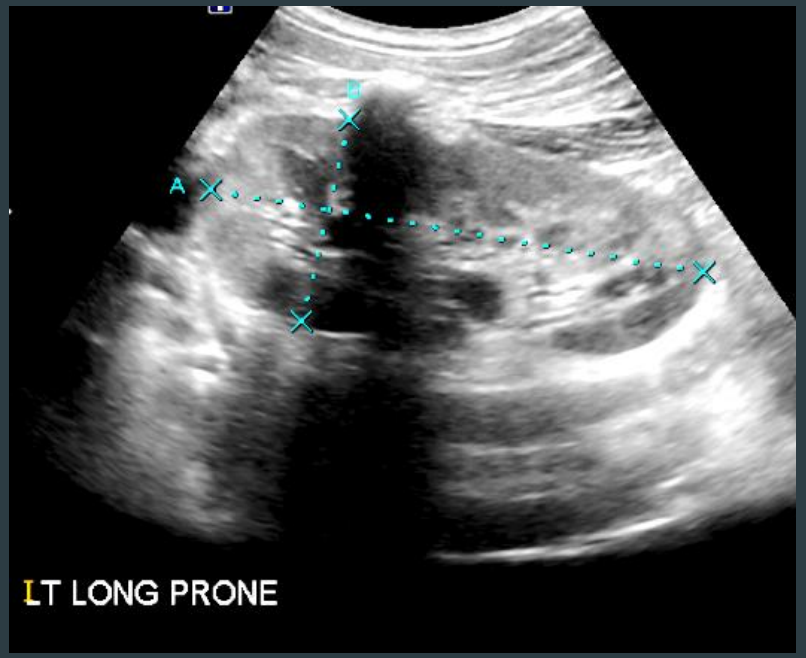
- BOWEL , MESENTERY, BLADDER : Difficult to detect with US

SOLID ORGAN INJURIES : LIVER seen best in CT exams



RENAL TRAUMA

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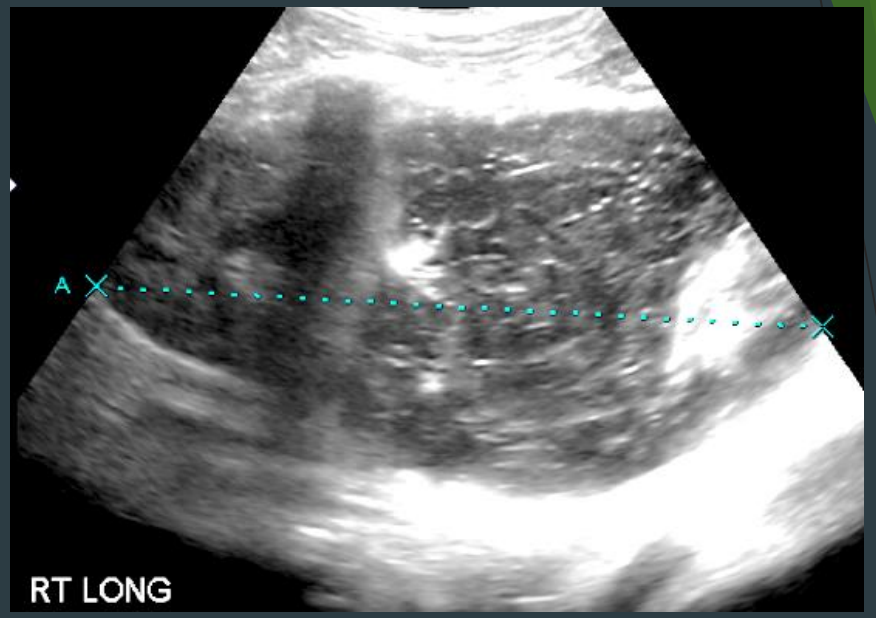
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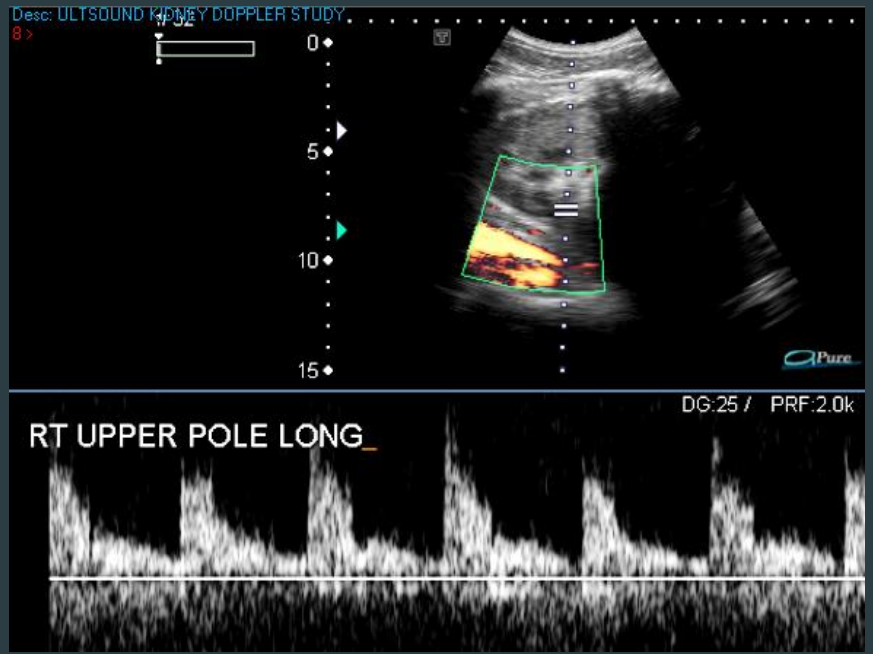
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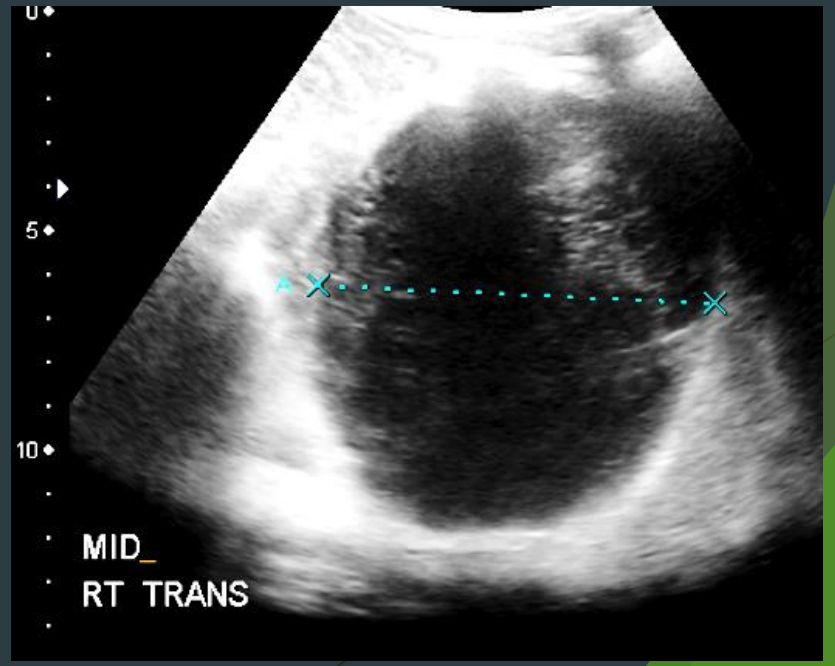
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RT TRANS

EXTENDED FAST : E- FAST PNEUMOTHORAX

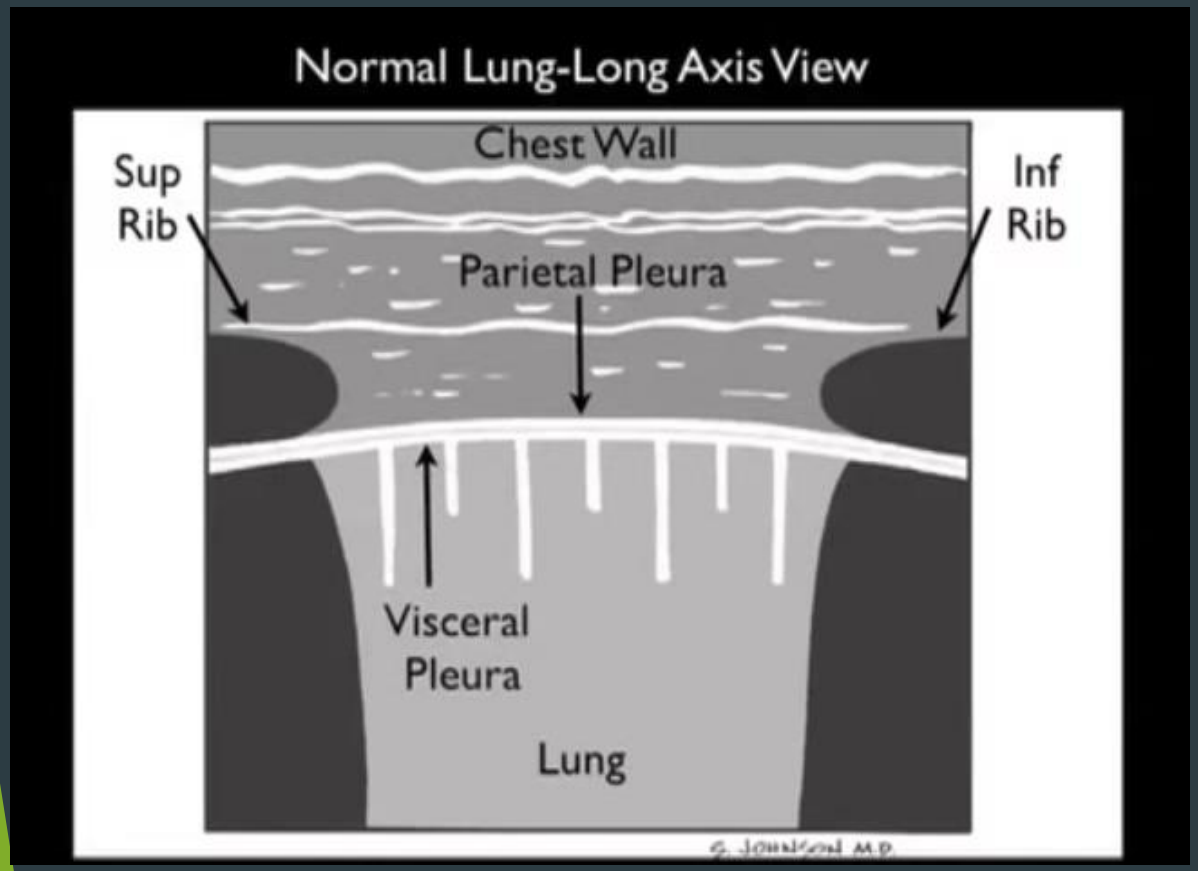
- CT exam remains the gold standard to detect anterior pneumothorax in trauma patients **

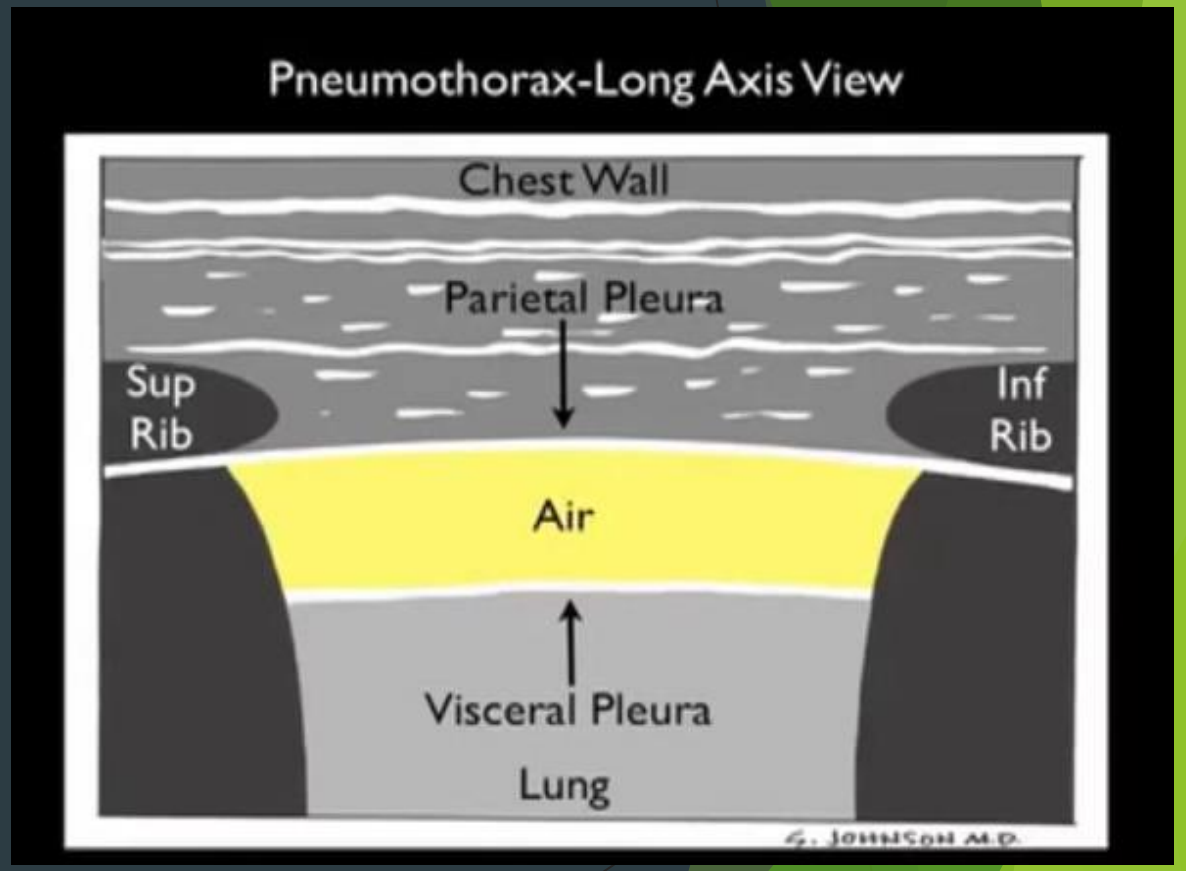
- Ultrasound has higher sensitivity than supine chest X – Rays **

(sensitivity 95 % ; specificity 91 % : has been reported in ICU cases)

- Probe placed at 2nd – 3rd intercostal space MC line , between two ribs

EXTENDED FAST : E- FAST PNEUMOTHORAX





EXTENDED FAST : E- FAST PNEUMOTHORAX

- Normal pleura (visceral and parietal) slide on each other in normal lung

  " LUNG SLIDING sign " : No Pneumothorax

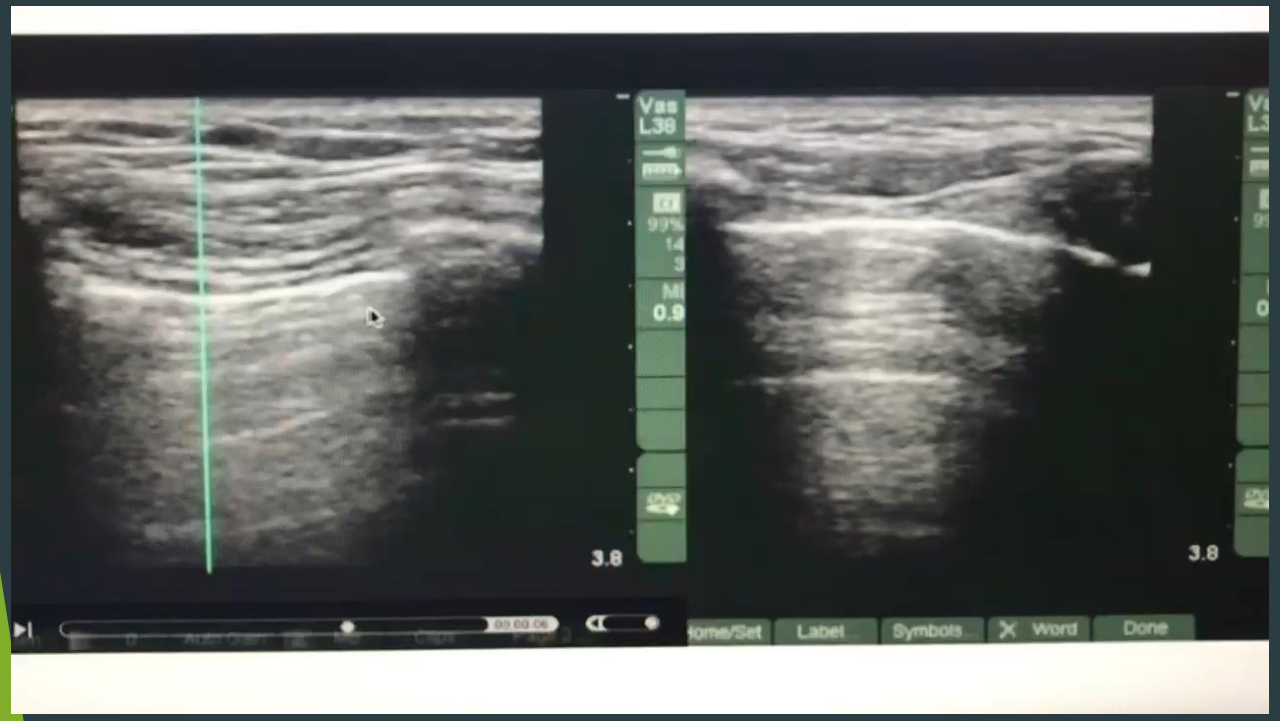
- M- mode at same site : anterior - motionless wall : horizontal waves

  posterior sliding : granular pattern : sand

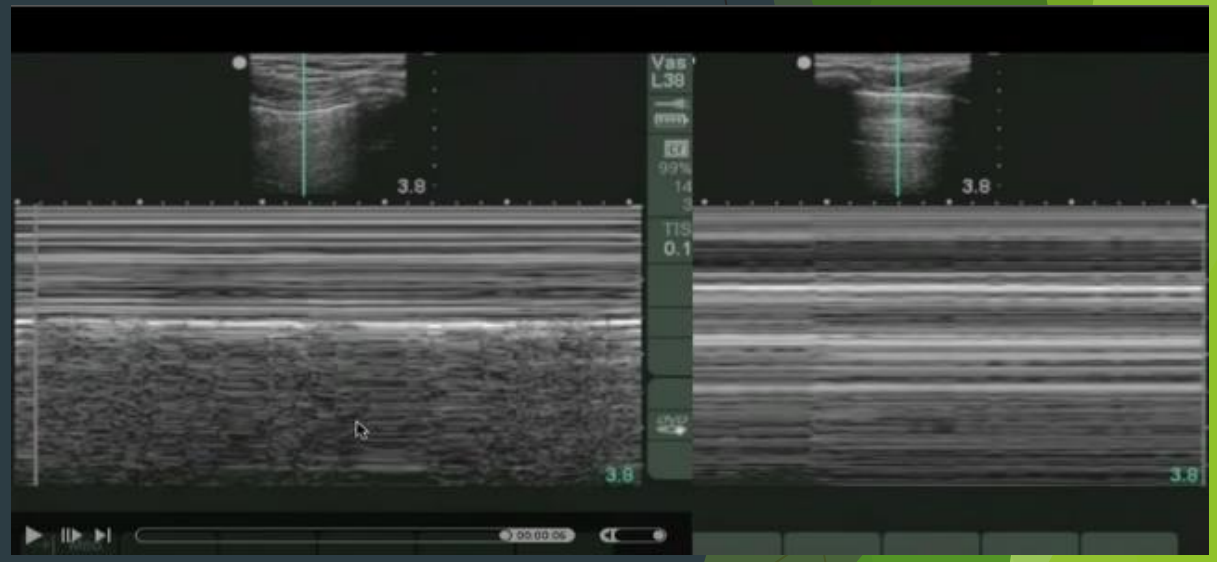
  " SEASHORE sign " : No Pneumothorax

EXTENDED FAST : E- FAST PNEUMOTHORAX

Normal Pneumothorax



Normal Pneumothorax



M - mode

LIMITATIONS OF FAST EXAM IN MAJOR TRAUMA

- Detection of free fluid in some injured children
- Detection of mesenteric, diaphragmatic , or hollow viscus injury
- Detection of retroperitoneal hemorrhage
- Technically limited due to patient's obesity ; bowel gas ; degree of injury ; rate of bleeding

LIMITATIONS OF FAST EXAM IN MAJOR TRAUMA

- Bright ambient light in Trauma suite, limits visibility of US monitor
- Patient movement ; either due to manual chest compressions also being done or combative patient
- Subcutaneous emphysema : air causes great US artifact
- Other diagnostic evaluations being done at same time ; small space

LIMITATIONS OF **FAST** EXAM IN MAJOR TRAUMA

- FALSE POSITIVE diagnosis of free - trauma fluid :
  - = ascites (chronic liver disease ; renal failure patients)
  - = ovarian cyst rupture
  - = inflammatory process of abdomen
  - = ventriculoperitoneal shunts
  - = peritoneal dialysis
  - = pre-existing pericardial effusion
  - = pre-existing pleural fluid

TRAINING

- Physicians / Sonologists from a variety of medical specialties may perform the FAST examination

  (Trauma Surgeons ; EMERG – MED physicians ; ER Radiologists)

- Supervised, properly trained sonographers can also obtain the ultrasound images

- Image interpretation should be performed by a supervising physician

Recommended FAST Educational Curriculum and Credentialing

- **Educational Phase (4 – 8 hours)**

  = didactic course : 1-2 hours ; principles of sonography ; indications, and how to perform and interpret FAST exams

  = hands on practical session : 3 - 4 hrs ; should include performance of FAST on models, either simulated or living; with or without intraperitoneal free fluid (peritoneal dialysis models) ; video sessions of positive and negative FAST exams

- **Proctored exams**

  = EM and Surgical series, usual proposal 20 -50 FAST exams
  (10 exams should not be enough)
  = Competency based certification : non numerical model

  ** Technical skill is crucial to obtain adequate images **

DOCUMENTATION

- As with all sonograms, focused sonograms require appropriate documentation
- Images should be stored as part of the medical record
- Description and interpretation of findings is required

SUMMARY : FAST

Radiographics : Emergency US in Major Trauma Korner et al

- Widely available, quick exam for “first look”
- Acceptable sensitivity for detection of free fluid (standard sites)
- Poor sensitivity for diagnosis of injury to solid organs
- Strongly dependent on the operator’s skill and experience
- If initially negative exam, can be repeated

RECOMMENDATIONS

Radiographics : Emergency US in Major Trauma Korner et al

- Don’t waste time ** (2 - 4 minute evaluation)

- Scan for free fluid and pericardial effusion first (Basic FAST)
- Look for pneumothorax, in patients at risk (E - FAST)

- If there is time, look for injuries to solid organs
  (although role of FAST for solid organ evaluation is limited **)

- Use FAST for overview, not for a definite diagnosis of site of injury
- Positive or equivocal FAST : → Stable patient : CT exam
  → Unstable patient : OR

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