Ultrasound in Internal Medicine

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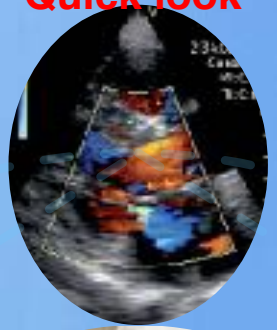
FADOI

PRESENTATION CONTENT

- Ultrasound Definition and Physics
- Short History of Ultrasound
- Basic features of US images
- Ultrasound Exam Performation
- Clinical Use of BEDSIDE Ultrasound

Potentially redefine physical exams…

Quick look



Palpation

consider another product'dual probe' with expanded indications

Auscultation

Percussion

…quick and immediate visualization.

Differences between ultrasound approaches

- **Traditional ultrasound**

•-Experts in ultrasound

•-Comprehensive exams (A-Z)

•-Multiple ultrasound views

•-Multiple imaging modes

•-Exam time approx. 20-30 mins

•-Advanced interpretation

• Ex-Hypertrophic cardiomyopathy

- **Point-of-care ultrasound**

•-Traditional/non-traditional users

•-Answer single clinical question

•-Single ultrasound view

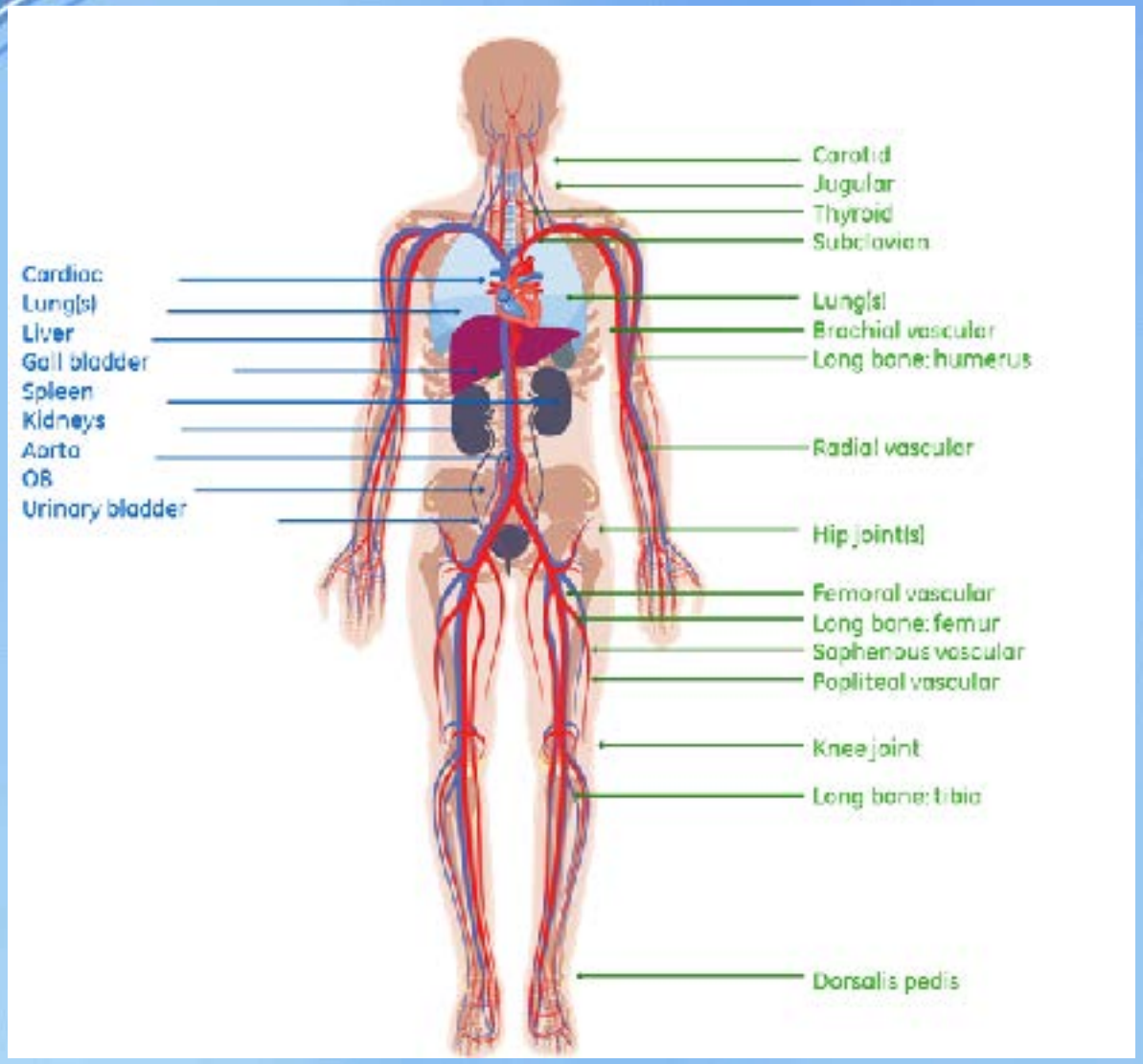
•-Single imaging mode

•-Exam time approx. 1-2 mins

•-Simple interpretation

•Ex- abnormal left ventricular function

Examples of point-of-care ultrasound



WHAT IS ULTRASOUND?
Basic Physics of Ultrasound

- **Ultrasound** is a medical imaging technique that uses **high frequency sound waves and their echoes**.

- The technique is similar to the echolocation used by bats, whales and dolphins, as well as **SONAR** used by submarines etc.

Why Ultrasound…?

- As an extension of clinical examination and of clinical skills
- It provides real time useful clinical answers
- It can be performed bedside
- It is a noninvasive technique
- Can be repeated to monitor the patient
- It is relatively cheap

In ultrasound, the following events happen

1. The ultrasound machine transmits **high-frequency** (1 to 12 megahertz) sound pulses into the body using a probe.

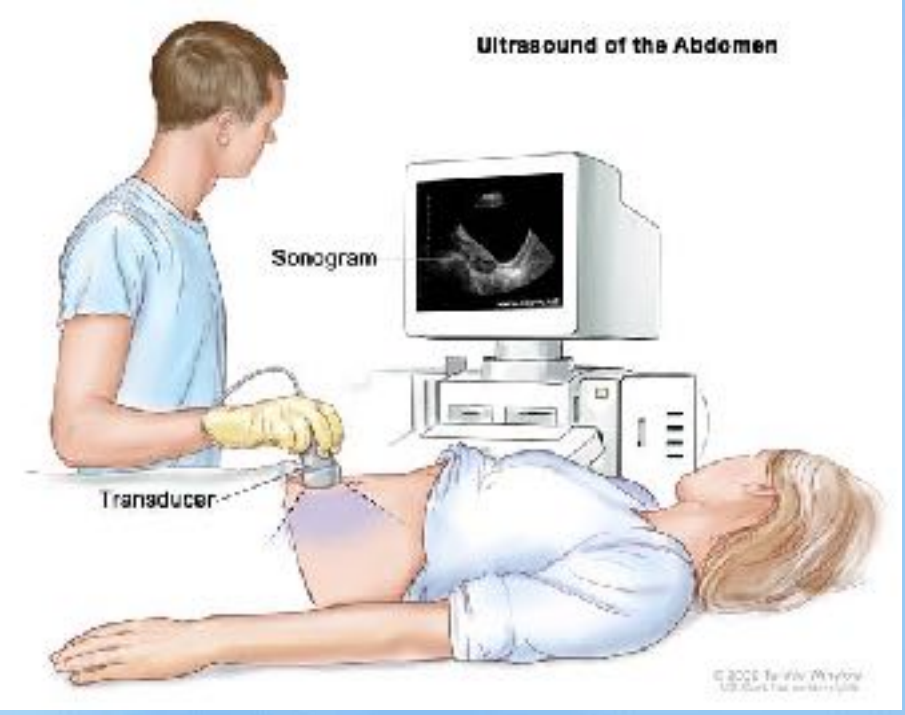
2. The sound waves travel into the body and hit a boundary between tissues (e.g. between fluid and soft tissue, soft tissue and bone).

3. Some of the sound waves reflect back to the probe, while some travel on further until they reach another boundary and then reflect back to the probe .

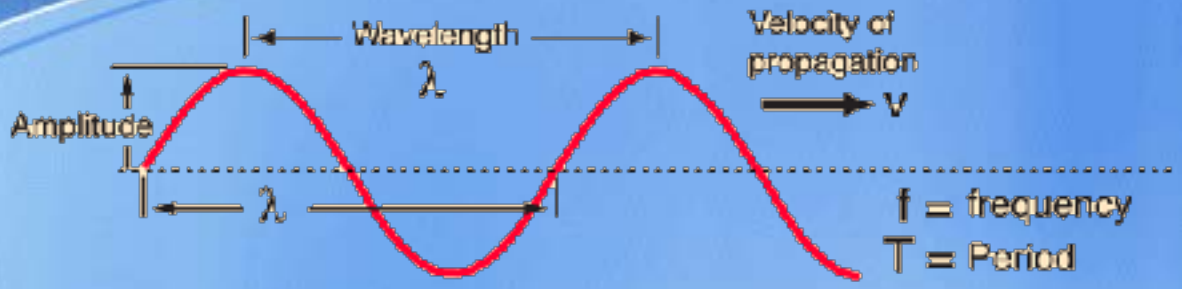
4. The reflected waves are detected by the probe and relayed to the machine.

5. The machine calculates the distance from the probe to the tissue or organ (boundaries) using the speed of sound in tissue (1540 m/s) and the time of each echo's return (usually on the order of millionths of a second).

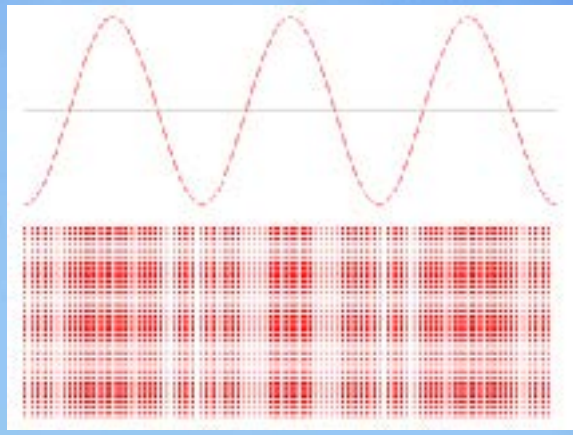
6. The machine displays the distances and intensities of the echoes on the screen, forming a two dimensional image.

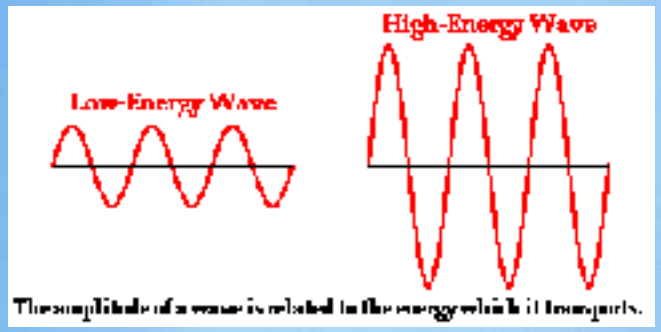


SOUND

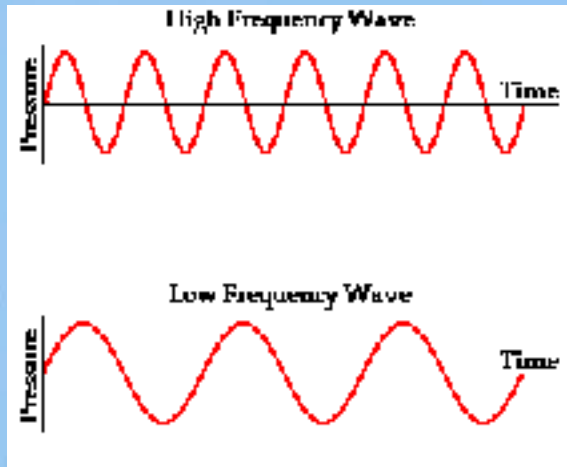


- Sound waves consist of mechanical vibrations containing condensations (compressions) & rarefactions (decompressions)that are transmitted through a medium.
- Sound is mechanical energy.
- Sound is not electromagnetic.
- Matter must be present for sound to travel



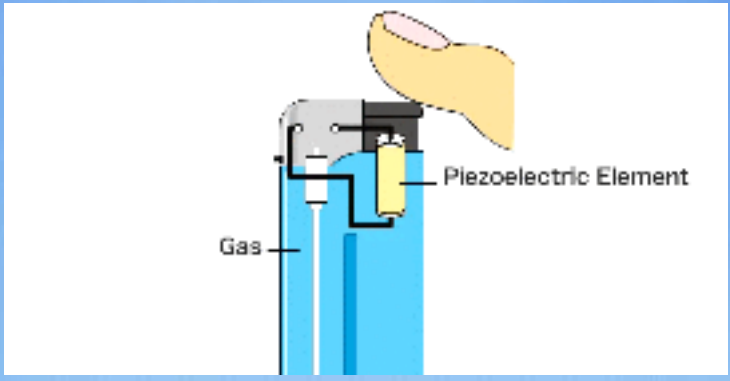


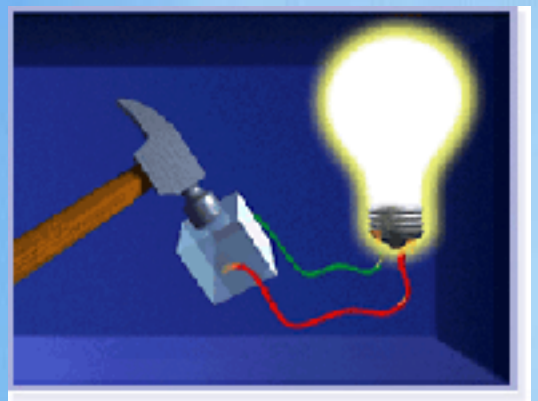
Compression Wave

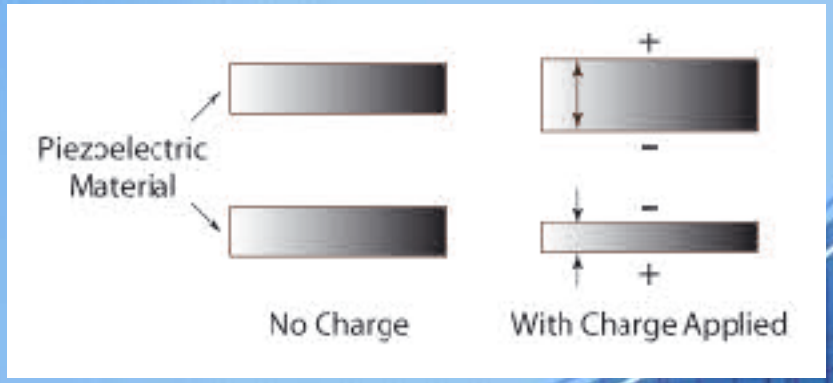


Piezoelectric effect

- To produce an ultrasound, a **piezoelectric crystal** has an alternating current applied across it. The piezoelectric crystal grows and shrinks depending on the voltage run through it. Running an alternating current through it causes it to vibrate at a high speed and to produce an ultrasound.



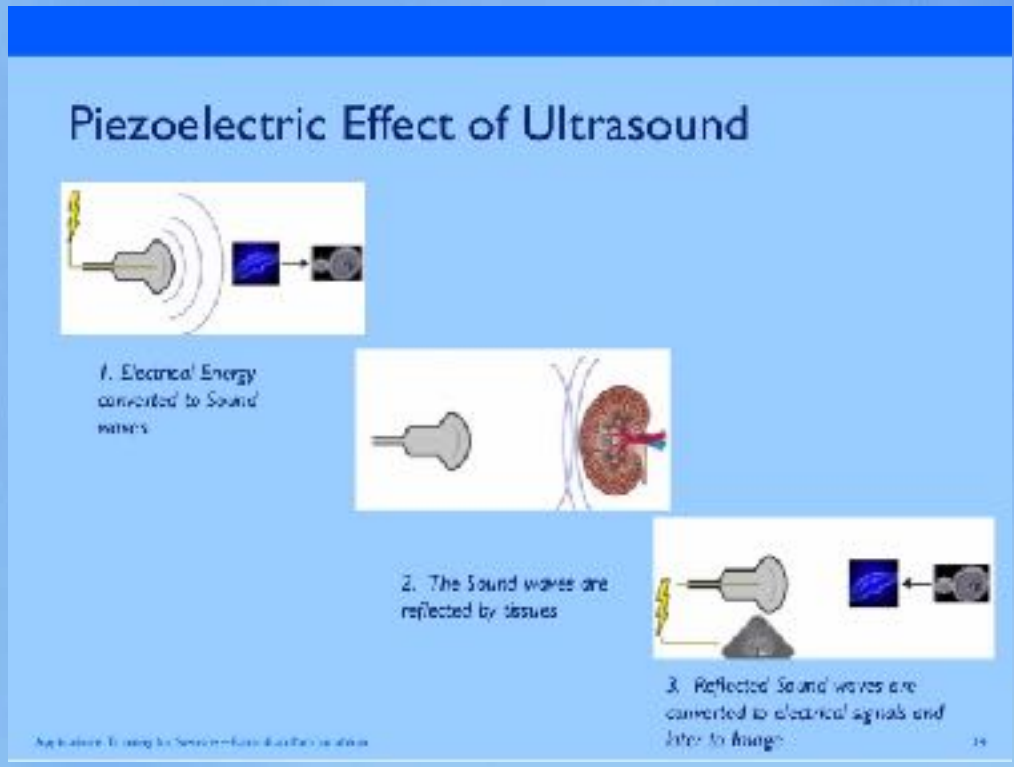




- This conversion of electrical energy to mechanical energy is known as the piezoelectric effect. The sound then bounces back off the object under investigation.

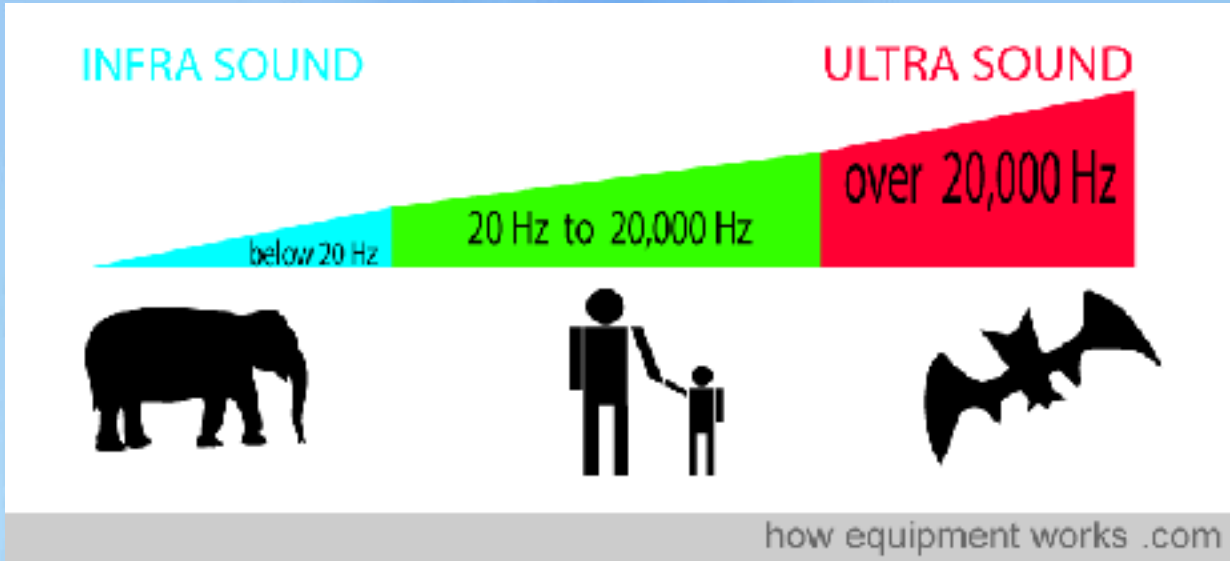
- The sound hits the **piezoelectric crystal** and then has the reverse effect - causing the mechanical energy produced from the sound vibrating the crystal to be converted into electrical energy.

- By measuring the time between when the sound was sent and received, the amplitude of the sound and the pitch of the sound, a computer can produce images, calculate depths and calculate speeds.



Categories of Sounds

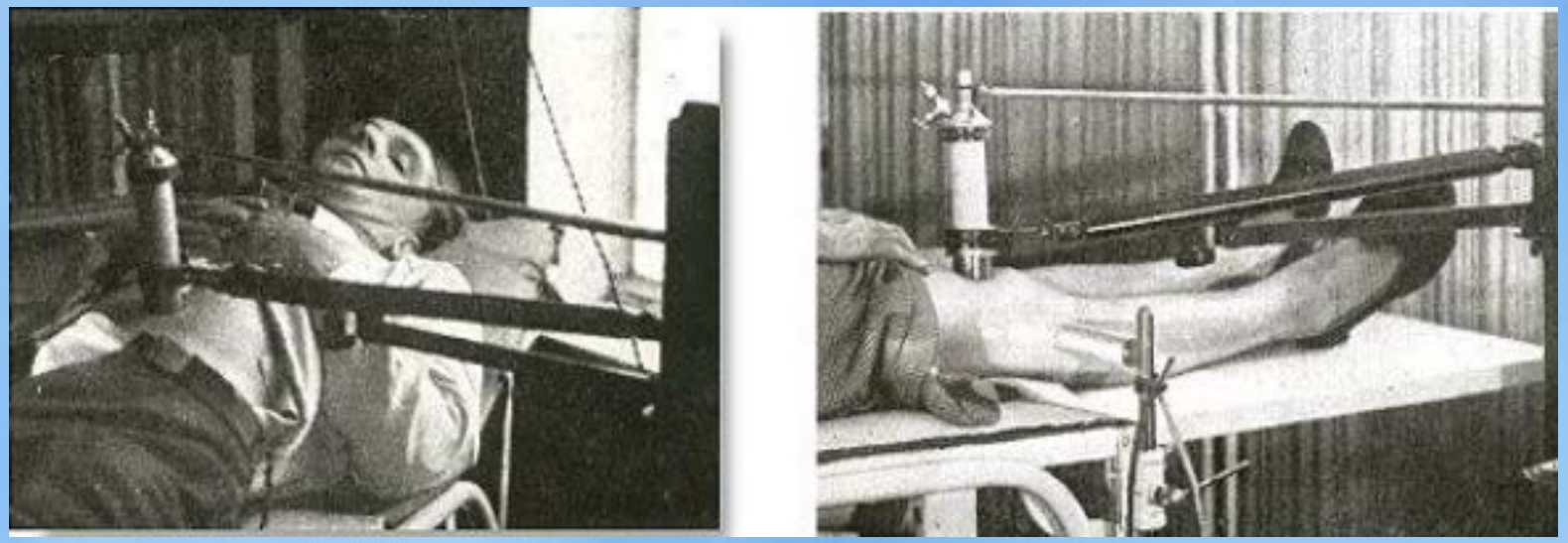
- Infrasound (subsonic) below 20Hz
- Audible sound 20-20,000Hz
- **Ultrasound above 20,000Hz**
- Nondiagnostic medical applications <1MHz
- **Medical diagnostic ultrasound >1MHz**



ULTRASOUND PULSES MAKING THE IMAGE

- Echoes occur when pulses of U/S hit reflectors
- A stream of echoes from each pulse return to transducer
- Deeper echoes from deeper tissues arrive later
- Stronger echoes arrive from stronger reflectors

All the energy comes from the transducer
All we "see" are reflections and scatter.

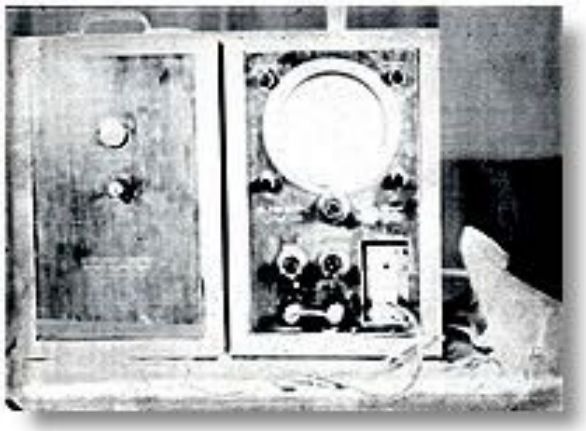


Treatment of gastric ulcers (left) and arthritis (right) in the 1940s.

DIAGNOSTIC ULTRASOUND

- Ultrasound diagnostics started to develop in early 40‘ of 20th century. It allows to obtain cross-sectional images of the human body which can also include substantial information about its physiology and pathology.
- Ultrasound diagnostics is based mainly on reflection of ultrasound waves at acoustical interfaces

History of Ultrasound

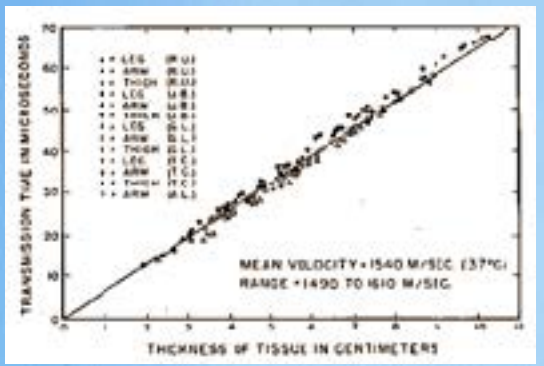


Ludwig's A-mode apparatus in his gallstone experiments

- George Ludwig, 1940s, **Naval Medical Research Institute** in Bethseda, Maryland.
- Classified experiments with the Navy
- Gall stones

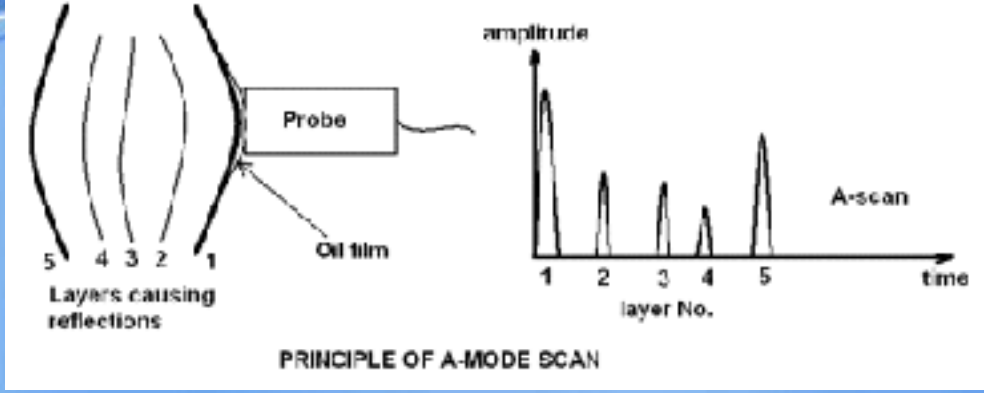
In a 1949 paper, he wrote:

"The possibility of detecting neoplasms by use of ultrasound has been considered. As with foreign bodies, the detection of a tumor would depend upon the impedance mismatch between it and the surrounding normal tissue. Tumors vary in composition and physical properties. It is reasonable to assume that in most cases, the density, elasticity, and velocity of sound would differ but slightly from that of normal tissue…



A-mode

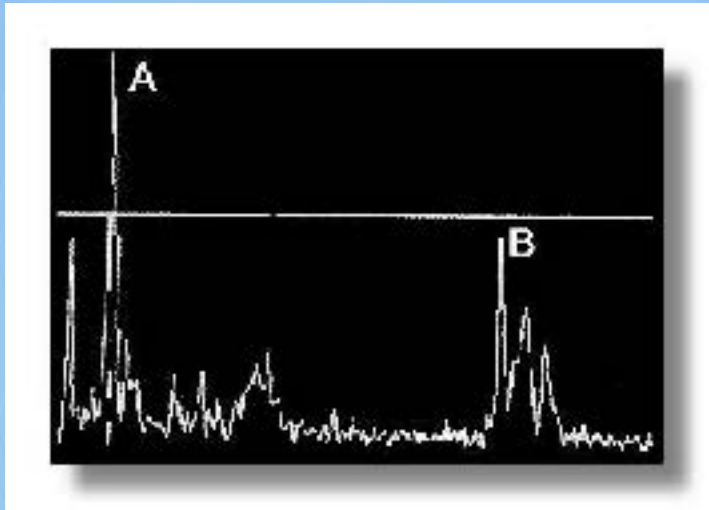
- A-mode ultrasound
- A = amplitude



PRINCIPLE OF A-MODE SCAN

Echo amplitude is proportional to the *intensity of reflected waves* (Amplitude modulation)

Distance between echoes shown on the screen is approx. proportional to real distance between tissue interfaces.



B-mode

- •B-mode ultrasound
  •B = brightness
  •Intensity of echoes in grey scale

- Brightness of points on the screen represents intensity of reflected US waves (Brightness modulation).

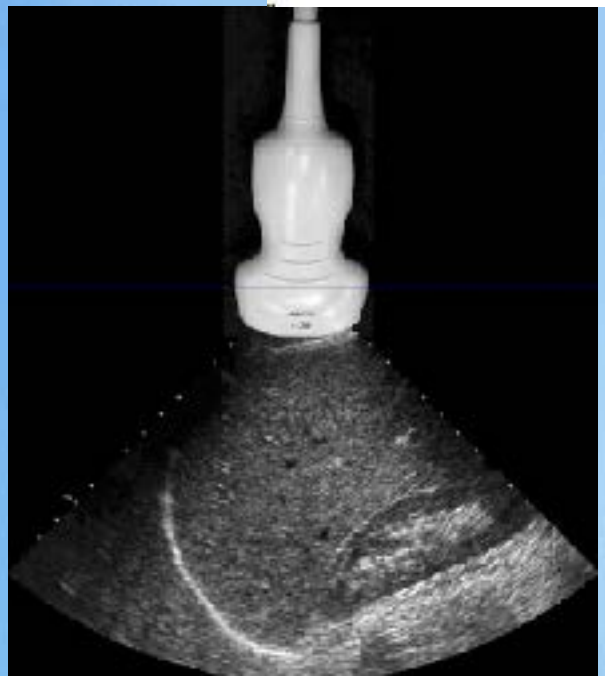
Transducers

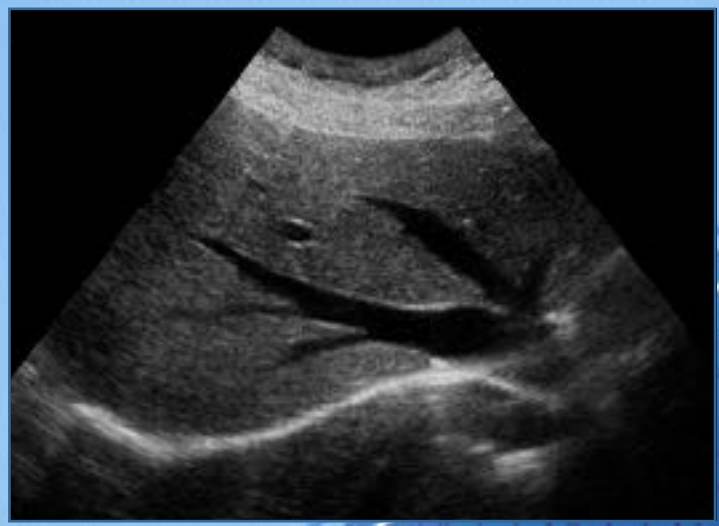
3.5MHz
convex probe
Application:
Abdomen, GYN, OB

7.5MHz
linear probe
Application:
Vascular, Small Parts

6.5MHz
micro-convex probe
Application:
Pediatric, Cardiac

6.5MHz
trans-vaginal probe
Application:
Vaginal

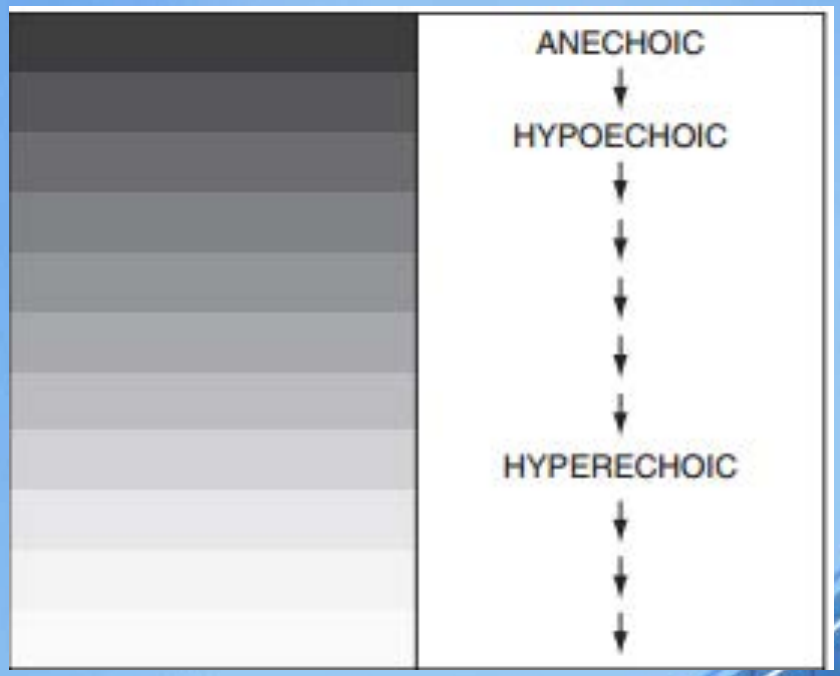




Basic characteristics of US images

Degree of reflectivity – echogenity. The images of cystic (liquid-filled) and solid structures are different. According to the intensity of reflection in the tissue bulk we can distinguish structures:

- **isoechogenic**
- **hyperechogenic**
- **Hypoechogenic**
- **anechogenic.**



Degree of reflectivity – echogenity.

- **Echogenic:** the ability of a structure to produce echoes
- **Anechoic**: no echoes : appears black on ultrasound
- **Hypoechoic:** less reflective and low amount of echoes when compared with neighboring structures, appears as varying shades of darker gray
- **Hyperechoic:** highly reflective and echo rich: when compared with neighboring structures appears as varying shades of lighter gray
- **Isoechoic**: having similar echogenicity to a neighboring structure

ANECHOIC

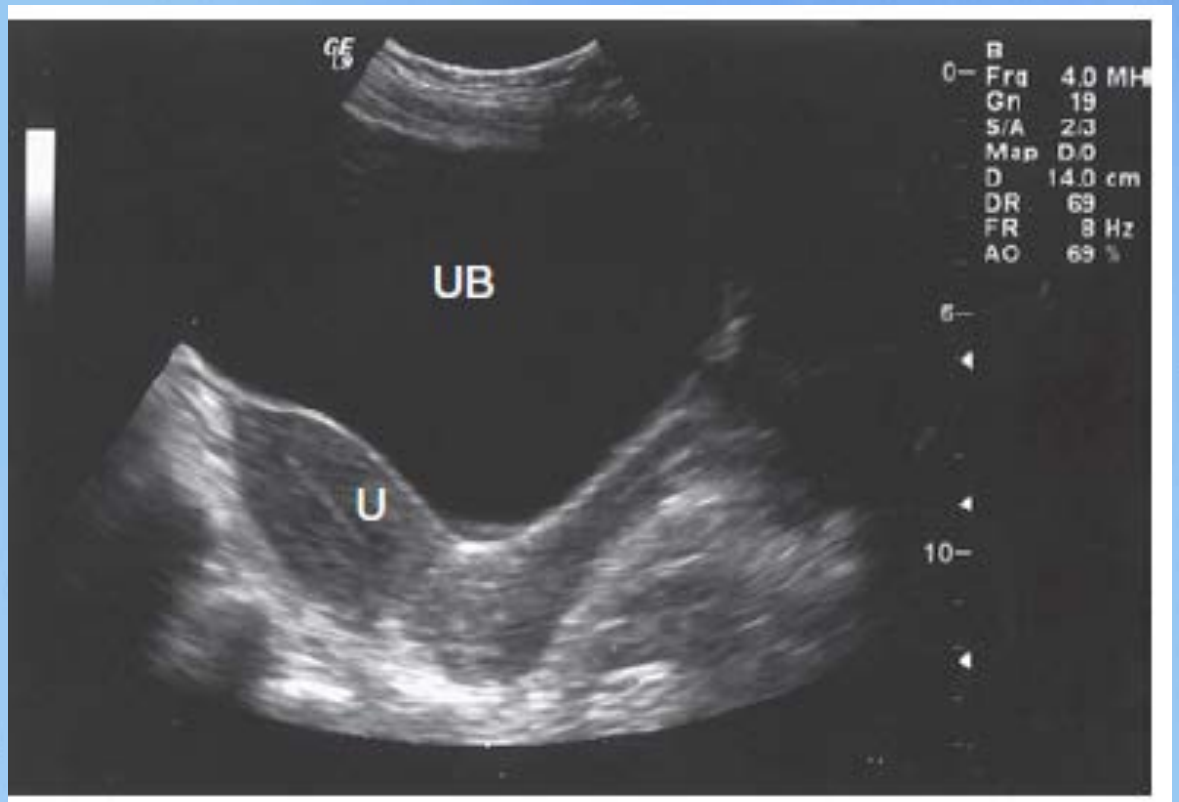


Figure 1-1 Anechoic. A transabdominal sagittal image of the female pelvis demonstrating the anechoic distended urinary bladder (UB) anterior to the uterus (U). Note the lack of echoes within the urinary bladder since it is filled with urine.

HYPOECHOIC

Figure 1-2 Hypoechoic. A transabdominal transverse image of the liver (L) demonstrating a hypoechoic (H) mass within the right lobe of the liver. Also, note the anechoic fluid (arrows) representing a right-sided pleural effusion.

HYPERECHOIC AND ISOECHOIC

Figure 1-3 Hyperechoic and isoechoic. A transabdominal sagittal image of the right upper quadrant. The liver (L) contains two areas (arrows) that are hyperechoic when compared with the rest of the moderate echogenicity of the liver parenchyma. The kidney (K) is isoechoic to the liver.

ULTRASOUND TEXTURE

- Homogeneous: organ parenchyma is UNIFORM in echogenicity
- Inhomogeneous or heterogeneous: organ parenchyma is not uniform in echogenicity

Ultrasound Artifacts:

Artifacts may be caused by the following:

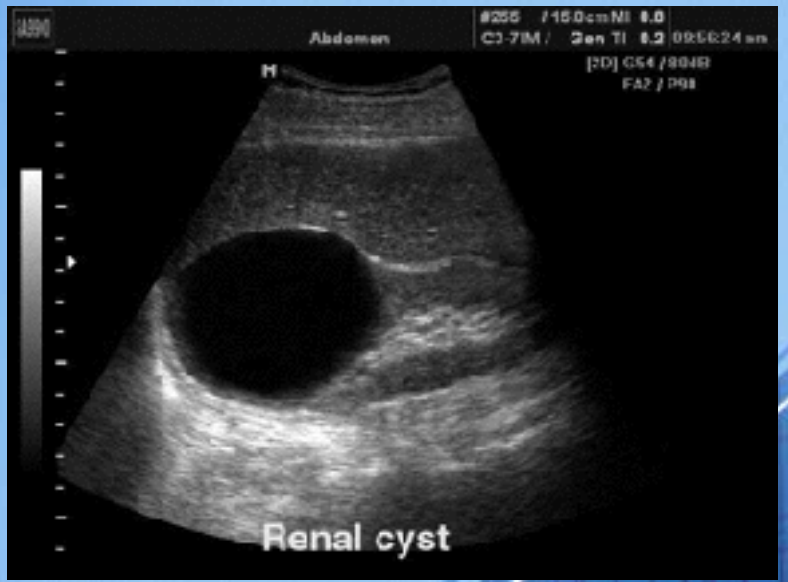
- US waves interacting with tissue
- Machine malfunction
- Improper machine settings
- Motion of the patients

Common Artifacts, examples…

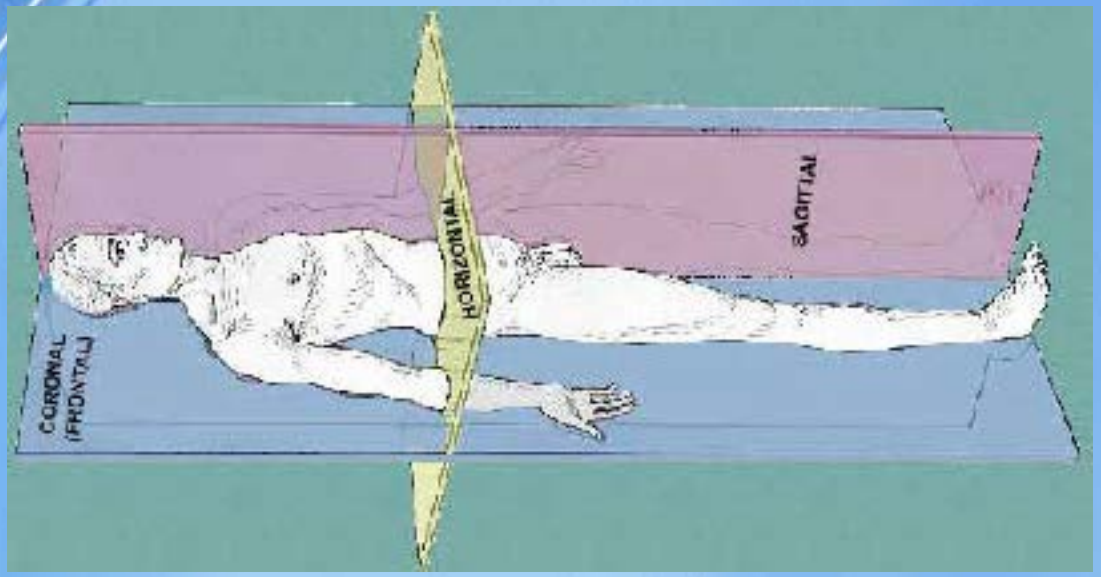
- Acoustic shadow caused by absorption and reflection of US by a kidney stone

THIS CAN BE USEFUL!!!

Hyperechogenic area below a cyst (low attenuation of US during passage through the cyst compared with the surrounding tissues)



PROBE ORIENTATION



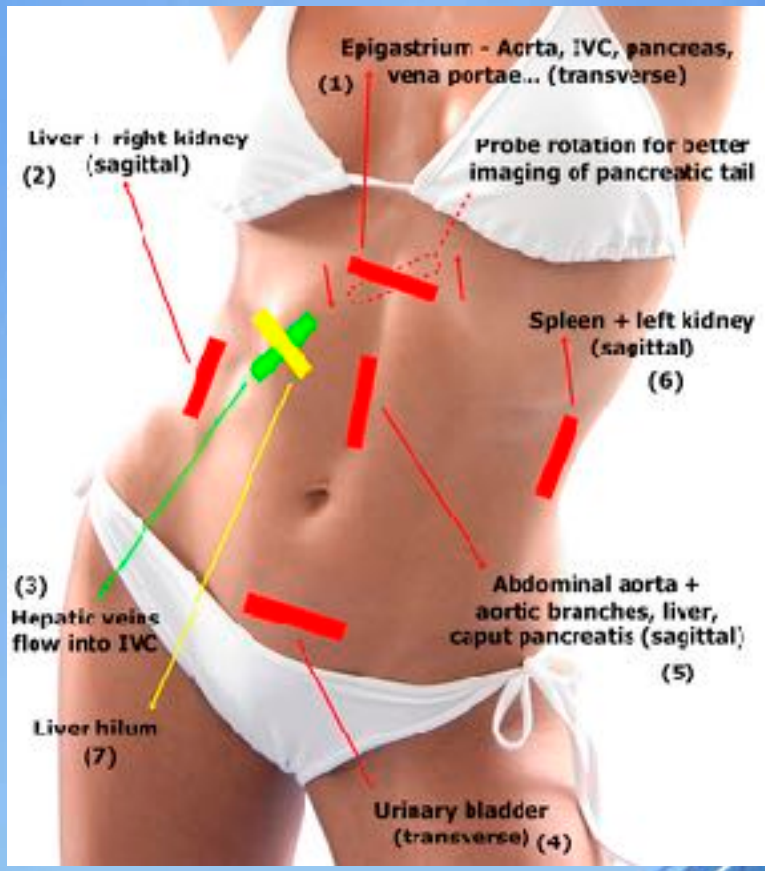
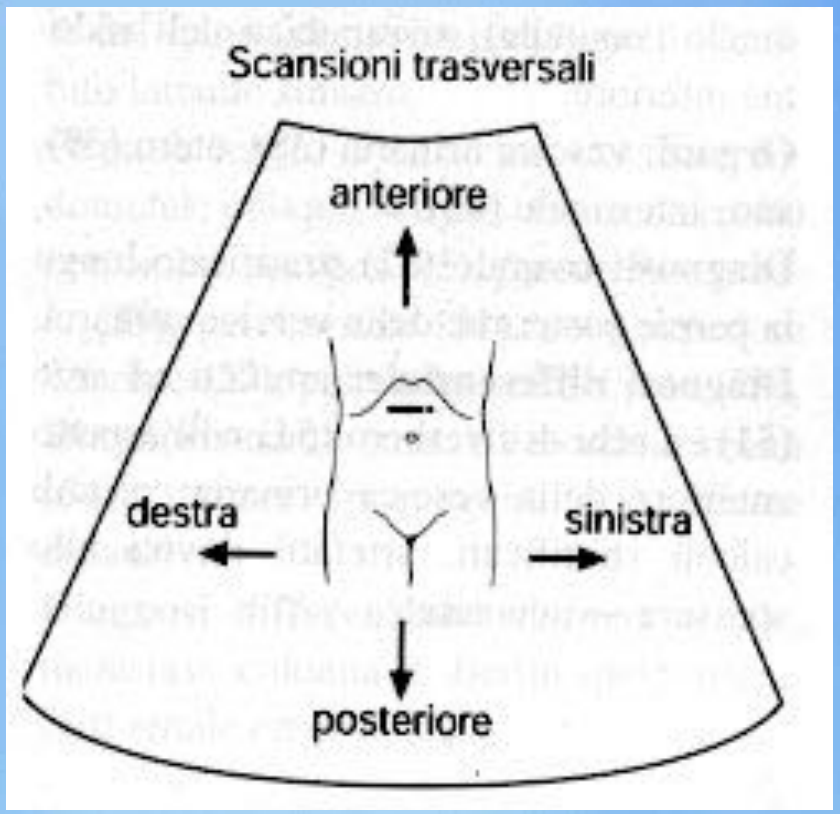


IMAGE ORIENTATION
CONVEX TRANSDUCER 3,5-5 MHz
TRANSVERSAL SECTION



TRANSVERSAL SECTION

VENTRAL

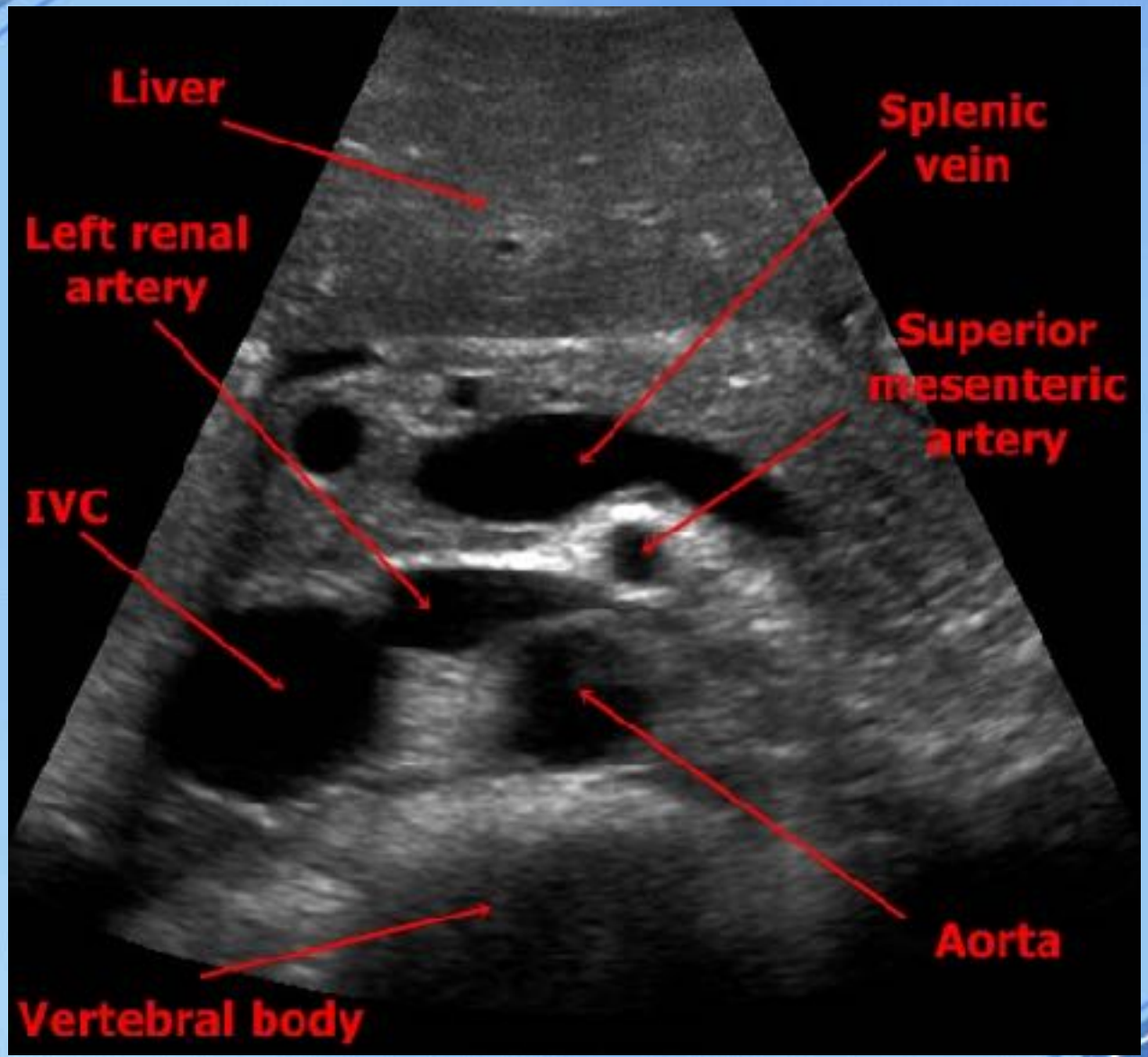
RIGHT

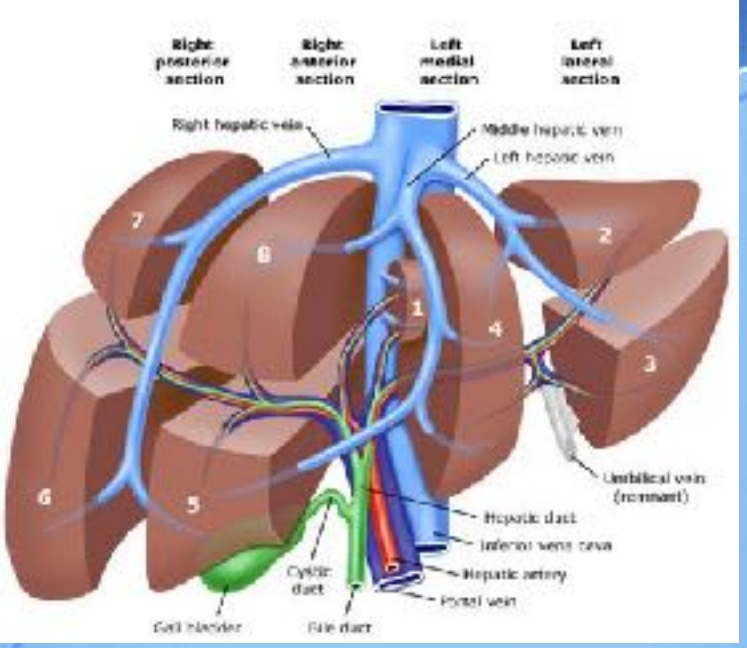
LEFT

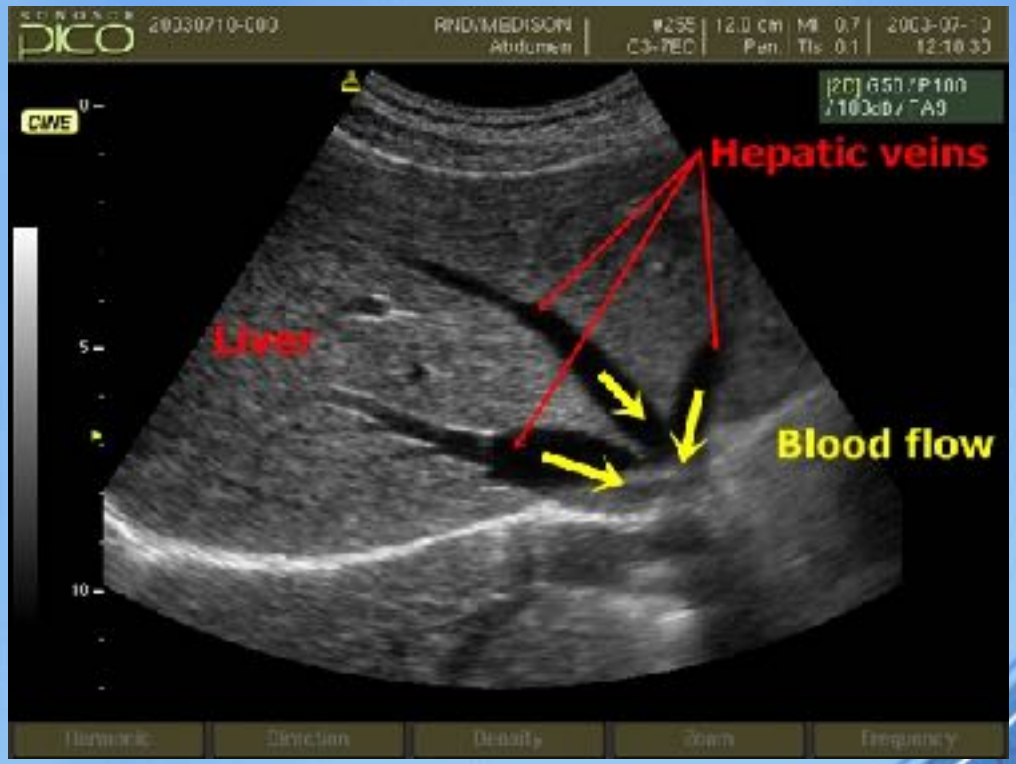
Like CT SCAN VIEW!!!
THINK TO LOOK PATIENT FROM HIS FEET…

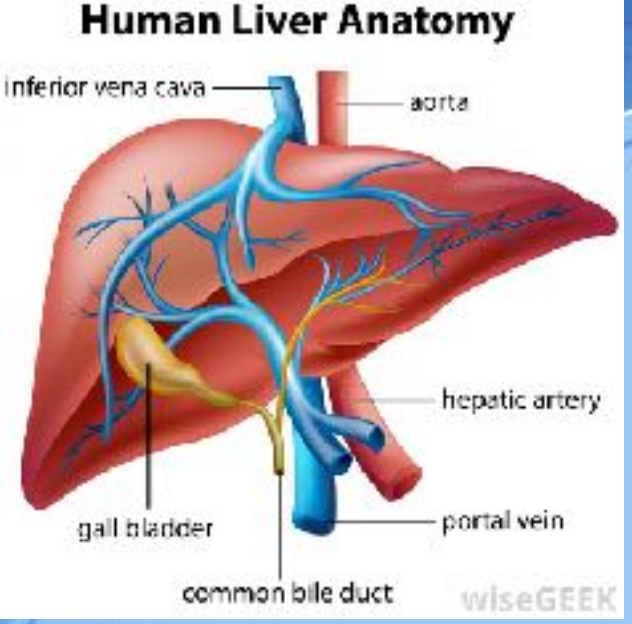
DORSAL

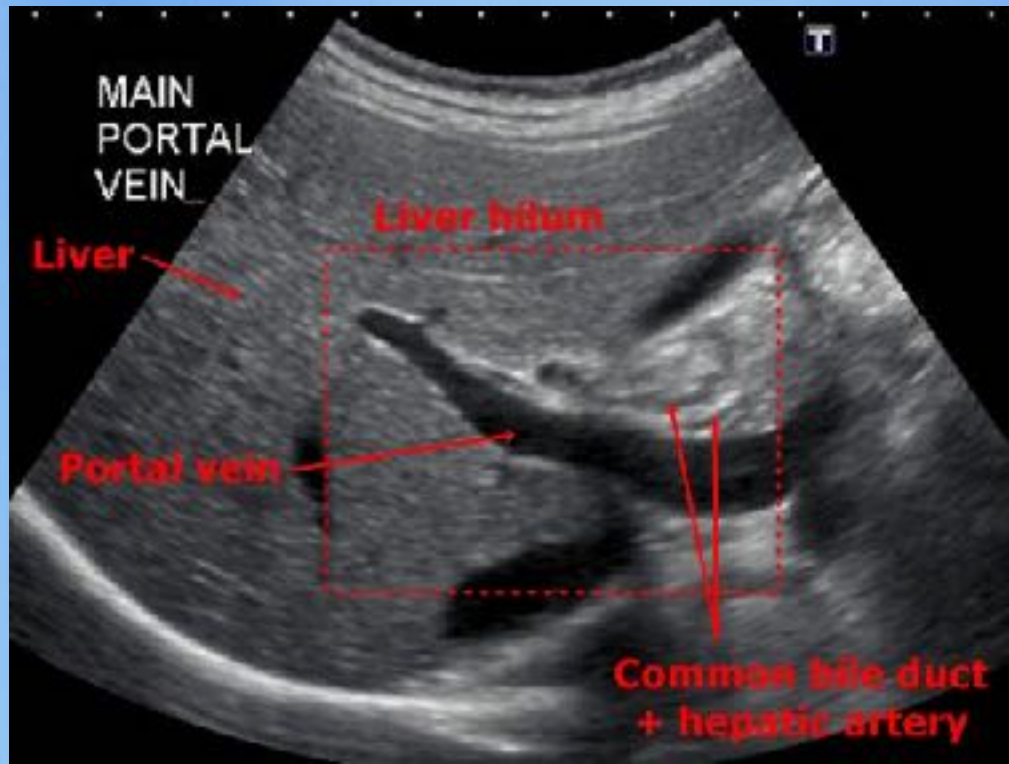
Transverse

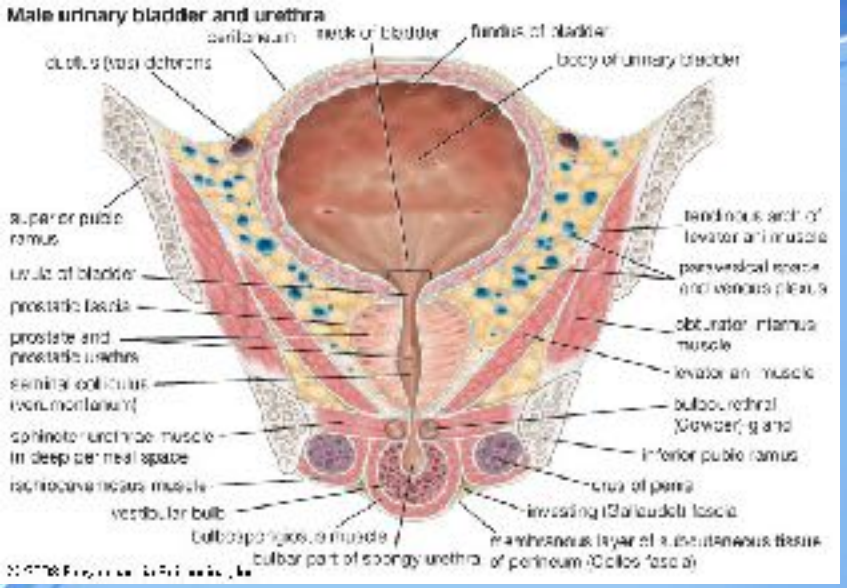

Liver
Splenic vein
Left renal artery
Superior mesenteric artery
IVC
Aorta
Vertebral body


Right posterior section
Right anterior section
Left medial section
Left lateral section
Right hepatic vein
Middle hepatic vein
Left hepatic vein
7
8
2
1
4
3
6
5
Umbilical vein (remnant)
Hepatic duct
Inferior vena cava
Cystic duct
Hepatic artery
Portal vein
Gall bladder
Bile duct


Hepatic veins
Liver
Blood flow
CWE

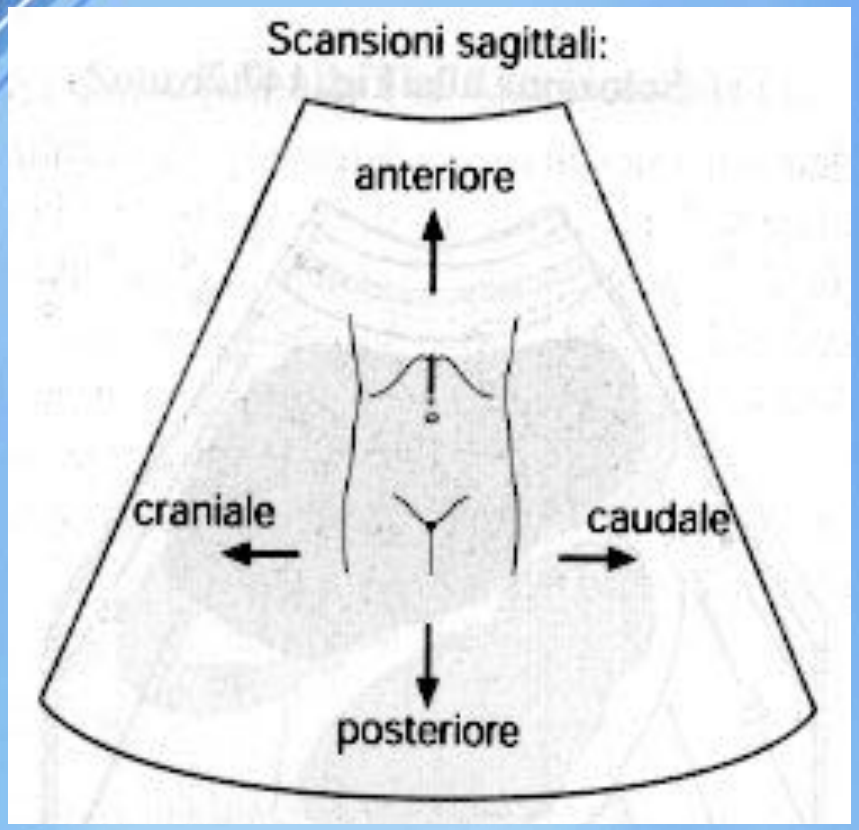

Human Liver Anatomy
inferior vena cava
aorta
hepatic artery
gall bladder
portal vein
common bile duct
wiseGEEK

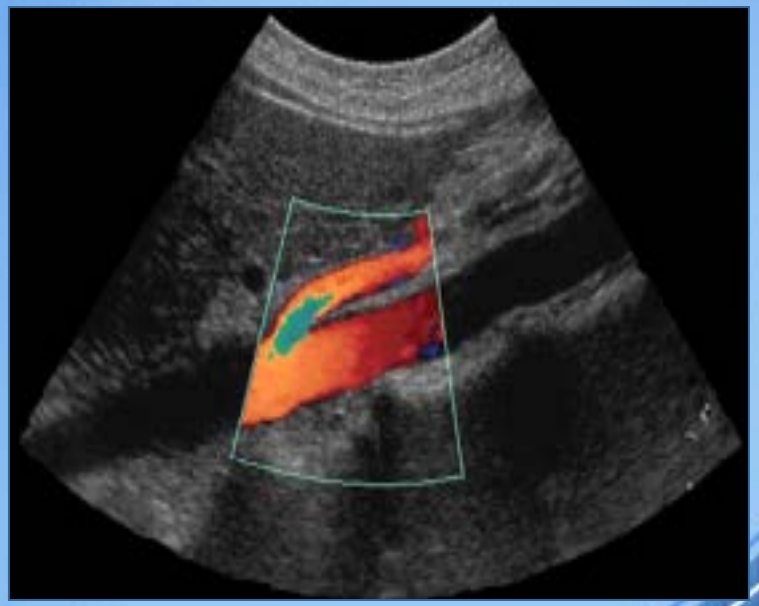

MAIN
PORTAL
VEIN
Liver hilum
Liver
Portal vein
Common bile duct
+ hepatic artery


Male urinary bladder and urethra
peritoneum
fundus of bladder
body of urinary bladder
ductus (vas) deferens
superior pubic ramus
tendinous arch of levator ani muscle
uvula of bladder
prostatic fascia
prostate and prostatic urethra
seminal colliculus (verumontanum)
sphincter urethrae muscle in deep perineal space
retrovesical space and venous plexus
obturator internus muscle
levator ani muscle
bulbourethral (Cowper) gland
inferior pubic ramus
ischiocavernosus muscle
crus of penis
vestibular bulb
investing (Buck's) fascia
bulbospongiosus muscle
membranous layer of superficial perineal fascia of perineum (Colles' fascia)
bulbar part of spongy urethra


SONOACE X4
OB
FP3 25D
C3-7ED
10.0cm MI 0.8
HGen. TIs 0.3
CINE
M
[2D] G48 / P100
86dB / FA6
FS12 / PG:C0
Urinary bladder
1 Auto Run
3 Start One
4 End One

IMAGE ORIENTATION
CONVEX TRANSDUCER 3,5-5 MHz
LONGITUDINAL SECTION

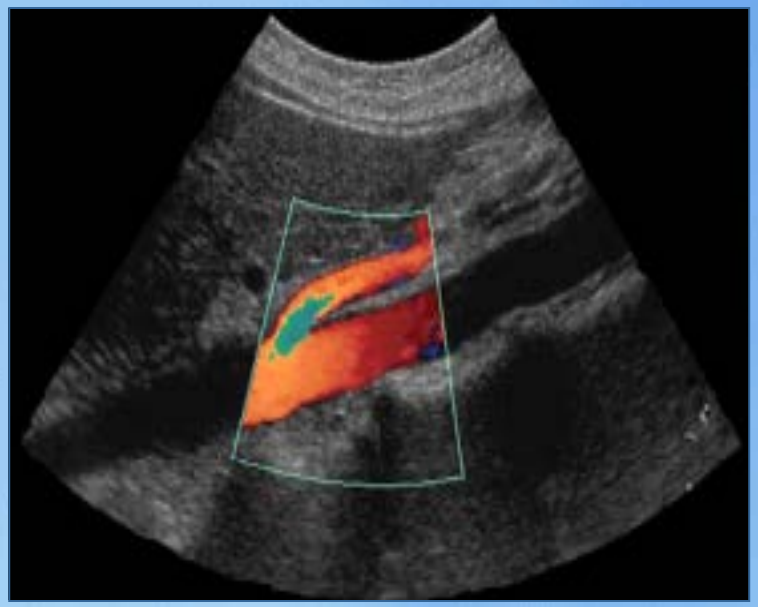




LONGITUDINAL ANTERIOR VENTRAL SCAN

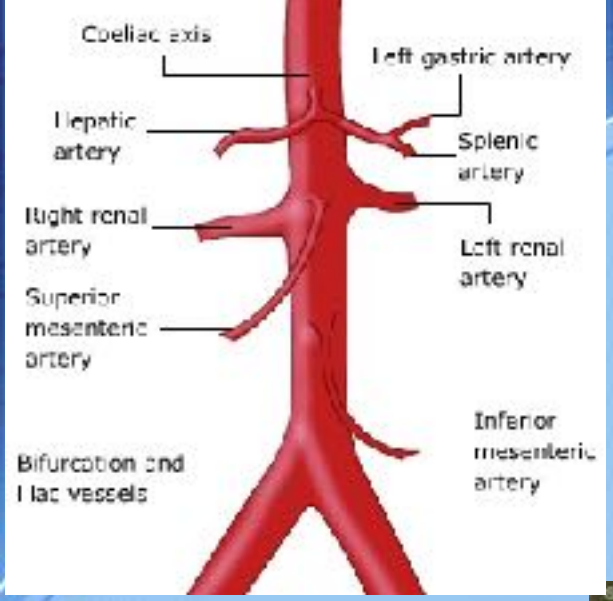
VENTRAL

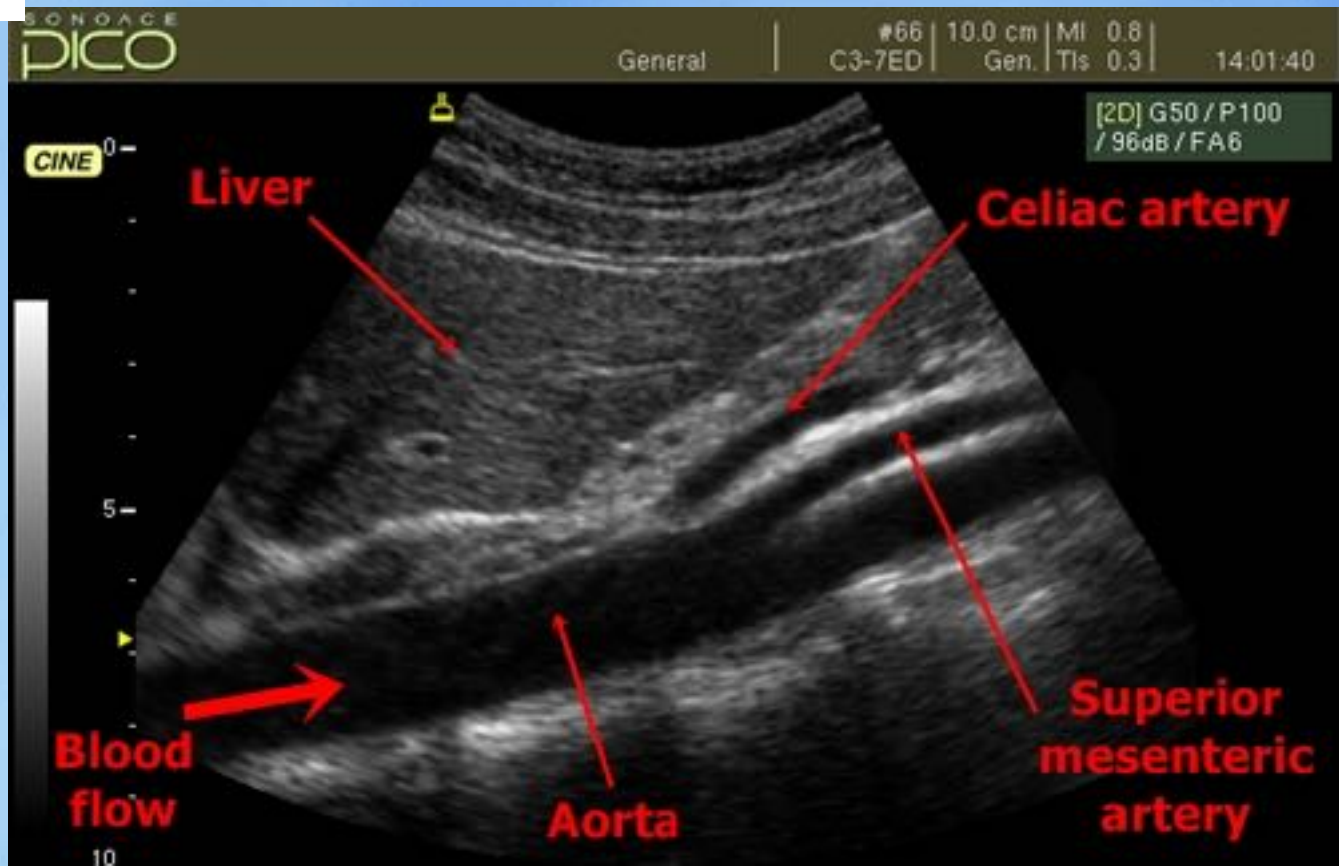
HEAD

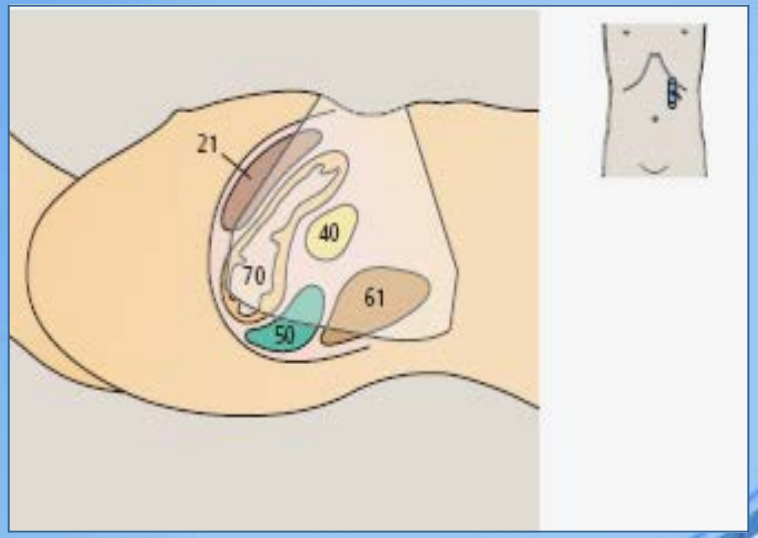


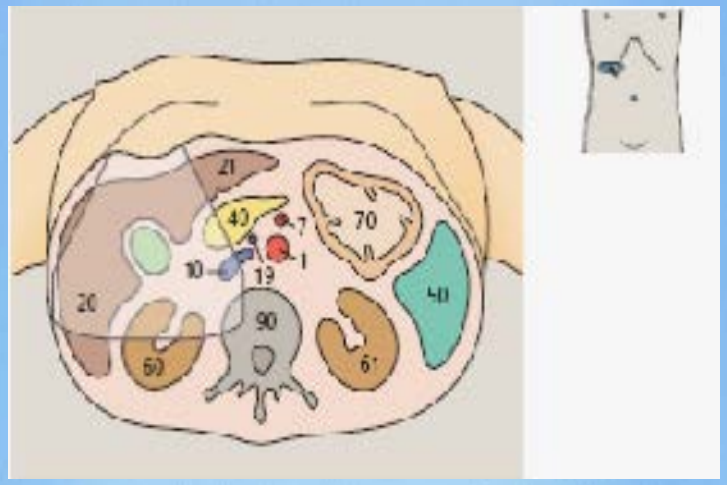
FEET

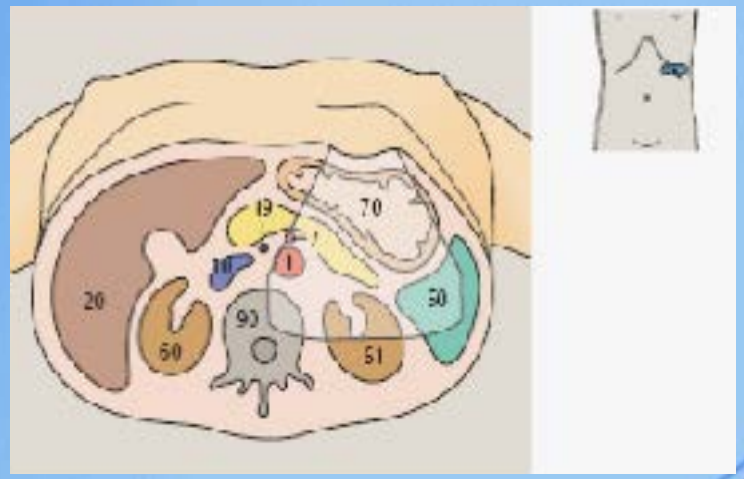
DORSAL


Coeliac axis
Left gastric artery
Hepatic artery
Splenic artery
Right renal artery
Left renal artery
Superior mesenteric artery
Inferior mesenteric artery
Bifurcation and Iliac vessels


SONOACE pico
General
#66
C3-7ED
10.0 cm
Gen.
MI 0.8
TIs 0.3
14:01:40
[2D] G50 / P100
/ 96dB / FA6
CINE
Liver
Celiac artery
Blood flow
Aorta
Superior mesenteric artery


21
40
70
61
50


70
40
20
90
60
51


70
20
90
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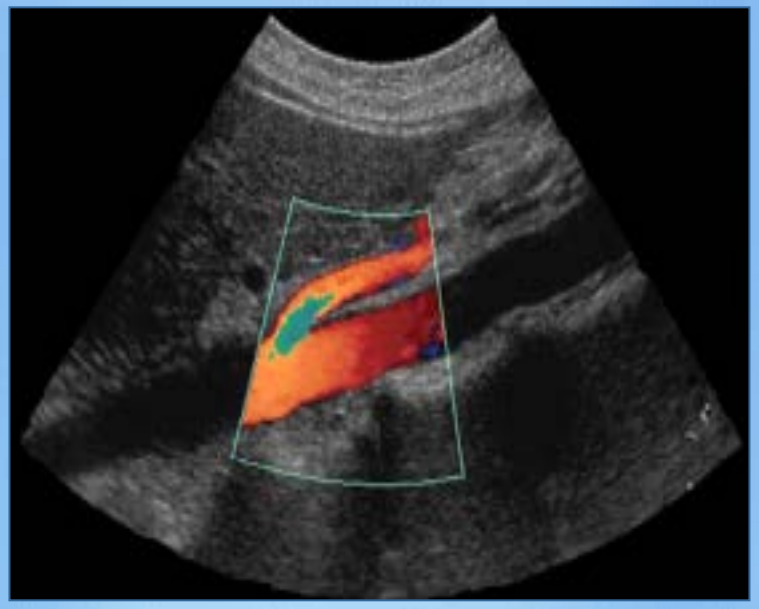
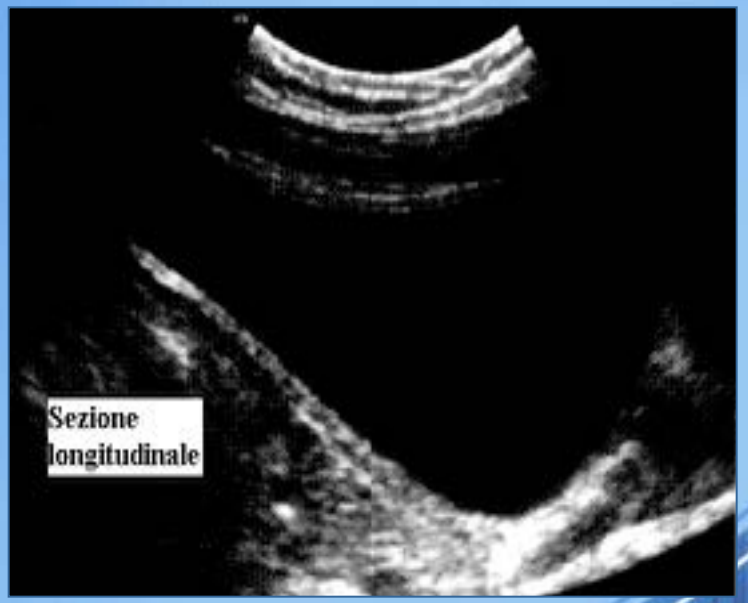
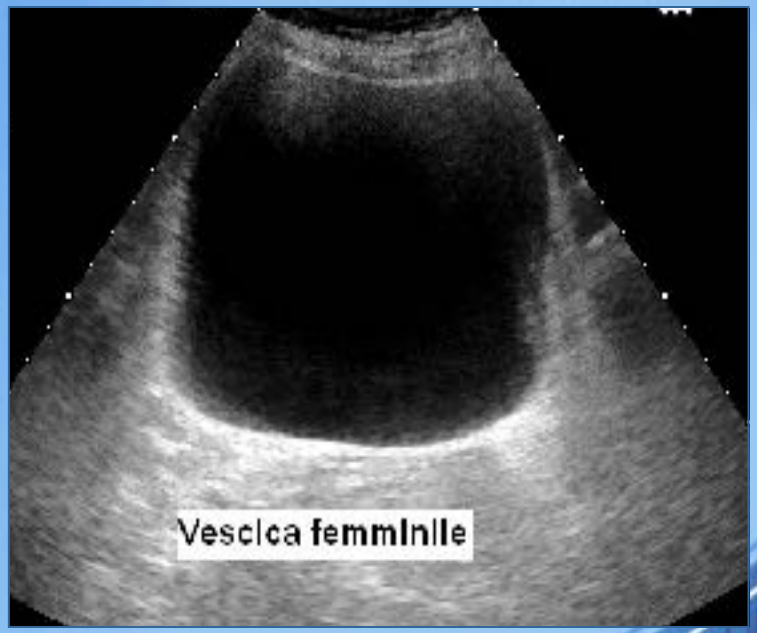
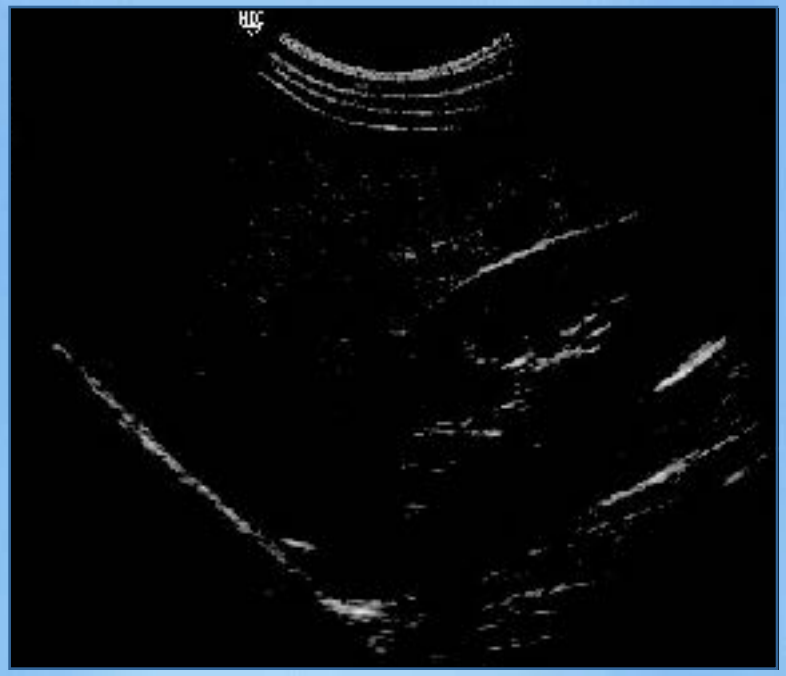
51

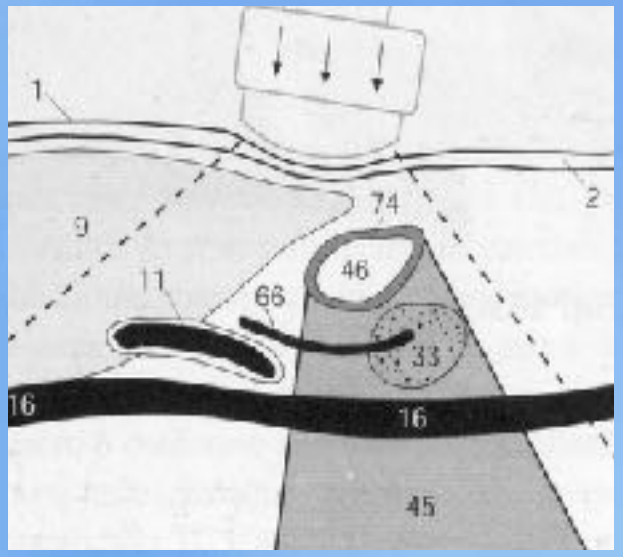



Sezione
longitudinale

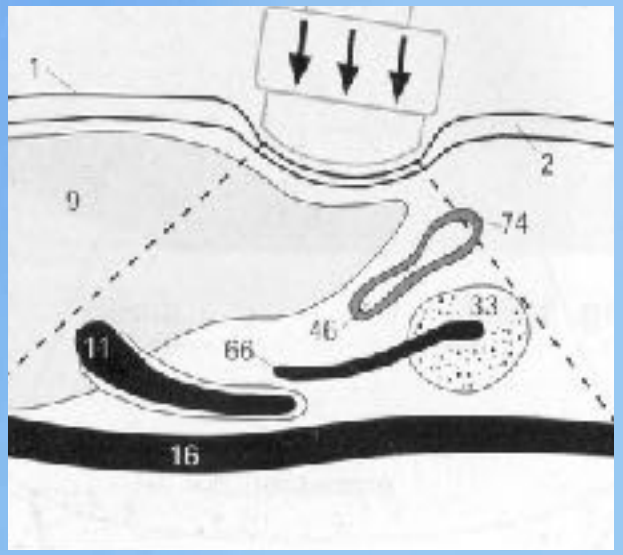

Vesclca femmlnlle



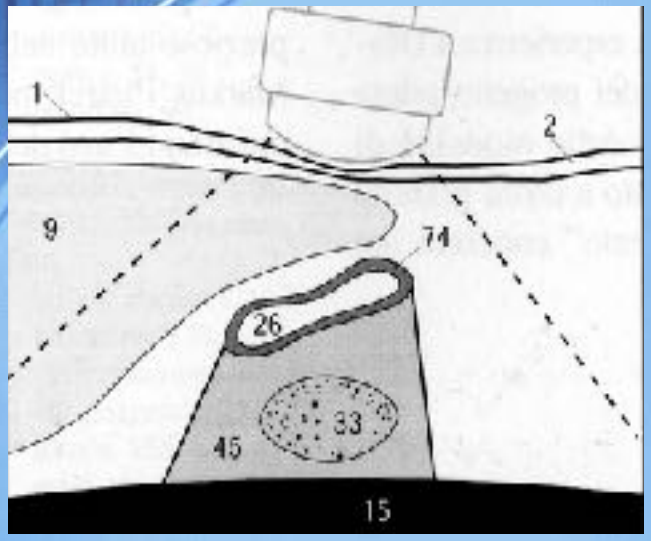
PRESSURE APPLIED TO PROBE

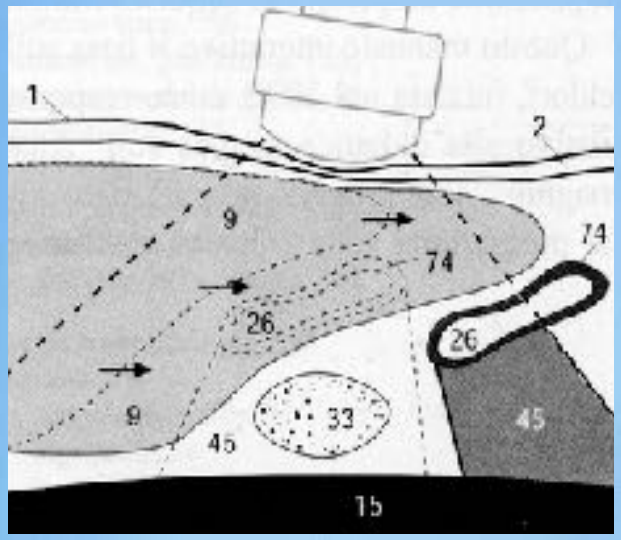


GRADUAL BUT EFFECTIVE !!!



CONDITIONS FOR A GOOD ABDOMINAL ULTRASOUND EXAMINATION





CORRECT PREPARATION (fasting, activated charcoal…)

PATIENT'S COOPERATION (POSITION, DEEP BREATH)

Palpation of the gall bladder

- **<u>Murphy's symptom</u>**

The pain is increased at pressing in Kehr's point while child inhales (diseases of gall bladder)

Clinical Scenario

- A 46 year old woman presents to the clinic complaining of epigastric pain that she experiences after eating a large meal.

On examination, the patient is an obese female who does not appear to be in any acute distress. She is afebrile, with stable vital signs. The exam is only significant for the patient experiencing mild tenderness upon palpation of the right upper quadrant of her abdomen.

ACR Appropriateness Criteria

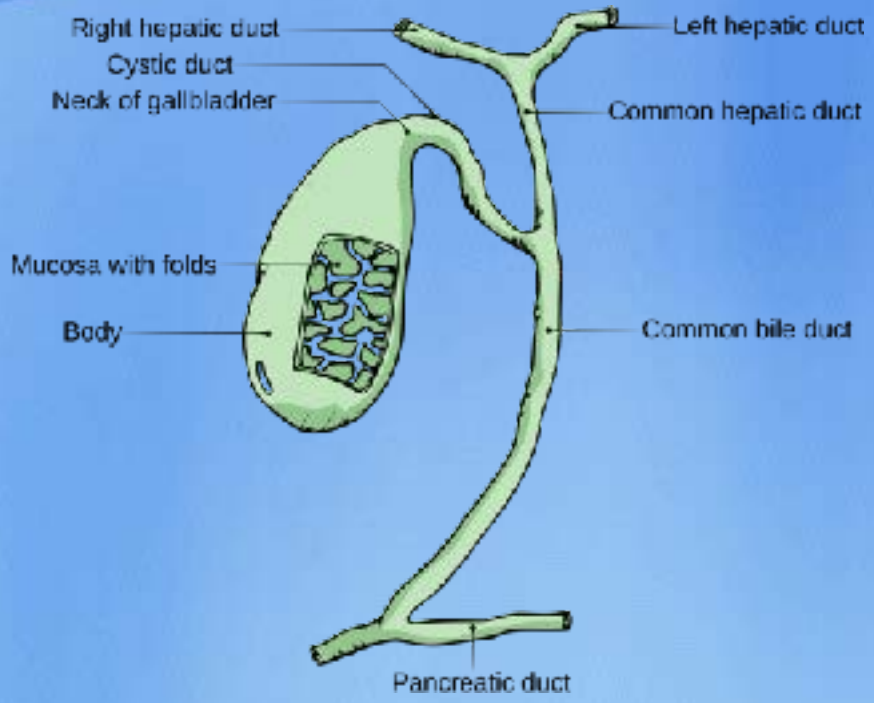
- For a patient with acute right upper quadrant pain, who is afebrile with a normal WBC count:

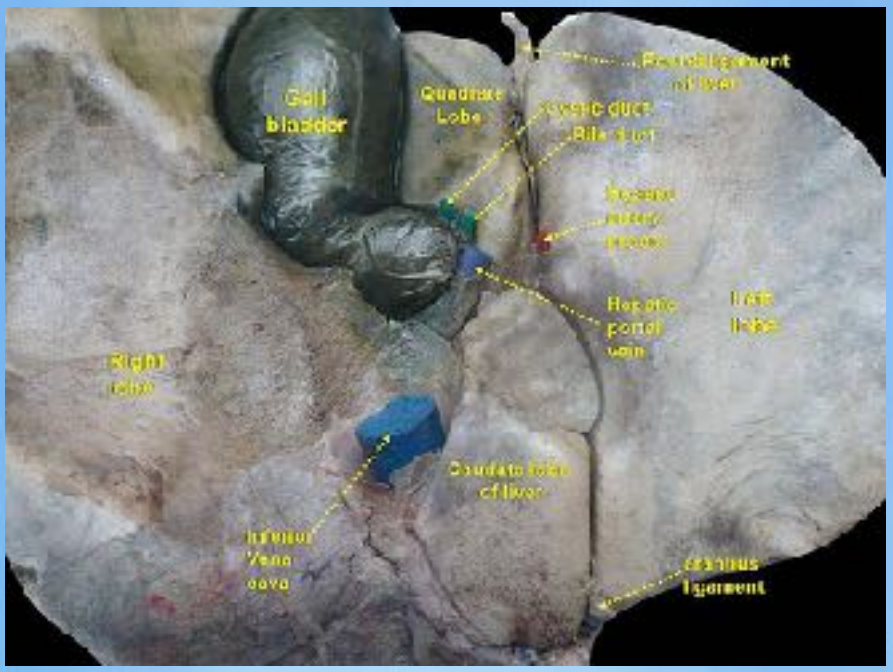
Radiologic Exam Procedure	Appropriateness Rating
US, abdomen	8
CT, abdomen	7
NUC, cholescintigraphy	6
X-ray, Upper GI series	6
X-ray, barium enema	4
X-ray, abdomen	4

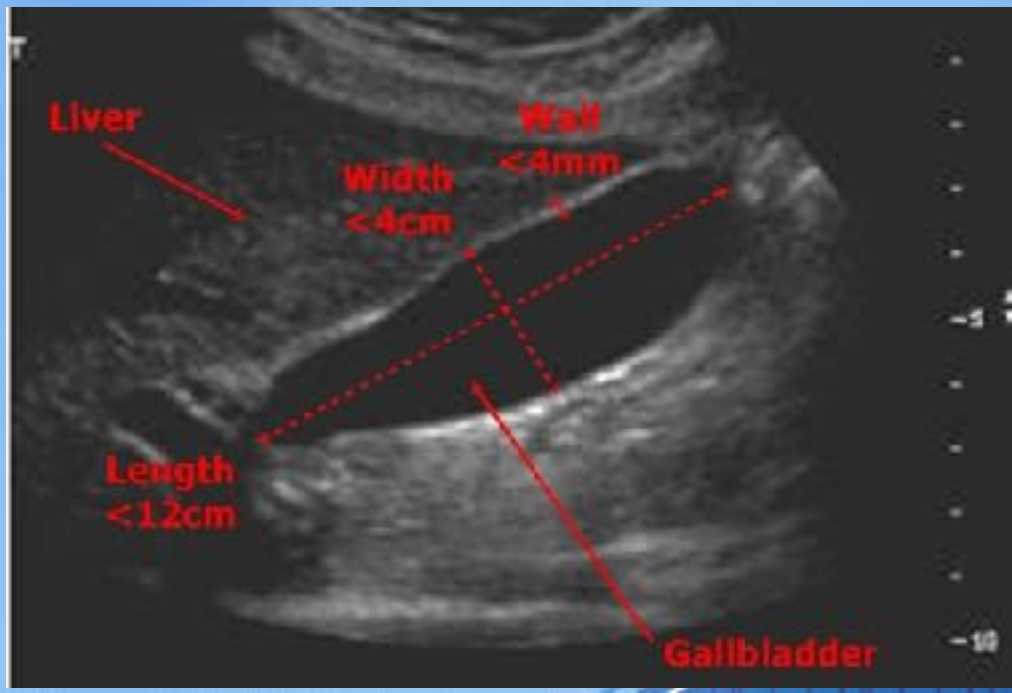
Ultrasound Abdomen

- The imaging modality of choice for the gallbladder is ultrasound. It is fast, real-time, non-invasive, and does not utilize ionizing radiation.
- 95% sensitivity for detection of cholelithiasis. Diagnosis based on visualization of a mobile, hyperechoic, intraluminal mass with acoustic shadowing.
- >90% sensitivity for detection of acute cholecystitis. Diagnosis based on presence of cholelithiasis, gallbladder wall thickening, pericholecystic fluid, and a sonographic Murphy sign.
- Limited by skill of operator, and pt's body habitus.

Normal Gallbladder







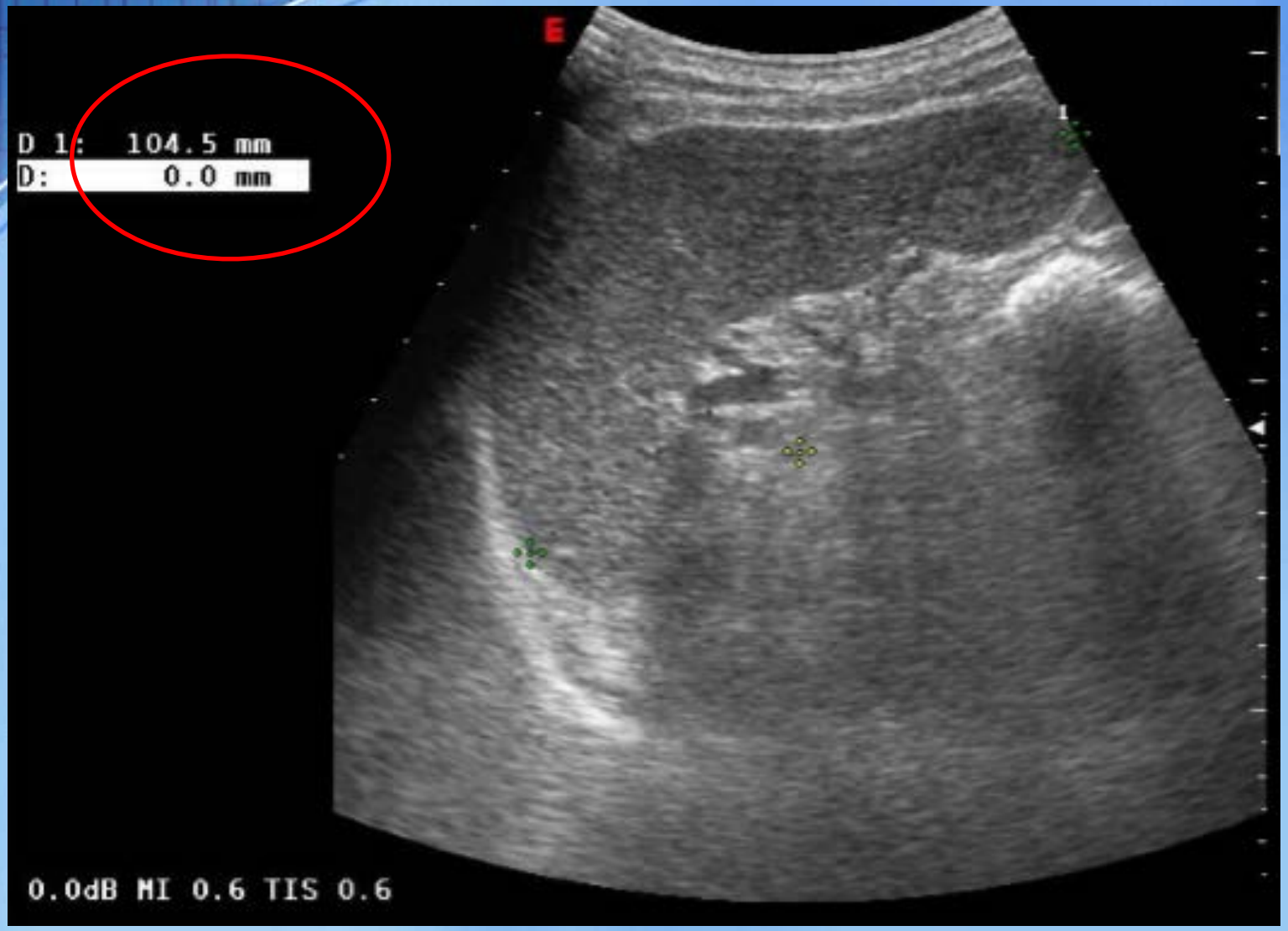
Gallbladder, with numerous stones present

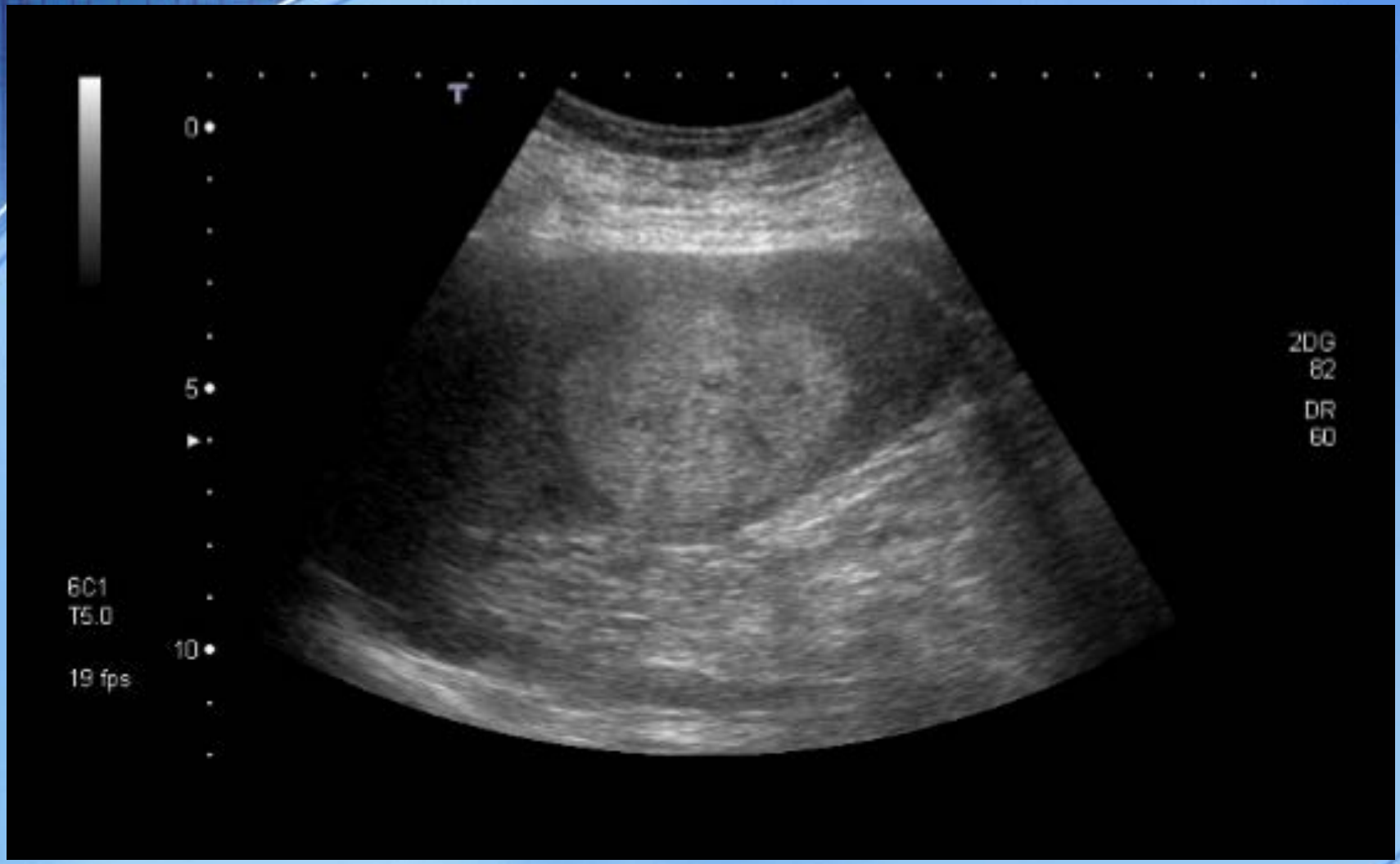
Clinical Scenario

Acute cholecystitis – notice increased gallbladder wall thickness

Palpating the Spleen

A spleen is not palpable unless it is enlarged. Use your left hand under left lower rib cage, position finger tips so they point to axilla and press inwards and upwards. You can also ask the patient to take a deep breath and feel again.


D 1: 104.5 mm
D: 0.0 mm
0.0dB MI 0.6 TIS 0.6


T
0
5
10
2DG
82
DR
60
6C1
T5.0
19 fps

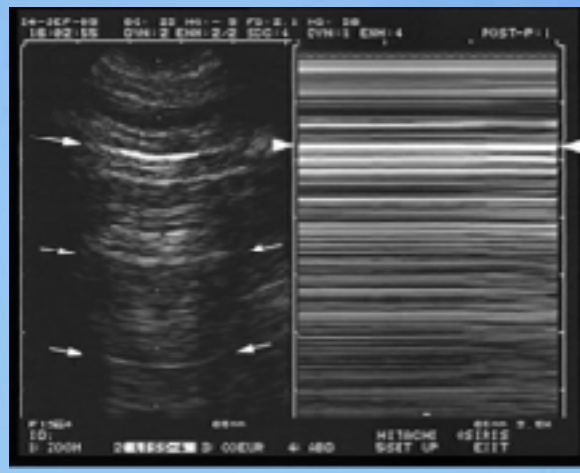
SEMEIOTICA ECOGRAFICA

LINEA PLEURICA → «Bat Sign» - «Sliding» – «Lung pulse»

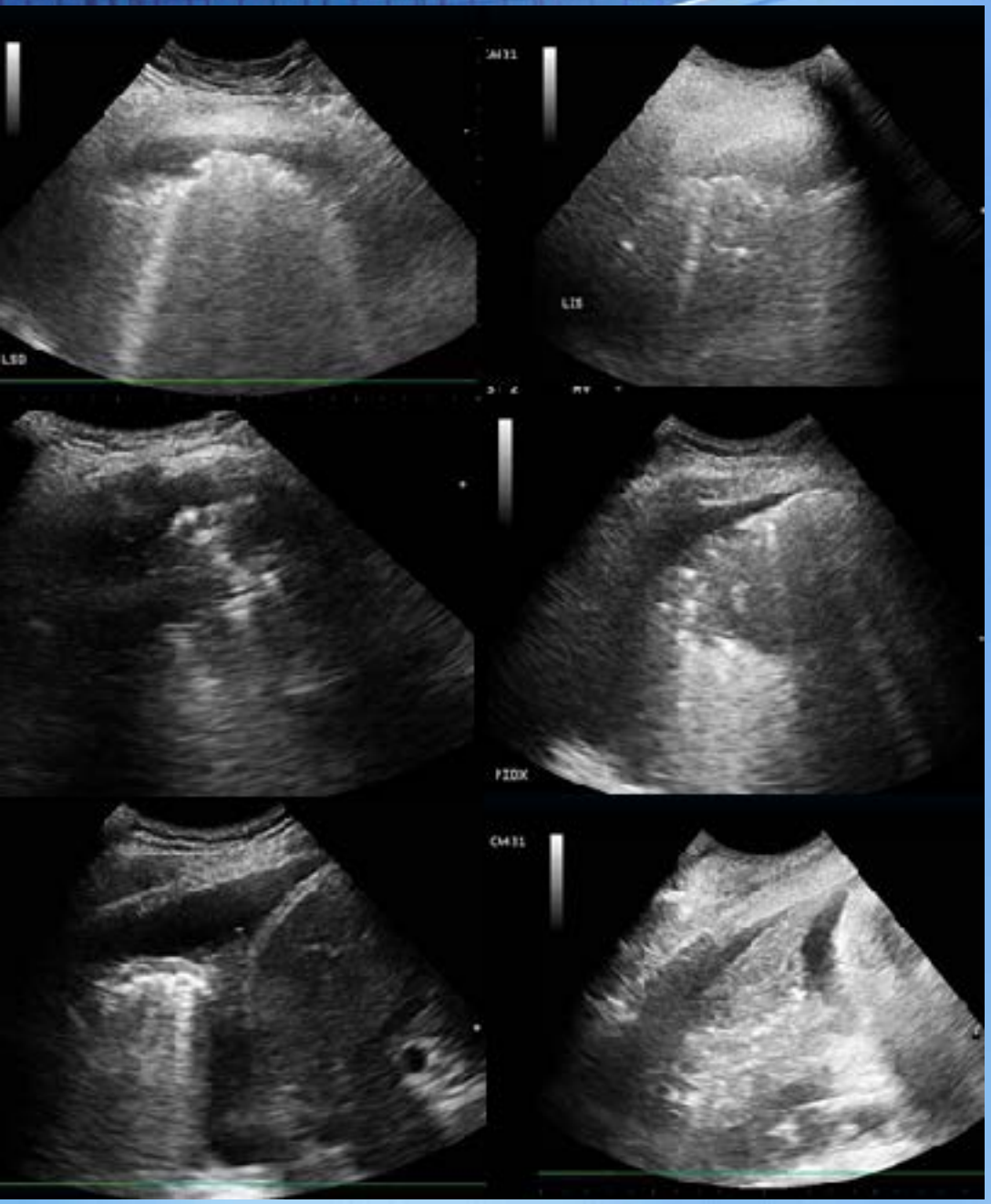
LINEE A: orizzontali e statiche, artefatti da riverbero della linea pleurica

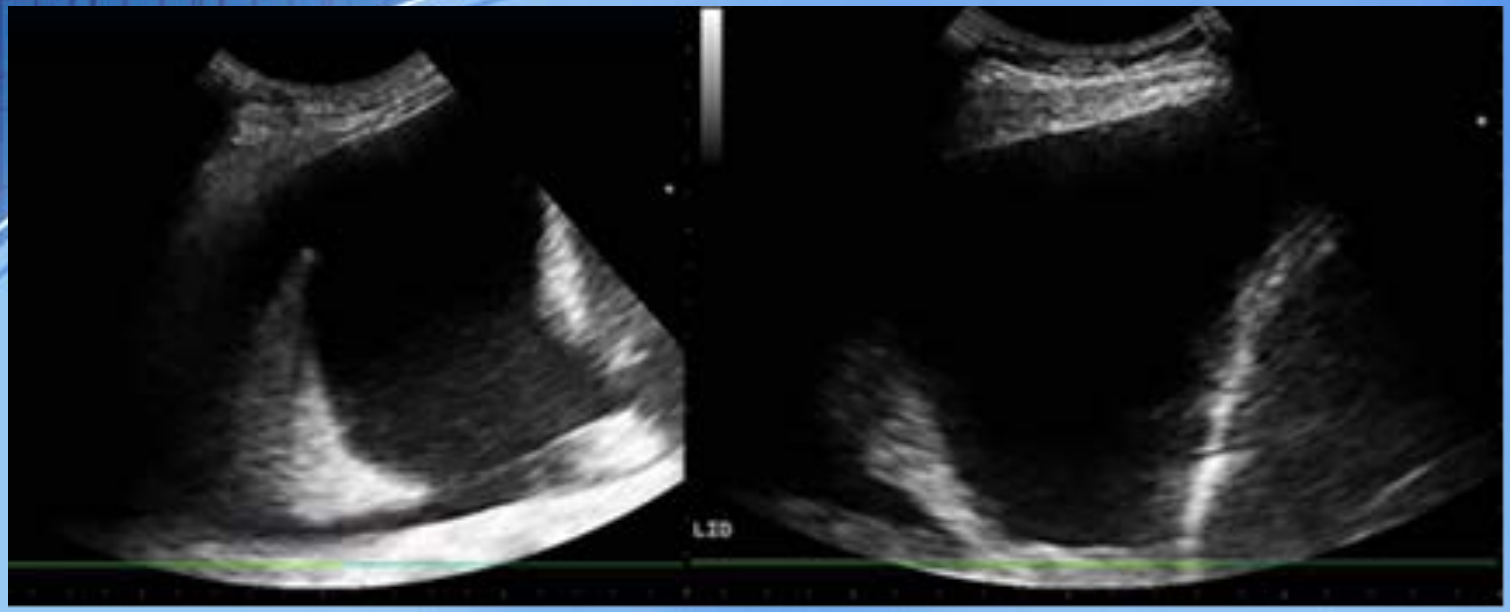
Pattern polmonare normale (modificata da Lichtenstein A. et al Intensive Care Med 2003, 29:2187–2192

Seashore sign. Modificata da Lichtestein DA, Chest 2008.



Segno della stratosfera o de codice a barre. Modificata da Lichtestein DA, Chest 2008;






CA431
17.8 mm
LISX

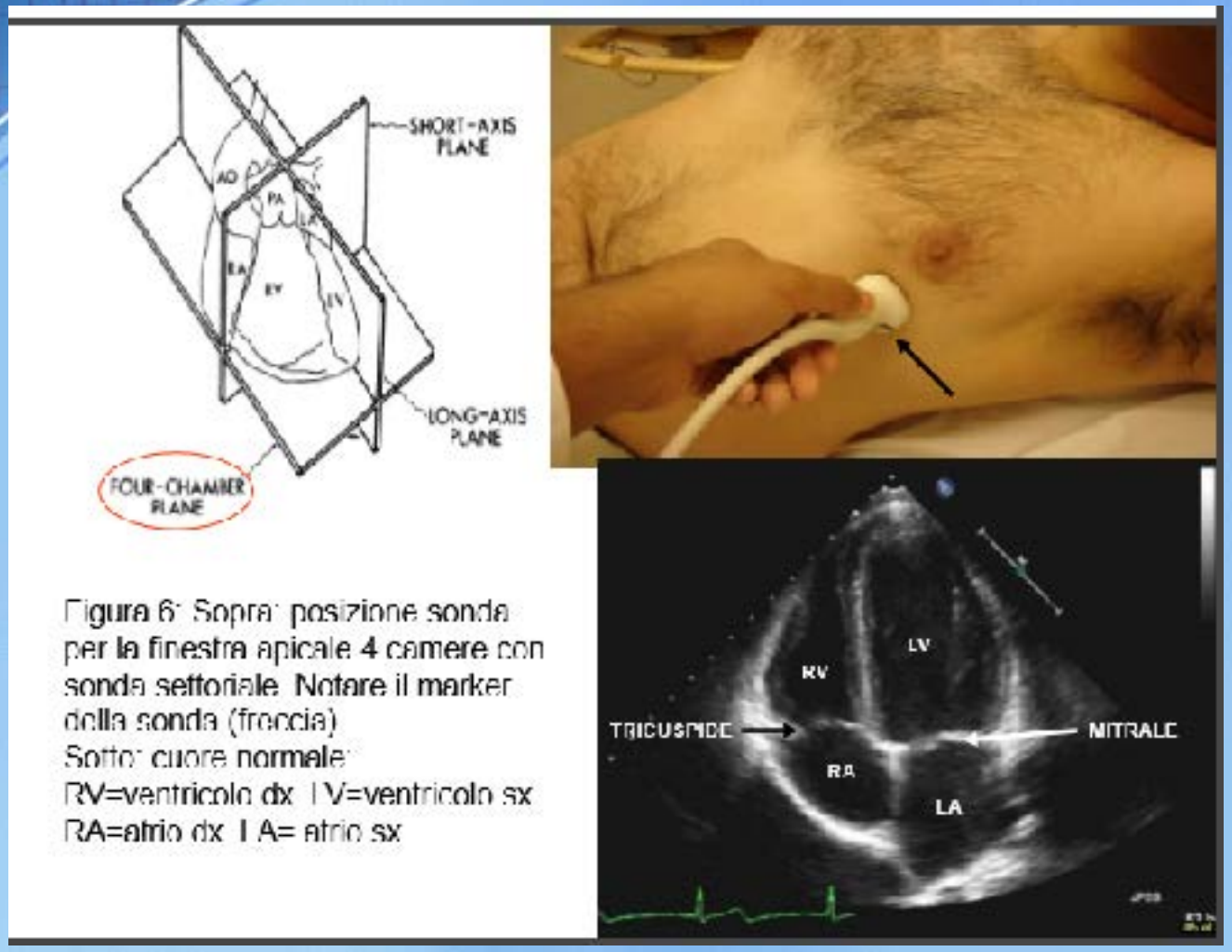


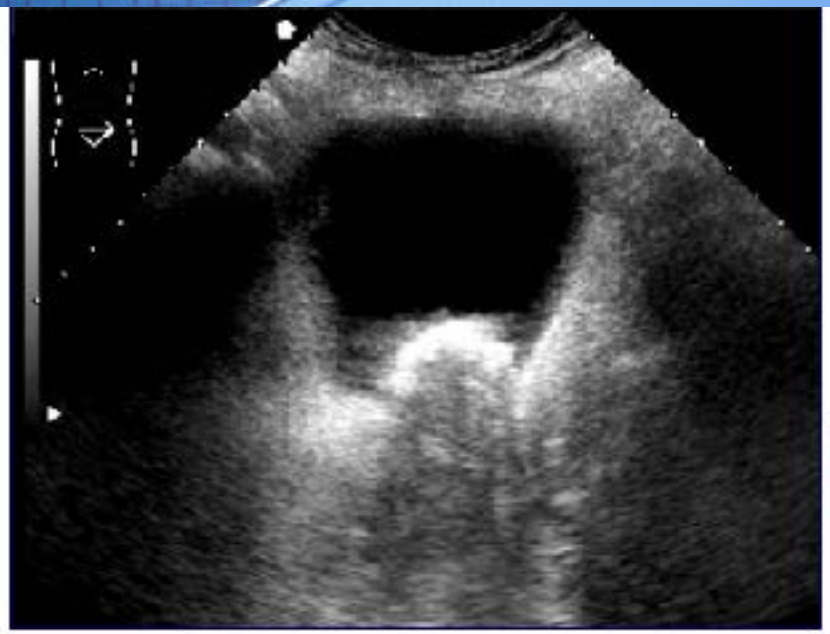
Figura 6: Sopra: posizione sonda per la finestra apicale 4 camere con sonda settoriale. Notare il marker della sonda (freccia)
Sotto: cuore normale:
RV=ventricolo dx LV=ventricolo sx
RA=atrio dx LA= atrio sx

Globo vescicale

Vescica in scansione longitudinale e trasversale. Sono misurati i tre diametri: longitudinale, trasversale ed antero-posteriore. Il volume calcolato con la formula dell'ellissoide (prodotto dei tre diametri x0.5) evidenzia un volume > 1.000 ml.

Cistite acuta

Pareti vescicali ispessite ed irregolari, nel lume sedimento ecogeno con livello modificato dalle variazioni di decubito.



Calcolosi vescicale

Formazione iperecogena con attenuazione distale nel lume vescicale (mobile con le variazioni di decubito).

Carcinoma vescicale

Formazione esogena aggettante nel lume dalla parete vescicale sn (fissa con le variazioni di decubito).

Carcinoma vescicale

Formazione ecogena ad impianto esteso ed aggettante nel lume dalla parete vescicale dx (fissa con le variazioni di decubito).

Carcinoma vescicale avanzato

Formazione ecogena disomogenea a carico della parete vescicale sn, a sviluppo intra e (prevalentemente) extra vescicale.

CONCLUSION

- Ultrasound are produced using the Piezoelectric effect
- US can be considered an extension of clinical examination and of clinical skills
- It provides real time useful clinical answers
- It can be performed bedside
- It is a noninvasive technique and can be repeated
- It is relatively cheap

- All we "see" are reflections… not real images
- Basic features of US images allow to identify different tissue and organs
- Correct Probe orientation is mandatory
- US is an operator-dependent technique

Thanks for your attention