Ultrasound in gynecology

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Technique

Background

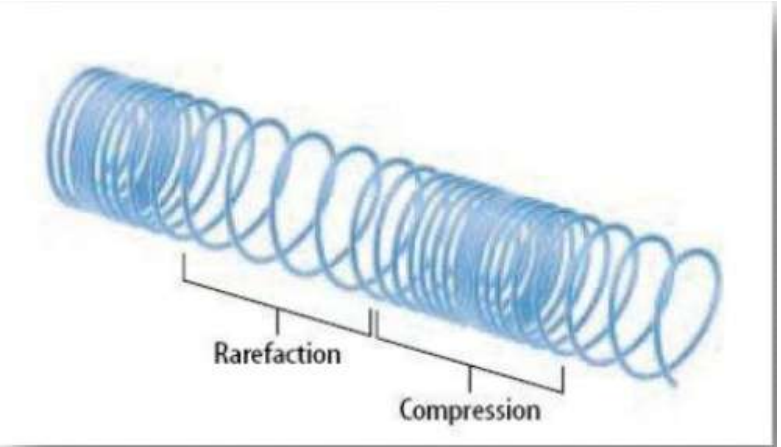
- Part of routine clinical examination
- High resolution technology
- Transvaginal probes
- Color Doppler applications
- Advanced 3D technology
- Systematic organ evaluation
- Additional incidental findings
- **Important adjunct to clinical examination in obese and virginal patients, when an adequate pelvic examination cannot be performed**

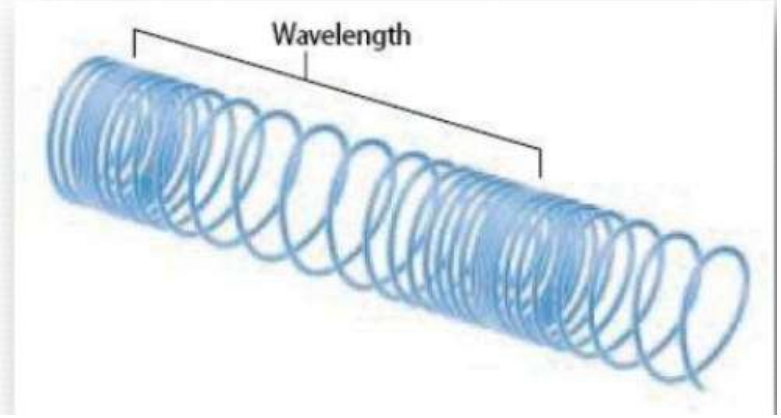
Indications (AIUM, ACR, ACOG practice guidelines)

- Pain syndromes:
  - Pelvic pain, dysmenorrhea
- Dysfunctional uterine bleeding:
  - Menorrhagia, metrorrhagia, menometrorrhagia
- Follow up of previously detected abnormality
- Evaluation and monitoring of infertile patients
- Menstrual irregularities:
  - Delayed menses, precocious puberty, oligomenorrhea
- Postmenopausal bleeding
- Abnormal pelvic examination
- Congenital anomalies
- Pre and post-op monitoring
- IUD localization
- Screening for malignancy in high risk patients

Principles

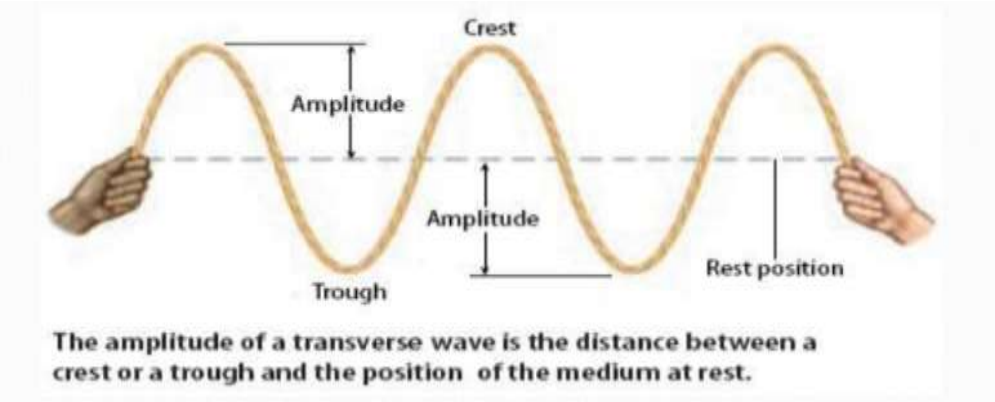
- High frequency sound waves and echoes
- Sound waves require a medium: water, air, etc
- Longitudinal compression wave:
  - Compression – squeezed
  - Rarefaction – spreads out
  - Wavelength – distance between compressions
- Frequency - no. of waves per second (Hz)
- Wavelength and frequency inverse related





Principles

- Amplitude:



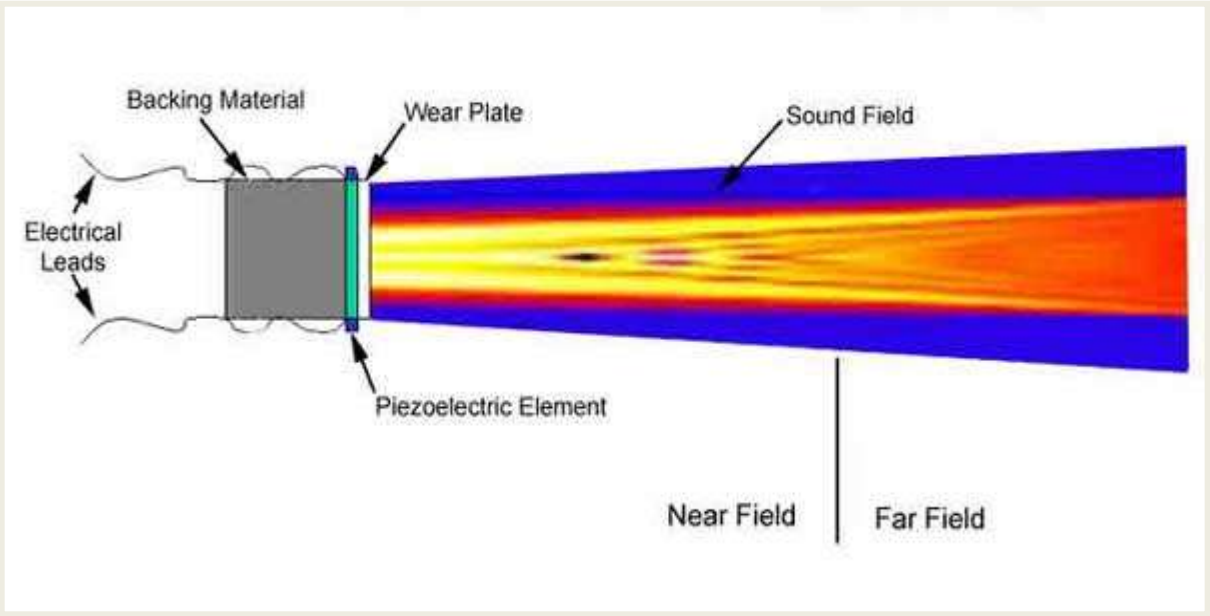
- Reflection - wave bounces of object and changes direction
- Refraction – bending of a wave passing from one medium to another
- Speeds are different in different media
- A change in speed results in a change of direction

Principles

- Sound travels faster in a denser medium and a higher temperature
- Different tissue thickness attenuates the wave
- B – mode – gray scale 2D imaging
- M – mode – for moving structures

Principles

- Medical ultrasound – 2->15 MHz
- Strong reflections – white (bone)
- Weak reflections – grey (most solid organs)
- No reflections – black (fluid in cyst, urine, blood flow)



Technical requirements

- Real time scanner
- Sector, curved linear array, or endovaginal transducers
- Sector format allowing 100-120 degrees
- Highest clinically appropriate frequency
- Reverberation may result from probe/vagina/condom surfaces

Principles

- Ultrasound parts:
  - Transducer/probe – piezoelectric crystals which move and create a wave
  - CPU – central processing unit – sends electrical currents to the transducer
  - Transducer pulse controls
  - Display
  - Keyboard/cursor/cine loops
  - Archive
  - Printers

Principles

- ↑ Frequency = ↑Resolution = ↓Penetration
- ↓ Frequency = ↑Penetration = ↓Resolution

transabdominal

≥3.5 MHz

transvaginal

≥5MHz

Higher frequency transducers (≥8 MHz) may limit field of view to 6 cm from probe

Technique

- Why?
  - Indications, interview
- How?
  - Full, empty or medium filled bladder
- Which transducer?
  - Transabdominal, transvaginal or transrectal?
- Timing
  - During menstrual phase

Setting of the machine

- Which setting?
  - Frequency, depth, gain, focal points, zoom, angle
- Which mode?
  - Color-Doppler vs. power-Doppler
- 3D/4D applications
  - Effective or show?

Anatomical landmarks

- Pelvic floor: Uretra, vagina, anal canal, levator ani
- Bladder: Base, dome, ureters
- **Uterus: Cervix, endometrium, myometrium**
- **Adnexa: Ovary, salpinx**
- Recto-sigmoid: Muscular layers, submucosa, mucosa
- Peritoneum: Pouch of Douglas, utero-vesical space

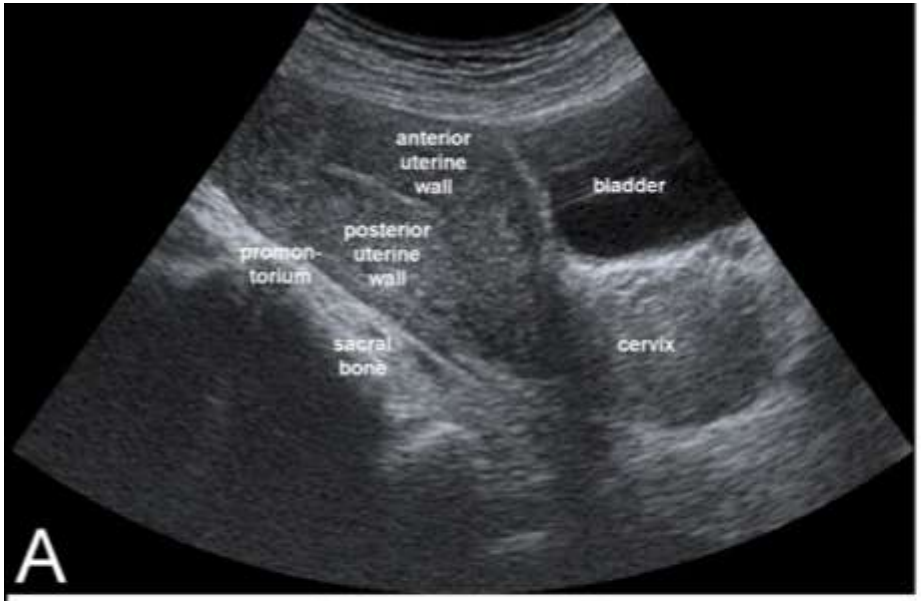
Procedure

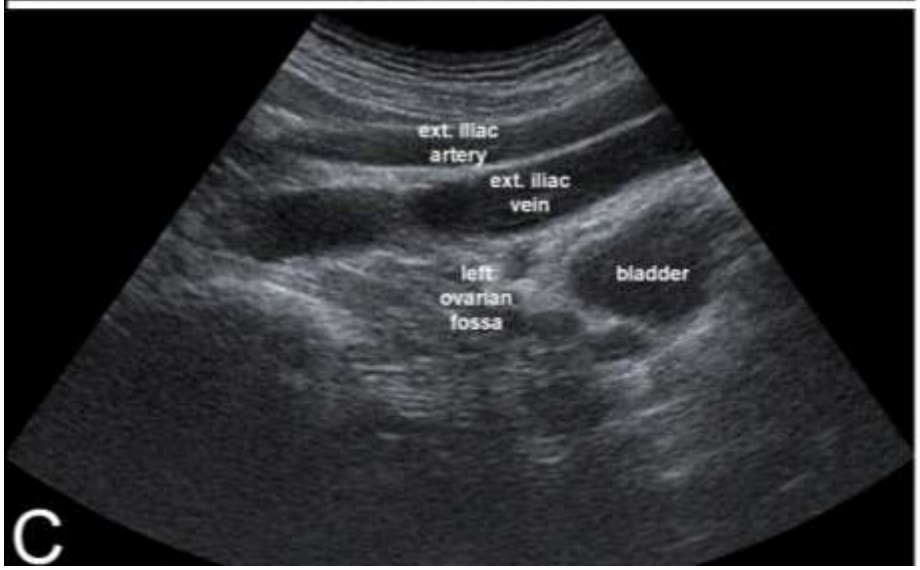
- Introduce yourself
- Know the OB-GYN history and exam indication
- Inform the patient about the exam: aims, modality
- Stand by patient side
- Cover the pelvis with a sheet
- Record name, surname and time set
- Keep a standardized, fixed, predetermined technique
- Start with a transabdominal scan then scan transvaginally

Start with a transabdominal scan

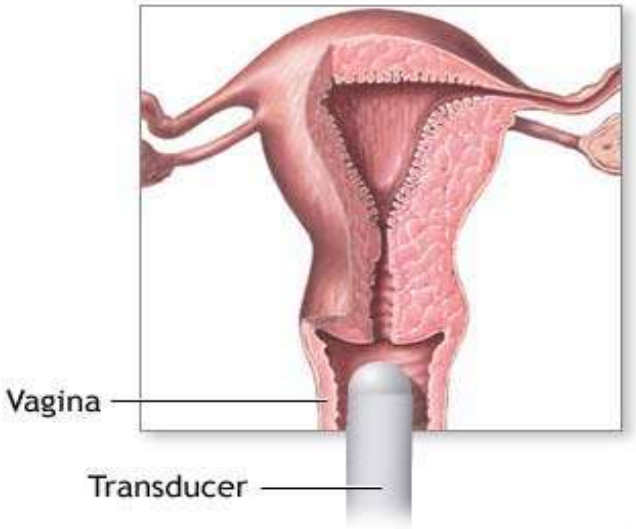
- Gives an overview of the pelvis (and abdomen)
- Mutual relationship of the pelvic organs
- Best way to measure uterine diameters
- Avoids overlooking masses located in the upper pelvis
- Takes less than 1 minute
- Longitudinal and transverse section
- Allows visualization of abdominal wall (although inadequate)
- Bladder does not have to be full (Benacerraf JUM 2003: 83.5% TVS only, 15% TAS without full bladder, 1.5% TAS completely full bladder)

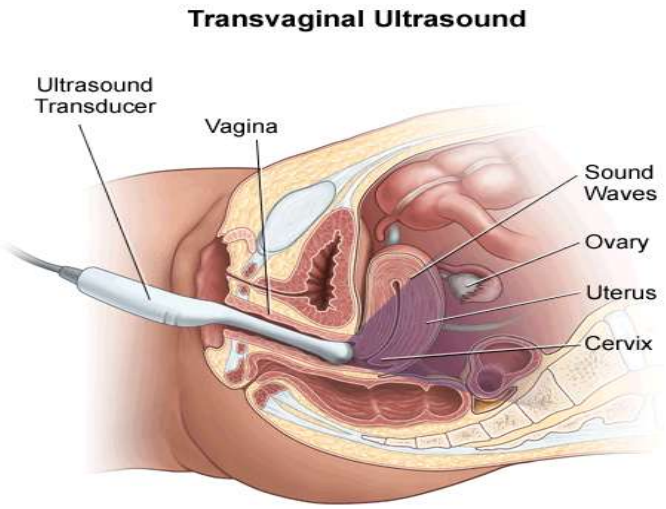
Start with a transabdominal scan



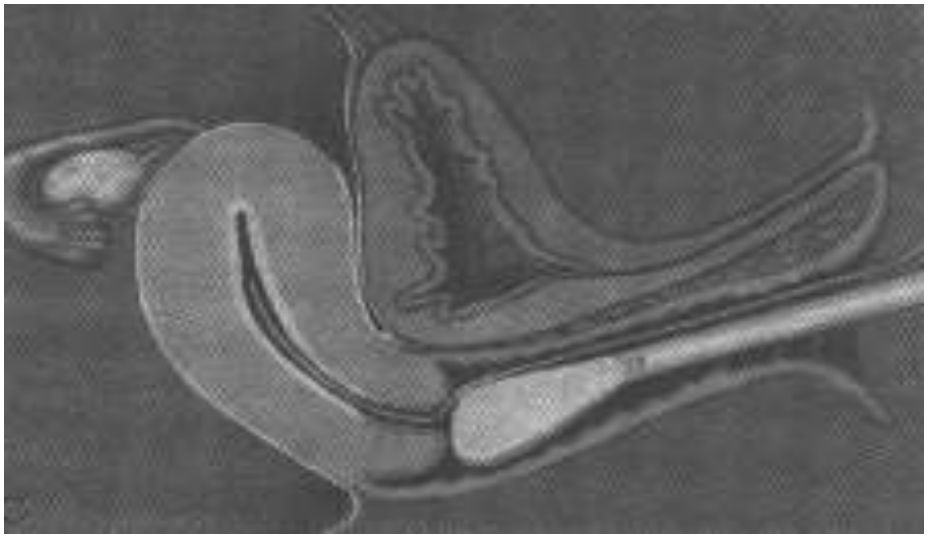


Transvaginal ultrasound

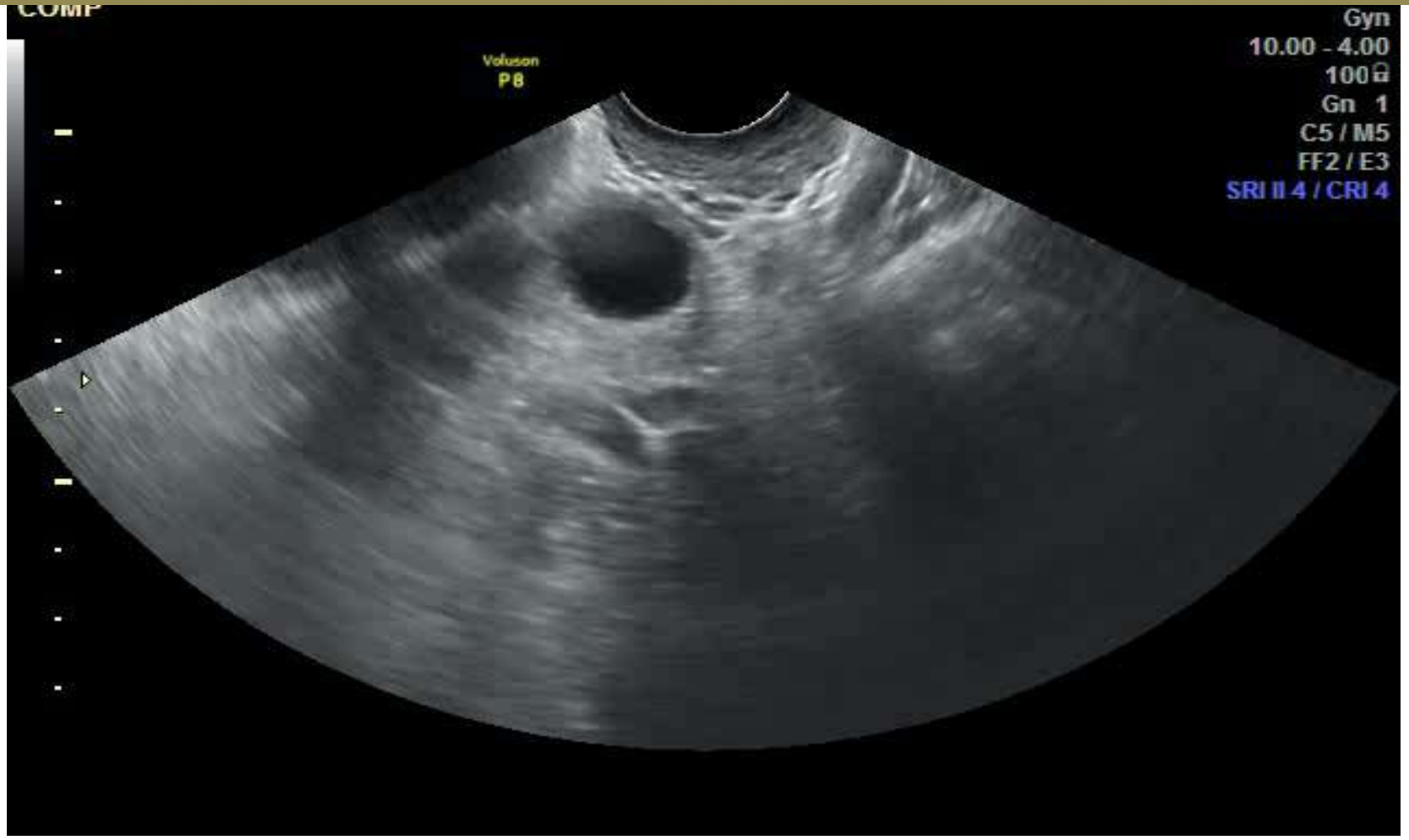




A.D.A.M.



Empty the bladder



Transvaginal ultrasound

- Ask the patient to void

- Probe insertion, sagittally, side to side movement
- Transverse orientation for semiaxial and semi coronal planes
- Variation of depths fundus to cervix
- Gradual probe withdrawal lower vagina and cervix

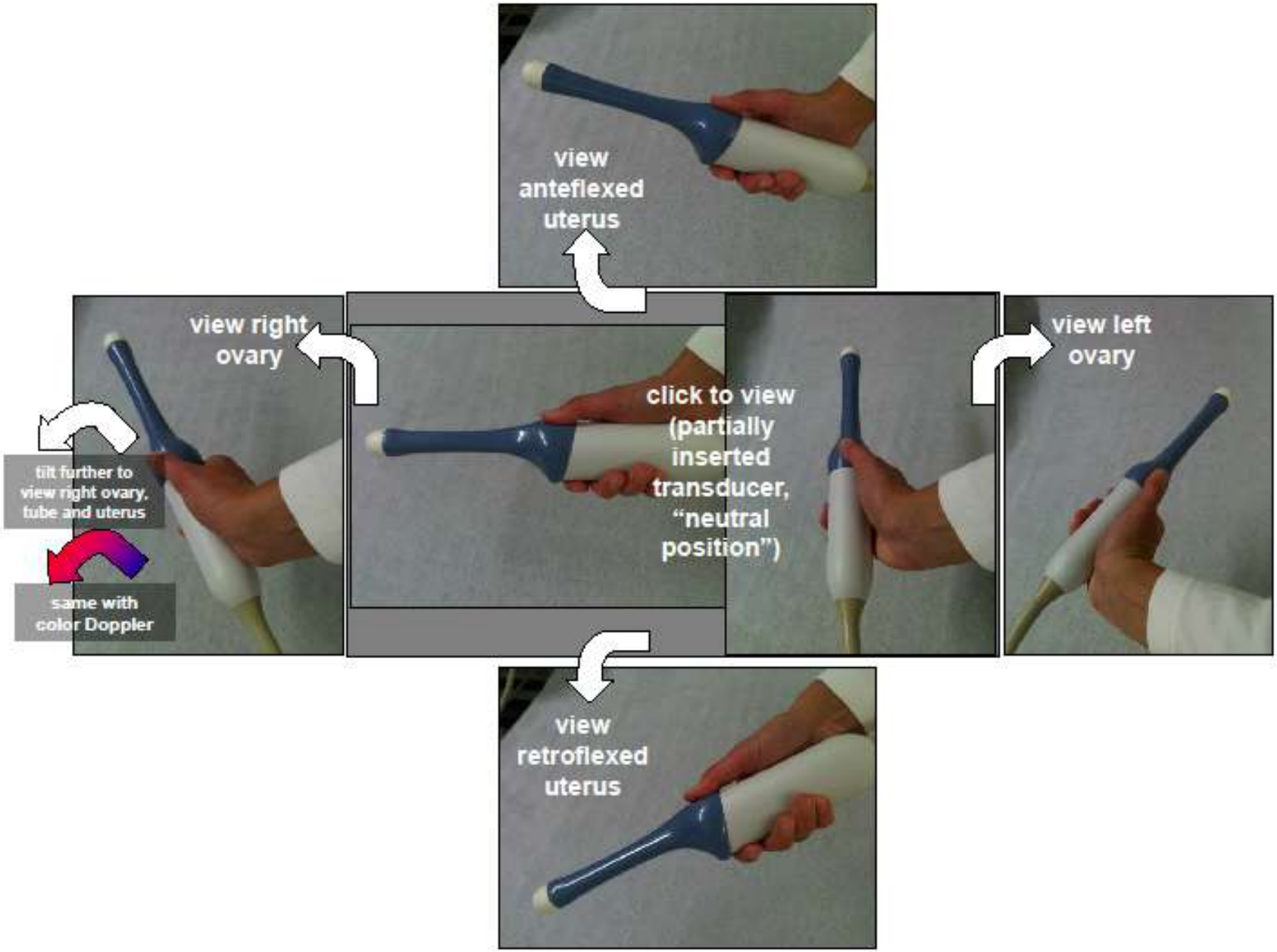
Take transducer out slowly

Longitudinal section

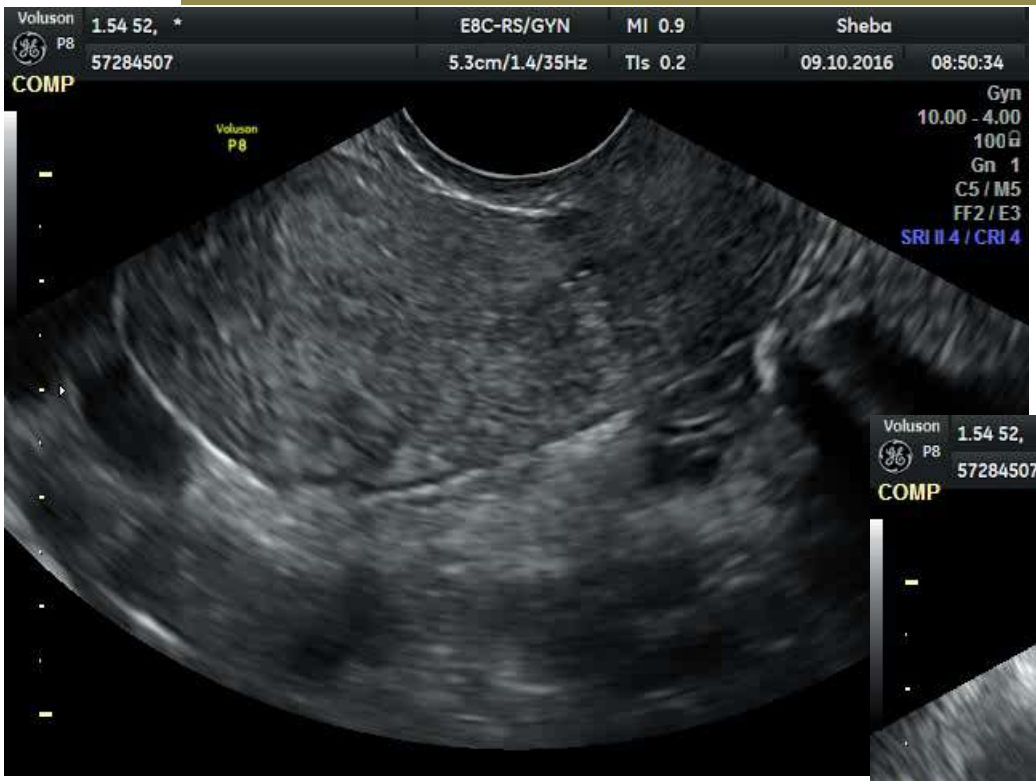
- Entire uterus on initial section
- Stabilize probe for constant orientation
- Entire endometrium
- Adjust depth, gain, focal zone
- Evaluate the whole organ from one tubal ostium to the contralateral
- Document bladder
- Document entire cervix

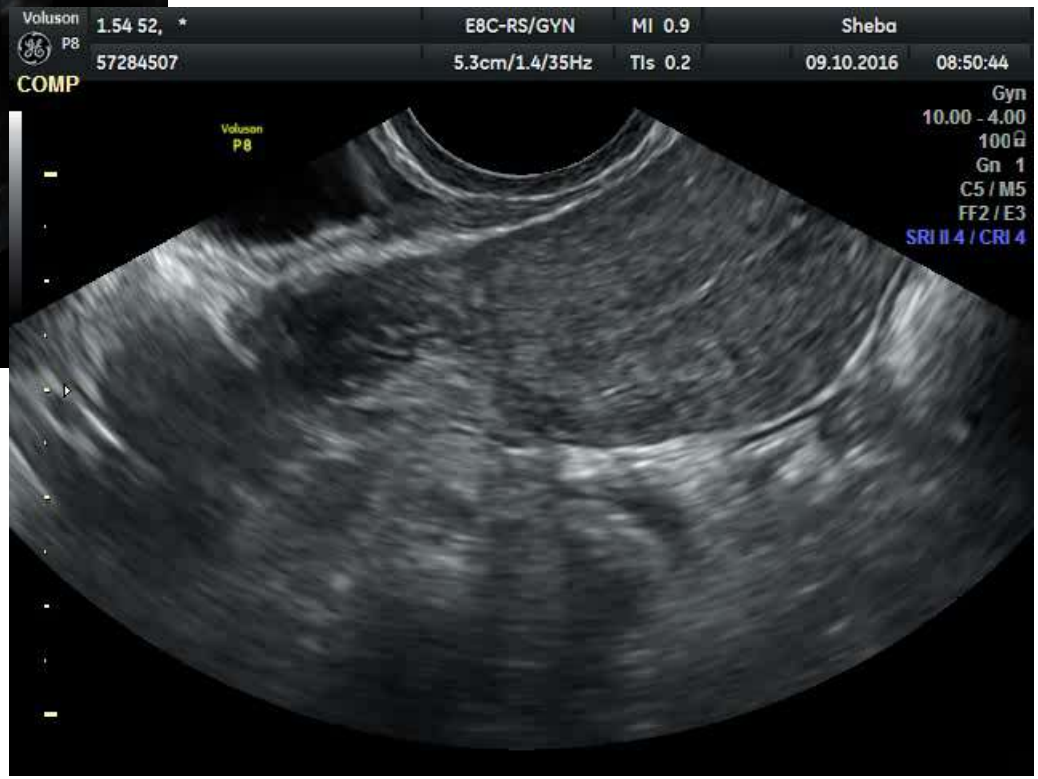
View entire uterus

Probe handling



Visualize the uterus



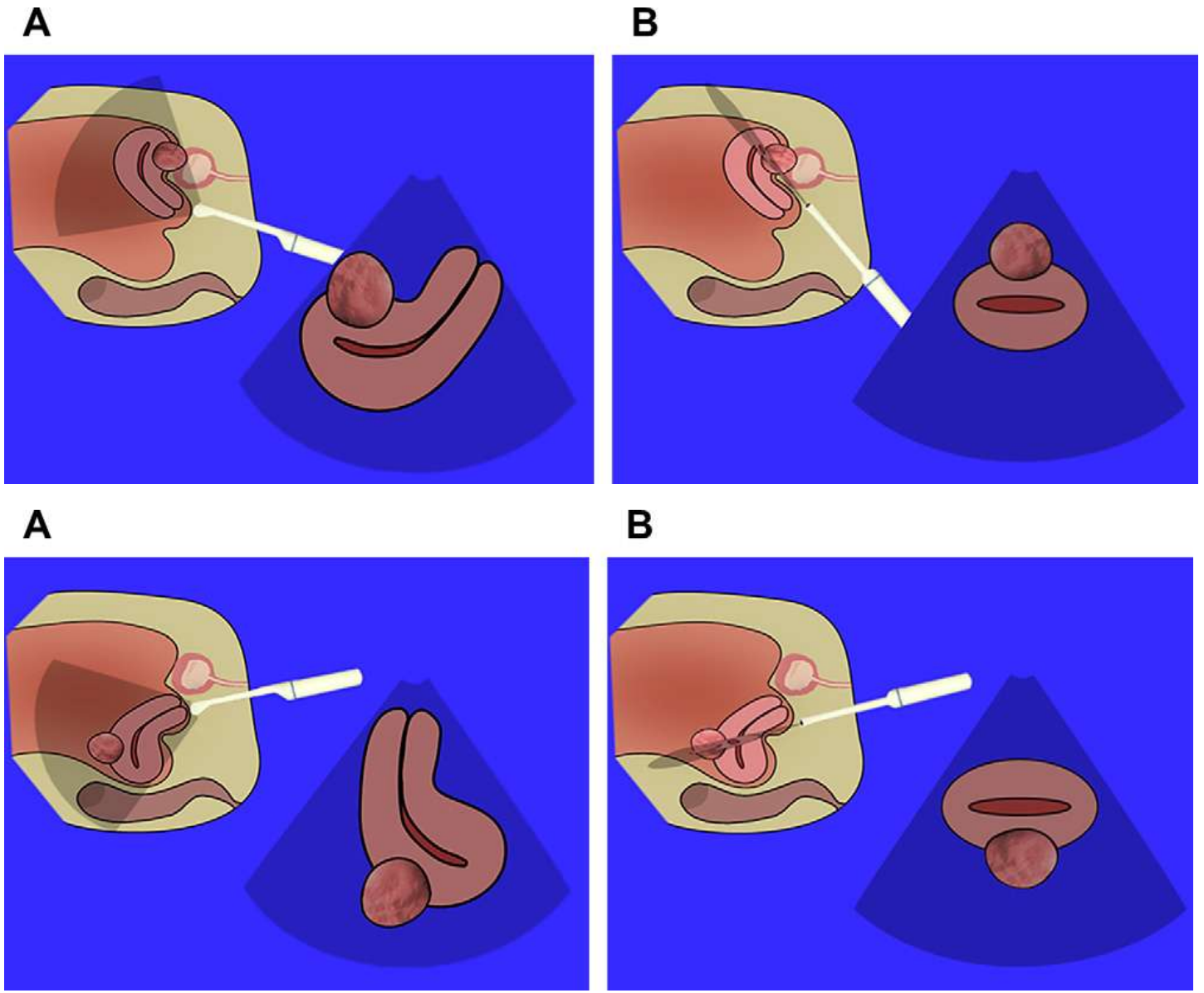


Orientation on screen

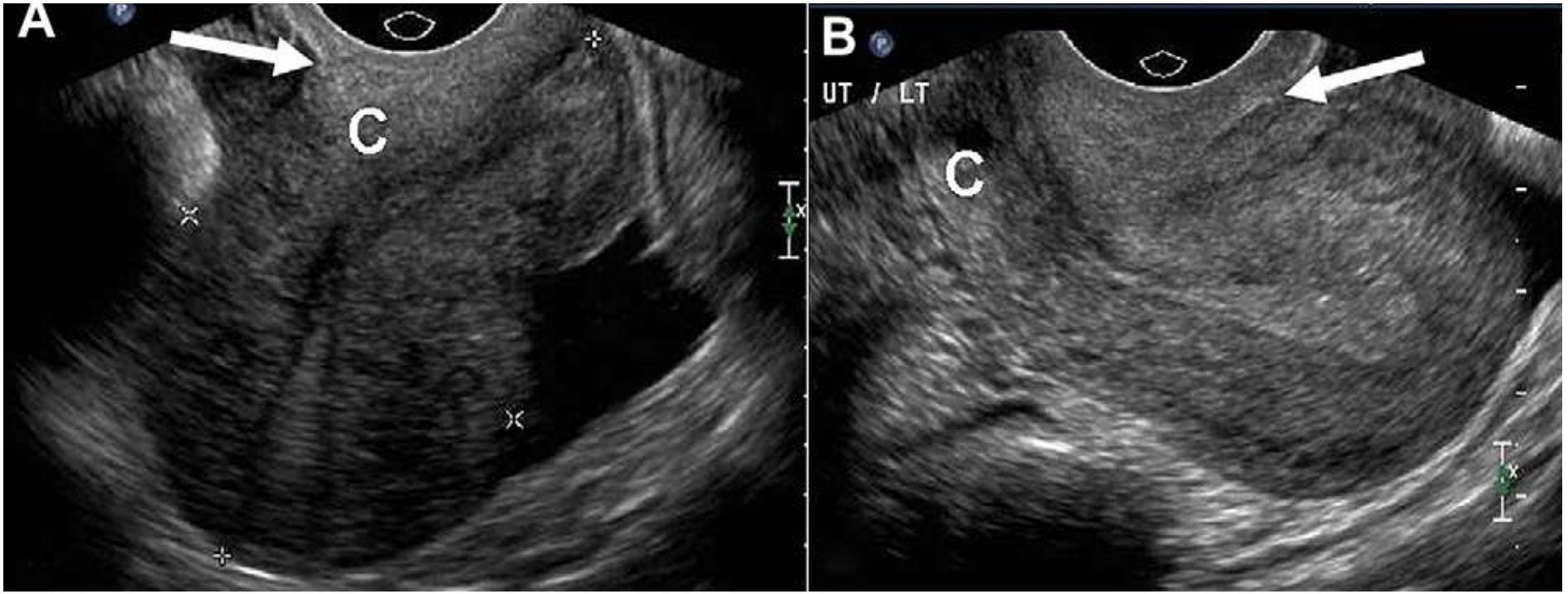
Anteverted uterus

Retroverted uterus

Orientation on screen



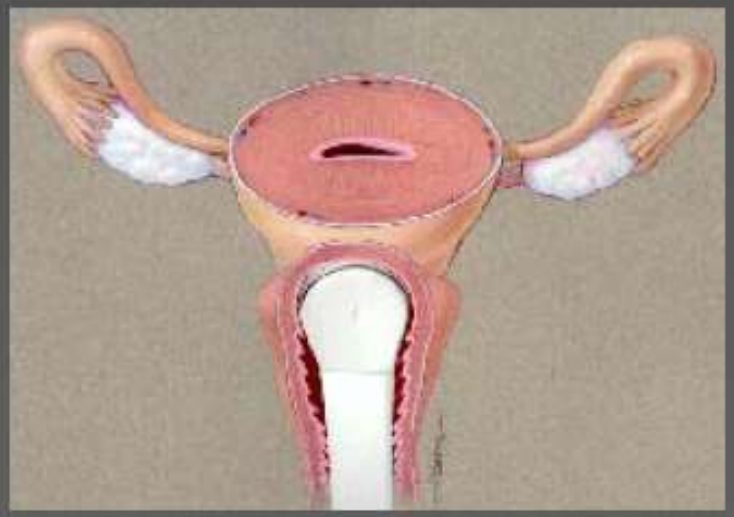
Location of probe



(A) Transvaginal sagittal, transducer in the anterior vaginal fornix (thick arrow): unfavorable, low-resolution image of a retroverted and mildly retroflexed uterus that is almost parallel to the US beam. (B) Transducer is gently manipulated into the posterior vaginal fornix (thick arrow) and light, steady manual pressure exerted on the uterus. The uterus changes into a more retroverted position and the body, fundus, and endometrium become more perpendicular to the beam.

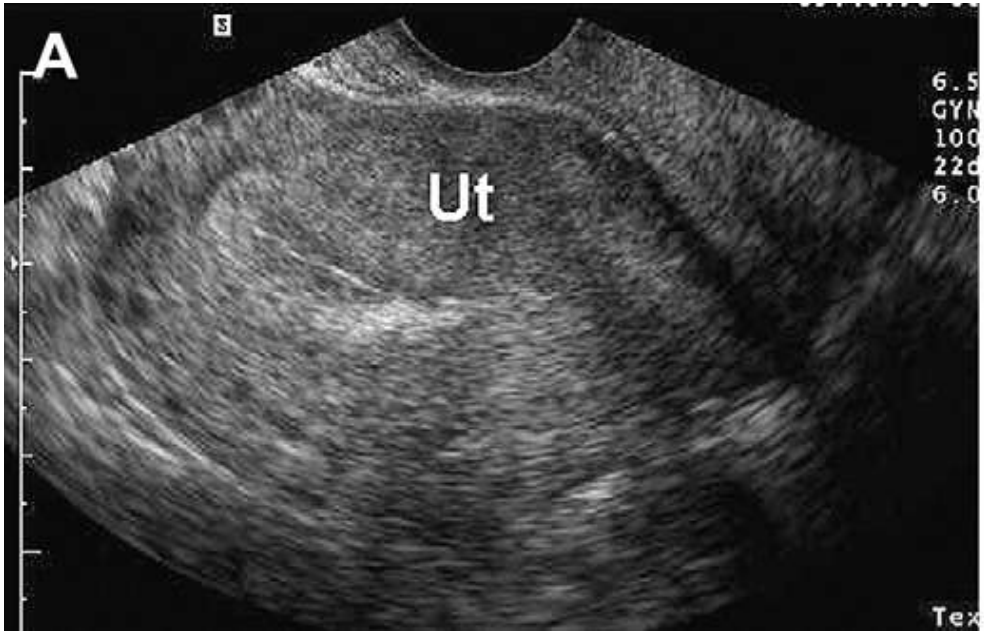
Transverse section

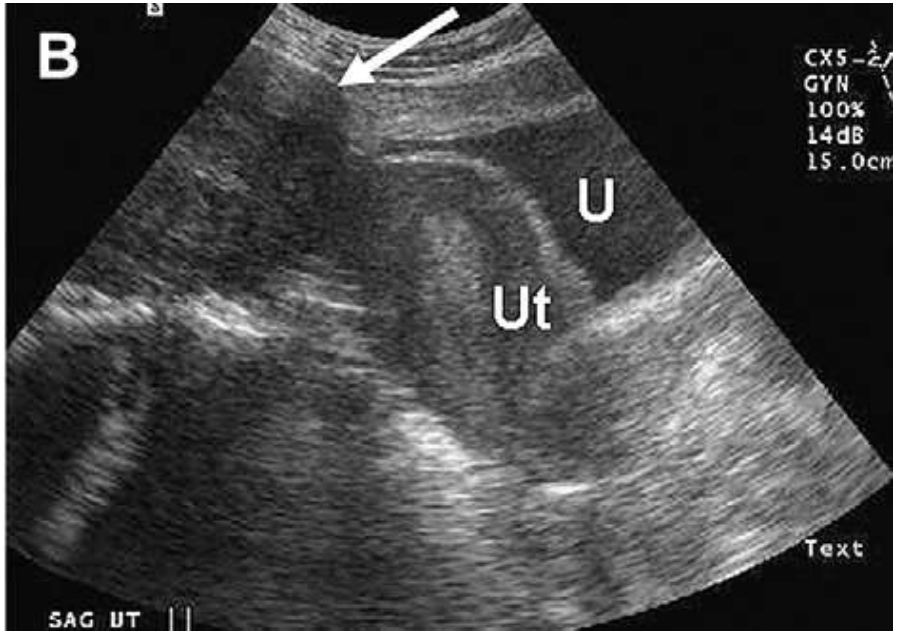
- Rotate anticlockwise the probe in order to obtain a transverse section
- Tilt the probe from the fundus to the cervix



Limitations of only TVS scanning

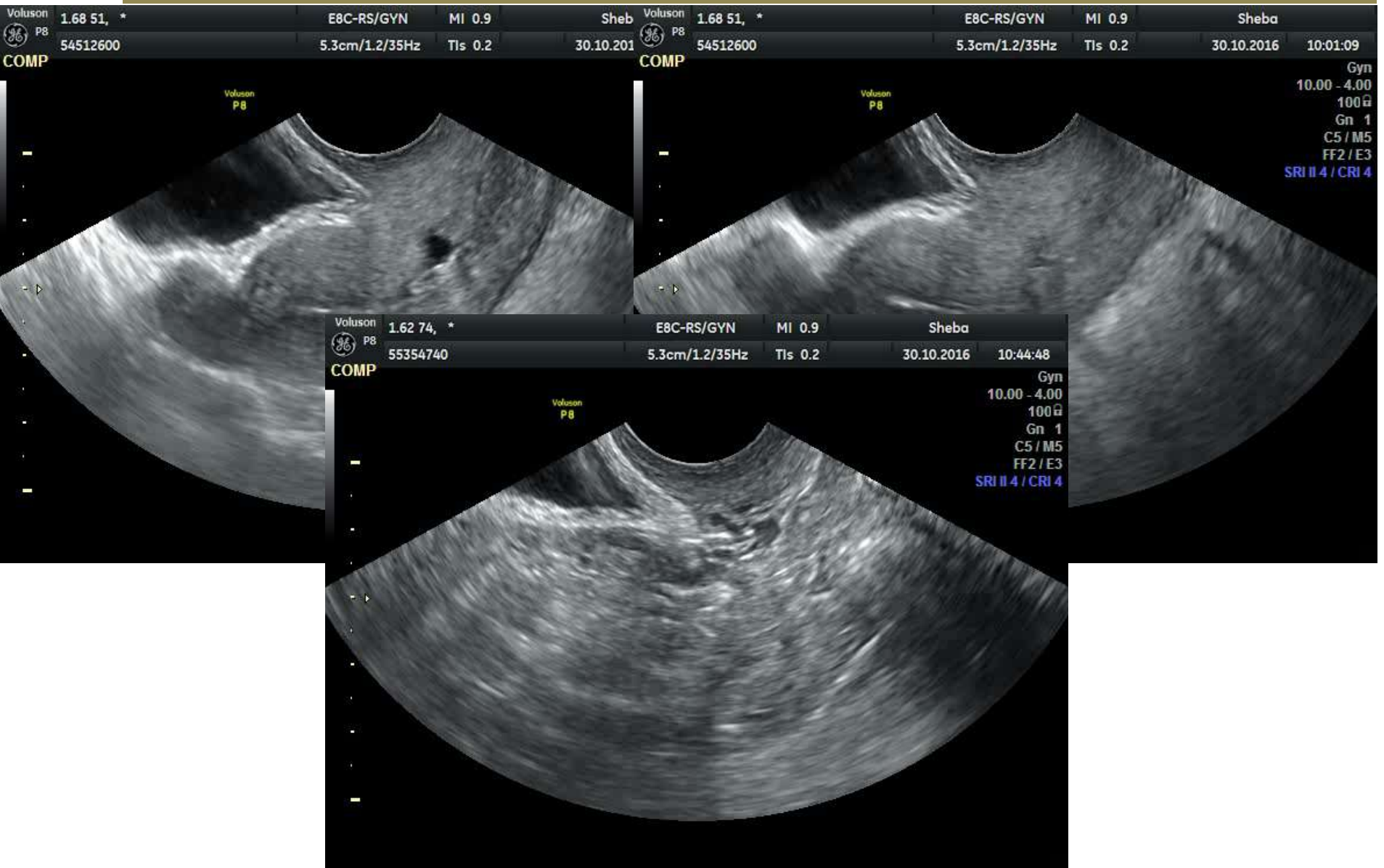
- High resolution TVS probes have limited penetration: uteri > 8-10 cm are incompletely evaluated





Note large pedunculated myoma in panel B

Uterus


Voluson P8
1.68 51, *
E8C-RS/GYN
MI 0.9
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Voluson P8
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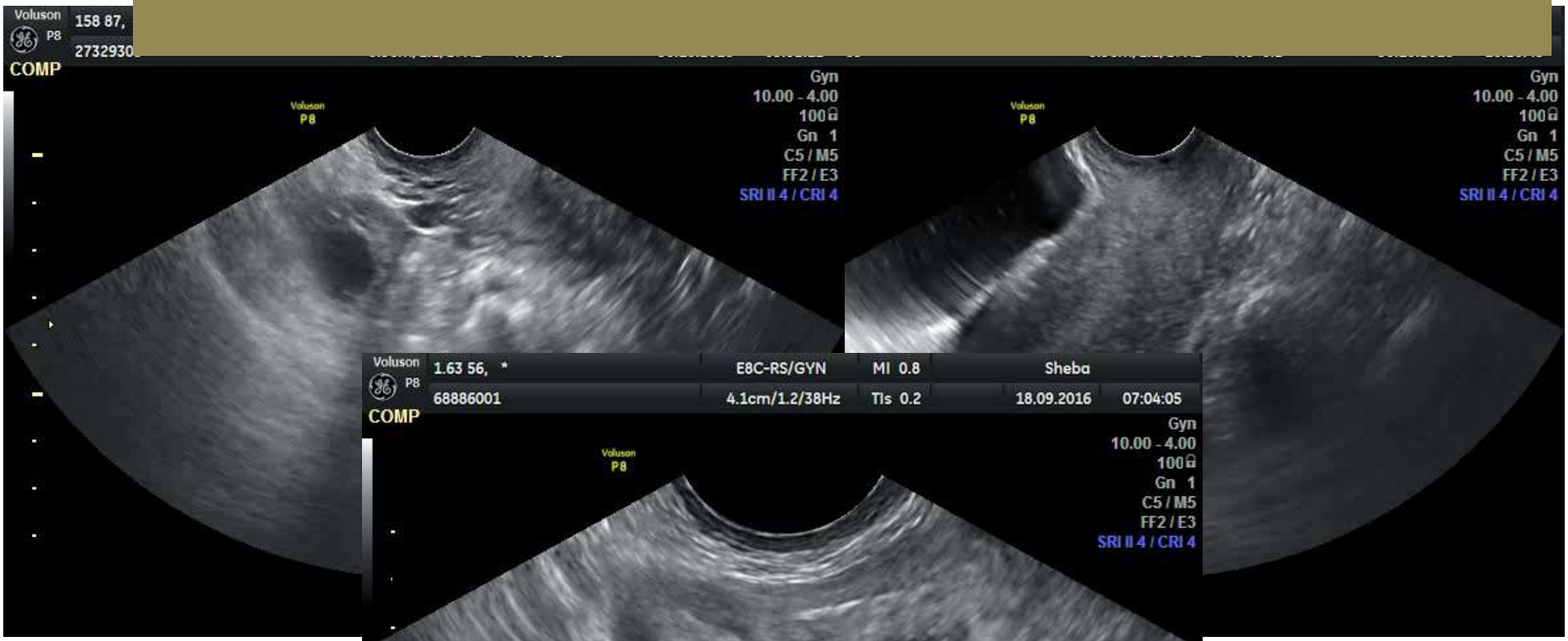
C5 / M5
FF2 / E3
SRI II 4 / CRI 4

How to look for the ovaries

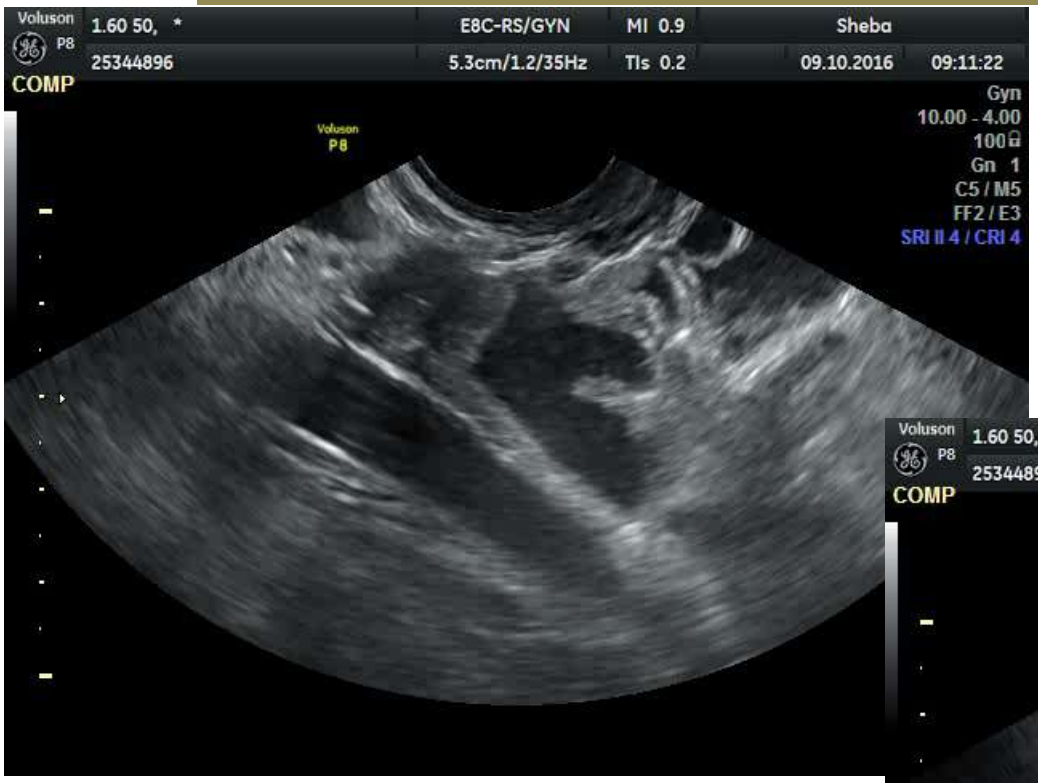
- After evaluating the uterus on a transverse section, find the level at which the utero-ovarian ligament lies
- Tilt the probe laterally
- Find out were the pelvic wall is
- Slip up & down until you find the ovary
- Go back to the transverse section of the uterus
- Do the same for the contralateral ovary

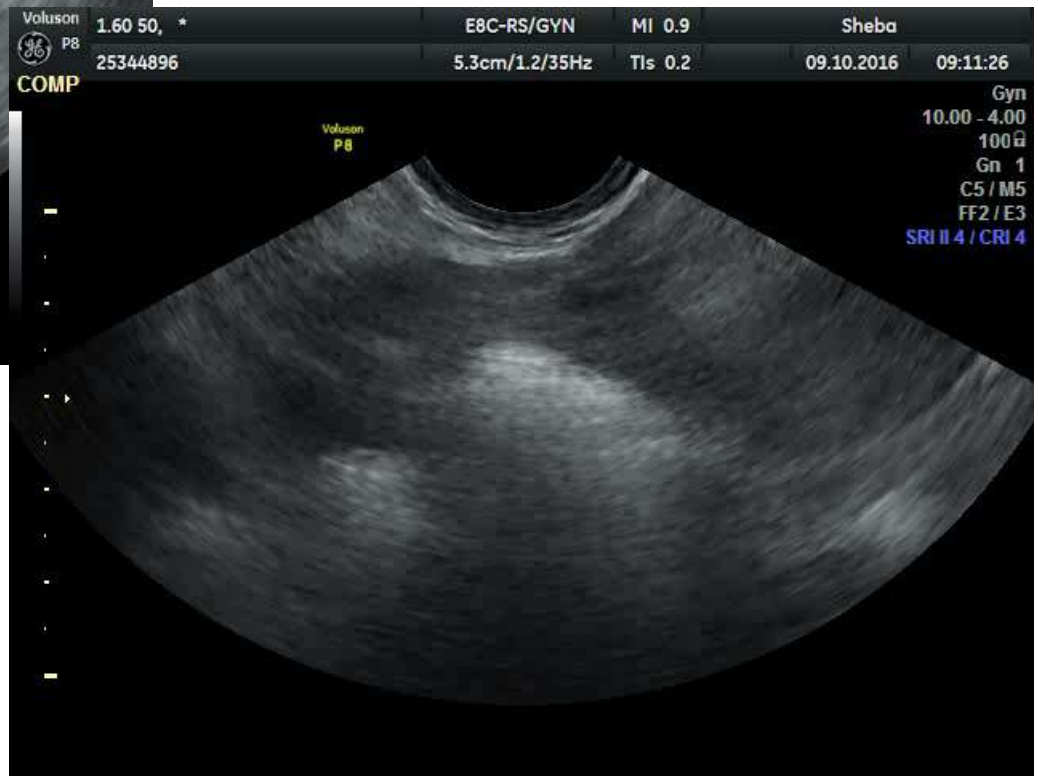
Look for the ovary



A
B
D
E
E

Visualize the iliac vessels





Remember – you have 2 hands

- Use the free hand to palpate the pelvis, it can be useful to:
  - Revert the uterus in cases of stretched uterus
  - Push the ovary toward to probe
  - Check for mobility
  - Separate masses in close proximity
  - Movement of internal echoes
  - Differentiating hollow structures

US is dynamic and interactive

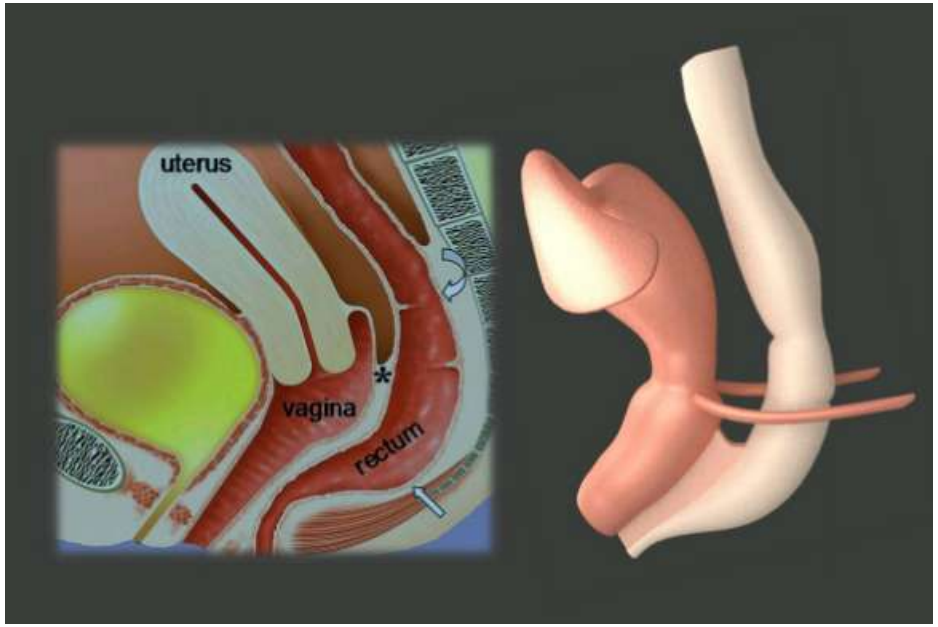
- Pressure and retraction of the probe allows to assess mobility and elasticity of the structures, as well as tenderness of a given organ

- Are organs fixed or mobile (sliding)?
- Organ tenderness?
- Elasticity
- Is there any peristalsis?
- Cyst contents (streaming, jelly)

Sliding sign and POD obliteration

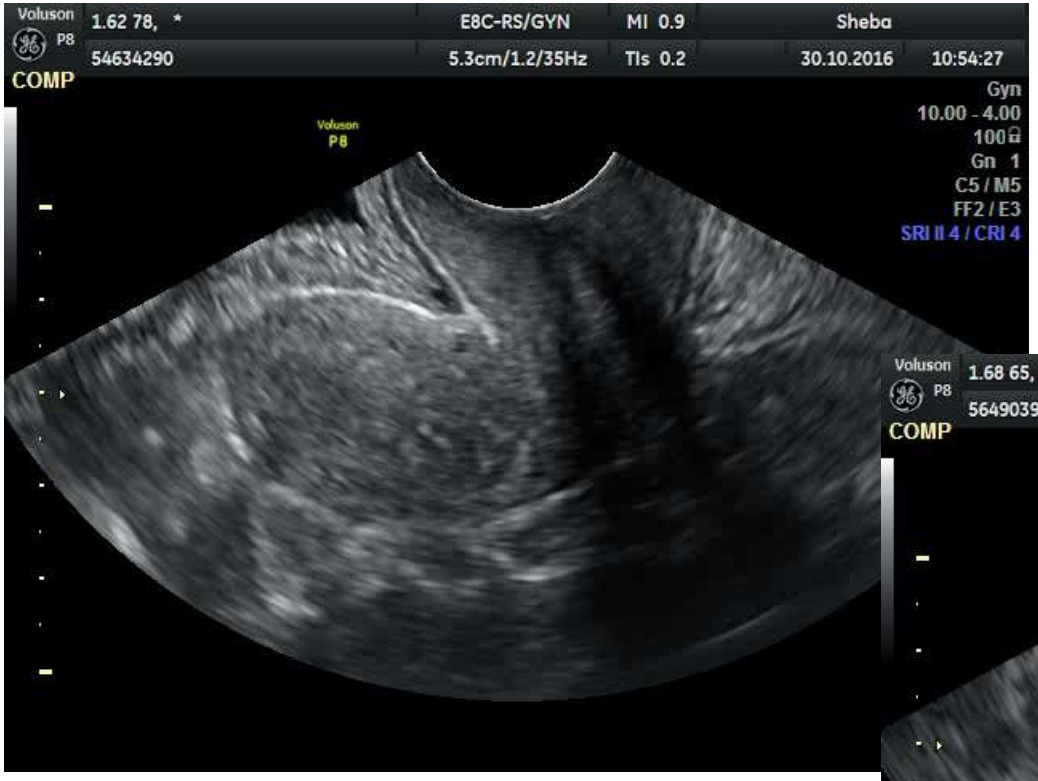
- Sliding sign – anterior rectum glides over posterior aspect of cervix and posterior vaginal wall
- Prediction of POD obliteration

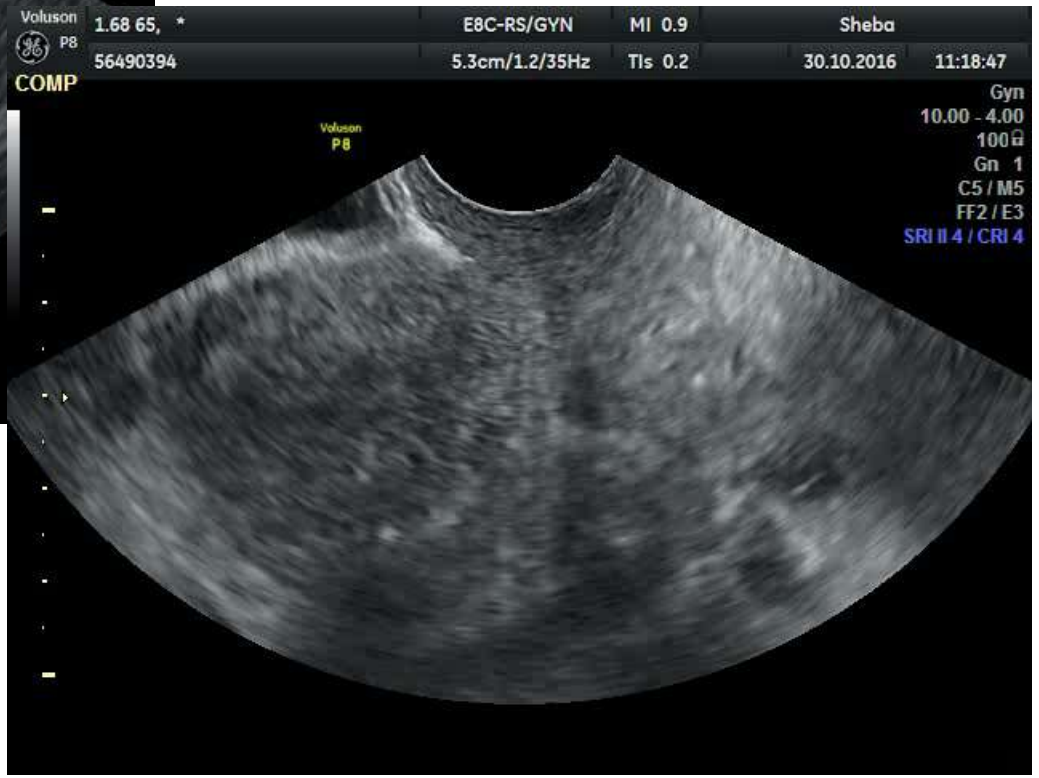
- Increased risk for bowel endometriosis
- DIE of rectum
  - Sensitivity 83.3-85%
  - Specificity 96-97.1%
  - Accuracy 93.1%



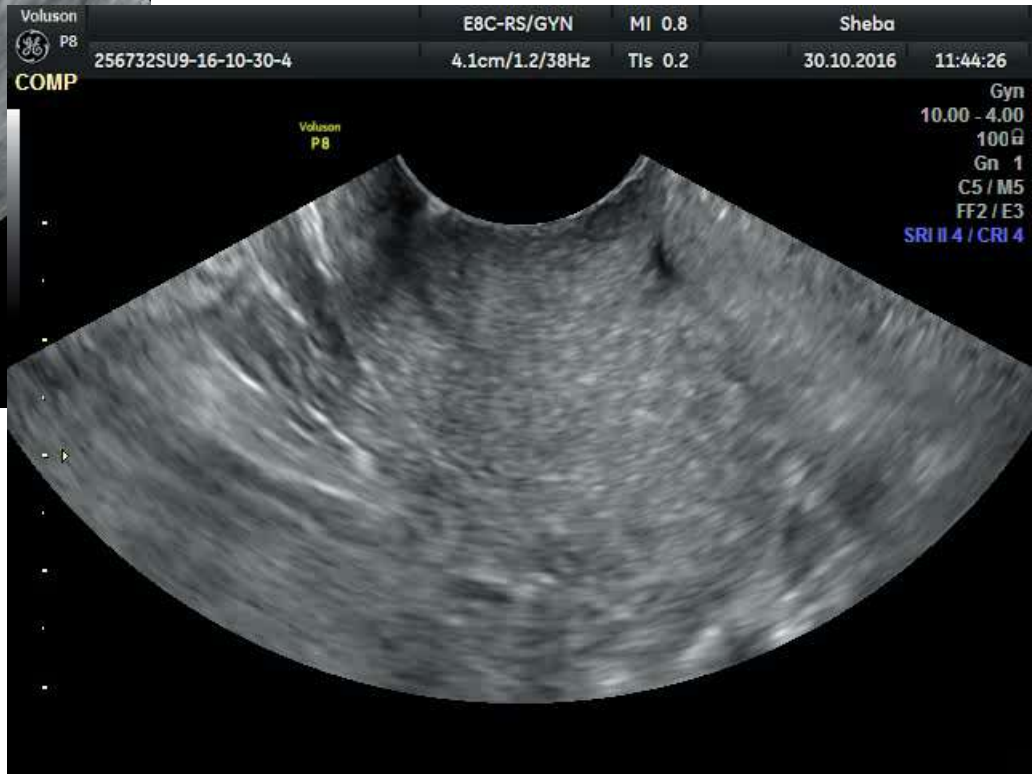
Guerriero 2010, Okaro 2006, Holland 2010, Hudelist 2013, Reid 2013

Sliding sign - anterior uterus



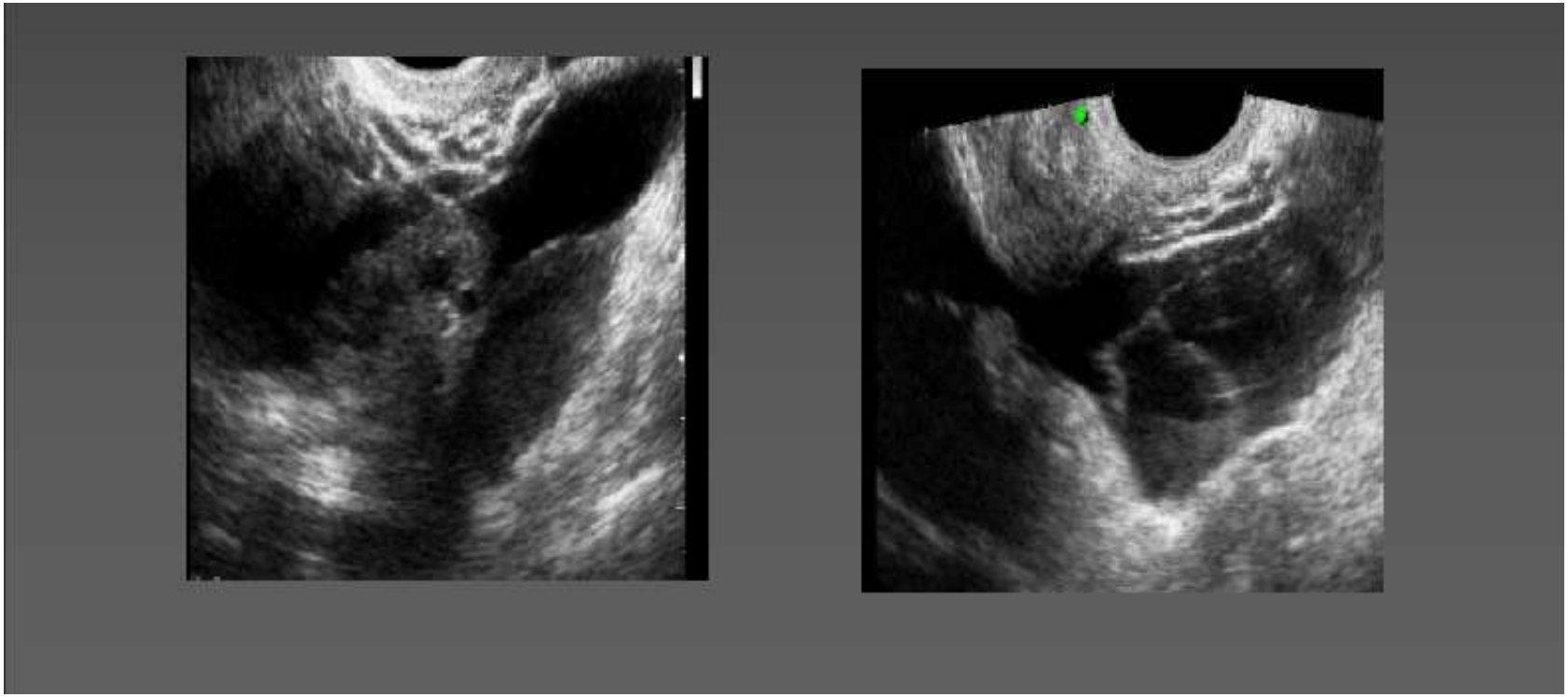


Sliding sign - posterior uterus

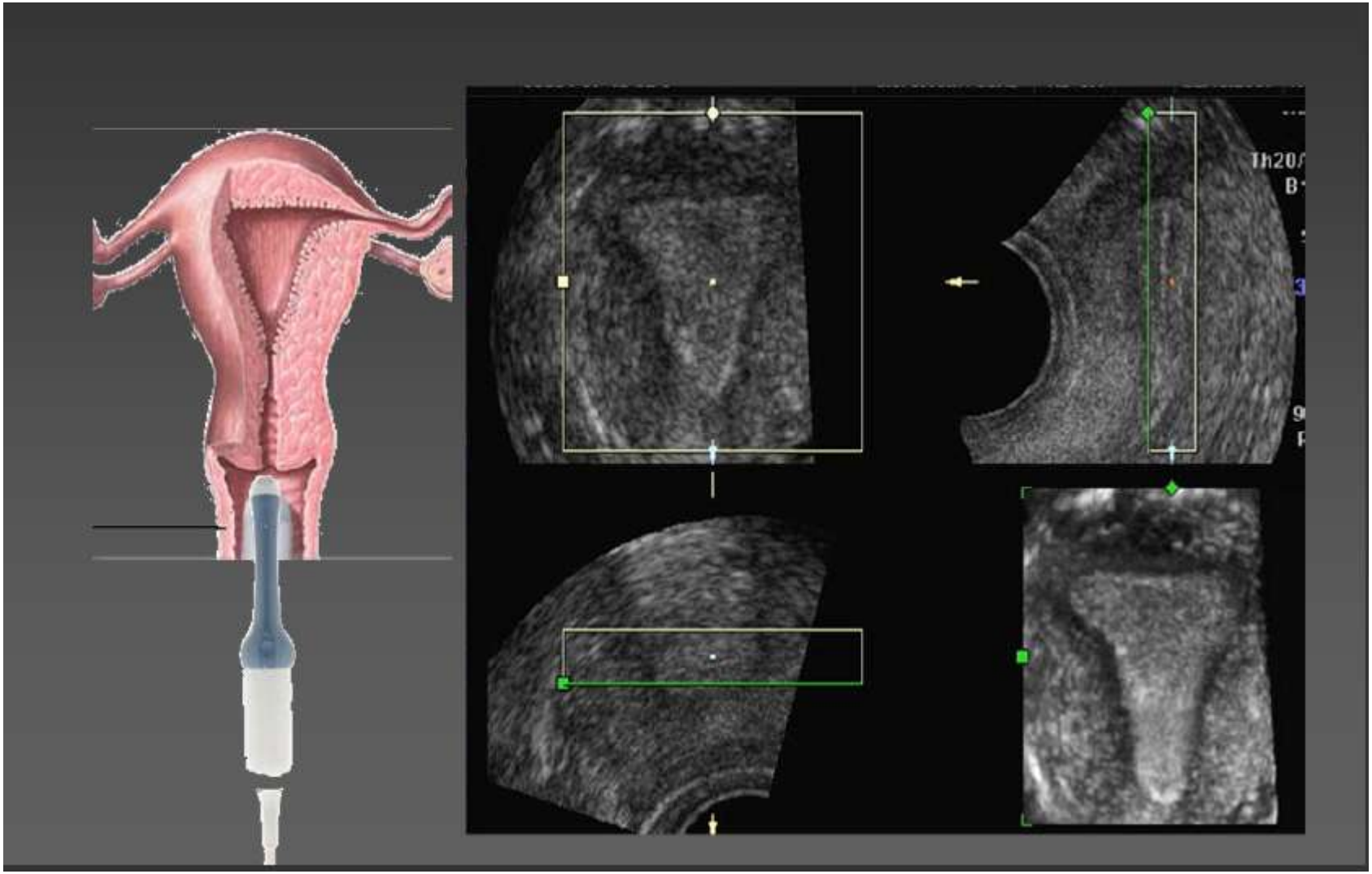


Flapping sail sign

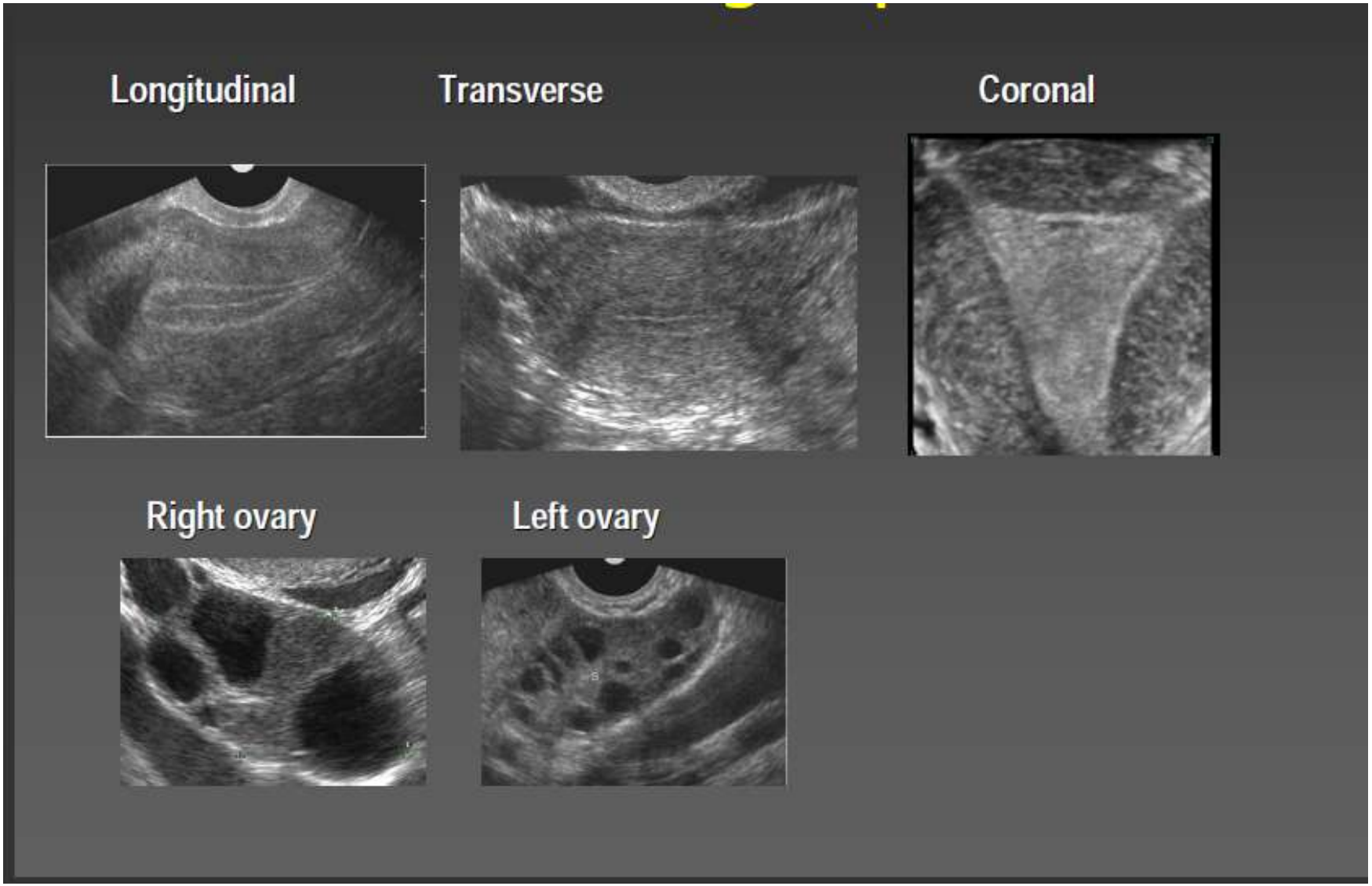
- Investigate the adherence/movement of adjacent structures



Coronal section



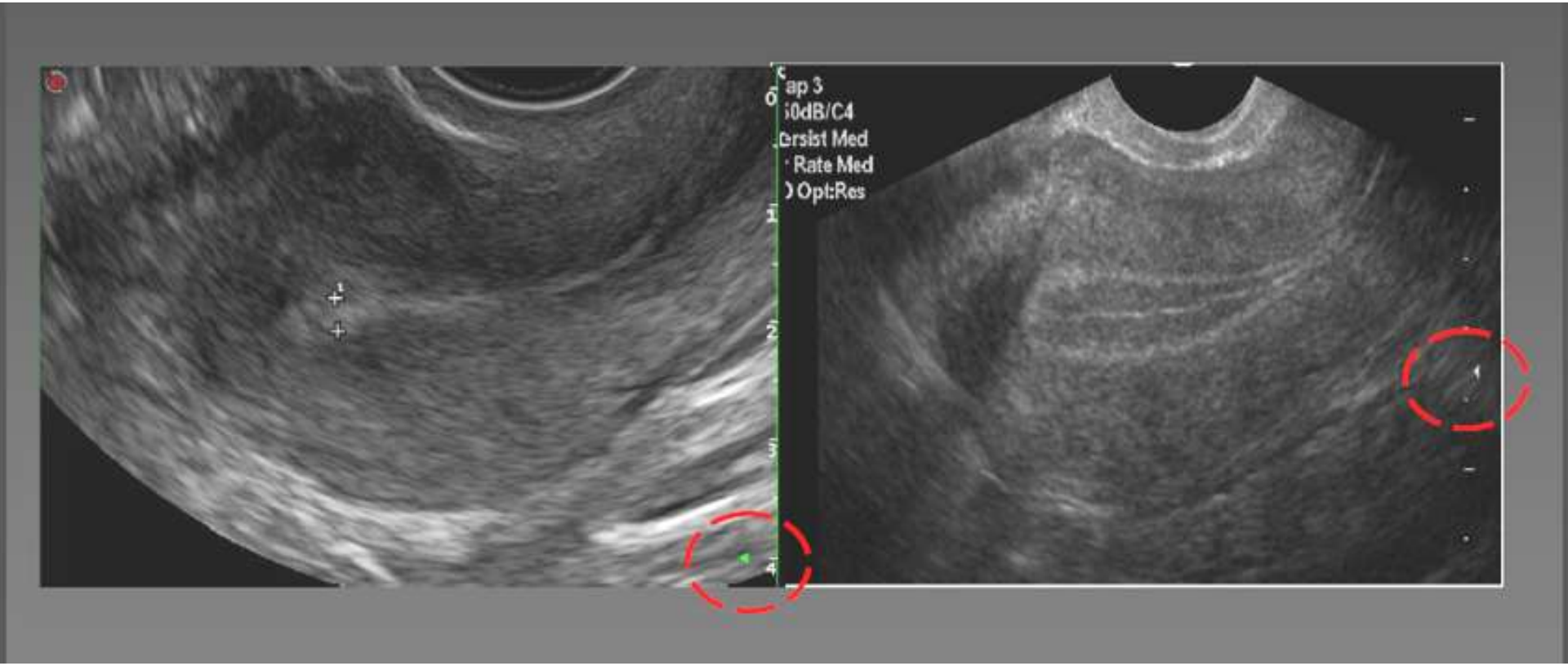
Standard images printout



Optimization of the image

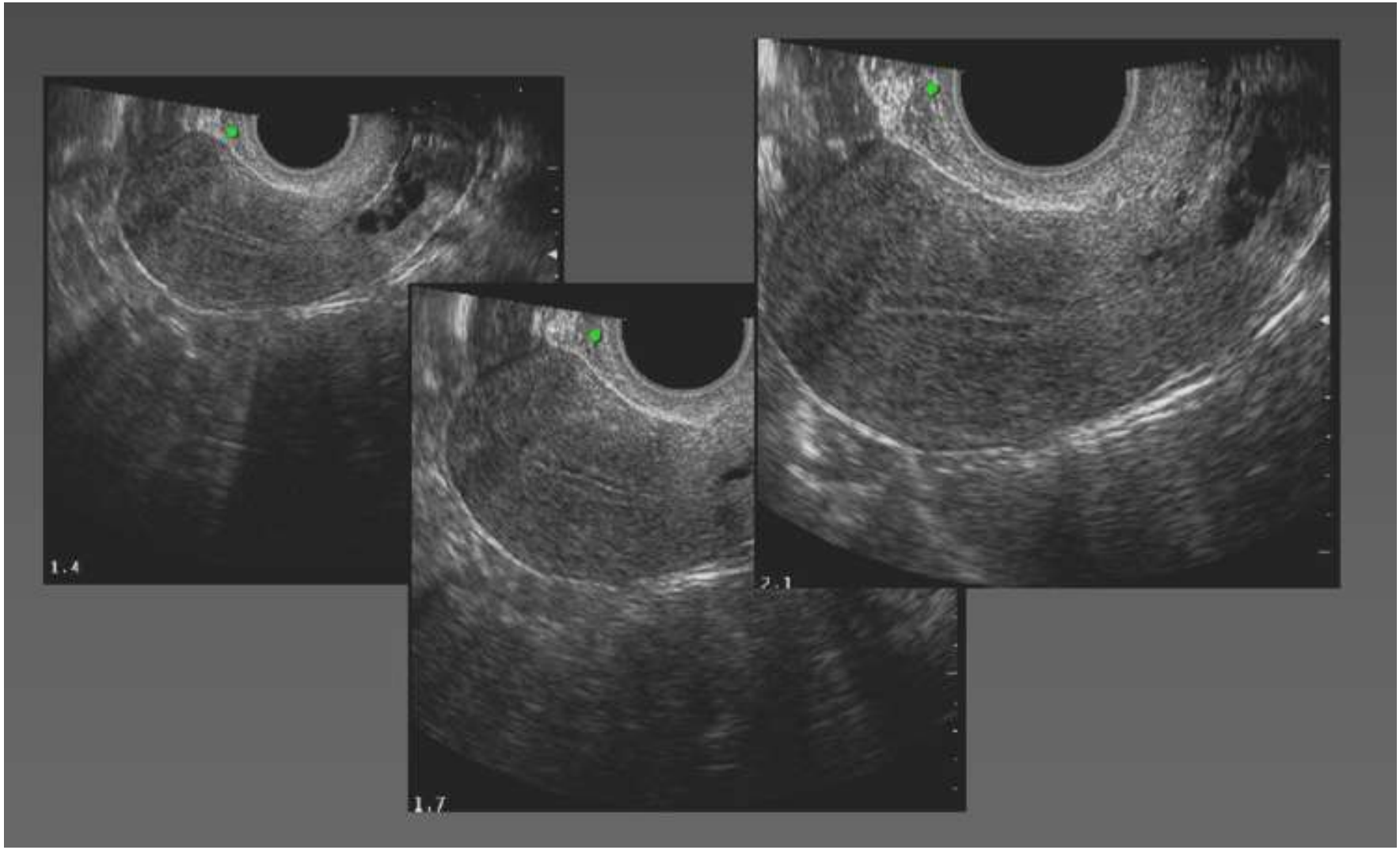
Adjust focal point

- ONE correctly placed



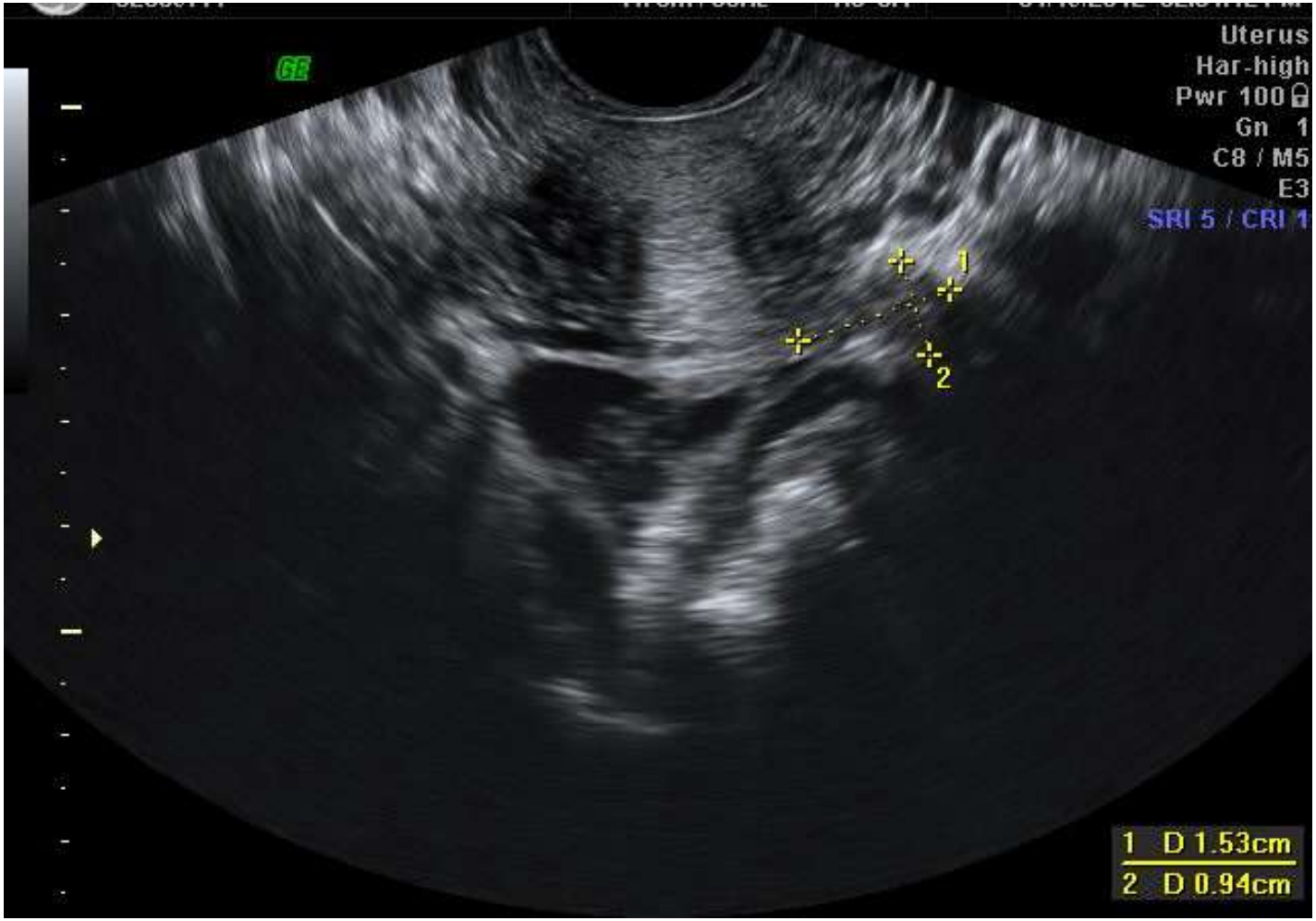
Adjust depth

- Small depth



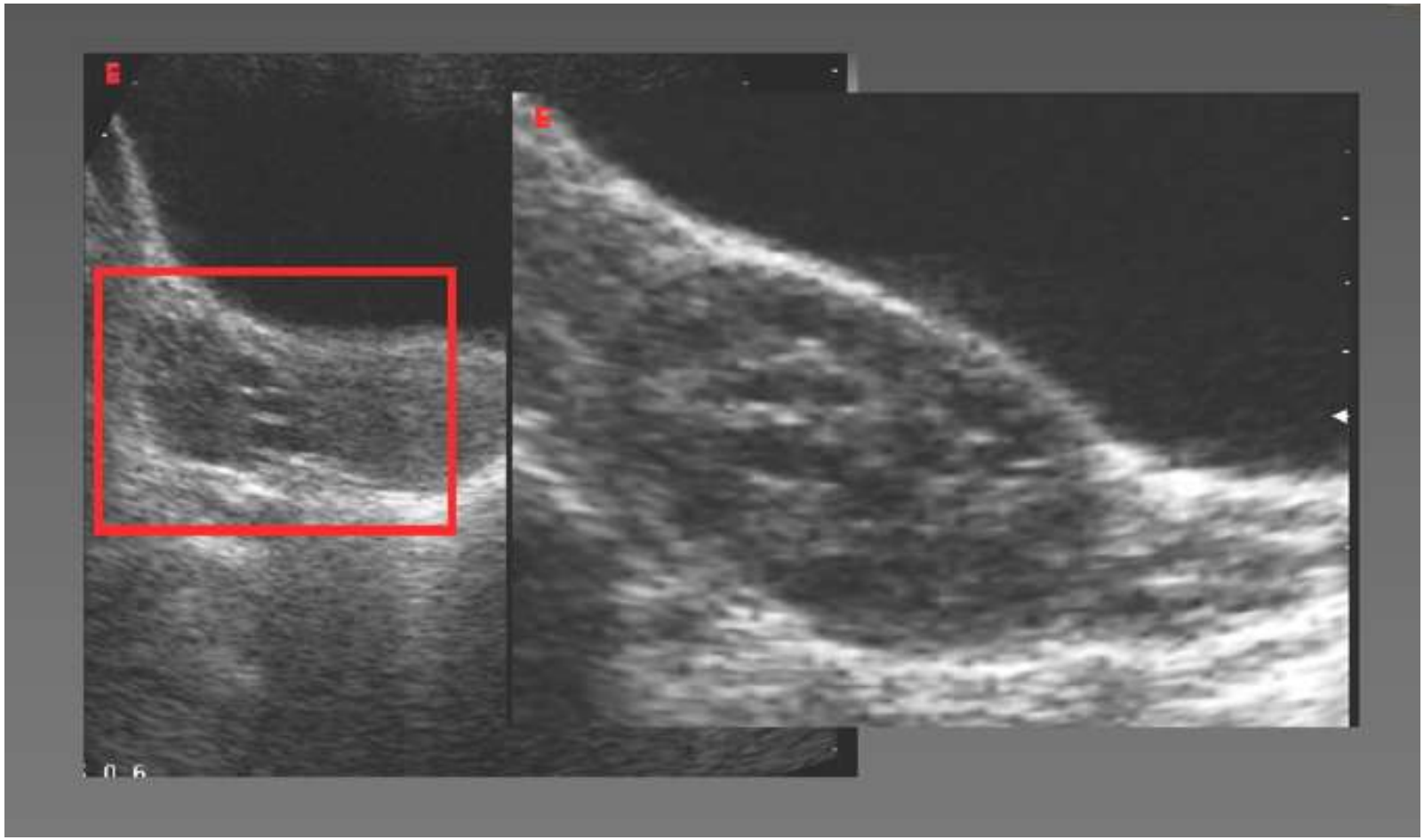
Adjust angle

- Small image angle

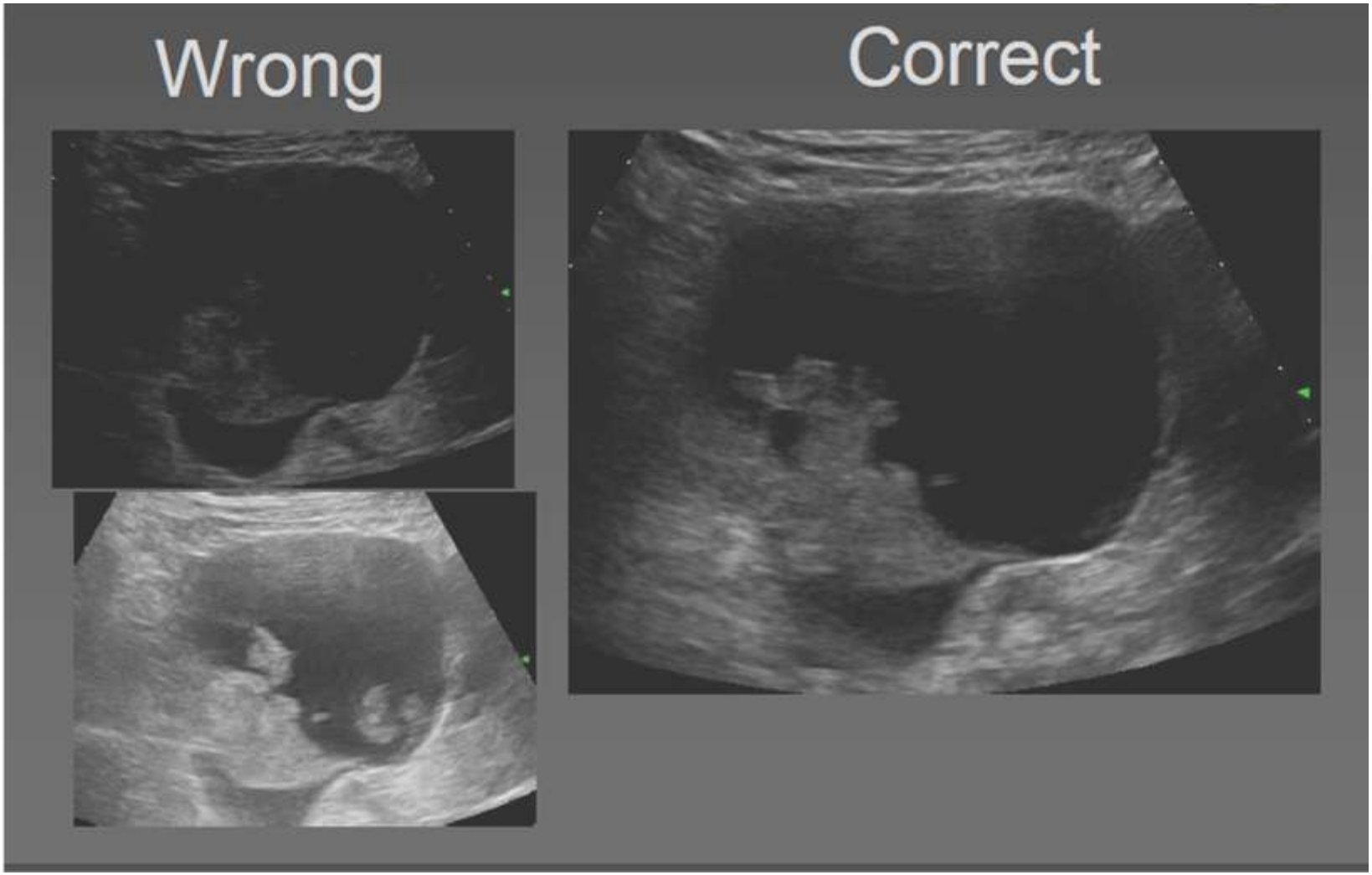


Adjust zoom

- True zoom

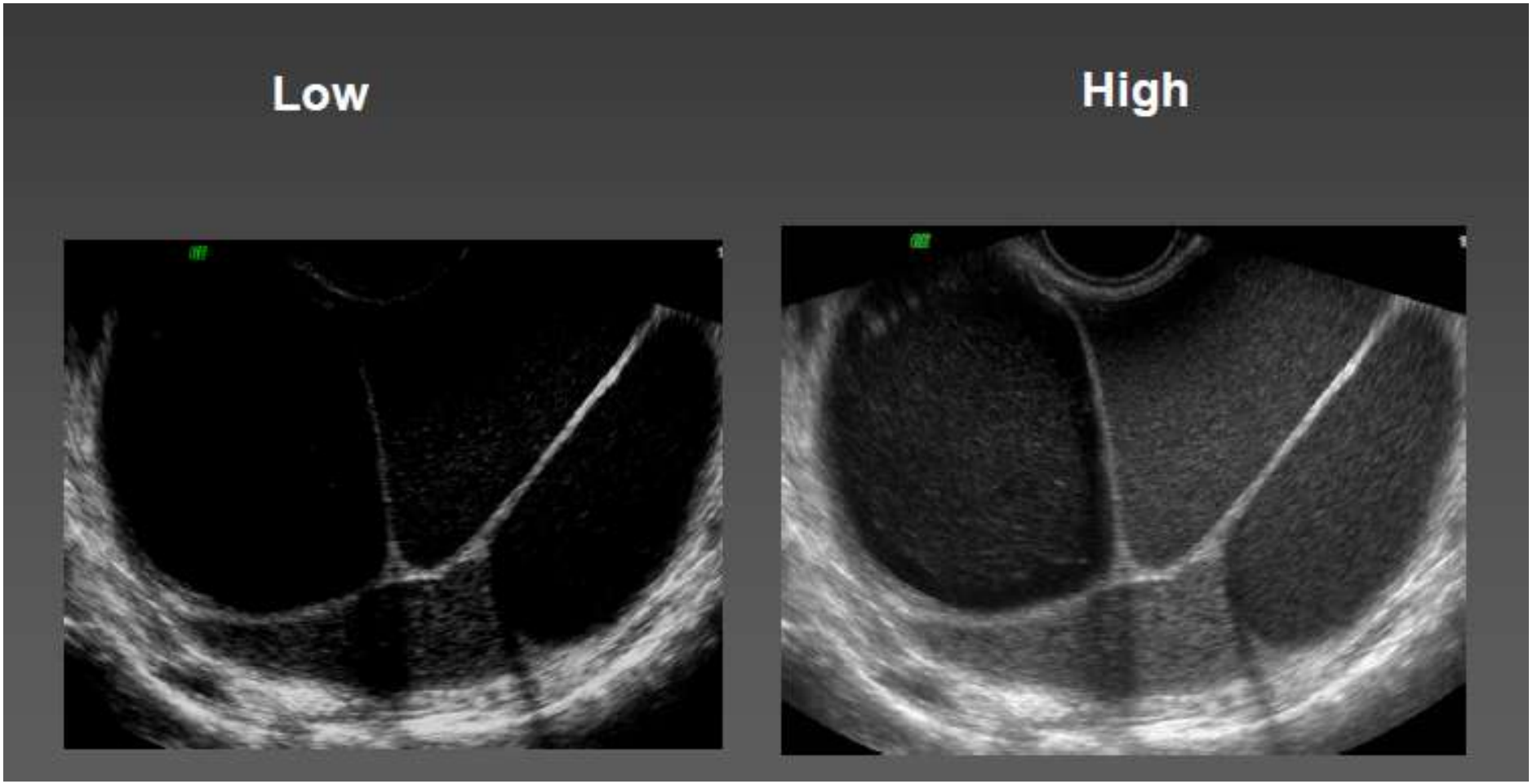


Adjust gain



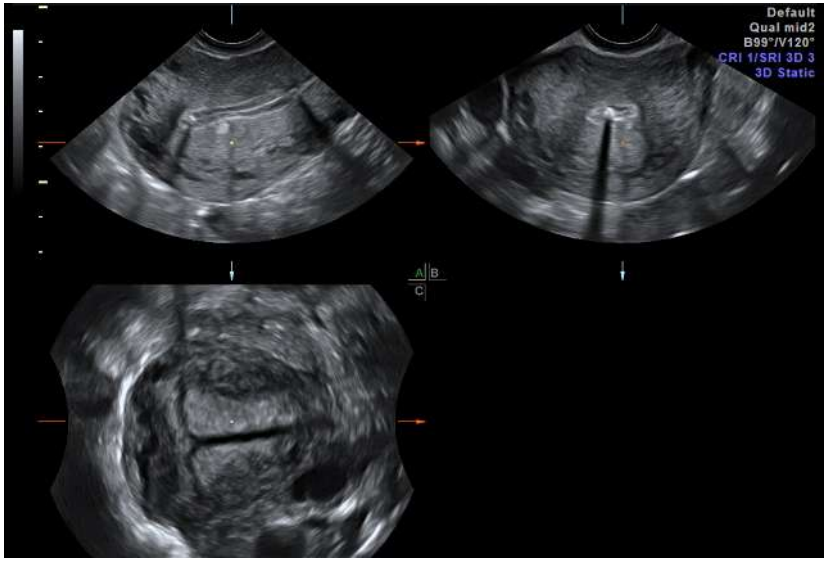
Test – lower gain, compare with adjacent fluid structures and increase gain

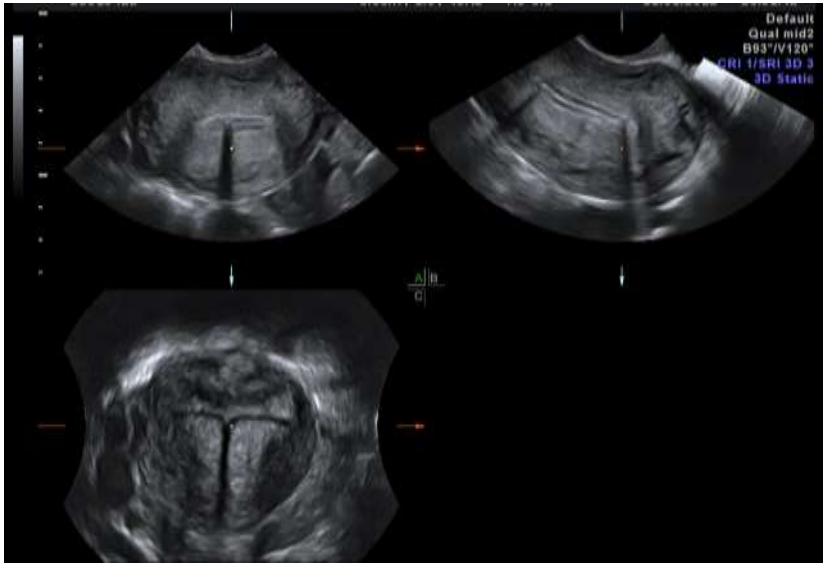
Adjust dynamic range



Adjust power level

Acoustic shadow





Blind spots in the pelvis

- Upper pelvis above the uterus
- Laterally along pelvic sidewalls
- Deep in cul-de-sac
- Markedly anterior to uterus

- Important when searching for ovaries
- Looking for ectopic pregnancies
- Remember TAS

What can we see?

Vulva, vagina and cervix

- Foreign body in vagina

- Vulvar cyst

The normal uterus

Uterus – normal anatomy

- Abdominal - full bladder
- Vaginal – empty bladder enables better visualization
- Position – anteverted, retroverted
- Size
- Shape – pear shaped
- Texture – homogenous, low to medium echogenicity

Normal dimensions of the uterus

Stage of Life	*Normal Dimensions (cm)*
Neonate	4 × 2 × 2
Child (pre-pubertal)	3 × 1 × 1
Woman (nulliparous)	8 × 4 × 4
Woman (multiparous)	9 × 5 × 5
Woman (postmenopausal)	7 × 2 × 2

Normal endometrial appearance and thickness

Phase	*Normal Thickness (mm)*	*Appearance*
Proliferative phase (pre-ovulation)	4-8	Triple layer (hyper-hypo-hyper)
Secretory phase (post-ovulation)	7-14	Uniform hyperechoic
Menstrual phase	1-2	Thin, broken echogenic line
Postmenopausal without bleeding	<8	Uniform hyperechoic
Postmenopausal with bleeding	<5 = endometrial atrophy > 5 = risk of carcinoma	Uniform hyperechoic
Postmenopausal on hormone replacement therapy	Add 1–2 mm to values listed for postmenopausal women	Uniform hyperechoic

Uterus – Menstrual cycle

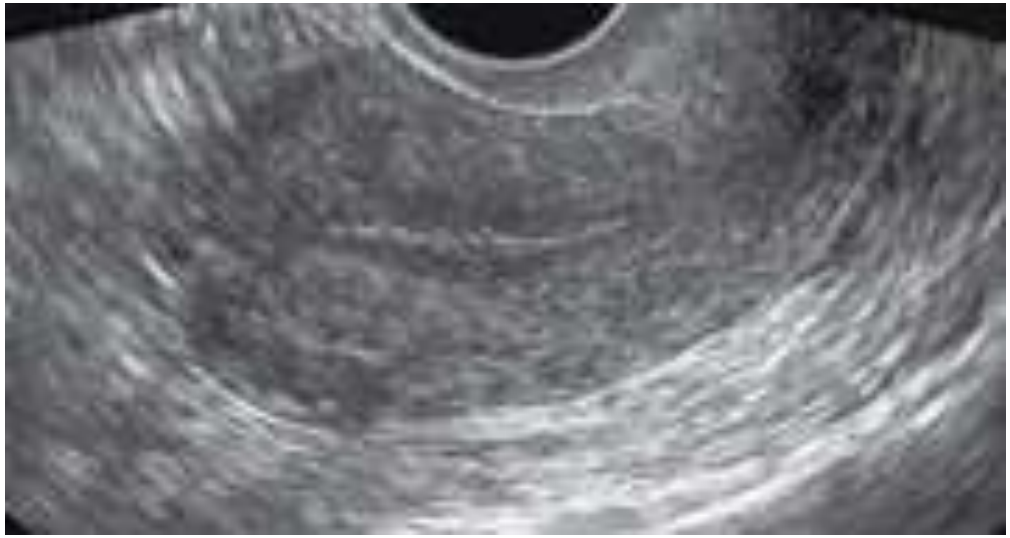
- Central line echogenicity:
- Hypo echoic – **proliferative phase** –
- Triple line endometrium – **late proliferative phase**, periovulation (edema, increased glycogen and mucus)
- **Secretory phase** – thickened and echogenic- 6-12 mm, echogenic (stromal edema), hypoechogenic interphase represents inner layer of myometrium (junctional zone)

Uterus – Menstrual cycle

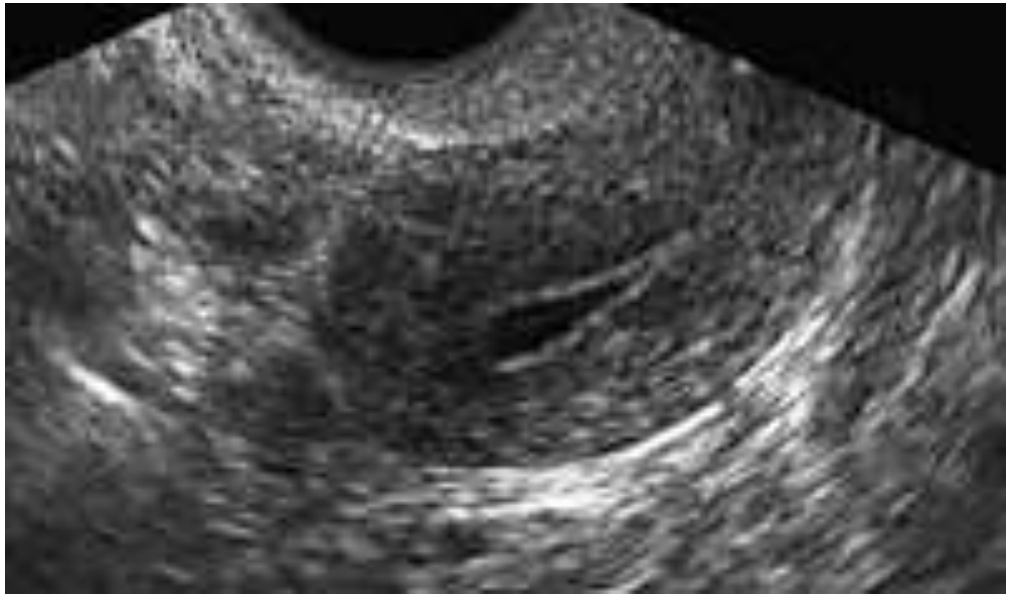
- Menstruation

Uterus – Menopause

- Post menopausal endometrium

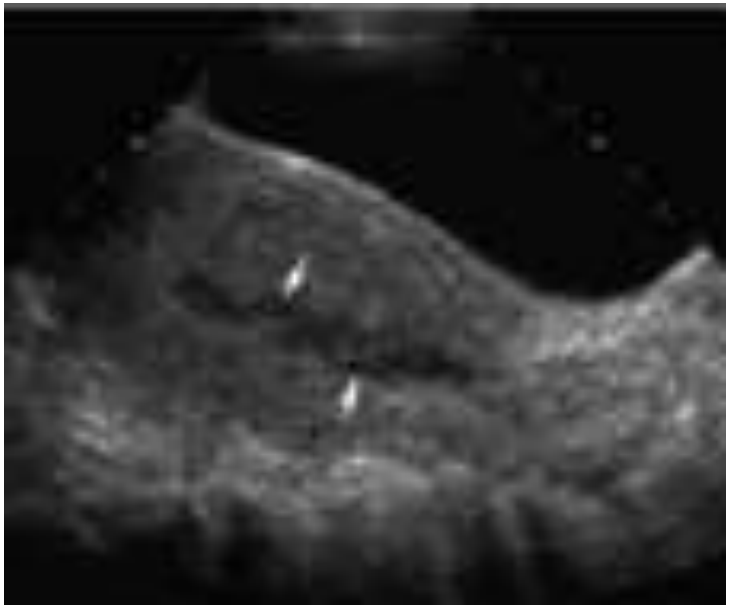


- Atrophic endometrium with fluid



Uterus – postpartum

Post CS



Postpartum

Uterus with?

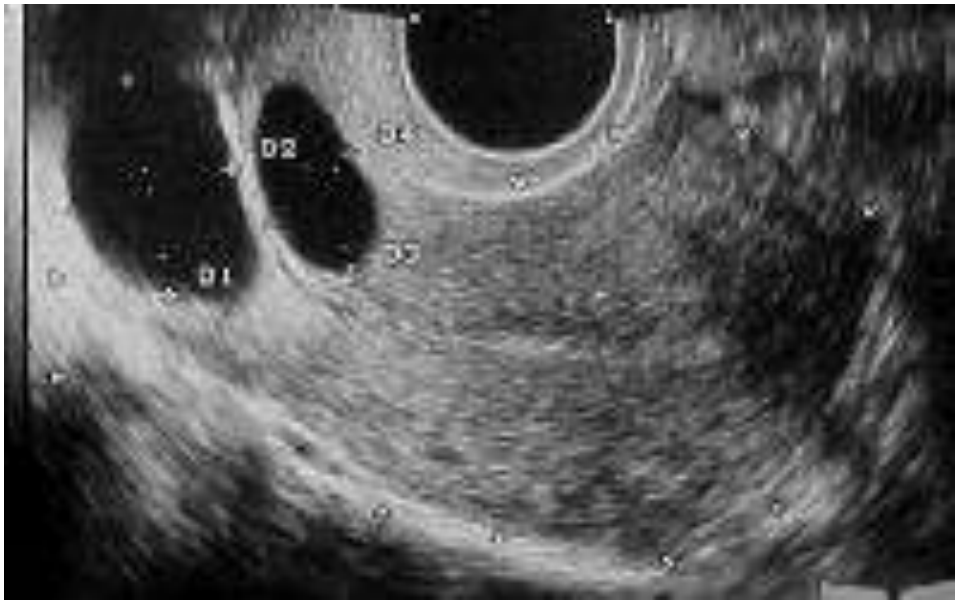
Prepubertal uterus

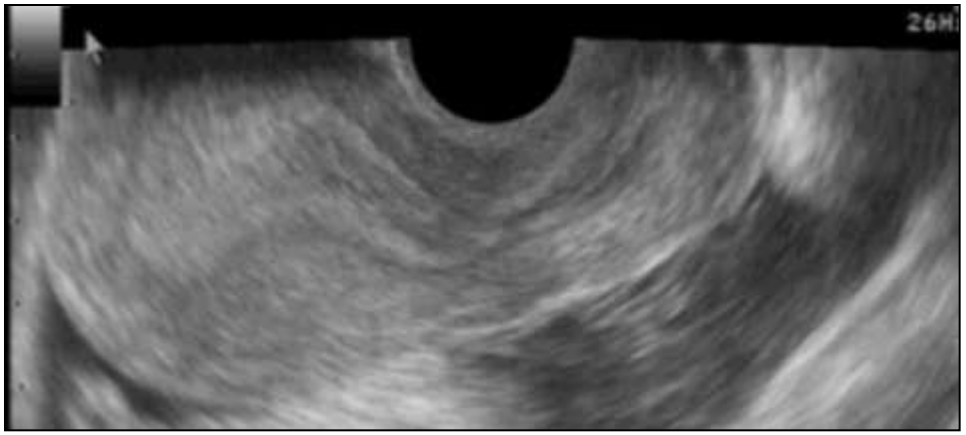
Causes of thickening of the endometrium

Secretory phase endometrium	Gestational trophoblastic disease
Decidual reaction of pregnancy	Endometrial hyperplasia
Early intrauterine pregnancy	Endometrial polyps
Ectopic pregnancy	Endometrial carcinoma
Incomplete abortion	Intrauterine adhesions

Uterus – Cervix

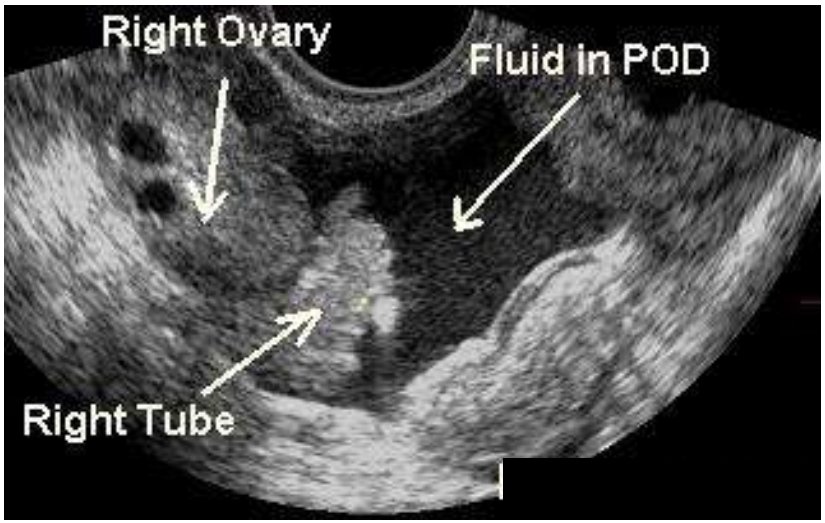
- Withdraw probe into vagina
- Linear echo of endocervical canal continuous with uterus
- Mucus in endocervical canal – echogenic interface
- Periovulation – hypoechoic due to higher fluid content

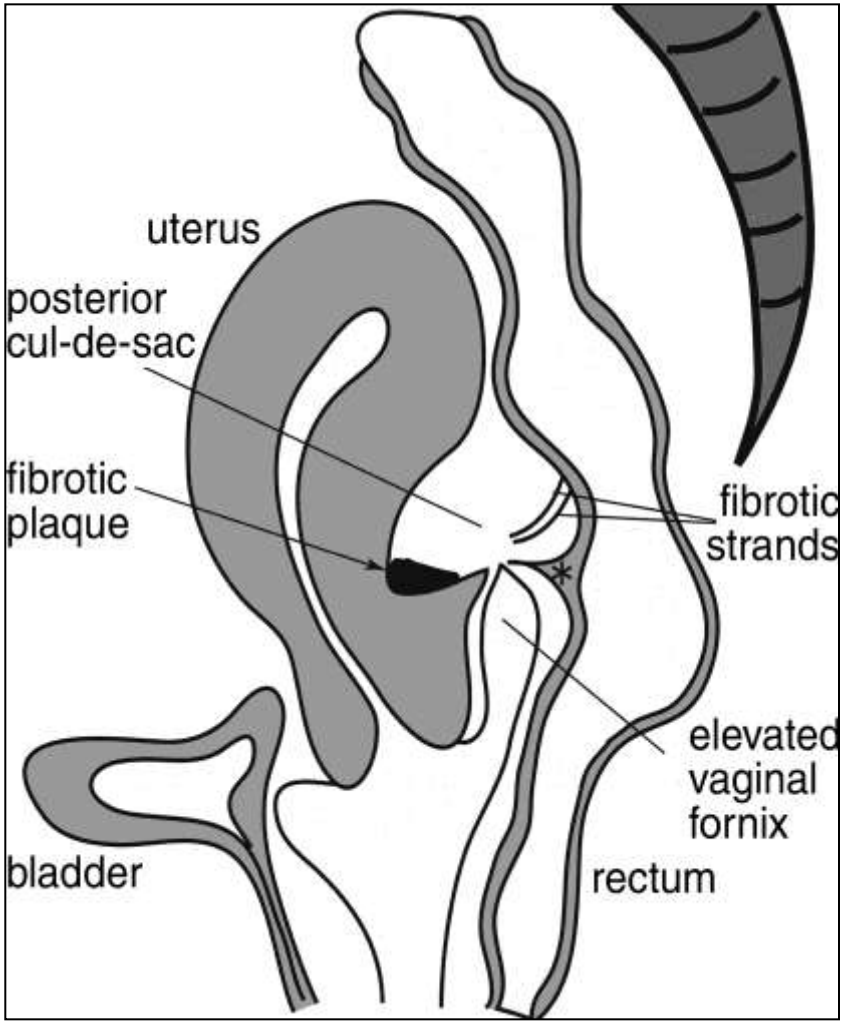




Pouch of Douglas

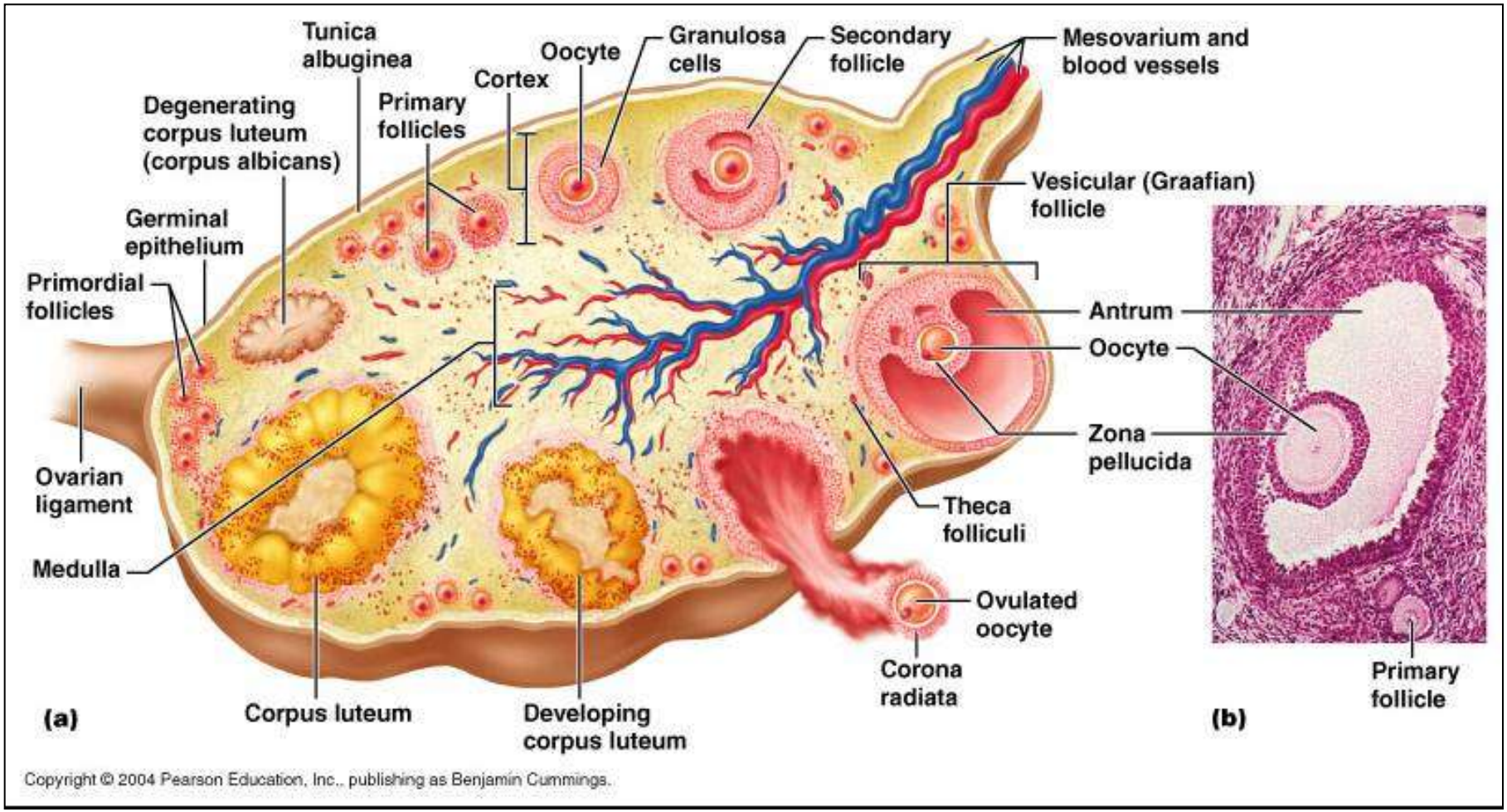
- Small amount of free fluid during ovulatory phase - 1-3 cc is detectable
- Visible > 8 ml



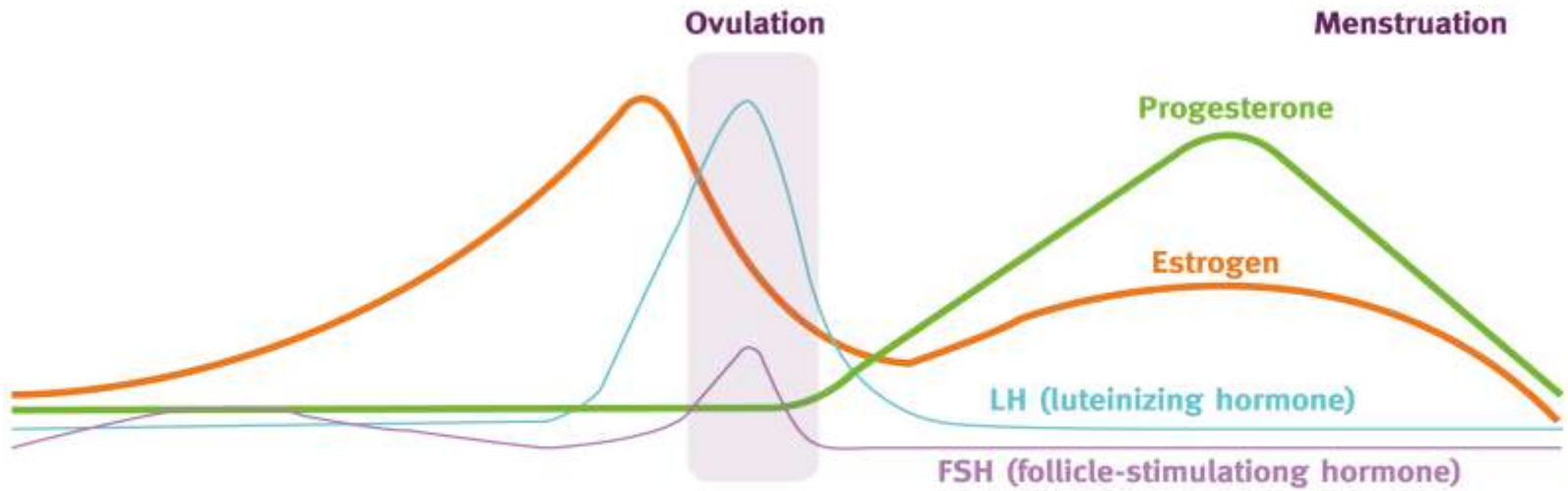


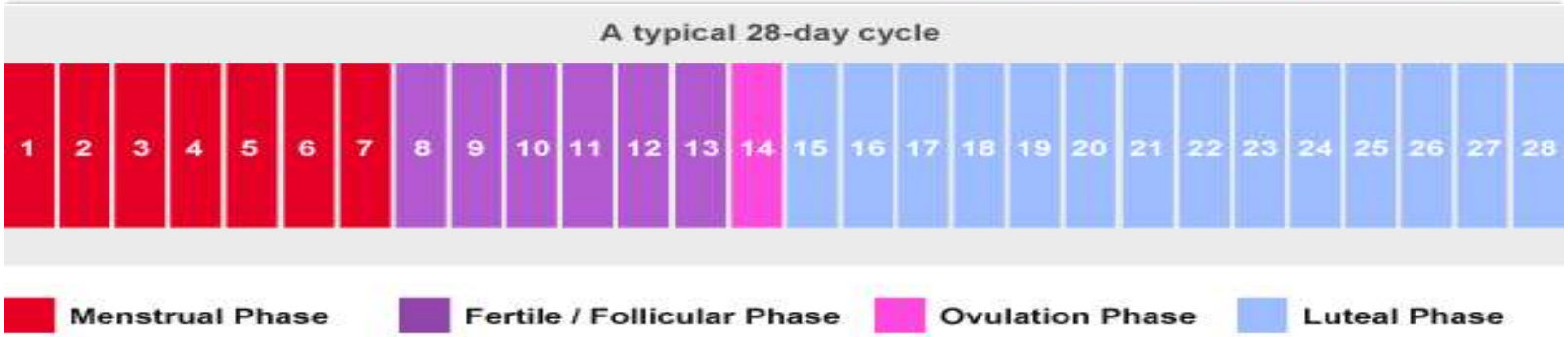
The normal ovary

Ovarian structure



Menstrual cycle

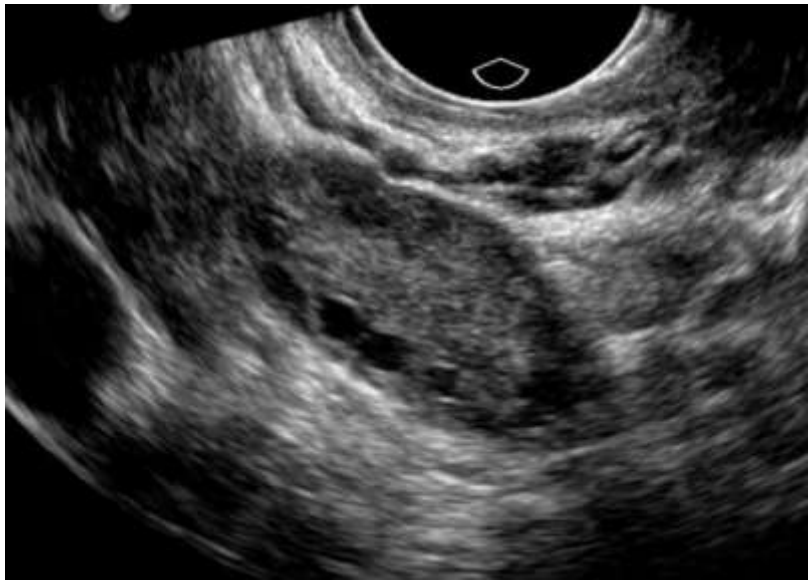




Normal size of the ovaries

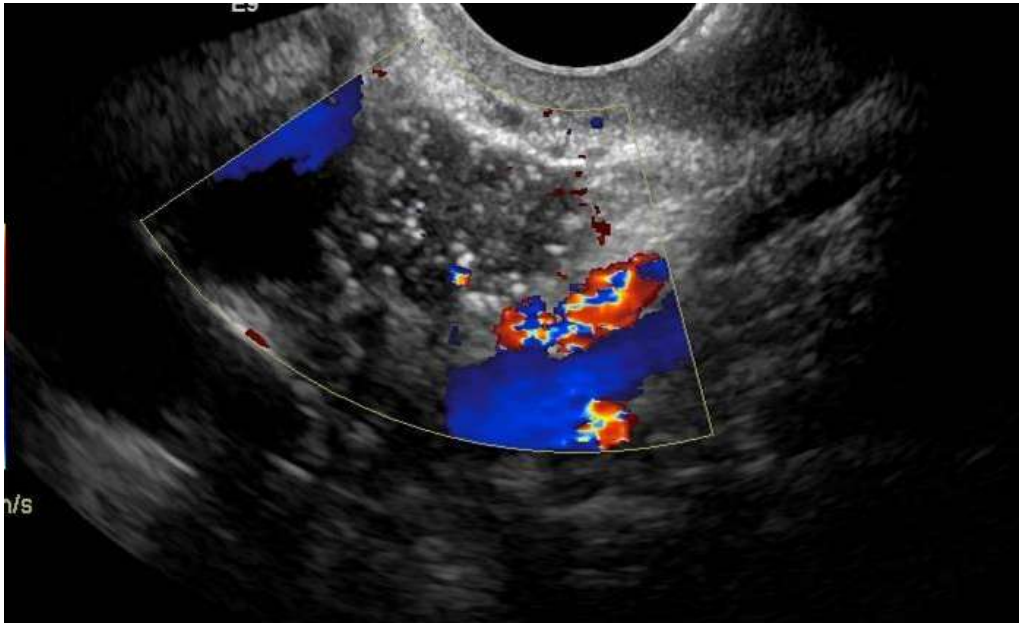
Phase of Life	*Mean Volume (cc)*	*Upper Limit of Normal Volume (cc)*
0-3 months	**1**	**4**
3 months-2 years	**1**	**3**
Premenarchal (3-15 years)	**3**	**9**
Menstrual female	**10**	**22**
Postmenopausal	**6**	**14**
>15 years after menopause	**2**	**4**

- Long axis 3 cm
- AP and transverse 2 cm
- Medial to pelvic vessels
- Postmenopausal – if more than twice the volume of their contralateral counterpart === abnormal



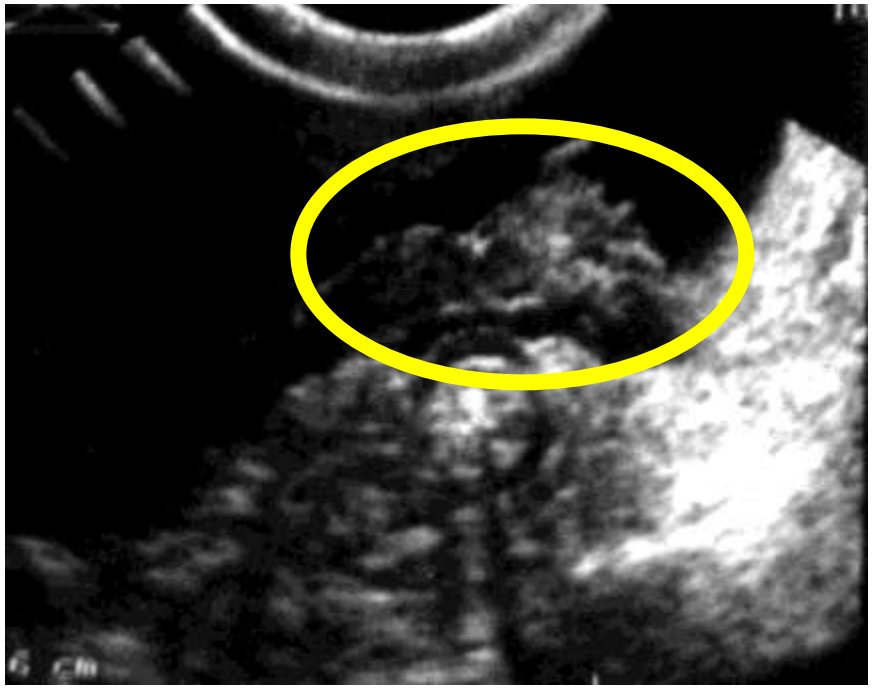
Ovary

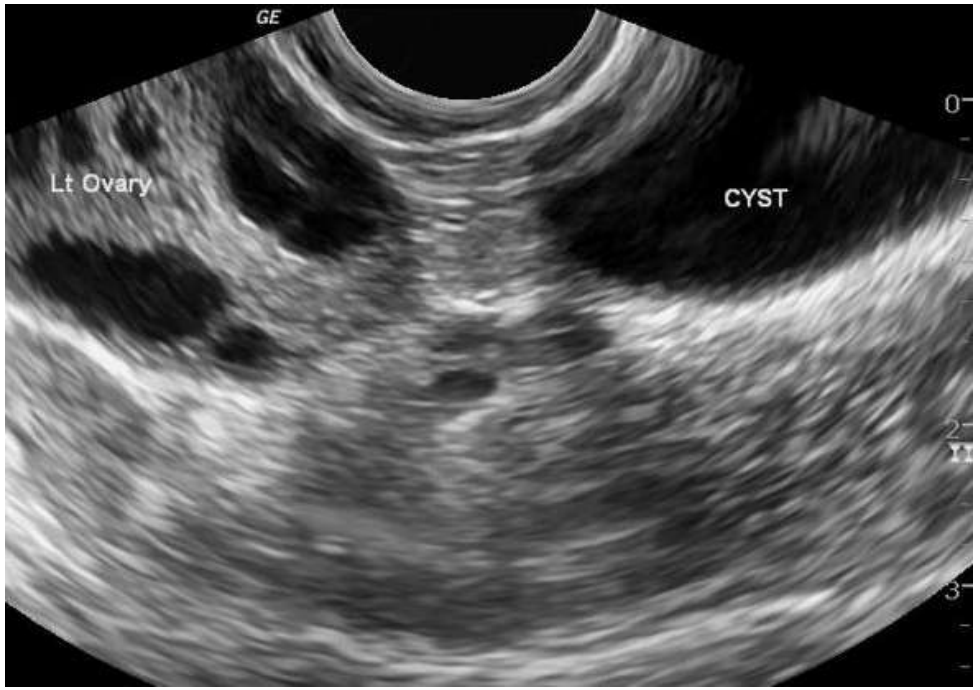
- Echogenic foci tiny cysts or calcified atretic follicles (central) calcified superficial epithelial occlusion cysts (peripheral)
- Without associated shadow - specular reflections from unresolved microscopic cysts
- With shadow – hemosiderin or calcified foci associated with benign histologic changes



The normal tube

Normal sonography of tube



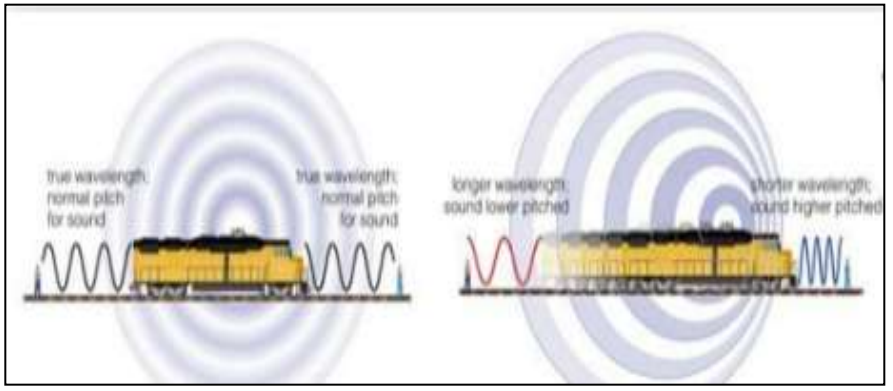


- Not detected normally unless surrounded by fluid
- 0.5-1 cm
- Find endometrial invagination = tubal ostia
- Ovarian and infundibulopelvic ligaments are usually not seen
- Cysts of Morgagni

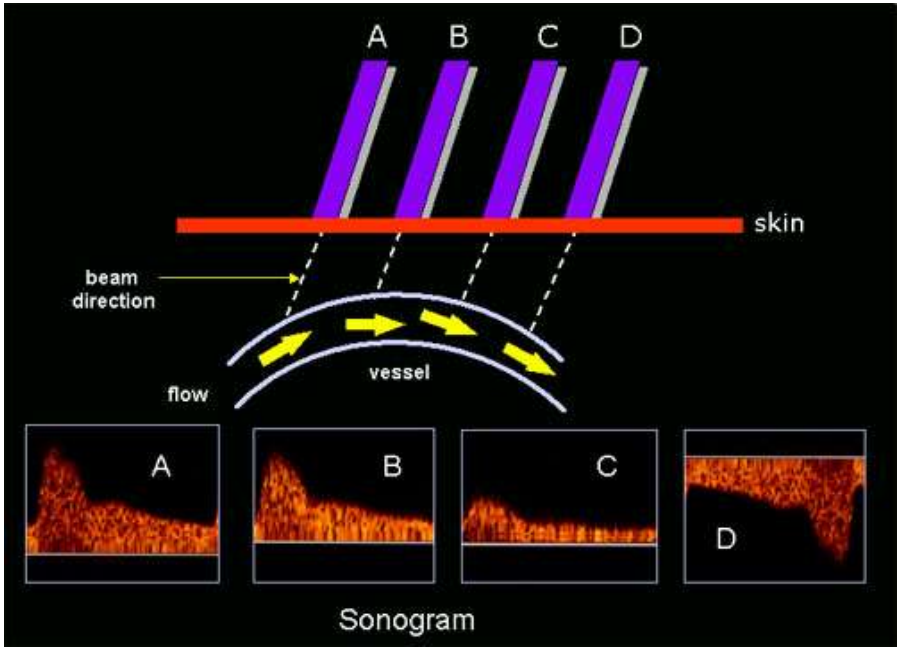
Doppler

Doppler effect

- Change in frequency when sound moves relative to the transducer

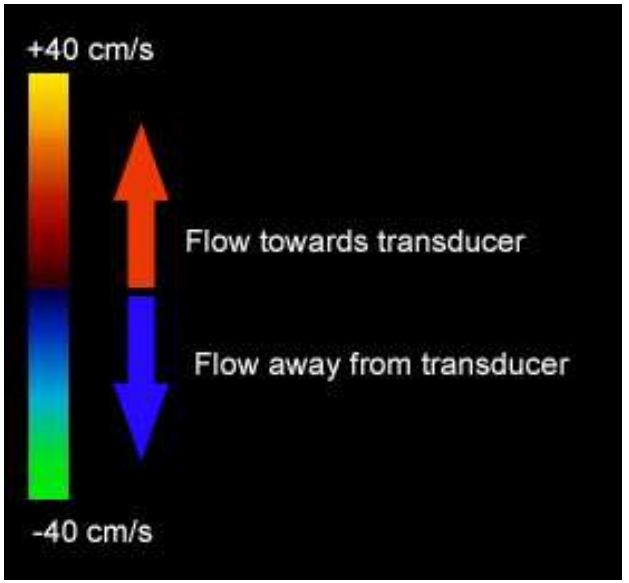


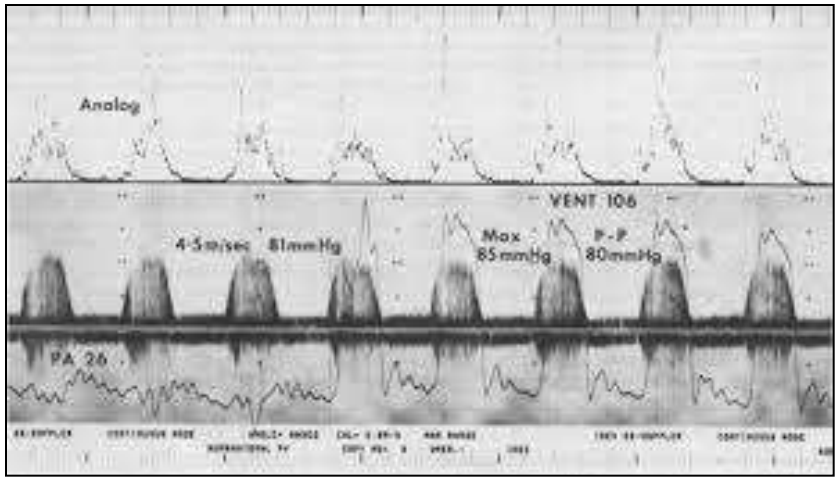
- Non-invasive velocity measurements of blood flow
- The sound wave undergoes a frequency (Doppler) shift by the moving fluid
- F=Fo*(c+v+cos(q))/(c-v*cos(q))
  - C – acoustic velocity in blood 1540 m/sec
  - Fo – transmitted frequency
  - Q – Doppler angle
  - V – velocity of blood



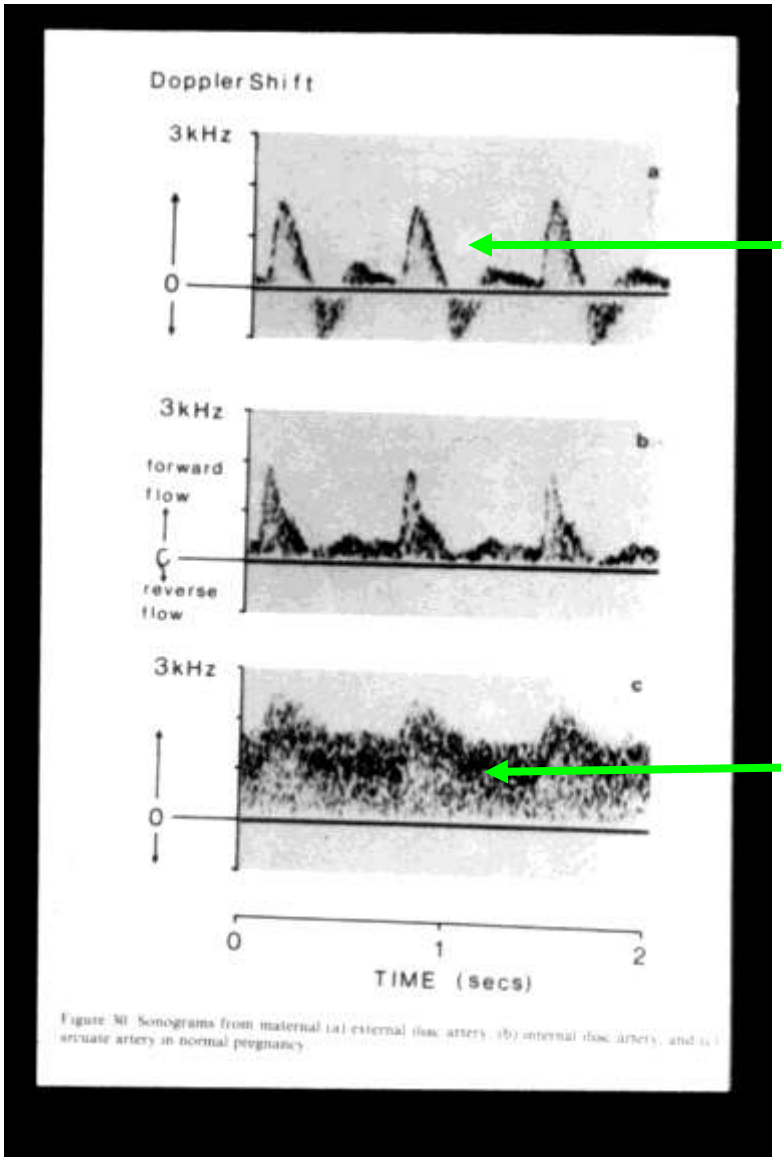
Types of Doppler

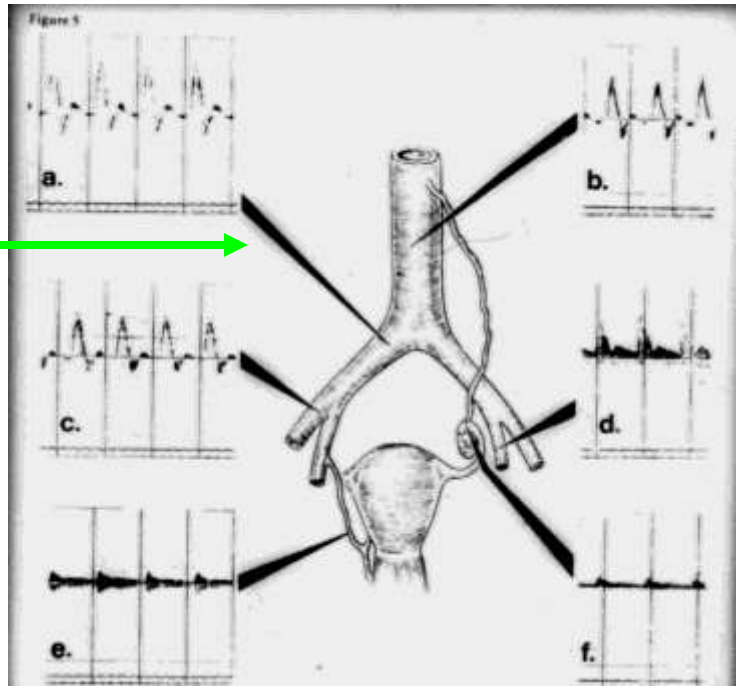
- Pulsed Wave Doppler (PW)
  - Measures velocity of blood in a small sample volume, produces short sound pulses. Same crystal sends and receives, aliasing
- Continuous Wave (CW)
  - Different crystals for sending and receiving, no aliasing
- Color Doppler
  - Visualizing velocity of blood within an image plane
  - Red – positive shift – towards transducer
  - Blue – negative shift – away from transducer

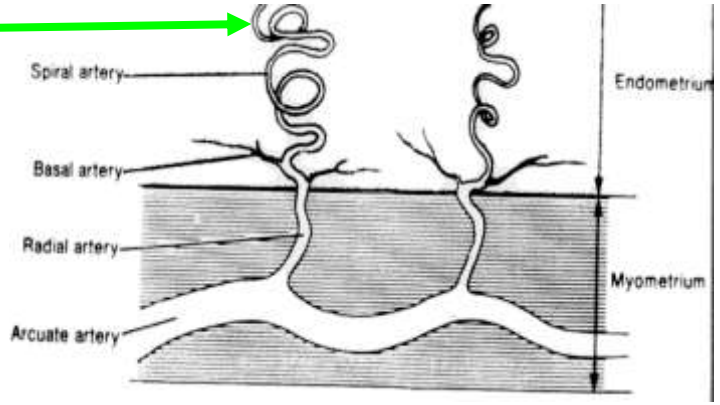




Doppler ultrasound







Doppler Indices

S/D ratio

Resistance Index

$$\frac{S-D}{S}$$

Pulsatility Index

$$\frac{S-D}{Mean}$$

Doppler neovascularization

Benign Tumors

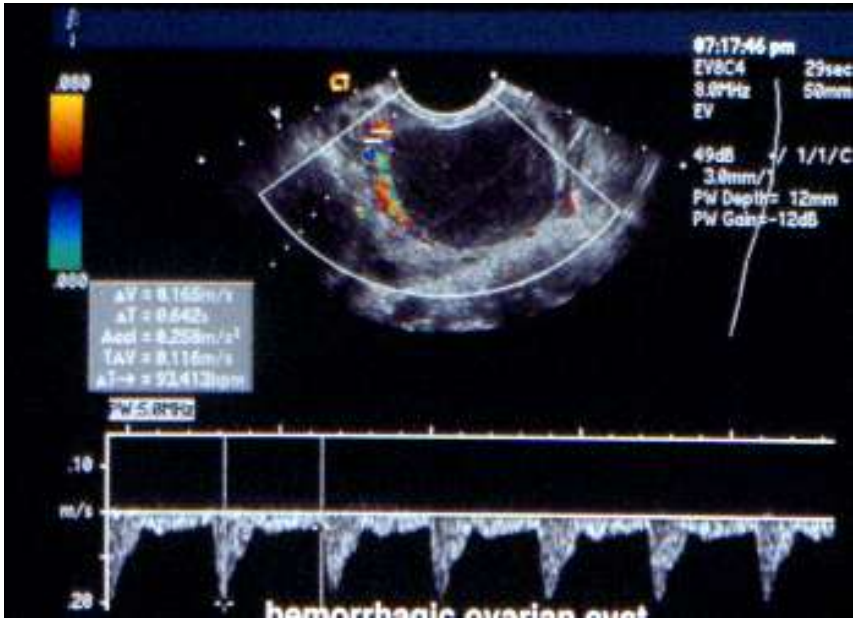
High RI > 0.4

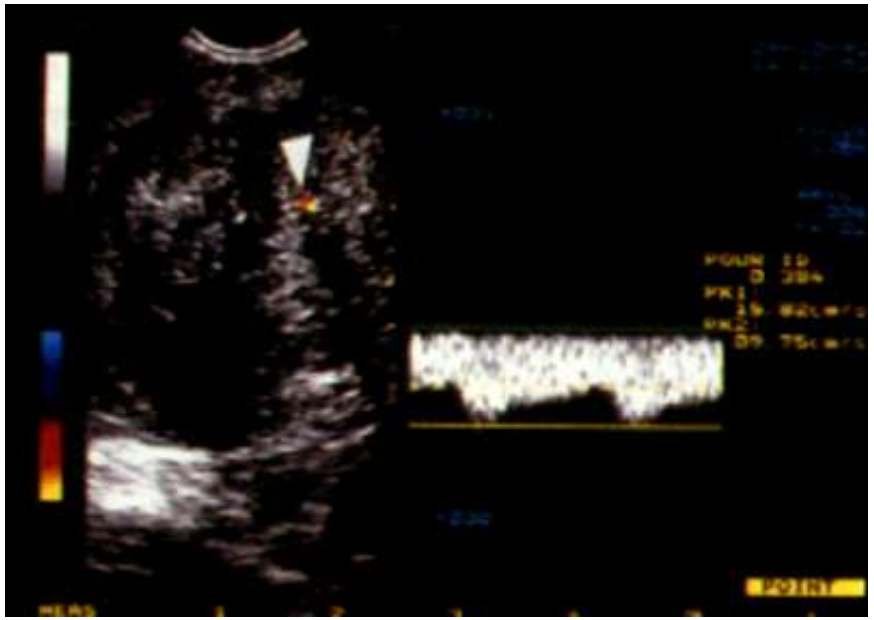
High PI > 0.7

Malignant Tumors

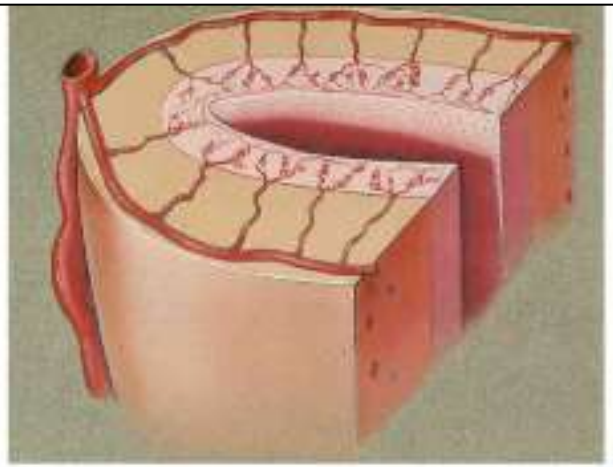
Low RI <0.4

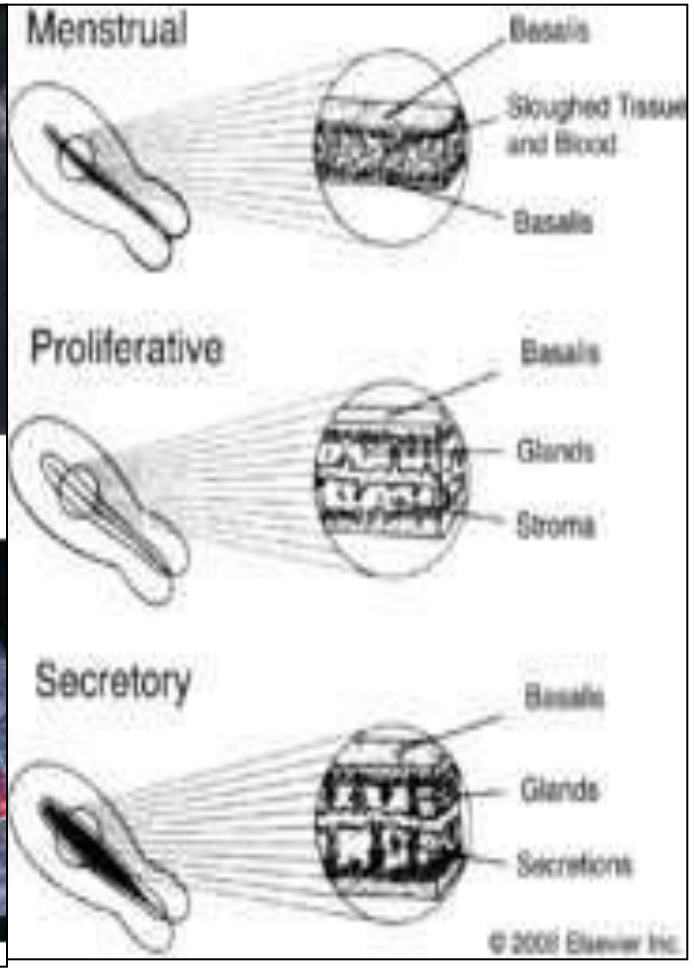
Low PI <0.7

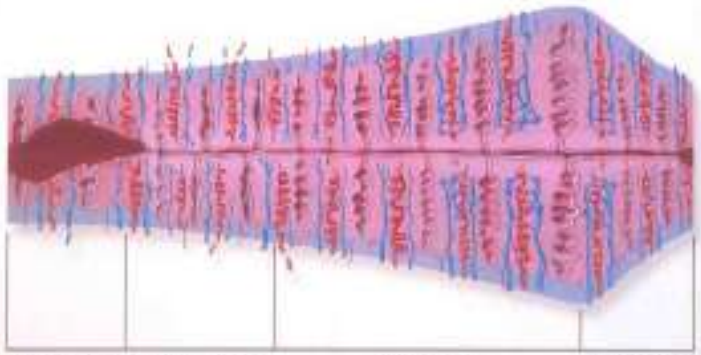




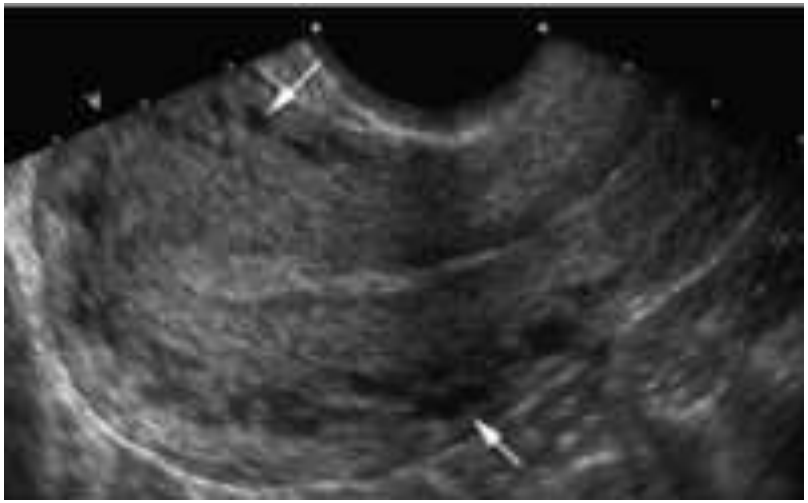
Uterus vasculature





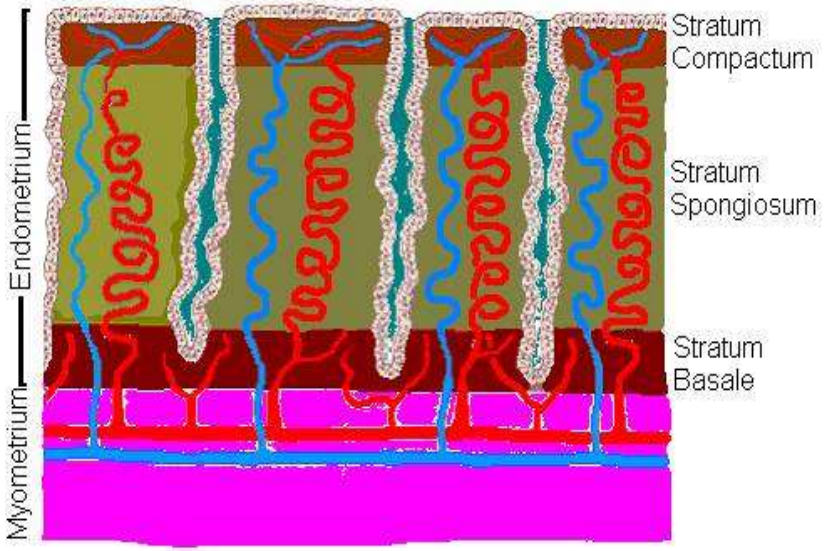


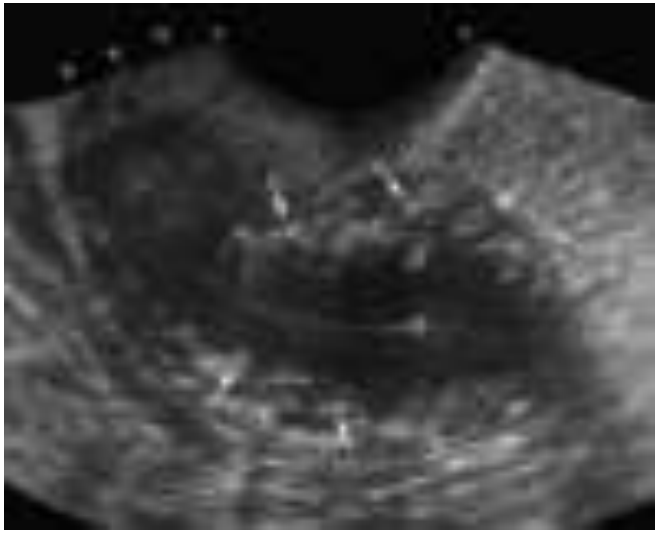
Uterus vasculature



Prominent arcuate vessels

Spiral artery Doppler

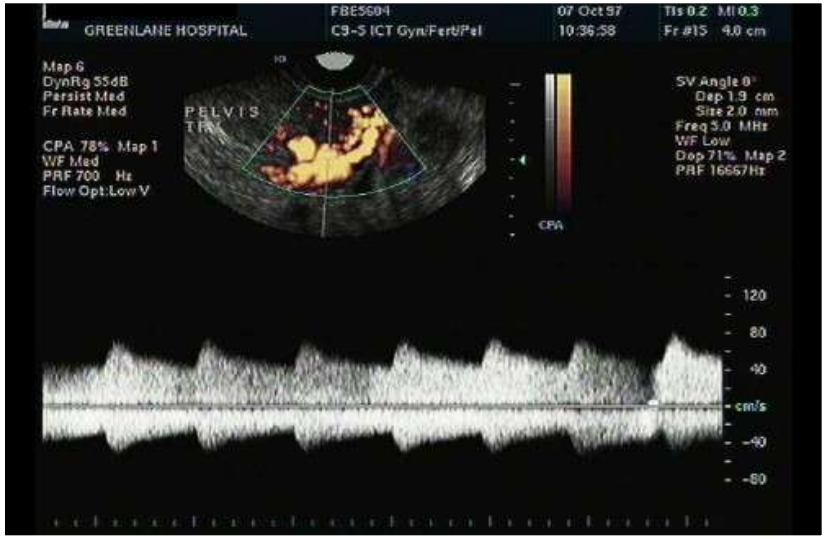


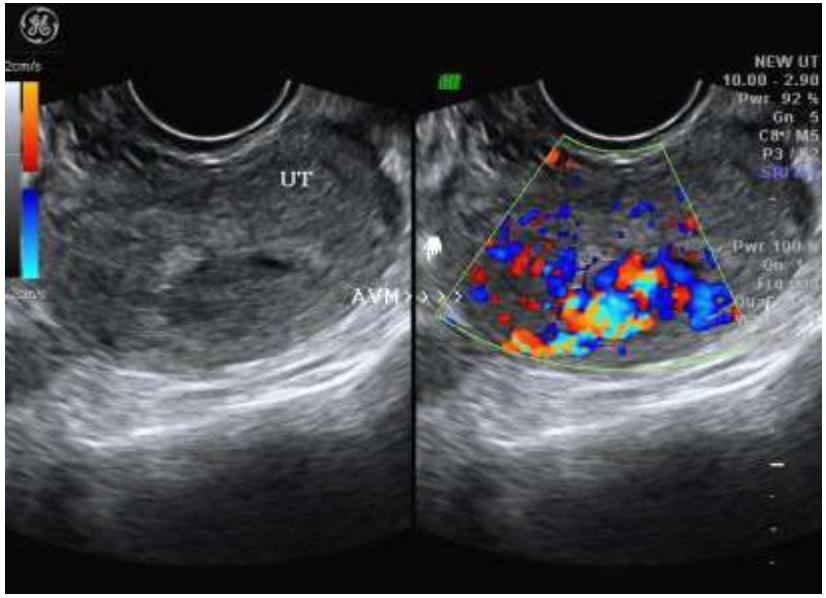


Arcuate artery calcifications

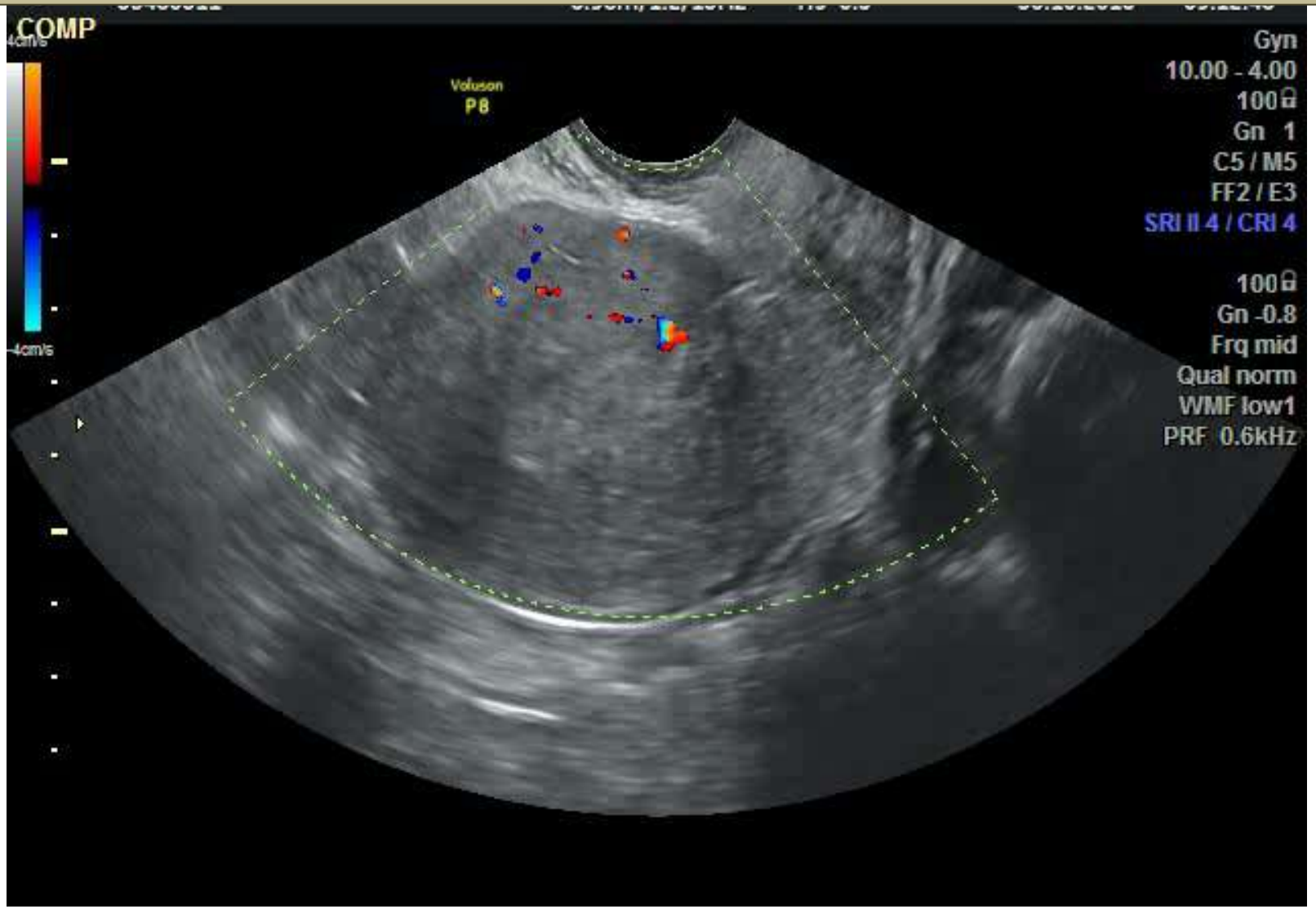
Uterus - Doppler

- Usually high resistance index (RI) depending on age, menstrual cycle phase, conditions such as pregnancy or tumors
- Secretory phase – uterine artery - increased end-diastolic velocity and decreased resistance index
- Arcuate arteries in myometrium – high to moderate resistance
- Example - AVM



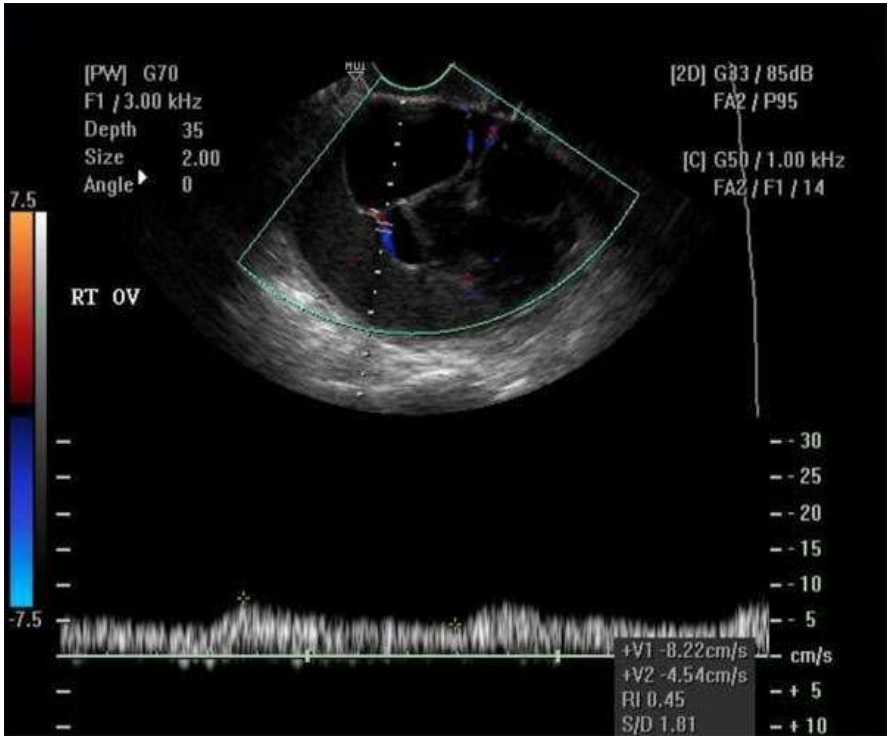


Doppler of endometrial polyp



Ovary - Doppler

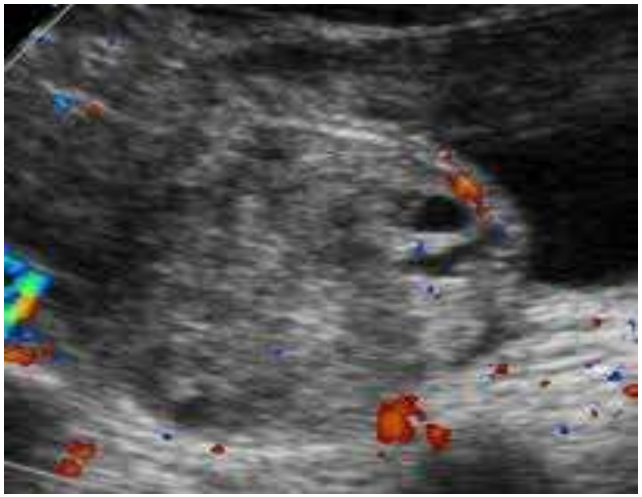
- Blood flow at edge of a developing follicle
- Clearer visualization during luteal phase
- Abundant color pattern emphasizes active corpus luteum
- Tumors:
  - High resistance - benign
  - Low resistance - malignant

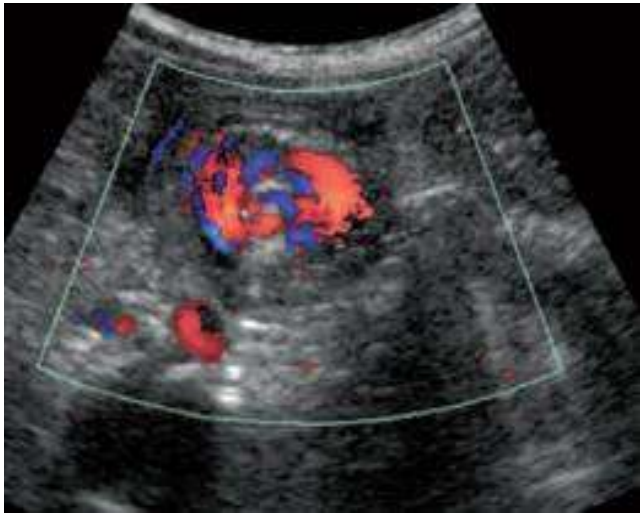


Vascular flow on a dividing septation in an ovarian malignancy

Doppler ultrasound in torsion

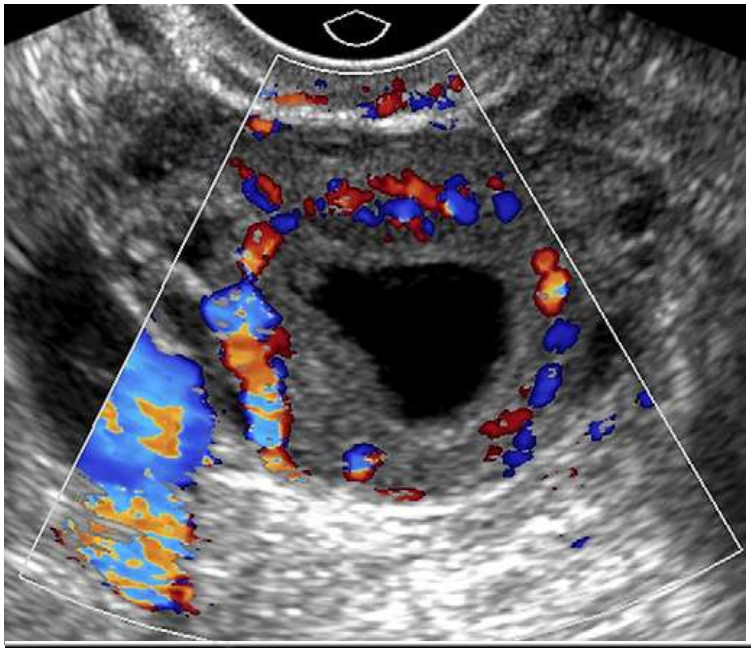
- Limited help
- Start with gray-scale image
- Enlarged edematous ovary with peripherally displaced follicles
- Ovarian mass that serves as the lead for the twist around a fulcrum
- Twisted vascular pedicle sign





Ring of fire

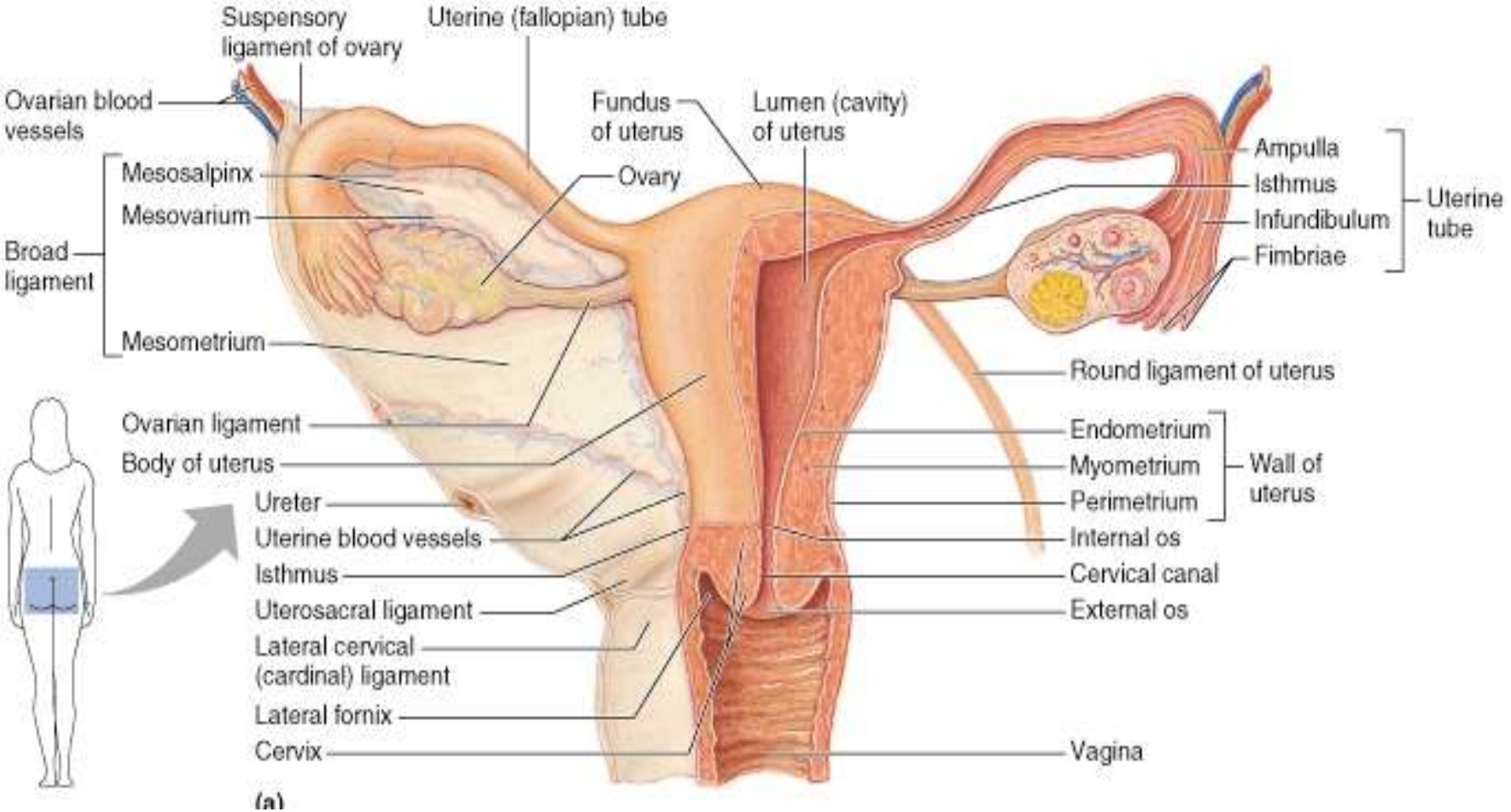
- Ectopic pregnancy
- Corpus luteum – rich diastolic flow low RI



- Concentric enhancement of vessels around the perimeter of a mass

Masses

Adnexae


Suspensory ligament of ovary
Uterine (fallopian) tube
Ovarian blood vessels
Fundus of uterus
Lumen (cavity) of uterus
Ampulla
Isthmus
Infundibulum
Fimbriae
Uterine tube
Mesosalpinx
Mesovarium
Broad ligament
Mesometrium
Ovary
Round ligament of uterus
Ovarian ligament
Body of uterus
Endometrium
Myometrium
Perimetrium
Wall of uterus
Ureter
Uterine blood vessels
Isthmus
Uterosacral ligament
Lateral cervical (cardinal) ligament
Lateral fornix
Cervix
Internal os
Cervical canal
External os
Vagina
(a)

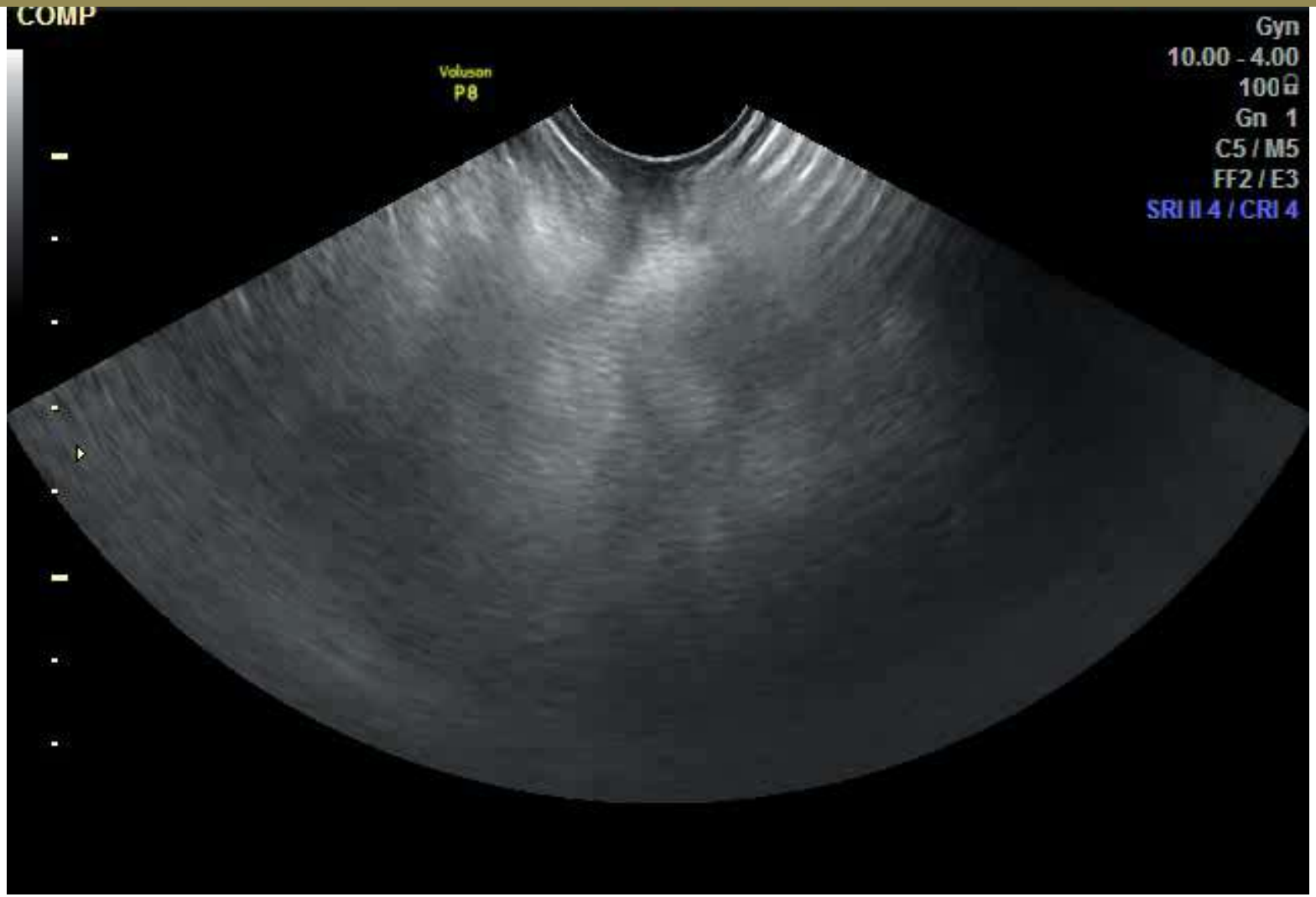
Other pelvic structures

- Bowel loops
  - Fusiform structure with intraluminal fluid and peristalsis, echogenic center (mucus and enteric contents) and hypoechoic rim (muscularis)
  - Intraluminal projections:
    - Valvulae conniventes – small bowel
    - Haustrae – large bowel
- Iliac vessels:
  - Arteries:
    - Width 5-7 mm
    - Pulsate with expansion of both walls
  - Veins:
    - Width 10 mm
    - No pulsation, low-level echoes
- Ovarian veins – 5 mm
- Distended ureter may look like vein but no pulsation
- Lower urinary tract abnormalities: calculi, TCC

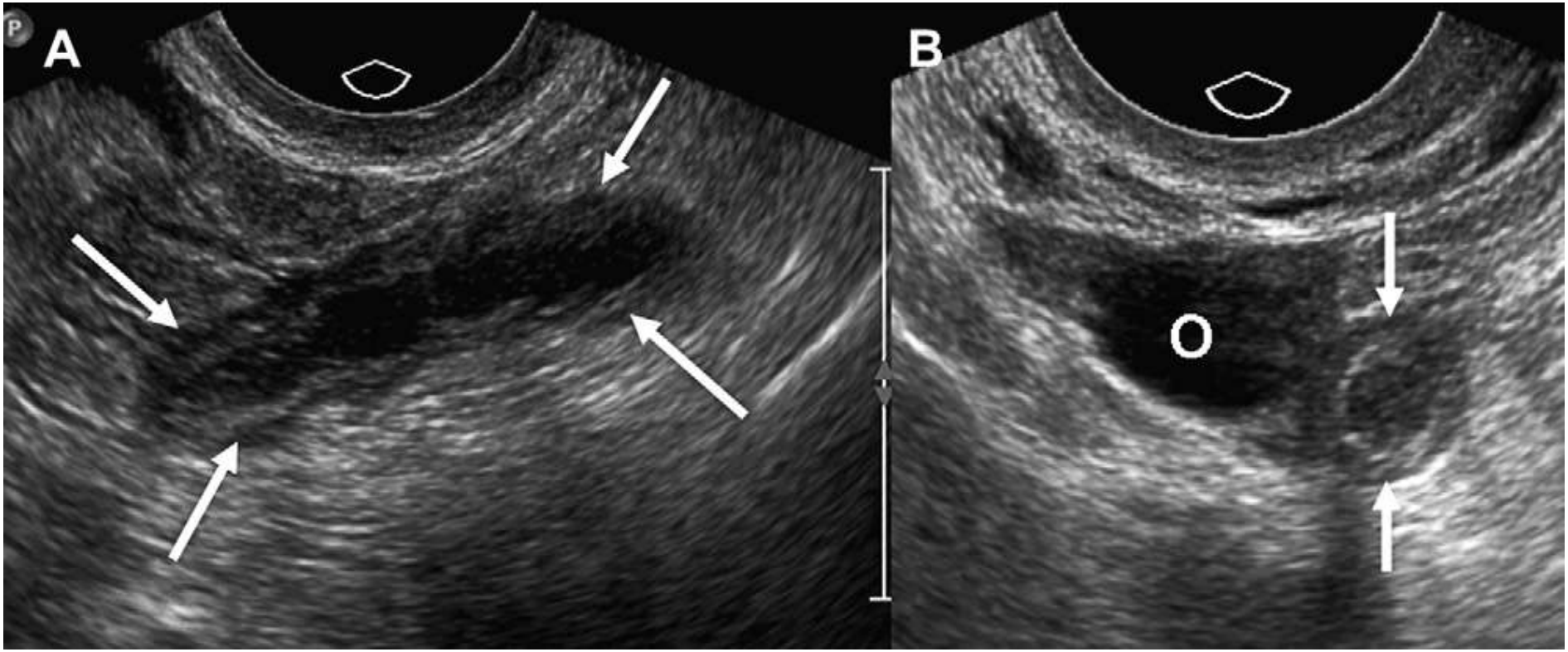
What is this?


30206729
6.5cm/1.2/32Hz
TIS 0.2
30.10.2016
09:00:50
COMP
Voluson
P8
Gyn
10.00 - 4.00
100
Gn 1
C5 / M5
FF2 / E3
SRI II 4 / CRI 4

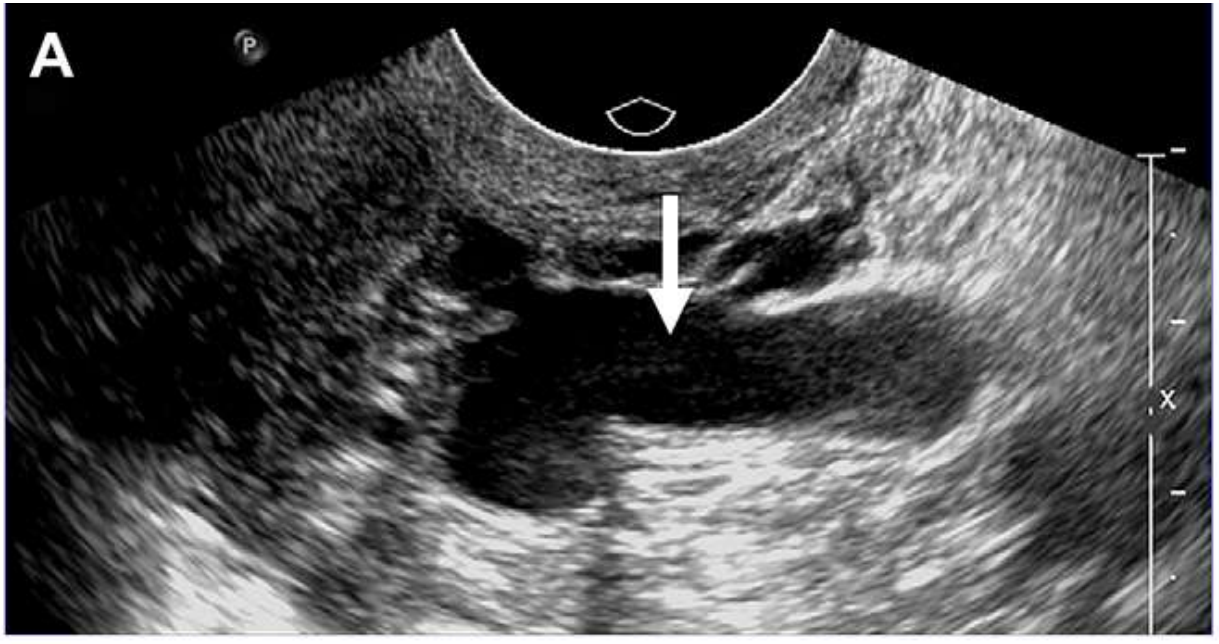
What is this?

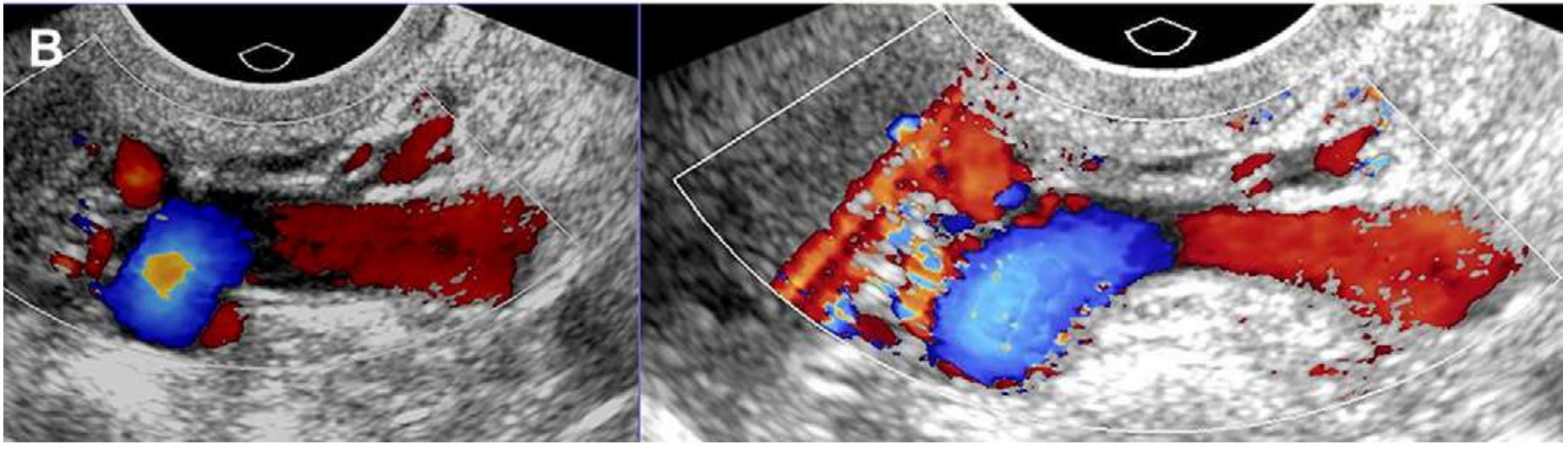


Other pelvic structures

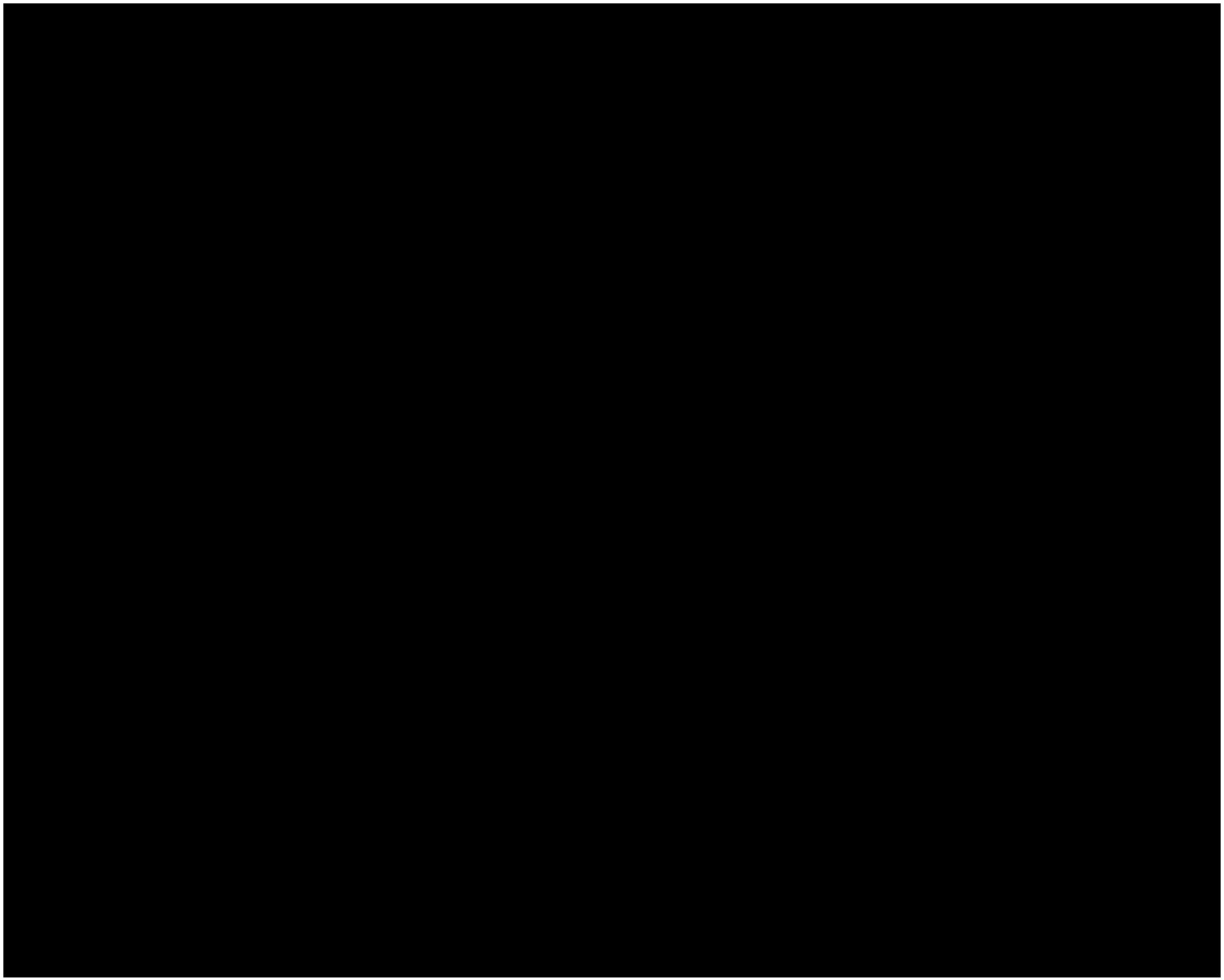


Doppler ultrasound

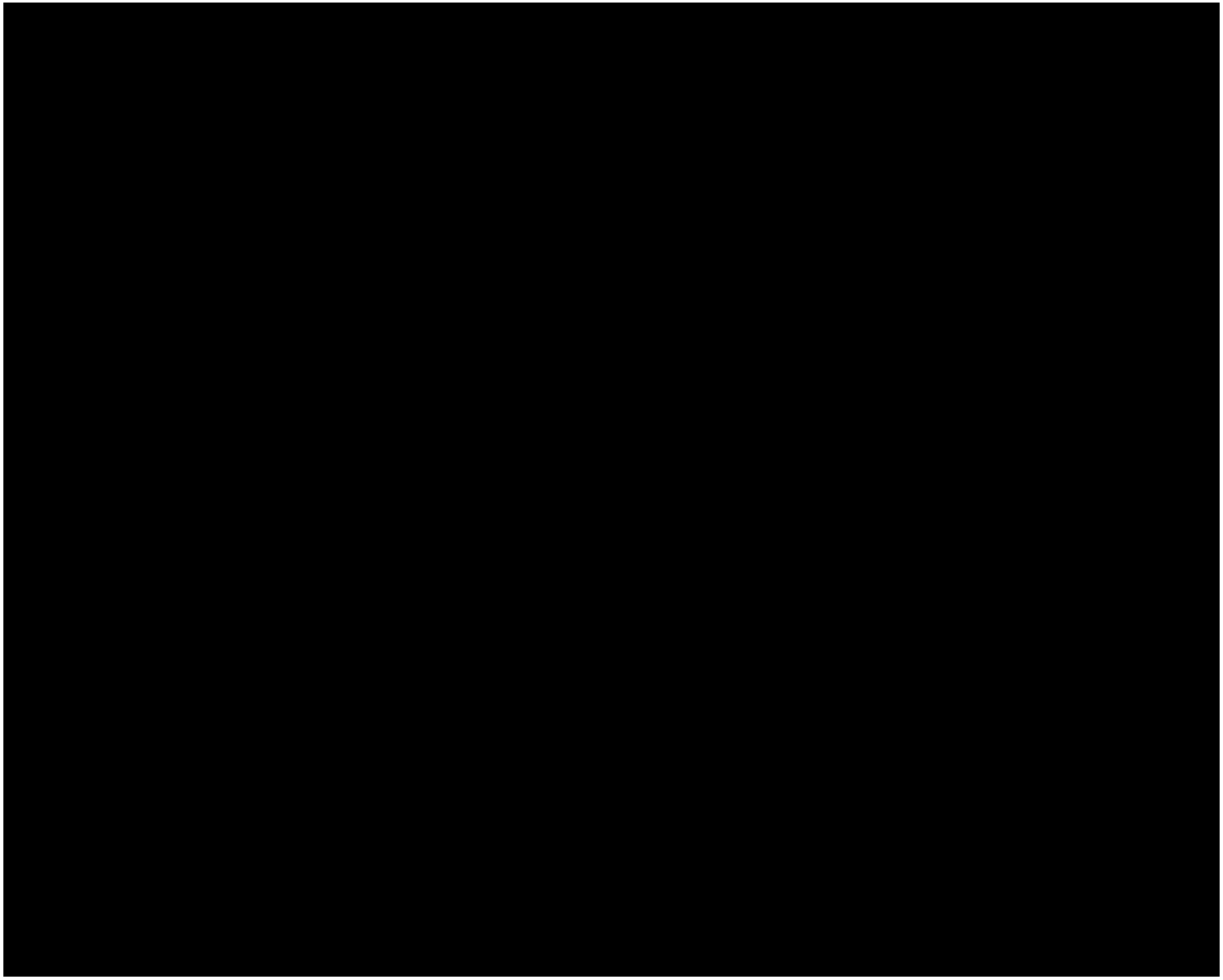




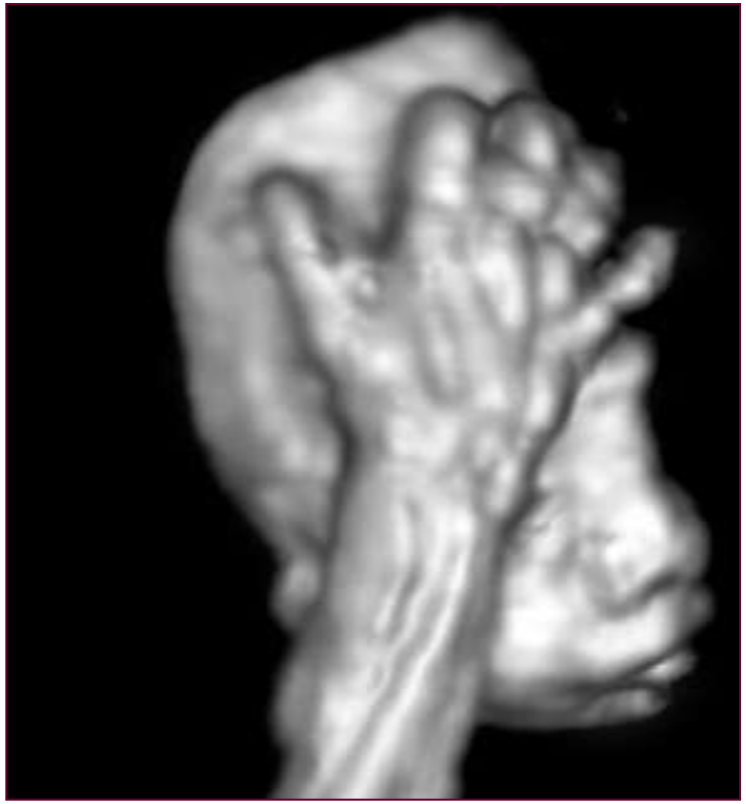
Examination example 1



Examination example 2



Thank you



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