OB GYN SONOGRAPHY REVIEW

The First Trimester

Course Outline

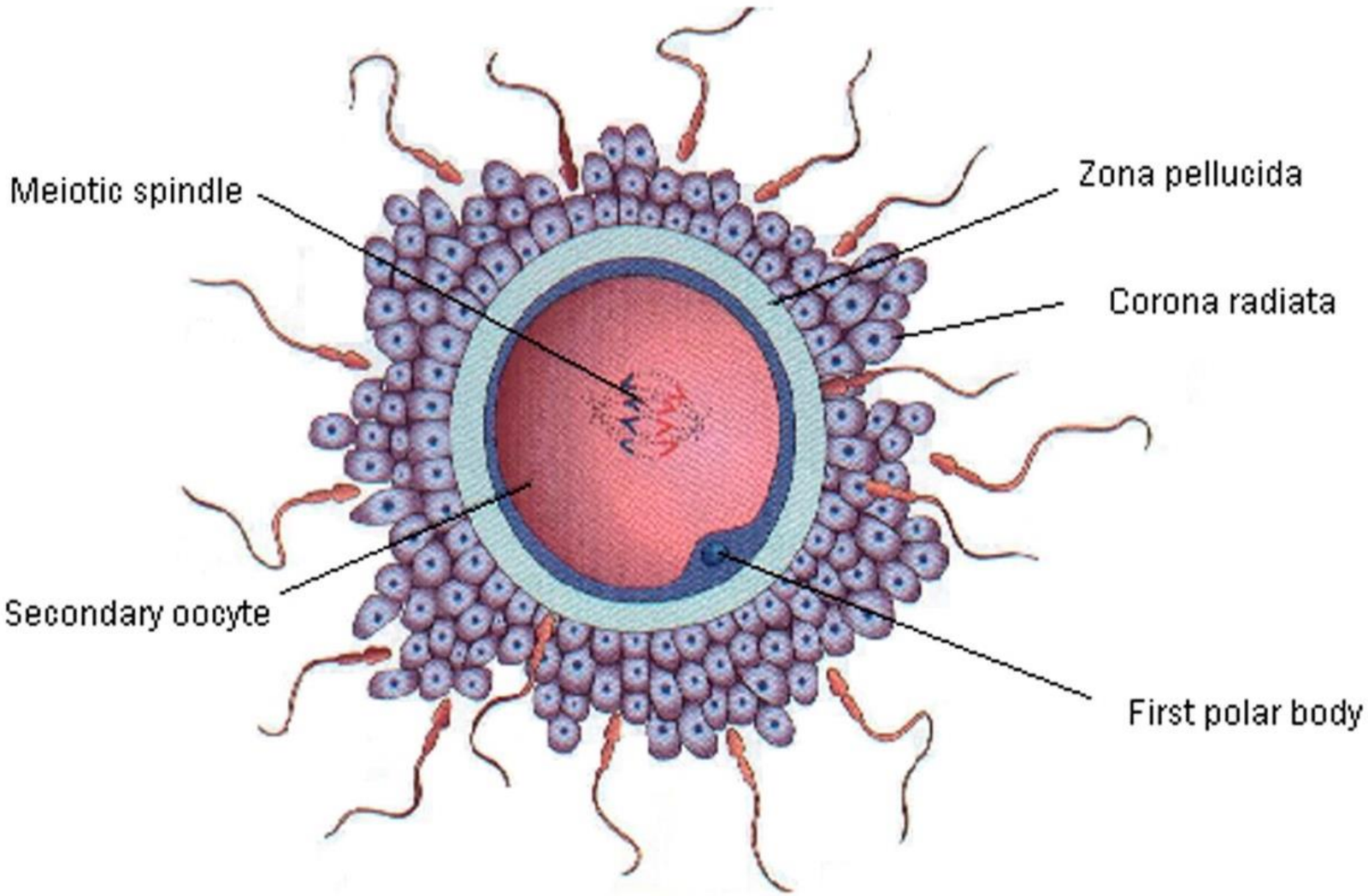
- Biology of reproduction
  - Fertilization
  - Implantation
  - Placentation
- Normal 1st trimester
  - Normal sonographic findings
  - Biometric measurements
- Abnormal 1st trimester
  - Ectopic pregnancy
  - Early pregnancy failure
  - Gestational trophoblastic disease

Biology of Reproduction

Fertilization

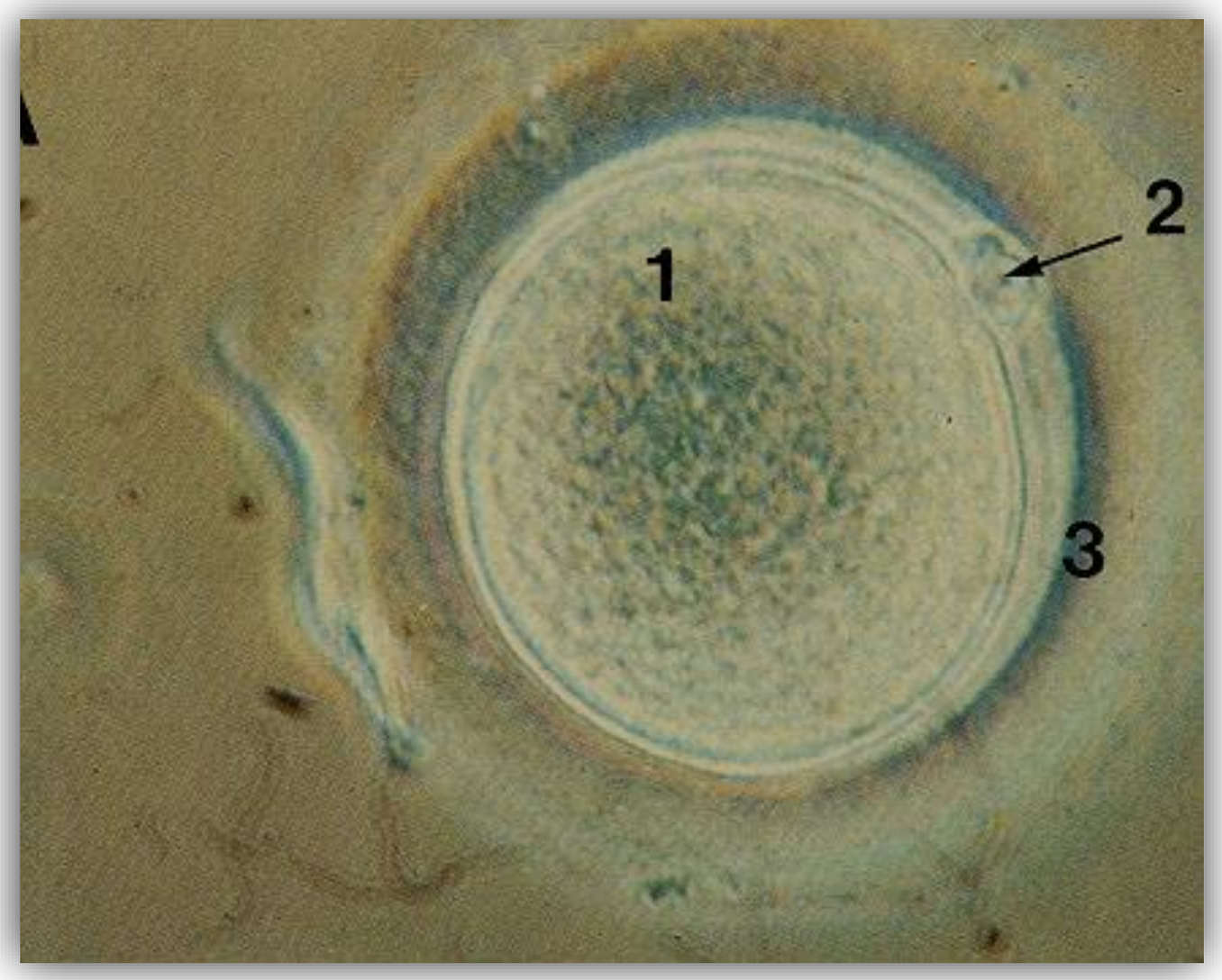
- An ovum and sperm fuse to form a single-cell zygote (*days 15-16*)
- Pre-embryonic stages are:
  - Morula - ball of cells
  - Blastocyst - inner cell mass, cystic cavity and outer trophoblastic cells
  - Trophoblast - cytotrophoblast (inner) and syncytiotrophoblast cells produce hCG

FERTILIZATION



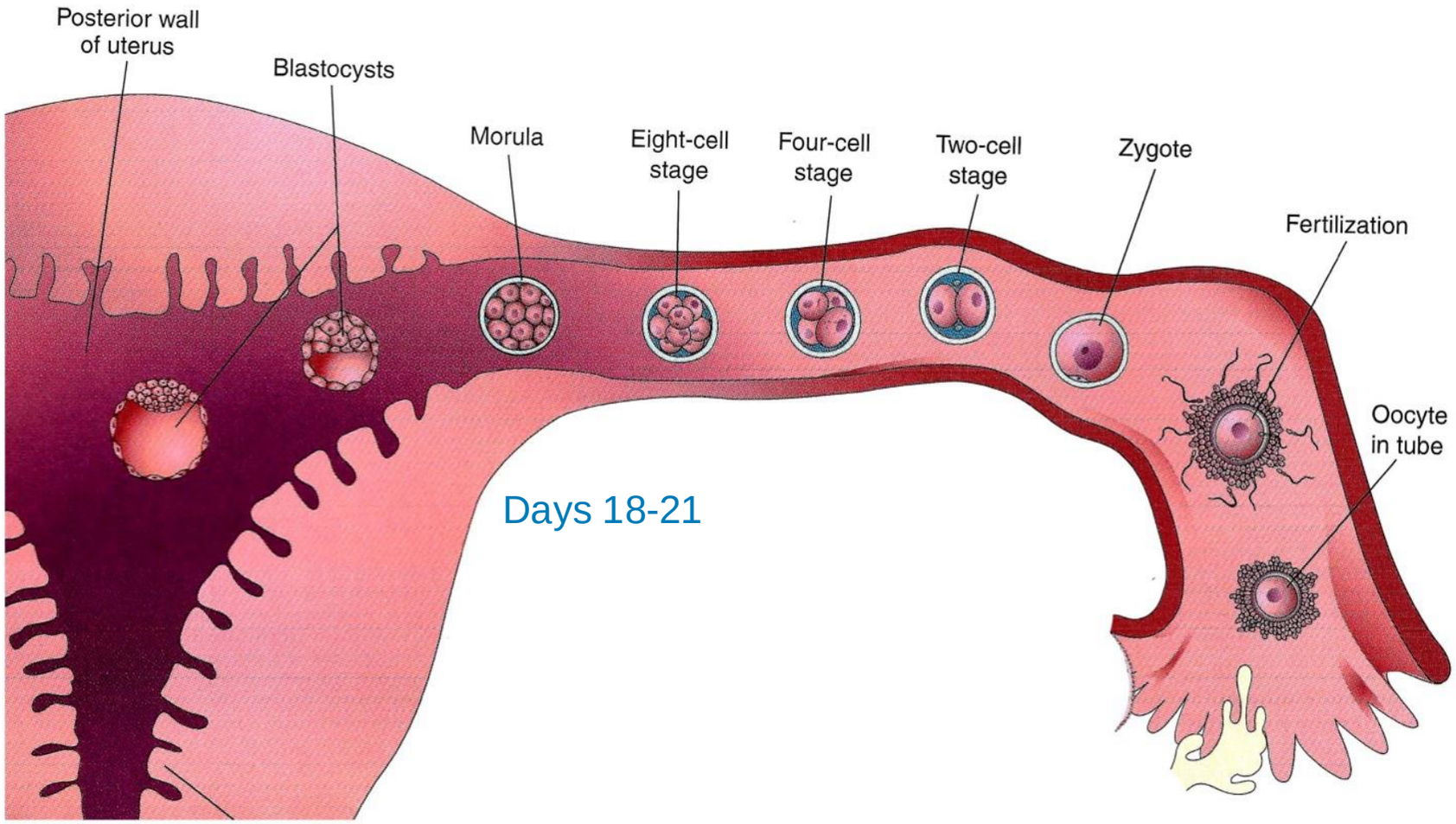
from: Moore & Persaud: The Developing Human: Clinically Orietned Embryology. 6th ed. p.36.

FERTILIZATION



1 = secondary oocyte
2 = first polar body
3 = zona pellucida

FERTILIZATION



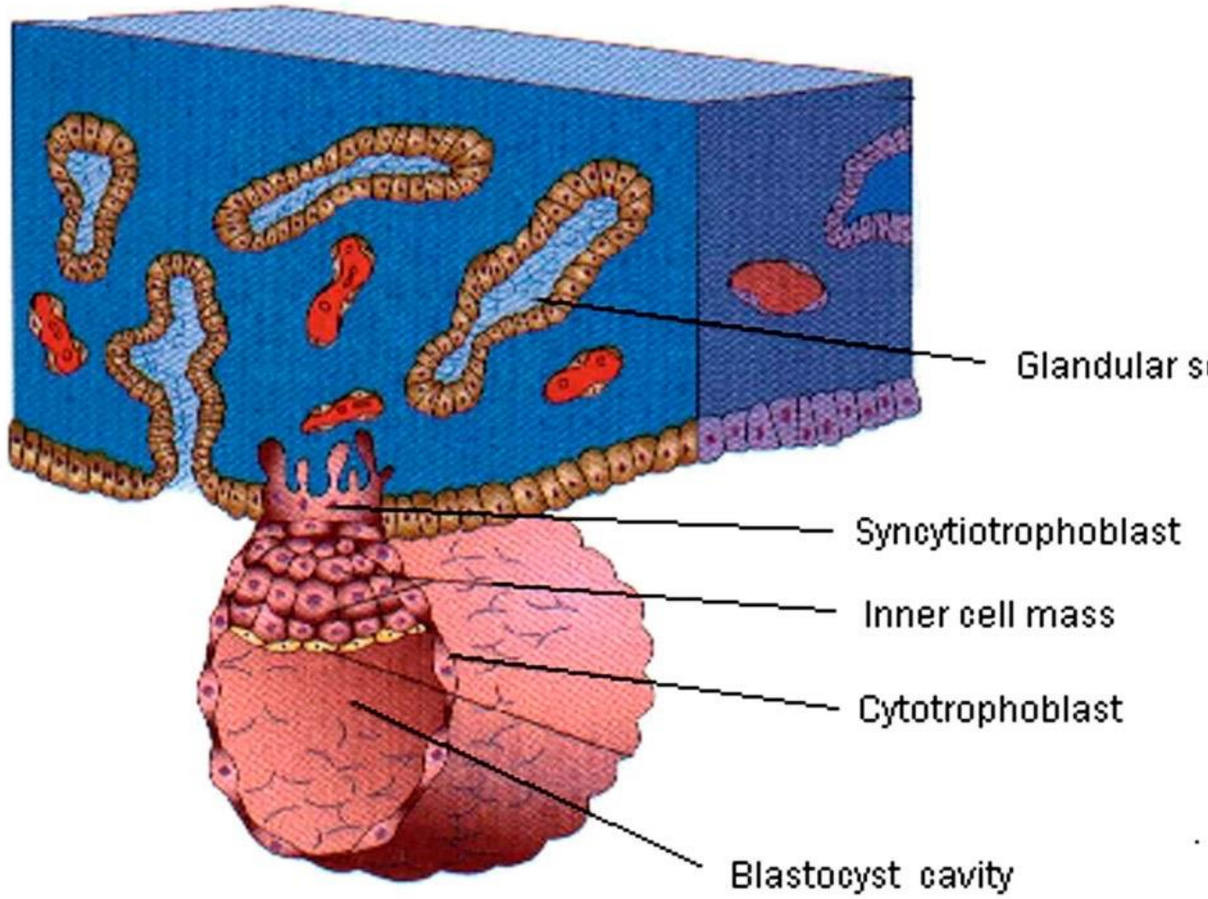
from: Moore & Persaud: The Developing Human: Clinically Orietned Embryology. 6th ed. p.44.

Days 14 - 18

Implantation

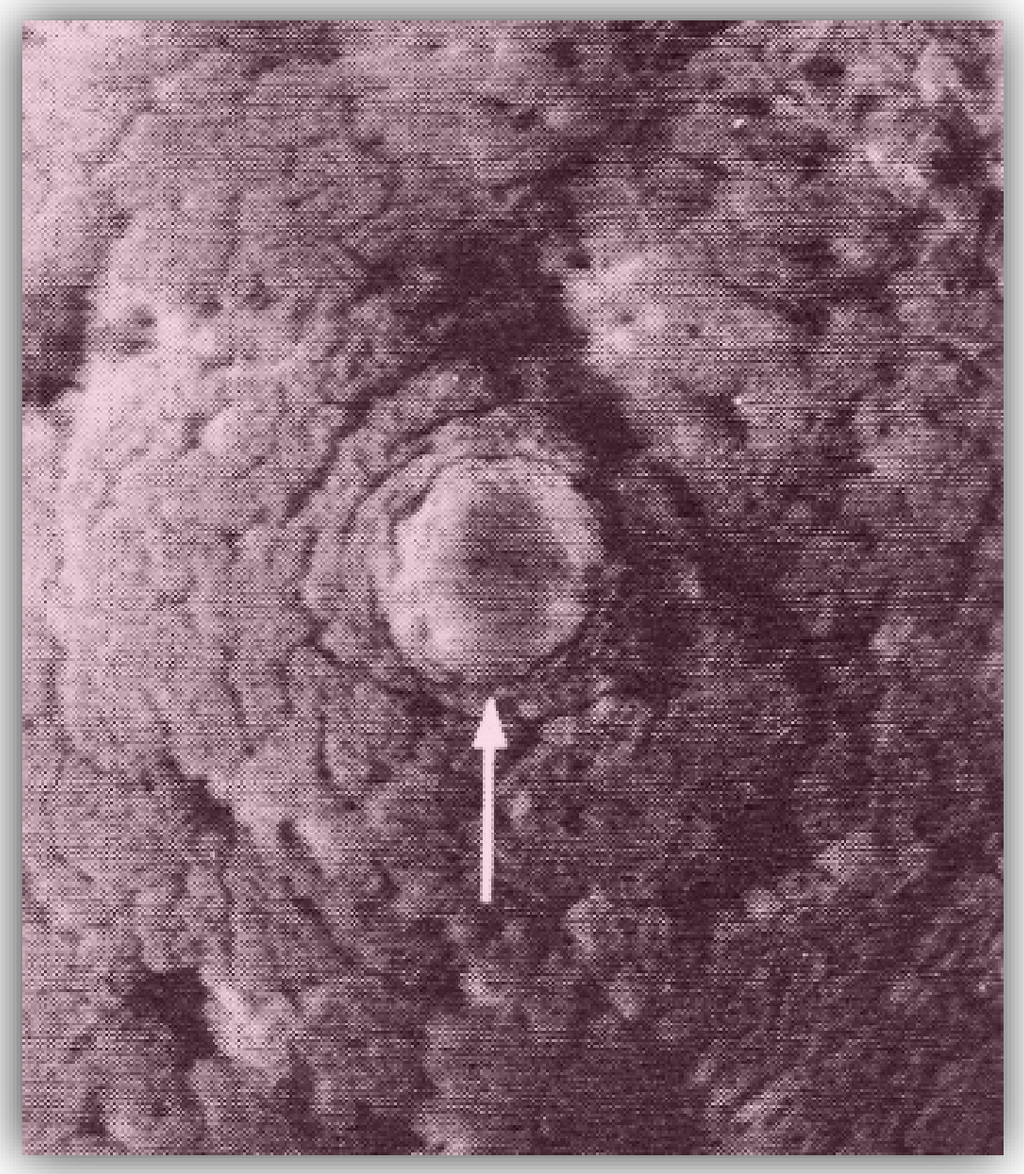
- Blastocyst implants in highly vascularized endometrium (*days 21-22*)
- Human chorionic gonadotropin (hCG) is secreted and seeps into maternal serum and urine
- Hemodynamic changes occur in decidua to support rapidly growing and metabolically active conceptus

IMPLANTATION



from: Moore & Persaud: The Developing Human: Clinically Oriented Embryology. 6th ed. p.43.

IMPLANTATION



Small hematoma over implantation site

Serum beta hCG Levels

- Human chorionic gonadotropin (hCG) is produced by the trophoblastic cells and is the basis of most current pregnancy tests
  - First detected 3 weeks after LMP
  - Doubles approximately every 48 hours
  - Plateaus at 8 – 9 weeks then declines

Two methods of testing

- Qualitative (+) *or* (-)
  - 25M mIU/ml threshold
- Quantitative (*numeric value*)
  - Detectable 6-8 days post conception
  - 1 mIU/ml threshold
  - Measured by three different radioimmunoassay methods
  - Useful for serial monitoring of serum levels

Quantitative hCG Methods

- First International Reference Preparation (IRP)
- Second International Standard (2IS)
- Third International Standard (3IS) *least common*

☑ **2IS = 2 x IRP**

Discriminatory Levels

- Serum levels at which an IUP will *ALWAYS* be seen if it is present in the uterine cavity
- Quantitative method only
- If discriminatory levels are present and an IUP is not identified sonographically, must suspect ectopic pregnancy

Discriminatory levels

US Method	*1st IRP (mIU/ml)*	*2IS (mIU/ml)*
Endovaginal	***1,000 – 2,000***	***500 – 1,000***
Transabdominal	***3,600***	***1,800***

Abnormal Levels

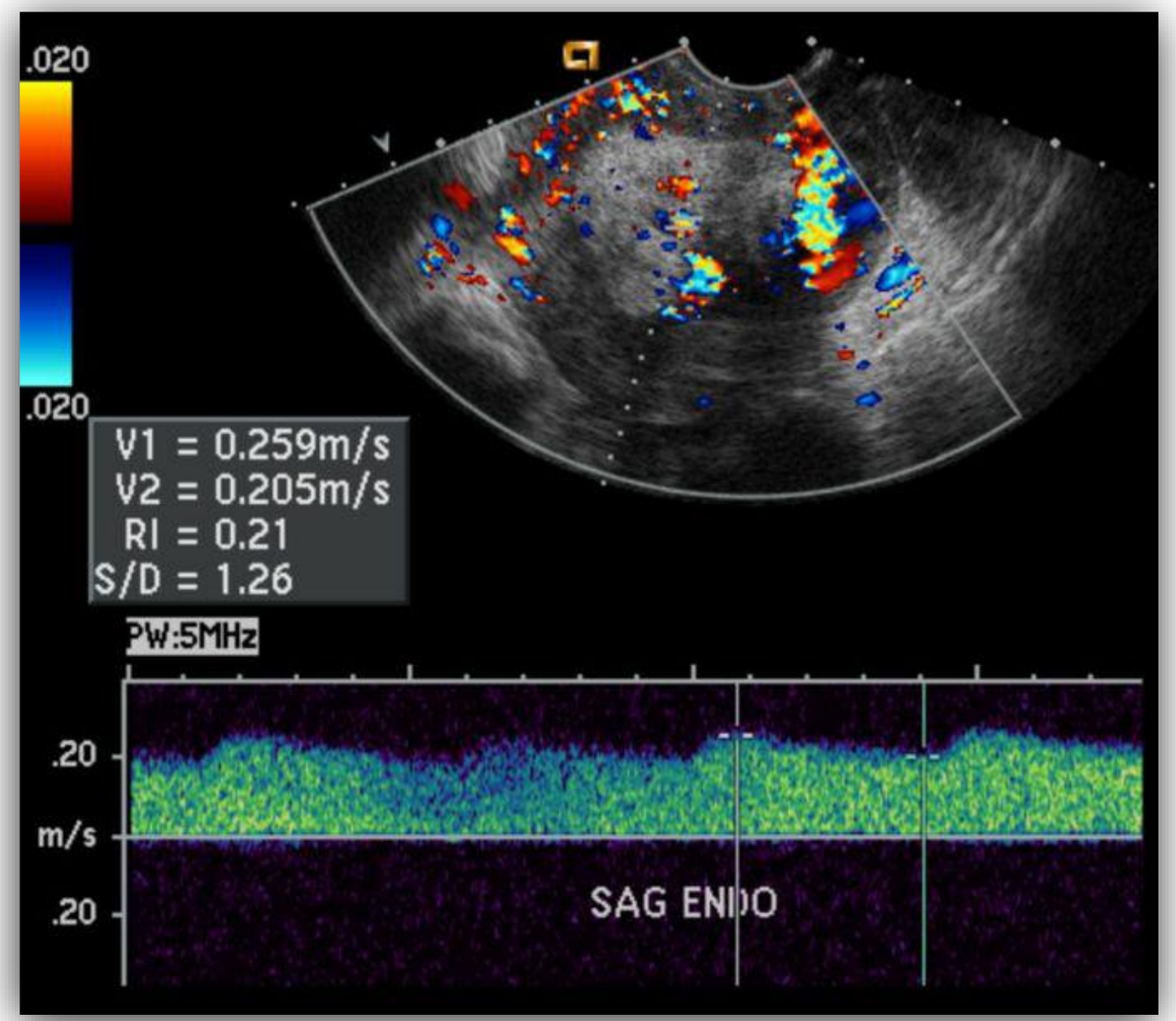
- Greater than expected for dates:
  - Incorrect dates (*farther along than expected*)
  - Gestational trophoblastic disease
  - Multiple gestations
- Less than expected for dates:
  - Incorrect dates (*not as far along as expected*)
  - Ectopic pregnancy (*maybe be normal for dates*)
  - Embryonic demise

Hemodynamic Changes

- Embryonic and trophoblastic tissue is very metabolically active. With Doppler assessment, spectral waveforms are typically high volume, low resistance

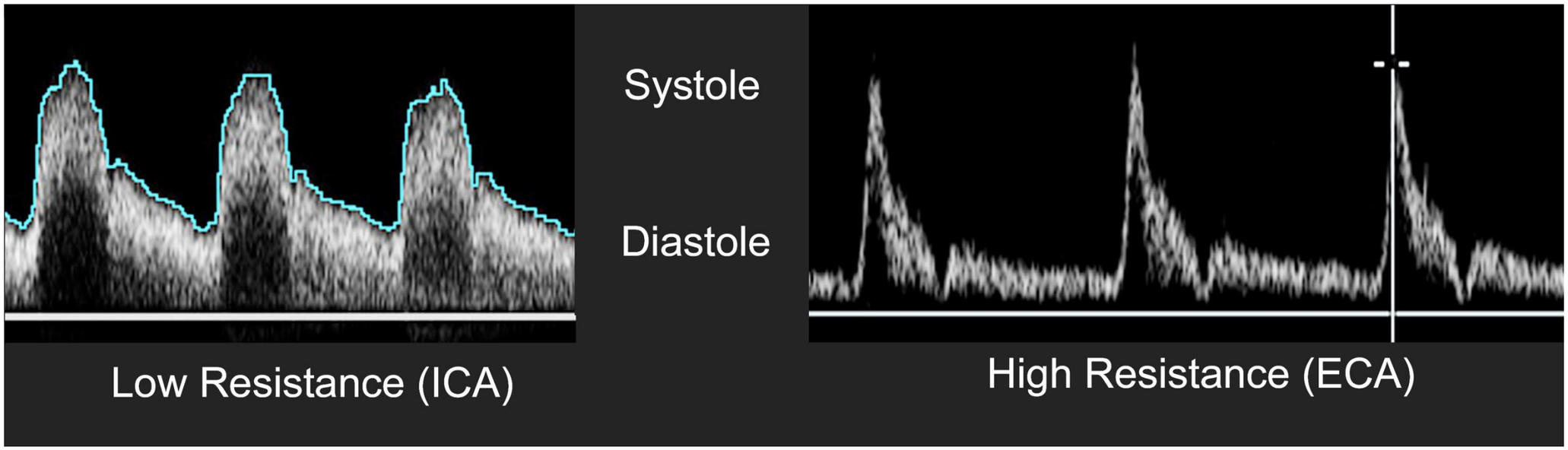
- Hemodynamic principle:
  - The more metabolically active a tissue bed is, the more perfusion it requires
  - Higher perfusion requirements result in:
    - High volume flow
    - Low resistance

HEMODYNAMIC CHANGES



High volume, low resistance waveform

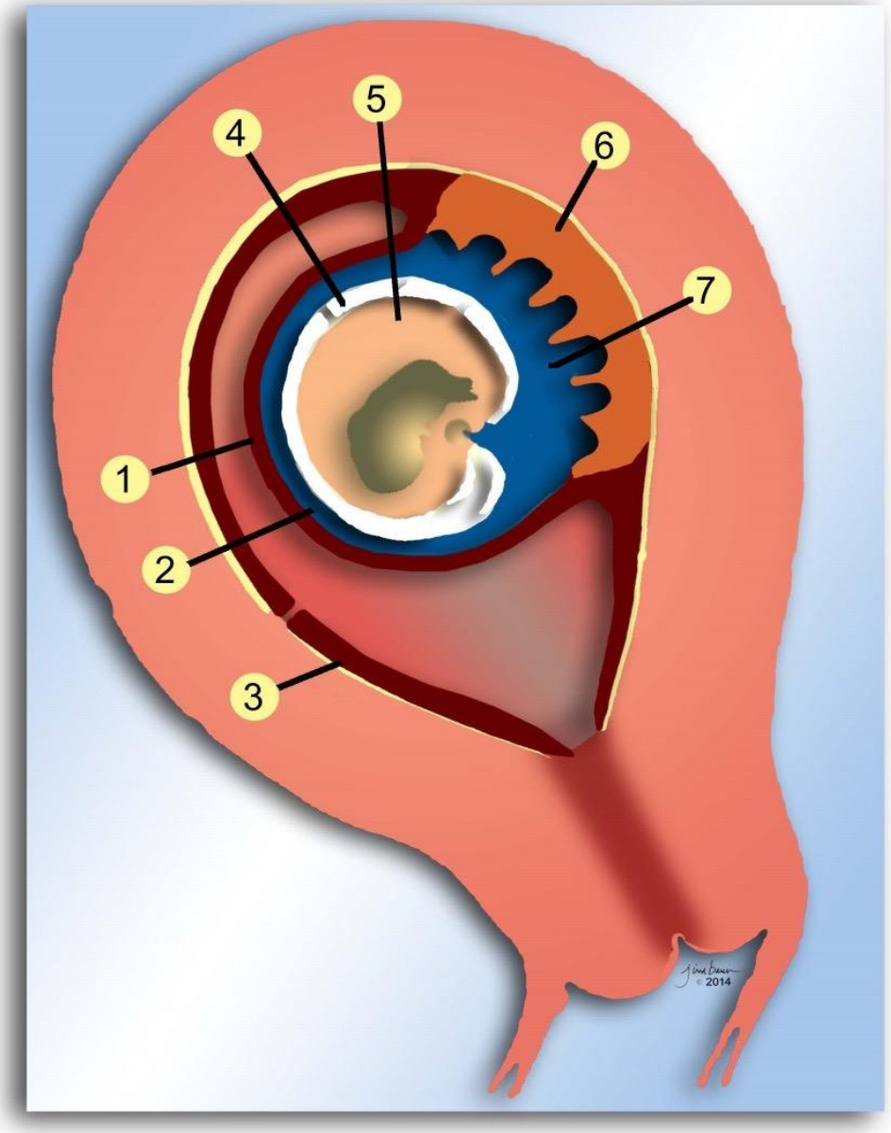
HEMODYNAMIC CHANGES



Placentation

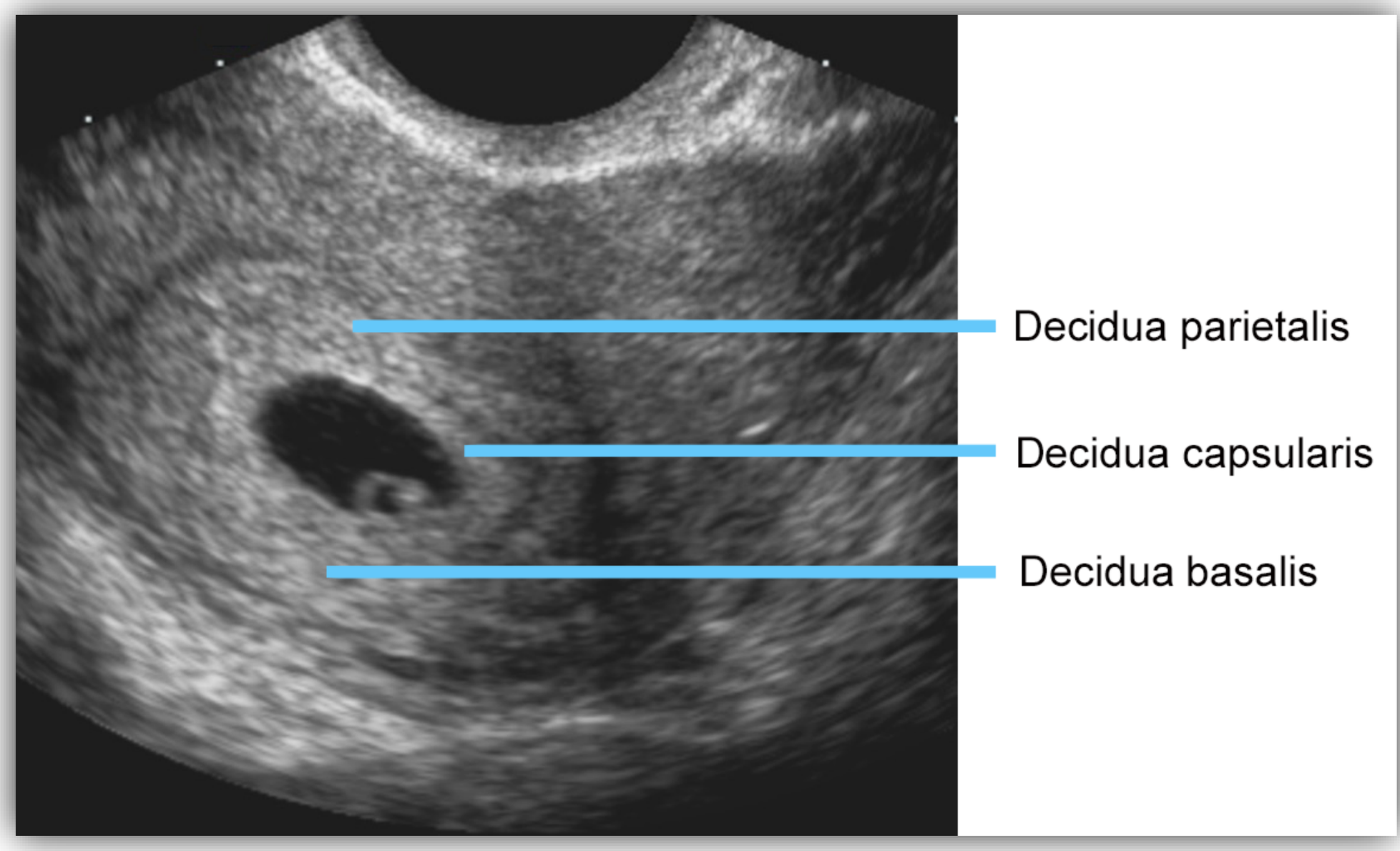
- Blastocyst penetrates endometrium ≈ 7 days post fertilization (≈ *3 weeks post LMP*)
- Small hematoma covers implantation site
- Three layers of endometrial decidua result:
  - Decidua basalis
  - Decidua capsularis
  - Decidua parietalis

PLACENTATION



1 = decidua capsularis
2 = chorion levae
3 = decidua parietalis
4 = chorionic cavity
5 = amniotic cavity
6 = decidua basalis
7 = chorion frondosum

PLACENTATION



Chorio-amniotic Separation

- Amnion and chorion normally fuse by 12 – 16 weeks
- Sonographic identification of separate membranes during the first trimester is a normal finding

PLACENTATION

Chorio-amniotic separation

Normal First Trimester

Normal Gestational Sac

- The first sonographic evidence of an intrauterine pregnancy is the gestation sac
- It is *ALWAYS SEEN* at the following discriminatory hCG levels:
  - Serum hCG ≥ 800 – 1,000 mIU/ml (EV, 2IS)
  - Serum hCG ≥ 1,800 mIU/ml (TA, 2IS)
  - Certain LMP ≥ 5 weeks

NORMAL GESTATIONAL SAC

5 weeks

Normal Sonographic Findings

- Round, oval, well-defined
- Echogenic, intact borders
- Positioned in fundus or mid-uterus
- Yolk sac when MSD ≥ 13 mm
- Double bleb sign (*5.5 weeks*)
- Double decidual sac sign (*5.5 – 6 weeks*)

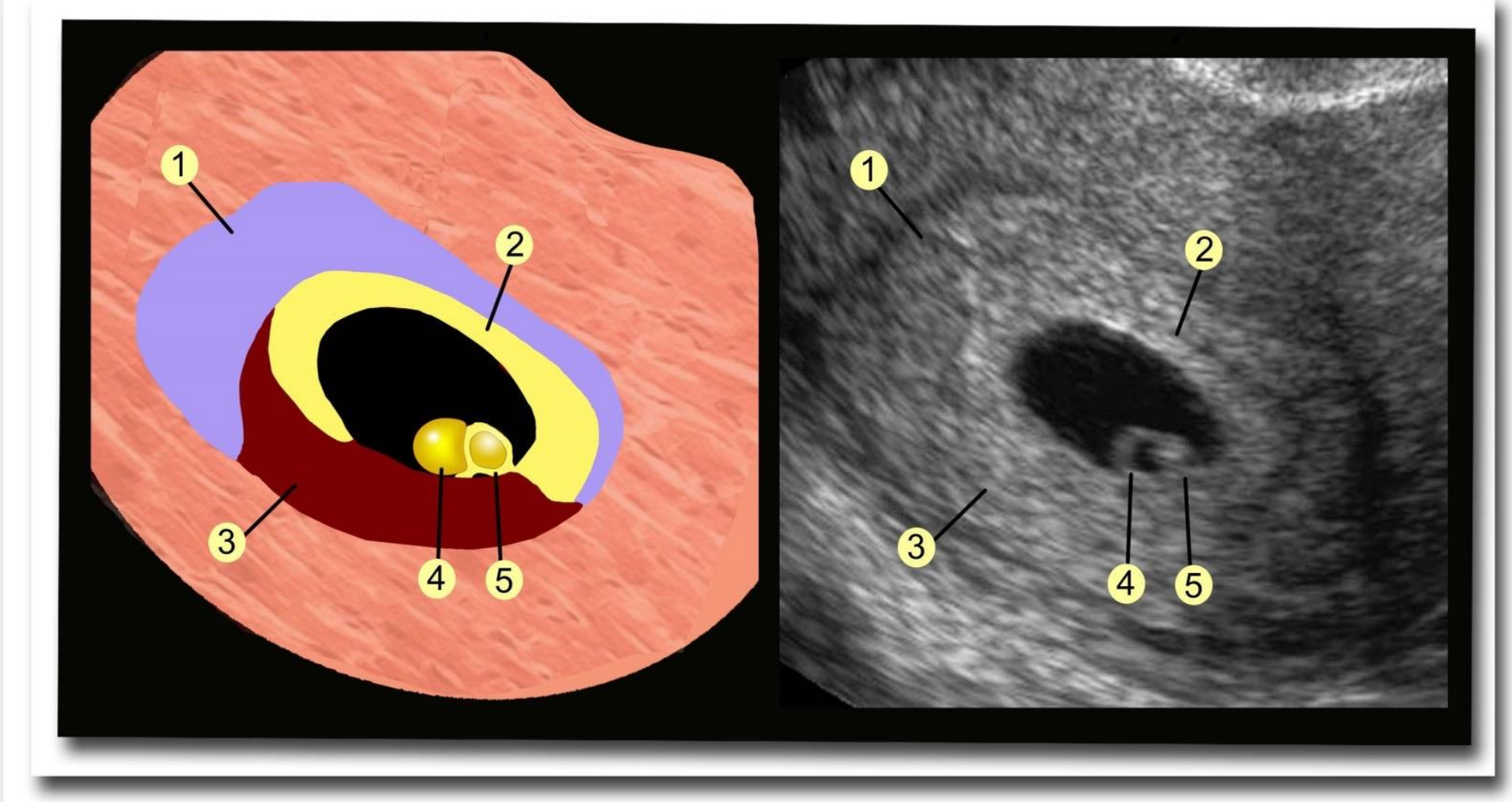
NORMAL GESTATIONAL SAC

- **Round, oval**
- **Well-defined, echogenic borders**
- **Positioned fundus to mid-uterus**

NORMAL GESTATIONAL SAC

Yolk sac when MSD ≥ 13 mm

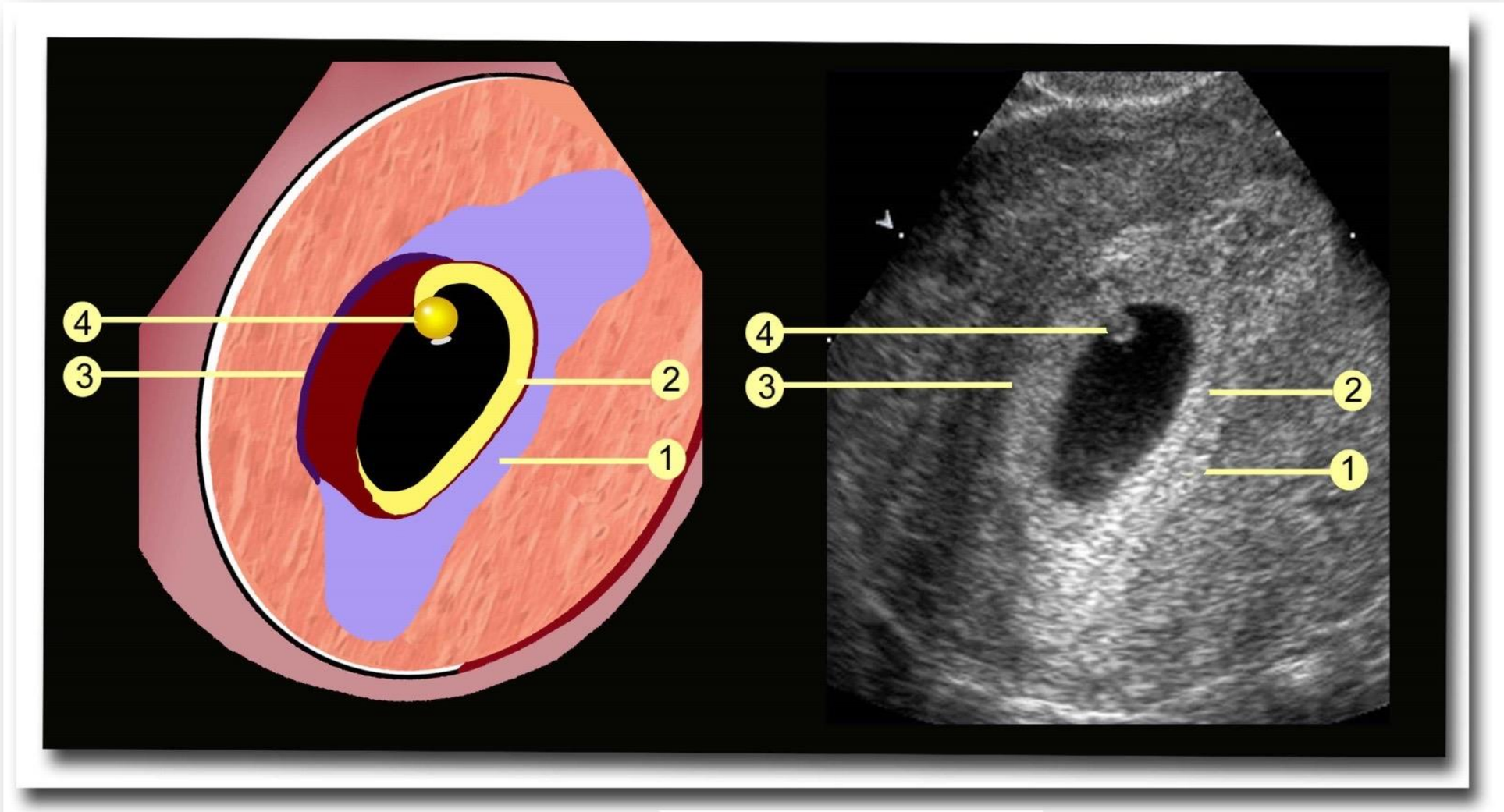
NORMAL GESTATIONAL SAC



1 = Decidua Vera
2 = Decidua Capsularis
3 = Decidua Basalis
4 = Yolk Sac
5 = Amniotic Sac

Double bleb sign

NORMAL GESTATIONAL SAC



1 = Decidua Vera
2 = Decidua Capsularis
3 = Decidua Basalis
4 = Yolk Sac

Double decidual sac sign

Yolk Sac

- Earliest embryonic structure identifiable with US
- Reliably seen by 5 wks in normal gestation
- Serves as a source of nutrients, RBCs for embryo
- Sonographic characteristics:
  - Spherical shape, smooth borders
  - Sonolucent center
  - Always seen when MSD ≥ 8 mm (5.5 wks)

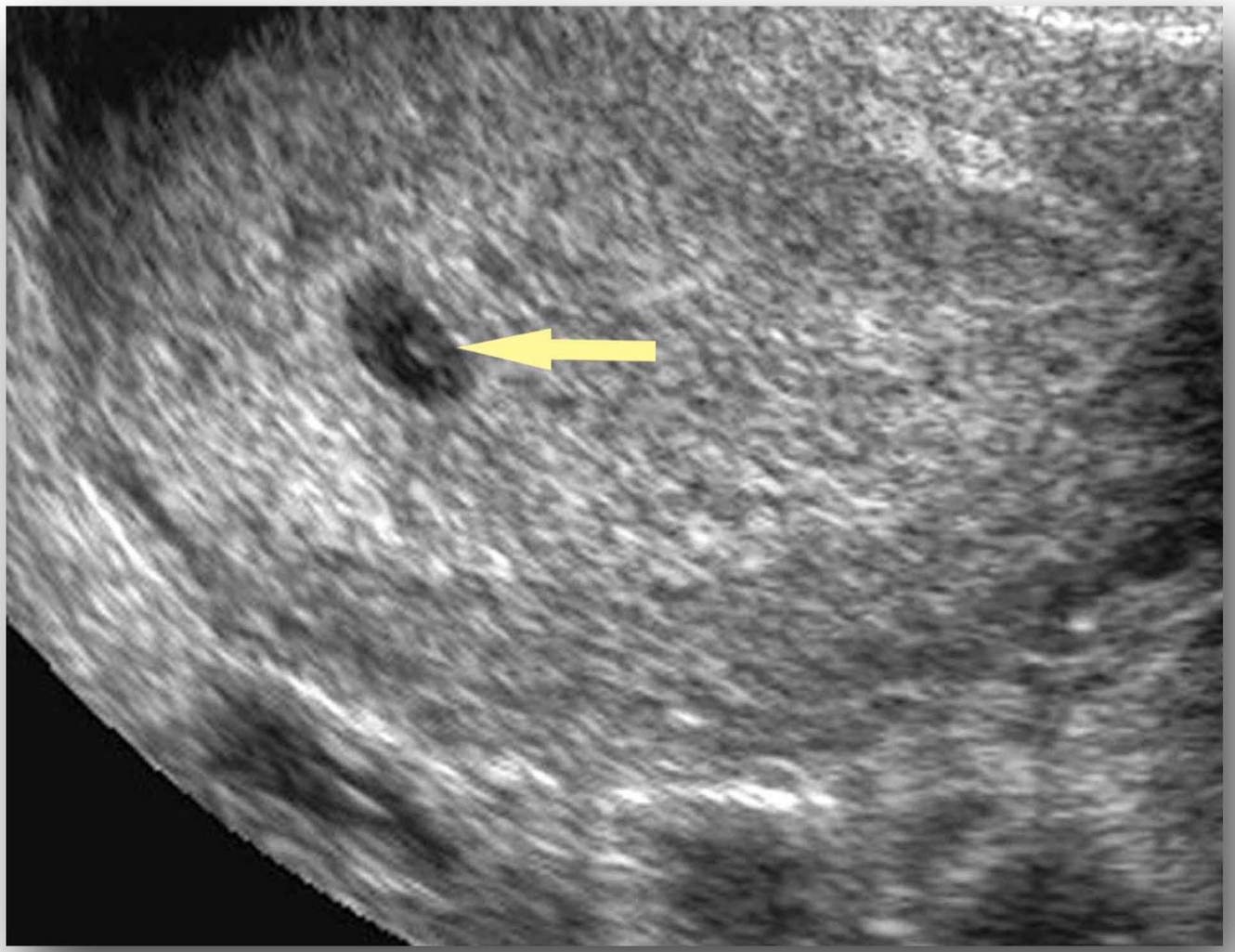
YOLK SAC

MSD ≥ 13 mm

Embryo

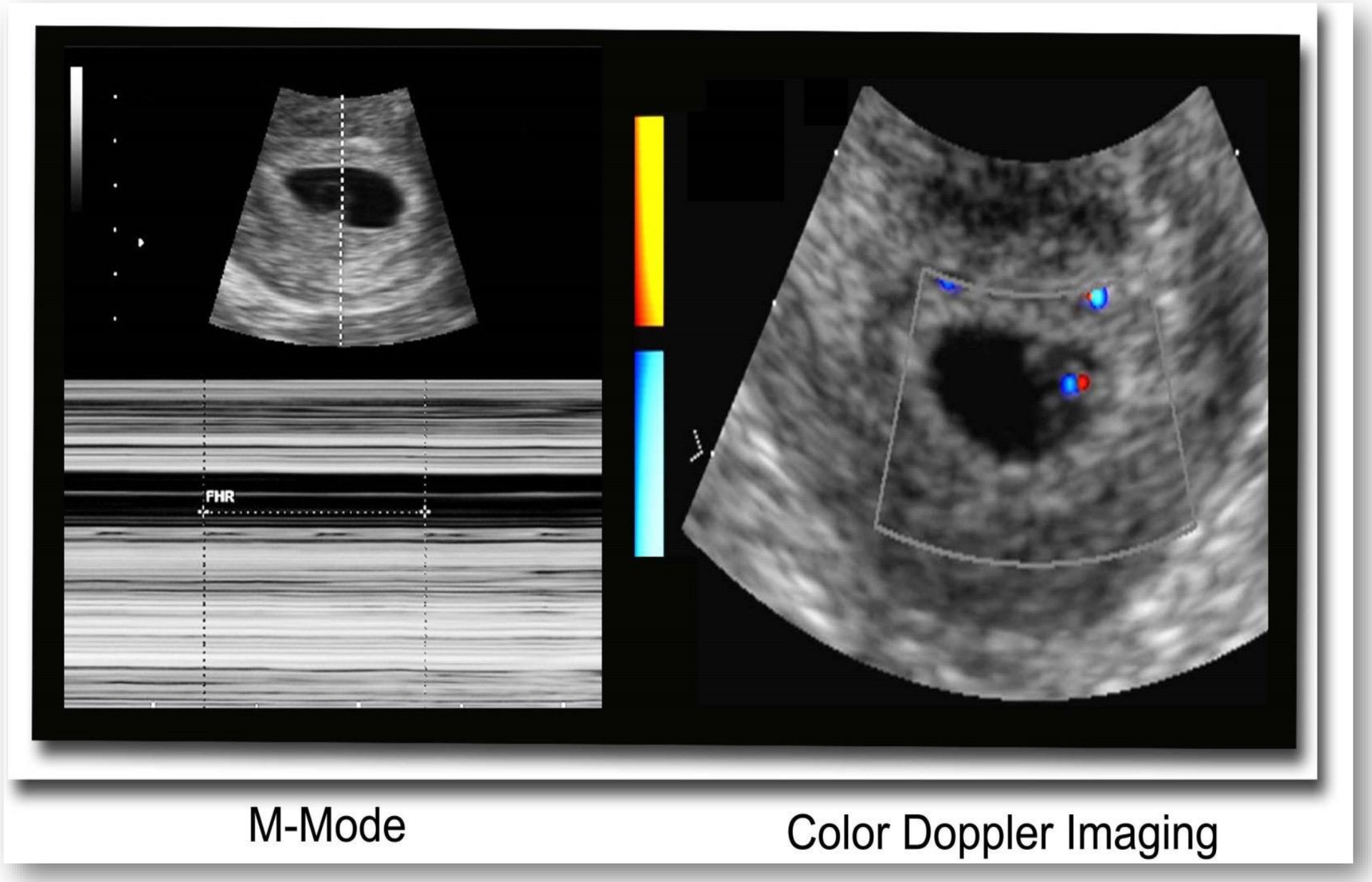
- Identifiable by 6 weeks (MSD ≥ 18 mm)
- Cardiovascular activity
  - Embryo ≥ 5 mm
  - MSD > 16 mm
- Embryonic anatomy
  - Midgut herniation
  - Prominent rhombencephalon
  - Nuchal translucency

EMBRYO



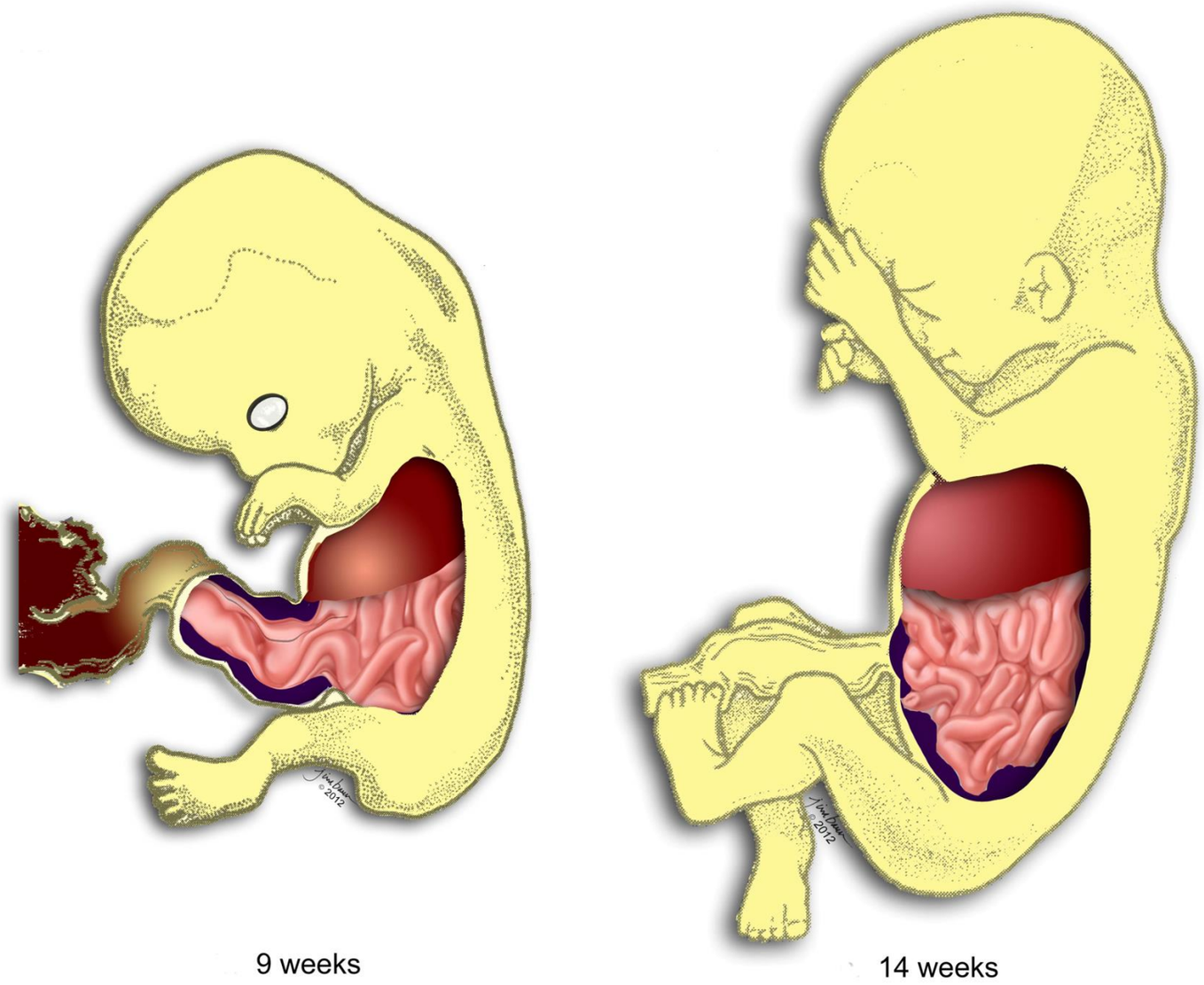
Identifiable by 6 wks (MSD ≥ 18 mm)

EMBRYO



Cardiac activity

EMBRYO

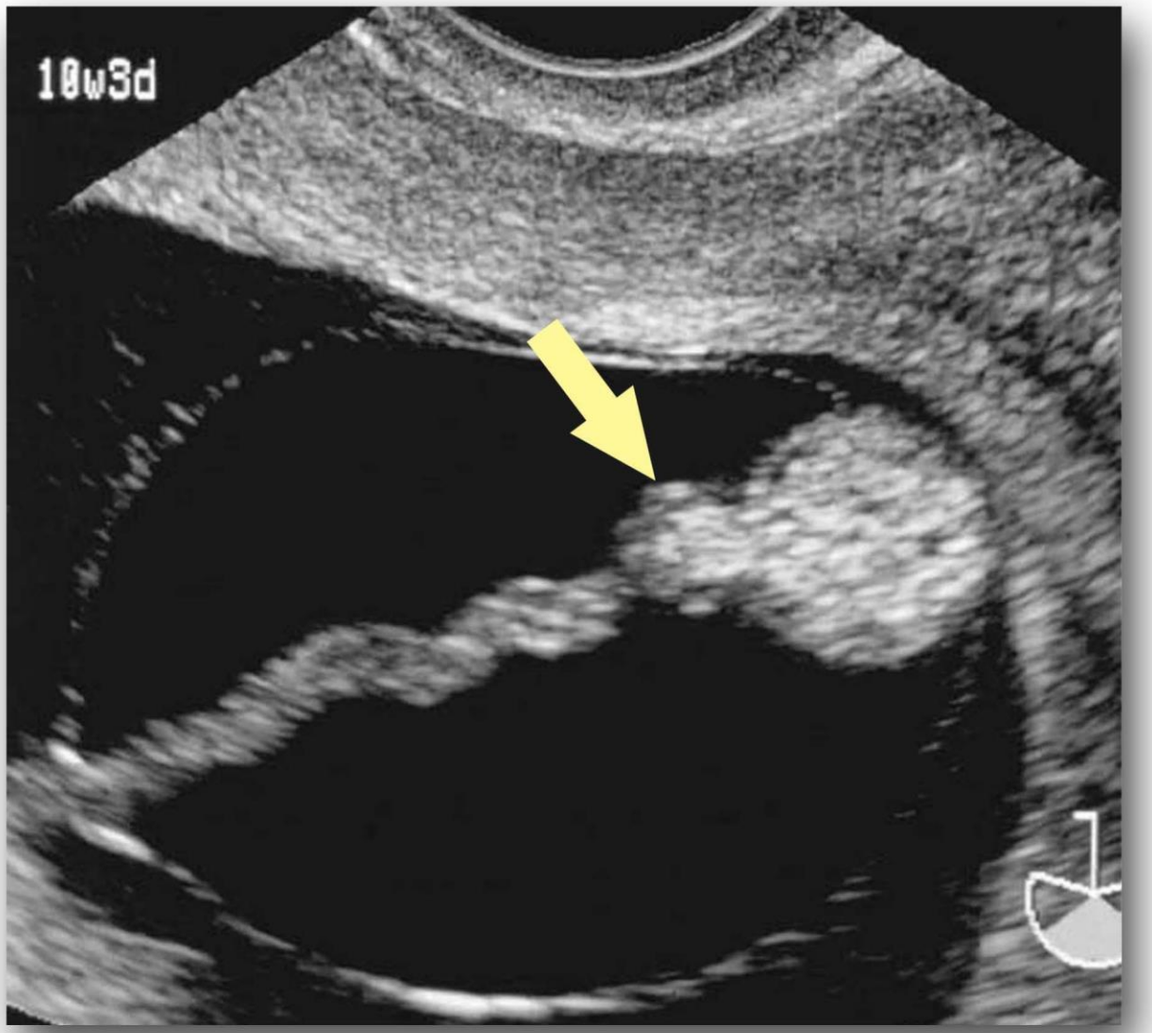


9 weeks

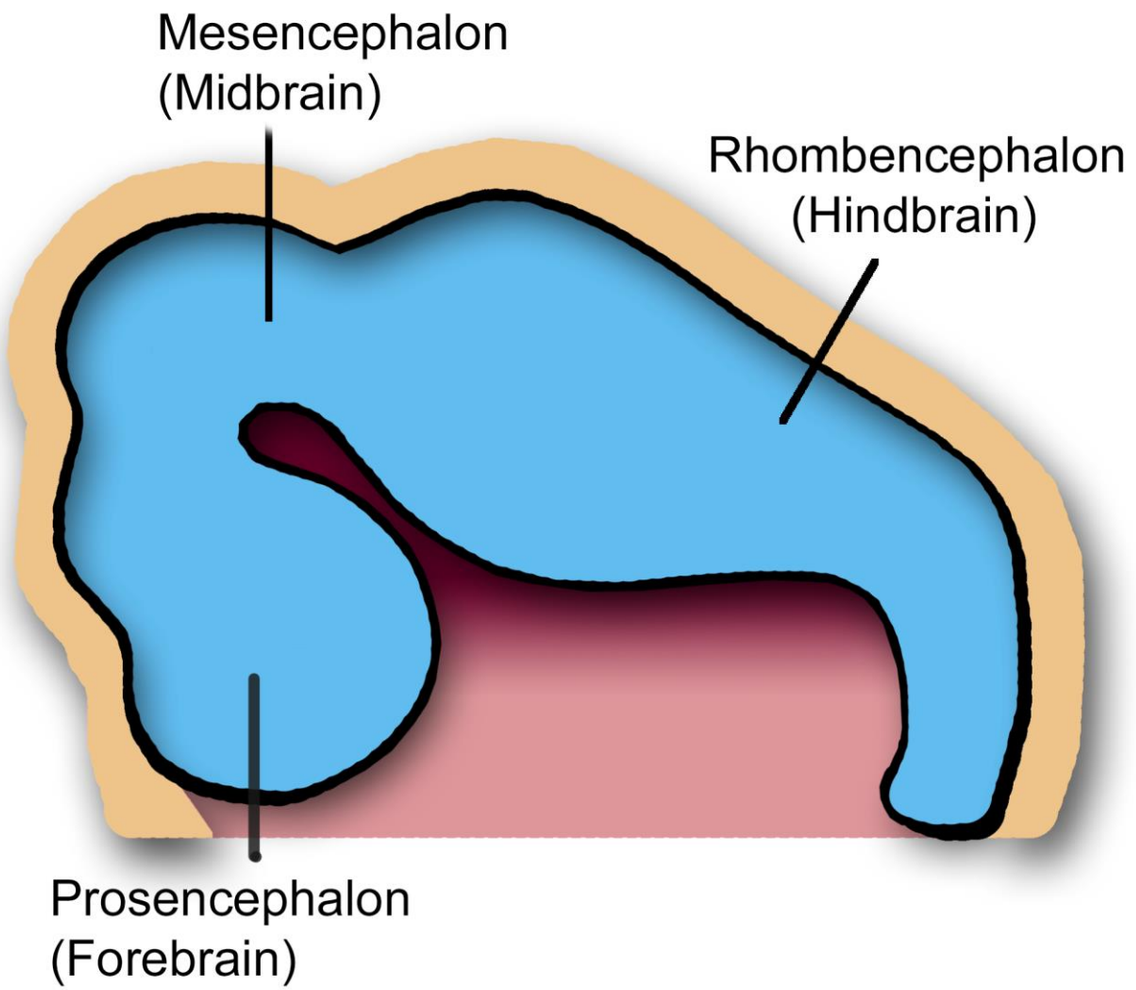
14 weeks

Normal midgut herniation

EMBRYO

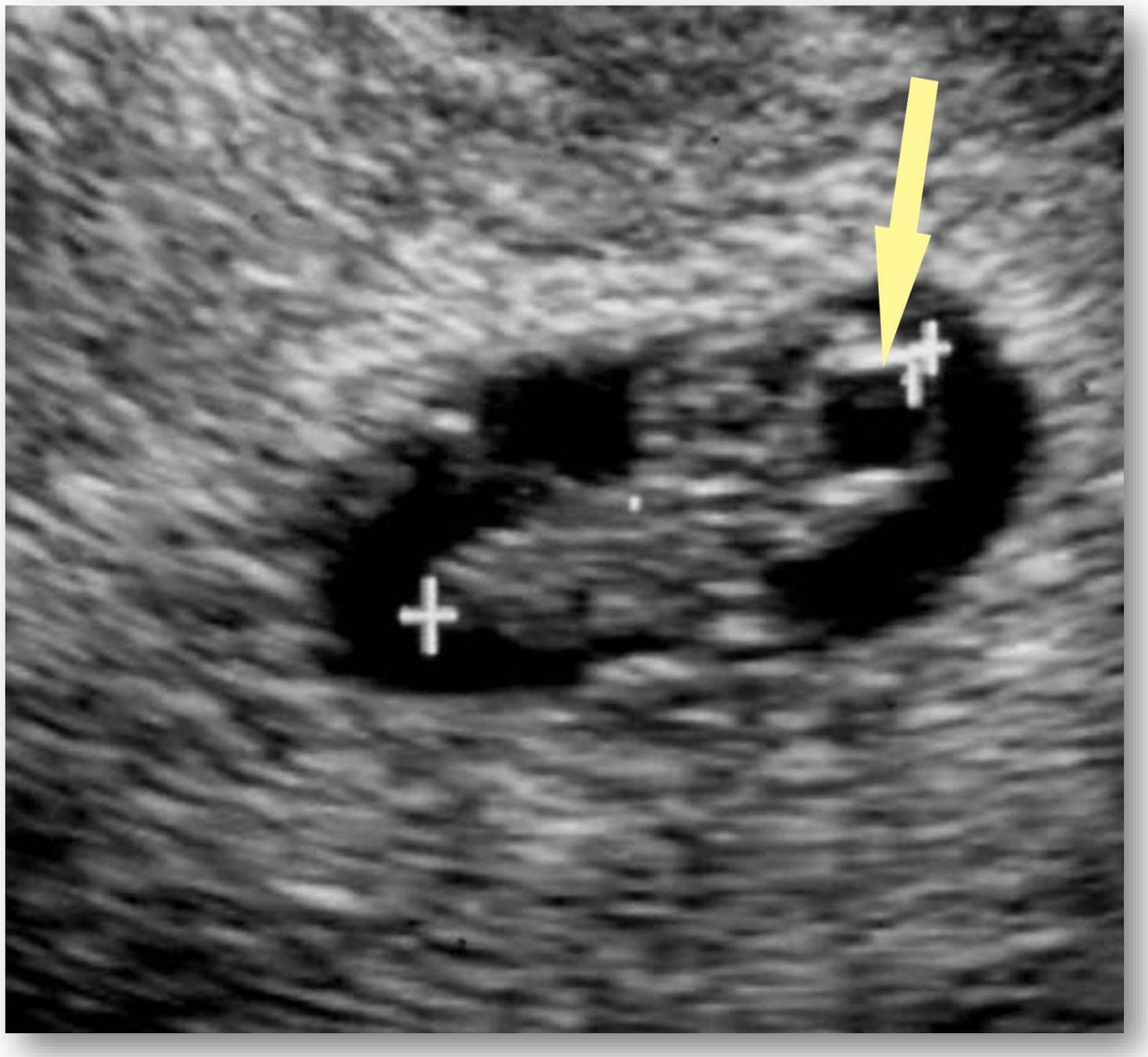


Normal midgut herniation



Prominent rhombencephalon

EMBRYO



Prominent rhomencephalon

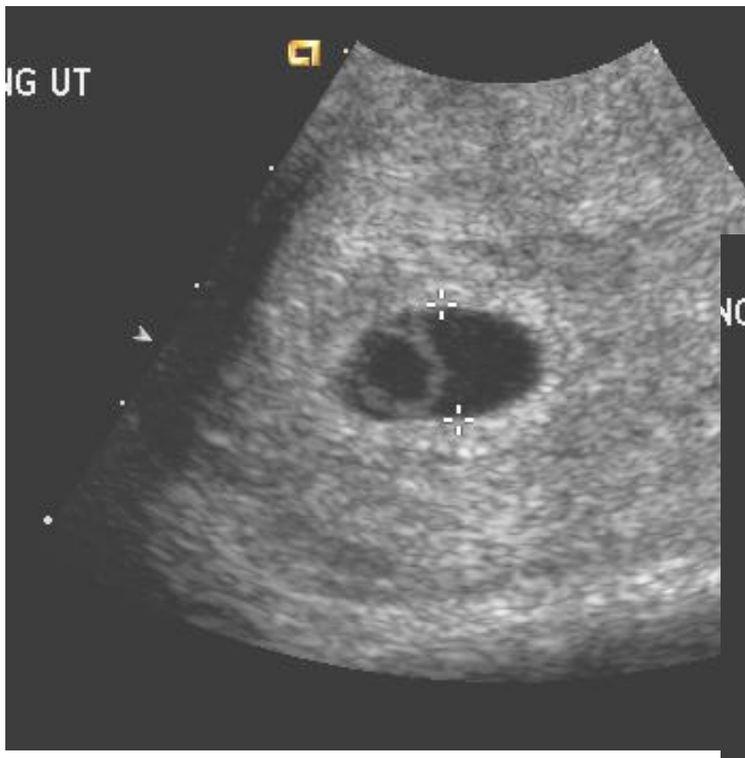
EMBRYO

Nuchal translucency

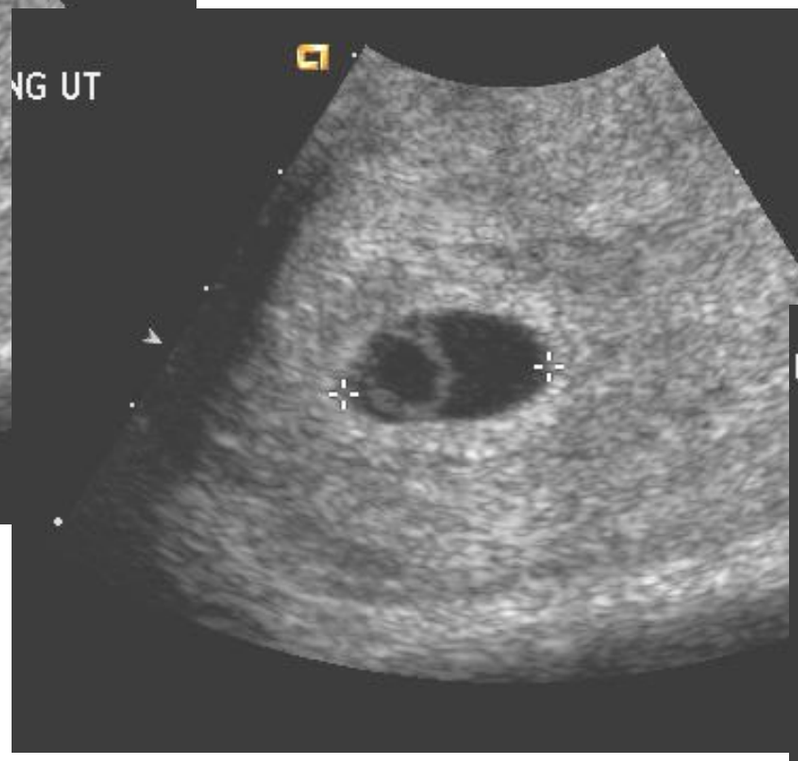
Biometric Measurements

- Mean sac diameter (MSD)
  - AP + Long + Trans ÷ 3 (L+W+D ÷ 3)
  - Rule of thumb: MSD = 5mm @ 5 weeks
  - Grows ≈ 1mm/day
  - Best used prior to 6 weeks
- Crown rump length (CRL)
  - Most accurate method of dating throughout pregnancy
  - Best used 6 – 10 weeks

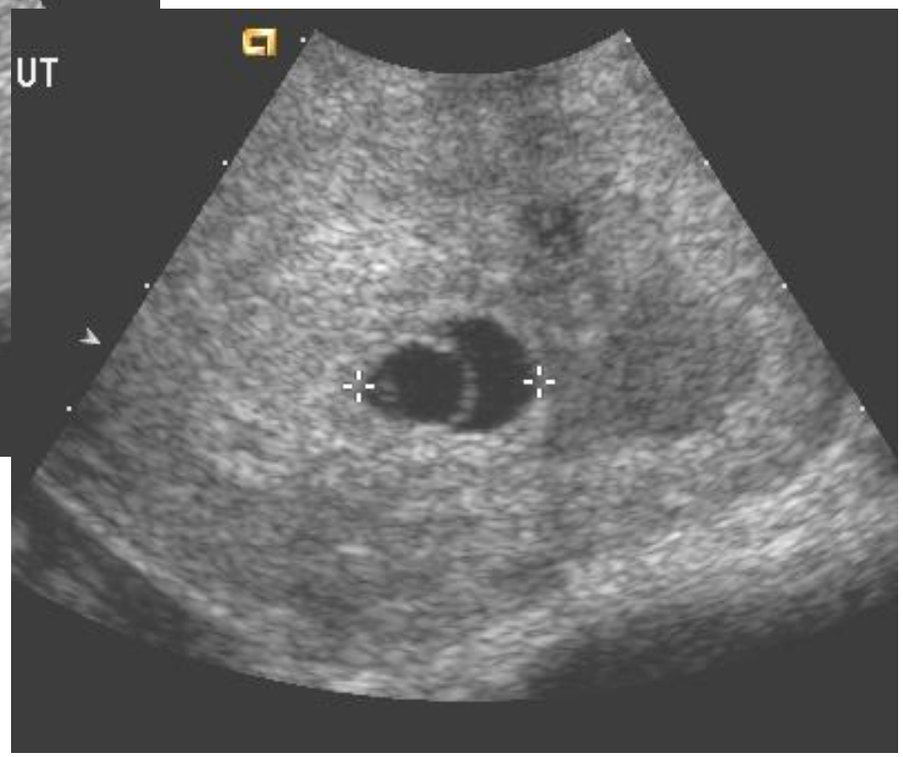
BIOMETRIC MEASUREMENTS



AP

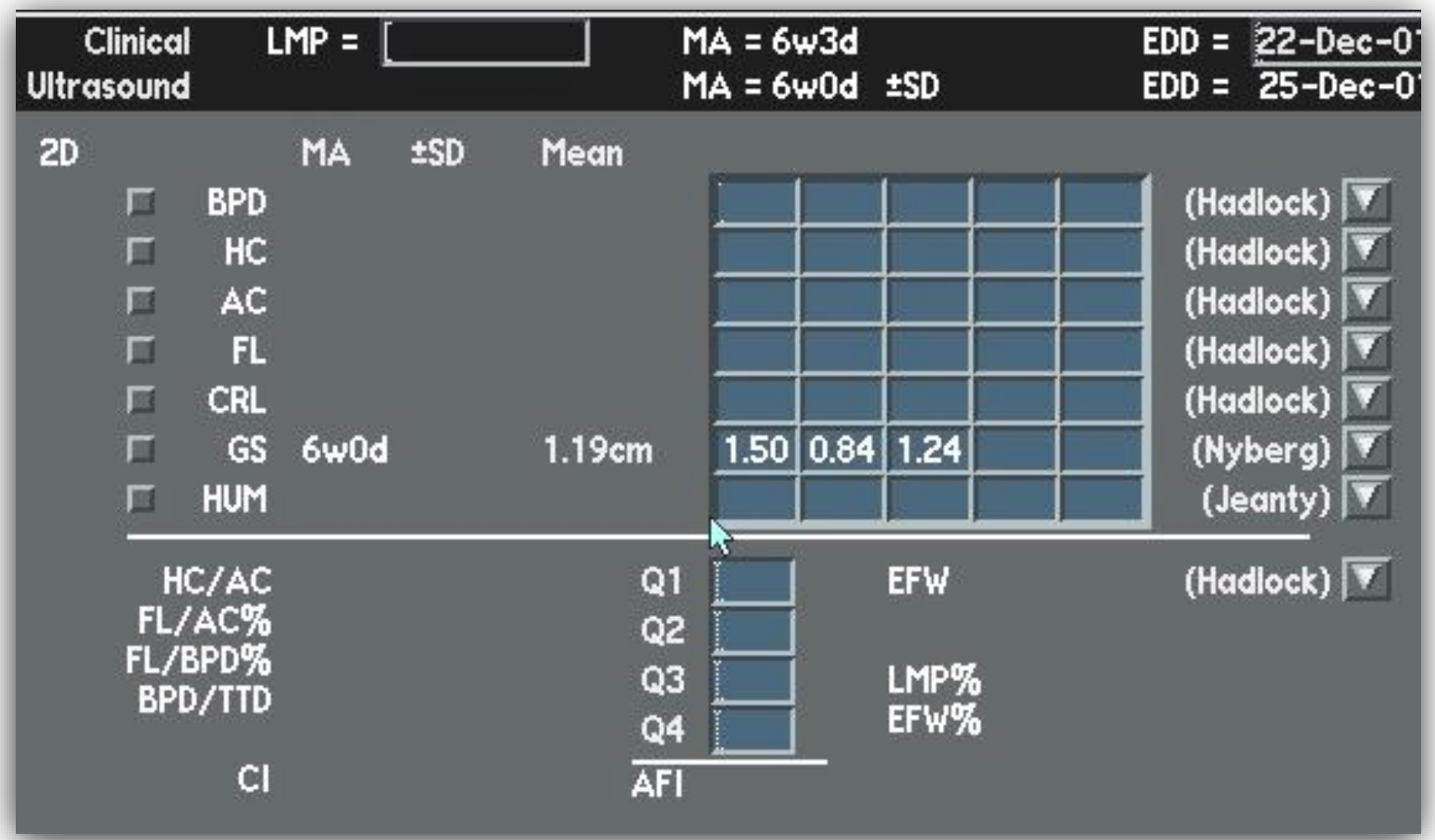


Longitudinal



Transverse

BIOMETRIC MEASUREMENTS



Crown Rump Length

- Most accurate of all measurement throughout pregnancy
- Accurate within 3 – 5 days if measured properly
- Measured from top of head to bottom of rump (excluding legs)
- Embryonic pole should be visible of the MSD measures ≥ 2.5 cm

BIOMETRIC MEASUREMENTS

7 weeks, 3 days

Crown Rump Length

Examples:

- ☑ **Size in cm + 6 = GA in weeks**
- ☑ **Size in mm + 42 = GA in days**

Crown Rump Length

Two rules of thumb:

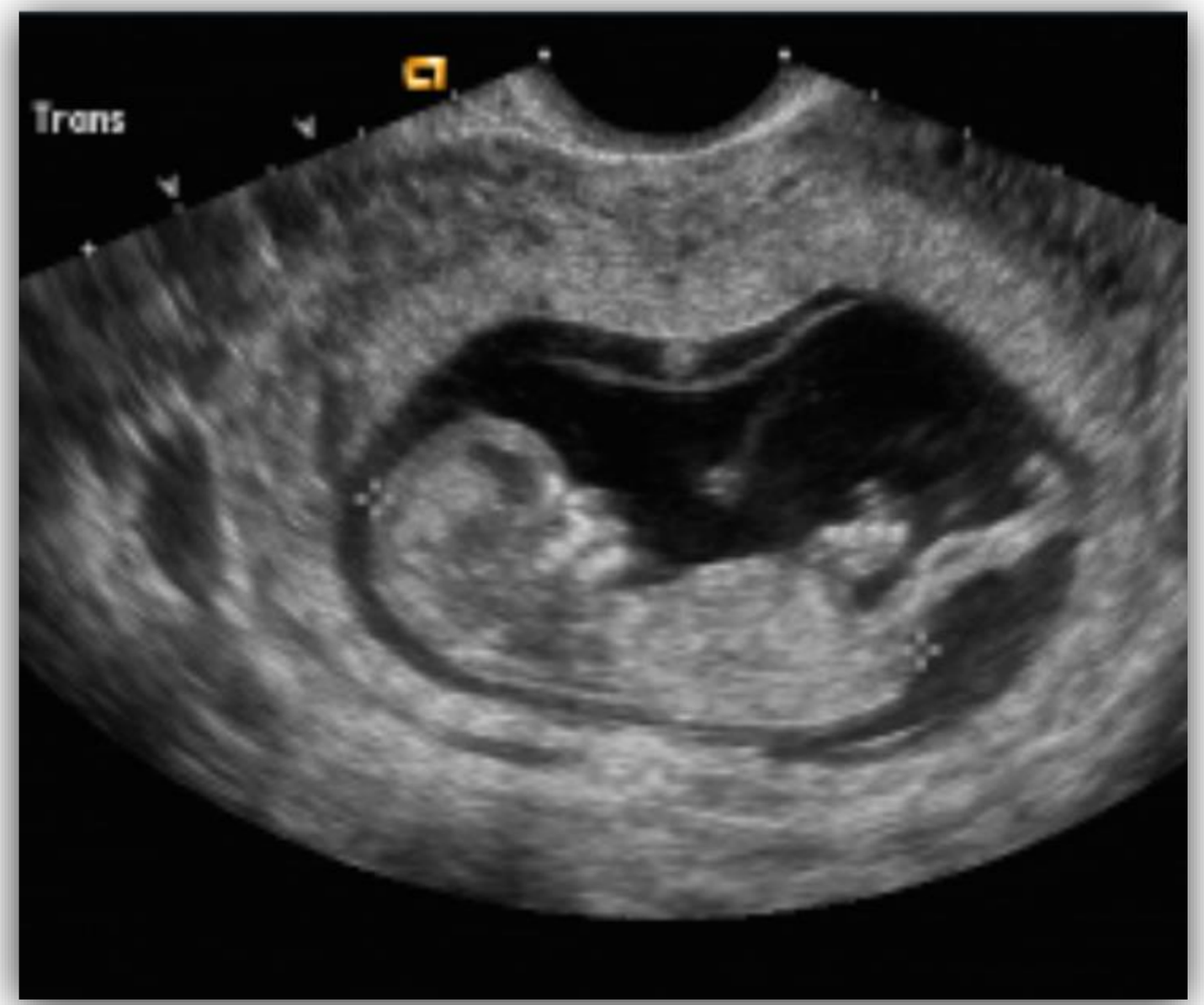
Size in cm + 6 = GA in weeks

CRL = 2 cm
2 + 6 = 8 weeks

Size in mm + 42 = GA in days

CRL = 20 mm
20 + 42 = 62 days
62 ÷ 7 = 8.9 weeks

BIOMETRIC MEASUREMENTS



10 weeks

BIOMETRIC MEASUREMENTS

0.7 cm + 6 = 6.7 weeks
7.0 mm + 42 = 49 days ÷ 7 = 7 weeks

Sonographic Demonstration of Viability

- Primary value of US in 1st trimester is sensitivity and reliability in confirmation of IUP and demonstration of viability

- Secondary value is in estimating gestational age due to:
  - Normal variations in 1st 14 days of menstrual cycle may delay fertilization
  - Variation in individual menstrual cycles

SONOGRAPHIC DEMONSTRATION OF VIABILITY

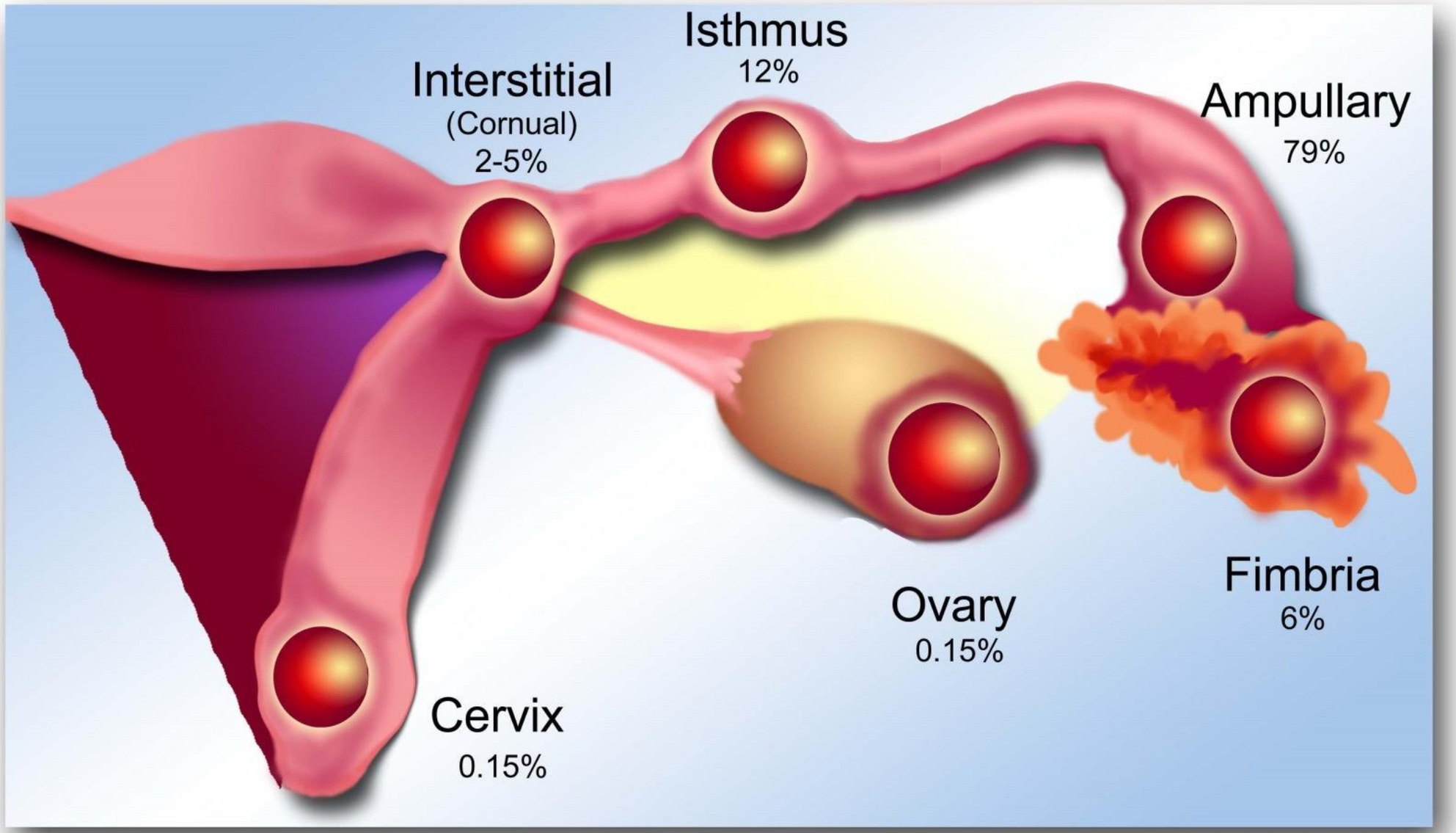
Measure	*Age (weeks)*	*MSD (mm)*
GS MAY be seen	***4.5***	***2***
GS ALWAYS seen	***5***	***5***
Yolk sac seen	***5***	***10***
CV activity seen	***6***	***18***
Embryonic pole seen	***6***	***18***

Abnormal First Trimester

Ectopic Pregnancy

- Implantation of the conceptus anywhere outside the central uterine cavity
- 90% are tubal in location but may implant:
  - Ovary
  - Ligaments
  - Abdominal wall
  - Intestine or anywhere in abdominal cavity
- Serious clinical sequelae may result from rupture

ECTOPIC PREGNANCY



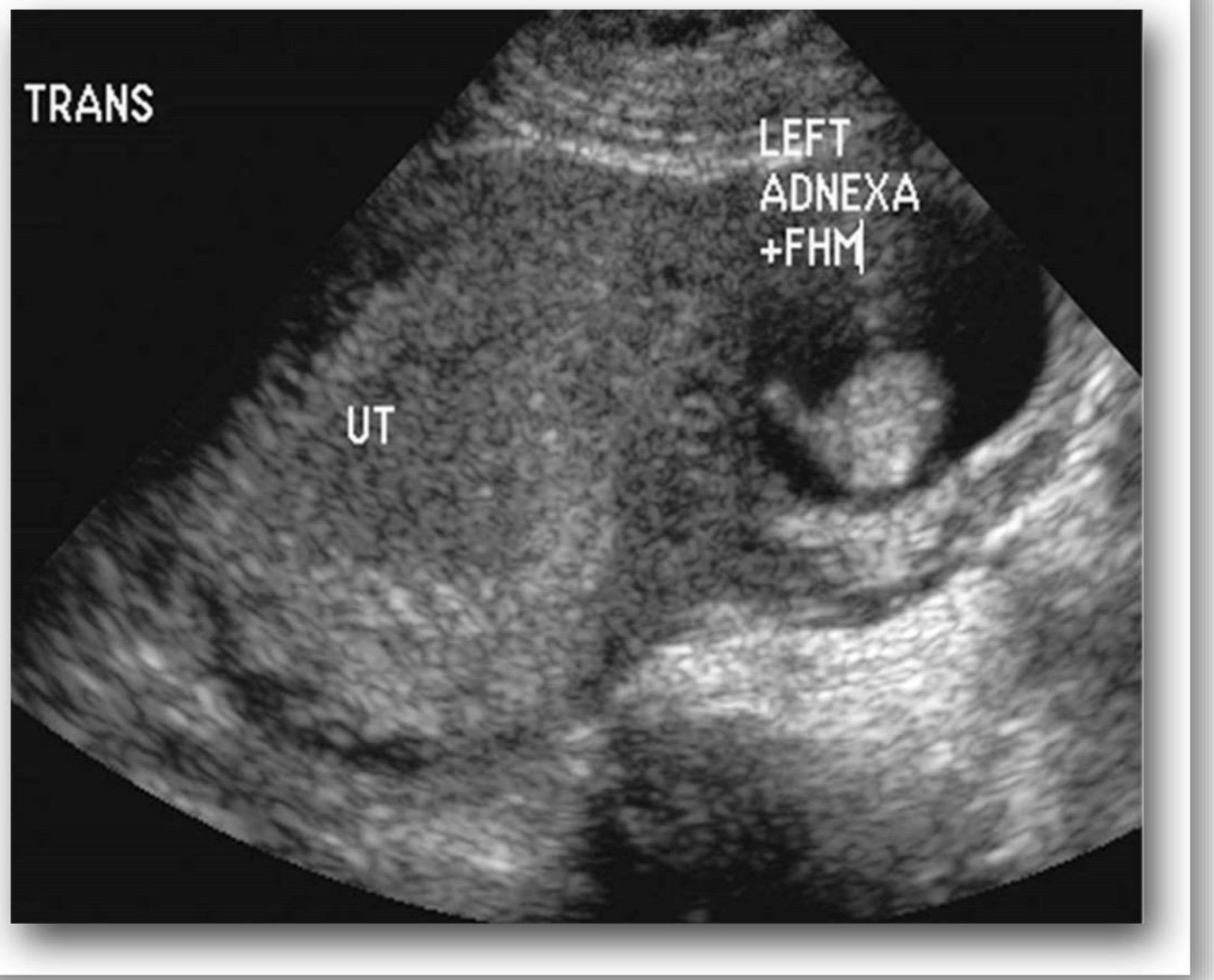
Clinical Presentation

- (+) serum pregnancy test
  - Variable levels for dates
- Adnexal mass on pelvic exam
- Pelvic pain/bleeding 1 – 8- wks post LMP
- Leuokocytosis
- Slight fever
- Pain referred to shoulder
  - Intraperitoneal hemorrhage

Sonographic Findings

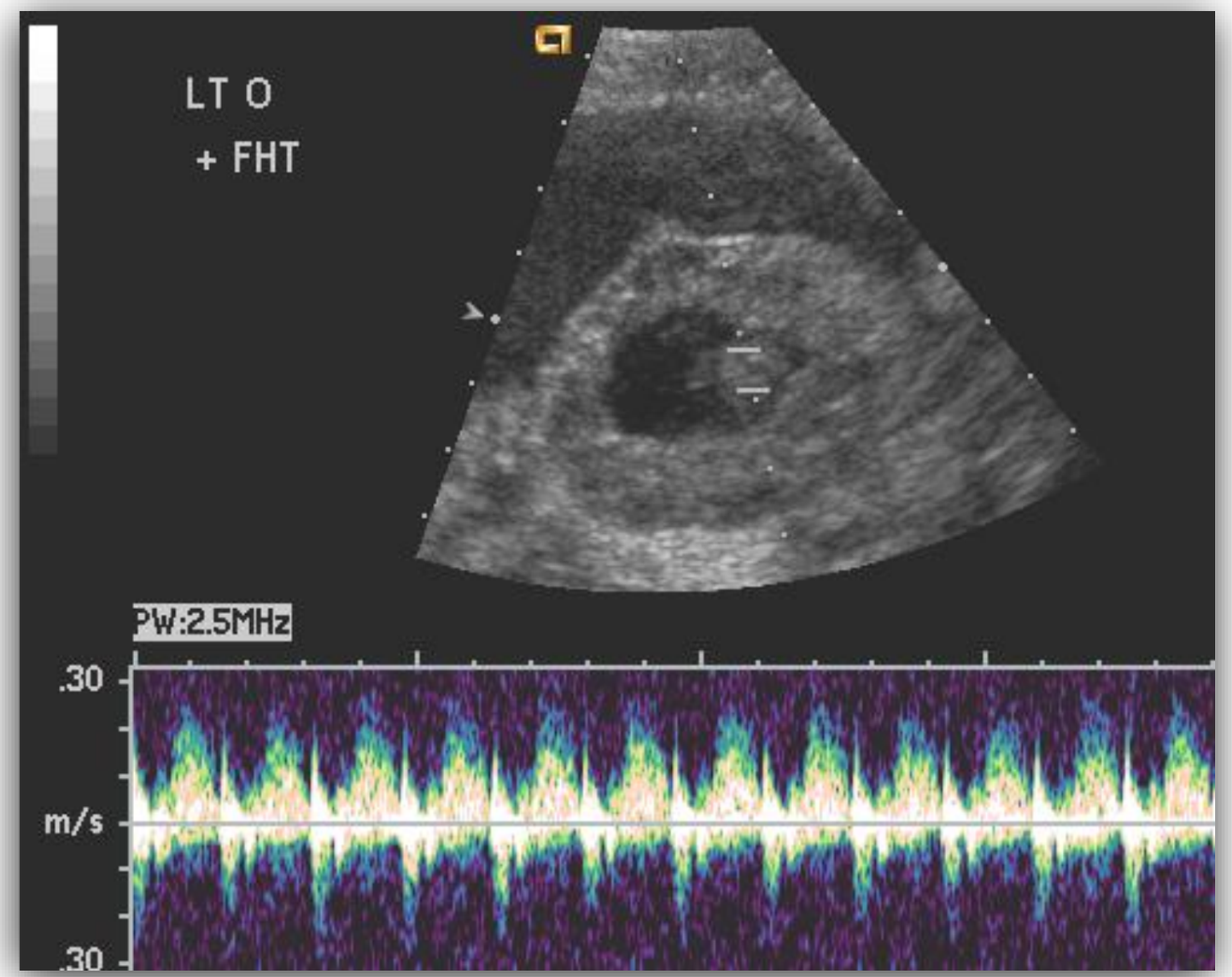
- Extrauterine GS w embryo
  - Pathognomonic
- Adnexal mass
- Free fluid
  - Cul de sac
  - Pericolic gutters
- Heterotopic pregnancy
- Doppler “ring of fire” sign

ECTOPIC PREGNANCY



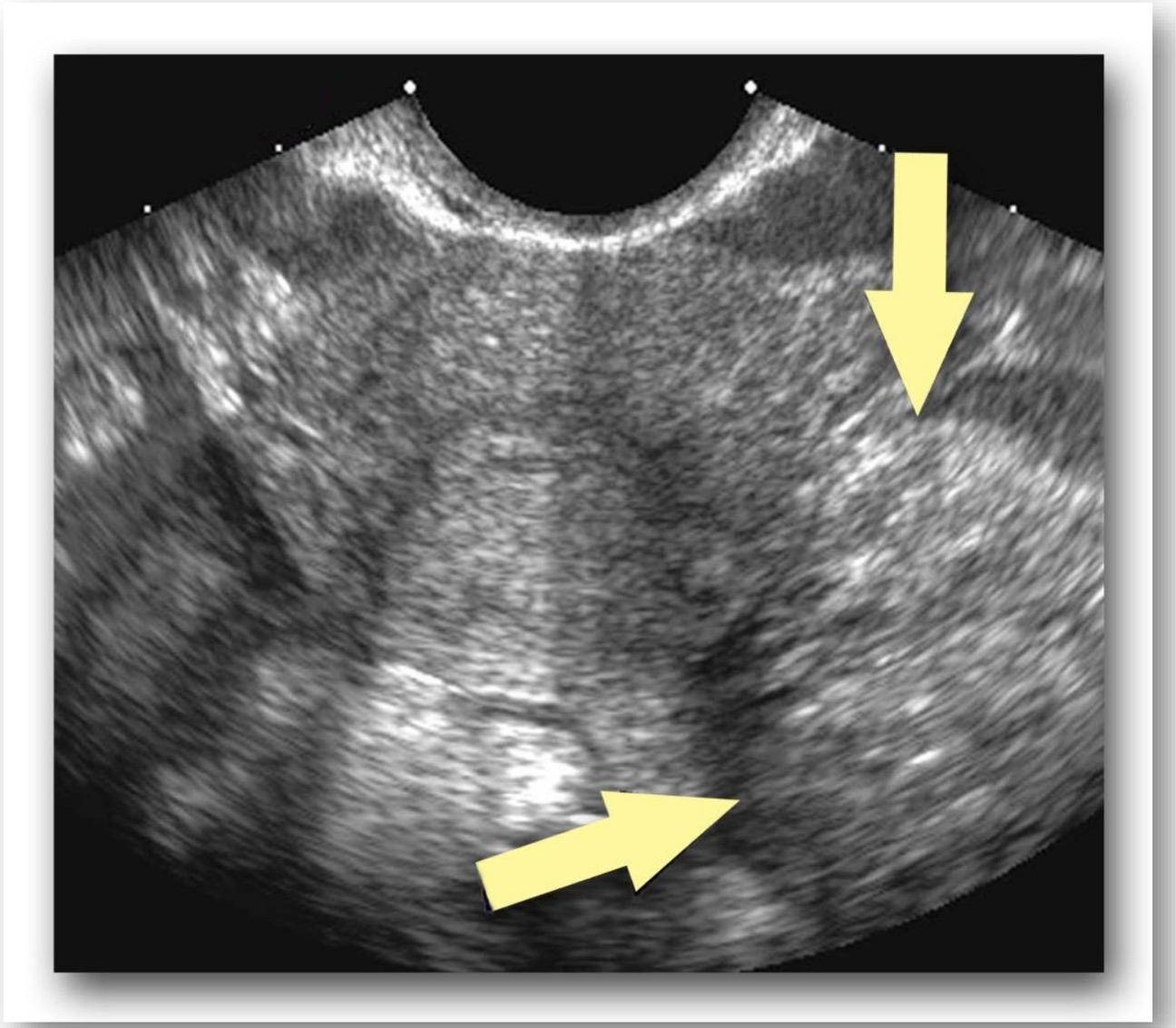
Extrauterine gestational sac

ECTOPIC PREGNANCY



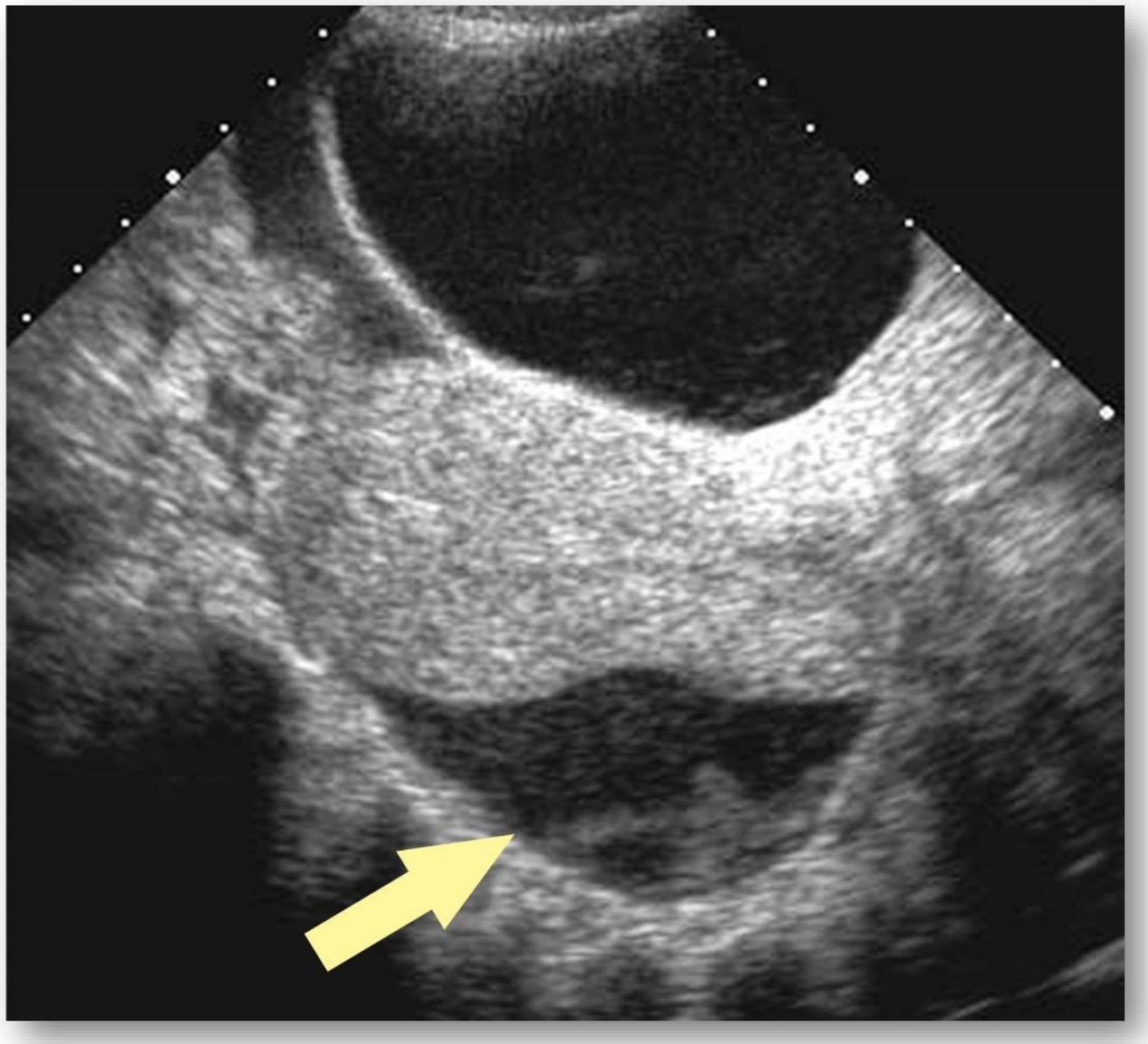
Extrauterine gestational sac with CV activity

ECTOPIC PREGNANCY



Adnexal mass

ECTOPIC PREGNANCY



Free fluid in posterior cul-de-sac

ECTOPIC PREGNANCY

Free fluid in right paracolic gutter

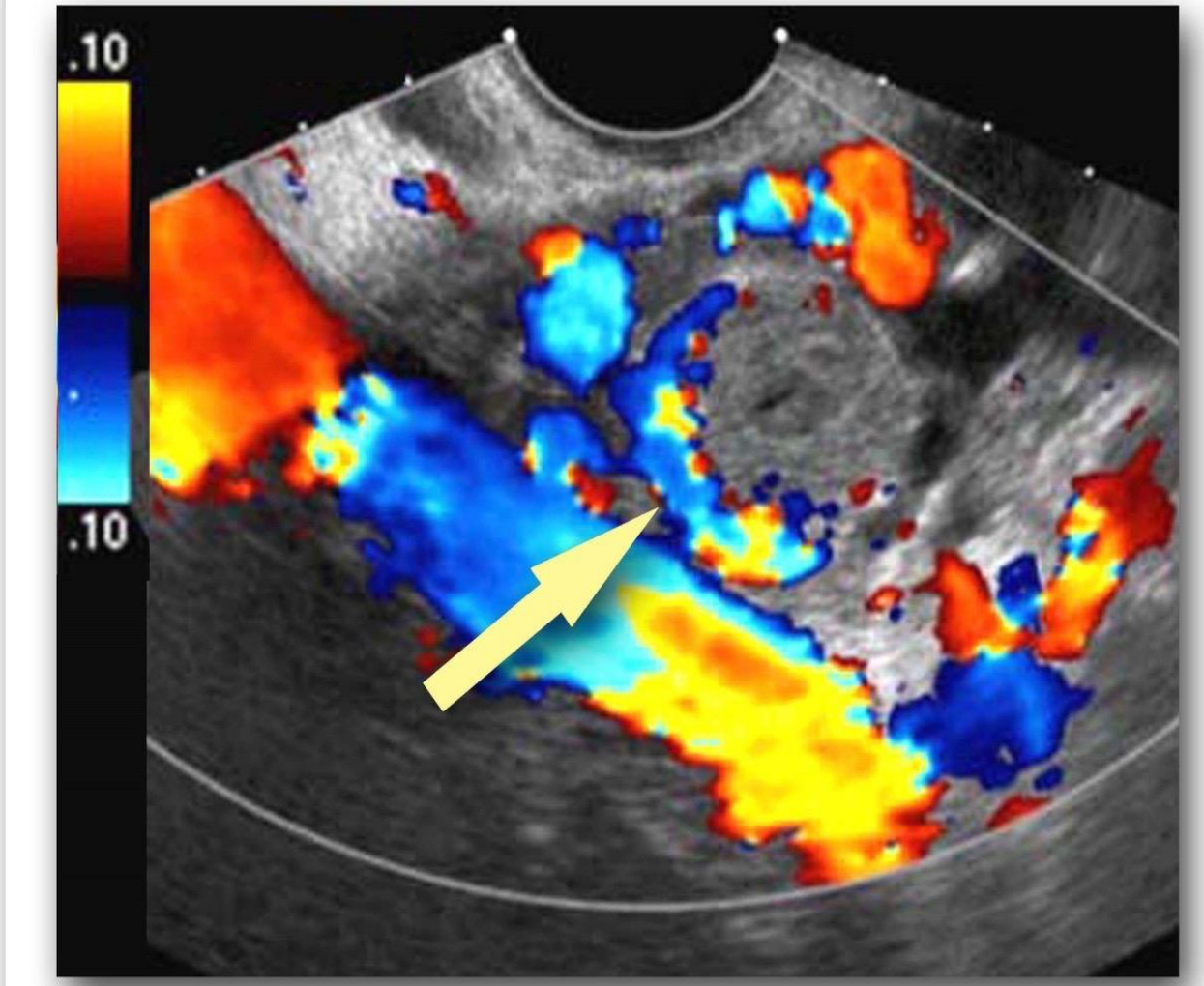
ECTOPIC PREGNANCY

Extrauterine

Intrauterine

Heterotopic pregnancy

ECTOPIC PREGNANCY

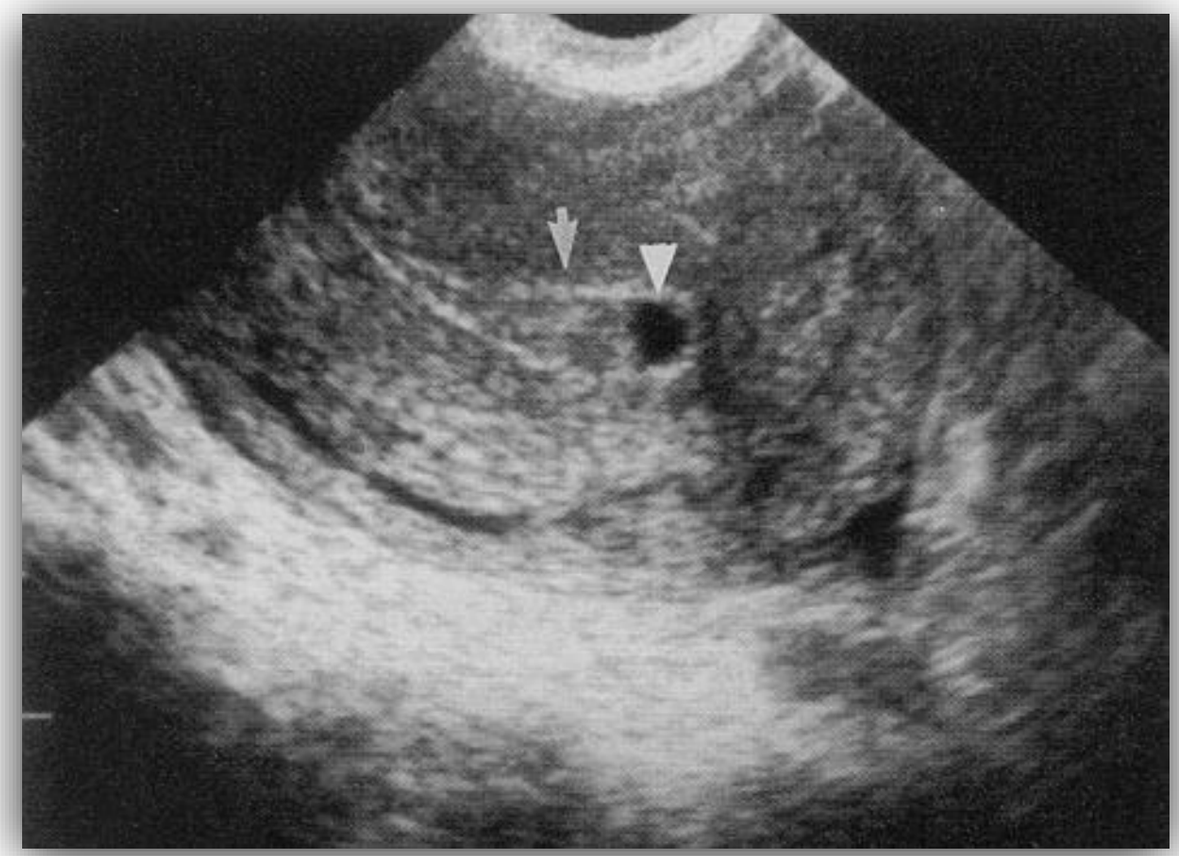


Doppler “ring of fire” sign

Sonographic Pitfalls

- Presence of endometrial fluid – “pseudogestational sac
- Misidentifying a corpus luteum cyst as an adnexal ectopic
  - *Corpus luteum cyst*: normal cystic enlargement of the ruptured dominant follicle in the presence of hCG
  - Necessary for production of progesterone and maintenance of endometrium after implantation

ECTOPIC PREGNANCY

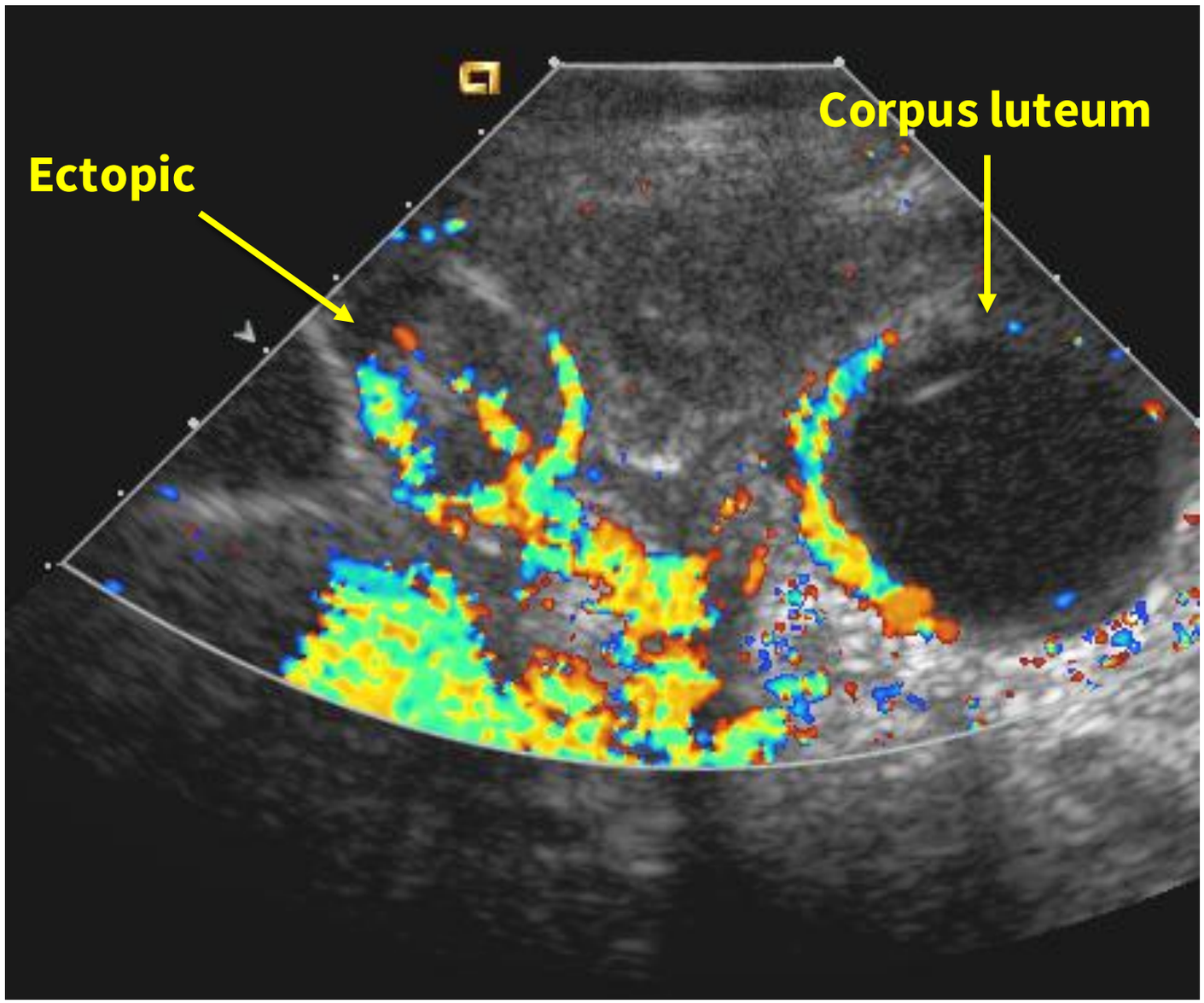


Pseudogestational sac

ECTOPIC PREGNANCY

Transverse adnexa

ECTOPIC PREGNANCY



Transverse adnexa

Abdominal Ectopic Pregnancy

- Specific sonographic criteria
  - Absence of myometrium surrounding the pregnancy
  - Poor visualization of placenta
  - Empty uterus separate from a fetus
  - Oligohydramnios
  - Unusual fetal position

ECTOPIC PREGNANCY

Abdominal ectopic pregnancy

Other Diagnostic Procedures

- When sonography is inconclusive, other techniques may be used to confirm the diagnosis of ectopic pregnancy
  - *Culdocentesis*: to detect free fluid/blood in the CDS
  - *Laparoscopy*: for direct visualization of adnexal or intra-abdominal masses
  - *Exploratory laparotomy*: assures a definitive diagnosis

Early Pregnancy Failure

- Spontaneous abortion (SAB) is the termination of pregnancy prior to 20 weeks of gestation
- Usually occurs 1 – 3 weeks after embryonic demise and the cause frequently cannot be determined

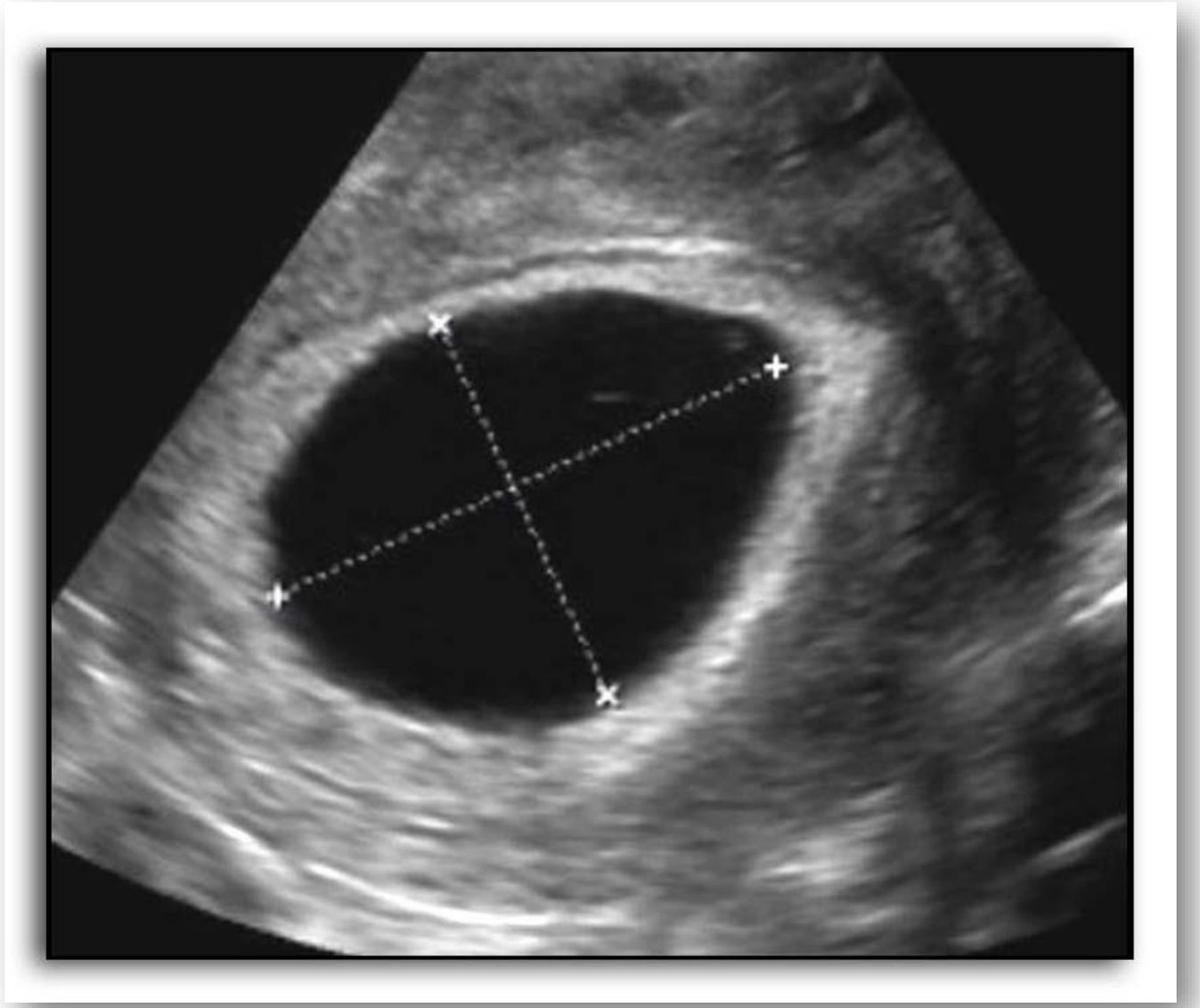
Early Pregnancy Failure

- Categories of SAB:
  - Complete abortion
  - Incomplete abortion
  - Missed abortion
  - Threatened abortion
  - Inevitable abortion
  - Anembryonic pregnancy

Role of Sonography

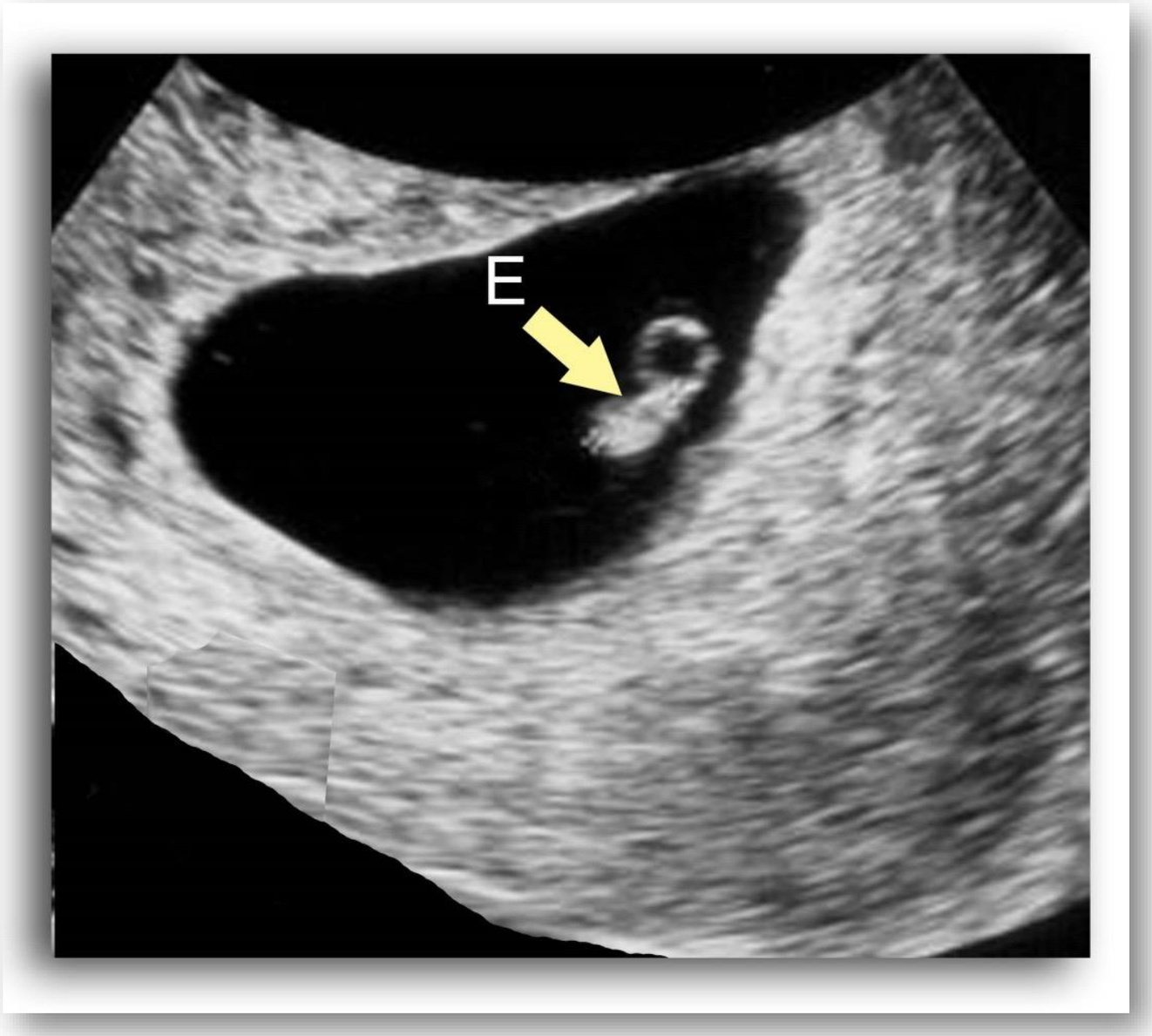
- Reasonable reliable indicators of pregnancy failure:
  - MSD ≥ 8 mm w/o yolk sac
  - MSD ≥ 16 mm w/o embryo
  - Embryo > 5 mm with absent CVA
  - MSD – CRL ≧ 5 mm (5.5 – 9 wks)
  - Sac much larger than embryo

EARLY PREGNANCY FAILURE



MSD ≥ 8 mm w/o yolk sac or embryo

EARLY PREGNANCY FAILURE



Sac much larger than embryo

Role of Sonography

- Less reliable indicators:
  - Irregular sac shape
  - Absent DDS sign
  - Low position of sac in uterus
  - Disproportionately large yolk sac
  - MSD growth < 0.6 mm/day. (normal = 1.13 mm/day)

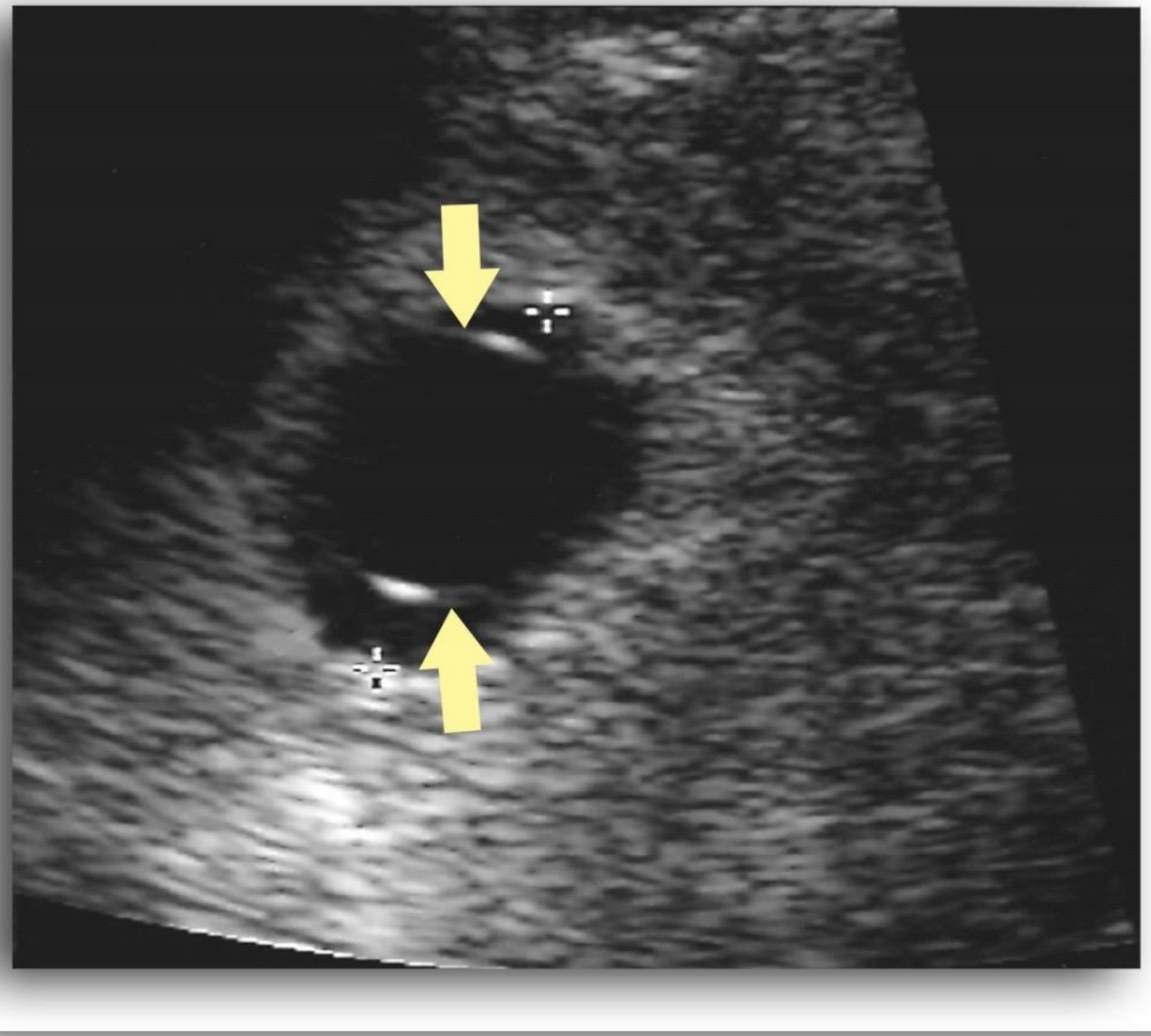
EARLY PREGNANCY FAILURE

Irregular sac shape

EARLY PREGNANCY FAILURE

Low position in the uterus

EARLY PREGNANCY FAILURE



Disproportionately large yolk sac

Complete Abortion

- Evacuation of all products of conception (POCs)
- Clinical signs include:
  - Rapid decline in hCG levels
  - Vaginal bleeding with passage of clots/tissue
  - Cramping
  - Cessation of pain and bleeding after passage of POCs
  - Disappearance of symptoms of pregnancy

Complete Abortion

- Sonographic findings include:
  - Empty uterus with “clean” endometrial stripe
  - Moderate to bright endometrial echoes
  - Presence of trophoblastic Doppler findings (CDI and PW waveforms) around the EC typically persist for 3 days post SAB

COMPLETE ABORTION

“Clean” endometrial stripe

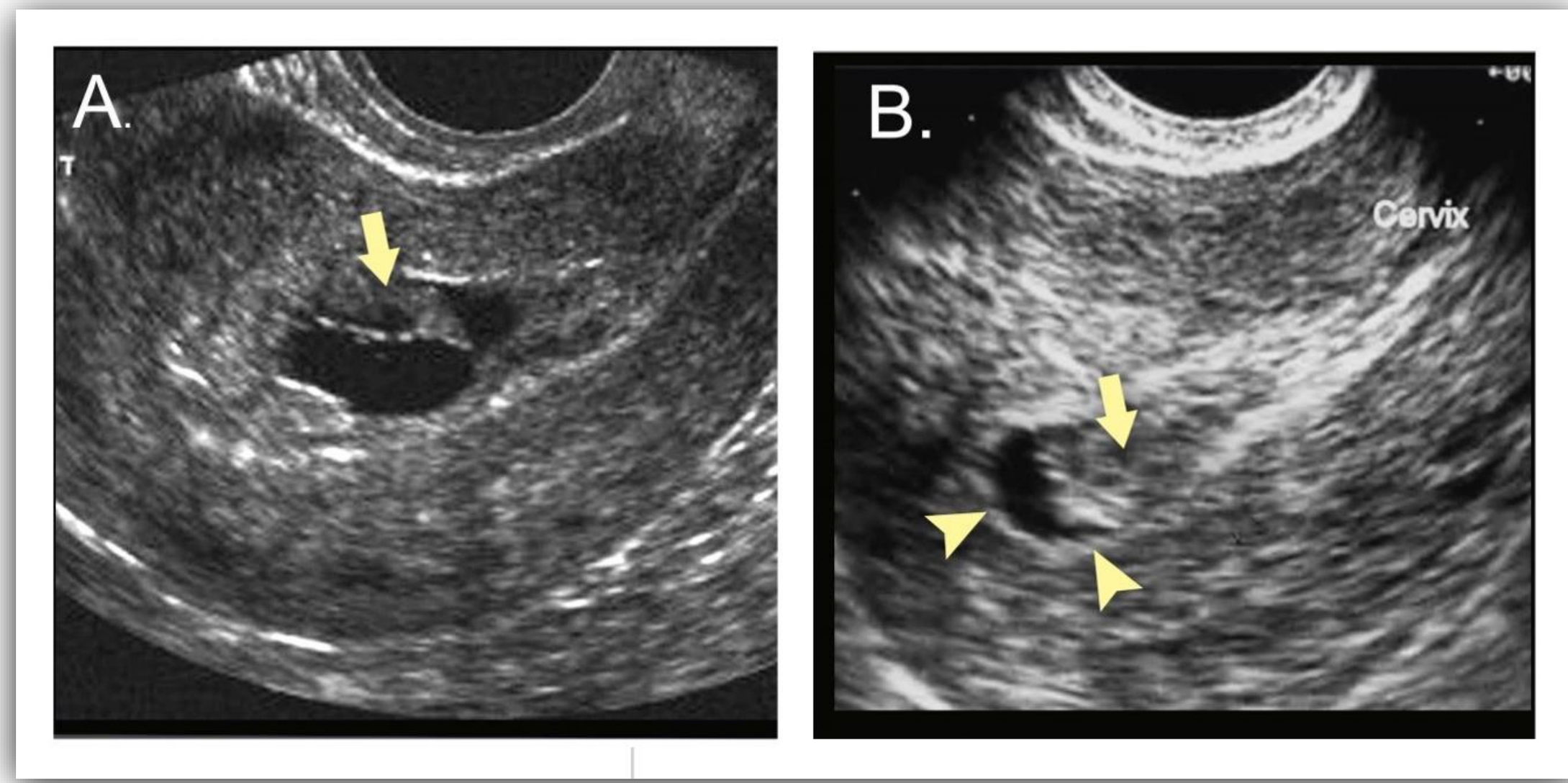
Incomplete Abortion

- Partial evacuation of products of conception (POCs) diagnosed early after the event
- Clinical signs include:
  - Slow fall of plateau of hCG levels
  - Moderate cramping
  - Persistent heavy bleeding

Incomplete Abortion

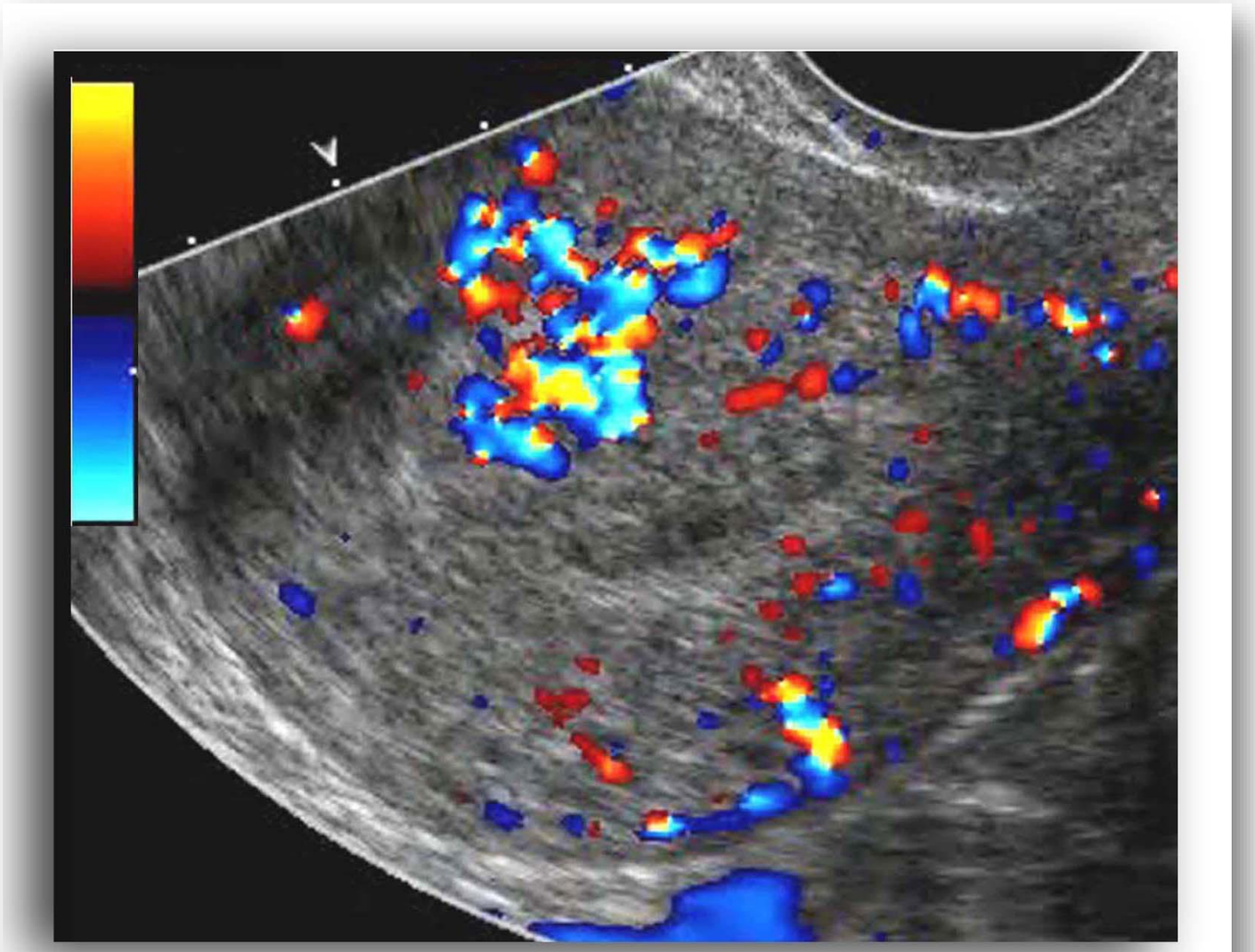
- Sonographic findings include:
  - Presence of a complex collection of echoes in the uterine cavity due to retained POCs, air bubbles, and bony fragments
  - Persistence of trophoblastic Doppler findings (CDI and PW waveforms) around the EC after 3 days post SAB

INCOMPLETE ABORTION



Echo collection in uterine cavity

INCOMPLETE ABORTION



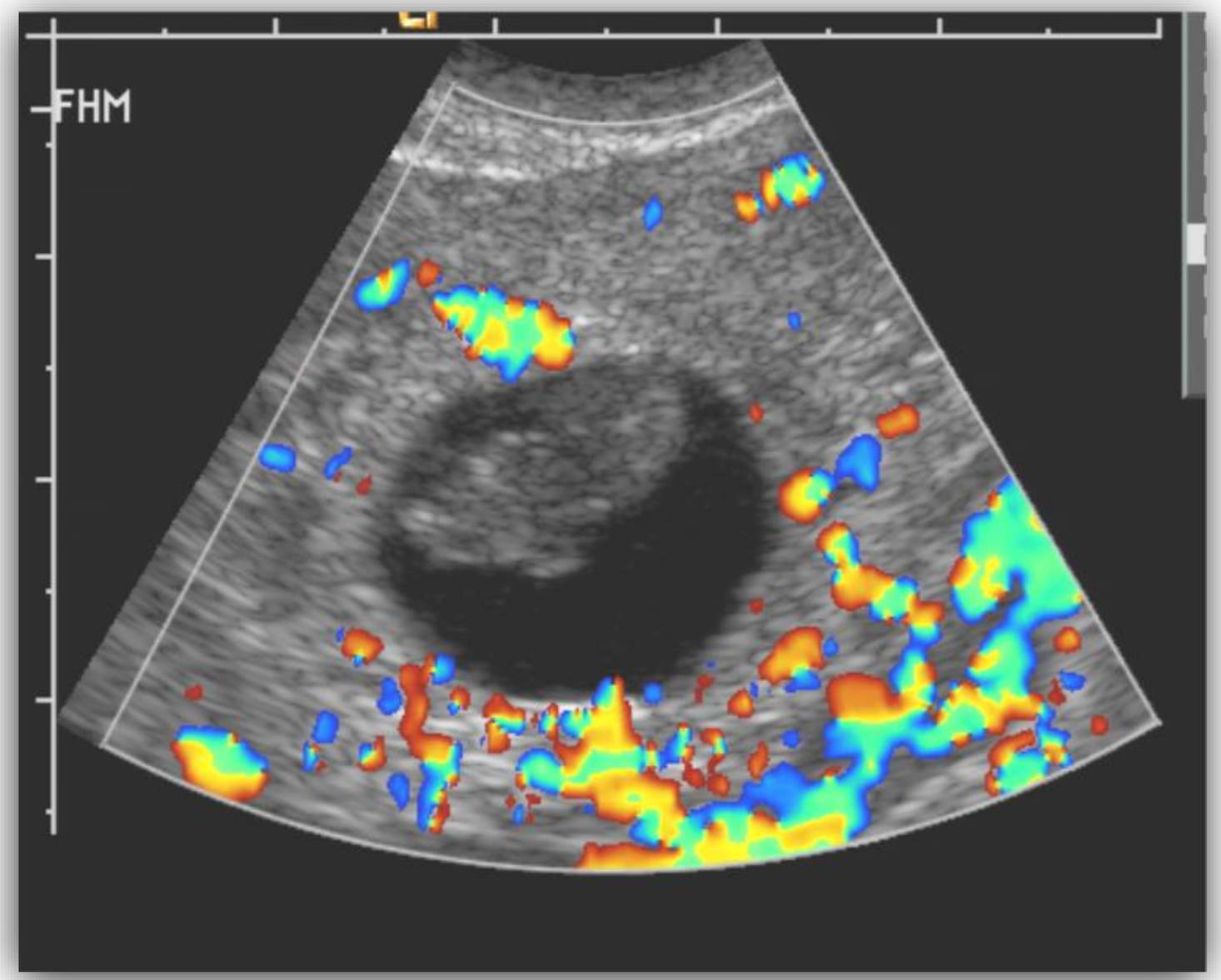
Persistent trophoblastic Doppler

Missed Abortion

- The presence of an embryo or POCs in the uterine cavity without evidence of CVA which may be retained long after the demise

- Clinical signs include:
  - hCG levels less than expected for dates
  - Loss of pregnancy symptoms
  - Decrease in uterine size
  - Brownish vaginal discharge without frank bleeding

MISSED ABORTION



Absence of CVA

Threatened Abortion

- A condition in which the future of the pregnancy may be in jeopardy but the pregnancy continues. It is NOT a sonographic diagnosis
- Clinical signs include:
  - Closed cervix
  - Slight bleeding or cramping

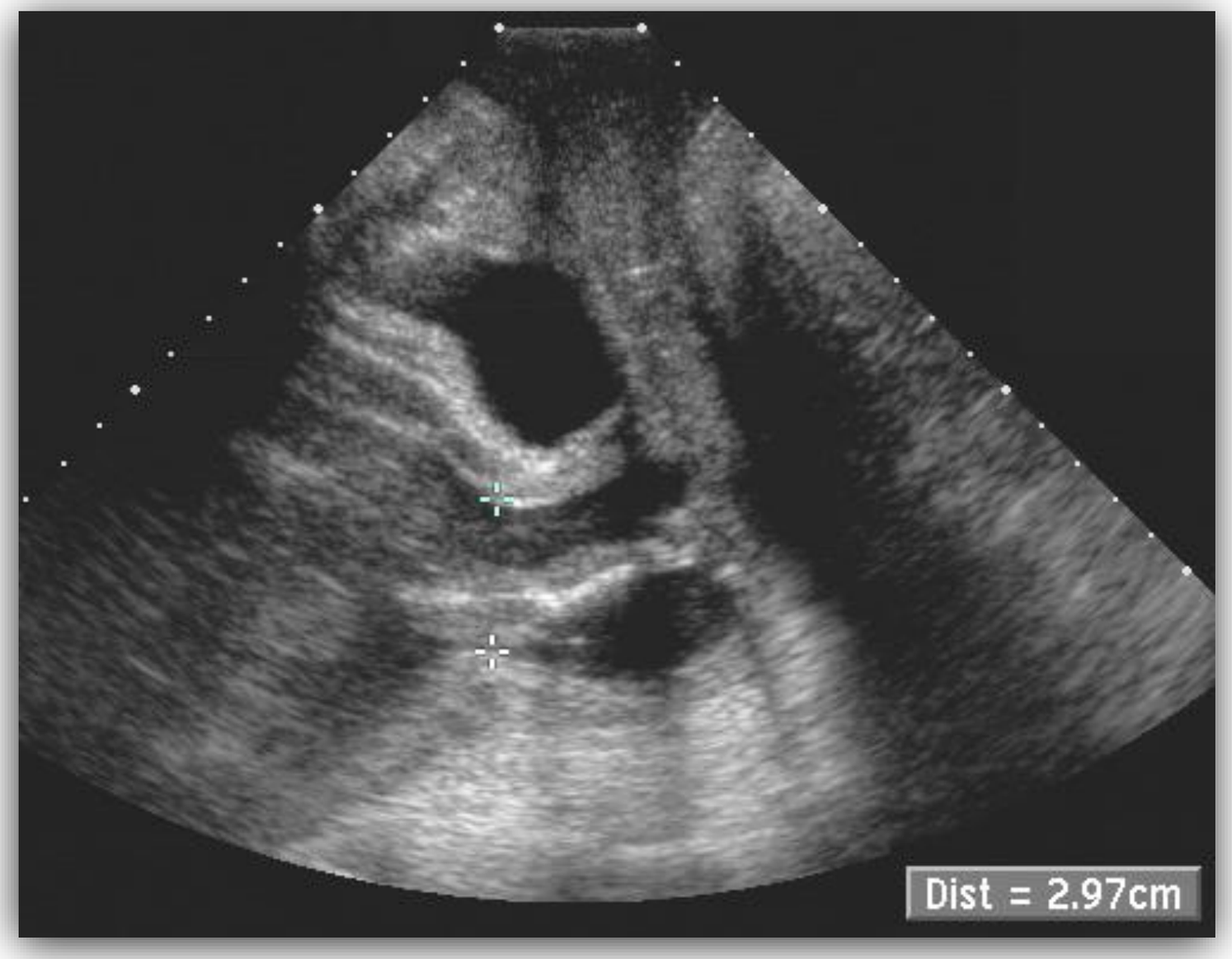
Inevitable Abortion

- A SAB is imminent when any two or more of the following clinical signs are present:
  - Moderate effacement of the cervix
  - Cervical dilation > 3 cm
  - Rupture of membranes
  - Bleeding for > 7 days
  - Persistent cramping

INEVITABLE ABORTION

Dilated cervix

INEVITABLE ABORTION



Dilated cervix

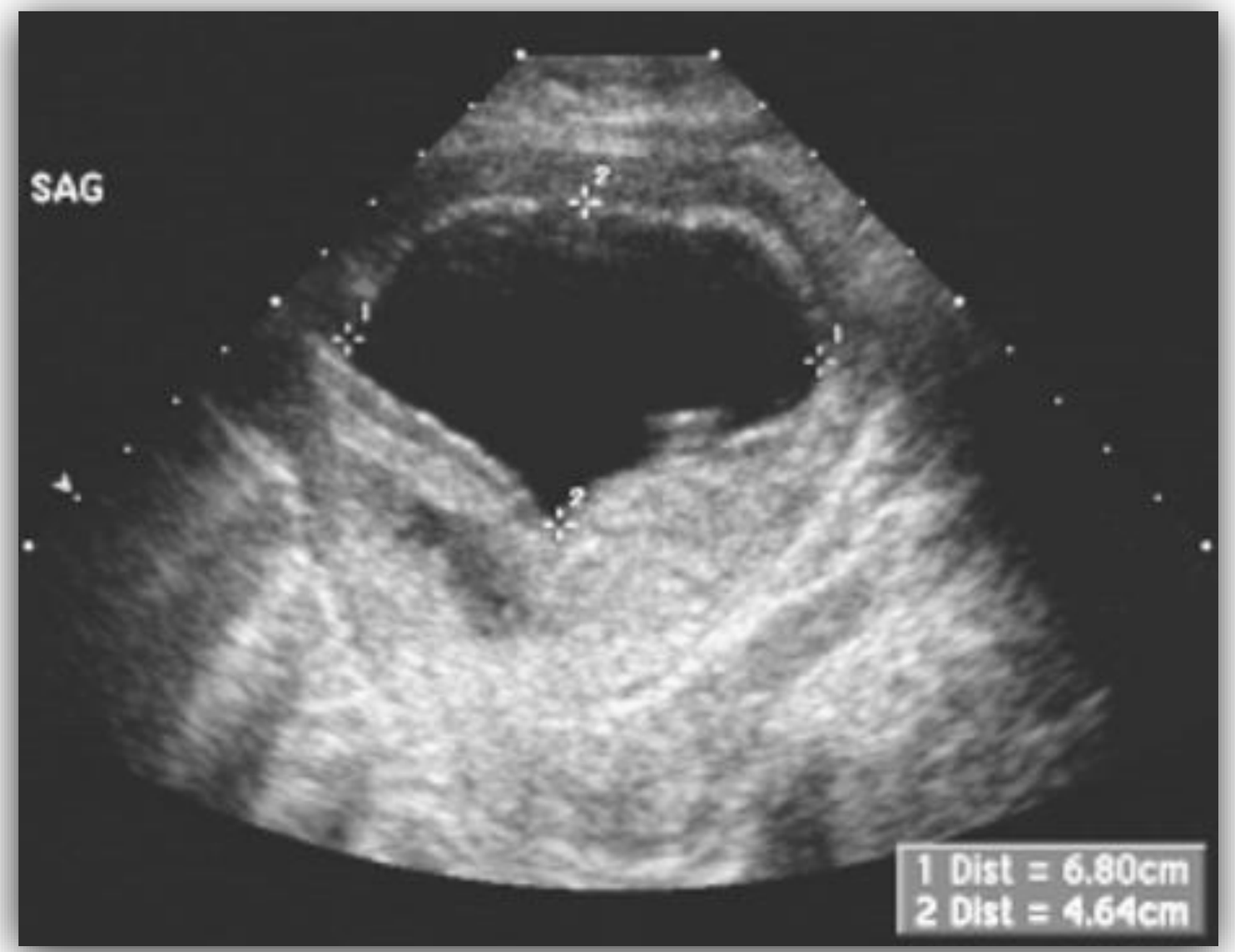
Anembryonic Pregnancy

- An empty intrauterine gestational sac resulting from embryonic demise or failure to develop at a very early stage. Formerly known as "*blighted ovum*".
- Clinical signs include:
  - Uterus small for dates
  - Variable hCG levels (may rise normally, then plateau or fall off)
  - Vaginal spotting
  - Closed cervix

Anembryonic Pregnancy

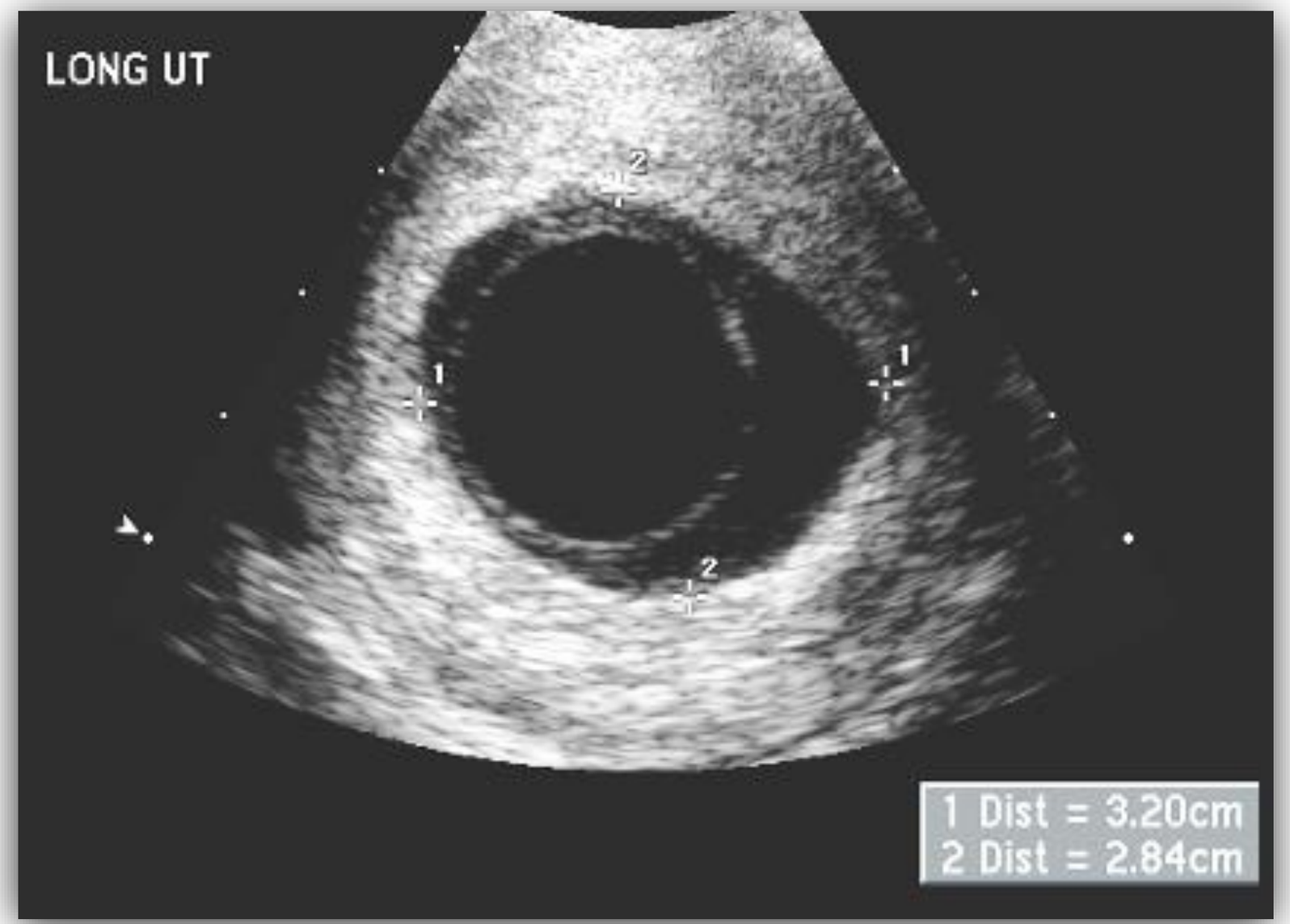
- Sonographic findings include:
  - No identifiable embryo in a gestational sac > 25 mm
  - Absence of the “double sac sign”

ANEMBRYONIC PREGNANCY



Absent embryo in sac > 25 mm

ANEMBRYONIC PREGNANCY



Absent embryo in sac > 25 mm

ANEMBRYONIC PREGNANCY

Absent embryo in sac with adjacent yolk sac

Gestational Trophoblastic Disease

- Results from excessive proliferation of trophoblastic tissue
- Excessive paternal genetic material
- Spectrum includes:
  - Complete hydatidiform mole
  - Partial mole
  - Mole with coexisting fetus
  - Invasive mole
  - Uterine choriocarcinoma

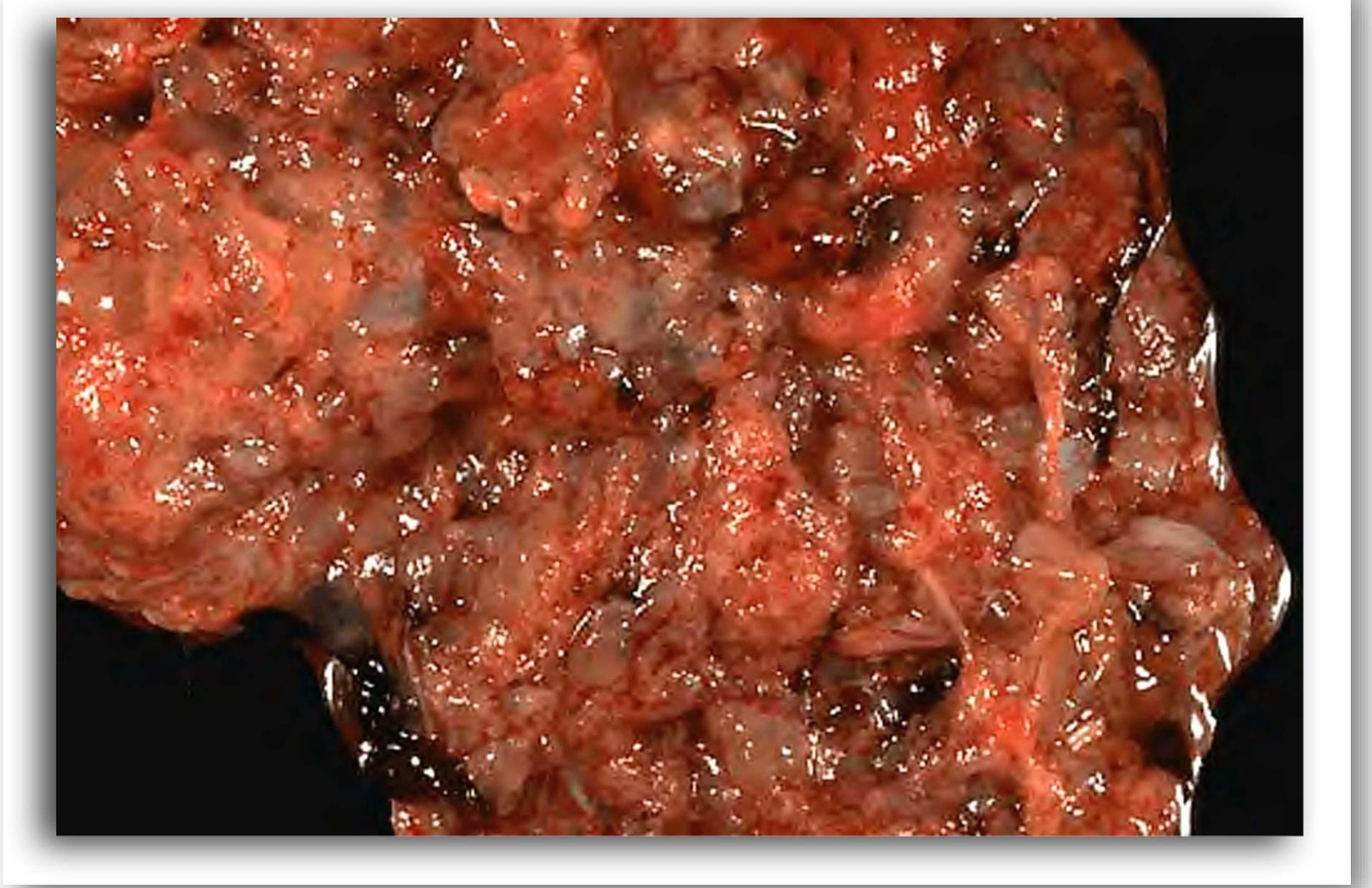
Clinical Signs

- Frequently pathognomonic of GTD:
  - **Markedly elevated serum beta hCG levels**
  - **Hyperemesis gravidarum**
  - Rapid enlargement of the uterus
  - Expulsion of vesicles *per vaginum*
  - Vaginal bleeding in the 1st trimester
  - Absence of fetal heart tones
  - Theca-lutein cysts in the adnexa
  - Onset of pre-eclampsia
  - Hyperthyroidism

Complete Hydatidiform Mole

- Most common form of GTD occurring at the rate of 1:1,500 pregnancies in the USA
- Pathologically, the chorionic villi are diffusely hydropic ("vesicular" appearance)
- No identifiable embryonic tissue is present
- Risk factors include:
  - > 20 and > 40 years of age
  - Low economic status
  - A diet deficient in protein and folic acid

COMPLETE HYDATIDIFORM MOLE



Gross pathology: “vesicular” appearance

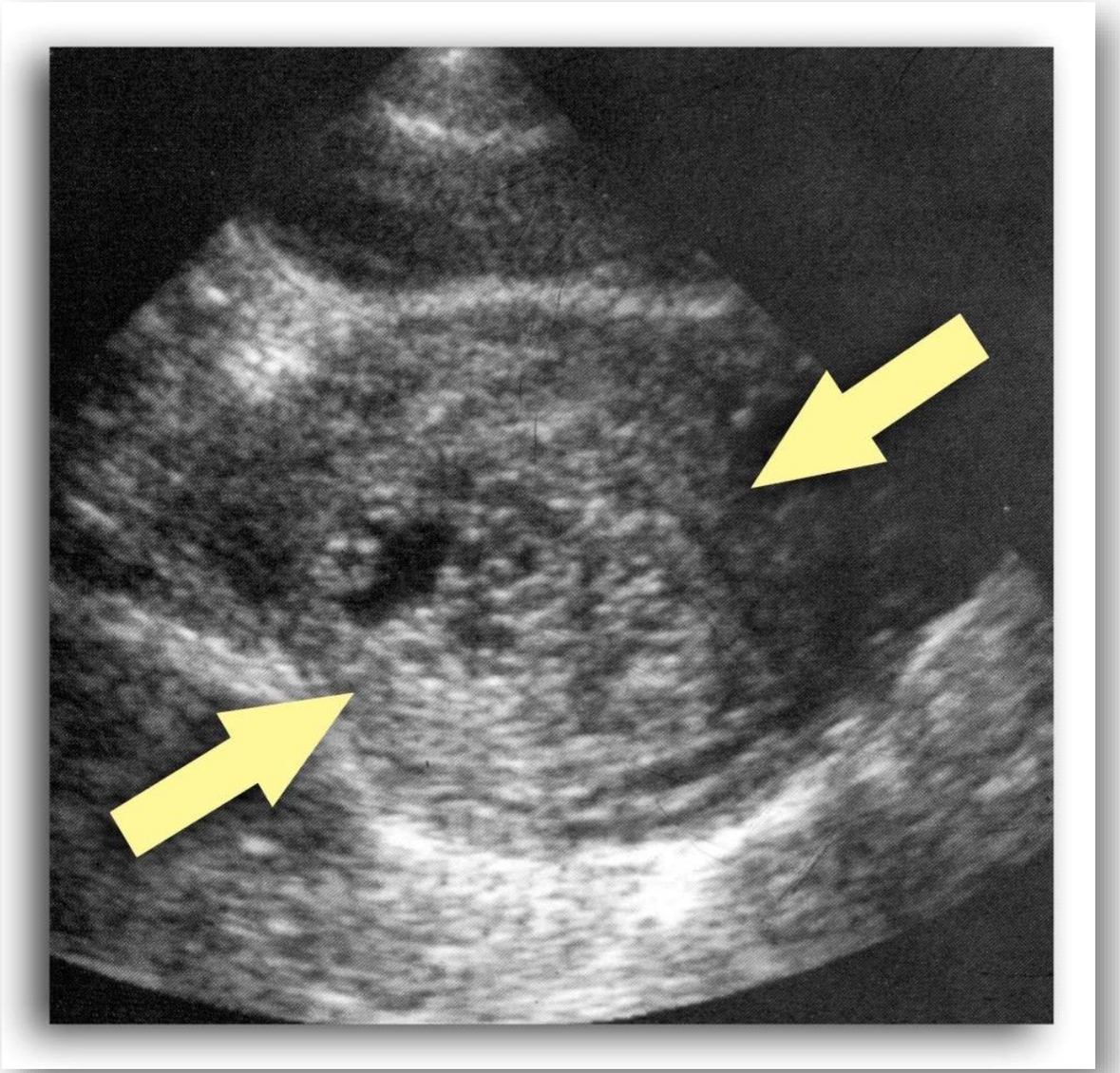
Sonographic Findings

- First trimester include:
  - Filling of the uterine cavity with echogenic, heterogenous material
  - Vesicular appearance of uterine contents
  - Possible fluid collections around the molar tissue
  - Appearance similar to a degenerating myoma
  - Adnexal theca-lutein cysts
    - Large, multi-septated cystic enlargement of ovarian follicles in response to excessive levels of hCG

Sonographic Findings

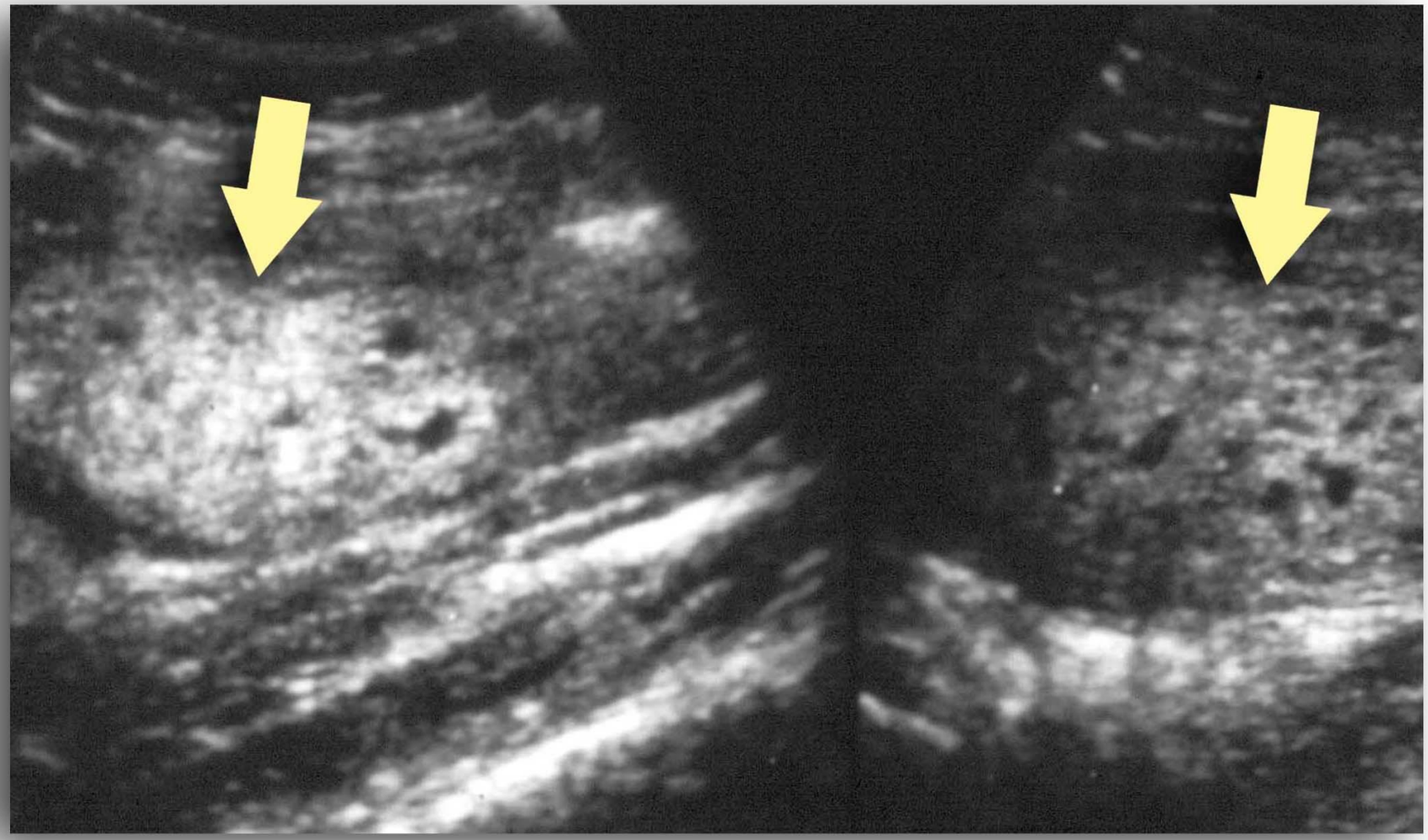
- Second trimester include:
  - Filling of the uterine cavity with heterogenous and hypoechoic areas
  - Increased uterine size
  - Adnexal theca-lutein cysts

COMPLETE HYDATIDIFORM MOLE



Echogenic filling of uterine cavity

COMPLETE HYDATIDIFORM MOLE



Vesicular appearance

COMPLETE HYDATIDIFORM MOLE

Theca-lutein cysts

COMPLETE HYDATIDIFORM MOLE

Theca-lutein cysts

Partial Mole

- Incomplete degeneration of a conceptus into trophoblastic tissue
- Pathologically, two types of chorionic villi are present – normal and hydropic
- Fetal and/or embryonic tissue is frequently identified
- Grossly abnormal fetus with triploidy malformations including:
  - Syndactyly
  - Hydrocephaly
  - IUGR

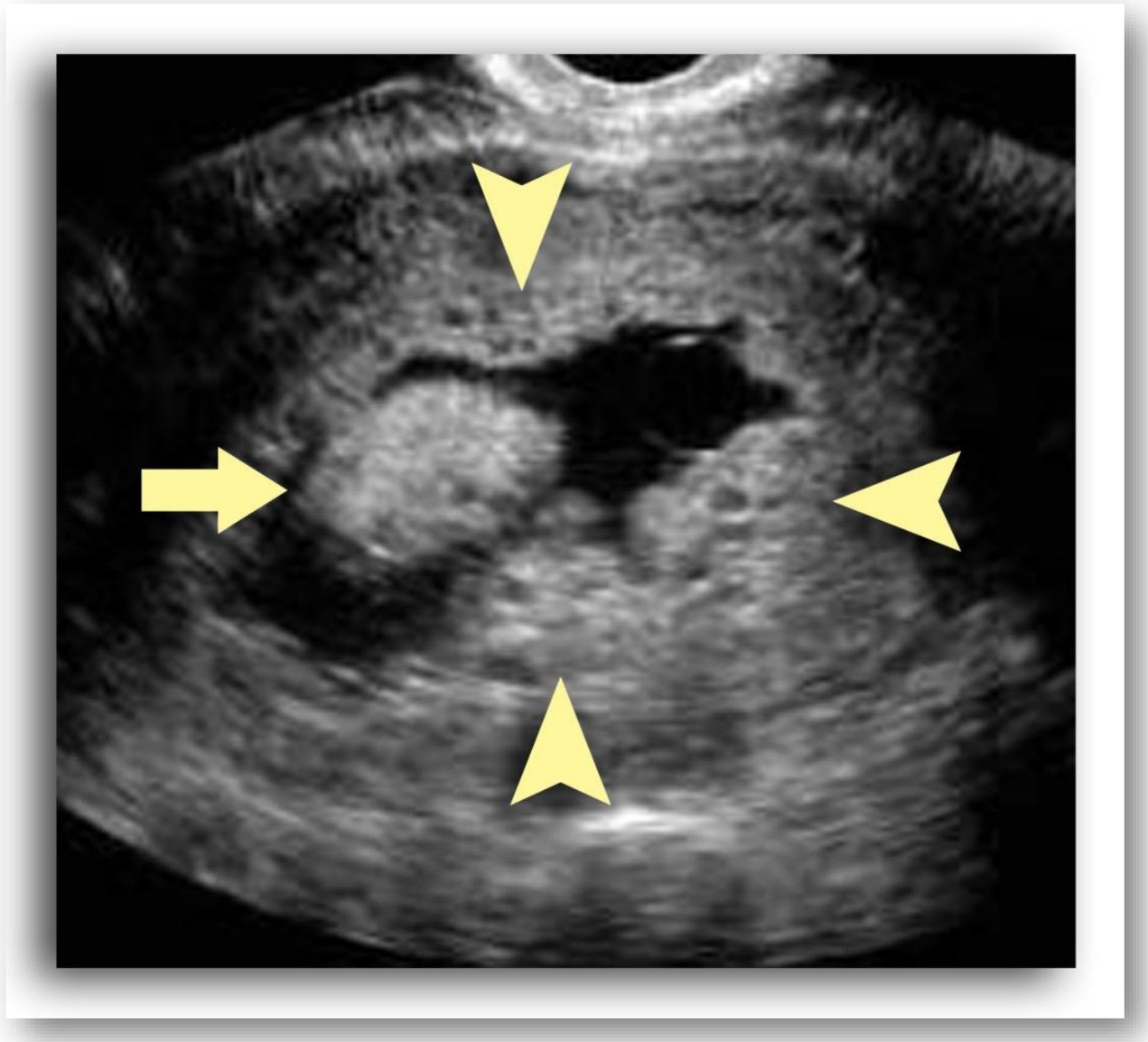
Sonographic Findings

- Grossly enlarged placenta with variously sized cystic foci
- Focal or diffuse areas of increased echogenicity in or about the placenta
- Presence of coexisting fetal tissue
- Grossly abnormal fetus (triploidy malformations)

PARTIAL MOLE

Normal and hydropic villi

PARTIAL MOLE



Abnormal placenta echogenicity with coexisting fetal tissue

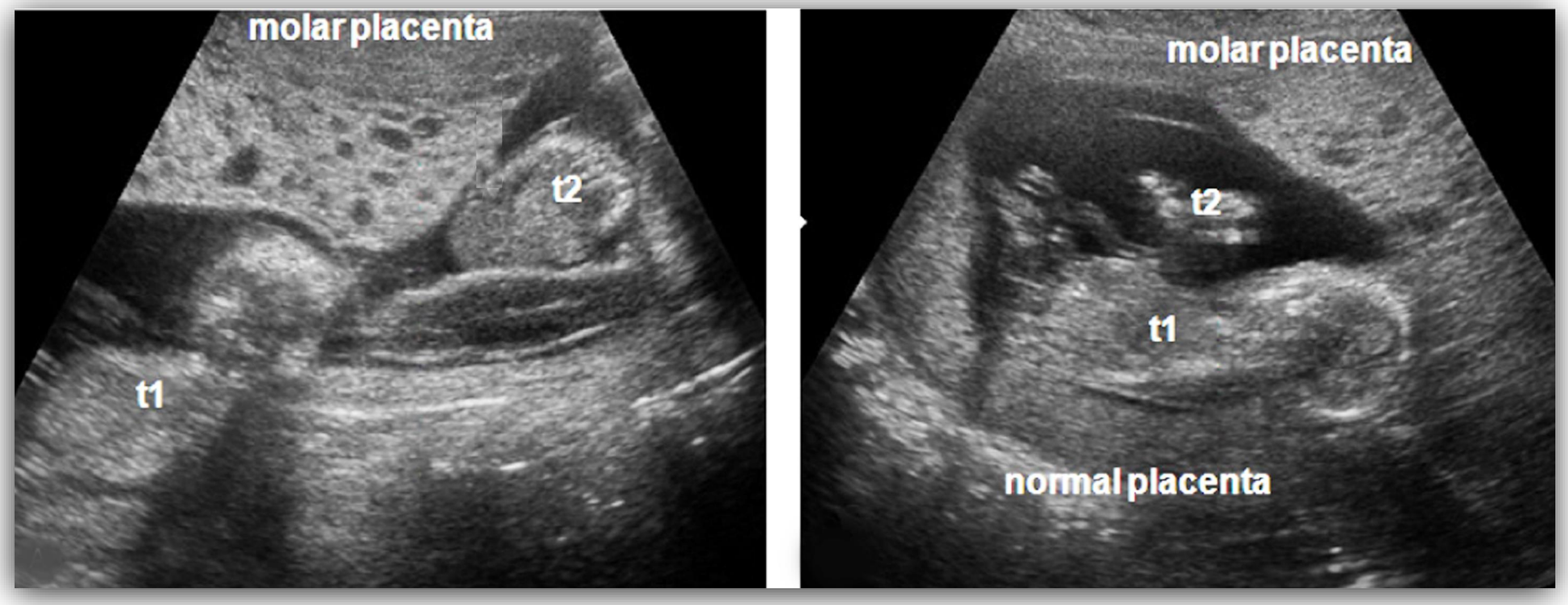
Mole with Coexisting Fetus

- Two conceptions occur. One develops normally, the other develops into a molar pregnancy
- Fetus typically has normal karyotype
- Rare occurrence. 1:10,000 – 1:100,000 pregnancies

Sonographic Findings

- Similar to partial mole
- Fetus has a normal karyotype and normal placentation

MOLE WITH COEXISTING FETUS



Mole with coexisiting fetus – twin pregnancy

Gestational Trophoblastic Neoplasia

- A spectrum of pathological entities that most commonly follows GTD but can also occur after a normal term delivery
- Recurrent GTD carries significant malignant potential
- Pathological classification of GTN includes:
  - Invasive mole
  - Uterine choriocarcinoma
  - Placental site trophoblastic tumors

Gestational Trophoblastic Neoplasia

- Typical clinical scenario:
  - History of molar pregnancy evacuation
  - Returns for regular serum hCG surveillance
  - An elevation during this period suggests recurrence of proliferation of trophoblastic tissue
  - Additional clinical and US evaluation is warranted

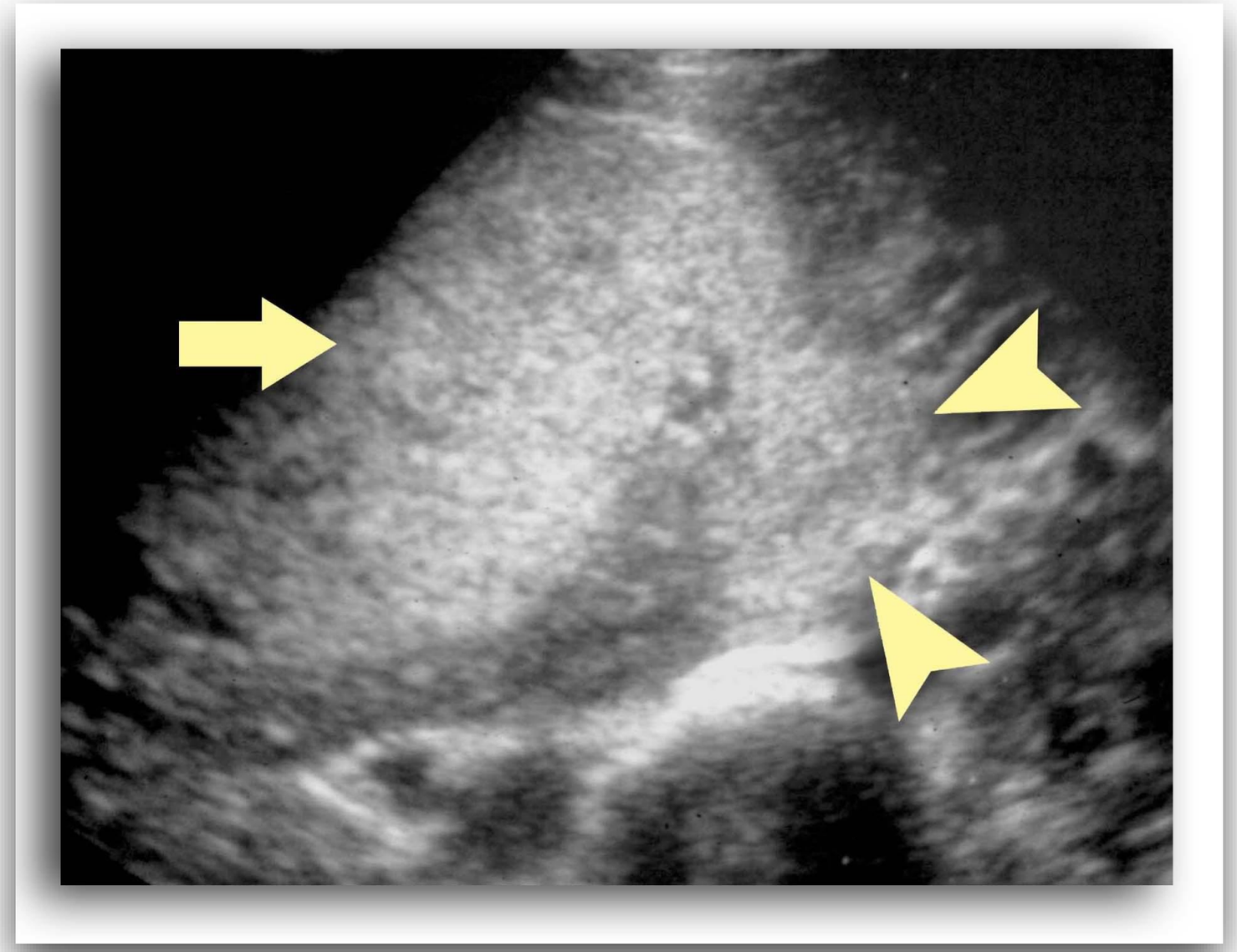
Invasive Mole

- Abnormal trophoblastic tissue invades the myometrium and/or adjacent anatomic structures
- Also called *chorioadenoma destruens*
- Carries potential for significant clinical sequelae from tissue invasion and potential uterine rupture
- Considered a malignant, non-metastatic form of GTD
- Follows molar pregnancy in ≈ 50% of cases

Sonographic Findings

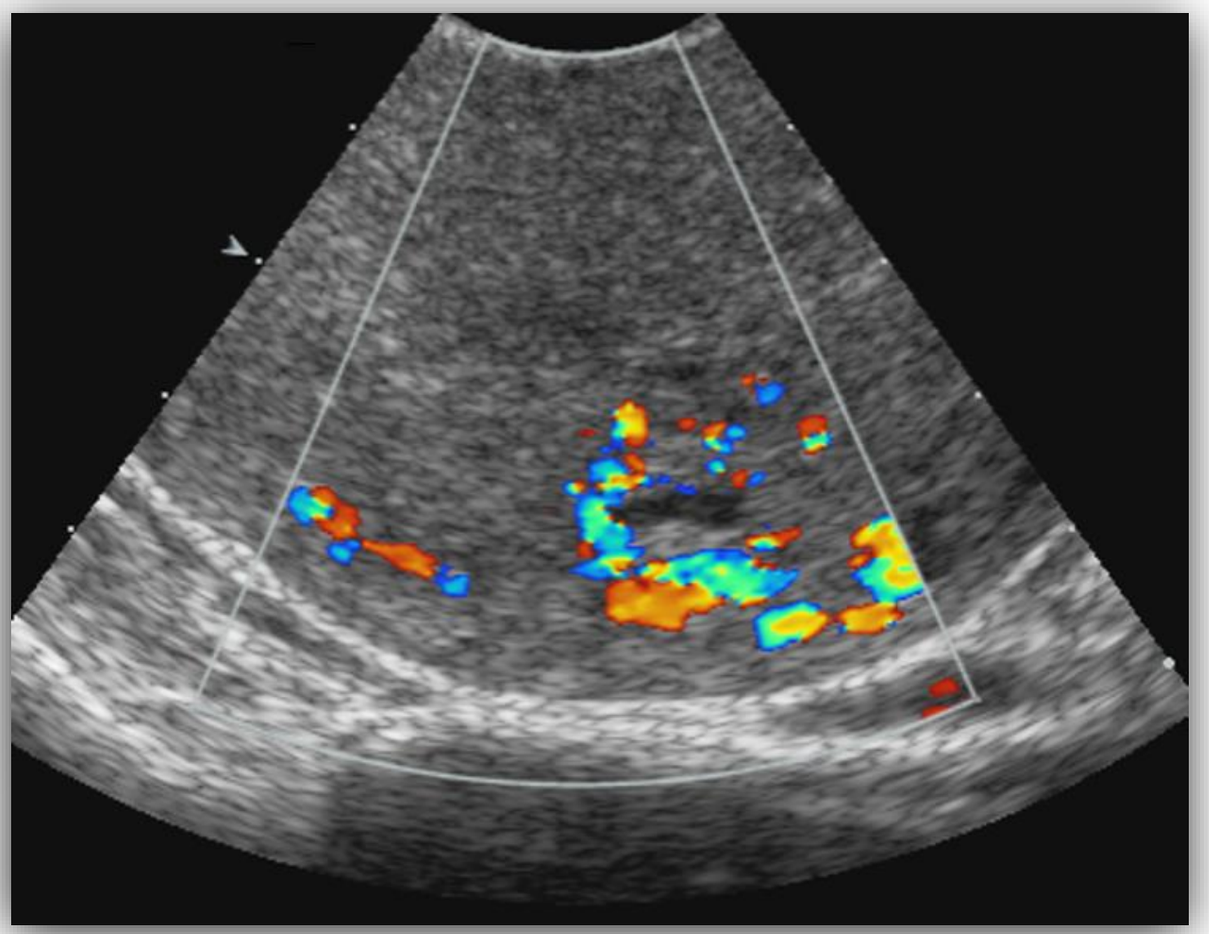
- Presence of focal or diffuse echogenic material within the uterine cavity
- Possible extension into myometrium
- Irregular, sonolucent areas around trophoblastic material
- Adnexal theca-lutein cysts

INVASIVE MOLE



Trophoblastic material invading myometrium

INVASIVE MOLE



CDI demonstrating typical trophoblastic flow patterns

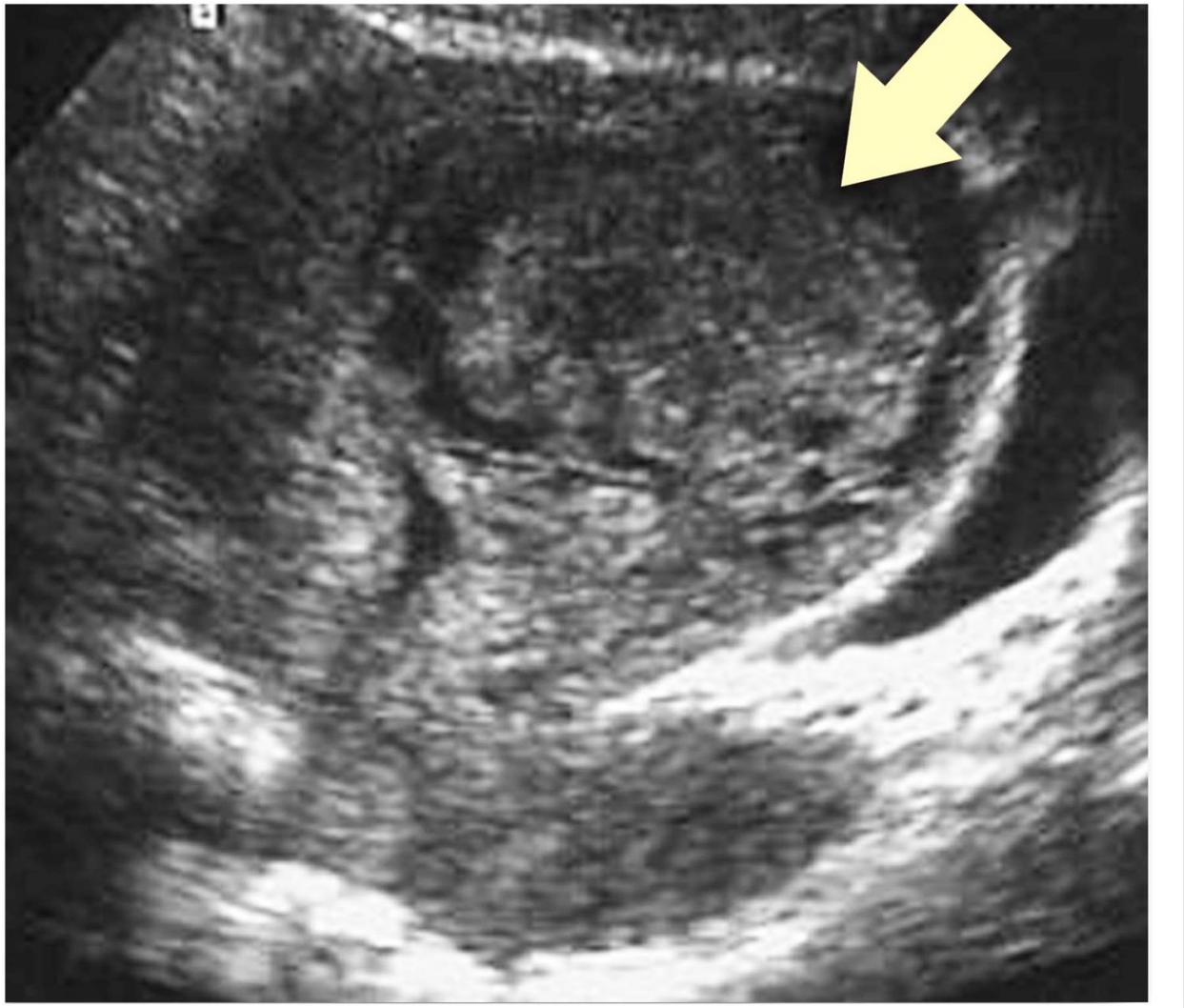
Uterine Choriocarcinoma

- Rare form of GTN occurs in 5% of GTD cases
- Pathologically is a purely epithelial tumor composed of syncytio- and cytotrophoblastic cells.
- No hydropic villi present
- Considered malignant, metastatic form of GTD
- Arises in ≈ 1:40 patients with previous molar pregnancy
- May also arise after ectopic pregnancy

Sonographic Findings

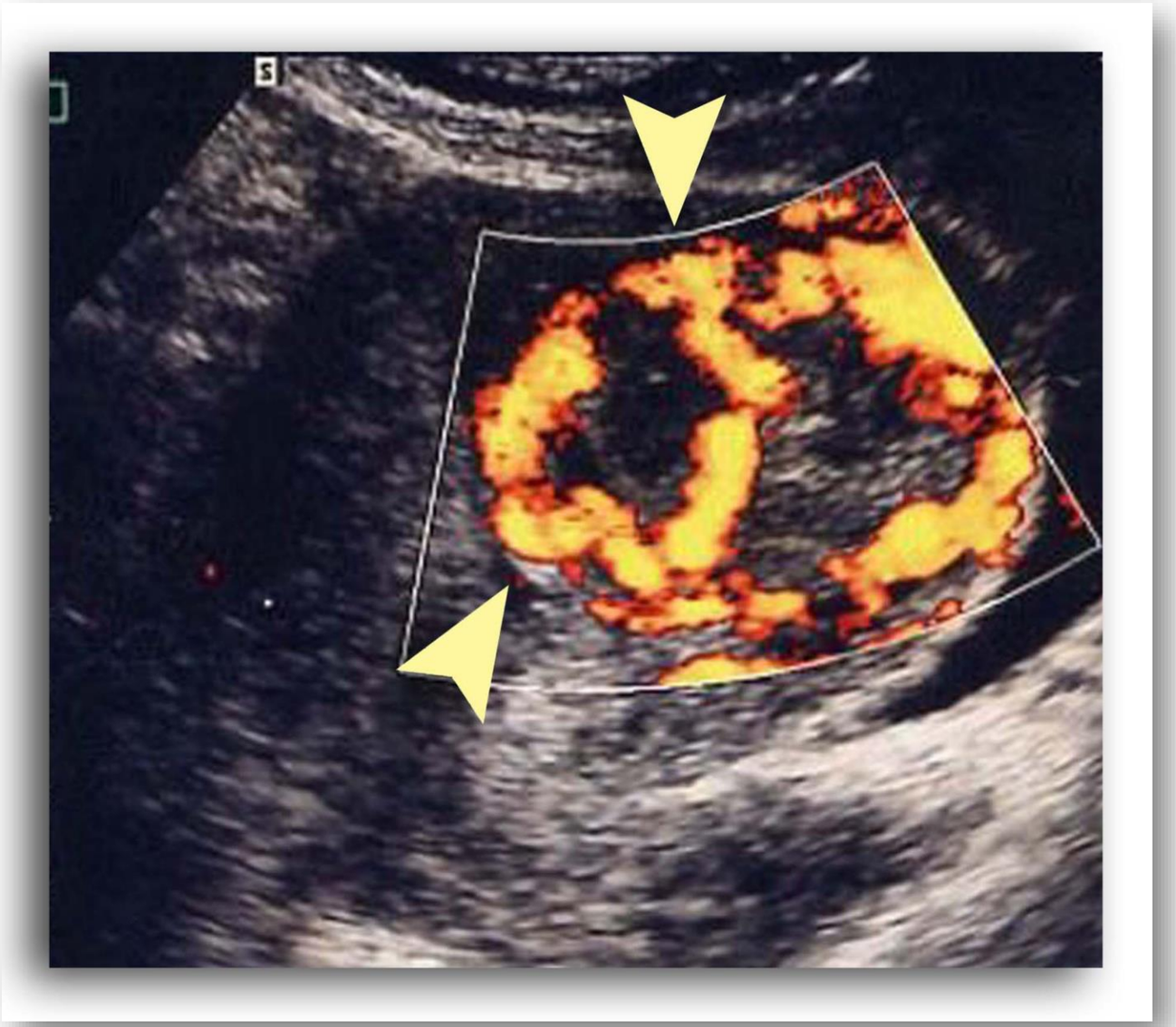
- Enlarged uterus
- Eccentrically situated irregular, complex mass within uterus
- Low-resistance hemodynamic patterns in and around the mass

UTERINE CHORIOCARCINOMA



Complex mass within uterus

UTERINE CHORIOCARCINOMA



Low-resistance Doppler patterns

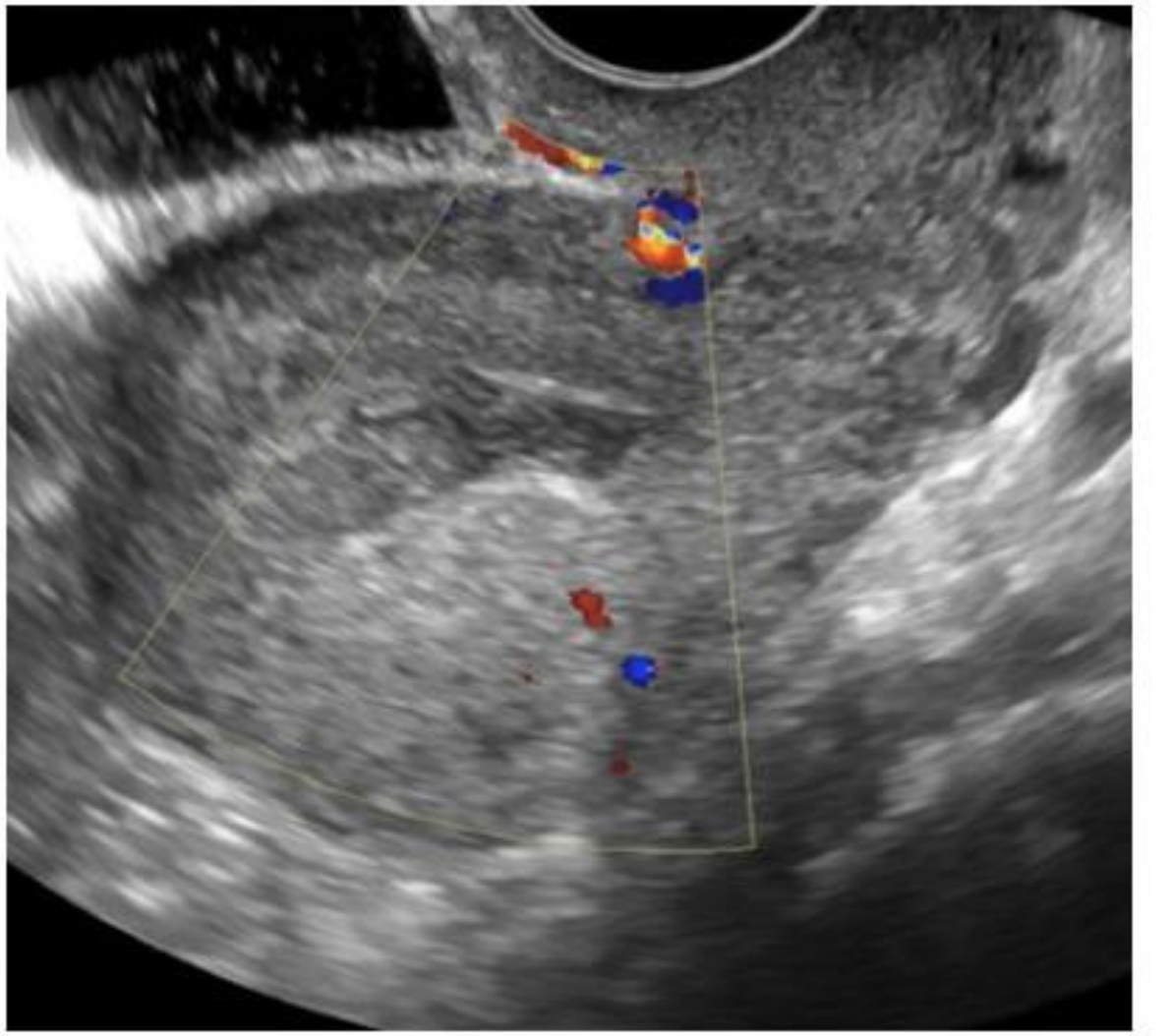
Placental Site Trophoblastic Tumor

- Rare form of GTN that may occur after normal delivery, evacuation of a hydatidiform mole, or terminated pregnancy
- Time to presentation varies widely: between 1 – 14 years
- 30% of patients may present with metastatic lesions at time of diagnosis
- May be benign but carries malignant potential

Sonographic Findings

- Enlarged uterus
- Heterogeneous lesion with the uterus
- Anechoic lacunae surrounding the lesion with low-resistance Doppler hemodynamic patterns
- Findings similar to uterine choriocarcinoma
- Differentiation cannot be made by ultrasound

UTERINE CHORIOCARCINOMA



Heterogenous lesion within uterus

OB GYN SONOGRAPHY REVIEW

The First Trimester