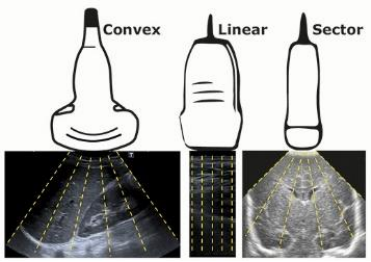
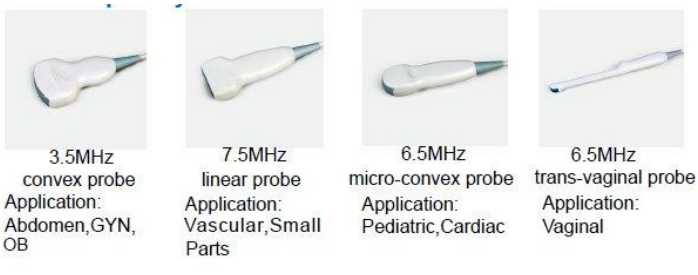
Rio Bravo Family Medicine
Ultrasound Manual: 2018

General Information



Transducers:

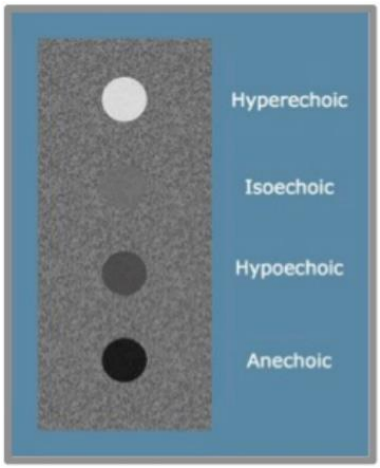
A. 3–5 MHz for abdominal areas.
B. 5–10 MHz for small and superficial parts
C. Linear: superficial structures and vessels
D. Curvilinear: Transabdominal scanning
E. Phased Array/Sector: Cardiac Ultrasound



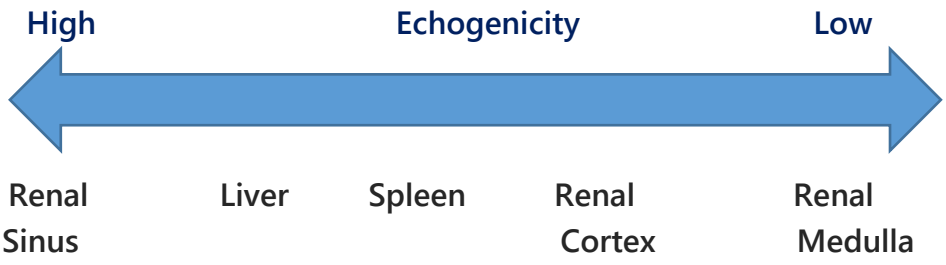
Guidelines for the examination

A. Know the patient's problem & medical Hx.
B. Settings & orientation of transducer is correct in relation to the image.
C. Systematic & complete exam of the whole body region
D. Examine each organ, structure or tumor in at least two planes.
E. Difficult situations or findings are doubtful, repeat exam a short time later.

B – Mode: Brightness display mode - gray scale imaging;
A. Blacks, grays and whites assigned according to density and penetration/absorption.
  1. Denser/less penetration = bright gray/white = air/bone
  2. Tissue/organs = gray
  3. Fluid = black; blood, ascites, bile



Echo pattern - Number & strength of echoes & their distribution
A. Echo free: Anechoic
B. Echo poor: hypoechogenic
C. Average: Isoechoic
D. Echo rich: hyperechogenic
E. Homogeneous or inhomogeneous
F. Echogenicity of abdominal organs on US:
  1. Darling Parents So Love Kids (From most to least echogenic):
    D: diaphragm P: pancreas S: spleen L: liver K: kidneys (cortex)



Abdominal US

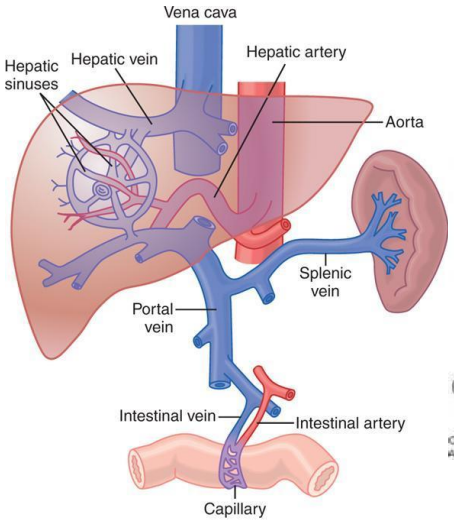
Liver

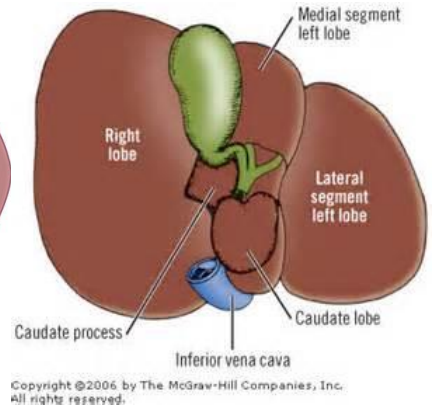
A. Homogenous, Heterogeneous. Echogenicity: Compare to right kidney.

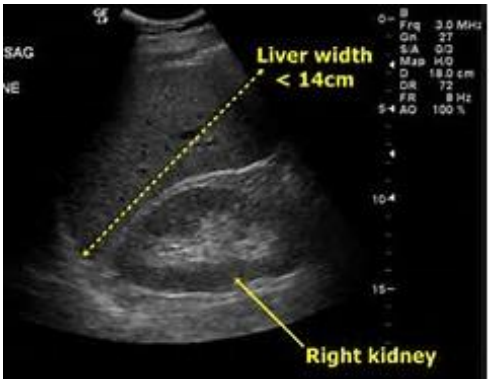
B. Width < 14 - 15 cm

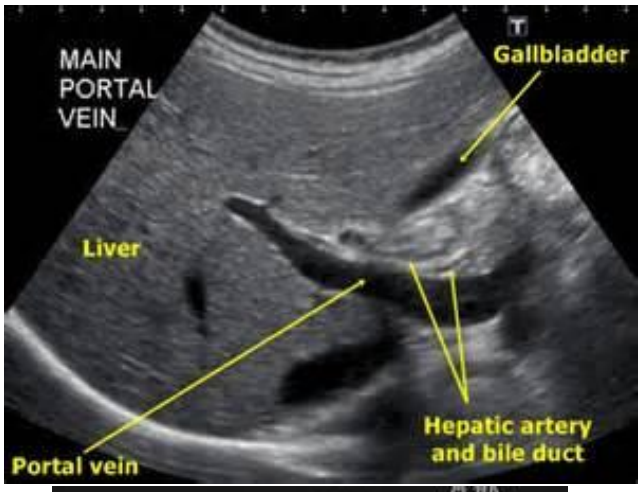
C. IVC, hepatic veins & main portal vein (< 13-15 mm)

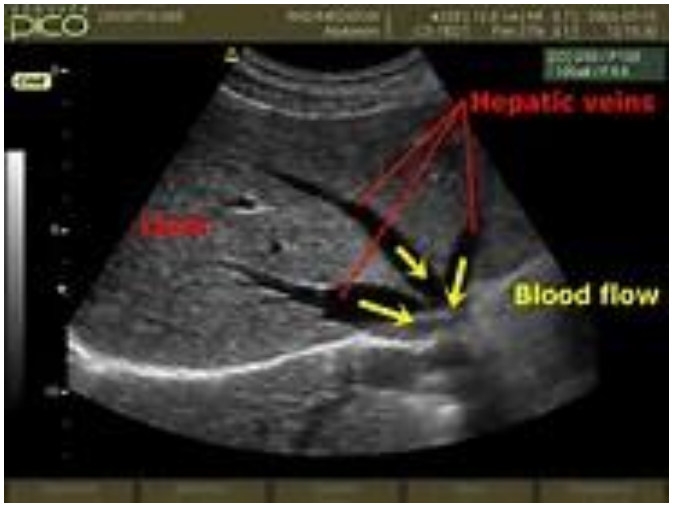
D. Hepatic lobes (Rt, Lt, & caudate) &, Rt. diaphragm & adjacent pleural space.

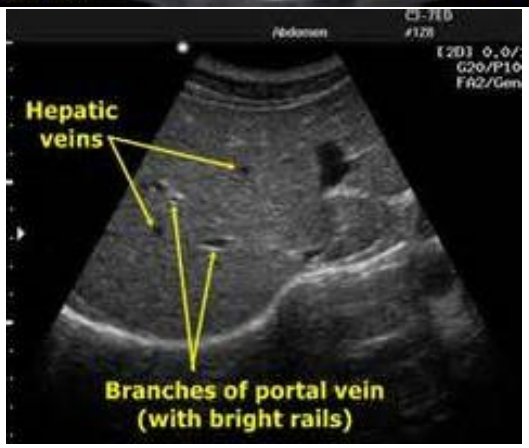












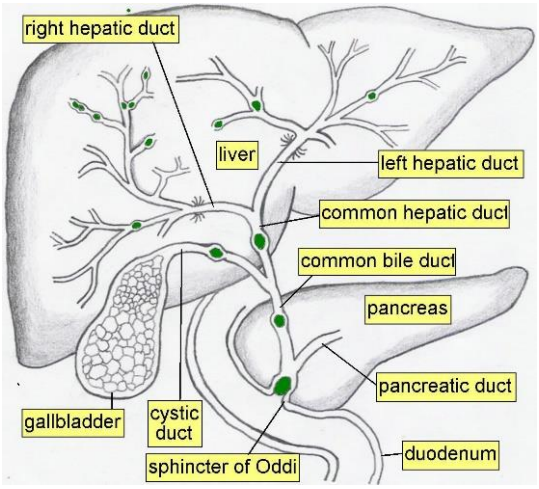
Abdominal US

Gallbladder: Fast for 6 hours

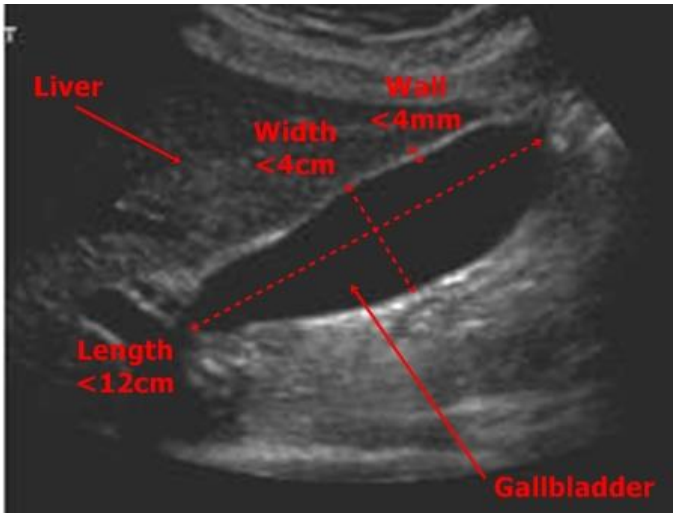
A. Size: length < 12 cm, Width < 4 cm, Wall< 4mm

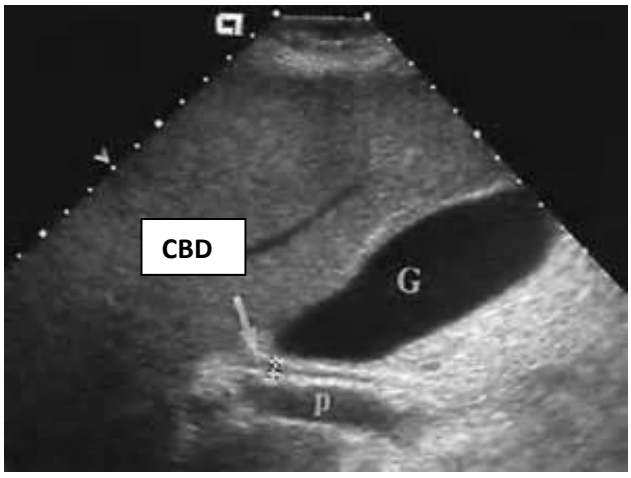
B. Stones, Sludge, Tumors, Polyps

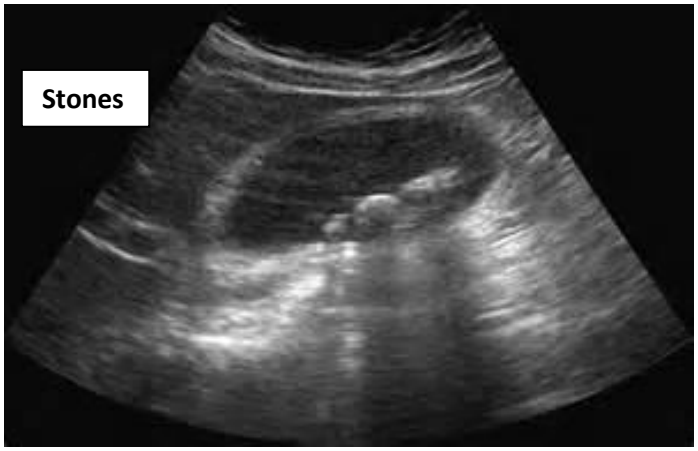
C. CBD upper limit normal 6 mm

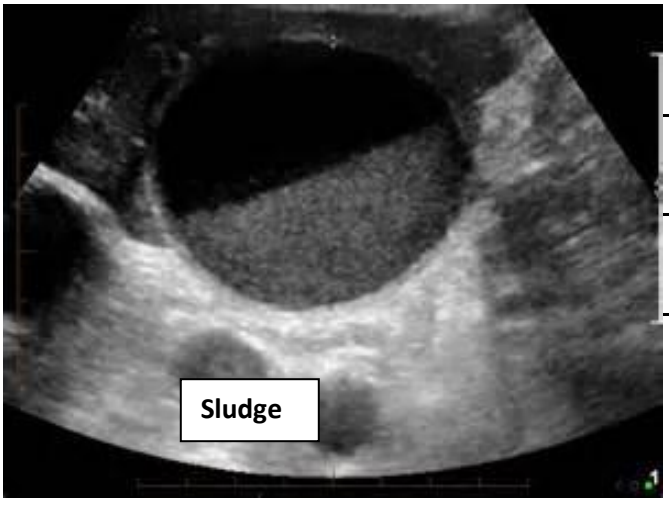


Normal measurements





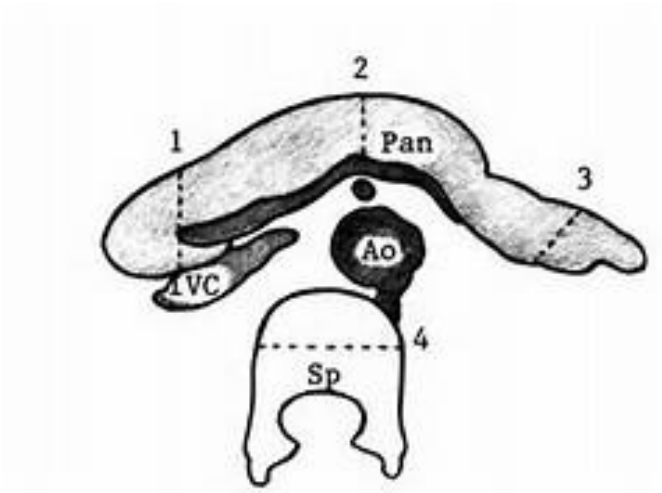


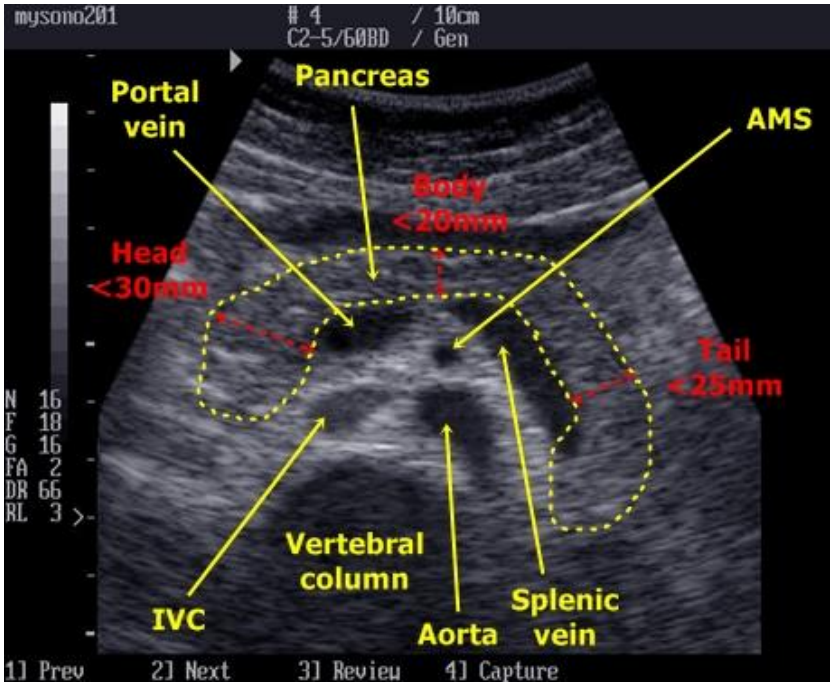


Abdominal US

Pancreas

A. Measure: Head (<3 cm), Body (<2.0 cm) and Tail (< 2.5 cm)
B. Evaluate Duct (1-2 mm)
C. Hypoechoic – similar to hepatic (slim, young) to Hyperechoic (obese, older)





- Often you will have problems with bowel gas overlying the pancreas.

- Ways to overcome this include:
  A. Deep inspiration / expirat.
  B. Distend the abdomen against the probe. (ask patient to push their stomach out as if they are pregnant!)

- Give the patient an oral water load (2-3 glasses). The water is used as a window to look through when it is in the stomach and duodenum.
- Scan with the patient erect.

Abdominal US

Kidneys

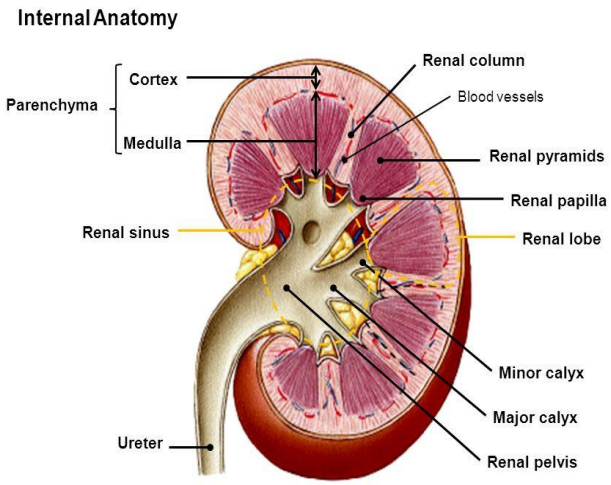
A. Length 9-12 cm, Width 4-6 cm. Increase echogenicity of parenchyma = Inflammation

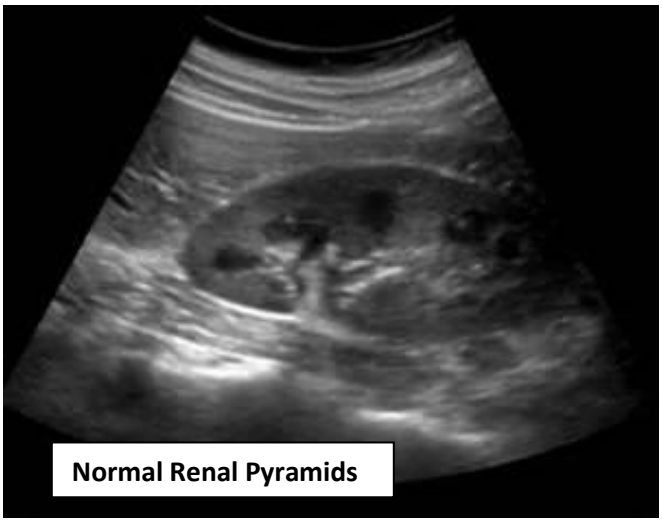
B. Renal Capsule: bright, smooth, echogenic line around the kidney

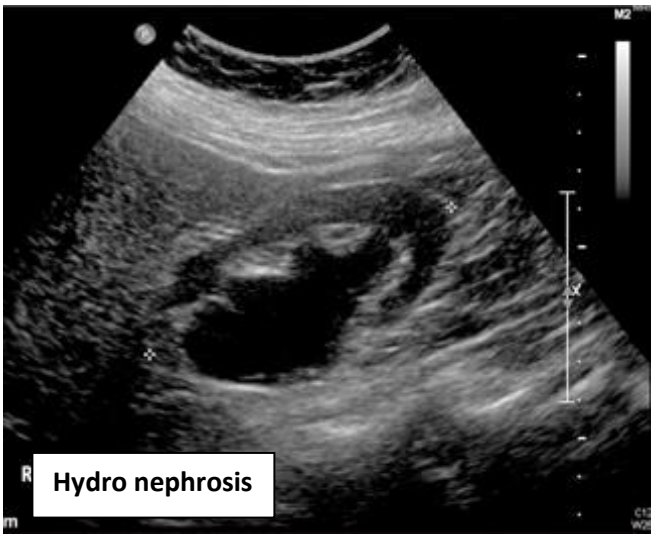
C. Cortex: less echogenic than liver but more echogenic than adjacent renal pyramids

D. Renal Medulla: contains the hypo-echogenic, renal pyramids (not mistaken for renal cysts)

E. Renal Sinus. The Innermost part of kidney. Has the greatest echogenicity







Abdominal US

Spleen: Normal 7 – 14 cm

A. Emergency diagnosis of splenic rupture & hemorrhage

B. Performed while the patient exhales b/c the upper pole of the spleen is otherwise covered by lung tissue

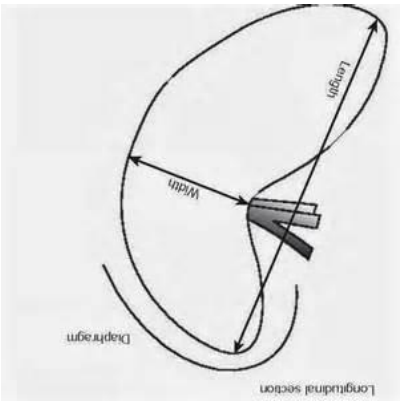
C. Crescent shaped. Outer convexity smooth. Inner margin may be indented or nodulous.

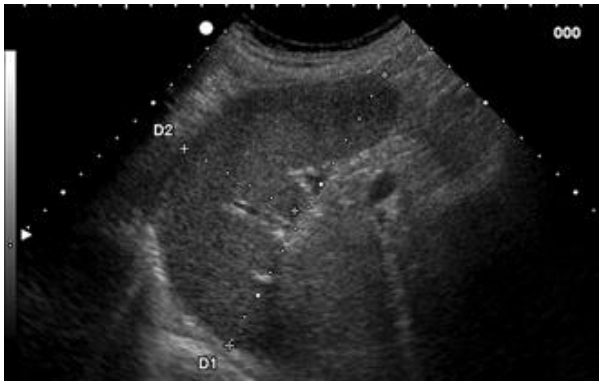
D. Homogeneous & slightly more echogenic than liver tissue & hyperechoic compared to kidney tissue.

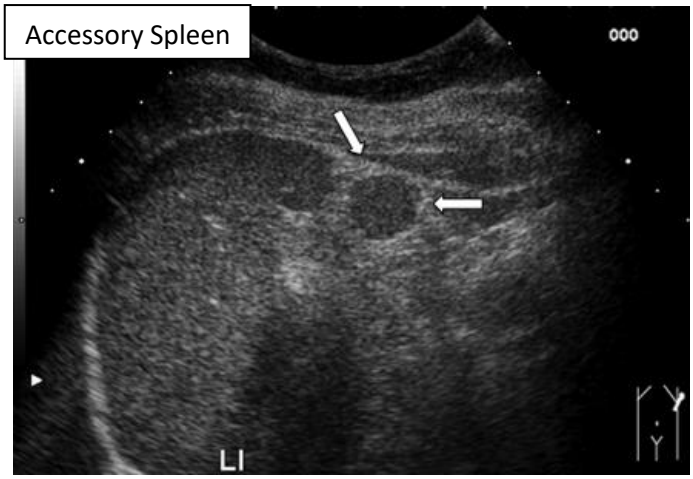
E. Accessory spleen: normal variant (90% solitary and 10% multiple)

1. Present in 10% - 25% of all patients.

2. Most are found at the lower splenic pole & typically less than 25 mm in diameter







Abdominal US

Inferior Vena Cava

A. Subxiphoid view of the heart: place probe on patient's abdomen just below the xiphoid bone with the marker facing to the right of the patient. Once an appropriate subxiphoid view of the heart is obtained, the probe is rotated 90 degrees until the marker is pointing toward the head of the patient.

B. CVP is a measure of blood volume & venous return. It reflects right side filling pressures.

1. Normal 5-10 cm H_2O:

2. Decrease: hypovolemia and shock

3. Increase: Fluid Overload, Vasoconstriction and Cardiac Tamponade.

shows expiratory (maximal) diameter of the IVC.

Correlations Between IVC Size and CVP

Inferior vena cava size (cm)	Respiratory change	Central venous pressure (cm H_2O)
<1.5	Total collapse	0-5
1.5-2.5	>50% collapse	6-10
1.5-2.5	<50% collapse	11-15
>2.5	<50% collapse	16-20
>2.5	No change	>20

Measurements. Diameter of the IVC for calc. of the Caval index is measured 2 cm from where it enters the Rt. atrium. An alternative way to visualize resp. variation is to use M-mode, w/ beam overlying the IVC 2 cm from Rt. atrium. Insp. & Exp. diameter measured on the M-mode image, at the smallest & largest locations, respectively.

C. Interpretation: Volume status based on IVC alone (Respiro phasic IVC Variation)

1. Inferior vena cava (IVC) is normally 1.5 to 2.5 cm in diameter (measured 3 cm from right atrium)
   a) IVC <1 cm in Trauma is associated with a high likelihood of Hemorrhage requiring Blood Transfusion
   b) IVC <1.5 cm suggests volume depletion
   c) IVC >2.5 cm suggests volume overload
2. Inferior vena cava (IVC) normally collapses more than 50% with inspiration or sniffing
   a) Consider measuring in M-Mode
   b) Caval Index = (IVC-exp diameter - IVC insp diameter) / (IVC-exp diameter) * 100
      1) Collapse <50% suggests volume overload
      2) Caval Index >50% suggests fluid responsiveness
3. Correlation between RA pressure (CVP) and IVC appearance
   a) CVP 0-5 cm: IVC totally collapses on inspiration and is <1.5 cm in diameter
   b) CVP 5-10 cm: IVC collapses >50% on inspiration and is 1.5 to 2.5 cm in diameter
   c) CVP 11-15 cm: IVC collapses <50% on inspiration and is 1.5 to 2.5 cm in diameter
   d) CVP 16-20 cm: IVC collapses <50% on inspiration and is >2.5 cm in diameter
   e) CVP >20 cm: No change in IVC on inspiration and is >2.5 cm in diameter

Abdominal US

Appendix

A. Indications: Focal RLQ pain, Rebound tenderness, Pelvic pain, Elevated WBC

B. LIMITATIONS: Bowel gas and patient habitus are the biggest limiting factors to visualizing the appendix.

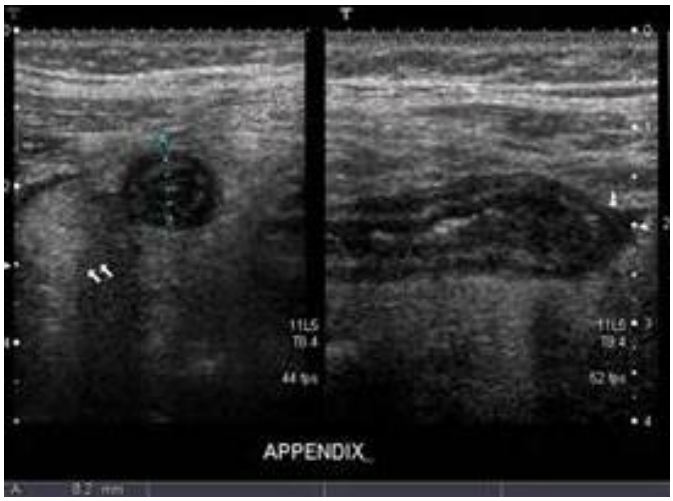
1. Up to 60% of appendix' are retrocaecal & thus may be obscured.

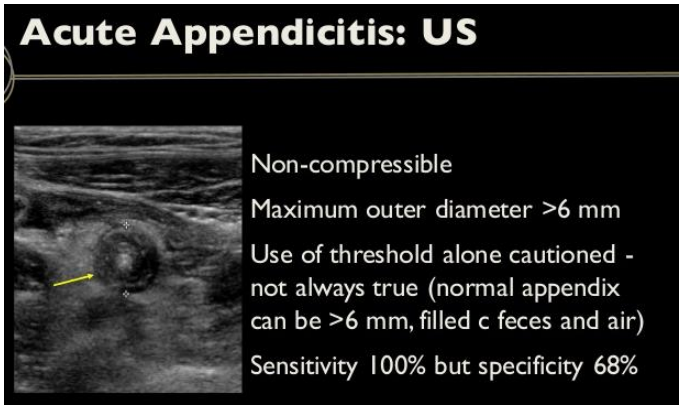
2. **Not identifying an appendix does NOT exclude appendicitis.**

***C. PREPARATION*:** Ideally the patient has fasted for 6 hrs. Water in the bladder is an advantage to rule out ovarian pathology.

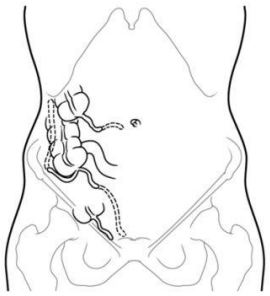
D. EQUIPMENT SELECTION & TECHNIQUE: High resolution probe **(7-15MHZ)**.

1. Be prepared to change frequency output of probe to adequately assess both superficial and deeper structures.





D. Appendix is highly sonographer dependent.



1. Transducer in transverse position, applying deep graded compression to displace the gas & bring the bowel closer to the probe.

2. Beginning at the hepatic flexure the bowel is traced down to the caecum.

3. The patient should point to the location of pain.

4. Include the entire pelvis of all females with right lower quadrant

5. Scan the renal and biliary systems of all patients with a normal appendix.

6. The external iliac artery and vein can provide a good landmark for finding the appendix b/c of the location & pulsatility, compressible, & having Doppler flow.

E. Findings of Appendicitis

1. Aperistaltic, noncompressible, dilated appendix (> **6mm** outer diameter)

2. Echogenic inflammatory periappendiceal fat change

3. Wall thickness can measure almost 3 mm or greater

4. Distinct appendiceal wall layers, Target appearance (axial section)

5. Appendicolith may be present which will cast an acoustic shadow.

6. Requires demonstration of it being blind ending and arising from the base of the caecum

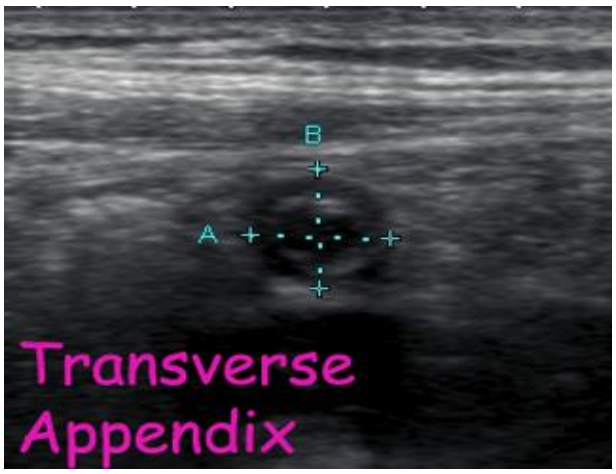
7. Perforated appendix: Hyperechoic with an echo-poor abscess surrounding the appendix.

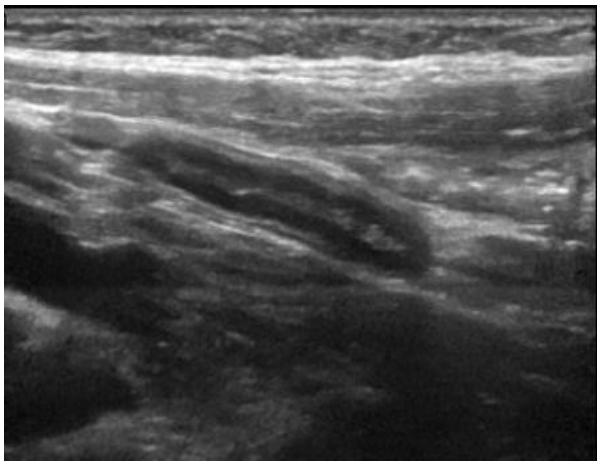
8. May be a reflective omentum around the appendix, thickened bowel, & enlarged lymph nodes.

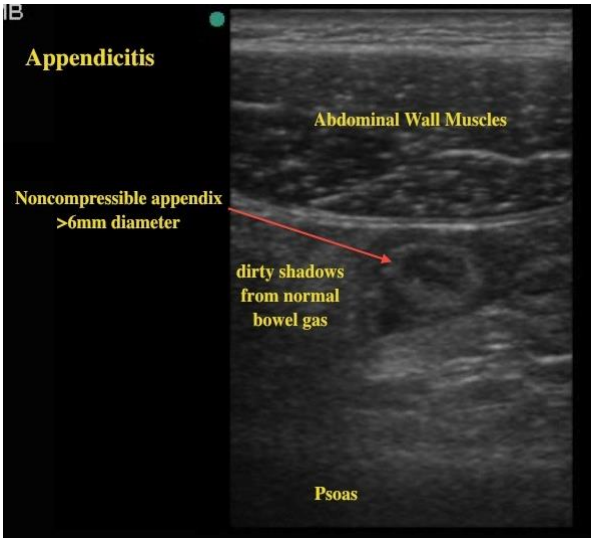
9. Asymmetrical wall thickening may indicate perforation.

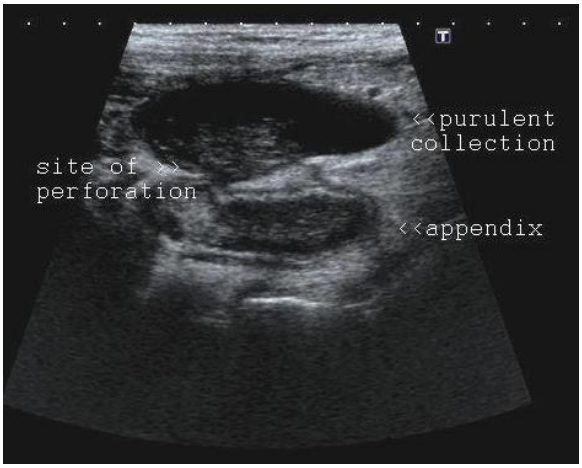
10. Fluid in the periappendiceal region

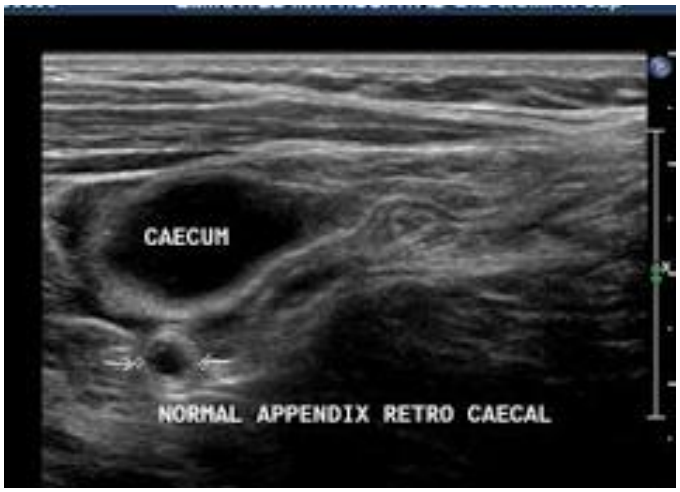
Abdominal US









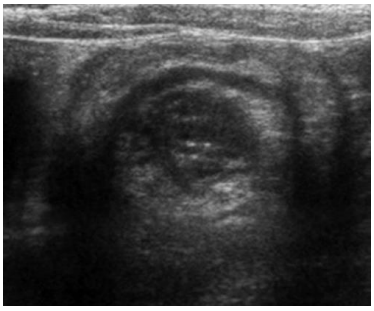


Video Appendix Sono 3

https://www.youtube.com/watch?v=1IoD9aY2gOM

Abdominal US

Intussusception

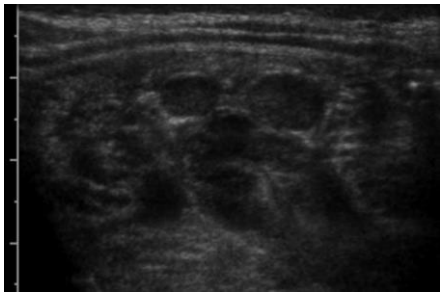


Ultrasound signs include:

A. **Target sign** also known as the **doughnut sign** or **bull's eye sign**.

1. The appearance is generated by concentric alternating echogenic & Hypoechogenic bands.

2. The echogenic bands are formed by mucosa & muscularis whereas the submucosa is responsible for the hypoechoic bands



B. **Pseudokidney** is an ultrasound finding in some cases.

1. It refers to the longitudinal ultrasound appearance of the Intussuscepted segment of bowel which mimics a kidney.

2. The fat-containing mesentery which is dragged into the intussusception, containing vessels, is reminiscent of the renal hilum, with the renal parenchyma formed by the edematous bowel.

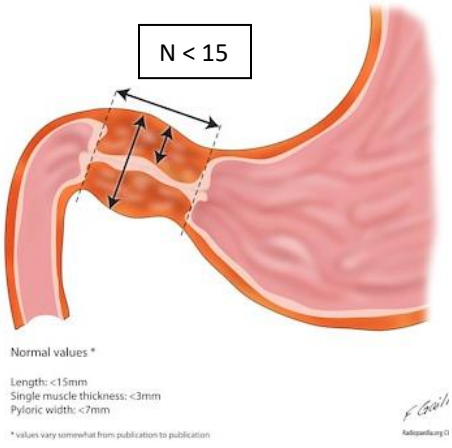
Pyloric Stenosis

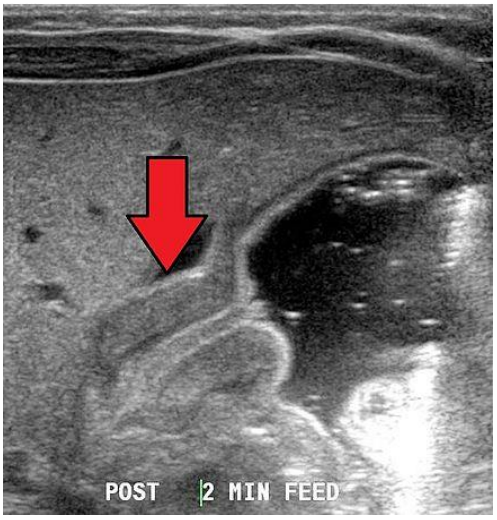
A. ultrasound technique is to find gallbladder then turn the probe obliquely sagittal to the body in an attempt to find pylorus longitudinally.

B. The hypertrophied muscle is hypoechoic, & the central mucosa is hyperechoic. Dx measurements include (mnemonic "number pi"):

- pyloric muscle thickness, i.e. diameter of a single muscular wall on a transverse image: >3 mm (most accurate [3])
- length, i.e. longitudinal measurement: >15-17 mm - NORMAL Less than 15 mm
- pyloric volume: >1.5 cc
- pyloric transverse diameter: >13 mm

With the patient right side down the pylorus should be watched and should not be seen to open.



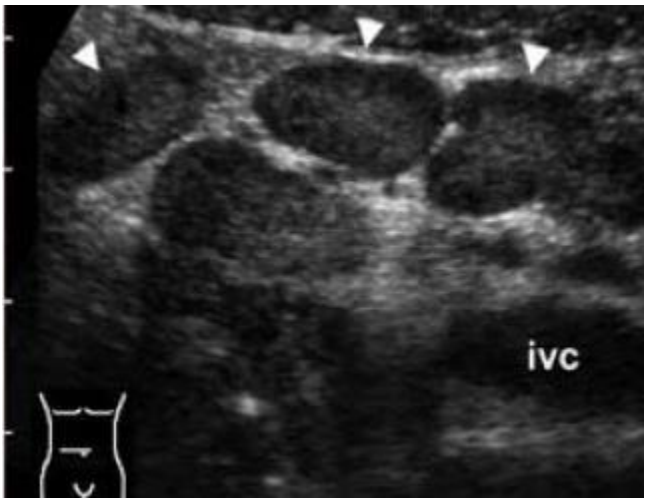


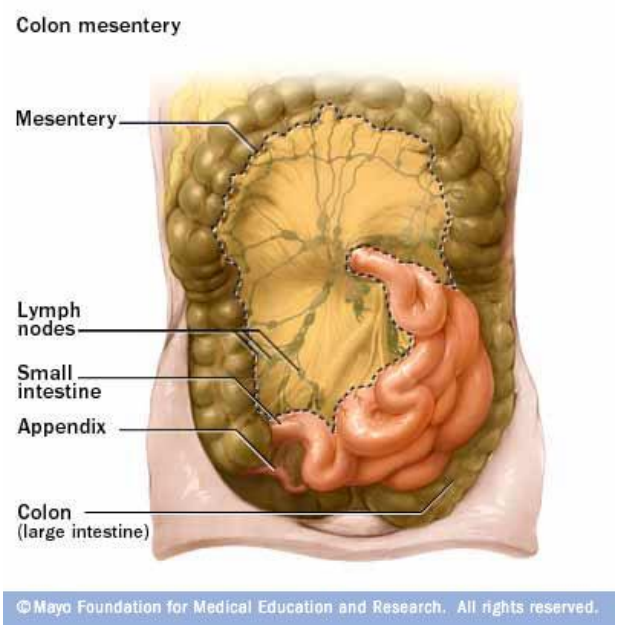
Abdominal

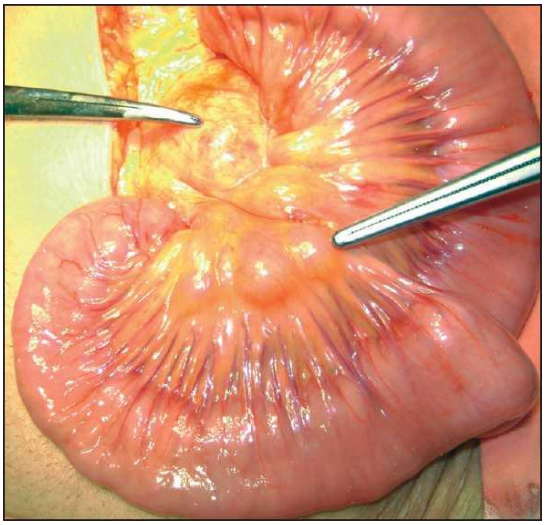
Mesenteric Adenitis

- Enlarged lymph nodes
  - 3 or more nodes with a short-axis diameter of at least 5 mm clustered in the right lower quad
    - enlarged lymph nodes are located anterior to the right psoas in the majority of cases, or in the small bowel mesentery.
- Ileal or ileocecal wall thickening may be present
  - wall is thicker than 3 mm over at least 5 cm of the bowel despite bowel lumen opacification & distention
- A normal appendix (if able to be identified)

A 14 year old boy with mesenteric adenitis. Sonogram of the right lower quadrant shows a cluster of enlarged mesenteric lymph nodes (arrowheads). The appendix was normal (not shown) and no other abnormalities were found







Pelvic Ultrasound

Bladder – should be included in Renal Ultrasound. Evaluate when full.

A. Volume (ml) = A x B x C x 0.5

1. Pre and post void residual

B. Bladder wall normal < 4 mm

1. Wall thickening:

a. Localized: CA, adjacent diverticulitis.

b. Generalized: Cystitis, Bladder outlet obstruction, neurogenic bladder.

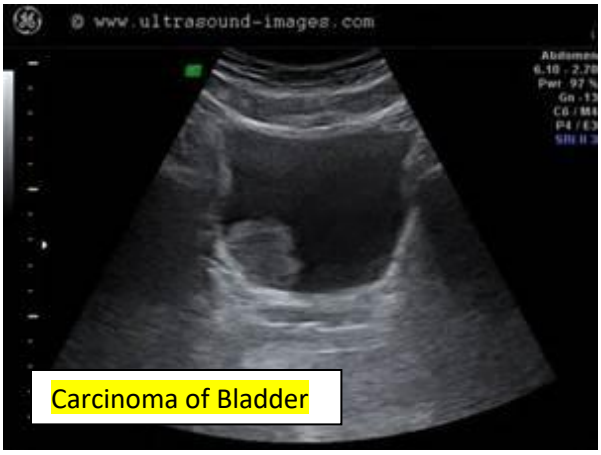
Prostate

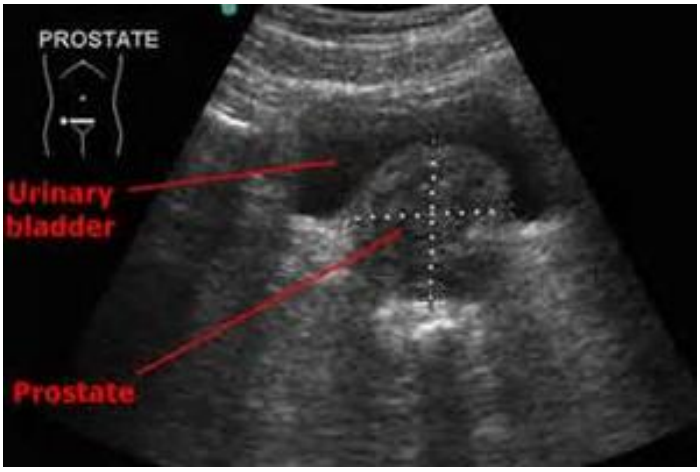
A. Volume = A x B x C x 0.5. Normal less than 25 ml

1. Enlarged prostate elevates and indents the floor of the bladder.

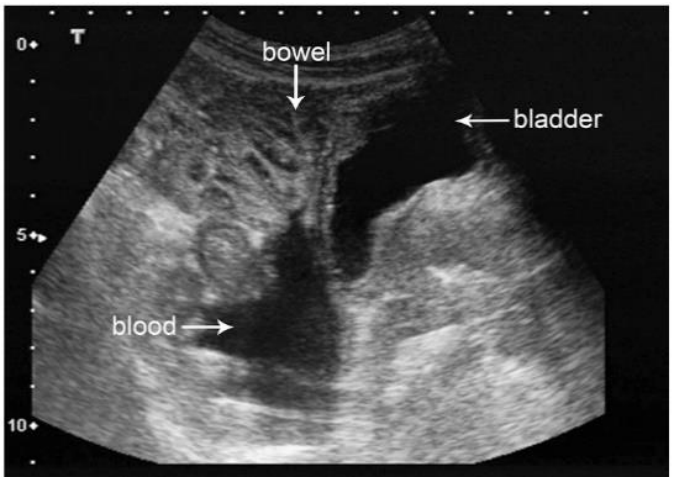
2. Increasing urethral compression can lead to hypertrophy of the musculature of the bladder wall.

B. Prostate CA: typically arises in the peripheral zone of the gland.





Free Fluid: Pouch of Douglas



Pelvic Ultrasound

Uterus:

A. Length, Width, Diameter

1. Postmenarchal nulliparous uterus is 5-8 cm in length, 1.5-3 cm thick, 2.5-5cm wide.

2. Parous: 8-11 x 6 x 4 cm

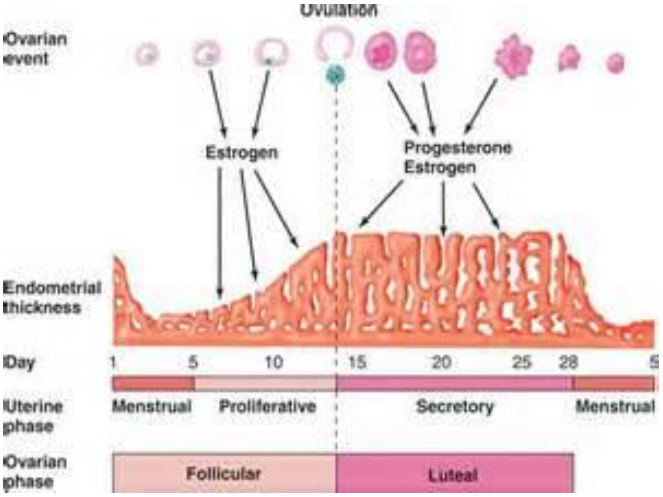
3. Post – menopausal: 4-6 x 2 x 2 cm

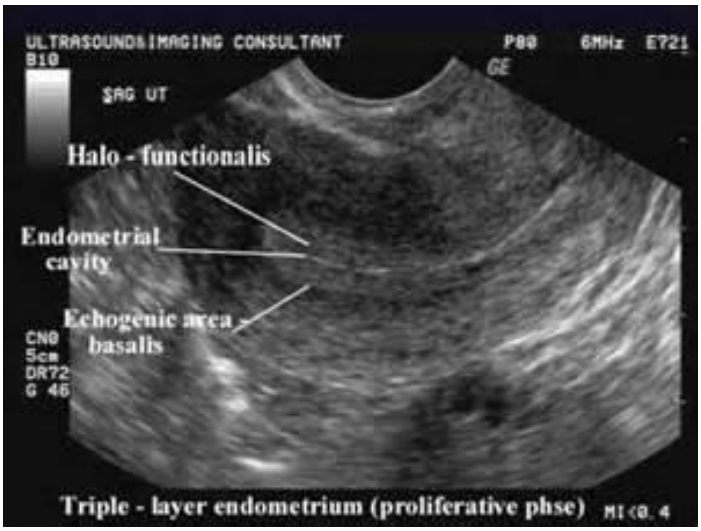
B. Myometrium: hypoechoic, homogeneous, & reasonably demarcated from the endometrial echos

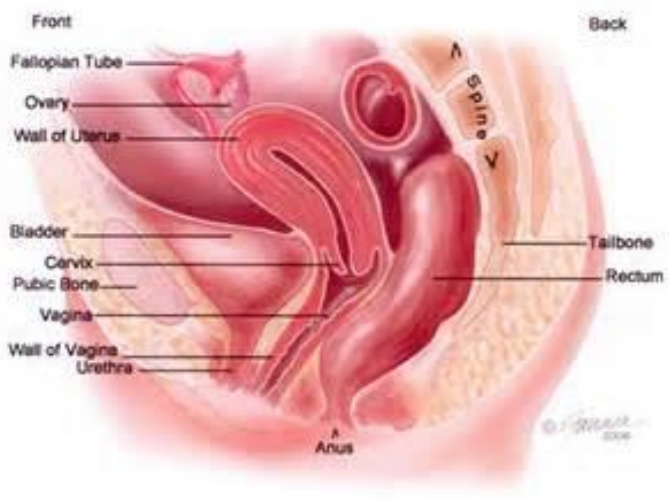
C. Endometrial Stripe: Anterior hyperechoic border, to posterior hyperechoic border.

1. Thickest portion in a mid-sagittal (longitudinal) view.

2. Post menses: 2-4 mm, Proliferative phase: < 8 mm, Secretory: < 15 mm, Post Menopausal: < 3-5 mm



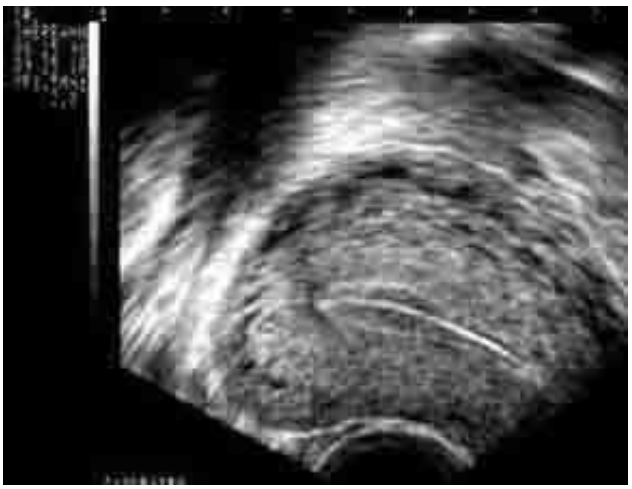




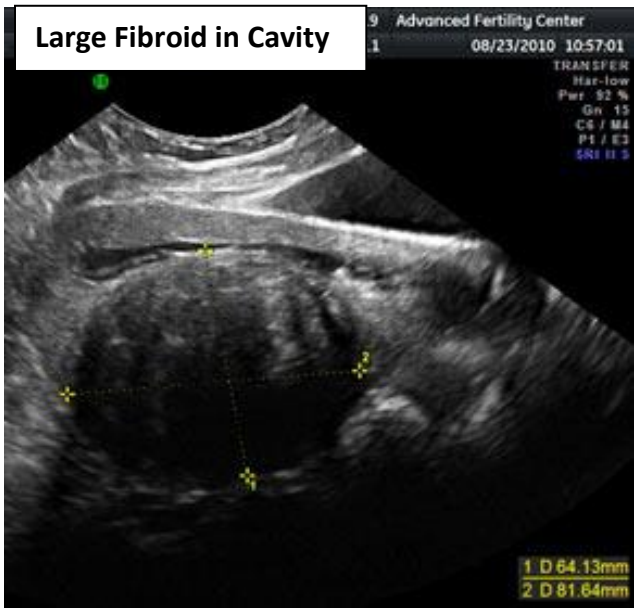
Pelvic Ultrasound

Uterus: Continued

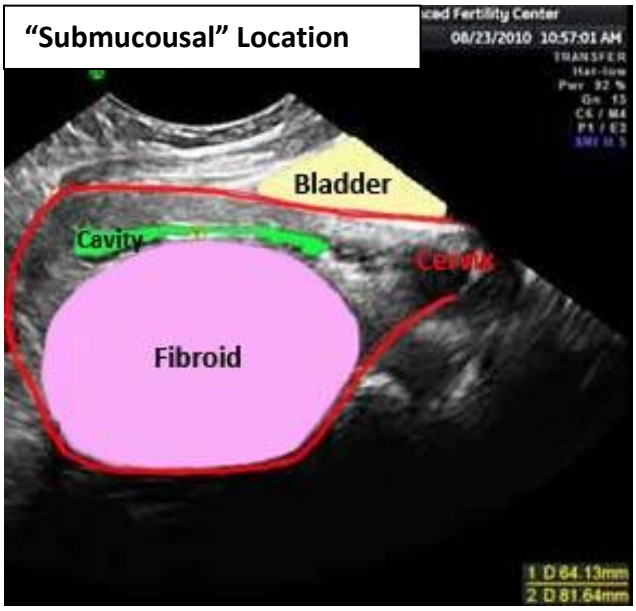
Uterus with a normal endometrial lining and no myomas visible. Image on right shows the uterus outlined in blue and the "triple stripe" uterine lining (landing pad for the embryos) outlined in yellow.



Large Fibroid in Cavity



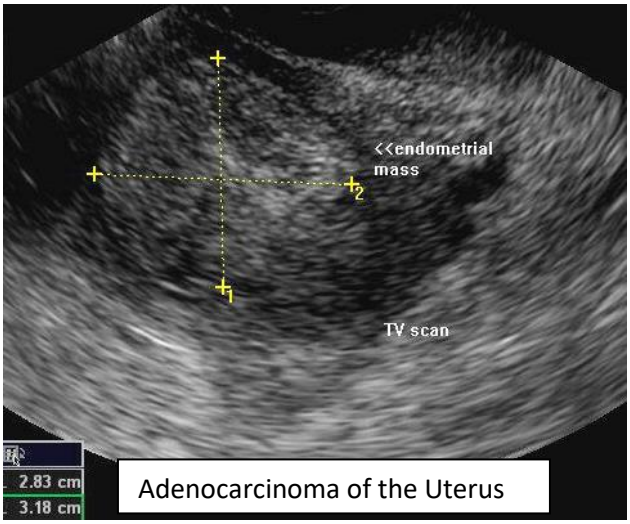
"Submucousal" Location



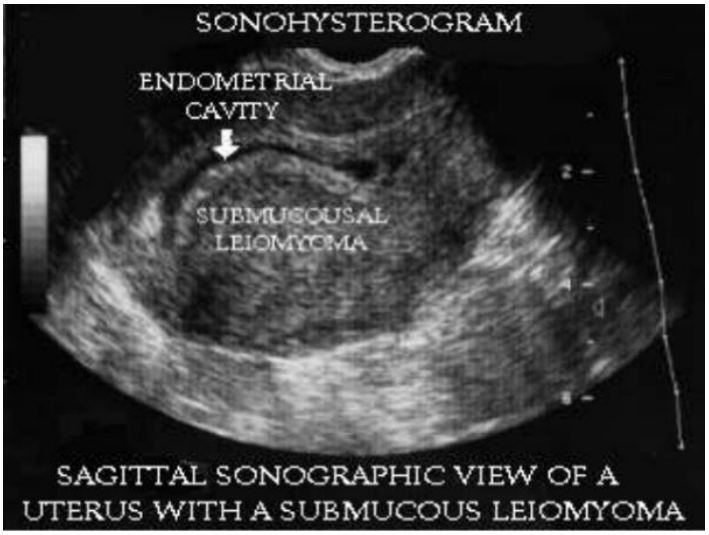
Endometrial Cancer: High-risk tumors Vs Low Risk Tumors are:
(1) more irregular endometrial myometrial boarder
(2) larger endometrium – endometrial thickness > 3, 5, 12 mm – various cutoffs with various Sensitivities /specificities
(3) non-uniform echogenicity
(4) a multiple, multifocal vessel pattern
(5) moderate or high color score

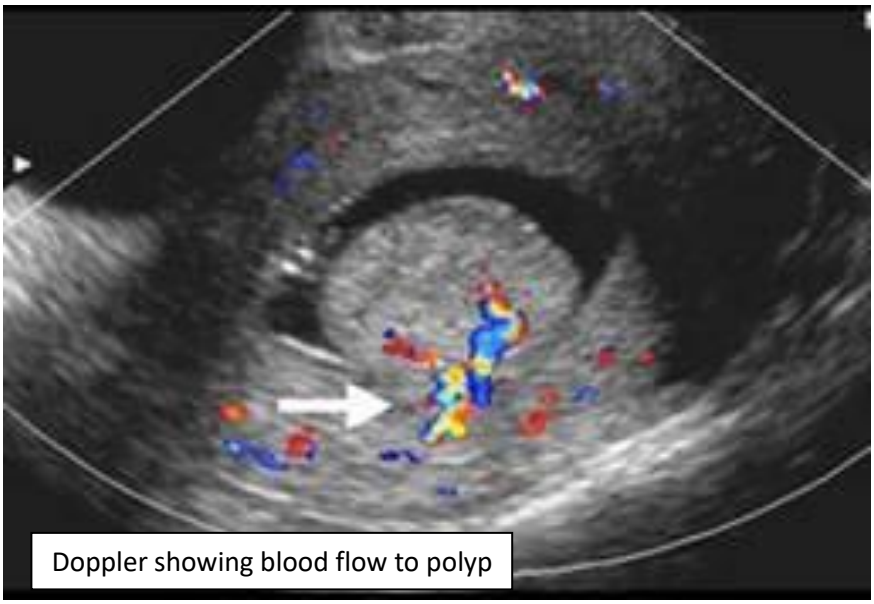
Sonographic evaluation of a uterine mass may identify features suggestive of sarcoma (mixed echogenic and poor echogenic parts; central necrosis; and color Doppler findings of irregular vessel distribution, low impedance to flow, and high peak systolic velocity); however, many of these characteristics may also be found in benign leiomyomas

Pelvic Ultrasound

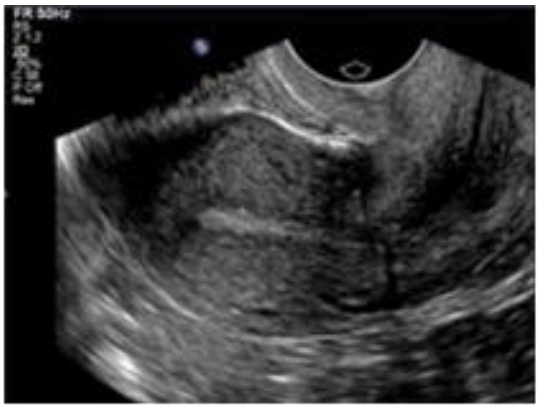


Adenocarcinoma of the Uterus





Doppler showing blood flow to polyp



Normal Uterus

Uterus with Fibroid

Pelvic Ultrasound

Transabdominal & transvaginal US of the uterus in this postmenopausal patient reveals:

1) Grossly thickened endometrium
2) Cystic lesions w/i the endometrial mass
3) invasion of the myometrium by the mass
4,5,6) Incr. Vasc. of the lesion on color doppler

- These US images suggest Stage 1B (FIGO) carcinoma of the endometrium.
  Patient underwent hysterectomy post pathology confirmed the presence of malignancy

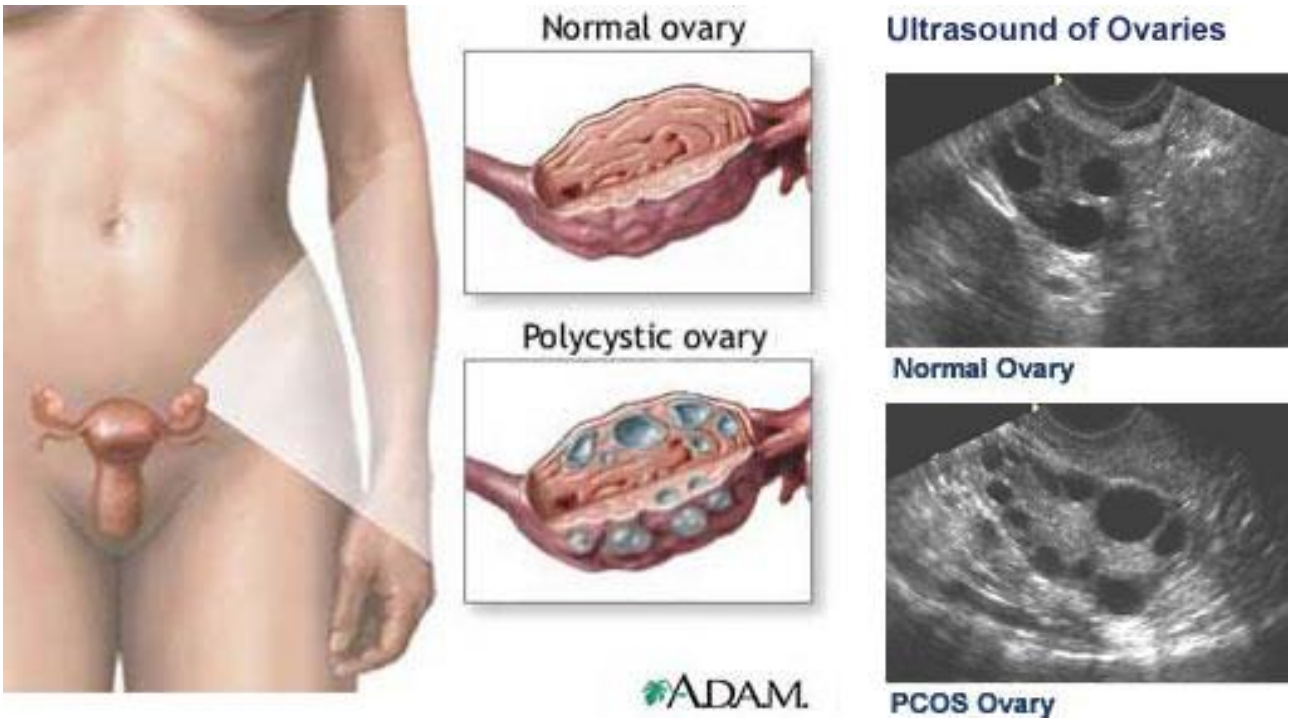
Pelvic Ultrasound

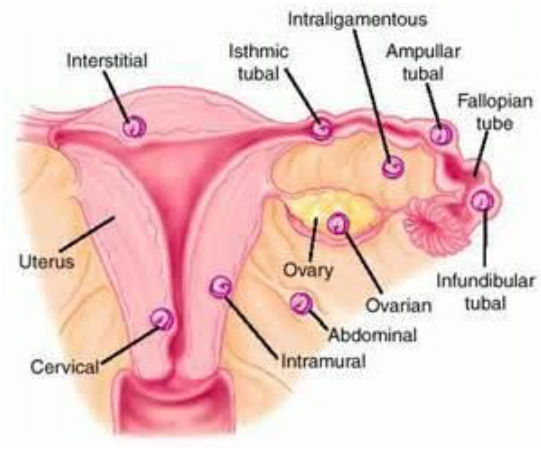
Ovaries: Volume

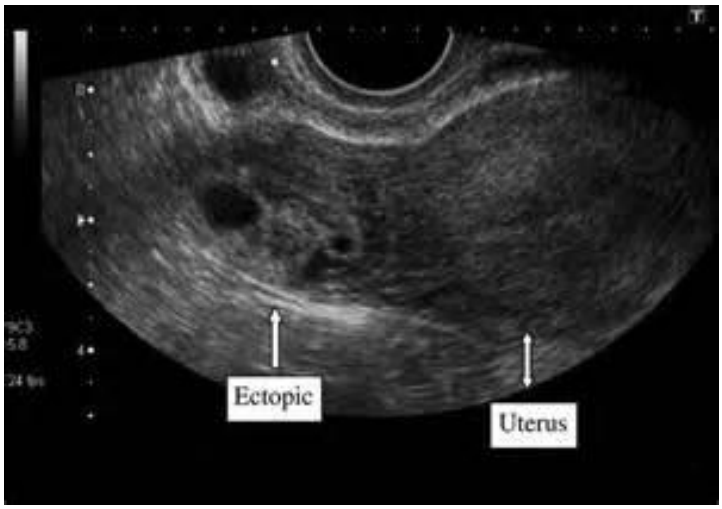
A. Volume (ml) = Length (cm) x Width (cm) x Depth (cm) x 0.52

1. Pre-pubertal: 0 - 8 ml, **2**. Post-pubertal: 0-18ml **3**. Post- Menopausal: 0-8 ml.

B. Difference btwn polycystic & normal ovaries is that although the polycystic ovaries contain many sm. antral follicles w/ eggs in them, follicles do not develop & mature properly - there is no ovulation.







Pelvic Ultrasound

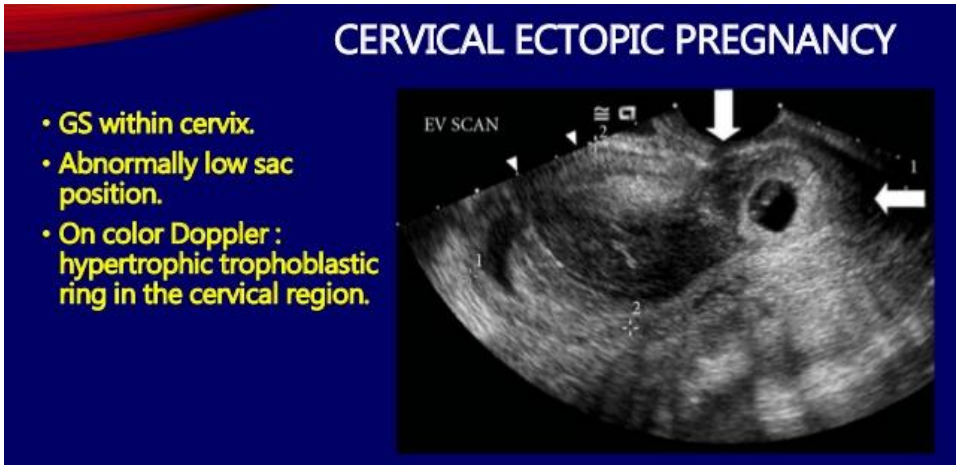
Tubo-ovarian abscess

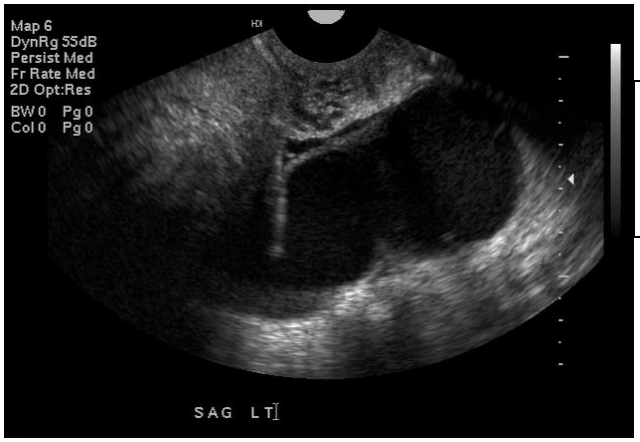
A. Transabdominal and endovaginal ultrasound is the initial imaging modality of choice
B. Often multilocular complex retro-uterine/adnexal mass(es) with debris, septations, & irregular thick walls
C. commonly bilateral, may be echogenic debris in the pelvis

Transvaginal US image left adnexa showing a **tuboovarian abscess.**

1. A complex solid and cystic mass is identified in the left adnexa.

2. The tuboovarian abscess is seen as a complex cyst (large arrow) and fluid filled tube (short arrow)





Anechoic tubular structures in the adnexa; c/w hydro-salpinx.

Ovaries

Polycystic ovarian syndrome (PCOS), anovulation syndrome associated with androgen excess.

A. AAFP https://www.aafp.org/afp/2016/0715/p106.html

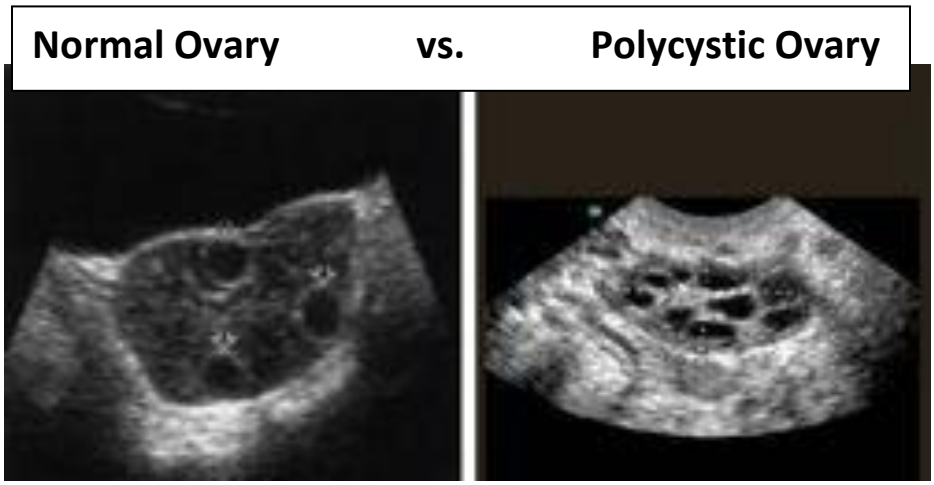
A polycystic ovary is defined as an ovary containing 12 or more follicles (**or 25 or more follicles using new ultrasound technology**) measuring 2 to 9 mm in diameter or an ovary that has a volume of greater than 10 mL on ultrasonography. A single ovary meeting either or both of these definitions is sufficient for diagnosis of polycystic ovaries. However, ultrasonography of the ovaries is unnecessary unless imaging is needed to rule out a tumor or the patient has met only one of the other Rotterdam criteria for PCOS. Polycystic ovaries meeting the above parameters can be found in as many as 62% of patients with normal ovulation, with prevalence declining as patients increase in age.

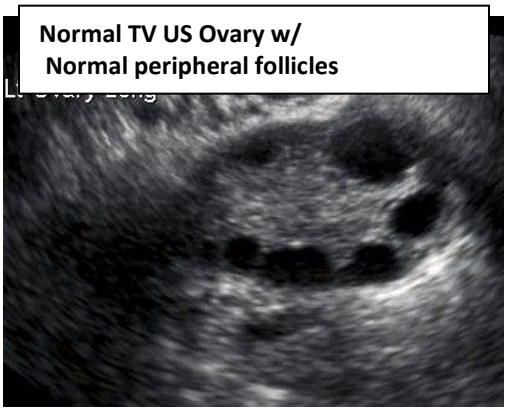
B. The revised 2003 ASRM/ESHRE Rotterdam consensus criteria require 2 of the following 3 criteria for the Dx: (1) oligo- or anovulation (2) hyperandrogenism (clinical or biochemical) & (3) follicle count on imaging. As well as the exclusion of other aetiologias, such as congenital adrenal hyperplasia, Cushing syndrome and/or an androgen-secreting tumour.

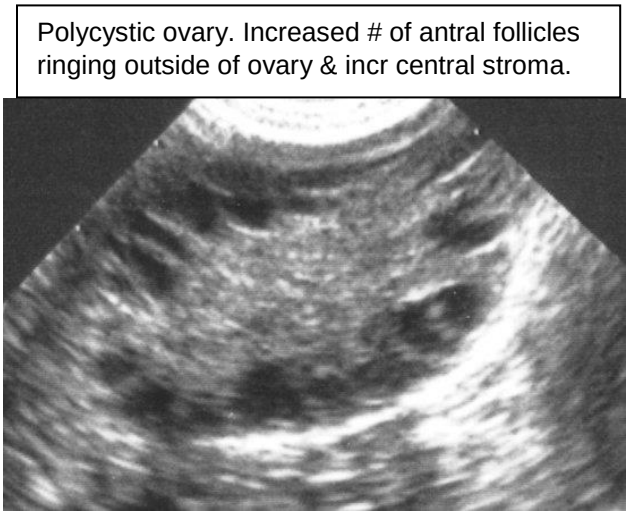
Other morphological features include:

- hyperechoic central stroma
- peripheral location of follicles: which can give a string of pearl appearance
- follicles of similar size measuring 2-9 mm

Ovaries may be normal in PCOS, and conversely, polycystic ovaries may be seen in women **without** the syndrome. Diagnosis requires correlation with features of hyperandrogenism & oligo-anovulation.



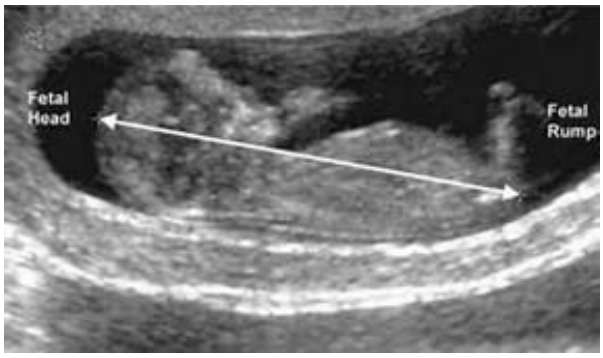




Obstetrical

if only one ultrasound during pregnancy: 18-22 weeks is the best

General



A. Number/Position

B. Placenta Location: Low lying (distance from Cervix)

C. Intrauterine/Extra-uterine

D. Viability

Dating: earlier is better

A. CRL: Crown Rump Length up to 12 - 14 weeks

1. Up to 84 mm then use BPD/HC/FL/AC

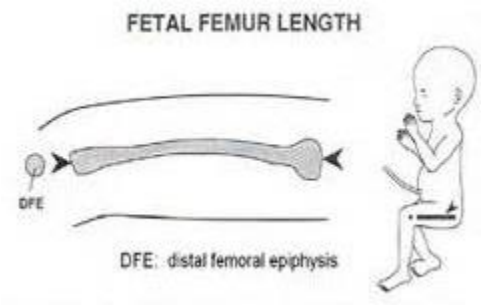
2. CRL > 7 cm should see cardiac activity

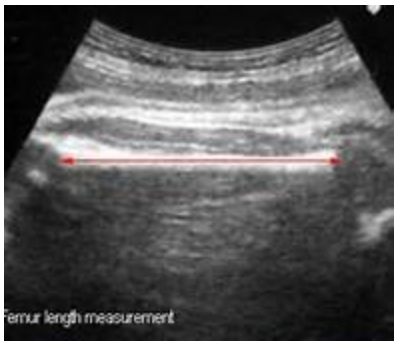
B. Bi Parietal Diameter (BPD): Outer to Inner

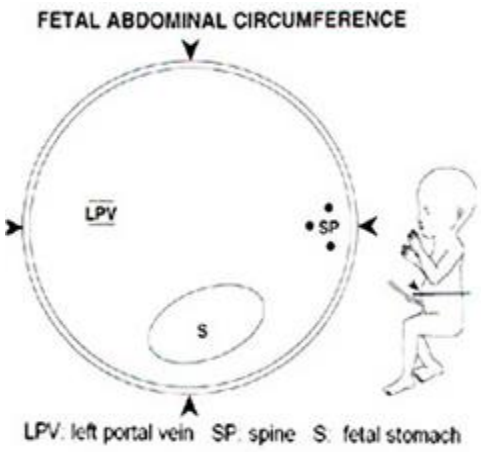
C. Head Circumference **-** Same landmarks as BPD but outer portion of Calvarium

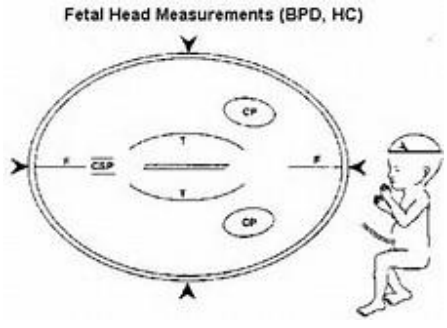
D. Abdominal Circumference – spine, stomach, portal vein

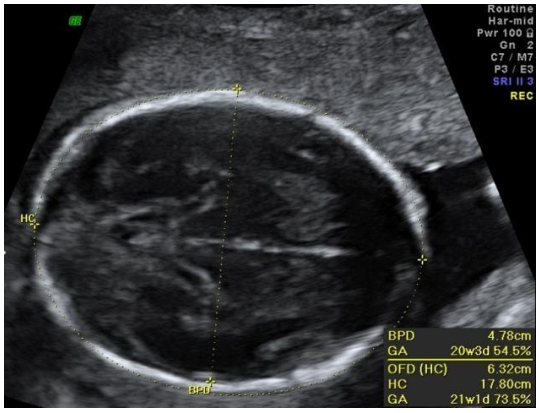
E. Femur









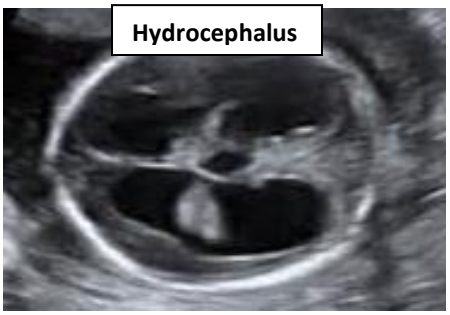


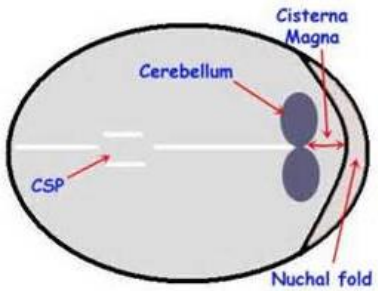
Obstetrical

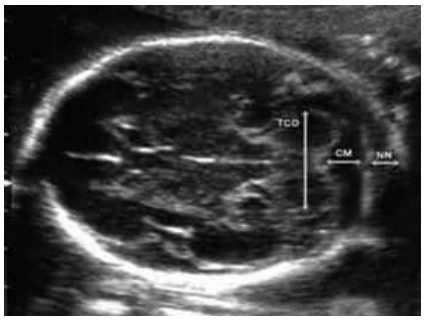
Fetal Anatomic Survey (FAS) "Head to Toe"

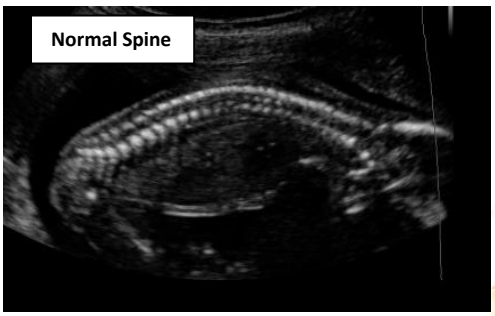
A. Fetal heart: left atrium closest to fetal spine. Position, 4 chambers, outflow tracts, rate

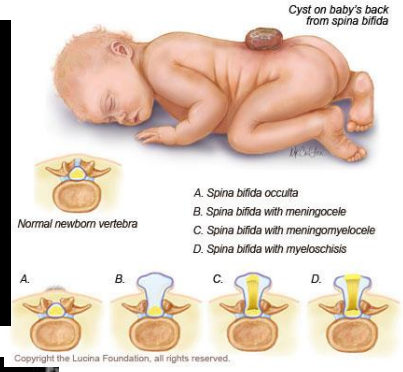
B. Brain: Cisterna Magna> 1 cm, Lateral Vent. > 1cm, A nuchal skin fold thickness of ≥6 mm: **abnormal** btw 14-21 wks

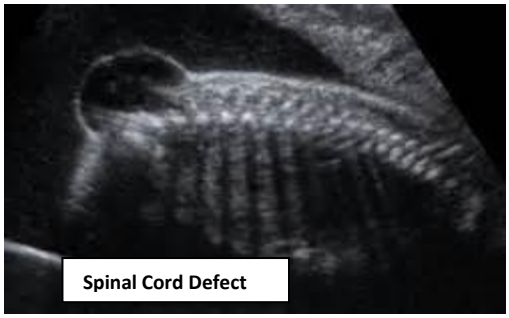


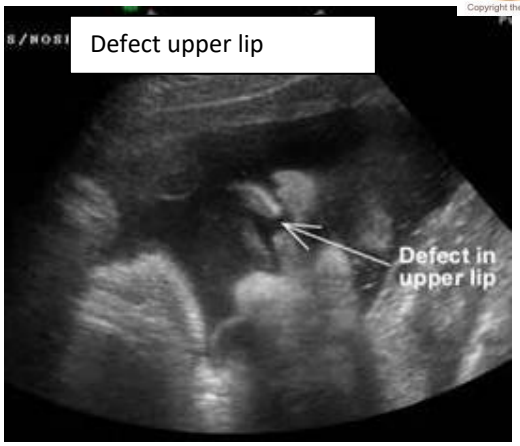


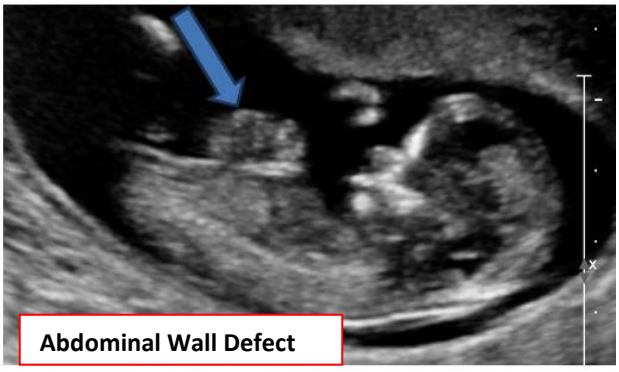












Obstetrical

Biophysical Profile (BPP): to ascertain fetal well being

Biophysical Variable	Normal (Score = 2)	Abnormal (Score = 0)
Fetal breathing movements	1 or more episodes of ≥20 s within 30 min	Absent or no episode of ≥20 s within 30 min
Gross body movements	2 or more discrete body/ limb movements within 30 min (episodes of active continuous movement considered as a single movement)	<2 episodes of body/limb movements within 30 min
Fetal tone	1 or more episodes of active extension with return to flexion of fetal limb(s) or trunk (opening and closing of hand considered normal tone)	Slow extension with return to partial flexion, movement of limb in full extension, absent fetal movement, or partially open fetal hand
Reactive FHR	2 or more episodes of acceleration of ≥15 bmp* and of >15 s associated with fetal movement within 20 min	1 or more episodes of acceleration of fetal heart rate or acceleration of <15 bmp within 20 min
Qualitative AFV	1 or more pockets of fluid measuring ≥2 cm in vertical axis	Either no pockets or largest pocket <2 cm in vertical axis

●10/10, 8/8 (nonstress test not done), or 8/10 (including +2 points for amniotic fluid)

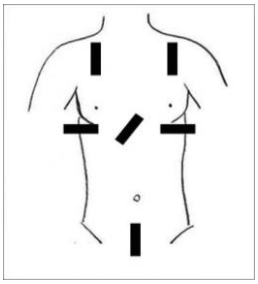
normal test result: BPP score of 8/10 by any combination of parameters is as reliable as a score of 10/10 for the prediction of fetal well-being as long as no points are deducted for amniotic fluid vol.

●6/10 (including +2 points for amniotic fluid) is an equivocal test result, as a significant possibility of developing fetal asphyxia cannot be excluded. US repeated w/I 24 hours to see if one of the absent acute variables returns to normal or, if pt. is at or near term, delivery is a reasonable option.

●6/10 or 8/10 with oligohydramnios (0 points for amniotic fluid) is an abnormal test, as the risk of fetal asphyxia within one week is 89/1000 with expectant management. These scores should be interpreted within the context of GA (eg, neonatal morbidity & mortality if the fetus is delivered) & maternal & obstetric factors (eg, risk of fetal death related to maternal, fetal, or obstetric disorder if the fetus is not delivered; whether cervix is favorable; maternal risks from continuing the pregnancy).

●0 to 4/10 Abnormal ; risk of asphyxia w/i 1 wk is 91 to 600/1000 w/ no intervention. Delivery usually indicated.

EFAST Exam



Extended Focused Assessment Sonography Trauma (EFAST Exam)

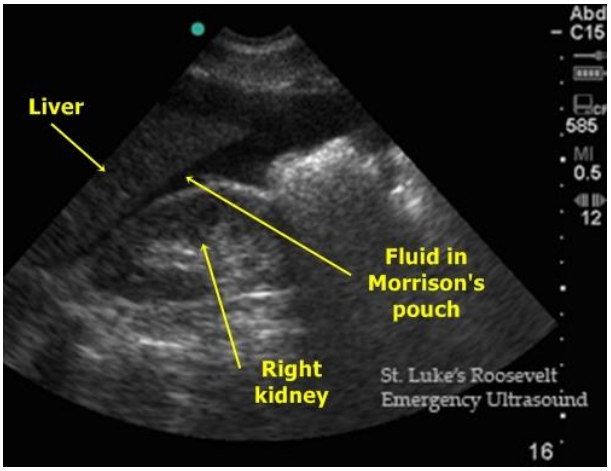
A. Thoracic View: Pneumothorax, Pleural effusion

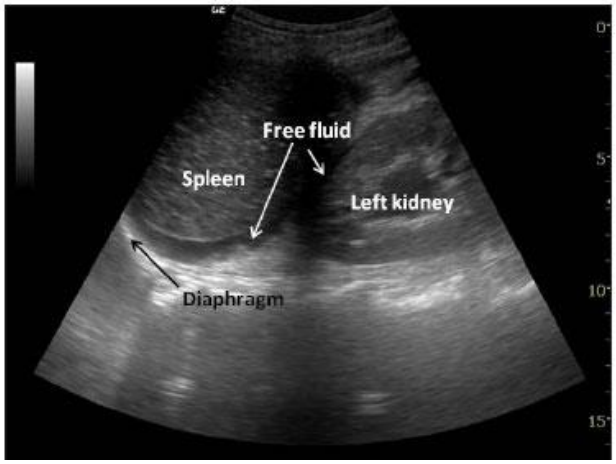
B. Hepatorenal: Morrison Pouch

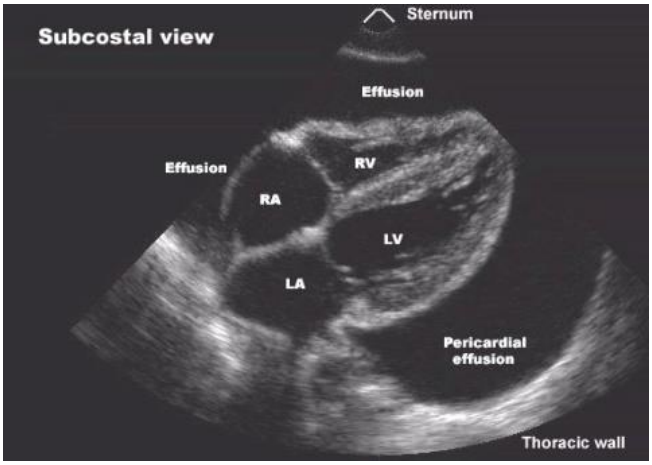
C. Pericardial/SubXiphoid: Pericardial Effusion

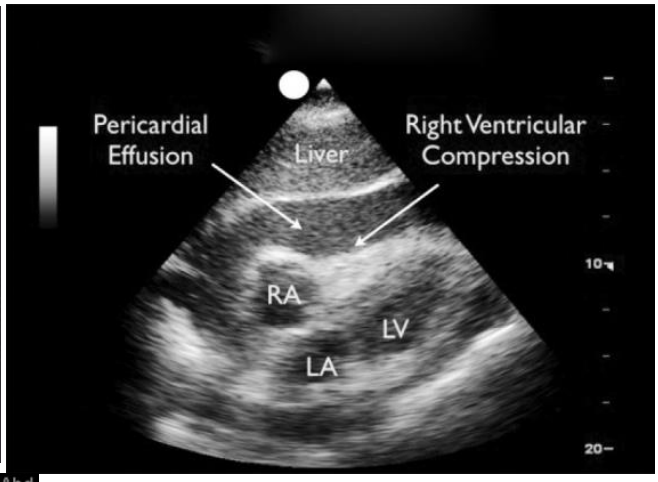
D. Splenorenal: Perisplenic

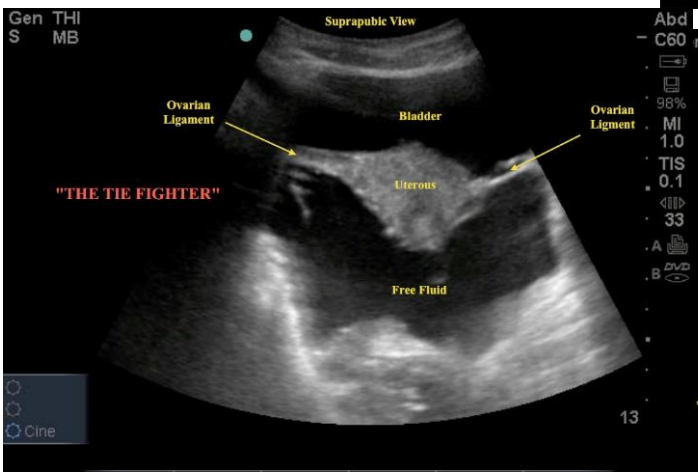
E. Suprapubic: Pouch of Douglas

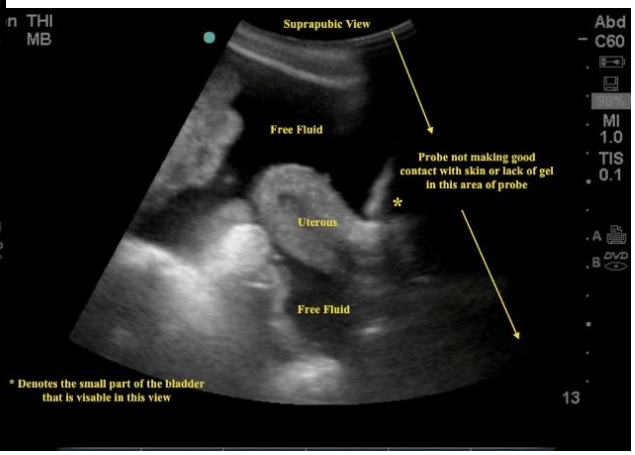












EFAST Exam

Pneumothorax: A straight linear array high frequency probe (5–13 MHz)

A. Probe @ 2nd or 3rd ICS in the mid-clavicular line in a sagittal orientation, & slide the probe caudally for eval. of a pneumothorax.

B. The upper rib/pleural line/lower rib profile has the appearance of a bat flying out of the screen and is referred to as the bat sign.

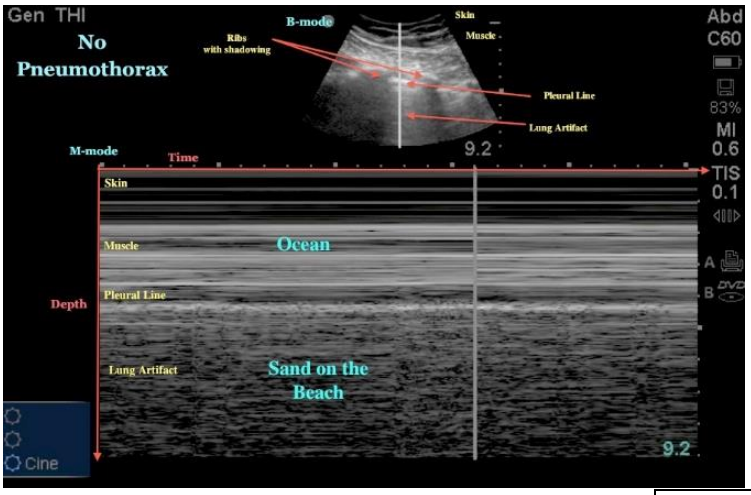
C. At the inferior edge of the thoracic cage, slide the probe laterally at the level of the 6th ICS in the anterior axillary line.

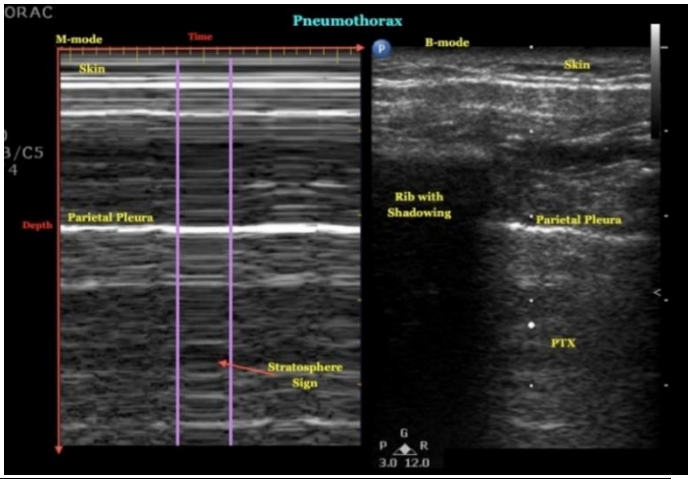
***B*- *Mode*:** Directly underneath the ribs is the pleural line: **Normal:** pleural line shimmers "*ants marching* in a line"

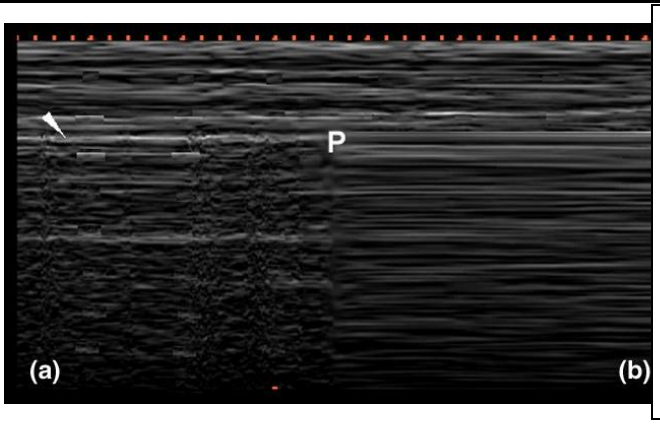
1. **Pneumothorax**: "dead line", no mvt. Chest wall will still move (Don't think Chest Wall mvt is pleural line mvt)

M mode images are an easy way to look for pneumothorax

1. Normal: Seashore sign: lines of the chest wall followed by granularity below pleural line.
2. Pneumothorax: Barcode sign: nothing but lines for the whole image, means there's a pneumothorax

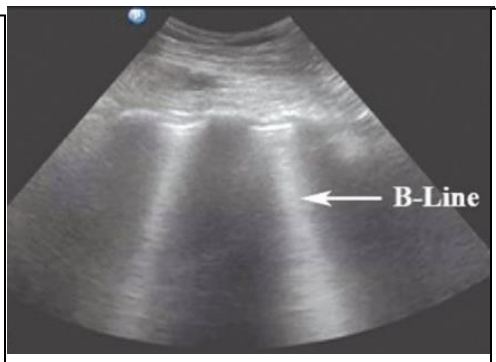






(a) Normal lung & **(b)** pneumothorax patterns using M-mode lung US. In M- mode, 1st find the pleural line (white arrow) &, above it, the motionless parietal structures. Below the pleural line, lung sliding appears as a homogenous granular pattern (**a**). With a pneumothorax & absent lung sliding, horizontal lines only are visualized (**b**). In a pt. examined in the supine position w/ partial pneumo, normal lung sliding & absence of lung sliding may coexist in lateral regions of the chest wall. In this boundary region, called the 'lungpoint' (**P**), lung sliding appears (granular pattern) & disappears (strictly horizontal lines) w/ inspiration when using M-mode.

'B-lines' or 'comet-tail artifacts' originating from the bright white hyperechoic pleural line, extending vertically to the edge of the screen. 'B-lines' move in synchrony with the sliding pleura in a normal well-aerated lung. ONLY seen w/ intact pleura. If you see this, there is no pneumothorax!



Pleural sliding is the most important finding in normal aerated lung. Visualize hyperechoic pleural line in between two ribs moving or shimmering back & forth. Lung sliding corresponds to the to-&-fro mvt. of the visceral pleura on the parietal pleura that occurs w/ respiration.

Other

A. M-mode or TM-mode (time motion) is used to analyze moving structures, (eg: heart valves.)

B. Ultrasound refers to use of sound waves of ultra high frequency 2-20 million Hertz

C. USG Probe: made of piezoelectric crystals capable of producing ultra high frequency sound waves.
- **1**. Transducer is also referred to as a probe.
- **2**. Types: curvilinear probe, linear probe, endovaginal probe & endorectal probe.

D. USG coupling gel: The interface between the transducer/skin is filled by air which can reflect the US waves emerging from the probes. To circumvent this a coupling gel is used. The transducer, coupling gel and skin have same acoustic impedance

E. Echogenicity: Appearance of various structures on an USG are referred in terms of echogenicity as
- **1**. Hyperechoic – reflect sound waves
- **2**. Hypoechoic. – partly reflect sound waves
- **3**. Anechoeic – absorb sound waves.

F. Posterior Acoustic Enhancement:
- **1.** Increased brightness seen beyond objects that transmit a lot of sound waves is referred to as posterior acoustic enhancement. – Area beyond fluid filled cysts display posterior acoustic enhancement.

G. Posterior Acoustic shadowing:
- **1**. Decreased brightness seen beyond objects that reflect major part of sound waves impinging on them.
- **2**. Tissues lying beyond gall stones exhibit posterior acoustic shadowing.

H. Doppler in Ultrasound:
- **1**. Doppler USG makes use of doppler shift
  - **a**. The variation in the frequency and wavelength of returning sound waves after impinging on a moving object.
- **2**. Doppler finds its application in detecting of vascularity of masses, direction of blood flow in vessels, to rule out obstruction in blood vessels, to detect perforator incompetence etc.

I. Reverberation: echoes are reflected partially by interfaces on their way back (internal reflections) or at the surface of the transducer itself. The echo is then reflected for a second time at the interface of its origin but twice the time is needed before it is recorded by the transducer. This may occur several times, the echoes becoming weaker after each reflection.

J**. Pediatric Normal Measurements**

Normal Values of Abdominal Sonography in Pediatrics

(The values for adults are on the other side)

For liver and spleen, the median (m) + 2 SD [cm] is listed in relation to the body size, with the measurements taken in the right or, respectively, left anterior axillary line (thus, for the liver not in the midclavicular line as in adults). The renal length is the length in [cm] in usual percentiles.

Body size	Spleen			Kidney			Liver		
[cm]	$\bar{m}$–2SD	$\bar{m}$	$\bar{m}$+2SD	5%	50%	95%	$\bar{m}$–2SD	$\bar{m}$	$\bar{m}$+2SD
Newborns	2.90	4.07	5.24	3.40	4.16	4.92	3.47	5.53	7.59
< 55	2.13	2.91	3.69	3.00	4.35	5.83	3.40	5.50	7.60
55 – 70	2.44	3.46	4.48	3.60	5.00	6.40	4.53	6.59	8.65
71 – 85	2.23	3.71	5.19	4.50	5.90	7.30	5.48	7.20	8.92
86 – 100	2.61	4.69	6.77	5.30	6.60	7.90	5.98	7.68	9.38
101 – 110	3.02	4.88	6.74	5.85	7.10	8.35	6.76	8.74	10.72
111 – 120	3.38	5.26	7.14	6.35	7.65	8.95	6.56	8.71	10.83
121 – 130	3.37	5.31	6.87	6.90	7.20	9.50	7.38	9.40	11.42
131 – 140	4.10	5.96	7.82	7.40	8.70	10.00	8.63	9.99	11.35
141 – 150	4.61	5.81	7.01	7.90	9.25	10.60	8.48	10.42	12.36
> 150	4.36	6.18	8.00	8.60	9.95	11.30	9.48	11.36	13.24

(Ref.: Dinkel E et al: Kidney size in childhood, Pediatr Radiol (15): 38-43) and Weitzel D: Sonographische Organometrie im Kindesalter, Mainz)

Liver Pathology

Cirrhosis with Ascites: free fluid surrounding the liver

1. Nodular contour to the liver surface.

2. Early on, the liver size may be enlarged.

A. As cirrhosis progresses, the liver becomes increasingly nodular & shrunken.

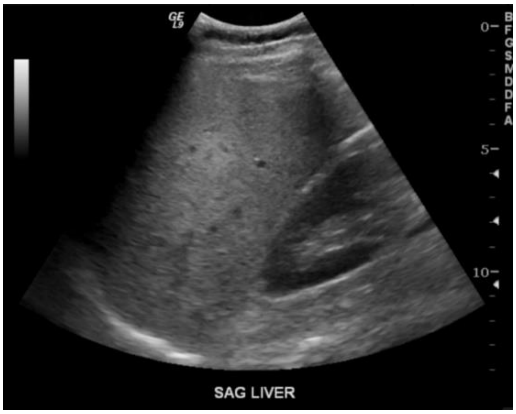
3. Will have a coarse echotexture.

Amoebic Liver Abscess

1. Solitary lesion, but can be multifocal
2. Usually Poorly defined or shaggy walls.
3. Generally, RND/oval, & mostly periphery of RT lobe.
4. typically, hypoechoic w/ fluid content or may present w/ a complex internal echo pattern.
5. Some degree of Post. acoustic enhancement (70–80%)
   Abscess cavity may last for wks or mos post med rx, (avg.7 mo.) In some cases, US changes persist for 12 mo or more, w/o clinical significance.

Hepatic hydatid disease - *Echinococcus* tape worm.

1. Multiseptated cyst with "daughter" cysts and echogenic material between cysts.
2. Appearances can vary. May show a double echogenic shadow due to the pericyst.
3. The stage of the cyst may be classified on U.S., 2001 WHO classification of hepatic hydatid cysts



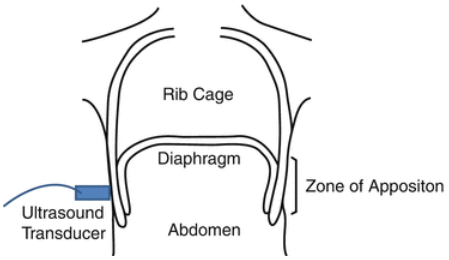
Steato-hepatitis: fatty liver

Three main findings of fatty liver disease on ultrasound are

1) Increased echogenicity as compared to the adjacent kidney (which must be measured at the same depth)
2) Decreased acoustic penetration
3) Decreased conspicuity of the hepatic veins.

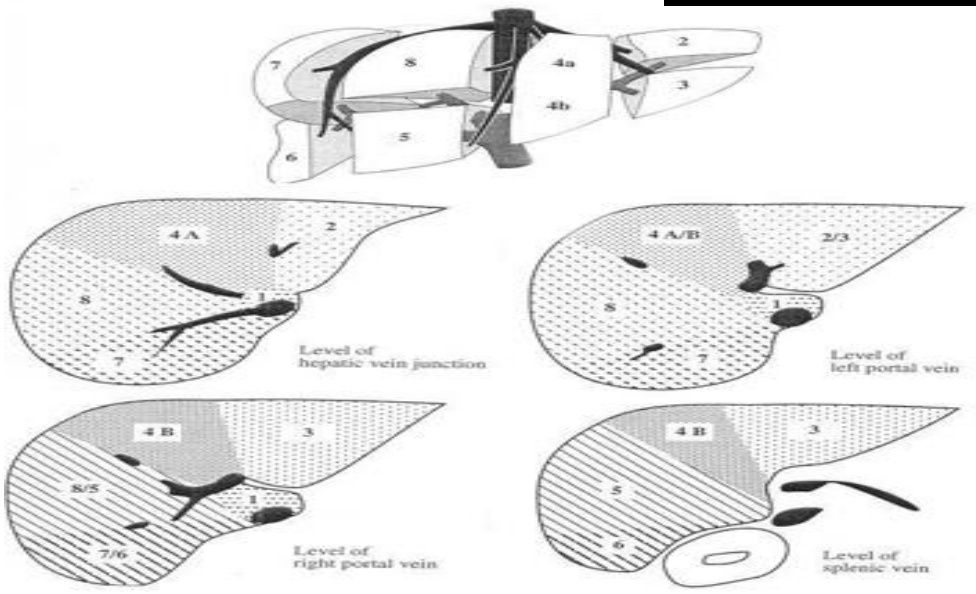
**The liver can be increased in size and certain areas of focal fatty sparing can be noticed, particularly around the gallbladder fossa.

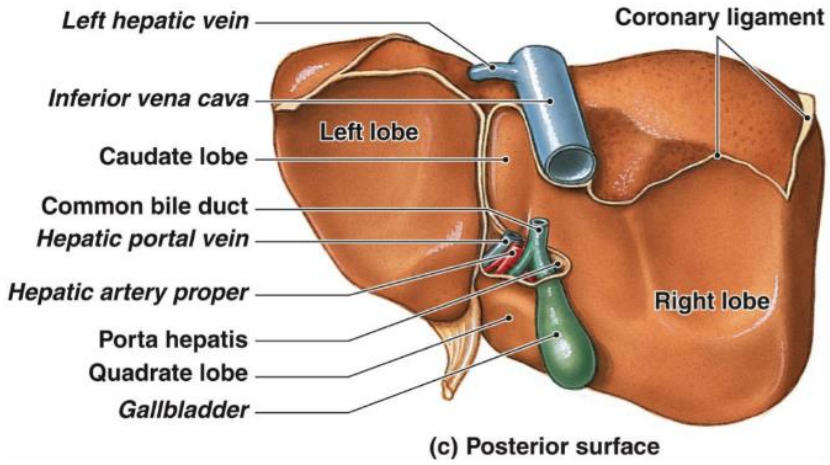
LIVER – fatty liver



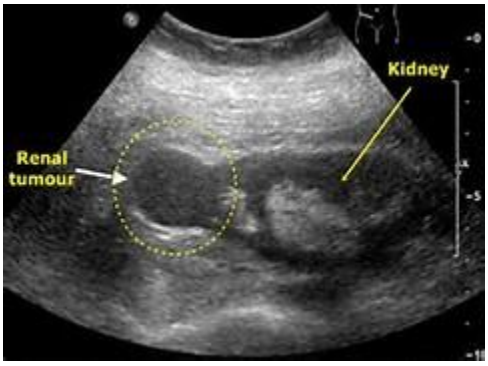
grade I: increased hepatic echogenicity with visible periportal & diaphragmatic echogenicity
grade II: increased hepatic echogenicity with imperceptible periportal echogenicity, without obscuration of diaphragm
grade III: increased hepatic echogenicity with imperceptible periportal echogenicity and obscuration of diaphragm

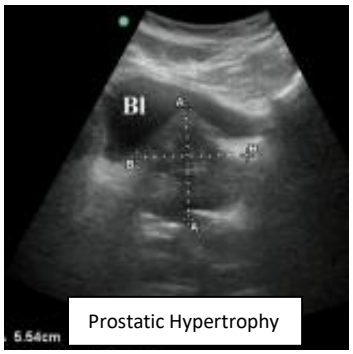
LIVER ANATOMY





Renal Ultrasound Images

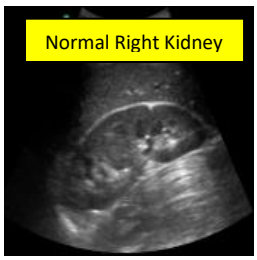


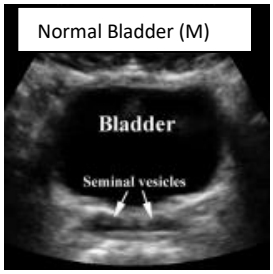


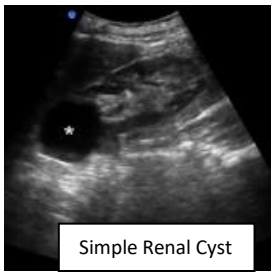
Medullary nephrocalcinosis. MCC are hyperparathyroidism, RTA, & medullary sponge kidney.

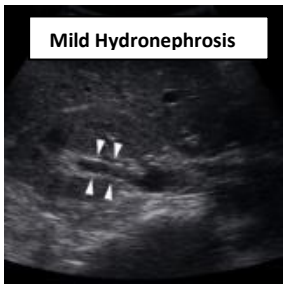
Rarer causes are papillary necrosis, hypercalcemia, hypercalciuria, prematurity, and primary hyperoxaluria.

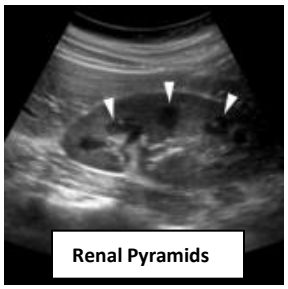
This patient had nephrocalcinosis due to Bartter's Syndrome, a hereditary disorder of ion transporters

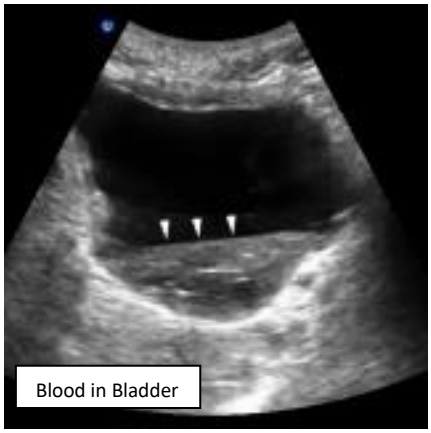






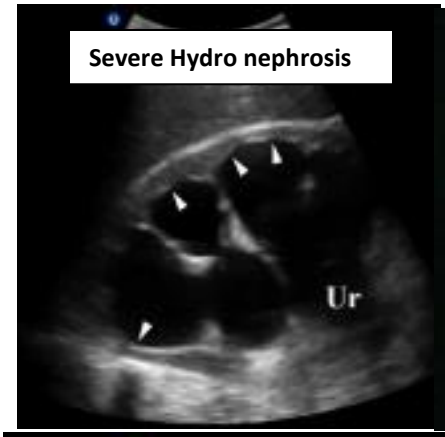


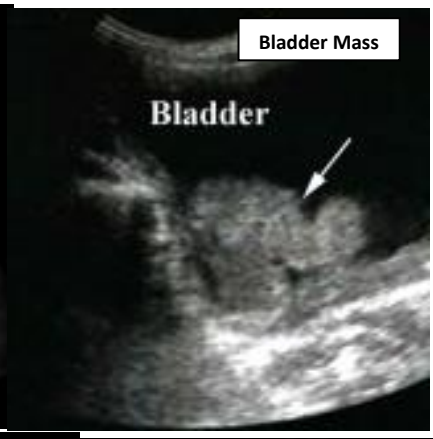


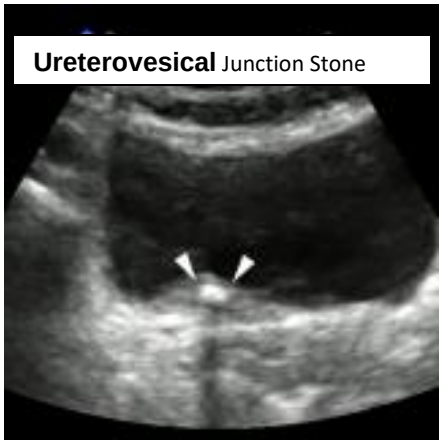


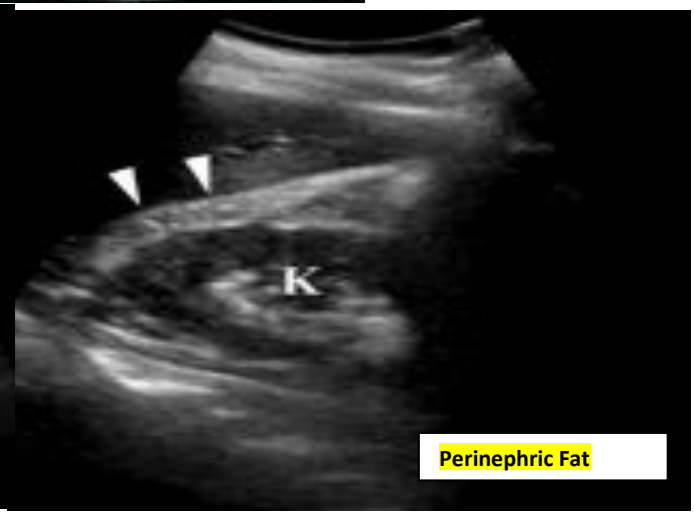
Hydronephrosis — "water inside the kidney" — distension & dilation of the renal pelvis & calyces.

Renal Ultrasound Images

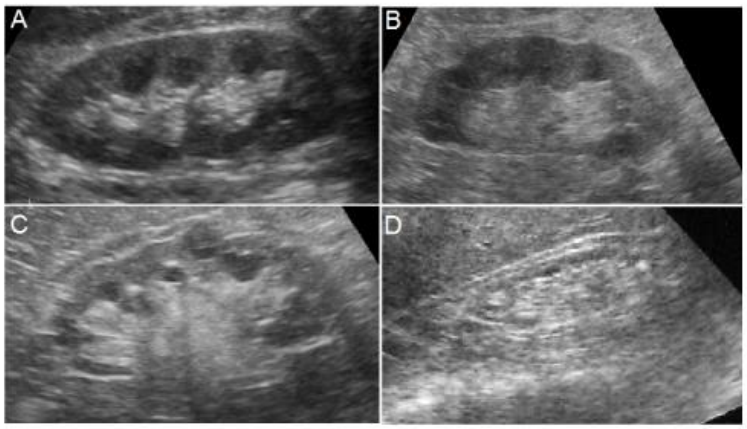








A, B, C, D - Morphological aspect of the kidney with **acute kidney injury** at B-mode renal ultrasound.



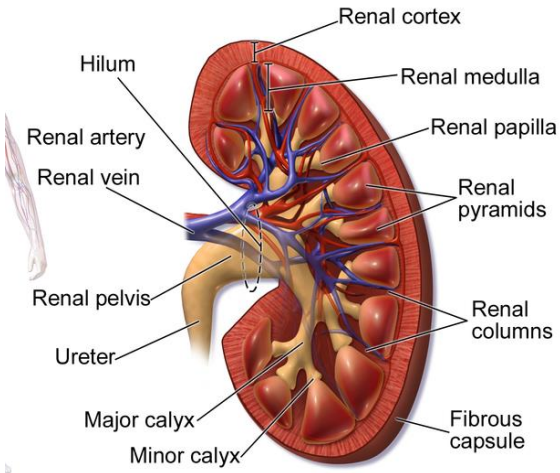
A Normal kidney size, cortical echogenicity, parenchymal thickness & corticomedullary differentiation w/ regular renal profiles.

B Normal kidney size, min. incr. in cortical echogenicity, w/ preserved parenchymal & corticomedullary differentiation. Initial irregularity renal profiles present.

C. Reduction kidney size & parenchyma, cortical hyperechogenicity, w/ poor cortico-medullary differentiation. Irreg. renal profiles. Acute renal deterioration in CKD stage III.

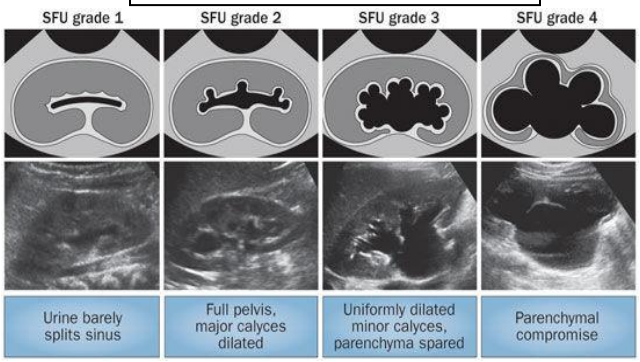
D. Reduction kidney size & parenchyma, strong cortical hyperechogenicity w/ absence in corticomedullary differentiation. Irreg. renal profiles. Acute renal deterioration in CKD stage V

Renal Ultrasound Images

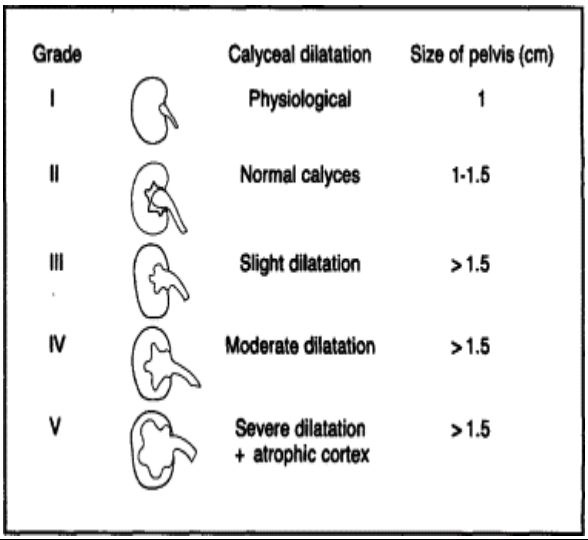


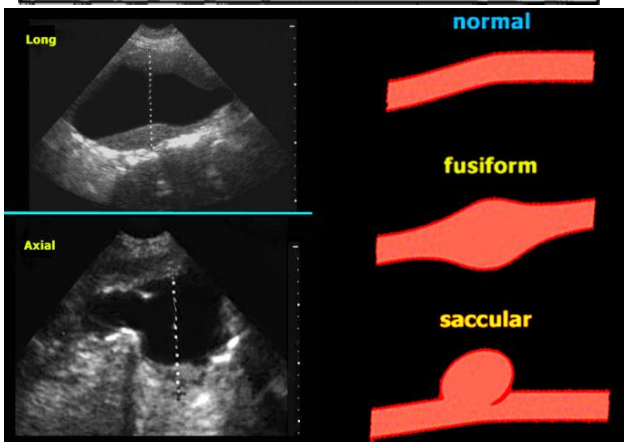
Kidney Anatomy

SFU = Society of Fetal Urology



Hydronephrosis





Sonographic finding of sub-renal aortic saccular aneurysm in a man 75 y/o with worsening

Renal Ultrasound Pitfalls

A. Renal cysts can be mistaken for hydronephrosis. Cysts are typically single & arise in the periphery of the kidney, but can be multiple as in polycystic kidney disease.

B. Collecting system located outside the kidney is termed extrarenal pelvis. This can mimic early hydro-nephrosis but is a normal developmental variant.

C. Overhydrated pt may have mild hydronephrosis w/o obstruction. kidneys show evidence of hydronephrosis.

D. Underhydrated pt. may not have hydronephrosis on US, despite presence of obstruction & renal colic

E. Mild hydronephrosis may be seen in pregnant pt or pt with a full bladder. Both kidneys will appear similar

F. Kidneys w/ chronic disease may not have normal sonographic appearance, making identification difficult

G. An adjacent structure, such as a fluid-filled gallbladder, may be mistaken as renal.

H. Pt. w/ mult. renal cysts may have liver cysts. Perform a US of the liver to screen for liver cysts. Certain forms of PCKD are asssoc. w/ intracerebral aneurysms; follow up is important in these pts.

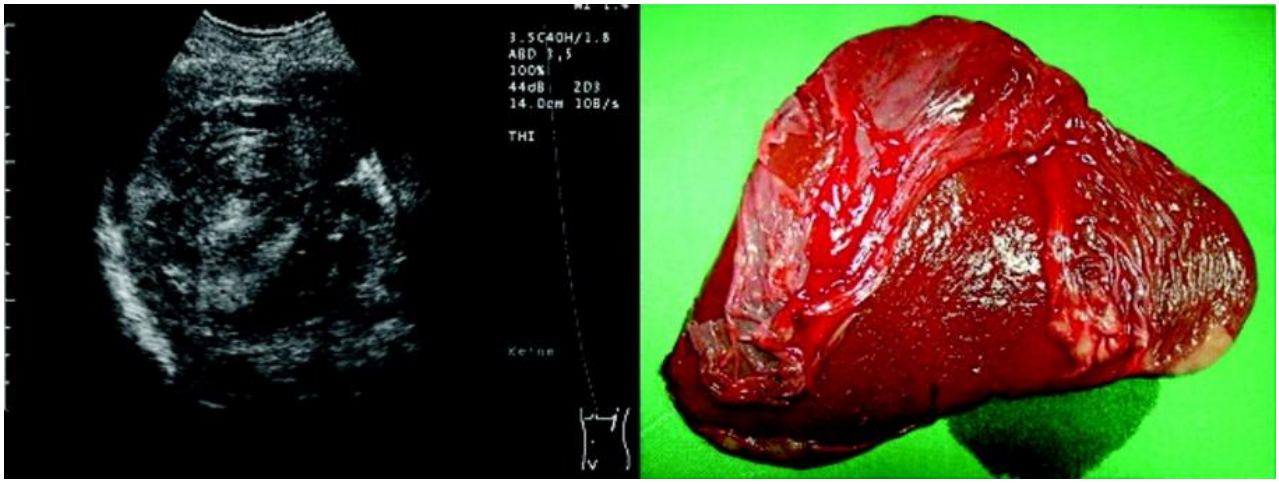
I. Be sure to scan the aorta for AAA in the patient who clinically appears to have acute renal colic, but in whom the renal scanning is normal.

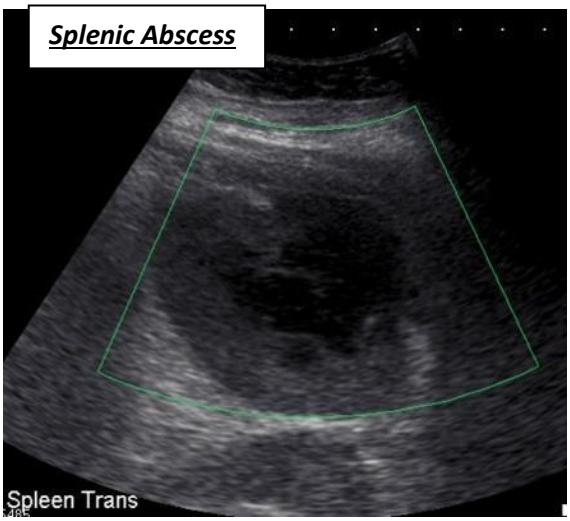
SPLEEN

1. MC indications for a dedicated Sonographic Assessment of the spleen

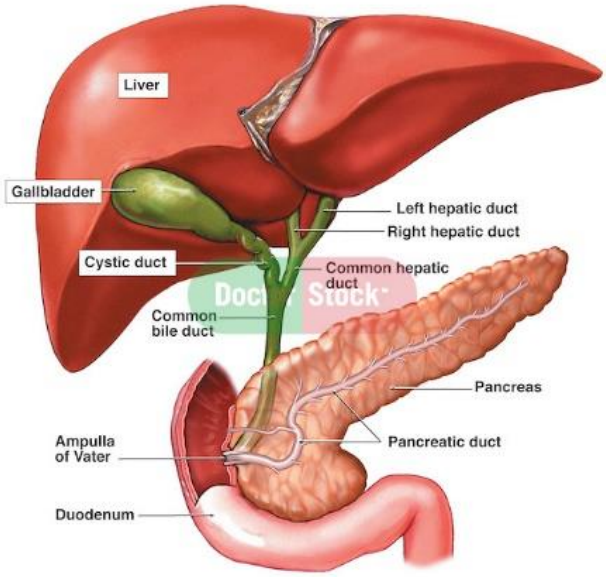
- **a**. size
- **b**. Document changes in vol. in pts with hematologic, ID or metabolic storage D.
- **c**. Dx of cysts, tumors, infarctions, abscesses and calcifications.
- **d.** Discomfort of unknown origin in the upper left quadrant of the abdomen
- **e.** Assessment of the spleen's vessels
- **f**. Portal HTN
- **g**. Local interventions

Rupture of the spleen is typically caused by blunt force trauma to the abdomen. An acute rupture of the spleen is often difficult to detect with sonography. Fissures may be hyperechoic or hypoechoic compared to splenic parenchyma. More severe lesions can also cause a subcapsular hematoma.

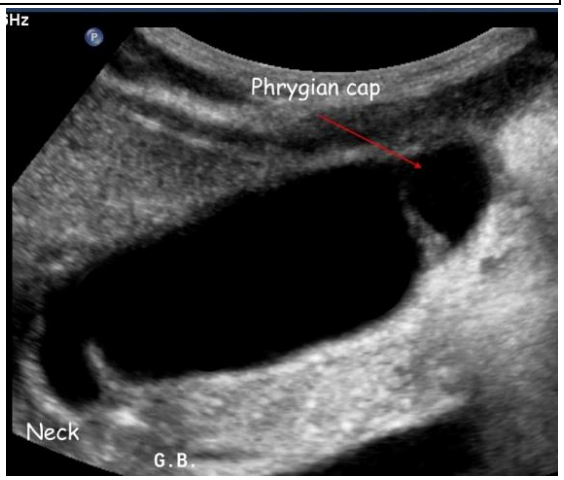


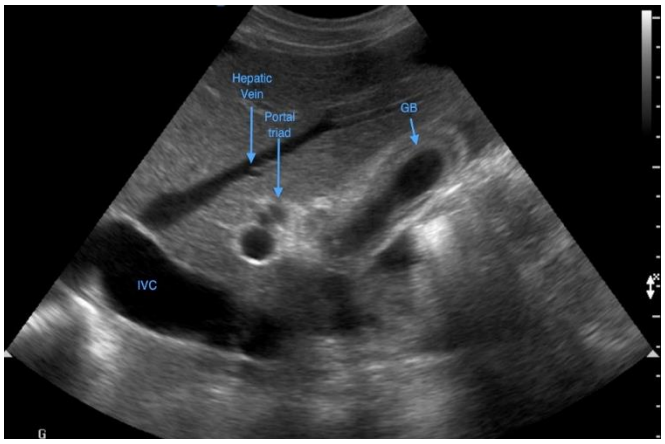


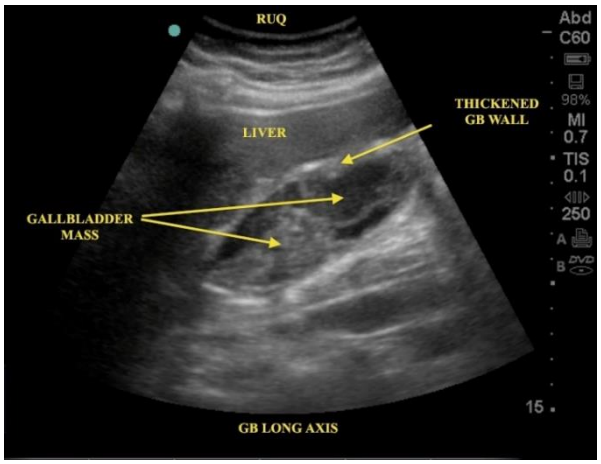
Gallbladder

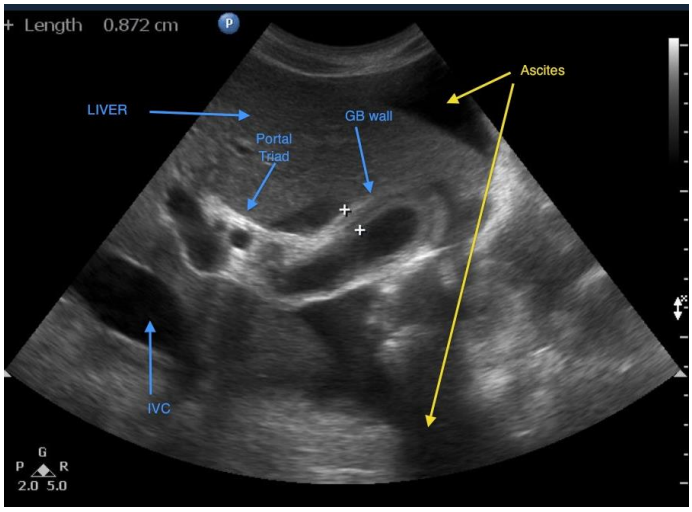


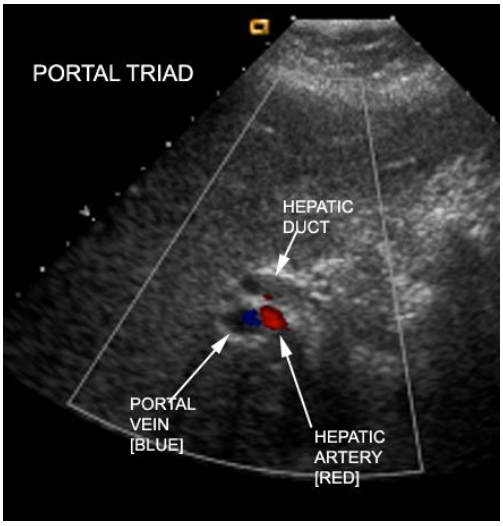
Phrygian cap, a folded over part of a GB. Harmless variant seen in a small % of people who have US exams of their GB





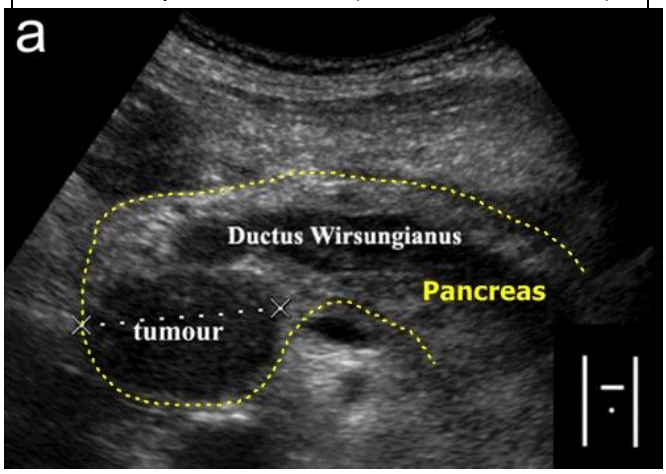


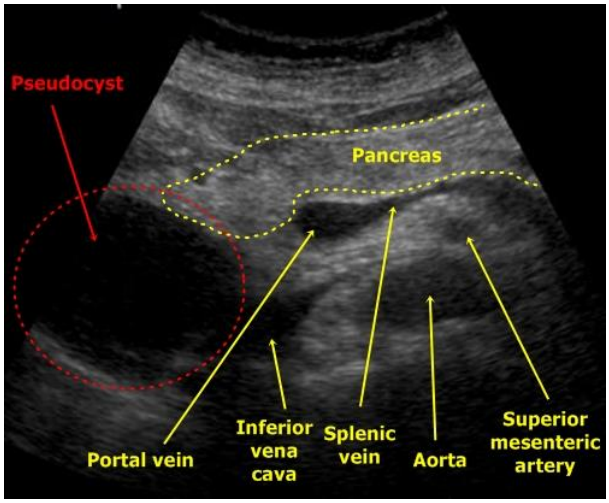




Pancreas

Pancreatic tumour – Panc. head is enlarged by a hypoechogenic mass. Tumour probably also blocks the pancreatic duct(seems to be dilated)



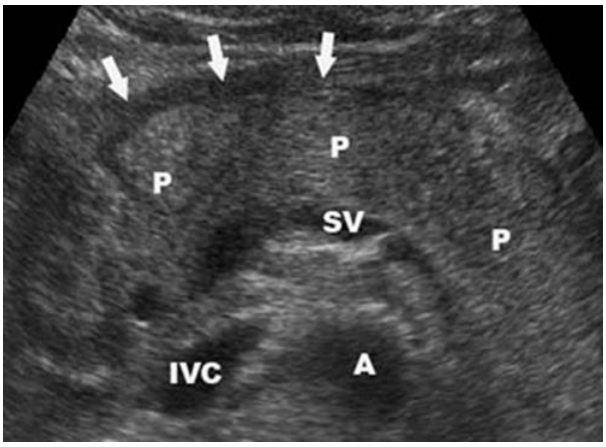


Acute pancreatitis –

(1) Pancreatic gland (P) is edematous

(2) Fluid visible in front of the pancreas. (Black anechogenic strip marked by arrows).

- Splenic vein (SV), aorta (A) and inferior vena cava (IVC).



<u>Chronic pancreatitis</u> –

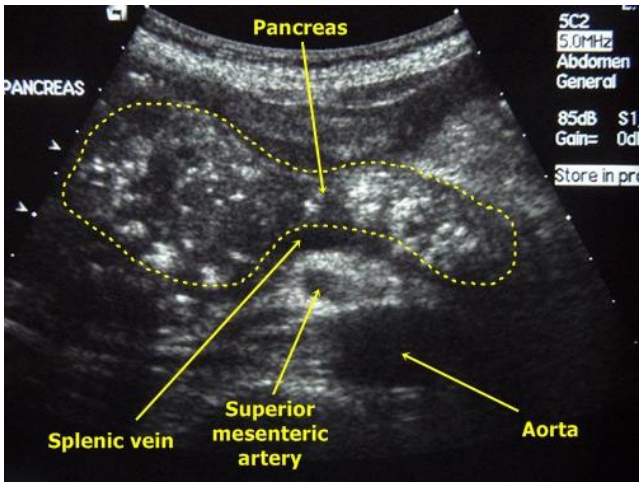
(1) Pancreatic duct is moniliformly dilated

(2) pancreatic tissue becomes granular,

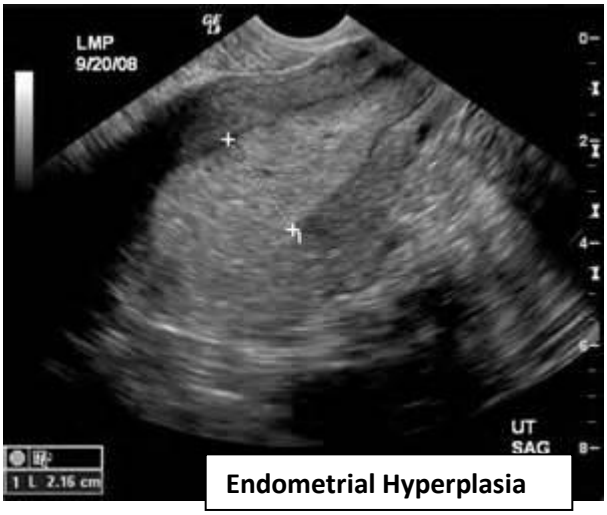
(3) fibrosis appears as dotted hyperechogenic areas.

(4) There are often calcifications present & eventually a cystoid could be seen (typically near pancreatic head).

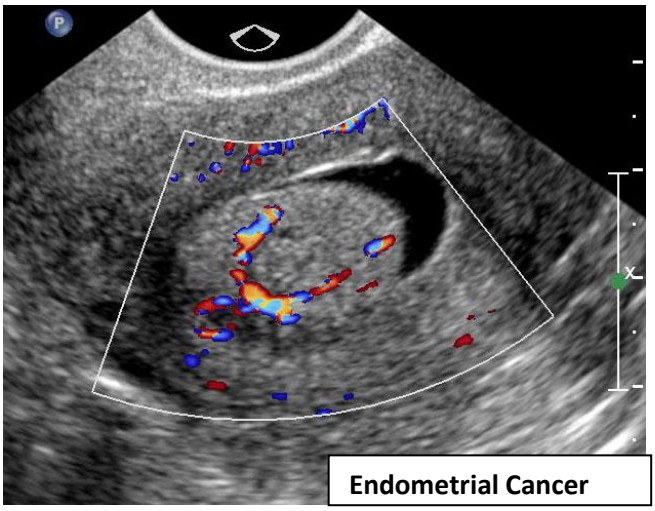
(5) The margins of the pancreas become rough.



Uterine



Endometrial Hyperplasia



Endometrial Cancer

Uterine

http://www.tbtam.com/2010/07/endometrial-thickness-in-post-menopausal-bleeding-is-3-mm-a-better-cutoff.html#.VQxdF5V0x2E

A new meta-analysis suggests that the commonly used 5 mm cut-off for endometrial thickness on transvaginal ultrasound may be a bit too optimistic at predicting the absence of endometrial cancer in women with post menopausal bleeding. European Researchers now suggest that 3 mm is a better cut off point, below which there is a 98% reduction in the chance of having cancer of the endometrium. A thickness of 4 mm gives a 95%, and 5mm a 90% reduction in odds of cancer.

That means if you have post menopausal bleeding (which has a 10% chance of being a cancer among all comers), an endometrial thickness below 3mm on transvaginal sonogram reduces your chance of cancer from 10% to 0.6%, while the old 5 mm cutoff would have reduced your odds to 1%.

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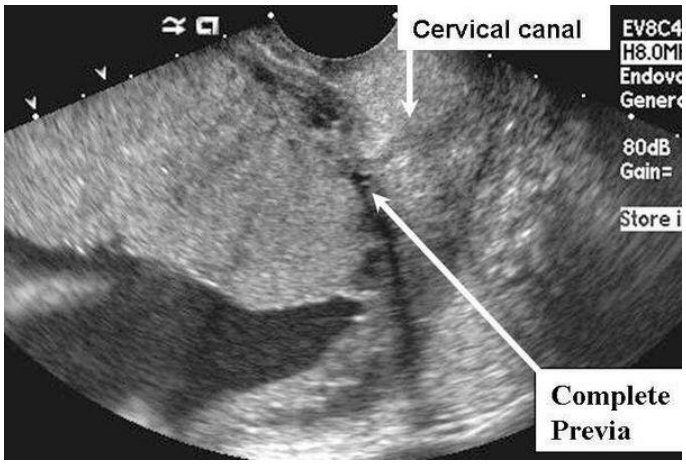
Nuchal fold measurement is obtained from the outer edge of the occipital bone to the skin surface in the transaxial plane of the fetal head at the level of the cavum septi pellucidum and cerebellar hemisphere.

- Nuchal fold can be spuriously thickened by angling caudally (intersecting the inferior level of the cerebellum and occiput).
- This nuchal skin fold increases with advancing gestational age and ranges between 1 and 5 mm in normal fetuses between 14 and 21 weeks gestation.
- A nuchal skin fold thickness of ≥6 mm is considered abnormal between 14 and 21 weeks.
- Excess skin along the back of the neck is well known in babies with Down syndrome (80% of neonates).
- There are many studies that have reported the relationship of a thickened nuchal fold with abnormal karyotypes.

Abdominal Circumference Landmarks



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Imaging Parameters for a Standard Fetal Examination

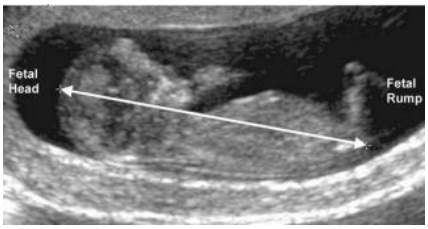
A. Fetal cardiac activity, number, & presentation should be reported.

1. Abnormal heart rate and/or rhythm should be reported.
2. Multiple pregnancies require documentation: chorionicity, amnionicity, comparison of fetal sizes, and gender.

B. A qualitative or semiquantitative estimate of amniotic fluid should be reported.

C. Placental location, appearance, and relationship to the internal cervical os should be recorded. The umbilical cord should be imaged, & the number of vessels in the cord should be evaluated.

D. Gestational Age Assessment



First-Trimester Crown-Rump Measurement

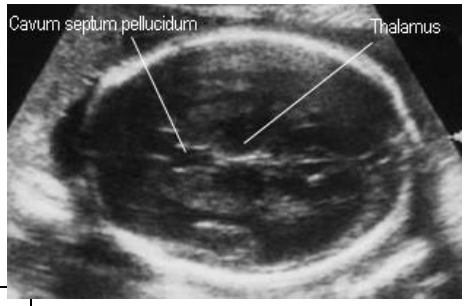
The most accurate sonographic dating of pregnancy.

Head Circumference

This measured at the same level as the biparietal diameter, around the outer perimeter of the calvarium. This measurement is not affected by head shape.

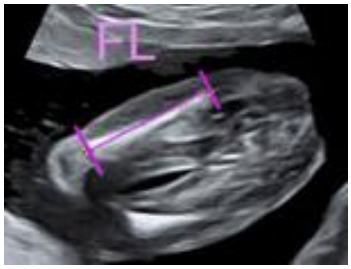
Abdominal Circumference Determined at the skin line on a true transverse view at level of the junction of the umbilical vein, portal sinus, and fetal stomach.

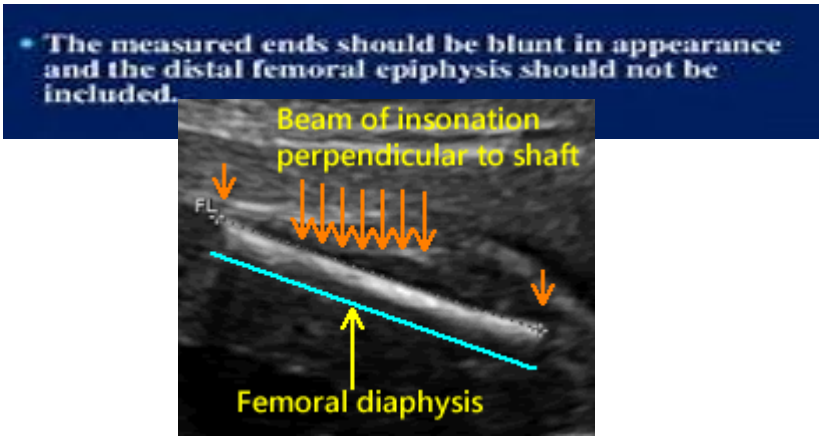
BPD measured on an axial plane that traverses the thalami, & cavum septum pellucidum. Transducer perpendicular to the central axis of the head, & thus hemispheres & calvaria should appear symmetric. Calipers should be placed at the: outer edge of the near calvarial wall and inner edge of the far calvarial wall. Cerebellar hemispheres should not be in image.



Femoral Diaphysis Length

After 14 weeks' GA Long axis of the femur shaft is most accurately measured with the beam of insonation being perpendicular to the shaft, excluding the distal femoral epiphysis.





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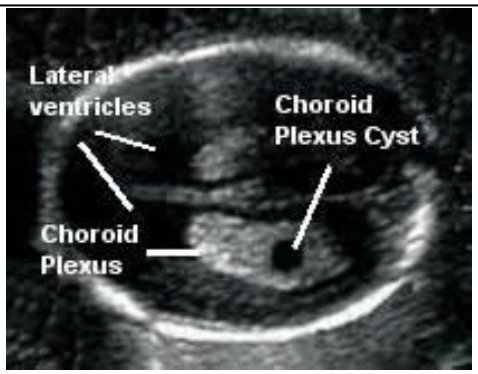
Fetal Weight Estimation: If previous studies have been performed, interval changes evaluated for growth. Scans for growth evaluation typically performed at least 3 weeks apart. Shorter scan interval may result in confusion as to whether anatomic changes truly are due to growth as opposed to variations in the measurement technique. Fetal wt. prediction can yield errors as high as ±15%.

Fetal Anatomic Survey Assessed by US post 18 weeks' gestational age. A more detailed fetal anatomic examination may be necessary if an abnormality or suspected abnormality is found on the Standard Examination.

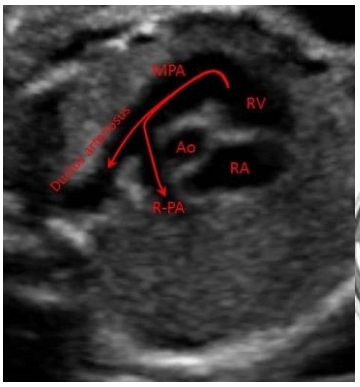
Head and neck:

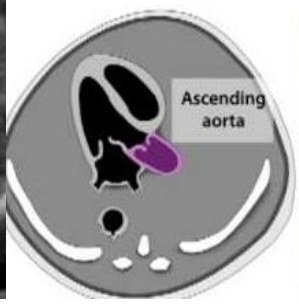
Cerebellum, Choroid plexus, Cisterna magna, Lateral cerebral ventricles, Midline falx, Cavum septi pellucidi



Chest

4-chamber view of the fetal heart.Extended cardiac examination to evaluate both outflow tracts.





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Abdomen: Stomach (presence, size, and situs), Kidneys, Bladder

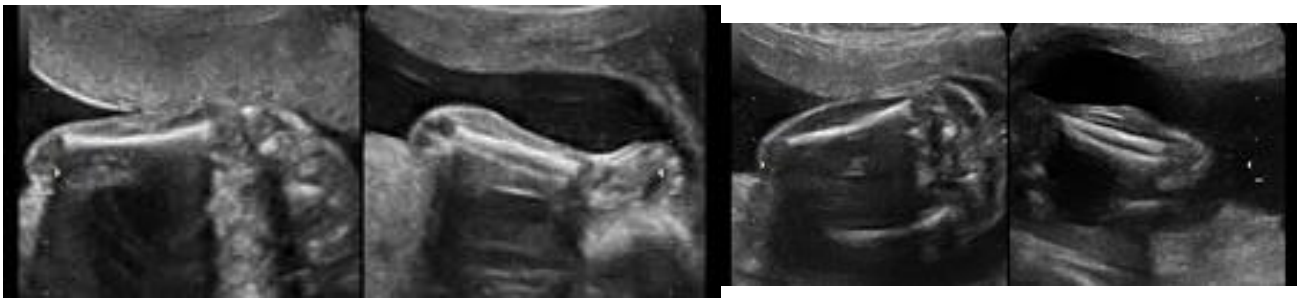
Umbilical cord insertion site into the fetal abdomen, & Umbilical cord vessel #

Spine

Cervical, thoracic, lumbar, and sacral spine

Extremities

Legs and arm (presence or absence)



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Anatomy Not Included in the Standard Examination

1. Mouth, lips, and nostrils. This view is one that is used to screen for cleft lip
2. Profile of face that includes nasal bone. Abnormal facial profiles may be associated w/ genetic syndromes.

The image on the left illustrates the diaphragm that separates the lungs and heart from the abdomen. If a diaphragmatic hernia is present, this could be life threatening in the immediate newborn period. Image on right illustrates the aortic arch.

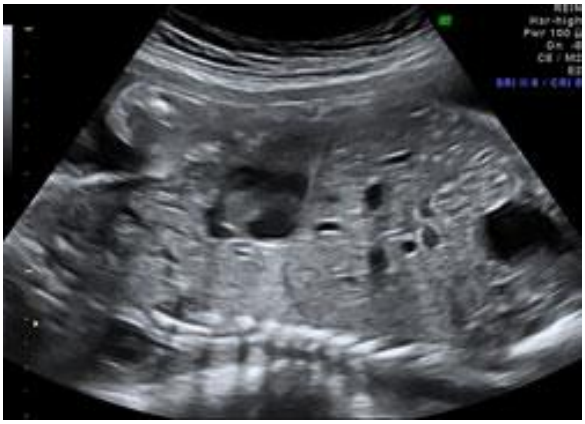
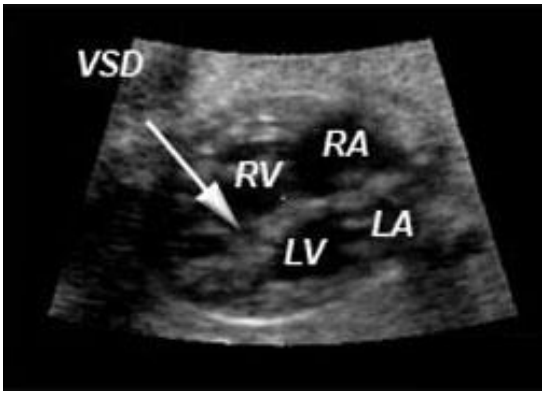
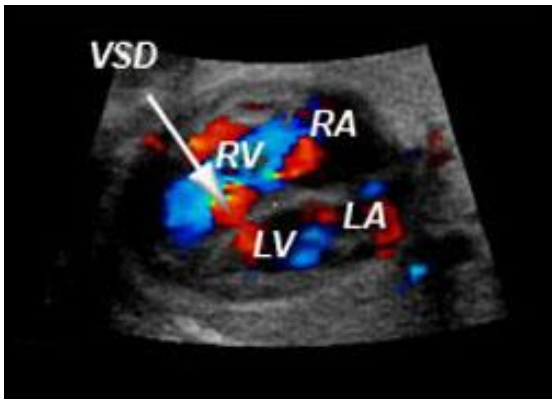


Image on LT is the four-chamber view of the heart. The VSD, which is a hole in the wall separating the ventricular chambers is difficult to see with B-mode ultrasound. Image on the right shows the blood crossing the ventricular septum. RA=right atrium, LA=left atrium, RV=right ventricle, LV=left ventricle.





Types of arrays

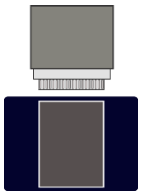
- Linear sequential array (switched array)
- Linear phased array (vector, sector)
- Curved sequential array (convex array, curvilinear sequential array).
- Curved phased array (convex array, curvilinear phased array).
- Annular array

The main differences to remember is that linear arrays are in a straight line (easy to remember) and curved are arranged on a curve. The real difference though is between sequential (switched) and phased (sector) arrays.

Sequential = Sequence Sequential arrays are lined up in a sequence. So the crystals are side by side and the face of the transducer is large. Each crystal creates a single scan line that runs straight from the transducer.

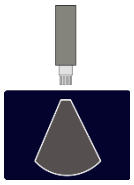
Phased = Phases. In a phased array there are less actual crystals so they fire in phases to create an image that has more scan lines than actual crystals. Each crystal creates multiple scan lines. They are fired in phases. If the shape of the top of the image is the exact shape as the bottom then it is a sequential array. If the shape is different, i.e. The top is flat and the bottom is curved then you have a phased array. Where this holds up still but is a little difficult to tell is in some transvaginal transducers as well as pediatric transducers. The top may be curved but they still cover more lines than there are crystals and you can see that the ratio will be different. Very curved on the top, with a normal curve on the bottom.

Linear sequential array



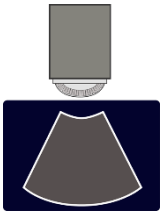
The image is rectangular. Each crystal is fired and creates a single scan line. So, the image corresponds to the width of the actual transducer. A simple linear array will not have steering. As the beams stay parallel to each other no matter the depth. The space between the beam stays constant because they run parallel to each other

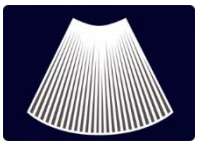
Linear phased array



A phased array works by exciting all the crystals in the transducer at the same time. This creates many individual waves which constructively interfere with each other to create a single pulse. Since the crystals are able to be fired at different times with a small delay between each pulse the beam that is formed is able to be steered as well as focused.

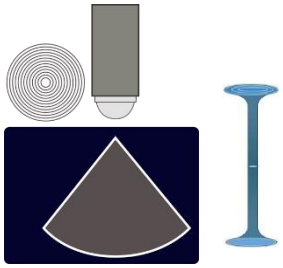
Curved sequential array





A curved or convex sequential (switched) array is aligned the same as a linear array. Crystals side by side with each crystal creating a single line on the screen but the transducer shape is curved so you get a classic fan shaped image. Beam steering is not necessary on this transducer because it naturally creates an image with an arc. You don't need beam steering on this transducer because it naturally creates an arc shaped image. A drawback to the curved array versus a linear array is that the beam at depth separates from the beam running parallel so you end up with gaps that the machine has to account for. So the deeper the image the greater the decrease in lateral resolution. A structure could sit in the gap between the beams and the machine would never know it exists.

Annular Array



Annular arrays are unique in their composition. They are created by taking a single crystal and cutting it into rings. Think of the cross section of an onion. Smaller and smaller rings. Because an annular transducer is steered mechanically it will have an image with a sector shape.

Annular beam profile

Benefit of an annular transducer is that the diff. crystal diameters have diff. acoustic properties. The large diameter crystals on the outer edge have a natural focus that is deep and the small diameter crystals on the inside have a naturally shallow focus. The transducer will use electronic focusing along the whole beam profile which creates a unique beam shape with a thin slice throughout.

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