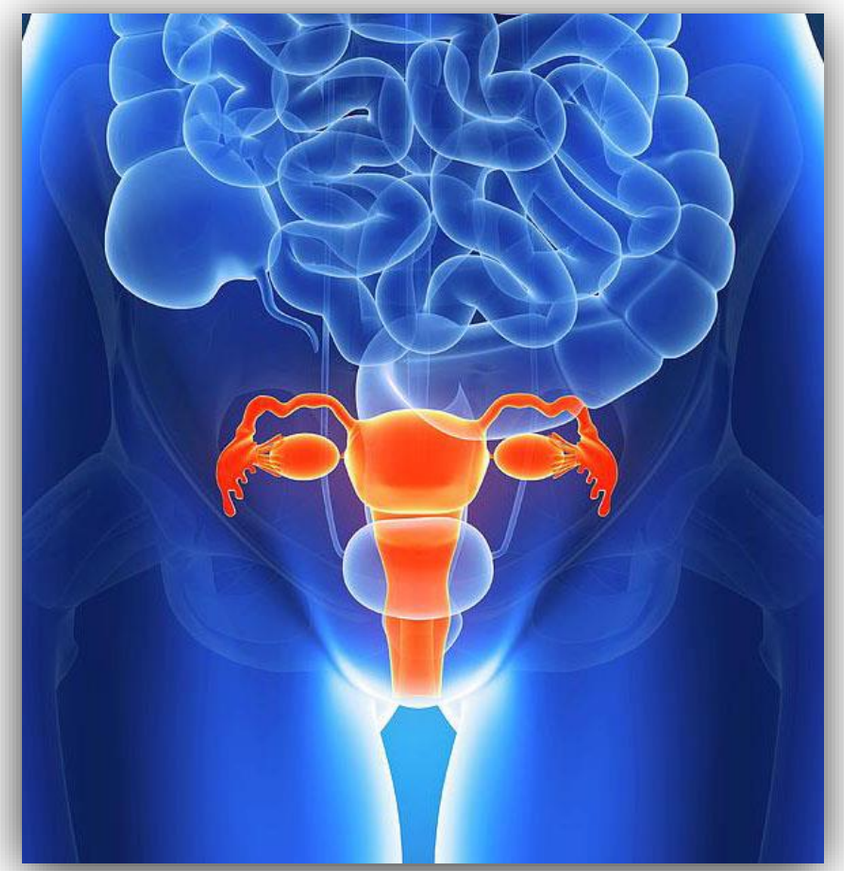
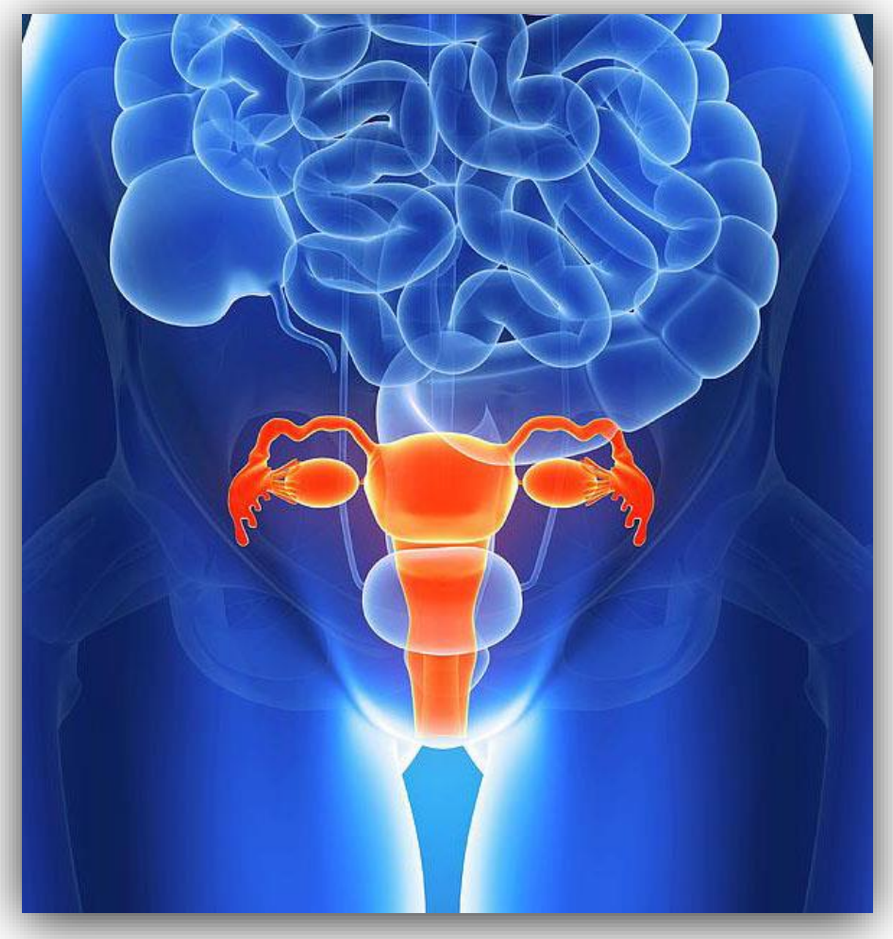
OB GYN SONOGRAPHY REVIEW

Pelvic Anatomy & Physiology



Course Outline

- Anatomy
  - Musculoskeletal
  - Visceral
  - Vascular
  - Anatomic variants
- Physiology
  - Menstrual cycle



Pelvic Anatomy

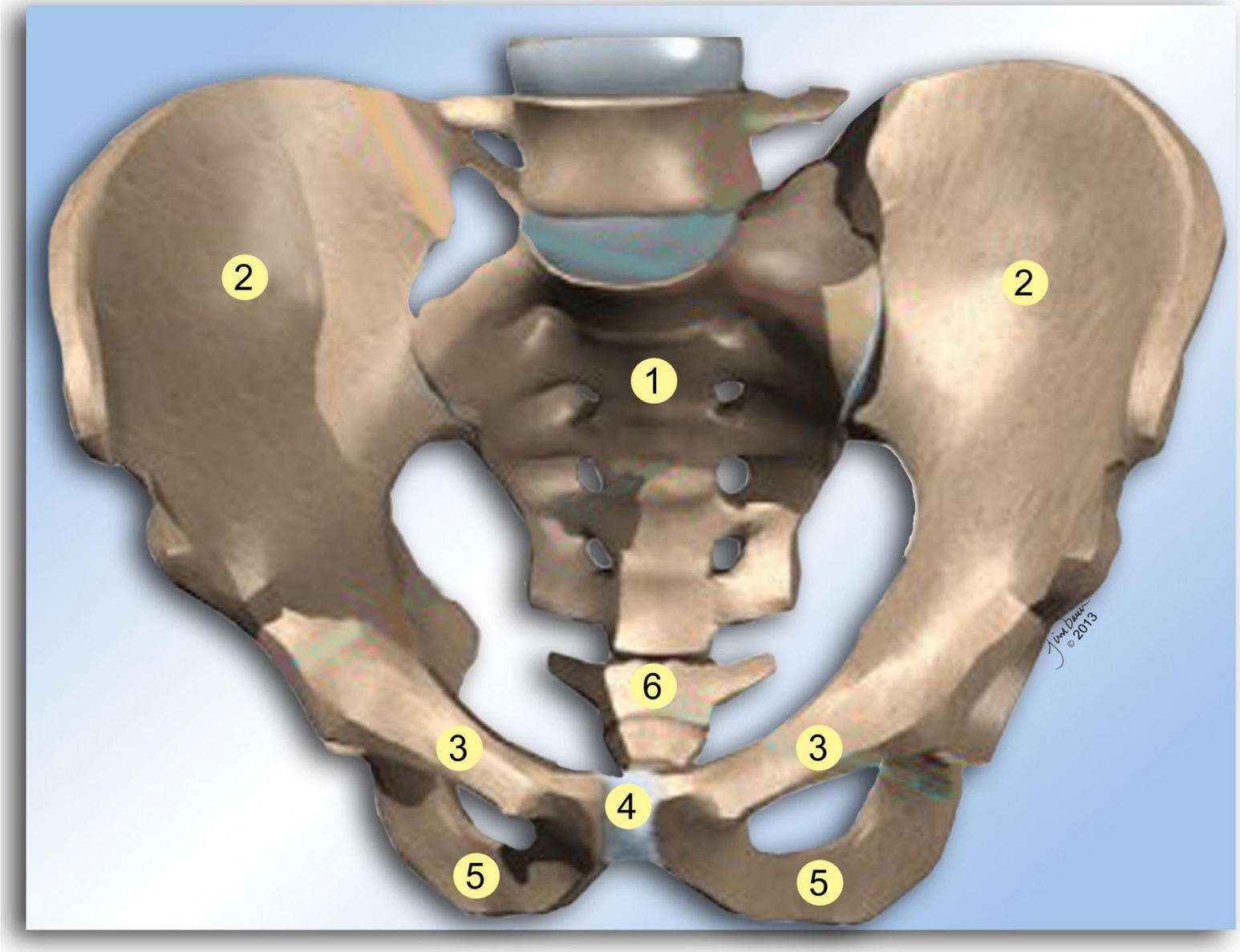
Musculoskeletal Anatomy

- The pelvic frameworks consists of skeletal, ligamentous, and muscular components
- Serves several anatomic and functional purposes:
  - Weight-bearing bridge between spine and lower extremities
  - Directs pathway of fetal head during delivery
  - Protects internal organs of reproduction

Skeletal Anatomy

- Skeletal components of the pelvis include:
  - Sacrum: posterior
  - Coccyx: posterior
  - Innominate bones: anterior, lateral, inferior
    - Iliac bones
    - Ischial bones
    - Pubic bones

MUSCULOSKELETAL ANATOMY

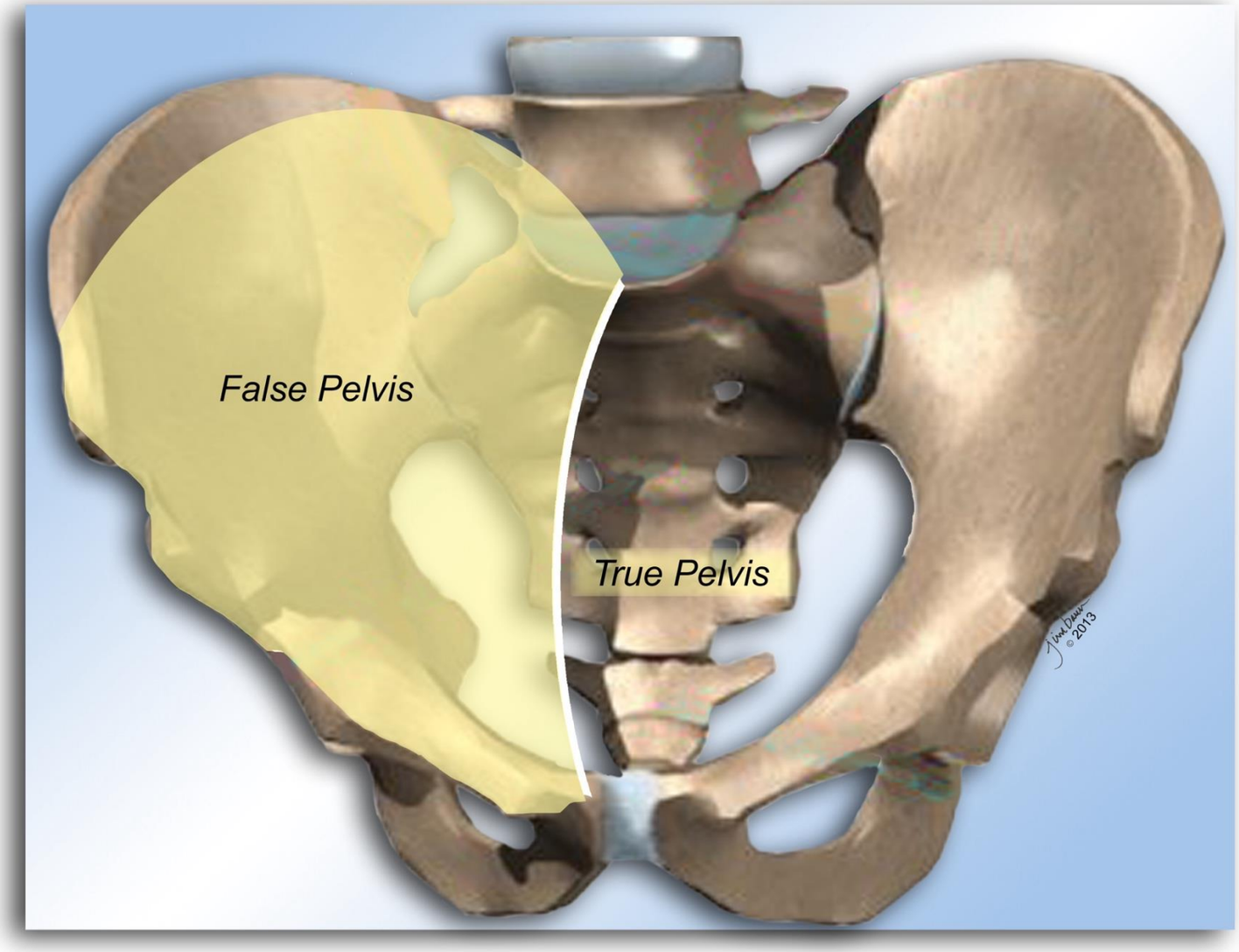


1 = Sacrum
2 = Ilium
3 = Pubic ramus
4 = Pubic Symphysis
5 = Ischium
6 = coccyx

Pelvic Cavities

- Pelvis is divided into two cavities delineated by the *linea terminalis*: (*sacral promontory to symphysis pubis*)
  - False pelvis:
    - Superior to *linea terminalis*
    - Contains mostly small bowel
  - True pelvis:
    - Inferior to *linea terminalis*
    - Contains urinary bladder and internal organs of reproduction

MUSCULOSKELETAL ANATOMY



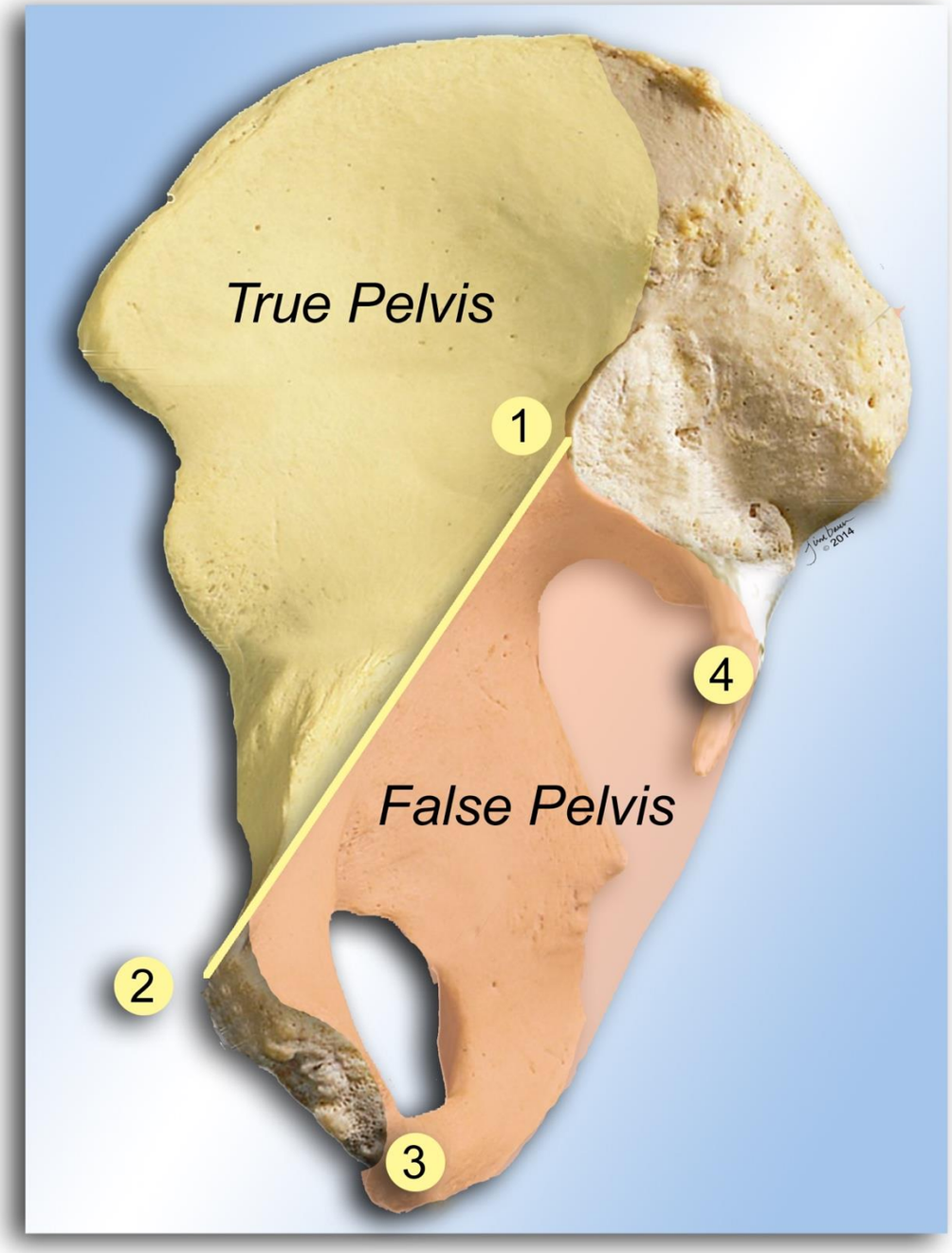
Pelvic Cavities

- True pelvis is further divided into
  - Pelvic inlet:
    - Horizontally oriented
    - Bounded by pubic rami anteriorly and sacral promontory posteriorly
  - Pelvic outlet:
    - Vertically oriented
    - Bounded by ischial tuberosities laterally and coccyx posteriorly

MUSCULOSKELETAL ANATOMY

Pelvic Inlet
1 = sacral promontory
2 = pubic bones

Pelvic Outlet
3 = ischial tuberosities
4 = coccyx



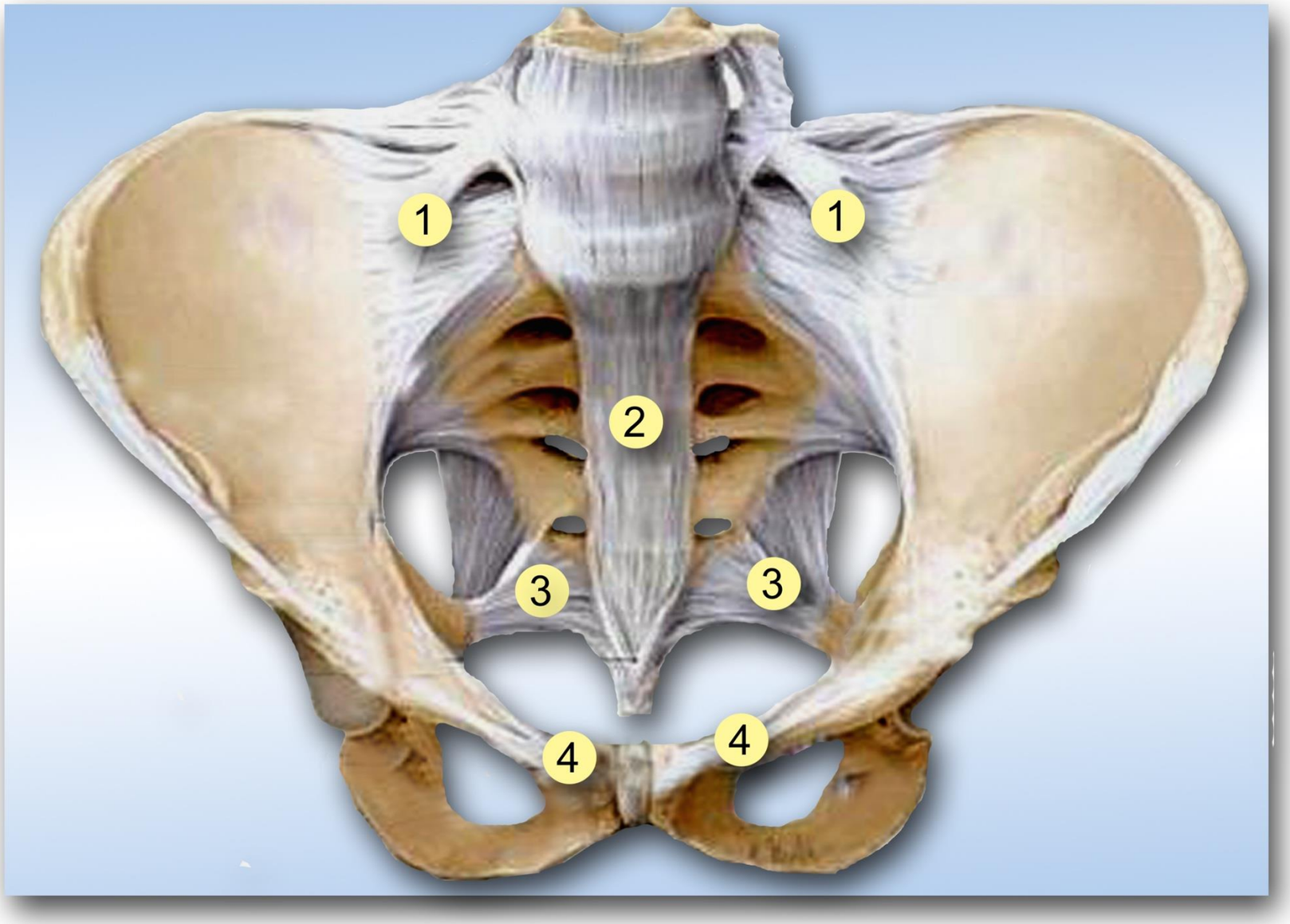
Ligamentous Anatomy

- Osseous ligaments: bind pelvic bones together
- Ovarian suspensory ligaments: serve to support and stabilize ovaries and fallopian tubes
- Uterine suspensory ligaments: suspends and anchors uterus in pelvic cavity

Osseous Ligament

- Bind pelvic bones together
  - *Sacroiliac ligaments*: binds sacrum and iliac bones
  - *Sacrococcygeal ligaments*: binds sacrum and coccyx
  - *Sacrosciatic ligaments*: binds sacrum, iliac bones, and coccyx
  - *Pubic ligament*: binds the paired pubic rami

OSSEOUS LIGAMENTS

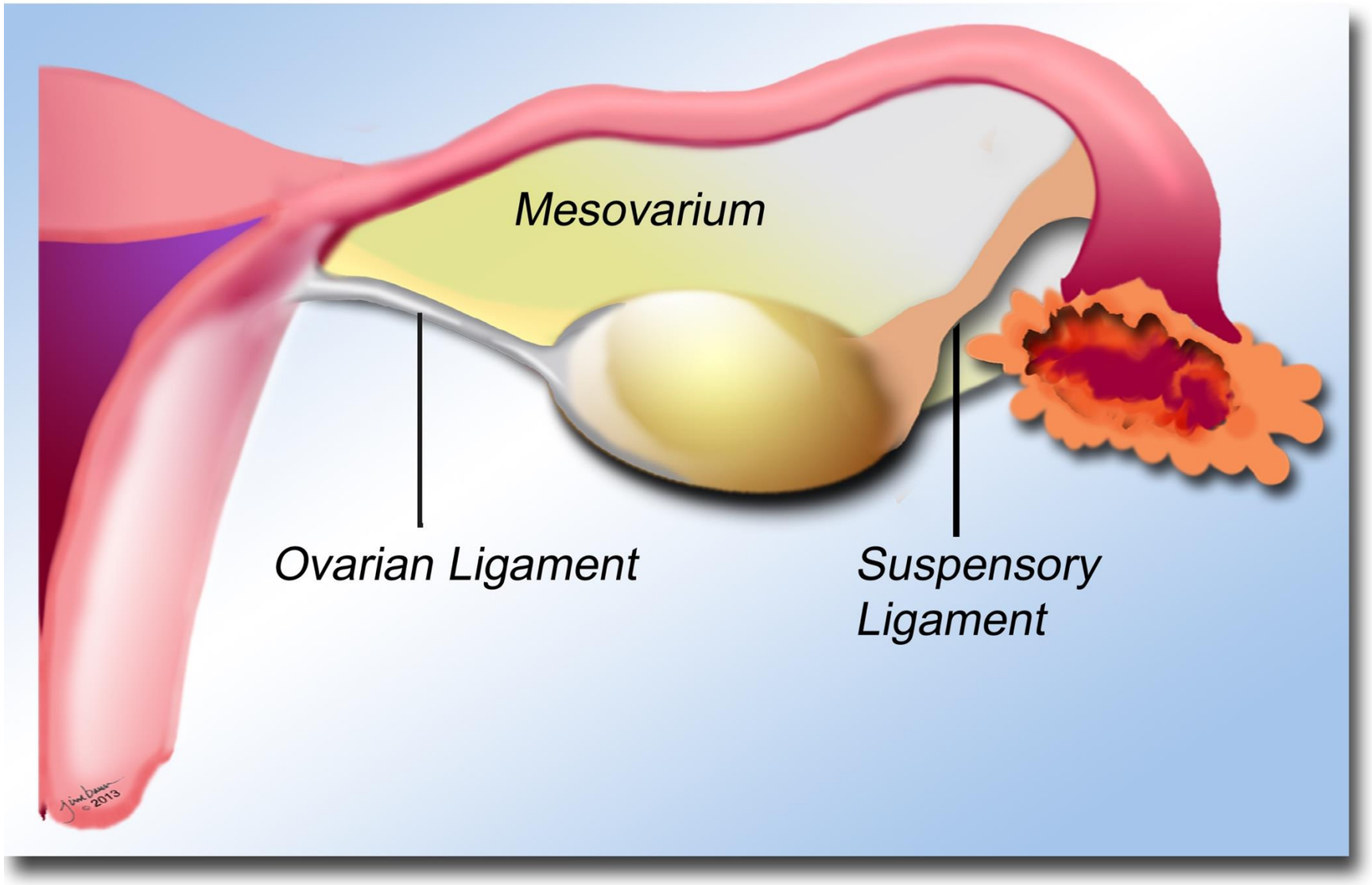


1 = sacroiliac ligaments
2 =sacrococcygeal ligament
3 = sacrosciatic ligaments
4 = pubic ligaments

Ovarian Suspensory Ligaments

- Serve to support and stabilize ovaries and fallopian tubes
  - *Mesovarium ligament:* attaches ovary posterior to broad ligament
  - *Ovarian (utero-ovarian) ligament*: attaches inferior pole of ovary to uterine cornu
  - *Suspensory (infundibulopelvic) ligament*: attaches superior pole of ovary to pelvic wall

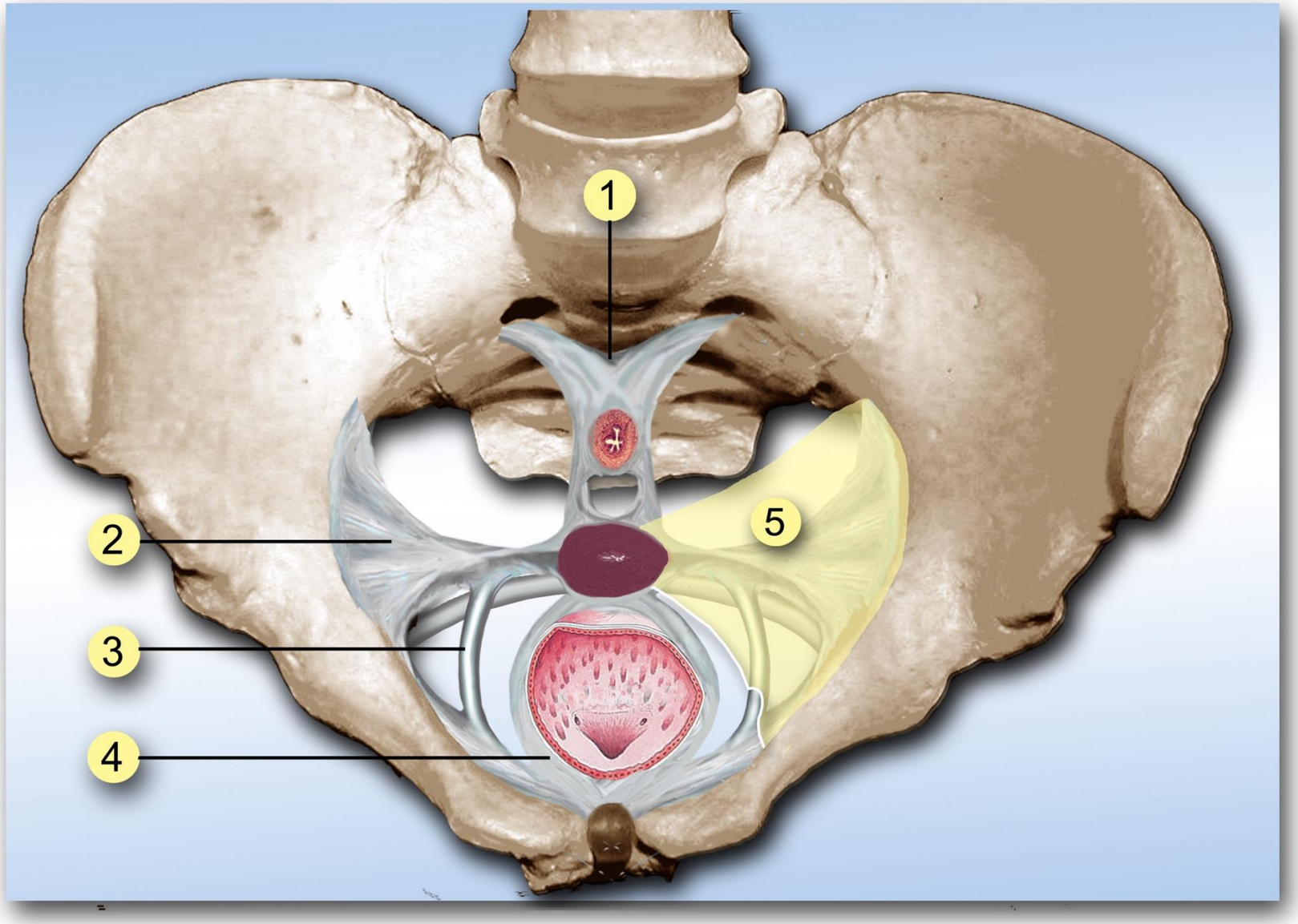
OVARIAN SUSPENSORY LIGAMENTS



Uterine Suspensory Ligaments

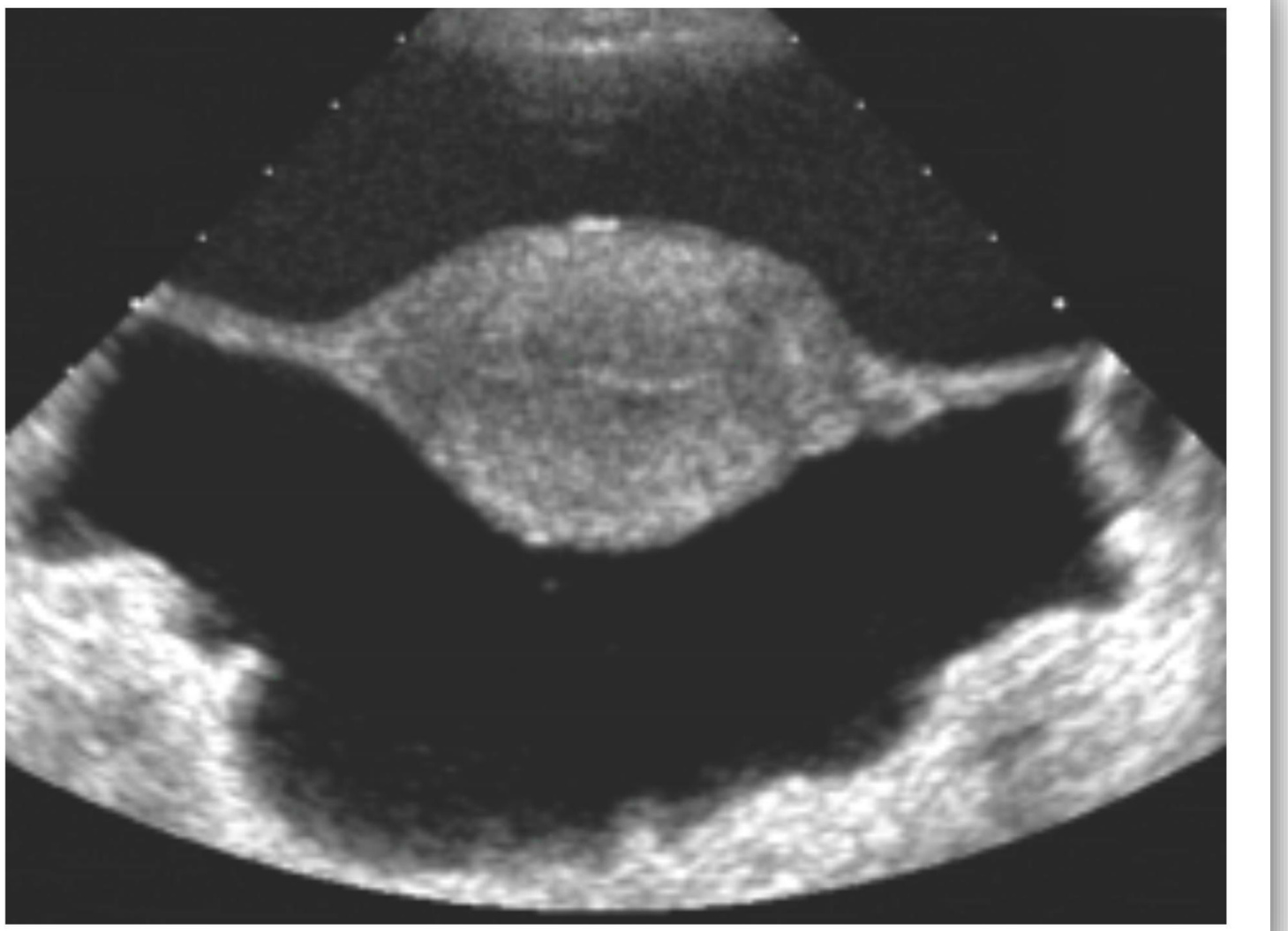
- Suspends and anchors uterus in pelvic cavity
  - *Uterosacral ligament*: attaches posterior cervix to to sacrum
  - *Cardinal ligament:* attaches lateral aspect of cervix and uterus to pelvis wall. Primary supporting ligament of uterus
  - *Round ligament*: attaches uterine cornu to anterior pelvic wall
  - *Pubovisicular ligament*: attaches bladder neck to pubic bones
  - *Broad ligament*: attaches lateral aspect of uterus to pelvic side wall. Contains fat, blood vessels and nerves. Ovary attached to posterior surface

UTERINE SUSPENSORY LIGAMENTS



1 = uterosacral ligament
2 = cardinal ligament
3 = round ligament
4 = pubovesicle ligament
5 = broad ligament

UTERINE SUSPENSORY LIGAMENTS



Broad ligament

Pelvic Muscular Anatomy

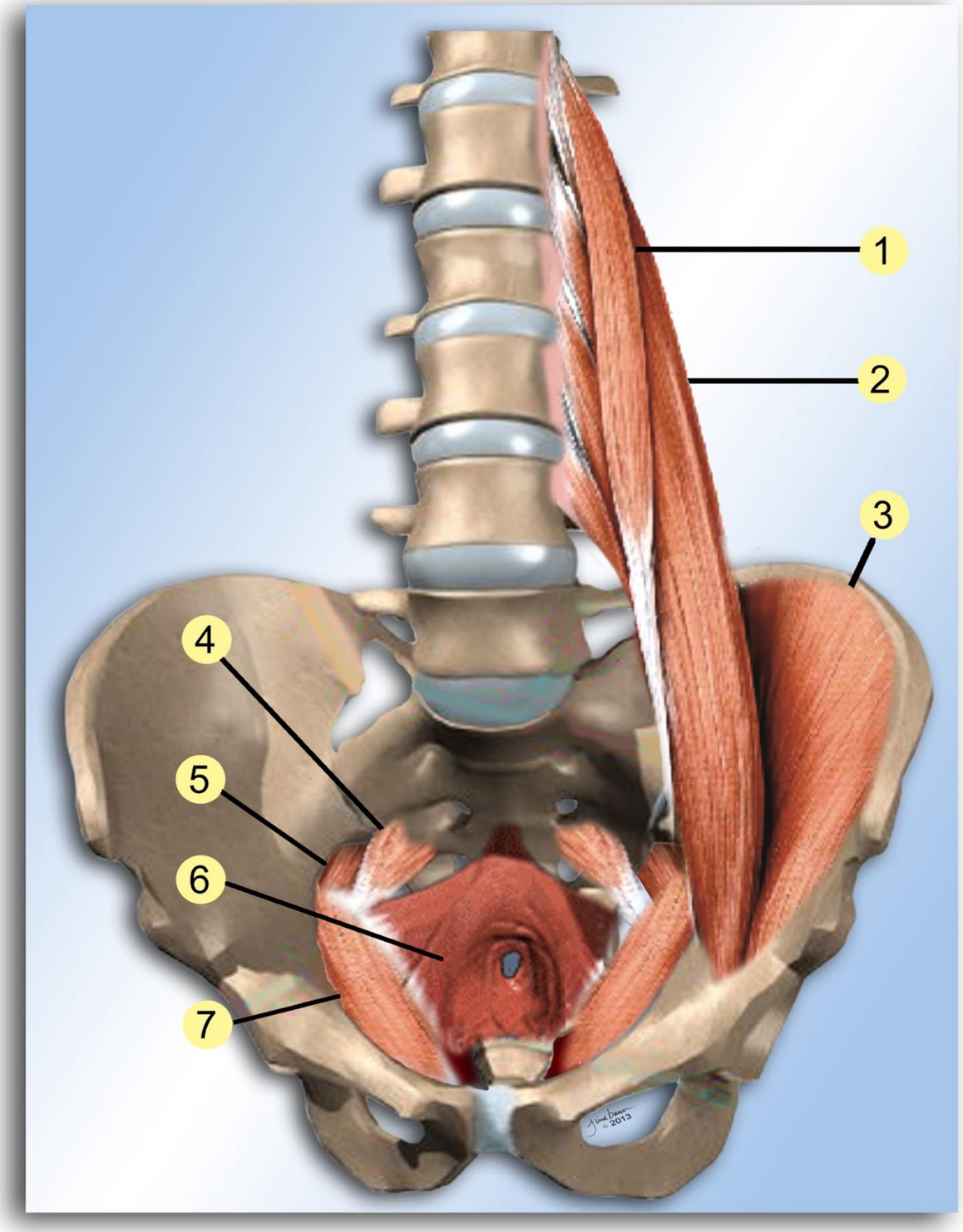
- Pelvic musculature supports and protects internal viscera. Paired muscles include:
  - *Rectus abdominis*: forms anterior margin of abdominal and pelvic spaces
  - *Psoas major*: courses posteriorly from lower thoracic vertebrae. At level of iliac crest merges with *iliacus* muscle to form *iliopsoas muscle*
  - *Iliacus*: arises at iliac crest along iliac bone

Pelvic Muscular Anatomy

- Pelvic musculature supports and protects internal viscera. Paired muscles include:
  - *Levator ani*: muscle group forming pelvic floor. Consists of:
    - Coccygeus
    - Iliococcygeus
    - Pubococcygeus
  - *Obturator internus*: located along inferior pelvic sidewall
  - *Piriformis:* located along posterior pelvic side wall

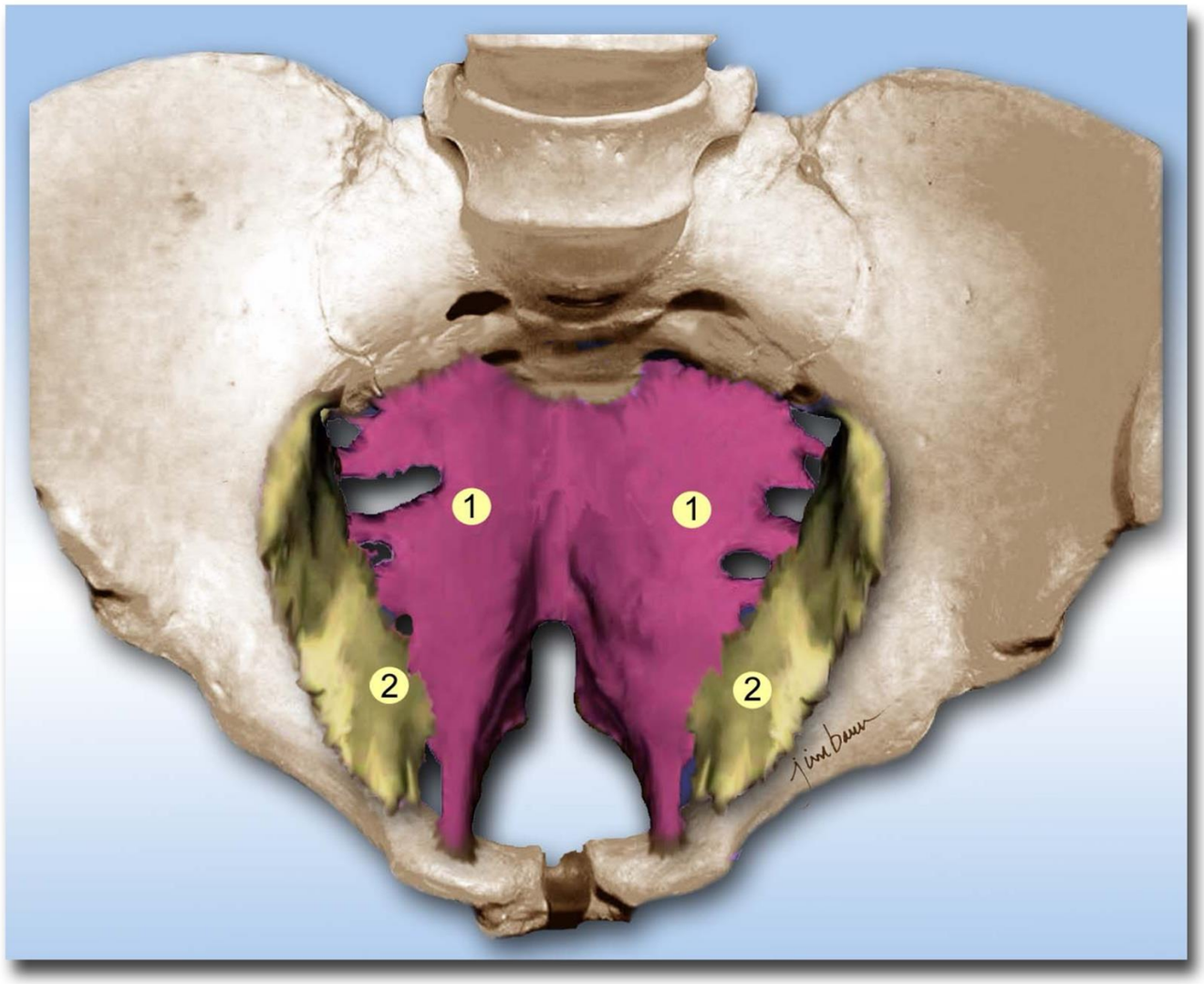
PELVIC MUSCULAR ANATOMY

1 = psoas minor
2 = psoas major
3 = iliacus
4 = coccygeus
5 = piriformis
6 = levator ani group
7 = obturator internus



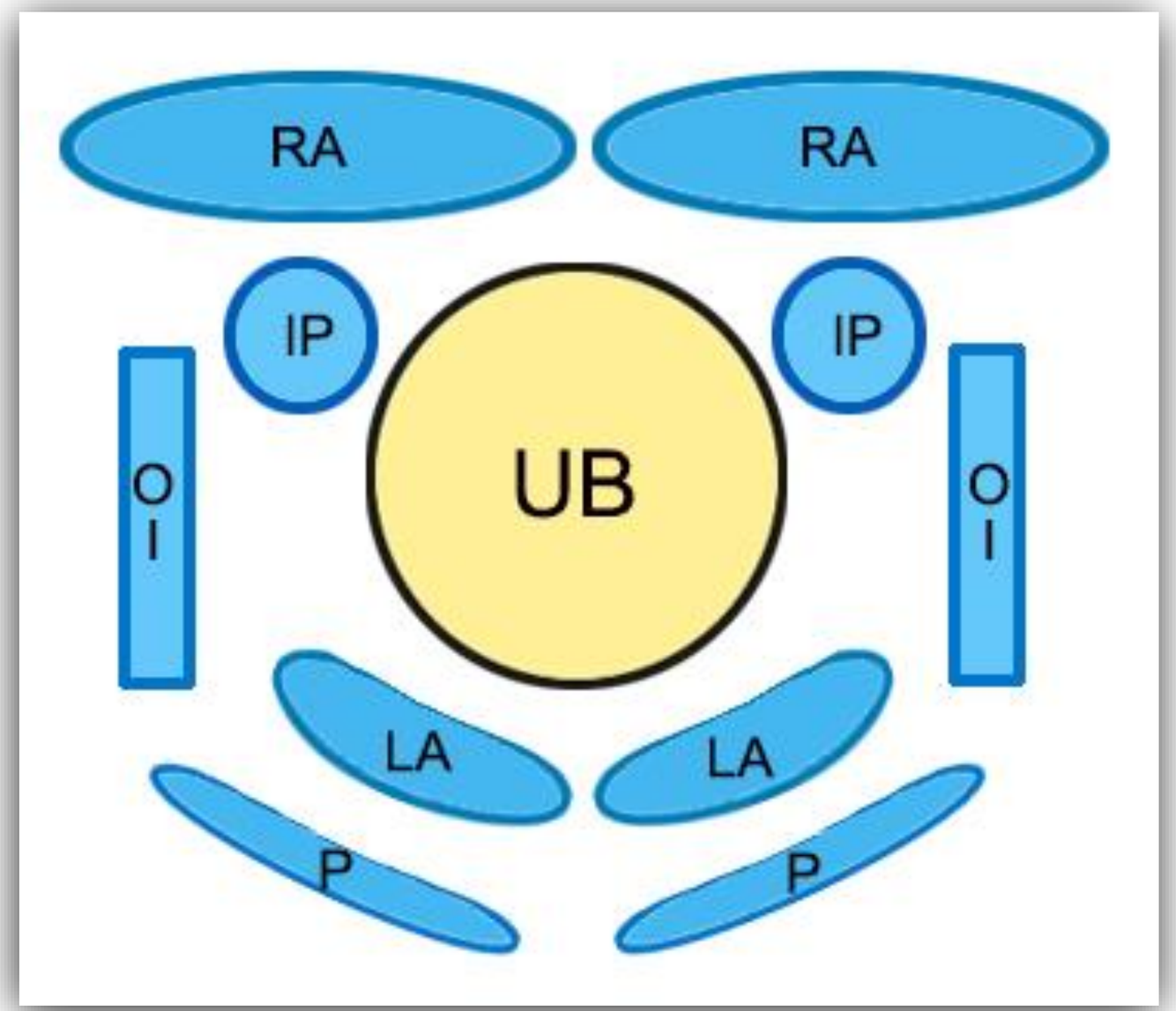
PELVIC MUSCULAR ANATOMY

1 = levator ani
2 = obturator internus



Pelvic floor musculature

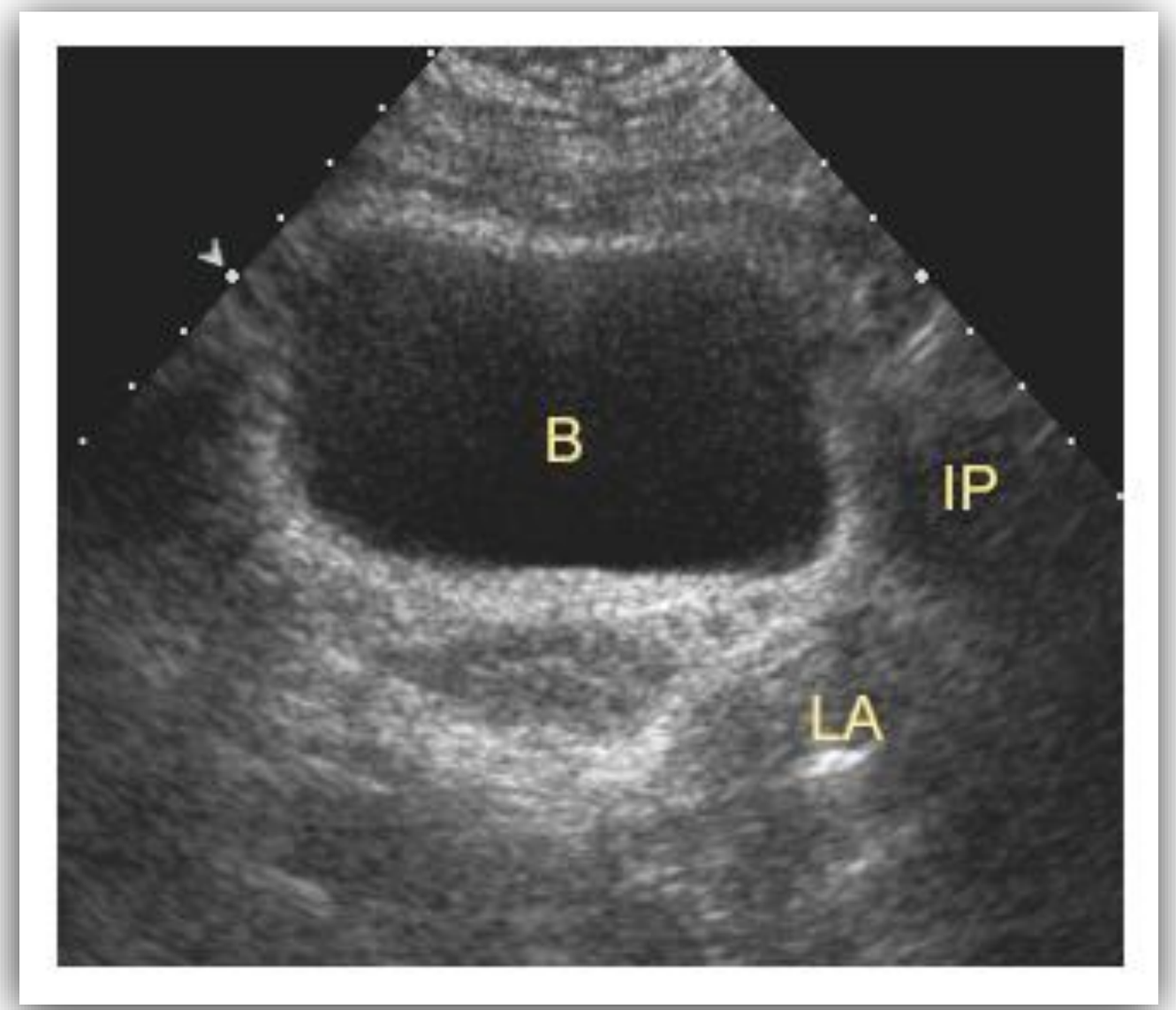
PELVIC MUSCULAR ANATOMY



Relational schematic

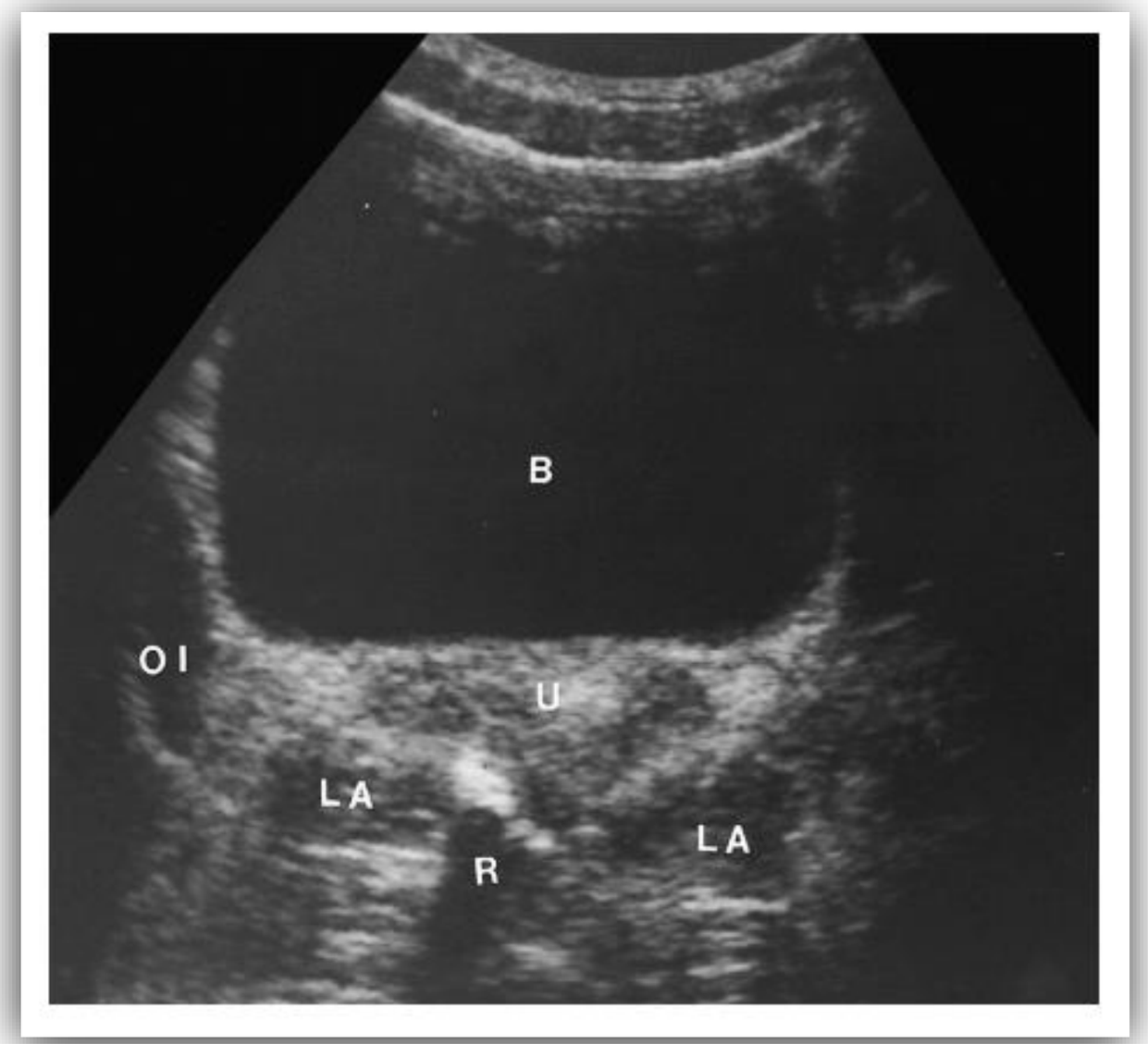
PELVIC MUSCULAR ANATOMY

B = bladder
LA = levator ani
IP = iliopsoas



PELVIC MUSCULAR ANATOMY

B = bladder
U = uterus
LA = levator ani
OI = obturator internus
R = rectum



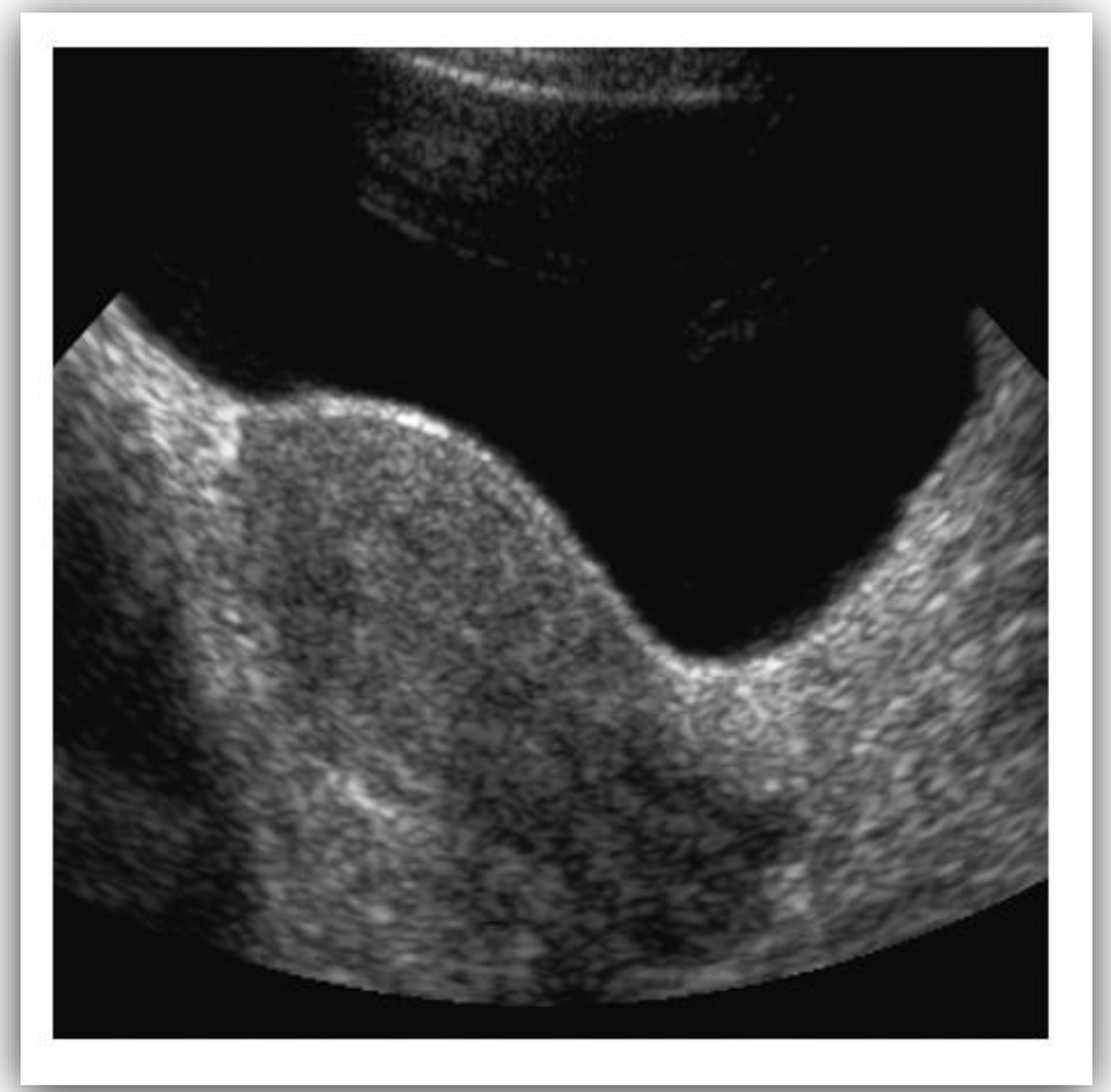
Visceral Anatomy

- Solid and hollow visceral organs located within the pelvic cavity include:
  - Urinary bladder
  - Uterus
  - Vagina
  - Fallopian tubes
  - Ovaries
  - Pelvic recesses

Urinary Bladder

- Musculomembranous, highly distensible sac located between symphysis pubis and vagina
- Adequately full for transabdominal US when dome of bladder extends above fundus of uterus

URINARY BLADDER



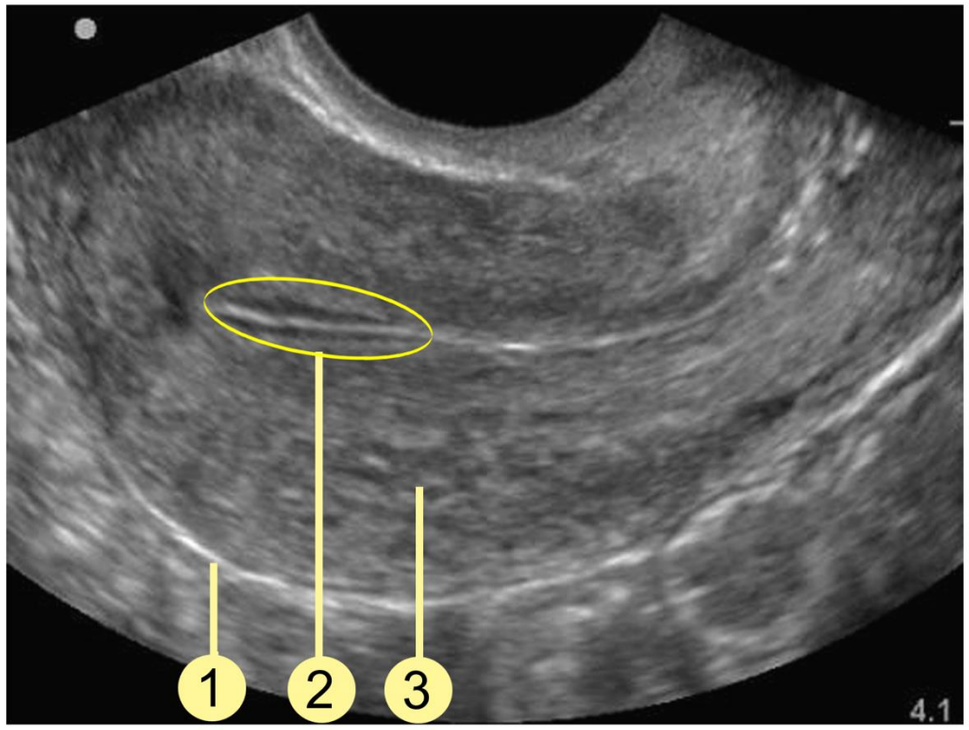
Adequately full urinary bladder

Uterus

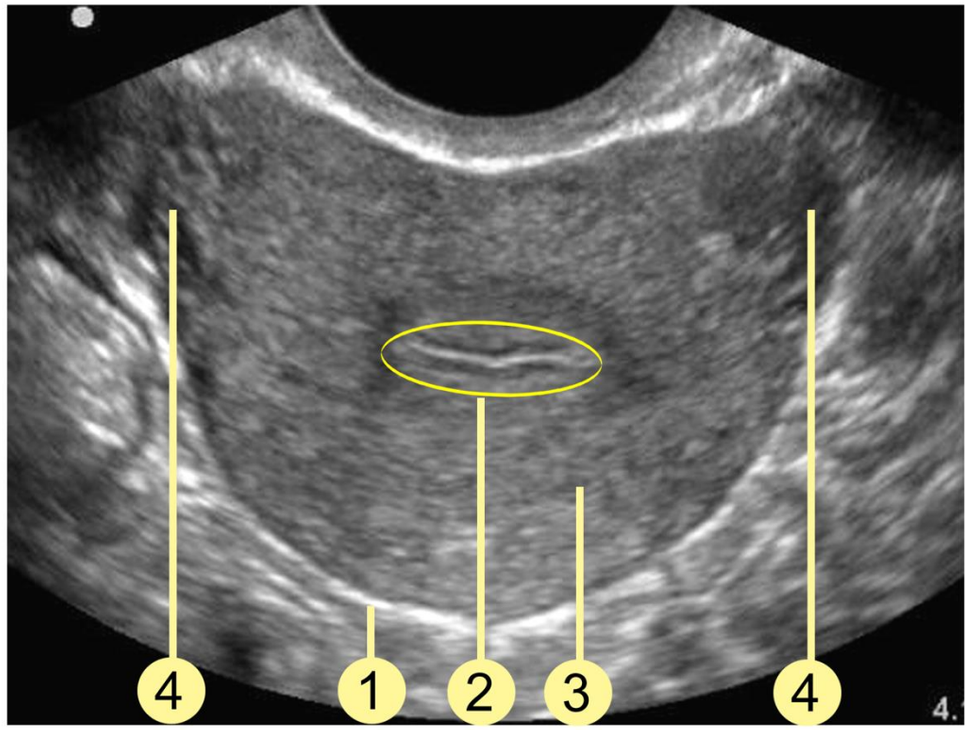
- Hollow, pear-shaped muscular organ located in pelvic posterior to urinary bladder and anterior to rectum

- Composed of three fascial layers:
  - *Serosa*: (perimetrium) thin outer layer of uterus
  - *Myometrium*: middle, smooth muscle layer
  - *Endometrium*: inner mucosal layer

UTERUS



Sagittal section



Axial section

Uterine layers

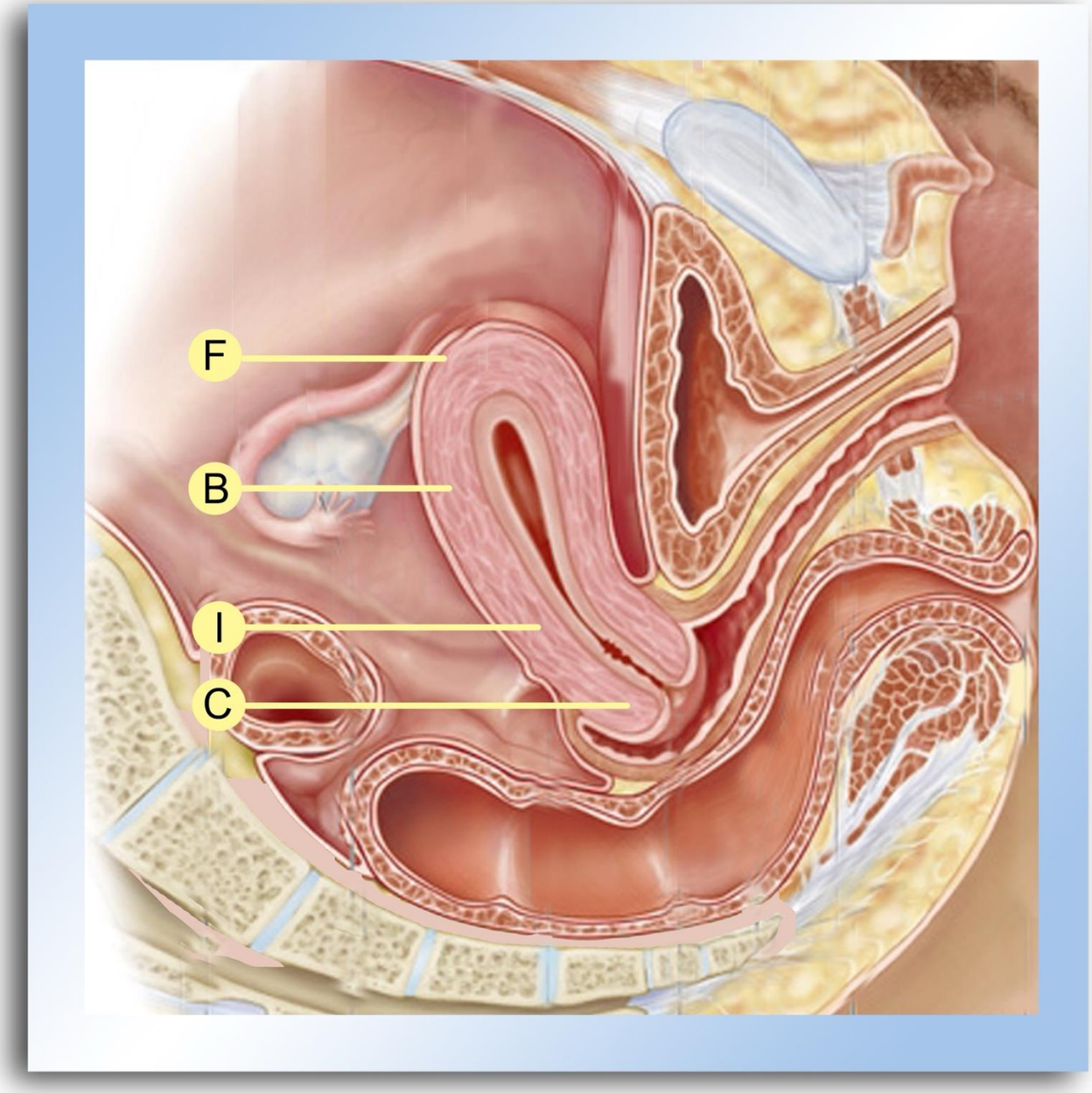
1 = perimetrium
2 = endometrium
3 = myometrium
4 = uterine cornu

Uterus

- Uterus is divided into the following anatomic regions:
  - *Fundus*: rounded, superior portion above insertion of fallopian tubes
  - *Corpus*: (body) largest portion. Contains uterine cavity
  - *Isthmus*: transitional segment between corpus and cervix. Called *lower uterine segment* in pregnancy
  - *Cervix*: cylindrical neck ≈ 3cm in length
    - Internal os: opening into uterine cavity
    - External os: opening into upper vagina

UTERUS

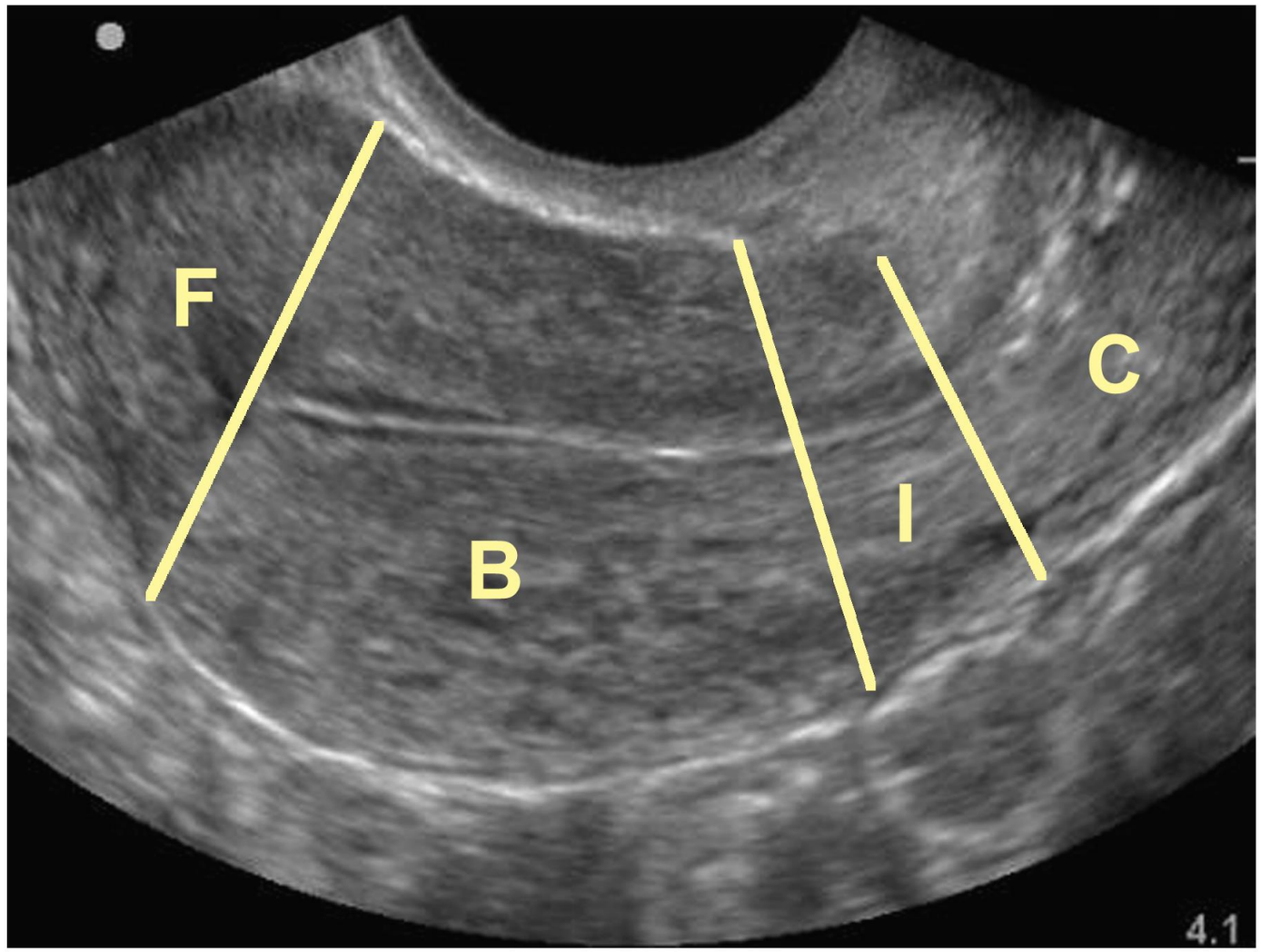
F = fundus
B = body (corpus)
I = isthmus
C = cervix



Uterine anatomic segments

UTERUS

F = fundus
B = body (corpus)
I = isthmus
C = cervix

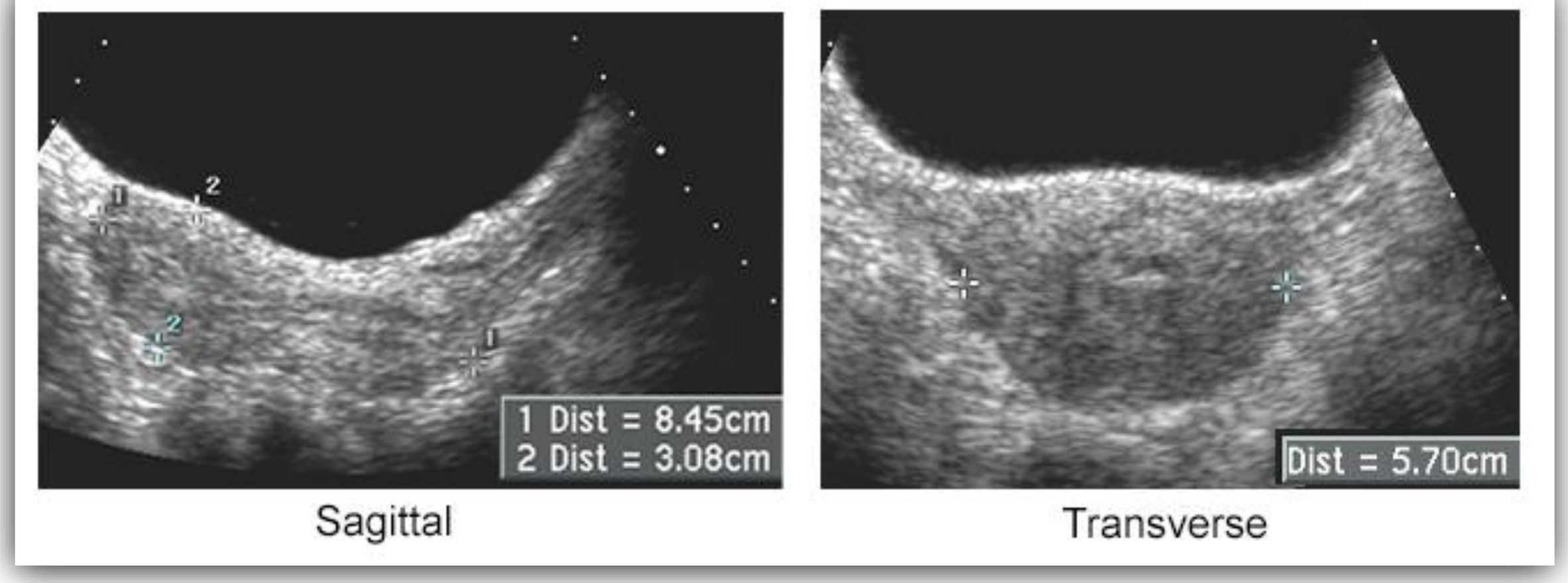


Uterine anatomic segments

UTERUS

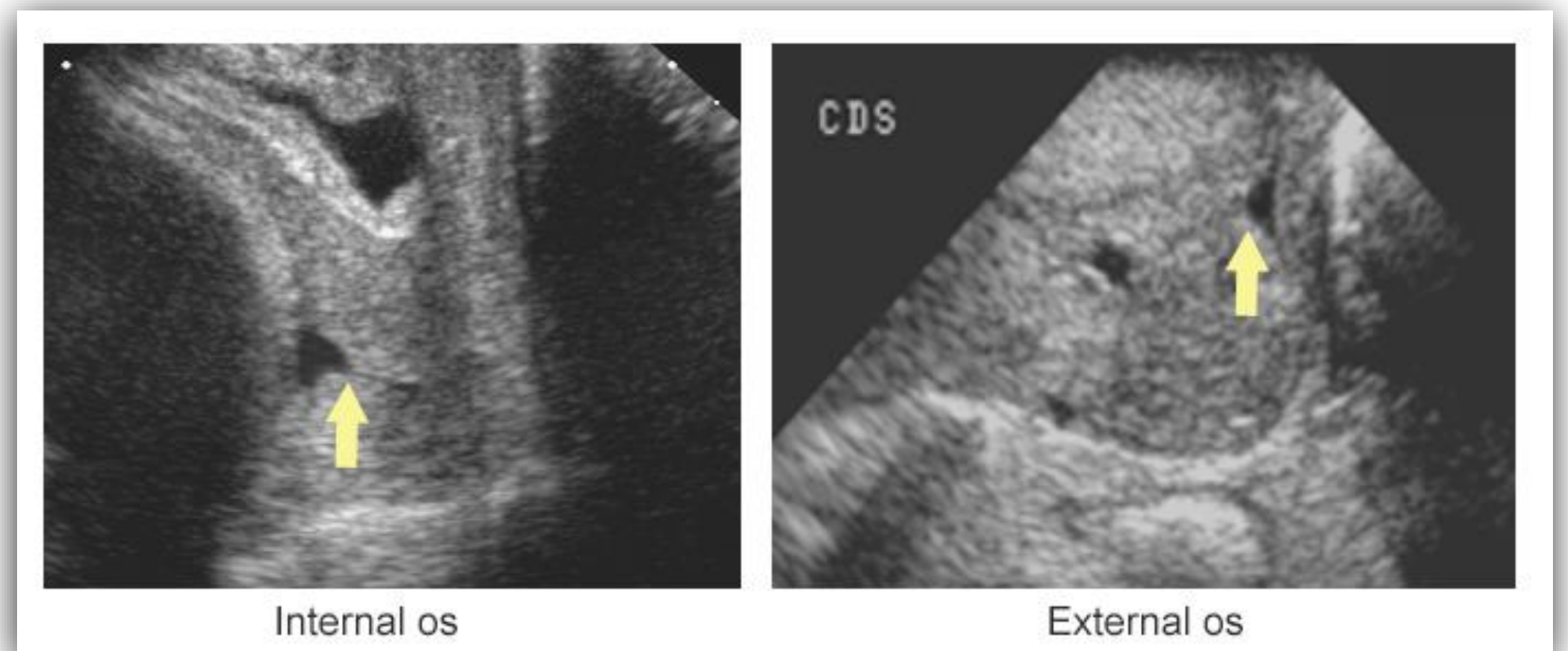
UTERINE SIZE		
AGE (years)	**Length (mm)**	**AP (mm)**
2 - 8	33	7.5
9 – menarche	43	13
Nulliparous	80	30
Multiparous	90	40
Postmenopausal	Varied based on parity	
A pediatric uterus has a relatively larger cervical length and width		
A postmenopausal uterus has a normal uterine configuration		

UTERUS



Normal nulliparous uterine size

CERVIX

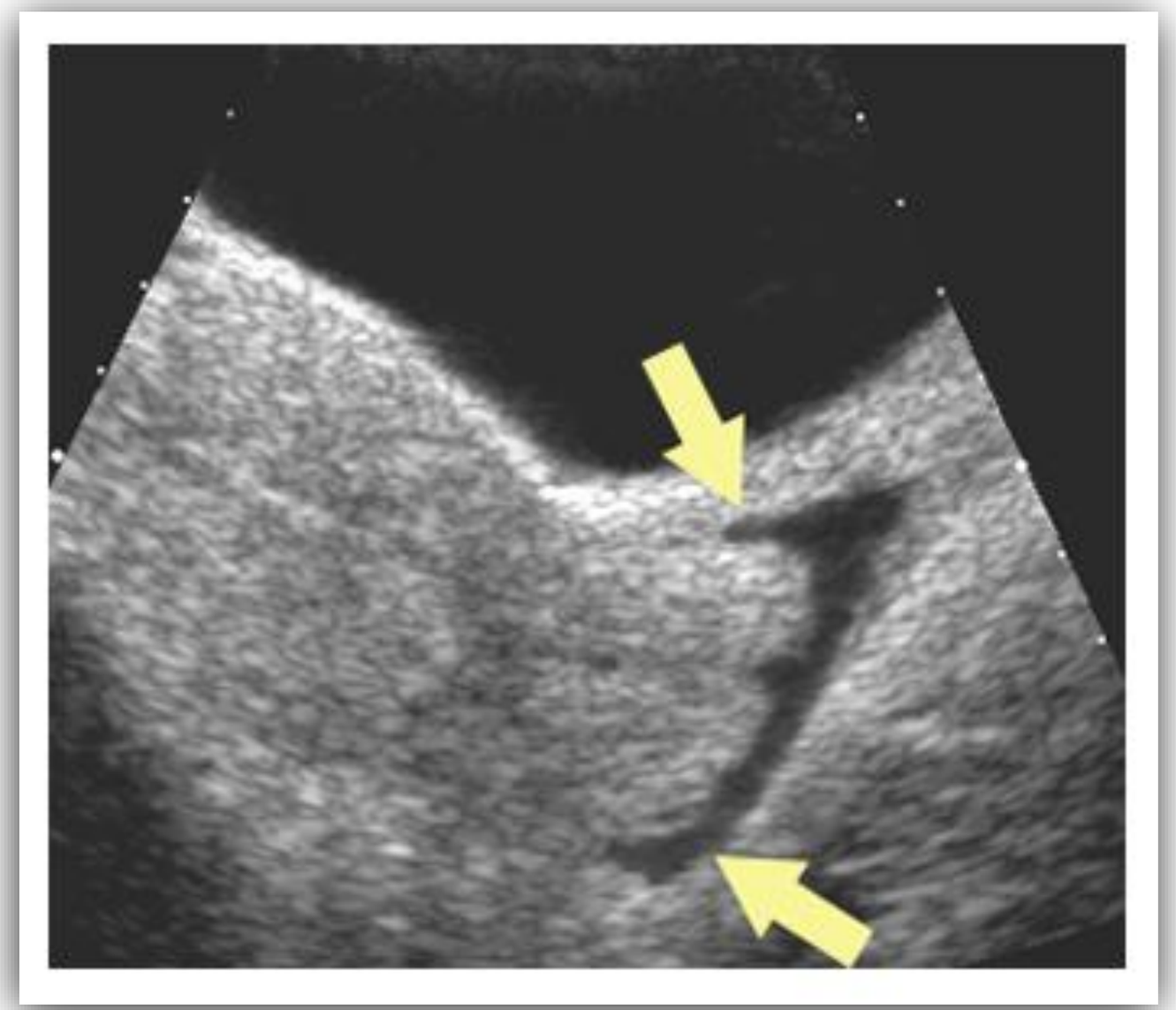


Cervical ora

Vagina

- Extends from external cervical os to external *vaginal introitus*
- Attaches circumferentially to cervix to form the *vaginal fornices*
  - *Anterior fornix*
  - *Posterior fornix*
  - *Lateral fornices (right and left)*

UTERUS

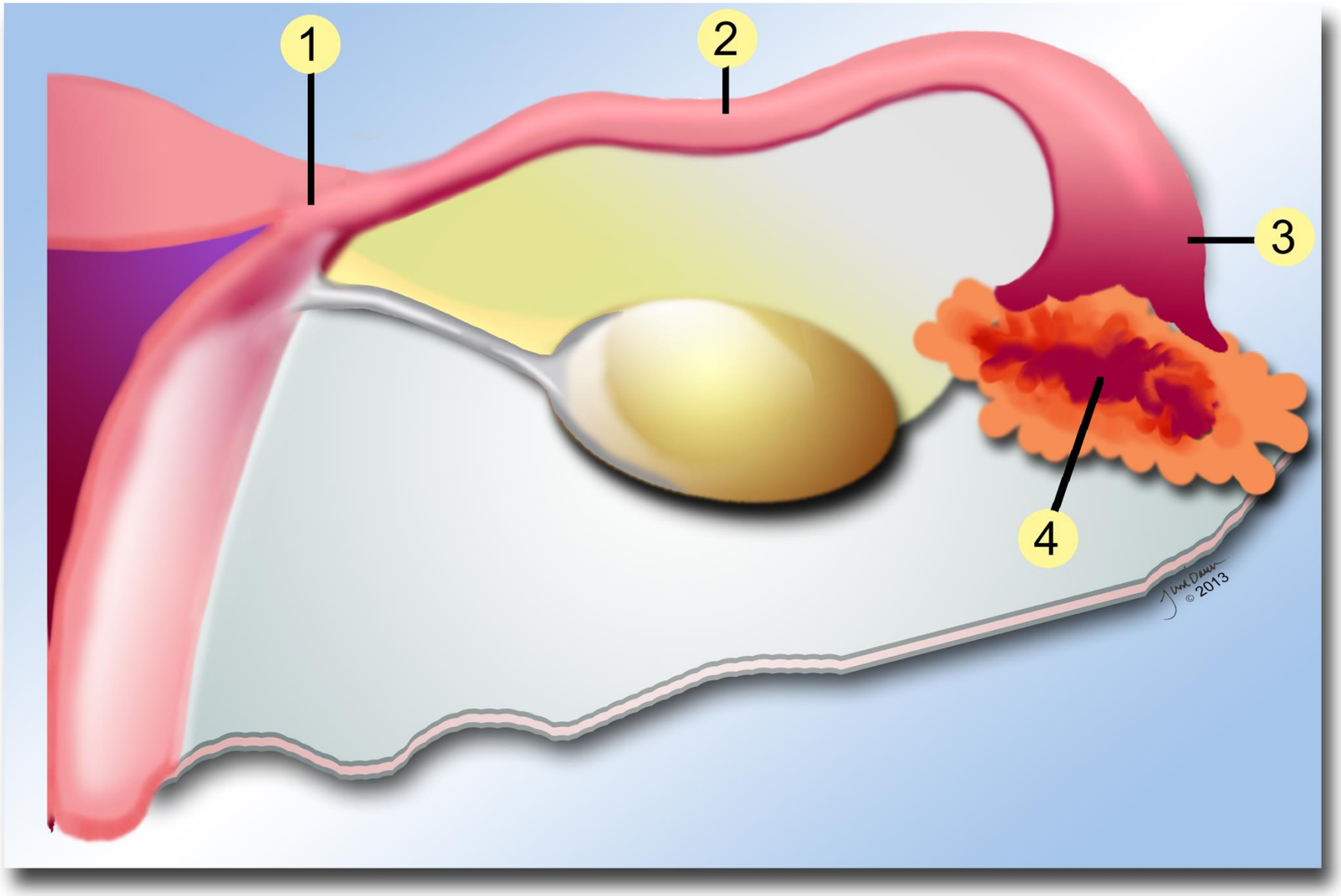


Vaginal fornices

Fallopian Tubes

- Musculomembranous tubes extending from each uterine cornu to corresponding ovary
- Anatomic regions are:
  - *Intramural (interstitial):* narrowest portion traversing uterine cornu
  - *Ampullary*: trumpet-shaped, open portion adjacent to ovary
  - *Infundibulum*: Inner, funnel-shaped cavity of ampullary portion

FALLOPIAN TUBES



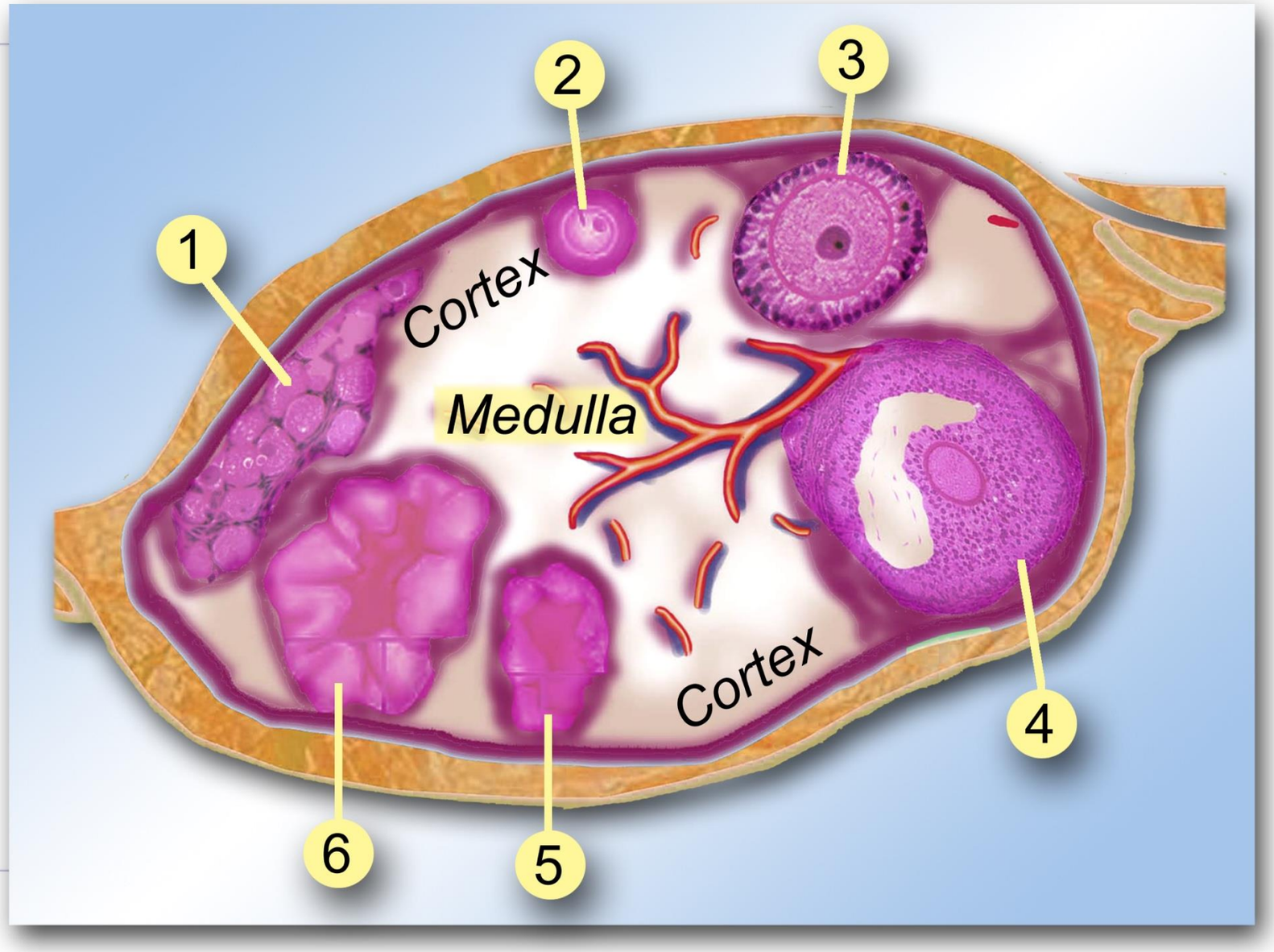
1 = interstitial portion
2 = isthmic portion
3 = ampullary portion
4 = infundibulum

Ovaries

- Paired, female internal reproductive organs that house and release ova (eggs)

- Histologic layers of the ovary:
  - *Cortex: outer layer that contains primary and secondary follicles*
  - *Medulla: inner, central portion which contains lymphatics, blood vessels, and nerves which enter through ovarian hilus*

OVARIES



1 = primary follicle
2 = secondary follicle
3 = primary oocyte
4 = Graffian follicle
5 = ruptured follicle
6 = corpus luteum

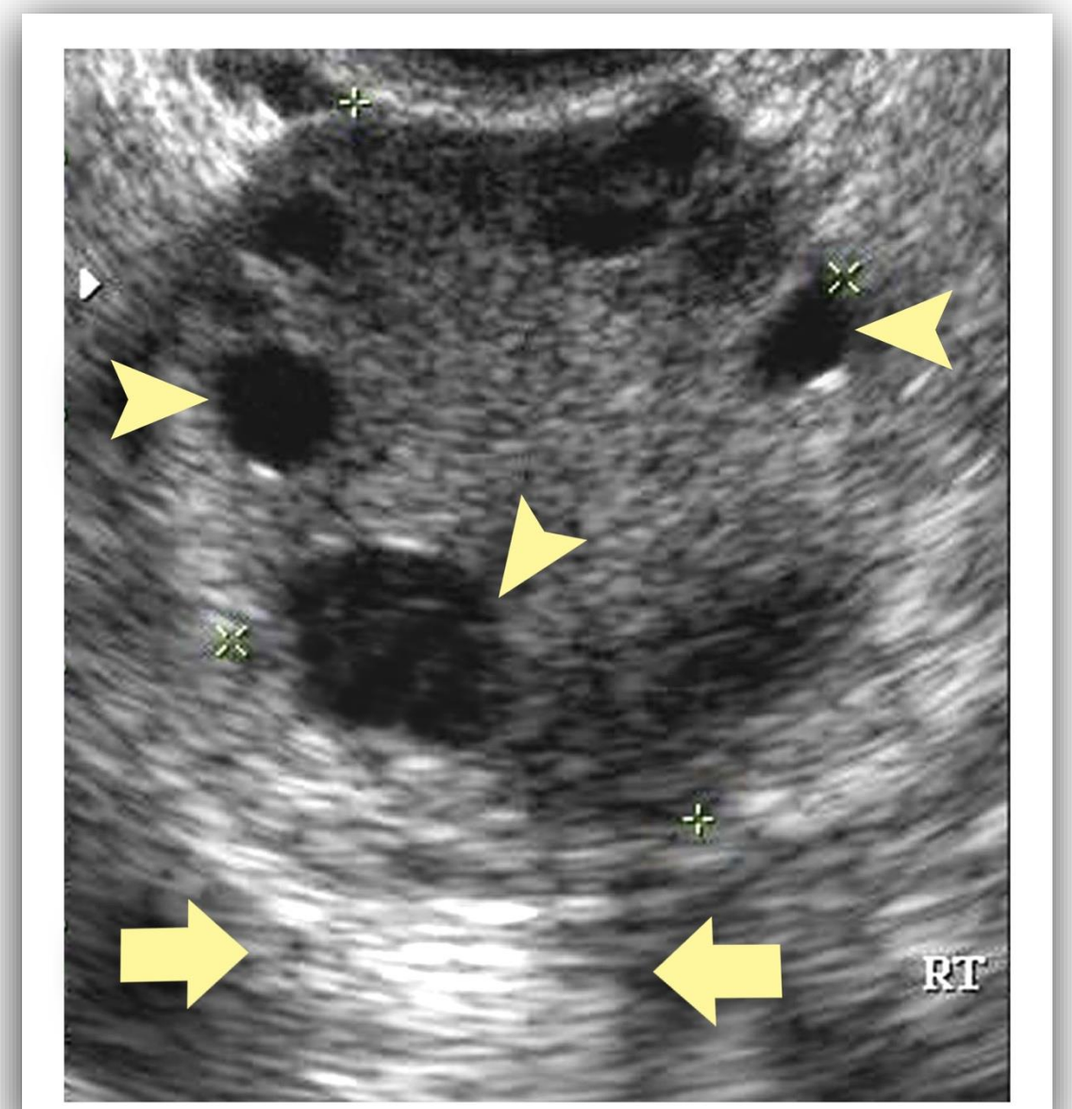
OVARIES

Ovarian Size		**Ovarian Volume** (length x width x AP in com) x 0.523
Premenopausal (varies with stage of ovulation)	3.5 x 2.0 x 1.5 cm	5.1 – 3.2 cm^3
Postmenopausal (varies with number of years since menopause)	2.0 x 1.0 x 0.5 cm,	1.3 cm^3

Sonographic Appearance

- During reproductive years, multiple active follicles are present
- Parenchyma is moderately to highly echogenic
- Differentiator from other adjacent structure is *posterior acoustic enhancement*
- Vary significantly in size and shape based on hormonal status

OVARIES

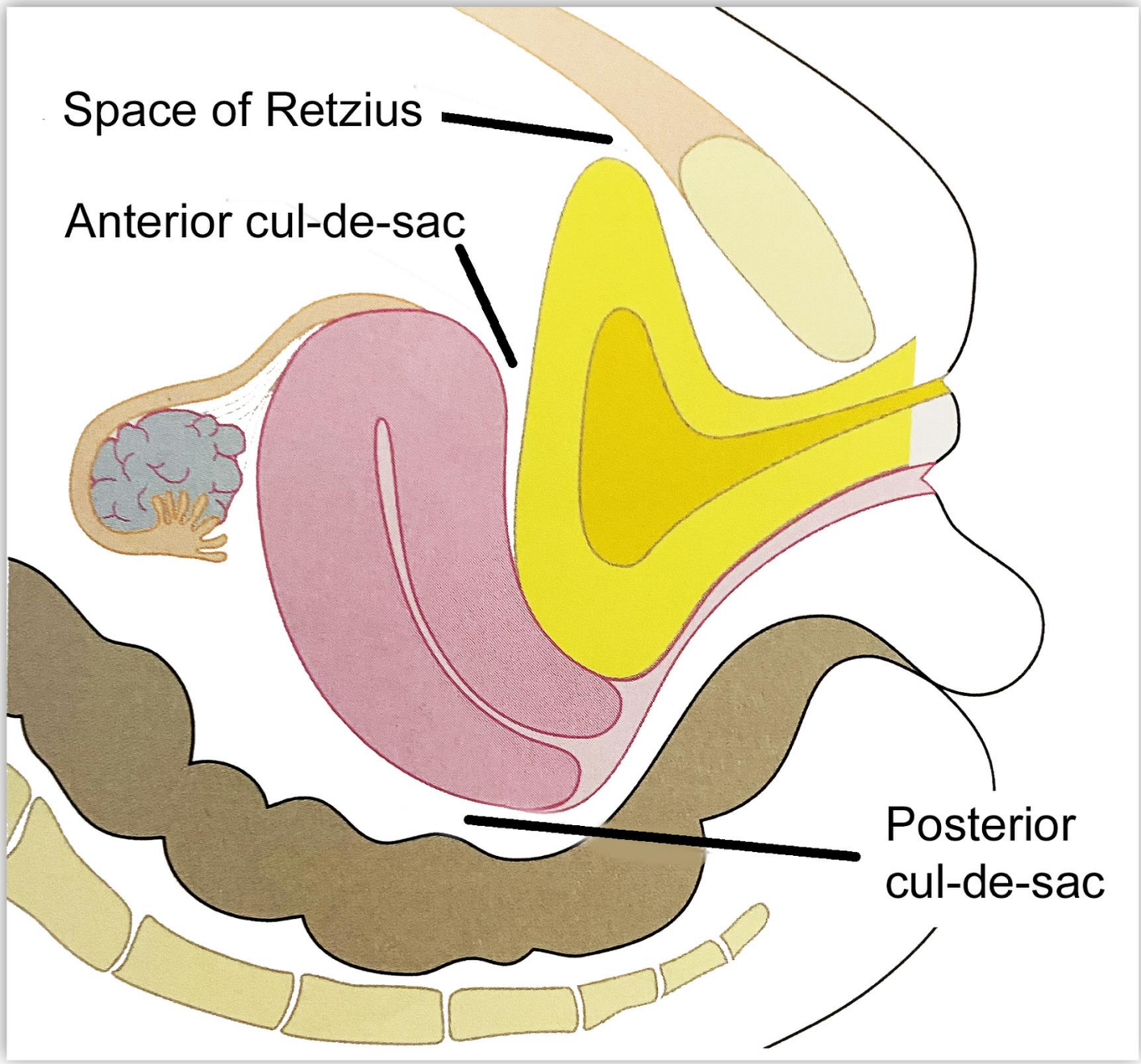


- **Echogenic solid ovarian parenchyma**
- **Arrows = posterior acoustic enhancement**
- **Arrowheads = fluid-containing follicles**

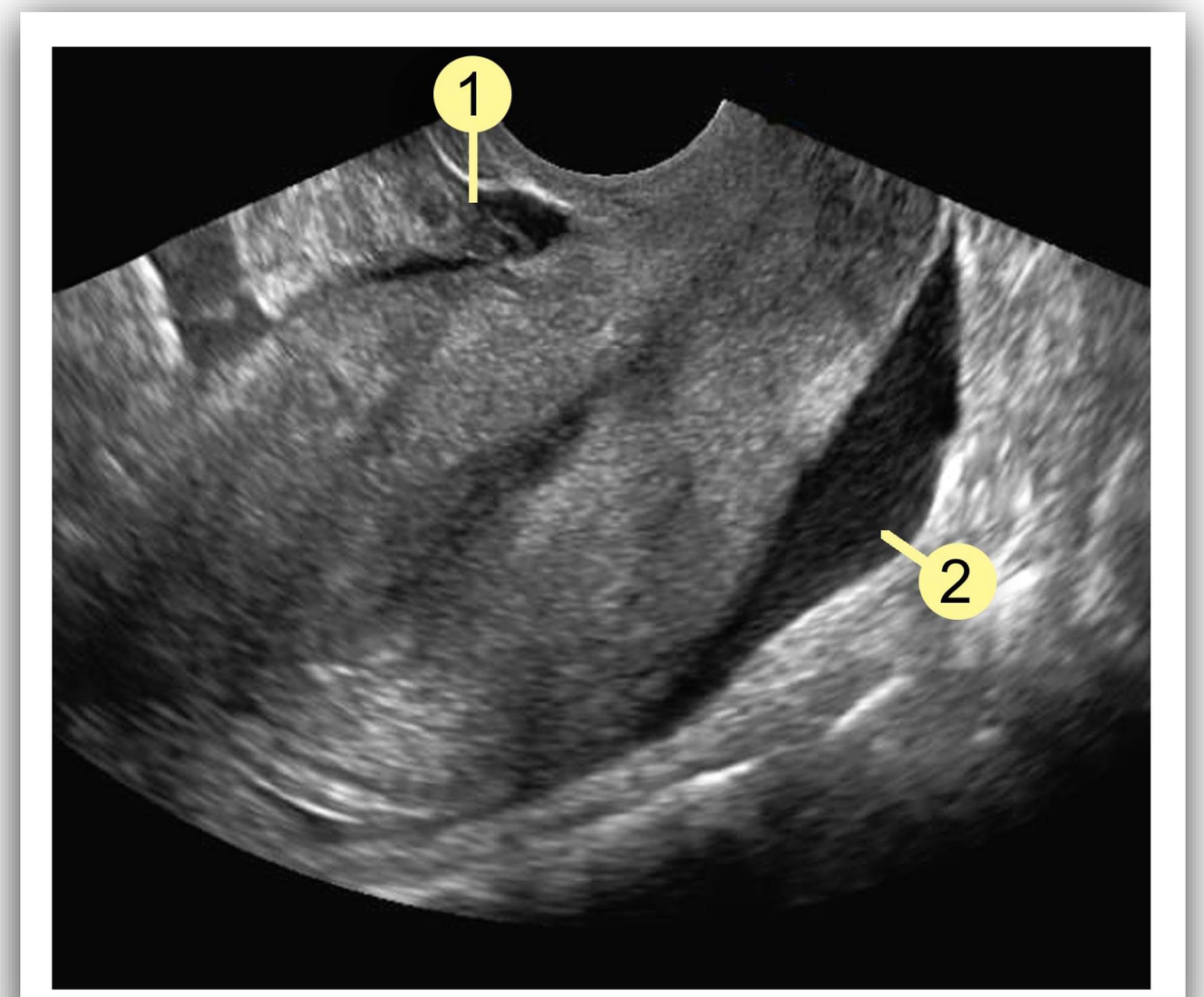
Pelvic Recesses

- Several potential spaces are formed in the pelvis by the draping of the peritoneum over the uterus
  - *Space of Retzius:* between anterior abdominal wall and anterior bladder surface
  - *Anterior cul-de-sac (uterovesical space):* between posterior bladder wall and anterior uterine surface
  - *Posterior cul-de-sac (pouch of Douglas):* between posterior uterine space and anterior surface of rectum

PELVIC RECESSES



PELVIC RECESSES



1 = anterior cul-de-sac
2 = posterior cul-de-sac

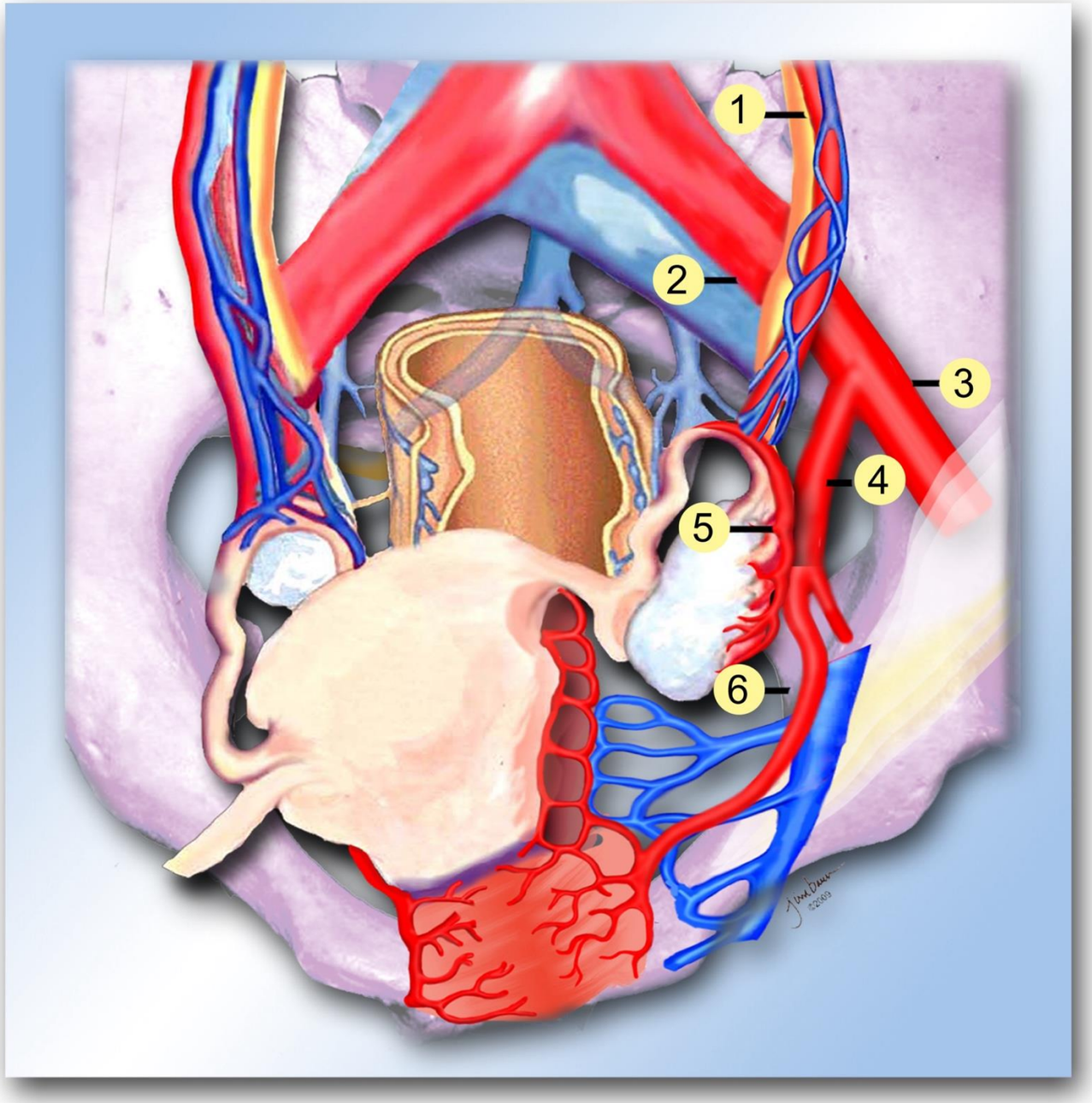
PELVIC RECESSES

Fluid in posterior cul-de-sac

Vascular Anatomy

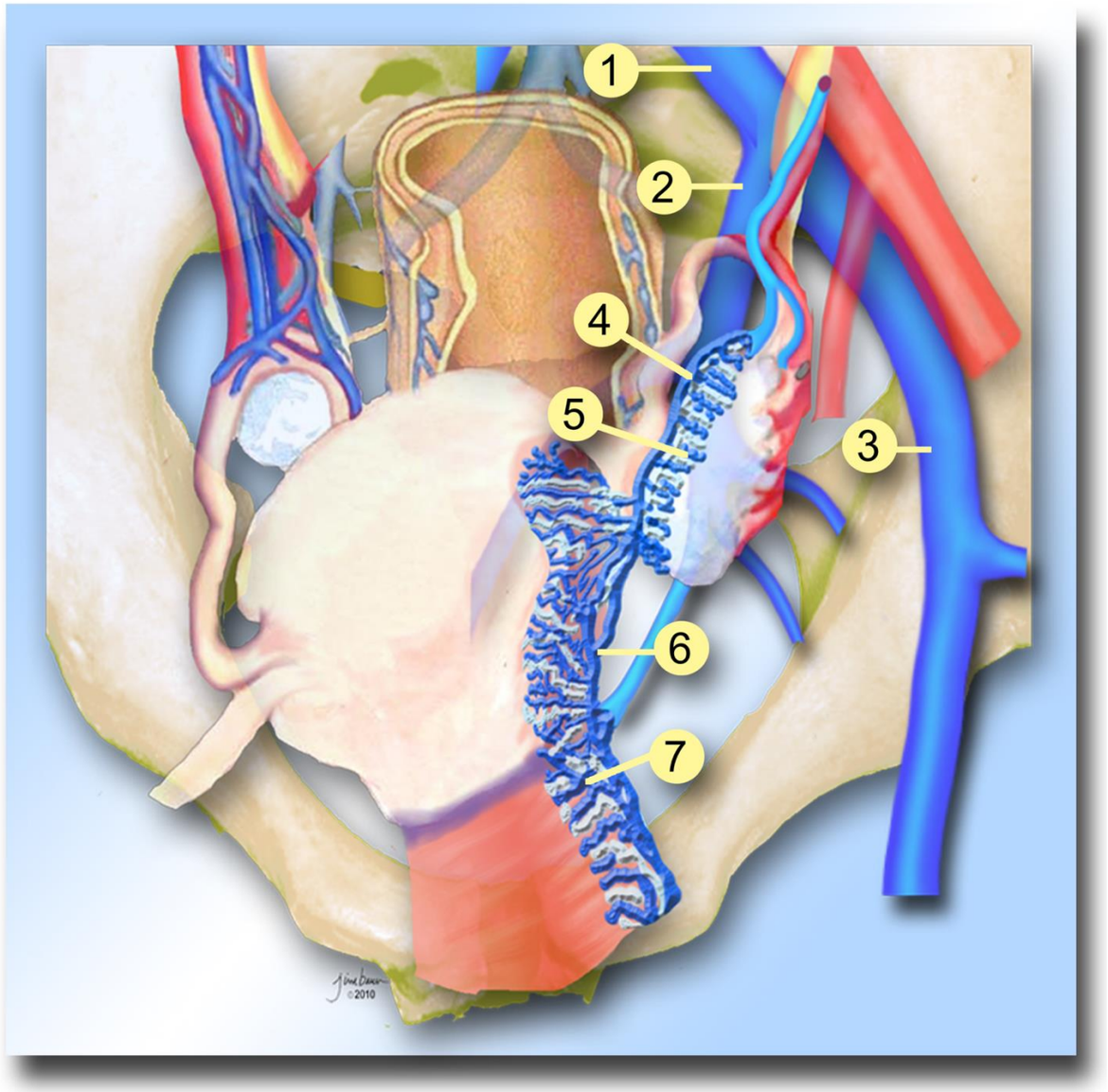
- Arterial and venous anatomy parallel each other
- Ovarian supply is from *gonadal arteries* which arise directly from abdominal aorta
- Uterine supply is from branches of the internal iliac (*hypogastric*) arteries that ascend along the lateral walls of the uterus from the cervix

VASCULAR ANATOMY



1 = gonadal a.
2 = common iliac a.
3 = external iliac a.
4 = internal iliac (hypogastric) a.
5 = ovarian a.
6 = uterine a.

VASCULAR ANATOMY

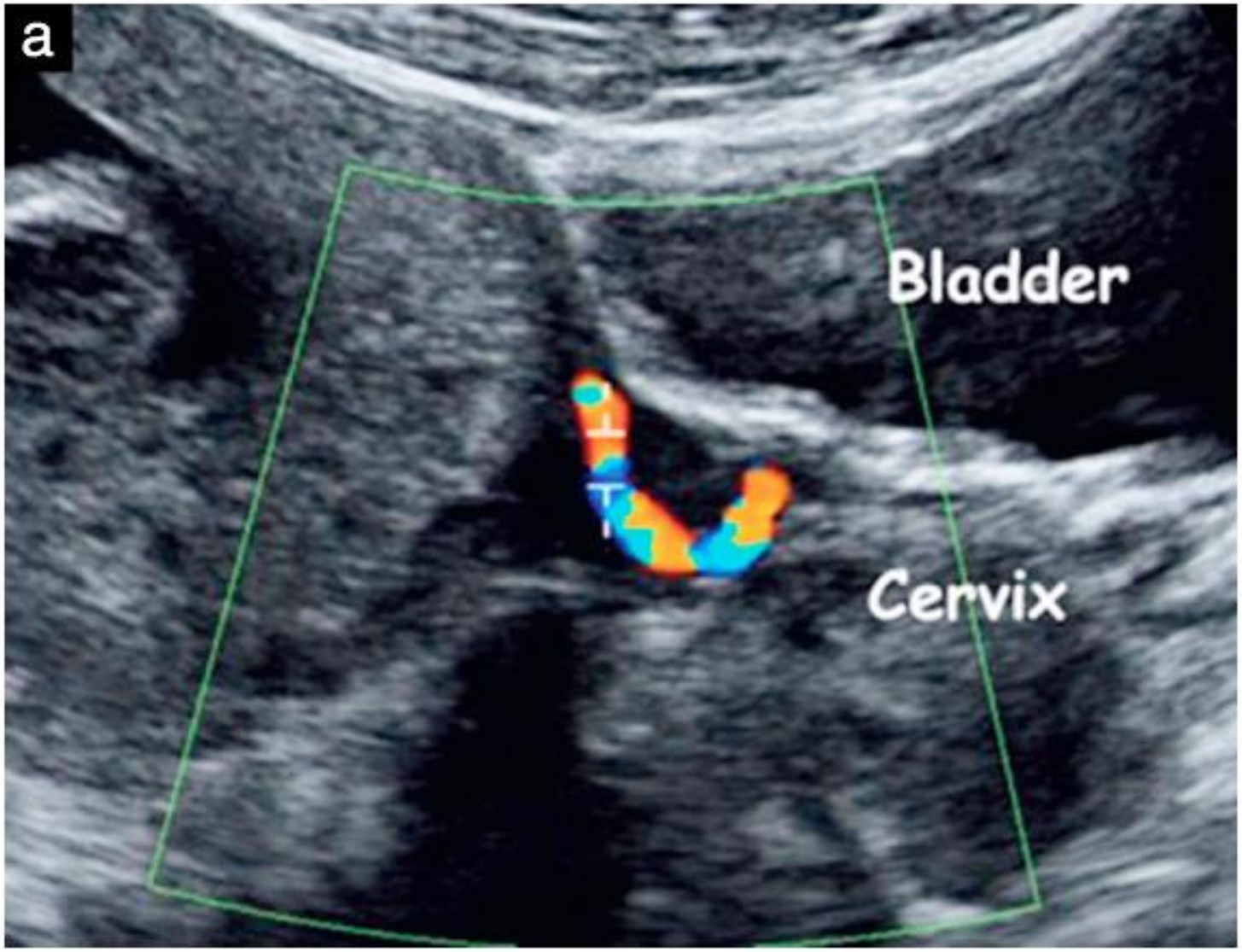


1 = common femoral v.
2 = internal iliac v.
3 = external iliac v.
4 = ovarian v.
5 = ovarian plexus
6 = uterine v.
7 = uterine plexus

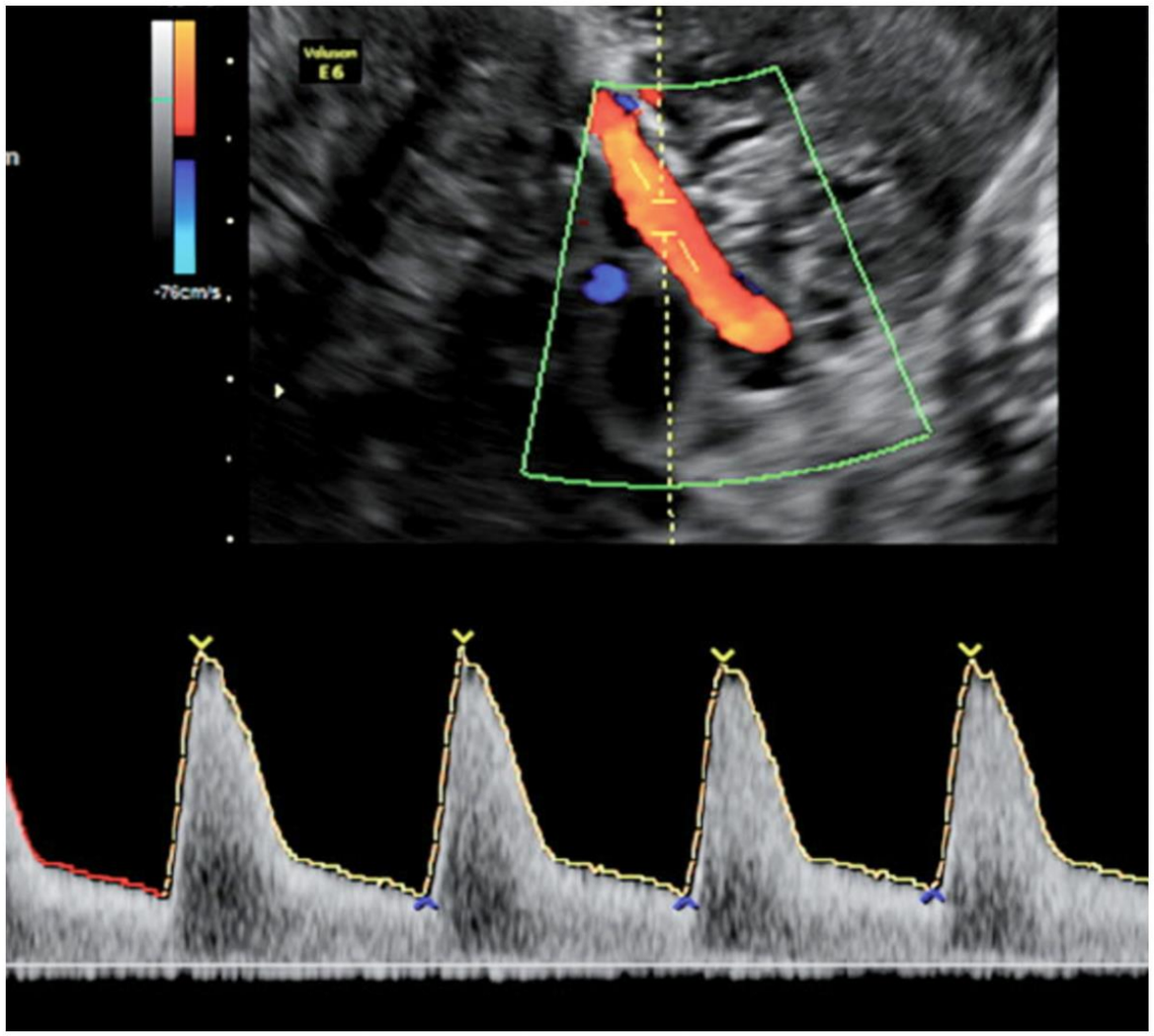
Uterine Artery Doppler

- Best identified as it inserts on lateral aspect of uterus just above cervix
- Dramatic changes in spectral waveform over menstrual cycle
- Values for RI and PI vary widely based on hormonal status
- Doppler studies have little clinical utility

UTERINE ARTERY DOPPLER



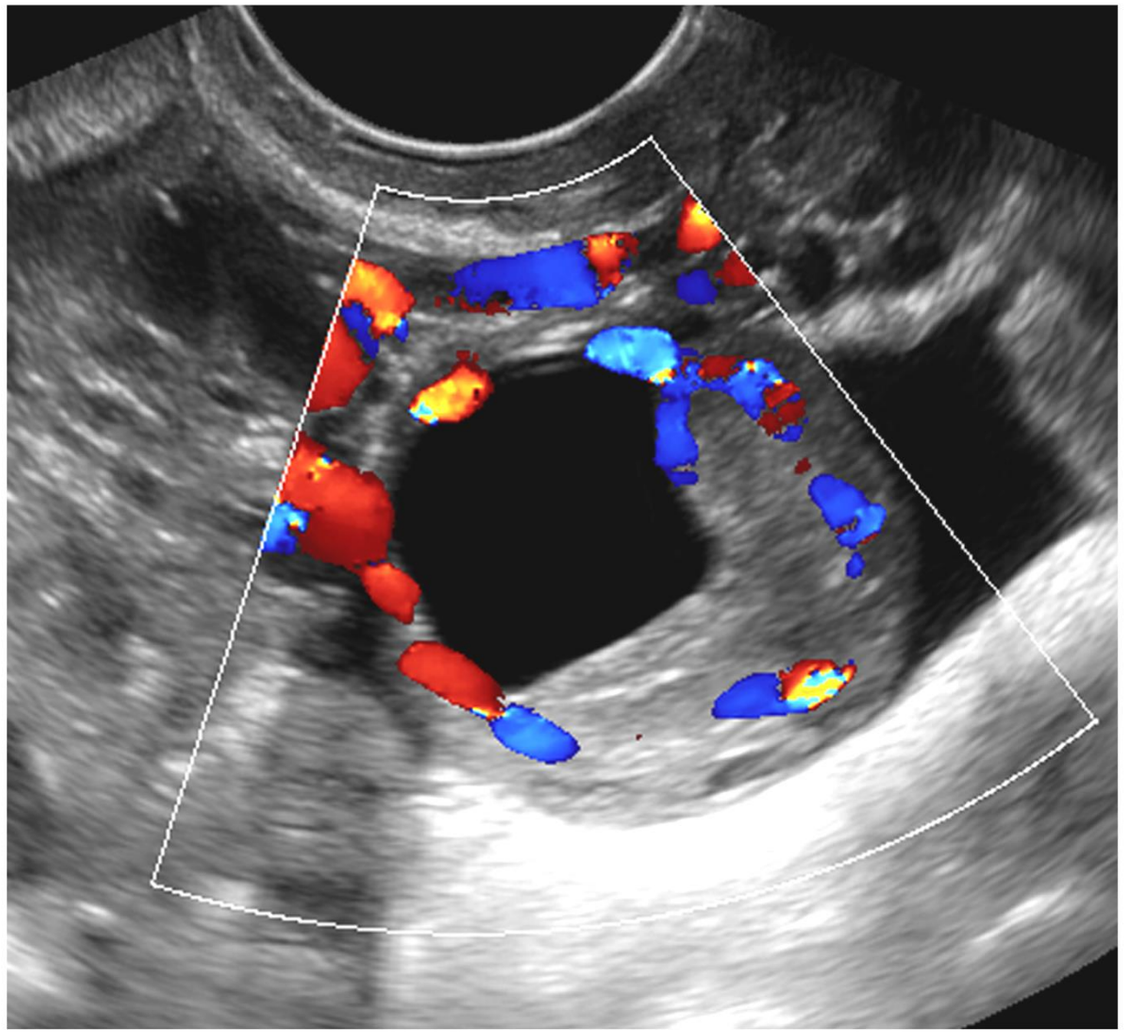
UTERINE ARTERY DOPPLER



Ovarian Artery Doppler

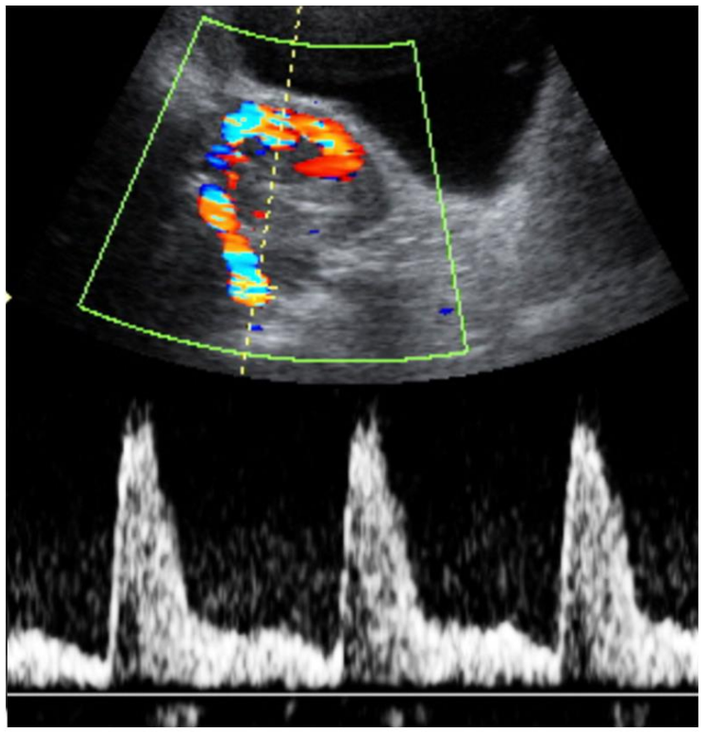
- Best identified coursing along superior margin of the ovary
- Resistance (RI) varies with metabolic status
- Metabolic status varies with stage of menstrual cycle
- Ovary containing dominant follicle requires more blood, *ergo*, lower RI values
- Nondominant ovary demonstrates higher RI values

OVARIAN ARTERY DOPPLER

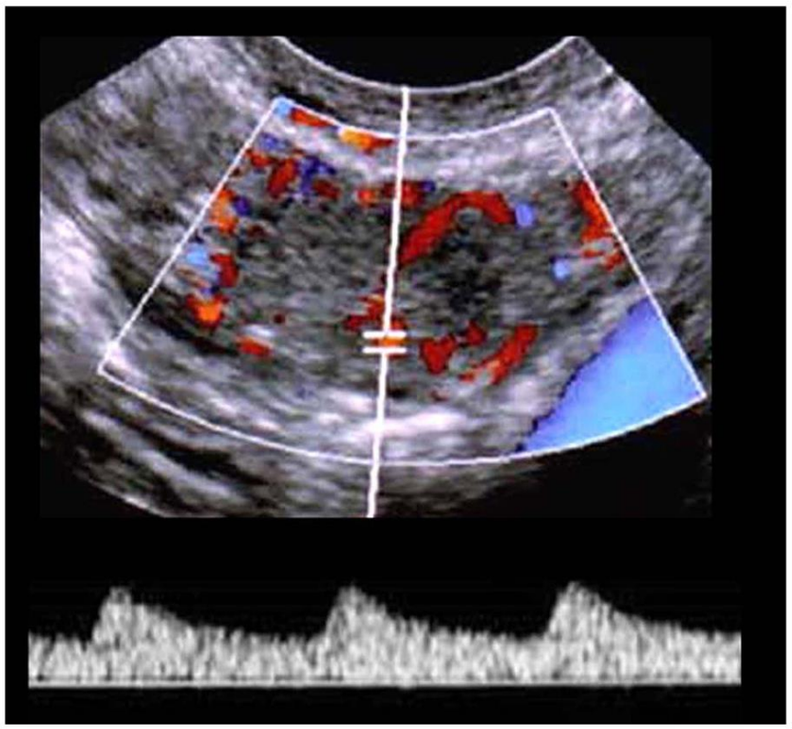


Flow in dominant ovary

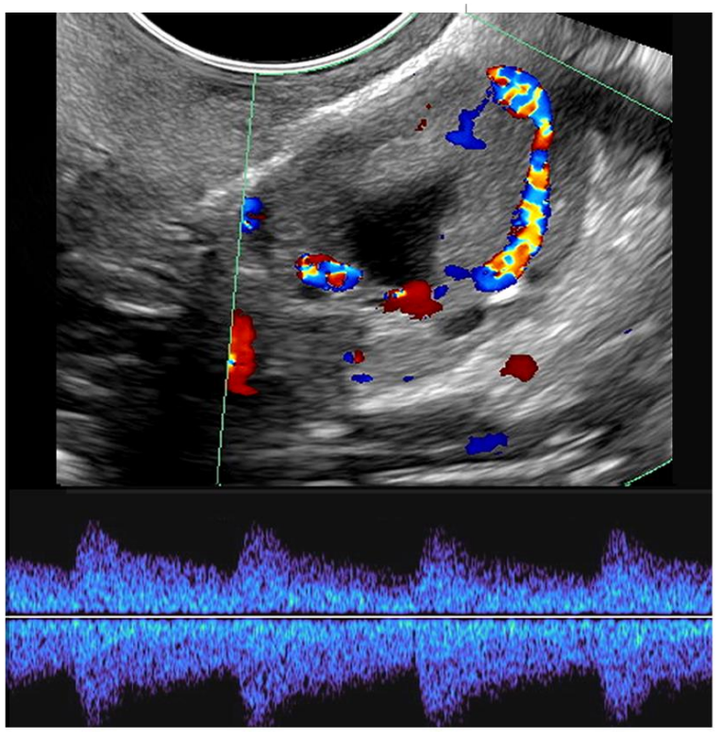
OVARIAN ARTERY DOPPLER



Nondominant ovary



Follicular phase



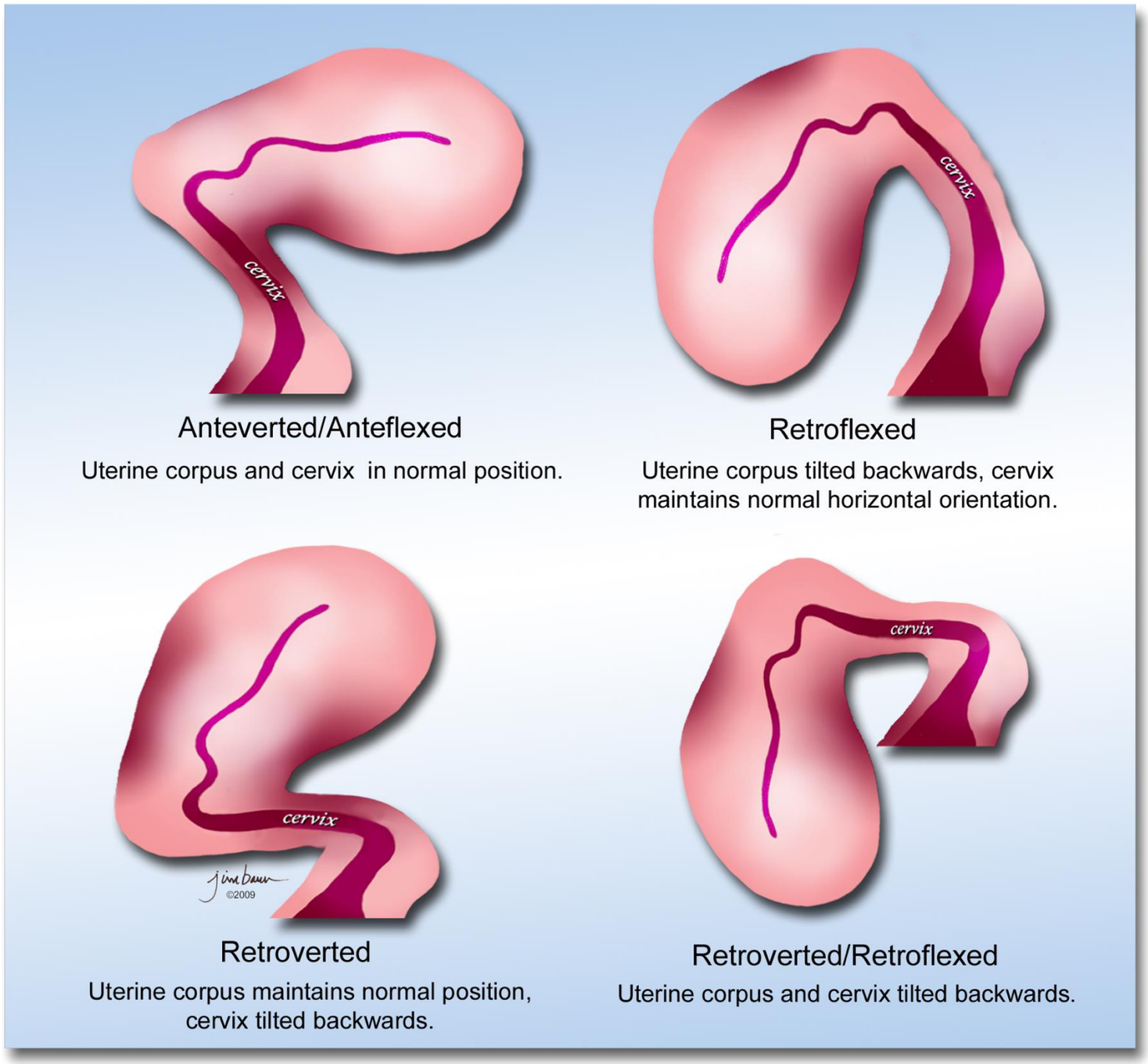
Ovulation

Anatomic Variants - Positional

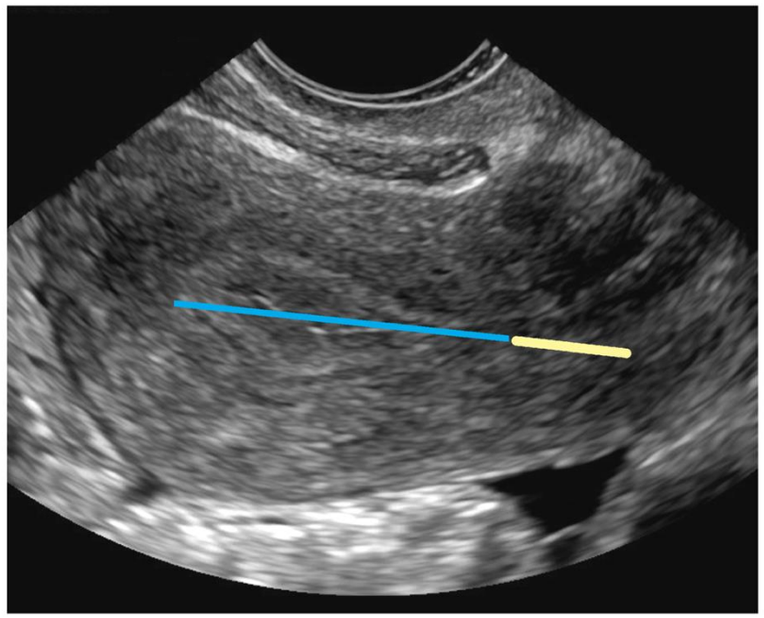
- Normal position (*anteverted*): uterine body tilted anteriorly from cervix
  - *Retroverted:* cervix tilted posteriorly; body normal position
  - *Retroflexed*: body tilted posteriorly; cervix normal position
  - *Retroverted/retroflexed*: both cervix and body tilted posteriorly

version - cervix
flexion - fundus

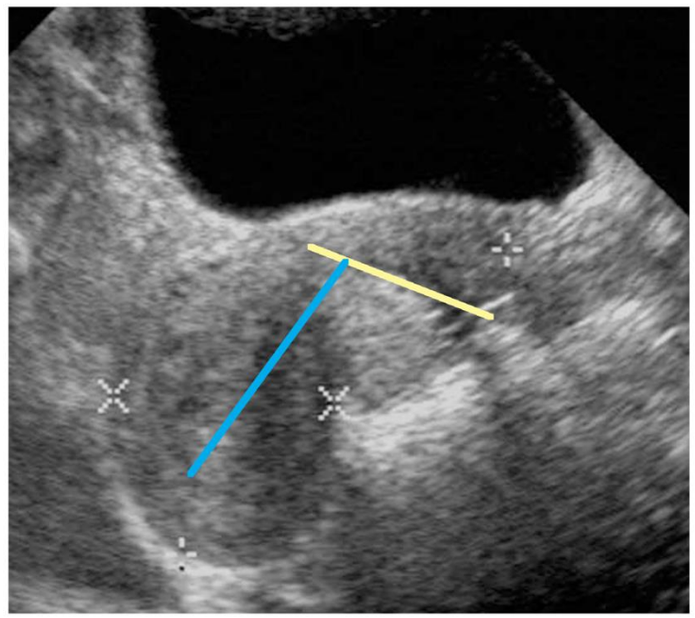
ANATOMIC VARIANTS - POSITIONAL



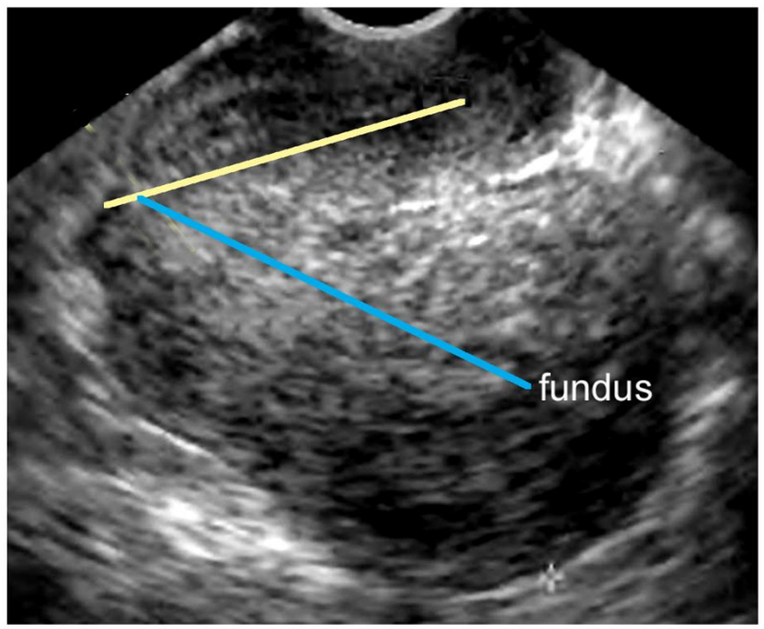
ANATOMIC VARIANTS - POSITIONAL



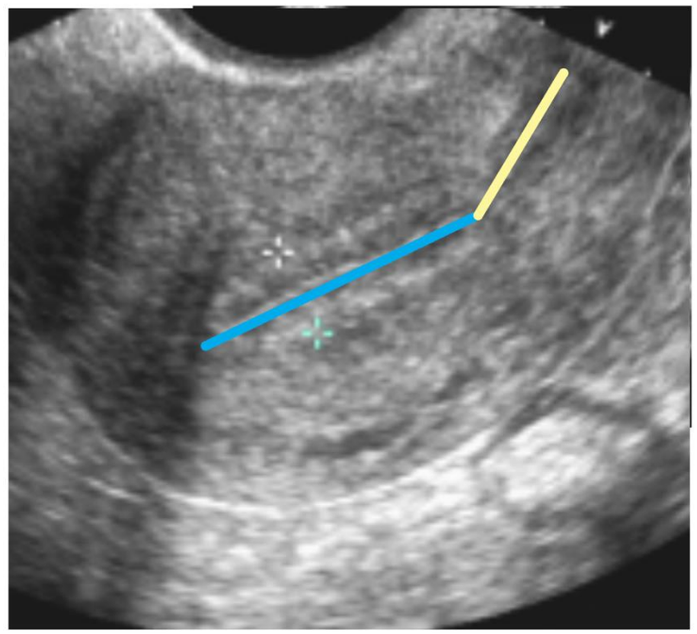
Anteflexed



Retroflexed



Retroverted

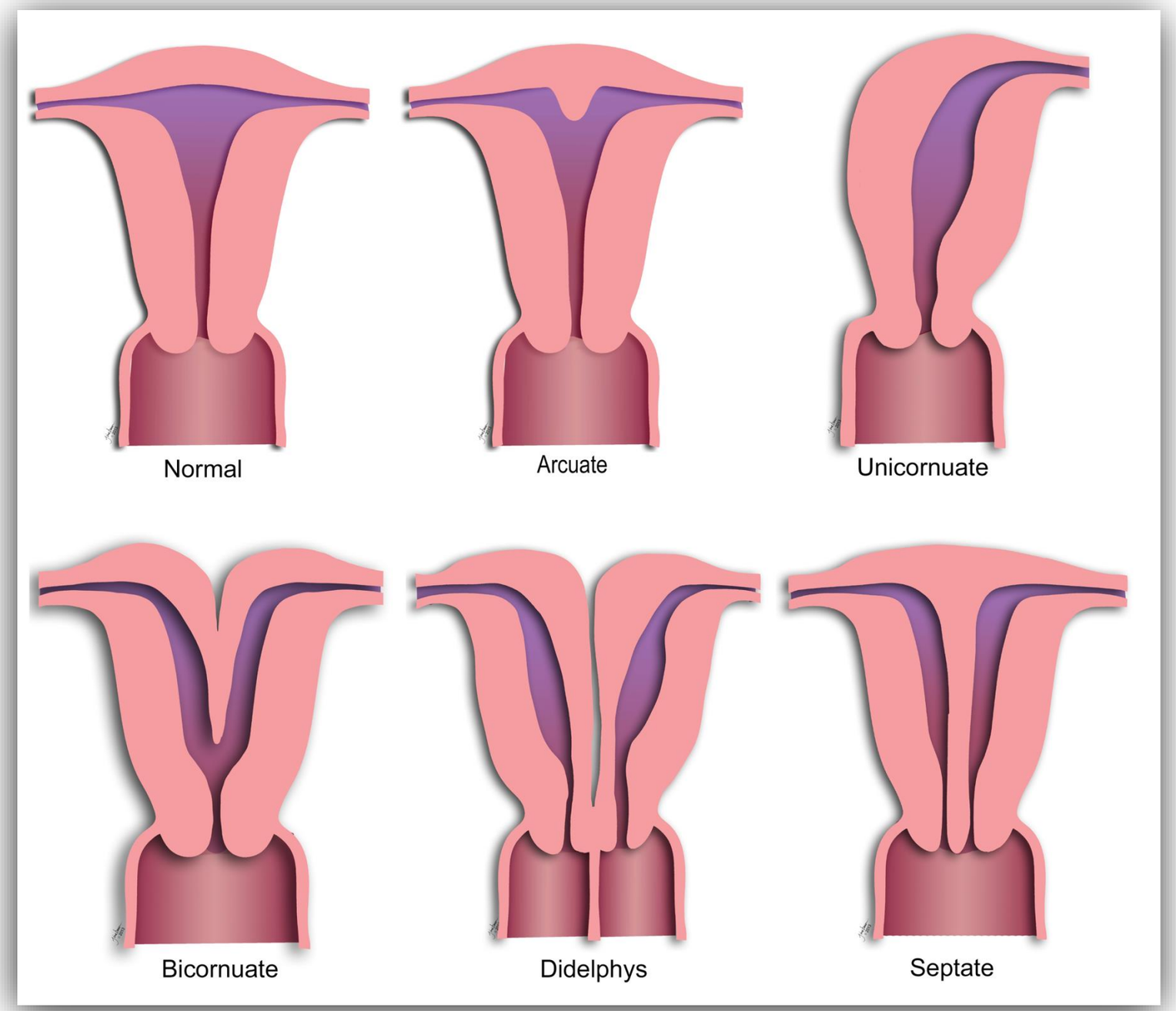


Retroverted/Retroflexed

Anatomic Variants – Müllerian Duct

- Spectrum of anatomic abnormalities resulting from failure of fusion of paired embryonic Müllerian ducts
- Uterine structural variants include:
  - Uterine agenesis
  - Arcuate uterus
  - Unicornuate uterus (*uterus unicornis*)
  - Bicornuate uterus (*uterus bicornis*)
  - Didelphic uterus (*uterus didelphys*)
  - Septate uterus (*uterus subseptus*)

ANATOMIC VARIANTS – MÜLLERIAN DUCT



Arcuate Uterus

- Indentation of myometrium into uterine fundus
- Sonographic findings:
  - Normal uterine contour
  - Indentation of myometrium into uterine cavity
  - No division of uterine horns

ANATOMIC VARIANTS – MÜLLERIAN DUCT

Arrow = indentation in fundus

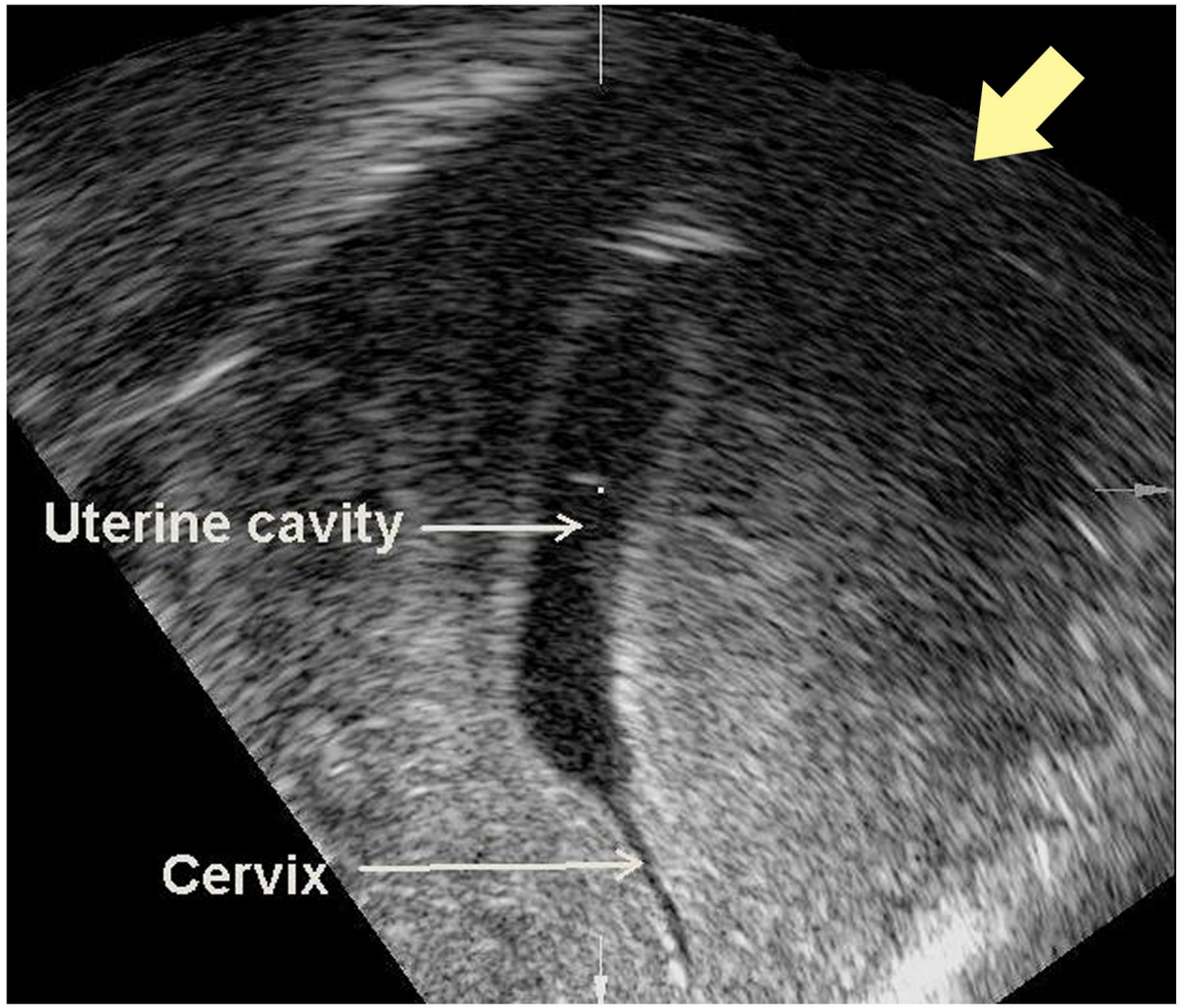
Arcuate uterus

Unicornuate Uterus

- Presence of a single uterine horn that may or may not communicate with cervix
- Sonographic findings:
  - Lateral displacement of uterine fundus
  - Asymmetric appearance
  - Loss of pear shape

ANATOMIC VARIANTS – MÜLLERIAN DUCT

Arrow = lateral deviation of fundus



Unicornuate uterus

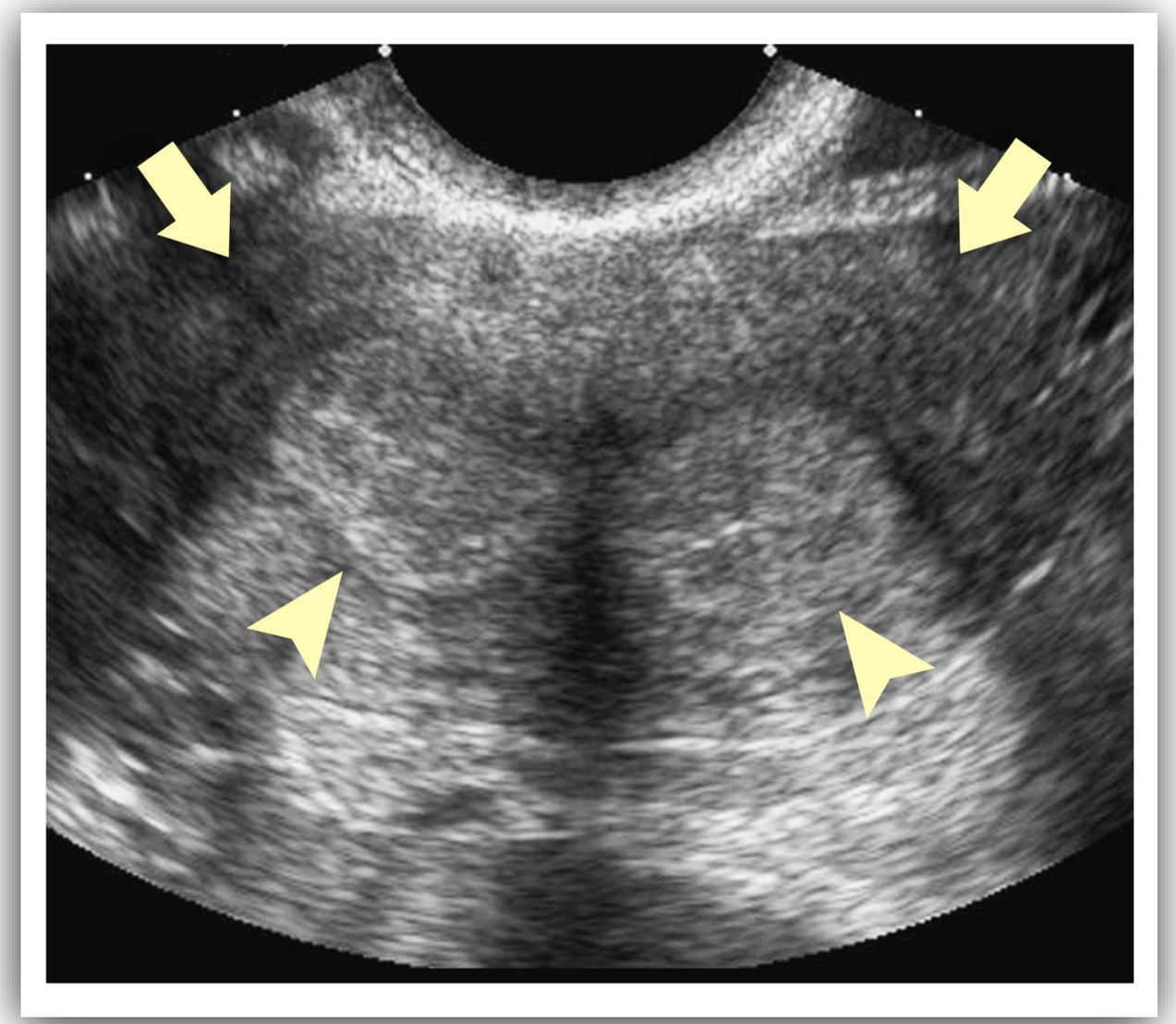
Bicornuate Uterus

- Two separate uterine horns contained within single uterine body
- Sonographic findings:
  - Widely divergent uterine horns
  - Caudally fused uterine cavities that communicate
  - Single, heart-shaped external uterine contour
  - Single cervix

ANATOMIC VARIANTS – MÜLLERIAN DUCT

Arrows = divergent uterine horns

Arrowhead = separate uterine cavities



Bicornuate uterus

Didelphic Uterus

- Presence of two separate uterine bodies and cervices
- Vaginal septum usually present
- Sonographic findings:
  - Separate divergent uterine horns
  - Separate uterine cavities that do not communicate
  - Two separate cervices

ANATOMIC VARIANTS – MÜLLERIAN DUCT

Arrows = two separated uterine horns

Didelphic uterus

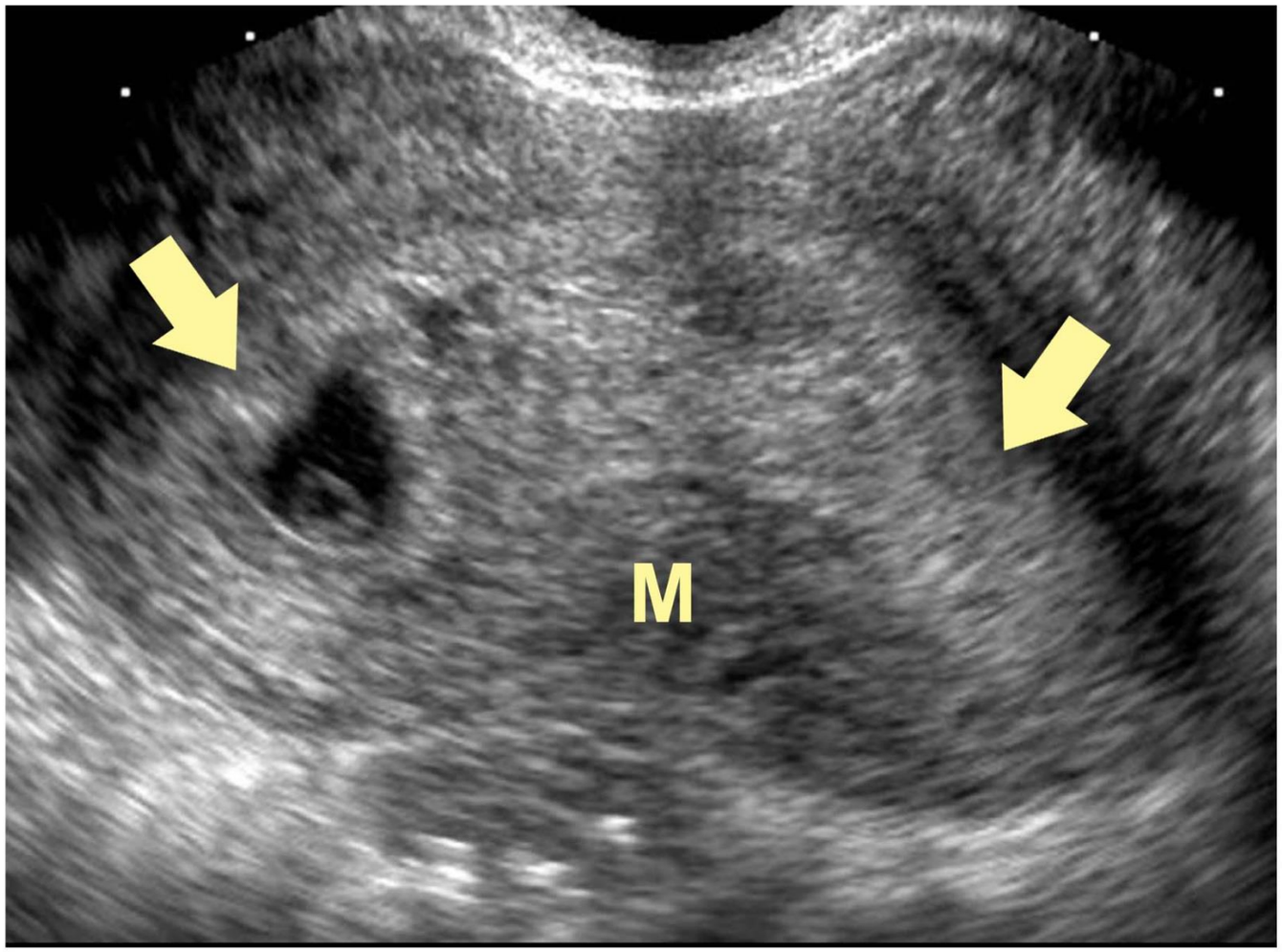
Septate Uterus

- Presence of two distinct uterine cavities separated by a septum
- Sonographic findings:
  - Endometrial cavities separated at fundus by myometrium
  - Widened fundus
  - Convex, flat, or mildly concave external uterine contour

ANATOMIC VARIANTS – MÜLLERIAN DUCT

Arrows = separate uterine cavities

M = myometrium



Septate uterus

Pelvic Physiology

The Menstrual Cycle

- Menstruation is the bleeding and shedding of the uterine lining that occurs at ≈ monthly intervals from menarche to menopause
  - *Menarche*: the onset of menses, usually between 11 – 14 years of age
  - *Menopause*: the termination of regular menses between 45 – 55 years of age
  - *Premature menopause*: termination of regular menses prior to 40 years of age

Hormonal Regulation

- A feedback mechanism exists between the ovaries and hypothalamus/pituitary complex

↓ estradiol levels (ovary) = ↑ FSH & LH (pituitary)

↑ FSH (pituitary) = ↑ estrogens (ovary)

↑ LH (pituitary) = ↑ progesterone (corpus luteum)

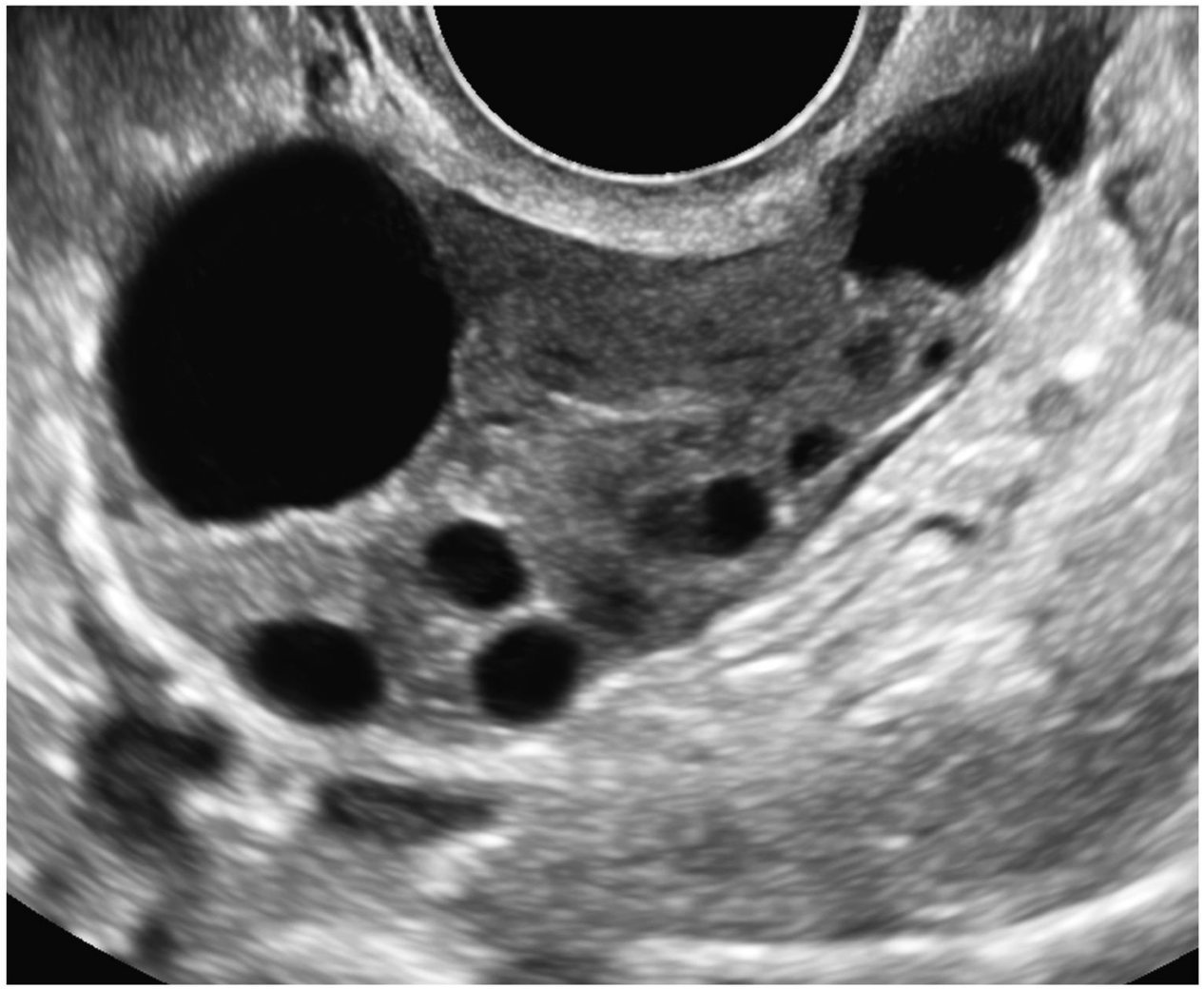
Ovarian Response

- The ovaries go through 3 phases in response to pituitary hormones:
  - *Follicular phase*: (days 1 – 14) growth of dominant follicle to between 14 – 30 mm
  - *Ovulatory phase*: (day 14) release of ovum from dominant follicle
  - *Luteal phase*: (days 15 – 28) involuted follicle persists and produces progesterone

Follicular Phase (Days 1 – 14)

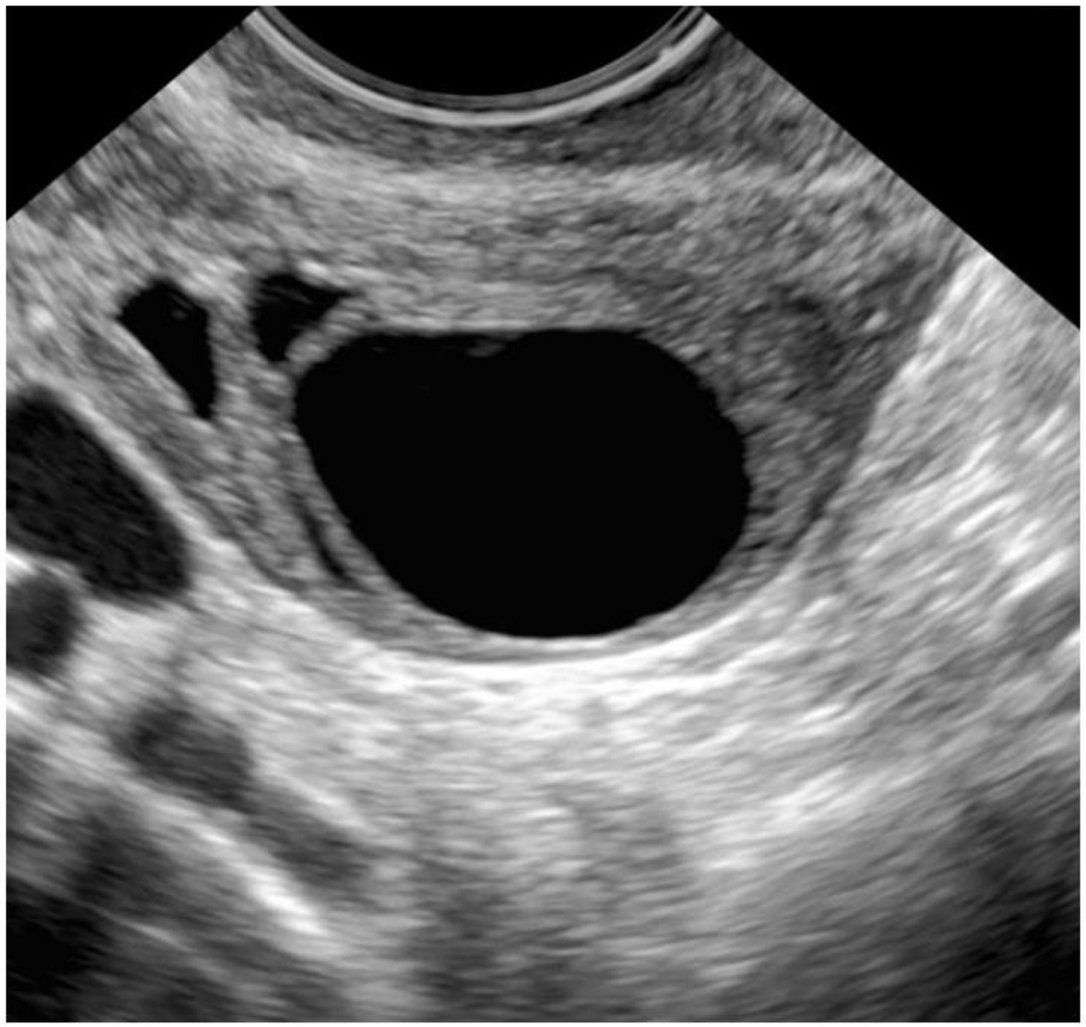
- Multiple follicles develop in both ovaries
- Primary follicle matures into dominant (*Graffian follicle*)
  - Any follicle > 11 mm will likely ovulate
  - Grows ≈ 2 - 3 mm/day
  - Line of decreased echogenicity around follicle = ovulation within 24 hours
  - Presence of *cumulus oophorus* = ovulation within 36 hours

OVARIAN RESPONSE – FOLLICULAR PHASE



Multiple follicles developing within ovary

OVARIAN RESPONSE – FOLLICULAR PHASE



Line of decreased echogenicity around follicle

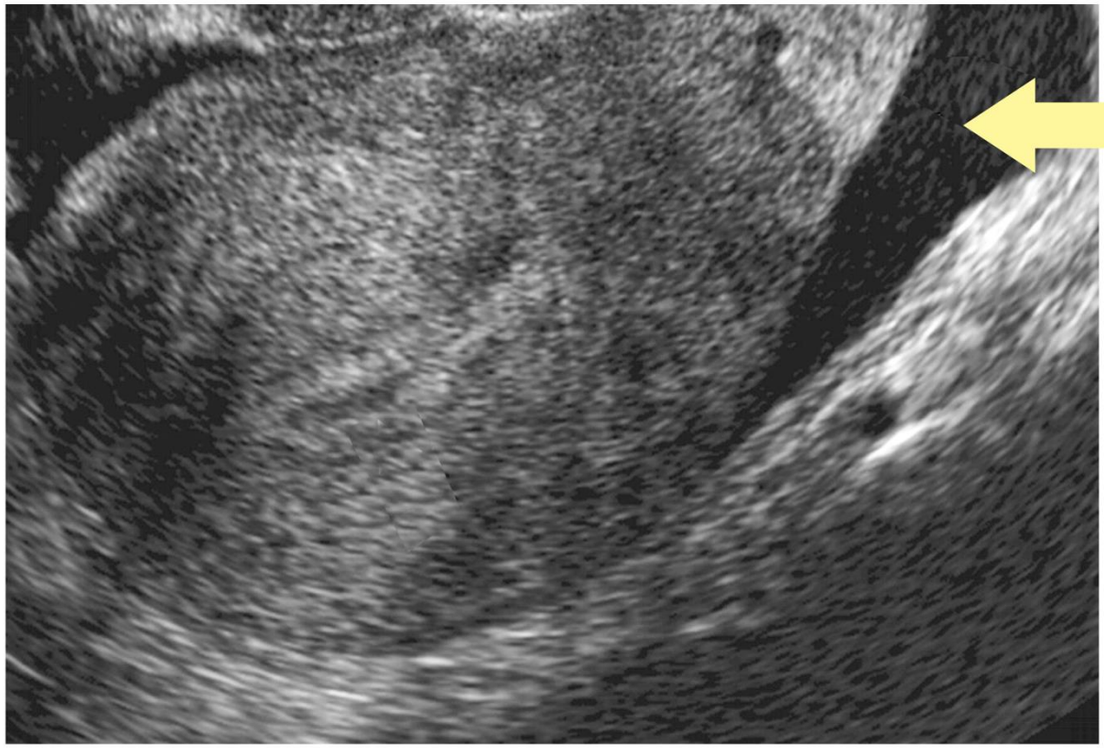
OVARIAN RESPONSE – FOLLICULAR PHASE

Graffian follicle present

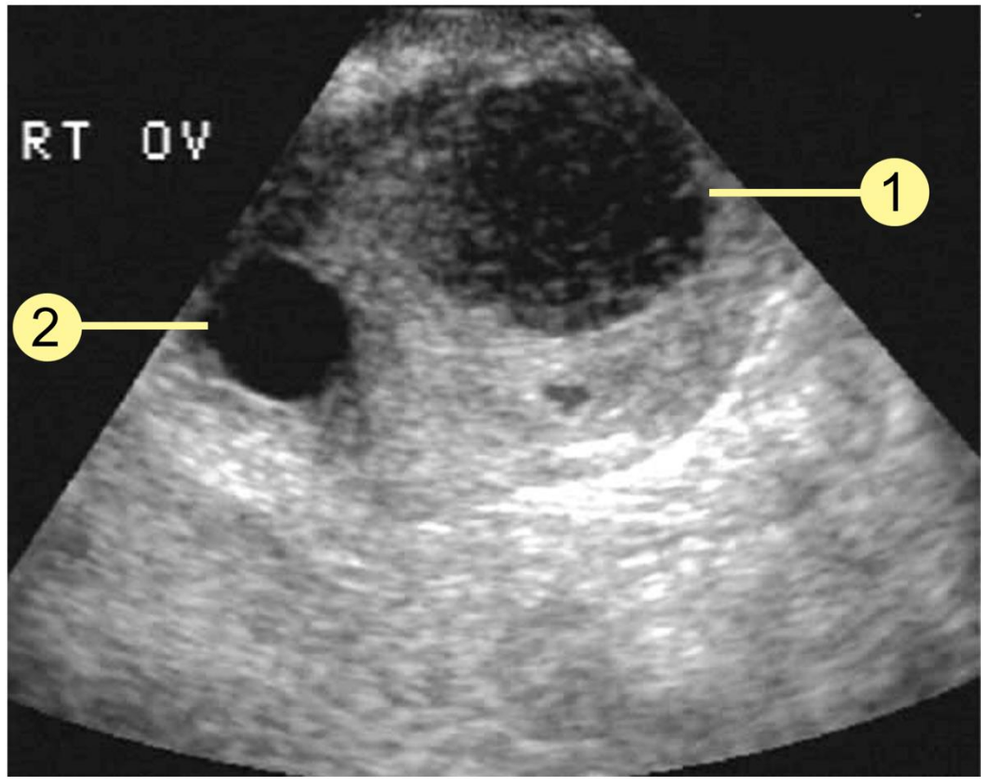
Ovulatory Phase (Day 14)

- Extrusion of ovum from dominant follicle
- Sonographic signs of ovulation include:
  - Sudden decrease in follicular size
  - Fluid in posterior cul-de-sac
  - Hemorrhage into dominant follicle

OVARIAN RESPONSE – OVULATORY PHASE



Fluid in cul de sac - *arrow*



1 = hemorrhage into dominant follicle
2 = non-dominant follicle

Sonographic signs of ovulation

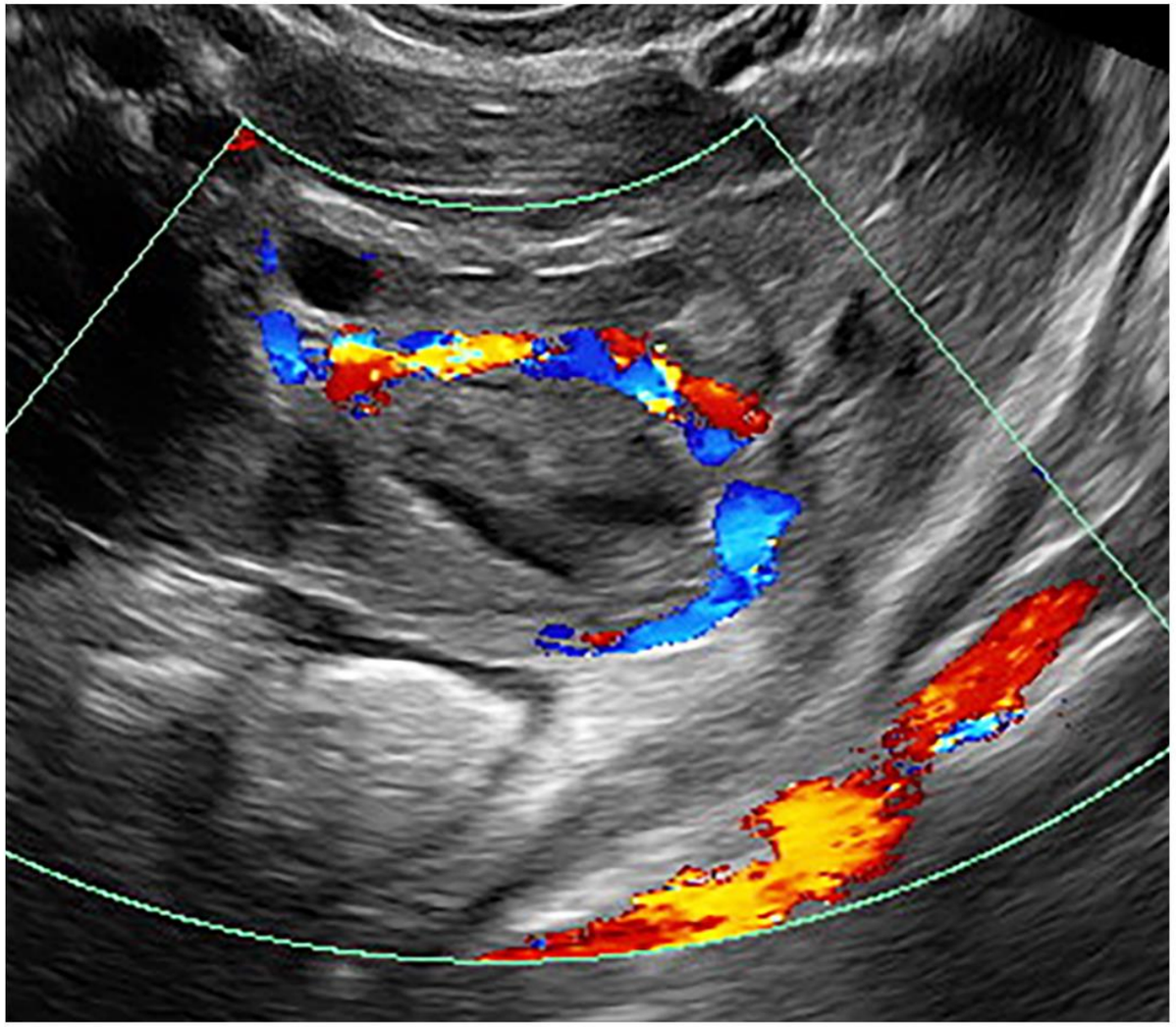
Luteal Phase (Days 15 - 28)

- Dominant follicle involutes into *corpus luteum* (yellow body)
- Produces progesterone which maintains secretory endometrium
- Sonographic signs of luteal phase include:
  - Replacement of dominant follicle with echogenic structure
  - Thrombus seen within antral lumen
  - Characteristic “ring of fire” peripheral vascularity

OVARIAN RESPONSE – LUTEAL PHASE

Thrombus seen in antral lumen

OVARIAN RESPONSE – LUTEAL PHASE



Corpus luteum “ring of fire”

Uterine Response

- Endometrial lining of the uterus changes in response to the hormones secreted by the ovaries
  - *Menstrual phase*: (days 1 – 5) sloughing of the degenerated endometrium
  - *Proliferative phase*: (days 6 – 14) regrowth of the endometrium in response to estrogen
  - *Secretory phase*: (days 15 – 28) continued growth of the endometrium measuring in preparation for implantation

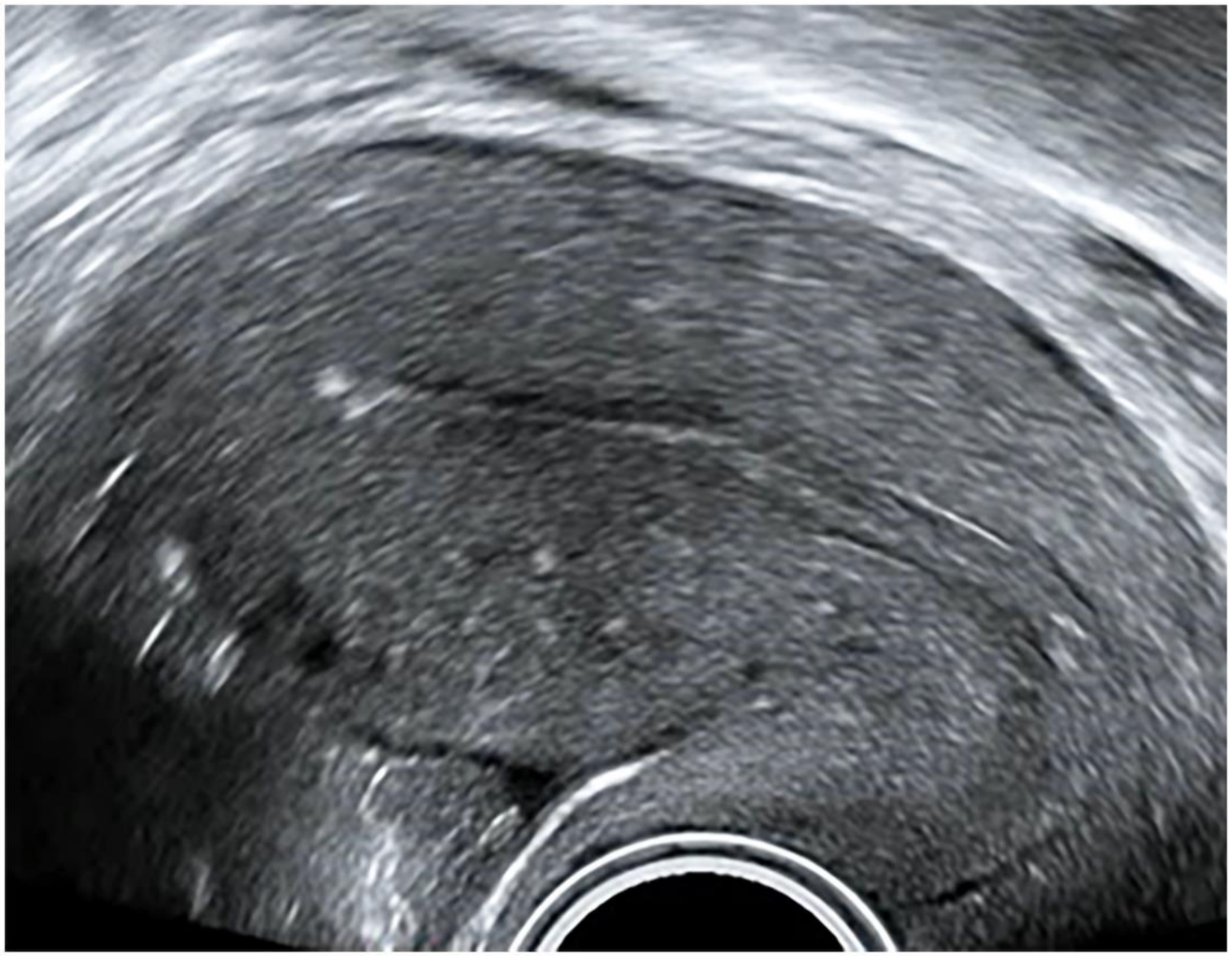
Menstrual Phase (Days 1 – 5)

- Ischemic endometrium degenerates and sloughs off
- Sonographic findings include:
  - Thickened, echogenic endometrium prior to start of menses
  - Complex appearance at beginning of menses
  - Thin, slightly irregular appearance after shedding
  - Max AP diameter (post menses) = 2 mm

UTERINE RESPONSE – MENSTRUAL PHASE

Complex appearance at beginning of menses

UTERINE RESPONSE – LATE MENSTRUAL PHASE



Thin endometrium after shedding

Proliferative Phase (Days 6 – 14)

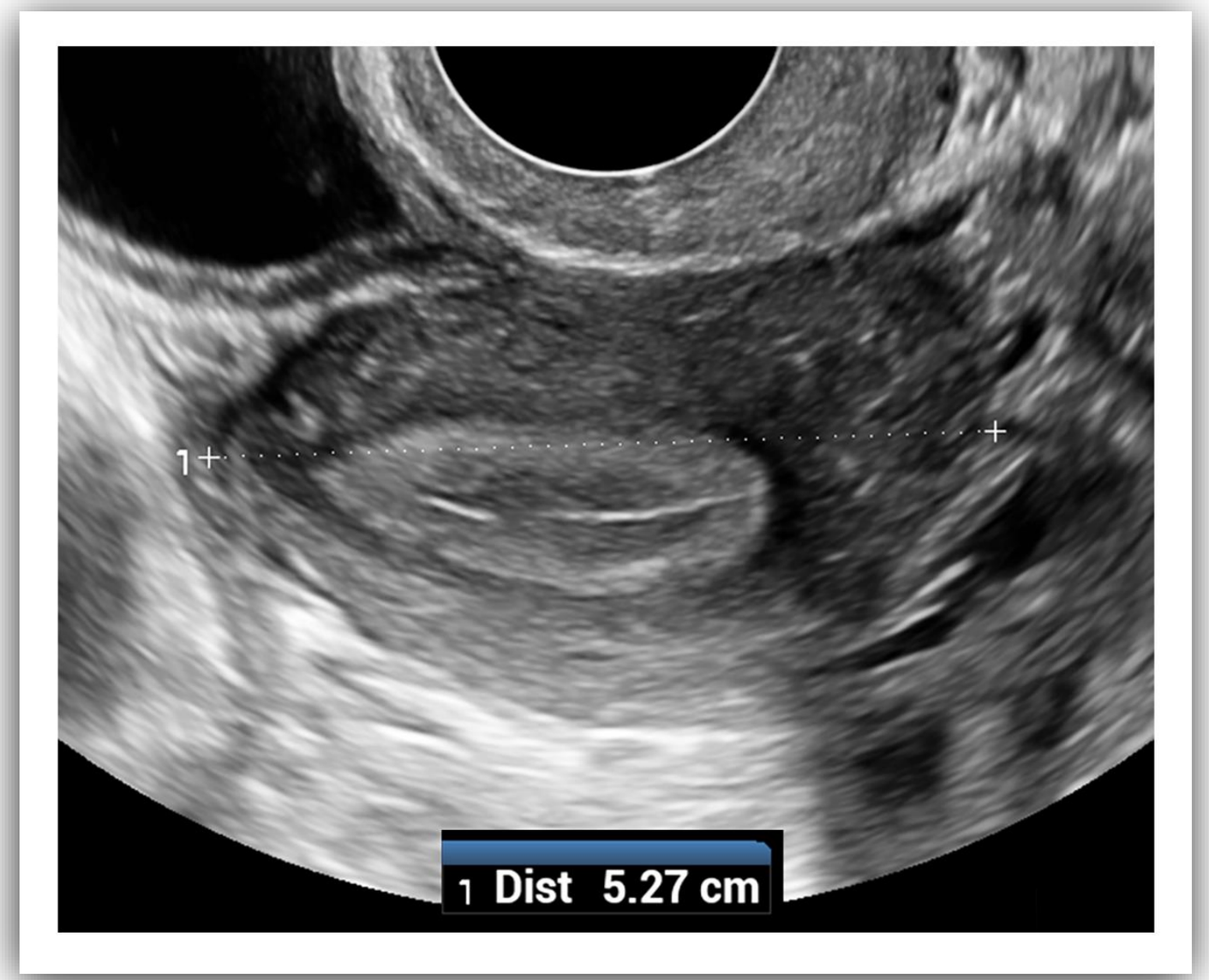
- Regrowth of the endometrium in response to increasing estrogen levels

- Sonographic findings include:
  - *Early secretory*: hyperechoic endometrium with faint central echo (5 – 7 mm)
  - *Late secretory (periovulatory):* thickened, isoechoic endometrium with multilayered pattern (up to 11 mm)

UTERINE RESPONSE – EARLY PROLIFERATIVE PHASE

Hyperechoic endometrium with faint central echo

UTERINE RESPONSE – LATE PROLIFERATIVE PHASE



Multilayered pattern

Secretory Phase (Days 15 – 28)

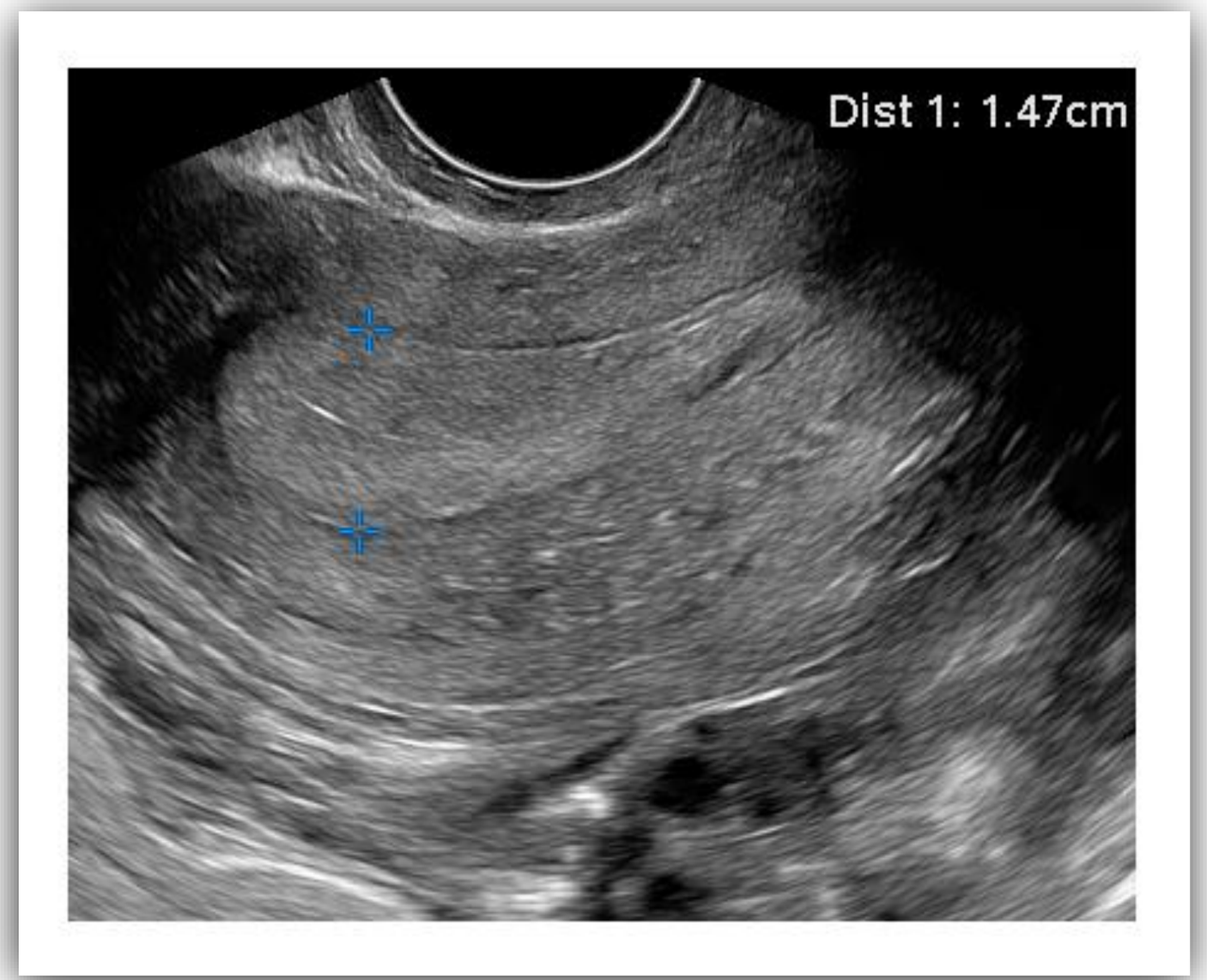
- Continued growth and maturation of endometrium in preparation for implantation

- Sonographic findings include:
  - Possible fluid collection (*mid-cycle*)
  - Increased AP diameter (7 – 16 mm)
  - Increased and more homogeneous echogenicity

UTERINE RESPONSE – SECRETORY PHASE

Fluid collection (mid-cycle)

UTERINE RESPONSE – SECRETORY PHASE



Homogeneous echogenicity

UTERINE RESPONSE – ENDOMETRIAL THICKNESS

Endometrial Thickness		
Uterine Response		**Endometrial thickness**
Menstrual (after menses stops)	**Histologic**	1 mm each side
	Sonographic	2 mm total AP
Proliferative (Days 6 – 14)	**Histologic**	2 -4 mm each side
	Sonographic	6 – 8 mm total AP
Secretory (Days 15 – 28)	**Histologic**	5 – 6 mm each side
	Sonographic	10 – 12 mm total AP

Abnormal Menstrual Patterns

- Abnormal bleeding patterns are categorized by *VOLUME* and *FREQUENCY*
  - *Hypermenorrhea (menorrhagia):* excessive volume
  - *Hypomenorrhea:* diminished volume
  - *Polymenorrhea*: bleeding occurring < 21 days apart
  - *Oligomenorrhea:* bleeding occurring > 35 days apart
  - *Menometrorrhagia*: bleeding irregularity in both frequency and volume
  - *Amenorrhea*: absence of menstrual flow

Dysfunctional Uterine Bleeding (DUB)

- Broadly defined as vaginal bleeding not related to estrus or endometrial pathology

- Many causes including:
  - Polycystic ovarian syndrome
  - Sexually transmitted diseases
  - Medications (OCPs, blood thinners, etc.)

OB GYN SONOGRAPHY REVIEW

Pelvic Anatomy & Physiology