Ultrasound 101

Matthew Reeves, MD, MPH
Mary Fjerstad, NP, MHS
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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

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)

BASICS OF ULTRASOUND PHYSICS

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

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

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

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

Transvaginal Ultrasound

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

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

Advantages of Transvaginal

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

Transvaginal: Better with empty bladder

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

Maximize your image settings

- Image size is the simplest to fix
  - Make it easier for you and your colleagues to see
  - Good: fills the screen/paper
  - Don’t waste space
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

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

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FIRST-TRI MESTER SONOGRAM

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
**First Trimester Scan: Transvaginal**

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

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**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

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**Transvaginal Transverse and Adnexa**

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

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**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

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**Gestational Landmarks: The Double Decidual Sign**

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

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**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

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

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)

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: \( \text{GA (days)} = \text{CRL (mm)} + 42 \)
  - Mean Sac Diameter: \( \text{GA (days)} = \text{MSD (mm)} + 30 \)

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
- \( \text{GA} = 42 + 5 = 6\text{w }5\text{d} \)
- If mismeasured: CRL = 3
  - \( \text{GA} = 42 + 3 = 6\text{w }3\text{d} \)
  - If CRL = 8
  - \( \text{GA} = 42 + 8 = 7\text{w }1\text{d} \)
- 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

- Yolk sac appears
- Prominent double decidual sign

6 Week Pregnancy

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

6.5 Week Pregnancy

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

6.5 Week Pregnancy

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

Cardiac motion with CRL=3mm

7 Week Pregnancy

- Embryo often visible transabdominally
- Amion may be visible
8 Week Pregnancy

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

9 Week Pregnancy

10 Week Pregnancy

- CRL usually can be measured transabdominally in most women

12 Week Pregnancy

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

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MULTIPLE GESTATIONS
Twins in the First Trimester

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

Monochorionic Twins

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

Dichorionic Twins

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

Twins: Chorionicity?

Chorionicity?
**Maternal Deaths in the United States, 1991-99**

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Risk of Death (per 100,000)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Legal Abortion</td>
<td>0.567</td>
</tr>
<tr>
<td>Miscarriage</td>
<td>1.5</td>
</tr>
<tr>
<td>Live Birth</td>
<td>1.9</td>
</tr>
<tr>
<td>Ectopic (operative)</td>
<td>31.5</td>
</tr>
</tbody>
</table>

*Source: Reference 14*

**Pseudosac**

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

**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)

**Echogenic free fluid**

- 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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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

Cesarean scar implantation

The endomtrium with Cesarean scar pregnancy

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CORNUAL ECTOPIC PREGNANCY

First image: Cul de sac

Cornual ectopic

Endometrium points to pregnancy
Cornual Ectopic, 12 weeks

Cornual ectopic, 6.5 wks

Cornual ectopic, 6.5 wks

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INTRAUTERINE DEVICES ON ULTRASOUND

Paragard

Paragard

End of Copper

End of Copper

Very echogenic
Paragard in retroverted uterus

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

Mirena on ultrasound

Pronounced shadowing with Mirena
- On some machines, the Mirena shadows more than others

Mirena on an older machine
- This is a scanned image from an old GE machine

Mirena can be hard to find
**Mirena in the cervix**

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.

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**Post-Abortal Insertion of Mirena**

- 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.

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**Mirena in cervix**

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**Mirena in a retroverted uterus**

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**Post-placental Mirena Insertion**
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 than identifying the ectopic
  - Technique is key to visualizing IUDs

Thank you

Questions