

Ultrasound 101

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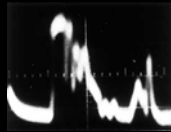


Objectives

- Understand basis physics of ultrasound
- How to apply principles
- Assessment of early pregnancy
 - Gestational age determination
- Appearance of intrauterine devices
- Endometrium after spontaneous & induced abortion



Second Trimester Ultrasound



BASICS OF ULTRASOUND PHYSICS



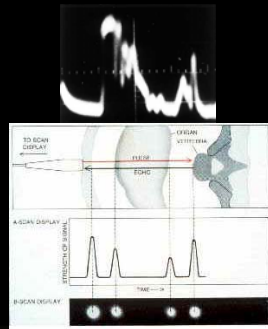
Principles of Ultrasound

- “Ultrasound”
 - Hertz = cycles/second
 - High Frequency Sound Waves
 - Greater than 20,000 Hz, the limit of human hearing
- 2MHz to 12 MHz for medical applications
 - Abdominal probes usually 3-5 MHz
 - Vaginal probes usually 5-10 MHz
 - Linear probes usually 8-12 MHz (Implanon)



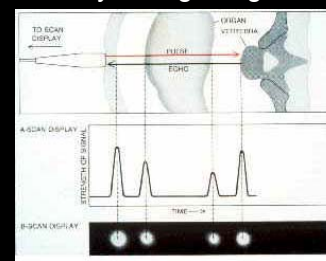
How Ultrasound Works

- Piezoelectric crystals convert electricity to mechanical energy and vice versa
 - Used in guitar pickups
 - Stereo speakers
 - Scales
 - Detonators
- Crystals convert electricity into sounds
- Then crystal converts sound back into an electric signal
- The computer calculates the time



How sounds travels: Interfaces

- Interfaces reflect sounds waves
- Greater density change = greater reflection



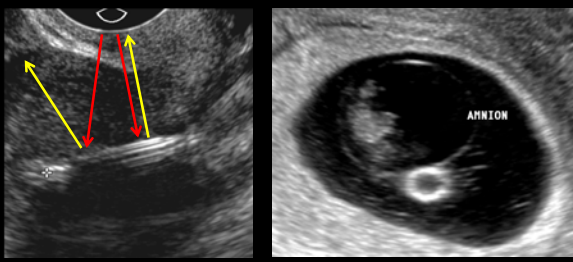
How sounds travels: Reflections

- The probe only receives what is reflected back to it
- But is shown in cross-section
 - Whereas a camera sees a "3-D reconstruction"



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Principles of Ultrasound: How sound travels: Reflections



- A structure at a right angle to the sounds waves will reflect more sound that the same structure at any other angle.

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How sound travels: Water




- "Increased Through-Transmission"
 - Image appears brighter on far side of water-filled structures
 - More sound waves reach the far side
 - Because none are reflected by the water

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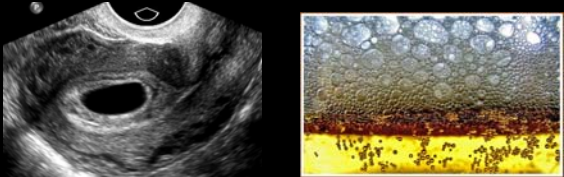
Water vs. Air

- Water transmits sound much better than air
- Full bladder pushes bowel gas out of the way
 - So that the pelvic organs can be seen more clearly



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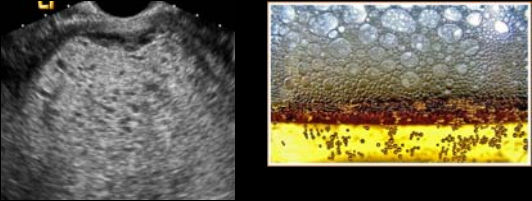
Cyst:Ultrasound: :Bubble:Light



- Effect is related to size
- Large bubbles transmit light just as large cysts transmit sound
 - No interference → no reflection
 - Increased through transmission

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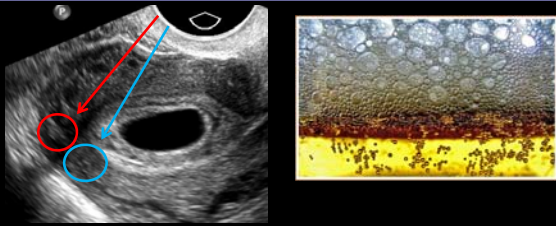
Cyst:Ultrasound: :Bubble:Light



- Small adjacent bubbles (aka foam) creates multiple interfaces that disrupts light transmission
 - Same with small cysts, as seen in a molar pregnancy
 - Reflective=Echogenic

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Cyst: Ultrasound: Bubble: Light



- Small adjacent bubbles (aka foam) creates multiple interfaces that disrupts light transmission
- But still has increased through transmission



Principles of Ultrasound Resolution

- Resolution proportionate to frequency
- Vaginal probe gives better images due to higher frequency
 - This is possible due to the shorter distance to the pelvic organs



Transabdominal

- Best for second and third trimester obstetric sonography
- For gynecologic or first trimester sonography:
 - Full bladder
 - Stay as close to the symphysis as possible
- Try to avoid scars or the umbilicus

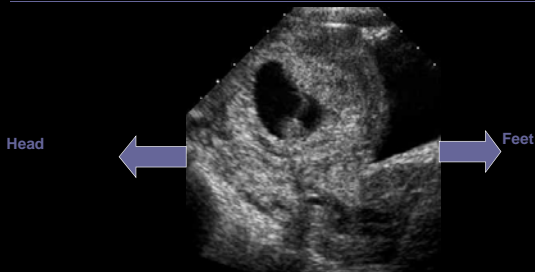


Transabdominal Probe

- All probes have a line or notch that marks the "top" of the probe
- Keep the line towards the patient's head or right
 - This will keep your images oriented properly
 - And keep you oriented!



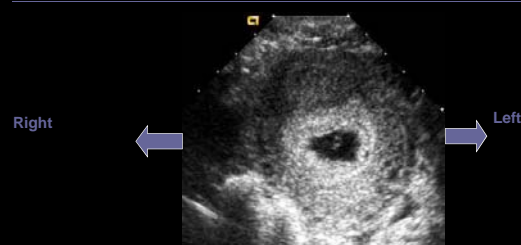
Transabdominal: Longitudinal Views



- Head to right; Feet to left
- Abdominal wall on top



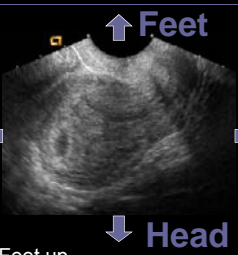
Transabdominal: Transverse Views



- Right to right & Left to left
 - If you keep notch on probe to the right!
- Abdominal wall on top



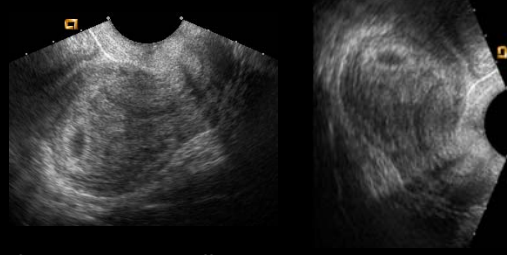
Transvaginal: Longitudinal Views



- Head down; Feet up
- Abdominal wall on right; Rectum to left
- Must "rotate" your mind

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Transvaginal Ultrasound




- Orientation is very different: Rotated 90 degrees
- Anatomy is much more apparent

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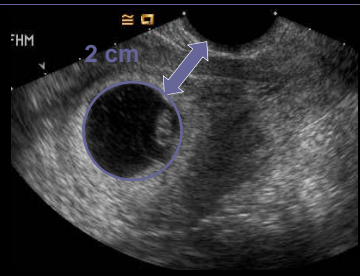
Transvaginal Probe

- Like abdominal probes, all vaginal probes have a line or notch that marks the "top" of the probe
- Keep the line facing up or to the patient's head or right
 - This will keep your images oriented properly and keep you oriented



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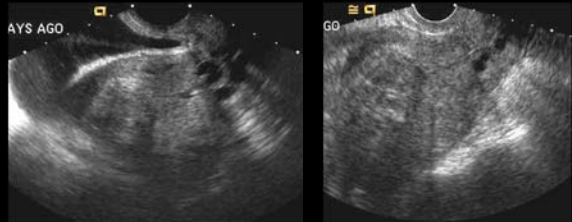
Advantages of Transvaginal



- Best for gynecologic or first trimester sonography
 - Probe is very close to uterus and ovaries

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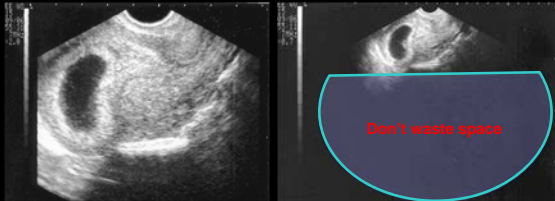
Transvaginal: Better with empty bladder



- A full bladder pushes uterus and ovaries away from the probe
- Creates artifactual distortion of image

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Maximize your image settings



- Image size is the simplest to fix
 - Make it easier for you and your colleagues to see

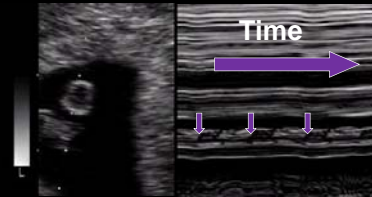
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Contraindications to Transvaginal Ultrasound

- Same as for a speculum exam
- Generally **gentler** to cervix than digital or speculum
 - You can watch as you approach the cervix
 - No metal



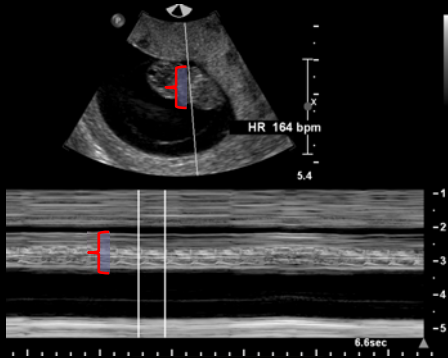
M Mode



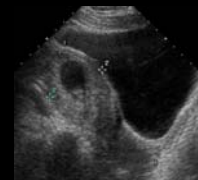
- Used to document fetal heart motion
 - Good for when you want proof of heart motion in chart
 - Or proof of absence of heart motion



M-mode



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FIRST-TRIMESTER SONOGRAM

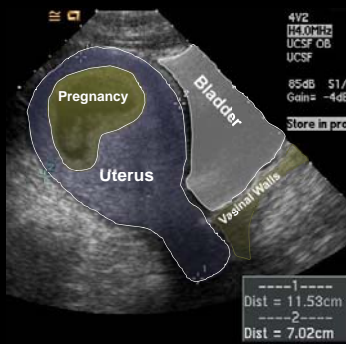


First Trimester Ultrasound: Goals (in order of importance)

- Rule in intrauterine pregnancy
 - Rule out ectopic
- Confirm normal pregnancy
 - Cardiac motion
 - Number of fetuses
- Date pregnancy
- Other
 - Evaluate adnexae
 - Assess free fluid in cul-de-sac



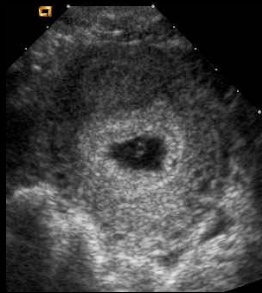
Transabdominal Anatomy in the Sagittal Plane



- Long Uterus view
 - "The papaya view"
- Confirms an intrauterine gestation
 - The pregnancy is seen to be connected to the cervix
 - Therefore not extrauterine

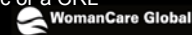
Transverse Transabdominal

- Then look in transverse plane
- Gestational sac should be surrounded by myometrium
- Look left and right into the adnexae
 - Checking for large masses
- Measure a CRL if possible



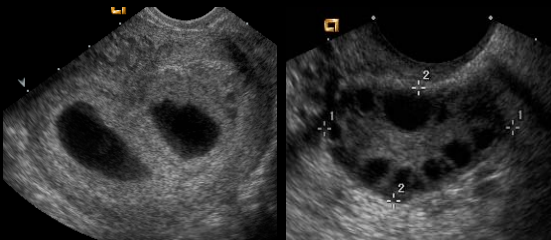
First Trimester Scan: Transvaginal

- Move probe side to side
- Freeze at the best view of the pregnancy
- Measure the sac or a CRL



Transvaginal Transverse and Adnexa

- Look at the uterus in the transverse view
 - Turn the probe counterclockwise to the right
 - So the notch faces right
- Look for ovaries
 - The more that you look, the better you will get!



Ruling Out Ectopic

- The Papaya View
- One image of the uterus longitudinally can effectively rule out ectopic
 - With gestational sac seen in fundus
 - In line with the cervix
 - Rules out free fluid

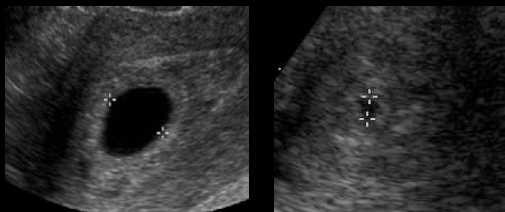


Free Fluid



Gestational Landmarks: The Double Decidual Sign

- It is the two decidual layers opposing each other
- Appears as soon as a sac is visible

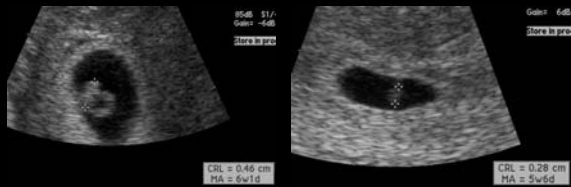


Gestational Landmarks: The Yolk Sac

- First structure to appear within gestational sac
 - Should be seen when MSD = 8mm
 - Pregnancy is abnormal if not seen by 13mm
- This definitively diagnoses an intrauterine pregnancy



Gestational Landmarks: Fetal Pole



- Fetal pole should be seen by MSD = 20 mm



Gestational Landmarks: Cardiac activity

- Fetal pole should be seen by MSD = 20mm
- Cardiac activity should be visible by 5mm CRL
 - This is always abnormal
 - It is usually visible by 3-4 mm



Gestational Landmarks: The Amnion



- Surrounds the embryonic pole
- Not usually seen until after about 8 weeks GA
 - Before 8 weeks, the amnion is not normally visible
- The embryo should almost fill the amnion



Mean Sac Diameter



- Measure diameter in 2 dimensions on a long (sagittal) view
- Then measure a third diameter on a transverse view
- Average the 3 measurements to get the MSD
 - For some purposes, the average of two measurements is enough (such as dating for abortions)
- GA (days) = MSD (mm) + 30 (Rossavik formula)



Mean Sac Diameter



Is 2 dimensions OK?

- Accuracy slightly decreased
 - But 3rd dimension would rarely change GA by more than 3 days
- But transverse good for documentation
 - Proves that you looked
 - Worth printing even if you don't measure the sac

GA (days) = MSD (mm) + 30

GA (days) = (15 + 11)/2 + 30 = 43



Crown-Rump Length

- Measure the maximum mid-sagittal length of the fetal pole
- Goldstein formula:
GA(days) = CRL(mm) + 42
 - Can be used up to 9 weeks
- CRL is preferred over the MSD
 - Don't use the MSD for dating once you can measure the CRL
- CRL is the best measurement from 6.5 to 12 weeks
 - and can be used up to 14 weeks



Calculations



- Let your machine do the work
- Otherwise:
 - Crown-rump length: $GA \text{ (days)} = CRL \text{ (mm)} + 42$
 - Mean Sac Diameter : $GA \text{ (days)} = MSD \text{ (mm)} + 30$



Determining Gestational Age

- The earlier the sono is the better!
 - Roughly an 8% error in GA determination
 - At 5 weeks, 8% is 4 days
 - At 10 weeks, 8% is 8 days
- Obtain Mean Sac Diameter (MSD) until embryo appears
- Then use Crown-Rump Length (CRL) until 12-13 weeks



How errors affect GA calculation

5mm embryo

- $GA = 42 + 5 = 6w \ 5d$

If mismeasured: CRL = 3

- $GA = 42 + 3 = 6w \ 3d$

If CRL = 8

- $GA = 42 + 8 = 7w \ 1d$

- Not very different!

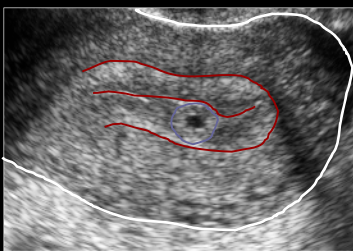


Early pregnancy by weeks

- Sequentially review timing of events and findings



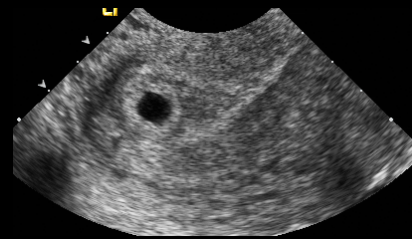
4.5 Week Pregnancy



- Very small sac within one layer of the decidua
- No embryonic structures



5 Week Pregnancy



- Clear double decidual sign
- May see Yolk sac (not in this example)

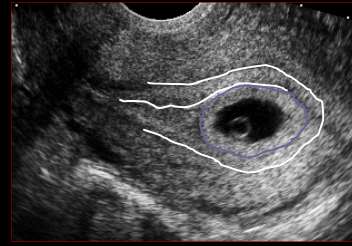


5.5 week Pregnancy



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6 Week Pregnancy



- Yolk sac appears
- Prominent double decidual sign

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6.5 Week Pregnancy



EV-804
 ECHOS
 UCSF OB
 UCSF
 85dB S1/
 Gain = -5dB
 Store in prog

CRL = 0.46 cm
 MA = 6w1d

- Embryonic pole visible
- Yolk sac and double decidual sign still present

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6.5 Week Pregnancy



Embryonic pole visible
 Yolk sac and double decidual sign still present

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Cardiac motion with CRL=3mm



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7 Week Pregnancy



CRL = 1.27 cm
 MA = 7w1d

7w 6d

- Embryo often visible transabdominally
- Amion may be visible

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8 Week Pregnancy

- Anatomy becomes more apparent
 - Head and limbs are identifiable
- Amnion usually visible

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8 Week Pregnancy

LONG

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9 Week Pregnancy

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10 Week Pregnancy

- CRL usually can be measured transabdominally in most women

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12 Week Pregnancy

- Beyond 13 weeks, a BPD should be obtained as well

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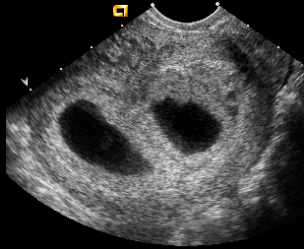
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MULTIPLE GESTATIONS

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Twins in the First Trimester

- This is the best time to diagnose twins
- Easiest to determine chorionicity



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Monochorionic Twins

- One gestational sac
- Two amnions, yolk sacs, & embryos



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Dichorionic Twins

- Two gestational sacs (chorion)
- Two amnions
- Two yolk sacs
- Two embryos



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Twins: Chorionicity?



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Twins: Chorionicity?



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Chorionicity?



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Chorionicity?



LONG

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Ultrasound in First Trimester



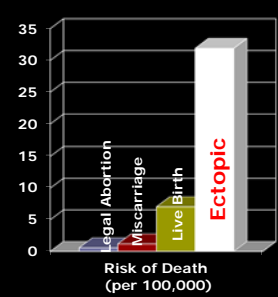
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SIGNS OF ECTOPIC PREGNANCY

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Maternal Deaths in the United States, 1991-99

| Pregnancy outcome | Number of deaths | Estimated number of outcomes | Rate (per 100,000 outcomes) |
|--------------------------|------------------|------------------------------|-----------------------------|
| Legal abortion | 71 | 12,509,937 | 0.567 |
| Miscarriage | 94 | 7,882,974 | 1.19 |
| Live birth | 2519 | 35,201,825 | 7.06 |
| Ectopic pregnancy | 237 | 742,599 | 31.9 |
| Fetal death | 275 | 285,615 | 96.3 |
| Total | 3,196 | 57,123,000 | 5.59 |



Risk of Death (per 100,000)

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Grimes, AJOG, 2005

Pseudosac



ID0 L.O.-TR

FAS PDS

SD 1.32cm

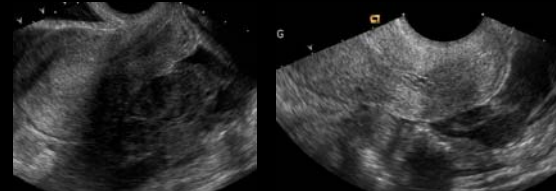
FD 0.76cm

FD 1.33cm

- The endometrium can resemble a gestational sac
- But will never have a yolk sac

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Free Fluid in the pelvis



- Blood seen in cul de sac
 - May be anechoic or contain echoes (clot)
- Raises concern for ectopic substantially
 - Not seen with all ectopics but uncommon with IUPs
 - This is an easy finding to identify (compared to funding the ectopic pregnancy)

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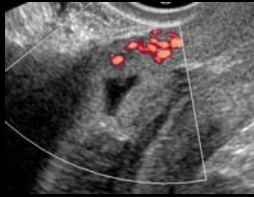
Echogenic free fluid



CDS

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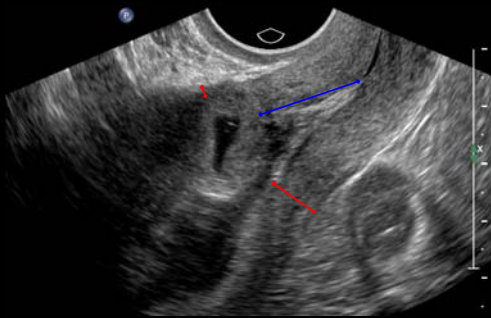
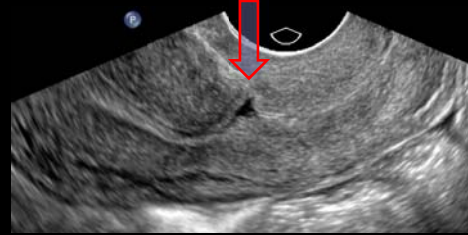


CESAREAN SCAR ECTOPIC PREGNANCY



Cesarean Scar

- Gestational sac implants within prior cesarean scar



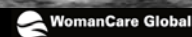
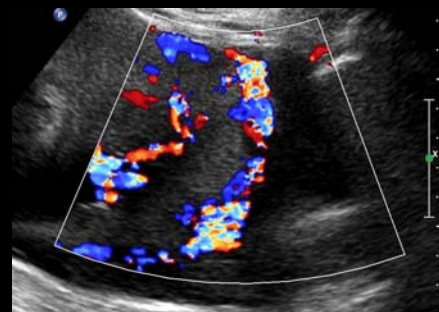
Doppler to verify anterior implantation



Distance to bladder



Development into accreta

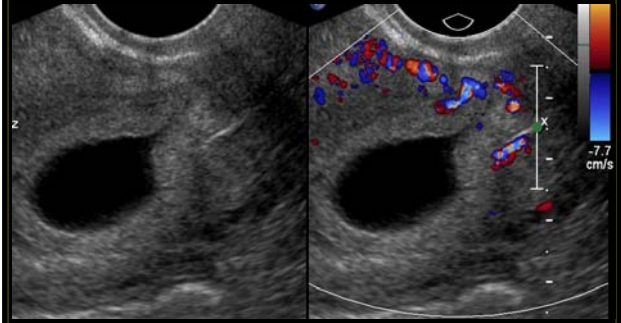


Cannula in uterus



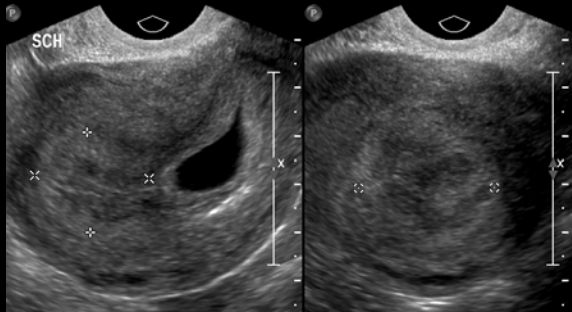
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Cesarean scar implantation



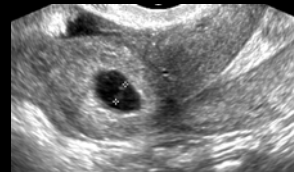
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The endometrium with Cesarean scar pregnancy



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CORNUAL ECTOPIC PREGNANCY

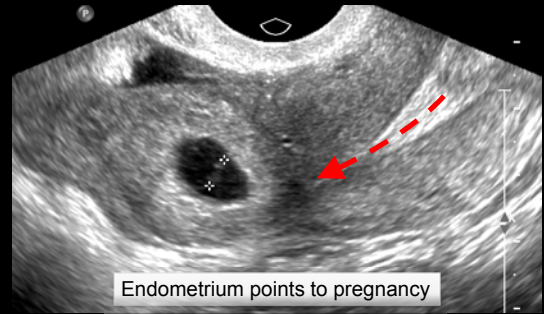
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First image: Cul de sac



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Cornual ectopic



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Cornual Ectopic on laparoscopy



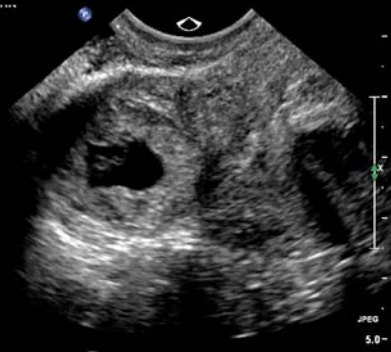
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Cornual Ectopic, 12 weeks



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Cornual Ectopic, 12 weeks



JPEG
5.0

Cornual Ectopic, 12 weeks



JPEG
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Cornual Ectopic, 12 weeks



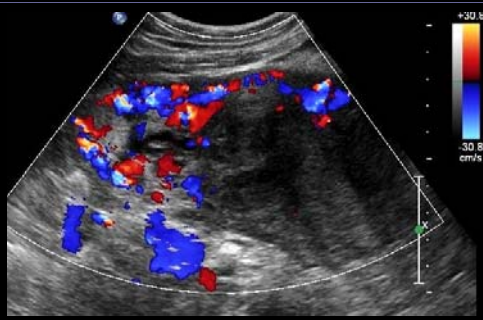
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Cornual Ectopic, 12 weeks



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Cornual Ectopic, 12 weeks



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Cornual ectopic, 6.5 wks



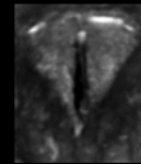
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Cornual ectopic, 6.5 wks



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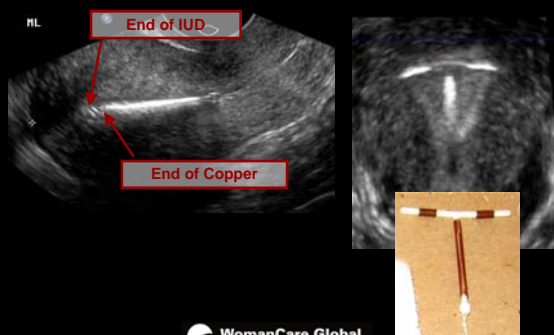
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**INTRAUTERINE DEVICES ON
ULTRASOUND**

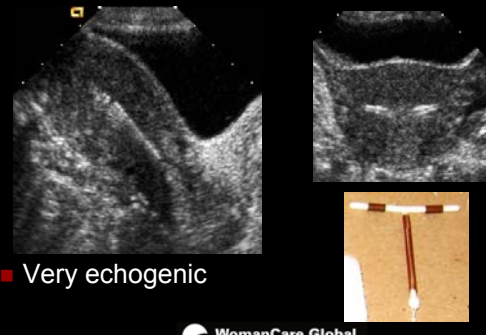
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Paragard



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Paragard



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Paragard in retroverted uterus



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Mirena



- Not very echogenic except where perpendicular to the probe
- Strings may be as echogenic as the IUD

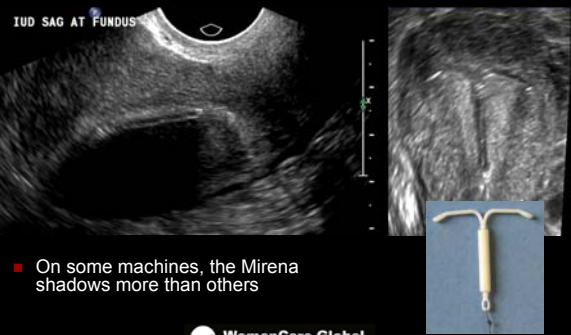
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Mirena on ultrasound



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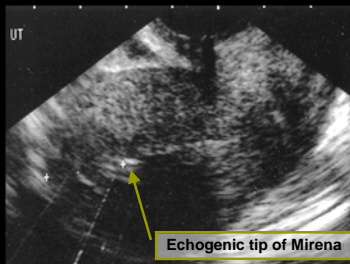
Pronounced shadowing with Mirena



- On some machines, the Mirena shadows more than others

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Mirena on an older machine



Echogenic tip of Mirena

- This is a scanned image from an old GE machine

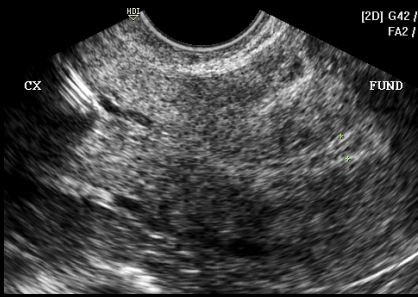
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Mirena can be hard to find



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Mirena in the cervix



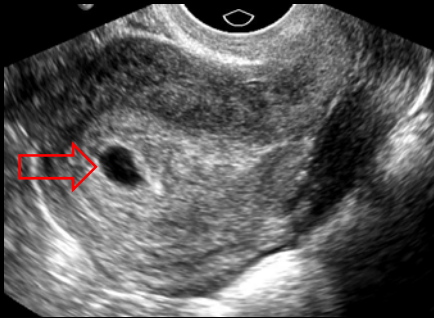
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Mirena in cervix



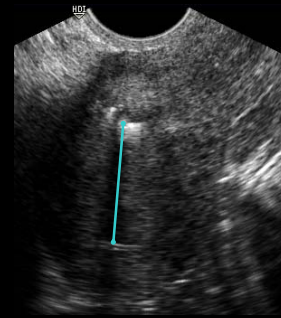
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Mirena in Cervix



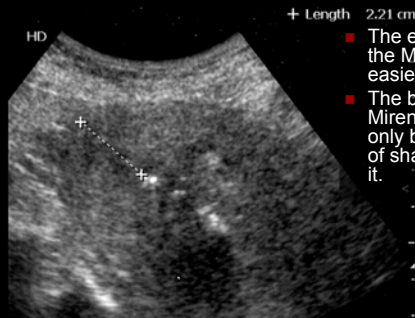
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Mirena in a retroverted uterus



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Post-Abortal Insertion of Mirena



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- + Length 2.21 cm
- The echogenic tip of the Mirena is the easiest part to see.
- The body of the Mirena is identifiable only by the presence of shadowing beneath it.

Post-placental Mirena Insertion



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Summary

- Understanding ultrasound physics aids in interpretation of unusual findings
- Gestational age is best estimated with MSD then CRL in the first trimester
- Signs of ectopic pregnancy are important to recognize
 - More that identifying the ectopic
- Technique is key to visualizing IUDs



Thank you

Questions