NORMAL FOETAL BIOMETRY AND FOETAL DOPPLER

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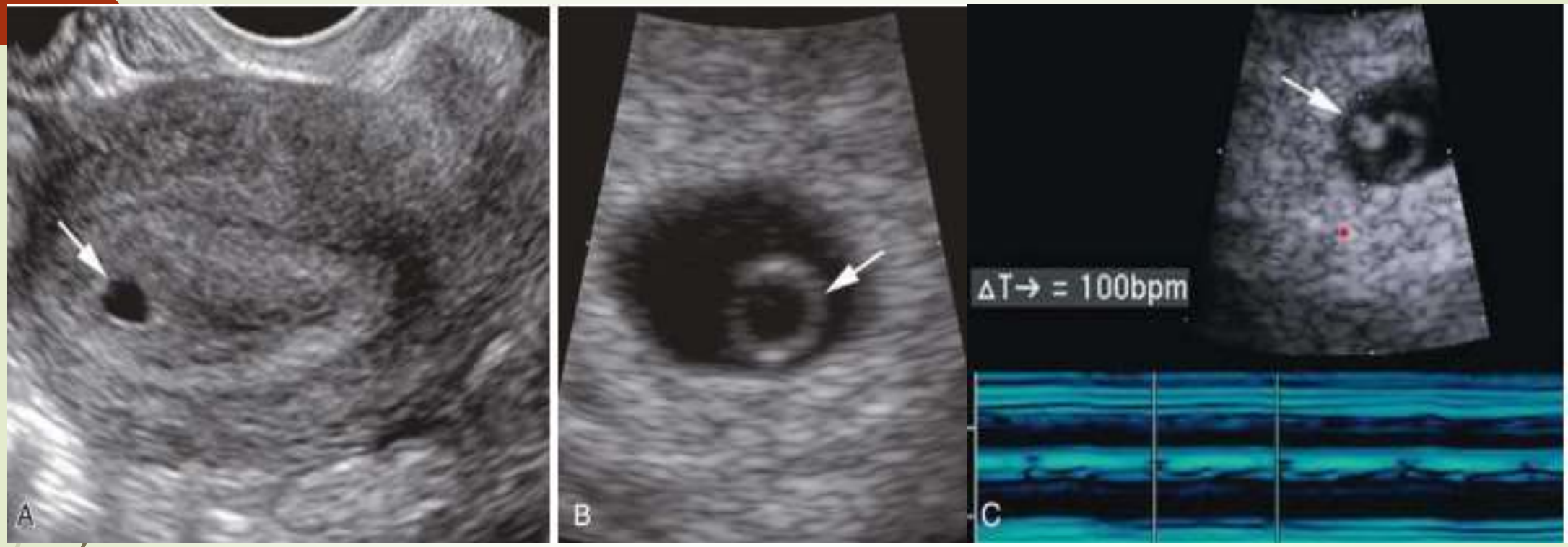
NORMAL FOETAL BIOMETRY

- **Antenatal ultrasound measurements that are used to indirectly assess the growth and well being of the fetus.**
- Sonographic measurements of fetal structures provide an accurate means of determining the age of a pregnancy, estimating fetal weight and assessing the normality of a number of fetal body parts.
- Gestational age - specifying the age of a pregnancy.
- Menstrual age - time elapsed since the first day of the woman's last menstrual period (LMP).
- Estimated due date (EDD) or estimated date of confinement (EDC) – date at which the gestational age of a pregnancy will reach 40 weeks

FIRST TRIMESTER DATING

- Earliest sonographic finding - small rounded intrauterine fluid collection in the central portion of the uterus.
- Intrauterine fluid collection with no visible yolk sac or embryo - gestational age of 5.0 weeks.
- Intrauterine fluid collection contains a yolk sac but no embryo-gestational age of 5.5 weeks.
- The presence of a embryo, less than 2 mm in size, with the embryonic heartbeat visible adjacent to the yolk sac - gestational age of 6.0 weeks.
- Accuracy of early sonographic milestones for dating pregnancy is ±0.5 week



A. small rounded intrauterine fluid collection (arrow) in the central portion of the uterus - 5.0 weeks' gestation.

B, Intrauterine gestational sac containing a yolk sac (arrow)- 5.5 weeks' gestation.

C, Intrauterine gestational sac containing a small embryo with heartbeat (arrow) adjacent to the yolk sac - gestational age of 6.0 weeks.

DATING BY CRL

- From the time the embryo is visible until the end of the first trimester, dating is based on the length of the embryo or fetus - measured from the top of the head to the bottom of the rump – CRL.
- Fetus should be in neutral position, neither hyperextended nor hyper flexed, the chin tucked against the chest.
- Calipers should be placed at the top of the fetal head and the bottom of the rump, not to include the yolk sac or lower extremities in the measurement.

Crown-rump length measurement. gestation sac with crown-rump length measured (calipers).
The yolk sac (arrow) adjacent to the fetus not included in the crown-rump length measurement

CRL measurement

SECOND AND THIRD TRIMESTER DATING

Most commonly used measurements

- Biparietal diameter (BPD)
- Head circumference (HC)
- Abdominal circumference (AC)
- Femur length (FL)

Femur length, together with biparietal diameter, head circumference, and abdominal circumference, are computed to produce an estimate of fetal weight.

BPD and HC measurements

- Measured on an axial image of the fetal head at the level of the paired thalami, third ventricle, and cavum septum pellucidum
- The BPD is measured from leading edge to leading edge of the calvarium - at the outer edge of the bony calvarium to the inner edge of the bony calvarium.

HC - measured by using elliptical calipers, outline the outer edge of the skull

Alternatively, HC may be calculated from BPD and occipitofrontal diameter (OFD)
HC = 1.62 × (BPD + OFD)

The cerebellar hemispheres should not be in the plane of the image.

Axial image of fetal head at the level of the paired thalami (arrows), third ventricle, and cavum septum pellucidum (arrowhead), with biparietal diameter (calipers 1)

Head circumference measured with elliptical caliper tracing (dotted line)

BPD and HC measurements

Abdominal circumference measurement

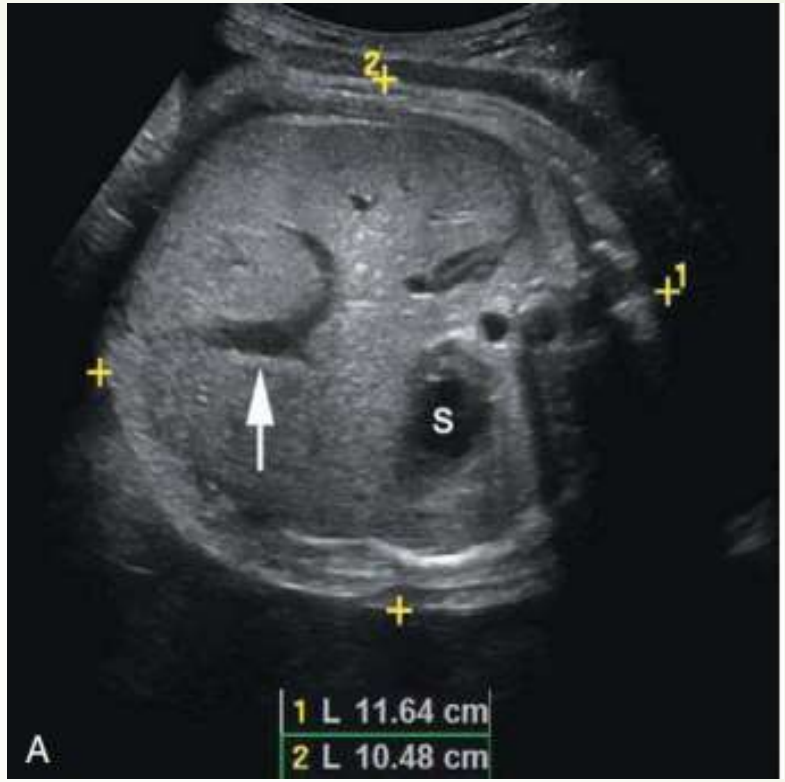
- On an axial image of the fetal abdomen, landmarks includes

Stomach

umbilical vein

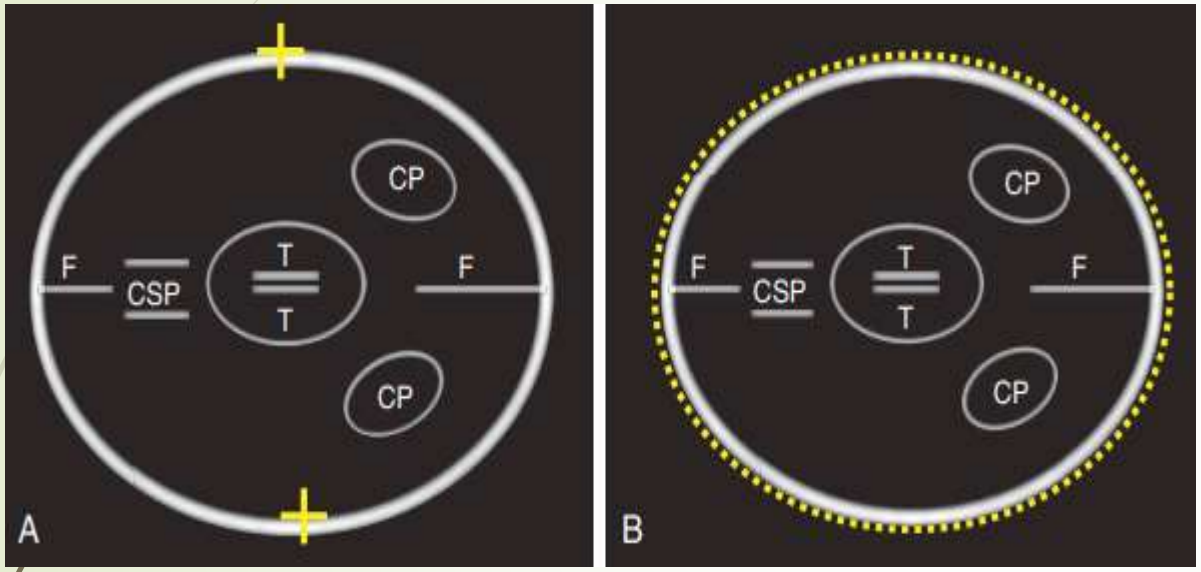
Portal sinus

- The abdomen should be as round as possible and the outer skin surface should be visible all the way around.
- For the AC , elliptical calipers outlining the outer surface of the skin around the abdomen

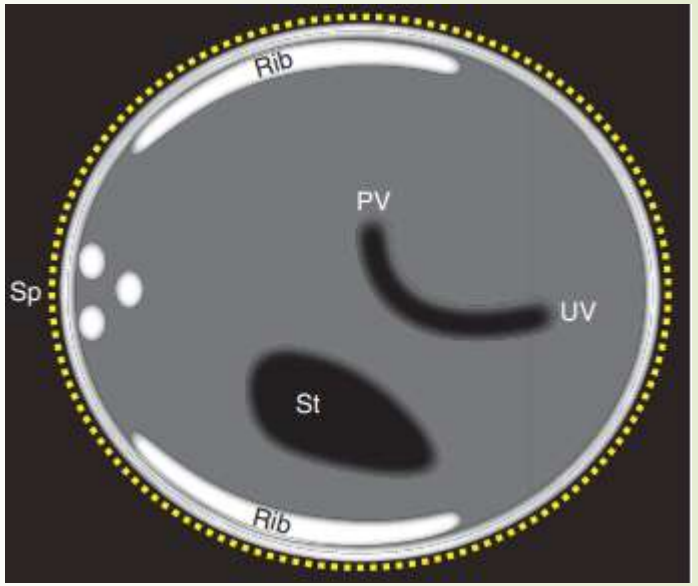


A, Axial image of the fetal abdomen at the level of the stomach (S) and intrahepatic portion of the umbilical vein (arrow)

Schematic Representation of BPD, HC and AC



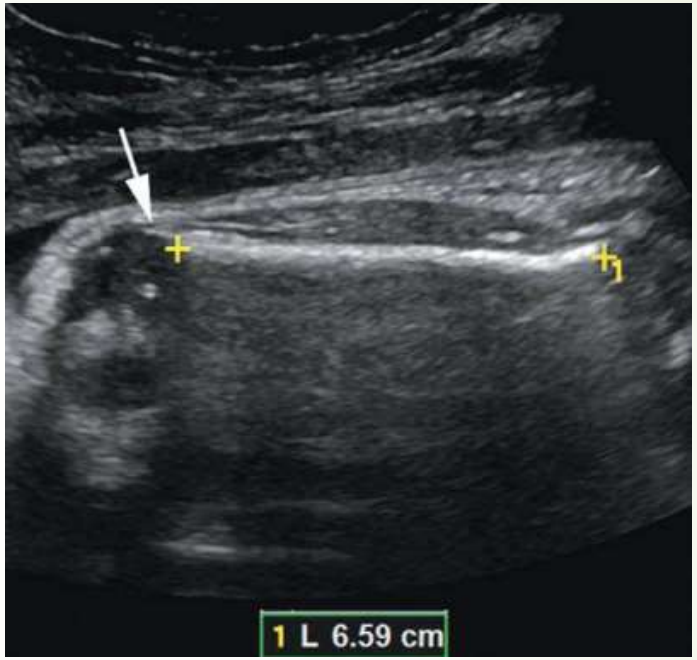
Anatomy at the level of appropriate measurement of the fetal biparietal diameter (A) and head circumference (B). CP, choroid plexus; CSP, cavum septum pellucidum; F, falx; T, thalami.



Anatomy at the level of appropriate measurement of the fetal abdominal circumference. PV; Sp, spine; St, stomach; UV, umbilical vein.

FEMUR LENGTH MEASUREMENT

- Measurement of the femoral diaphysis
- **Transducer aligned along the long axis of bone,** Image the femur as perpendicular to the ultrasound beam as possible.
- Placing the calipers at either end of the ossified diaphysis.
- Not to include - any of the femoral epiphysis (appear as a linear projection from the proximal or distal end of the diaphysis)



Sonogram of femur with ossified diaphysis measured (calipers). The linear projection from the diaphysis of the femoral epiphysis (arrow) is not included in the measurement.

Gestational Age in the Second and Third Trimesters

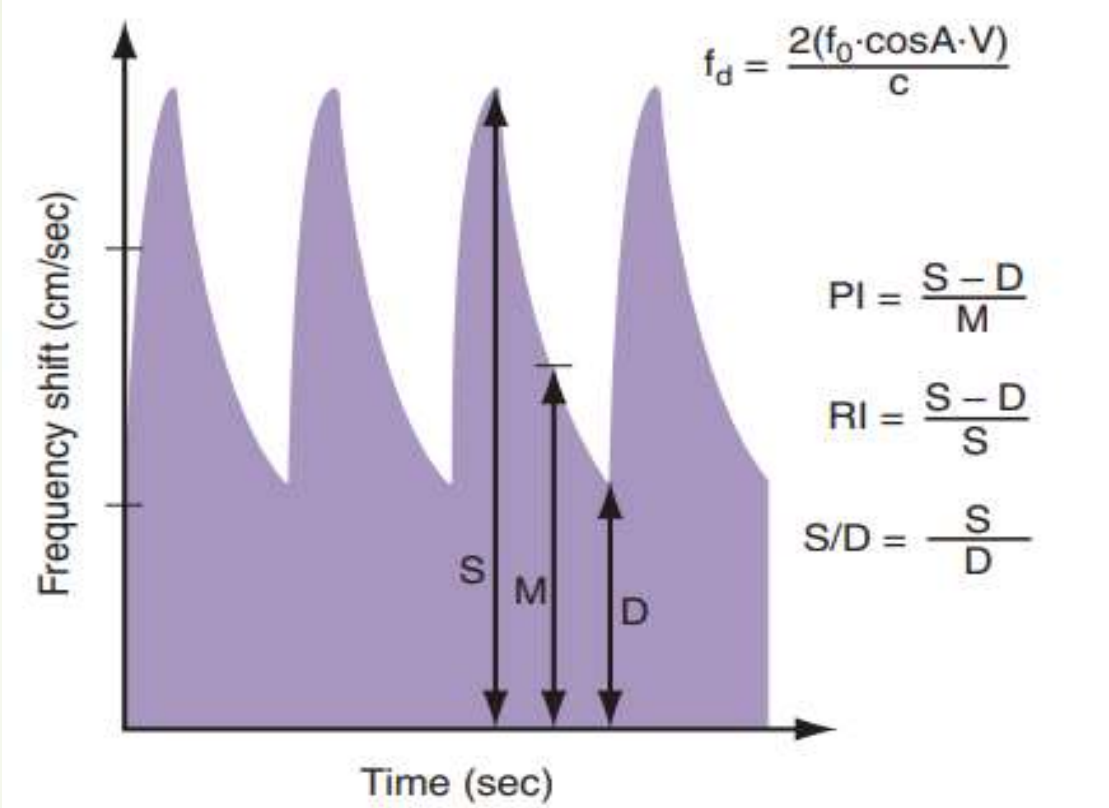
- Gestational age assigned based on a single measurement, such as the BPD, corrected BPD, HC, or FL, or on a combination of measurements.
- Corrected BPD and HC—more accurate than the BPD alone or FL alone in the second trimester.
- Accuracy before 20 weeks is approximately ±1.2 weeks.
- By the third trimester, the accuracy of the FL is similar to that of head measurements.

ERROR

- Accuracy during the second trimester ±1.2 weeks early in this trimester and approximately ±2.0 weeks by the end of the trimester.
- Accuracy during the third trimester - broad error range of more than ±3.0 weeks.

NORMAL FETAL DOPPLER

- The aim is to describe pulsed Doppler ultrasound and its different modalities: spectral Doppler, color flow mapping and power Doppler, commonly used to study the maternal–fetal circulation.
- Uterine arterial Doppler assessment
- umbilical artery Doppler assessment
- Middle cerebral artery assessment
- Ductus venosus waveform

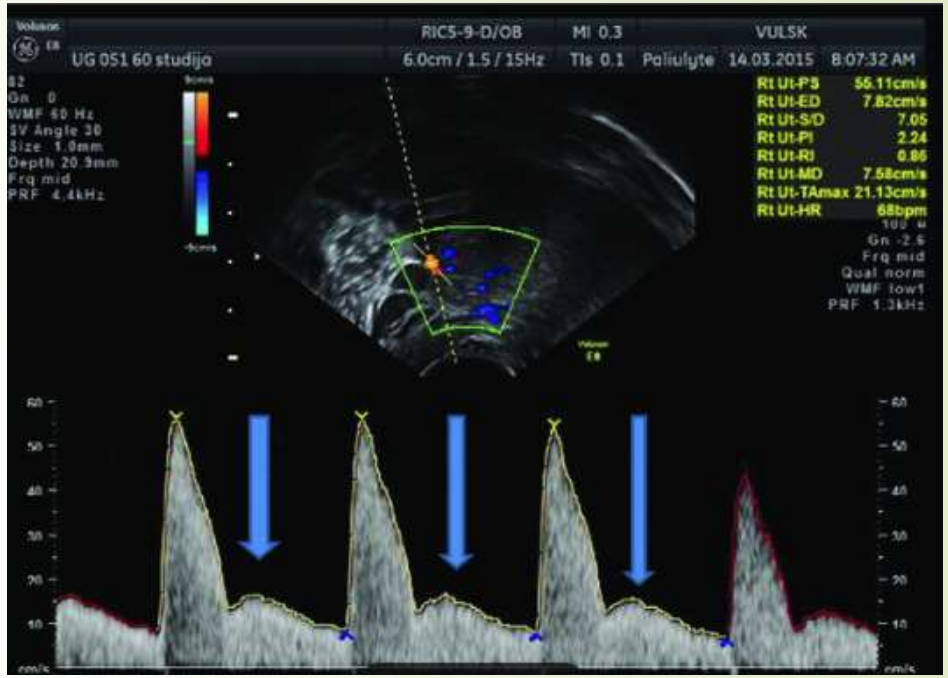


Doppler indices
D, diastole; M, mean; PI, pulsatility index; RI, resistance index; S, systole.

Uterine arterial Doppler assessment

- Using real-time color Doppler ultrasound, the main branch of the uterine artery is located easily at the cervicocorporeal junction.
- Measurements are performed, either transabdominally or transvaginally.
- Measurements reported independently for the right and left uterine arteries, and the presence of notching should be noted.

- Notching is defined qualitatively as reduced early diastolic velocities before the maximum diastolic velocity in the Doppler waveform.
- Notching can be either systolic or diastolic, it is typically seen as a trough-like notch between the systolic and diastolic phases.
- Notch can be a normal finding in a non-pregnant uterus and even in a gravid uterus, up to 16 weeks, but notching typically begins to disappear in the gravid uterus by 13 weeks with clearly established diastolic flow by 20 weeks secondary due to greater trophoblastic invasion of the myometrium blood flow gradually drops during gestation. An abnormally high resistance can persist in pre-eclampsia and IUGR.



Notching of Uterine Artery

Uterine arterial Doppler

The parameters used in the assessment of uteroplacental blood flow include:

- **RI** = resistive index
- **PI** = pulsatility index
- presence of persistent diastolic notching

Resistive index (RI)

- **RI = (PSV-EDV) / PSV** = (peak systolic velocity - end-diastolic velocity) / peak systolic velocity
- normal (low resistance) RI <0.55
- high resistance
  - bilateral notches RI >0.55
  - unilateral notches RI >0.65

Pulsatility index (PI)

- **PI = (PSV - EDV) / TAV** = (peak systolic velocity - end-diastolic velocity) / time-averaged velocity

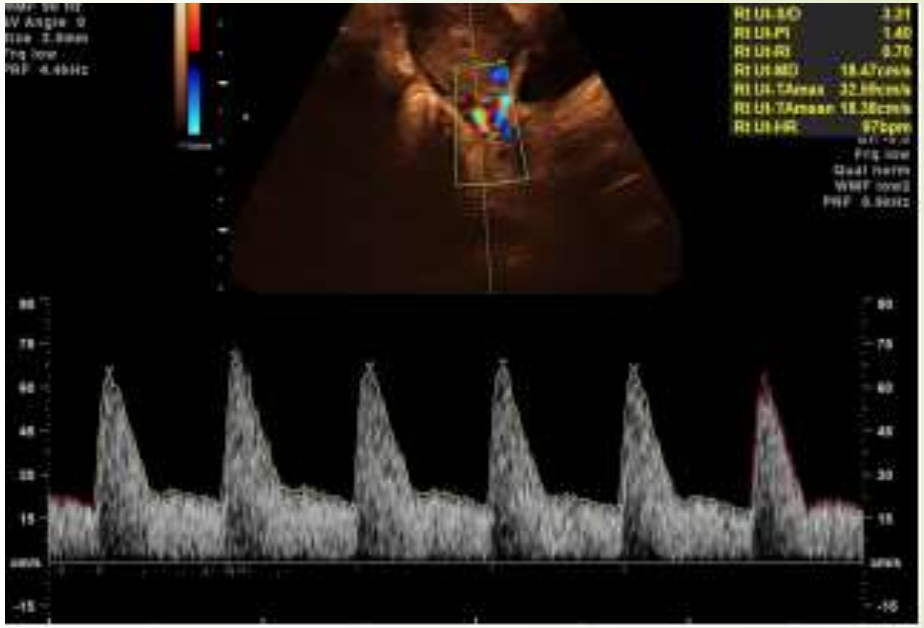
Abnormal patterns include

- persistence of a high resistance flow throughout pregnancy
- persistence of notching throughout pregnancy
- reversal of diastolic flow throughout pregnancy: severe state

First-trimester uterine artery evaluation

1. Transabdominal technique

- a mid-sagittal section of the uterus is obtained, and the cervical canal is identified.
- The probe is then moved laterally until the paracervical vascular plexus is seen.
- Color Doppler is turned on and the uterine artery is identified as it turns cranially, to make its ascent to the uterine body



Waveform from uterine artery obtained transabdominally in first trimester.

2. Transvaginal technique

- empty her bladder and placed in the dorsal lithotomy position.
- Transvaginally, the probe is placed in the anterior fornix.
- Similar to the transabdominal technique, the probe is moved laterally to visualize the paracervical vascular plexus, and the same steps are carried out in the same sequence as for the transabdominal technique.

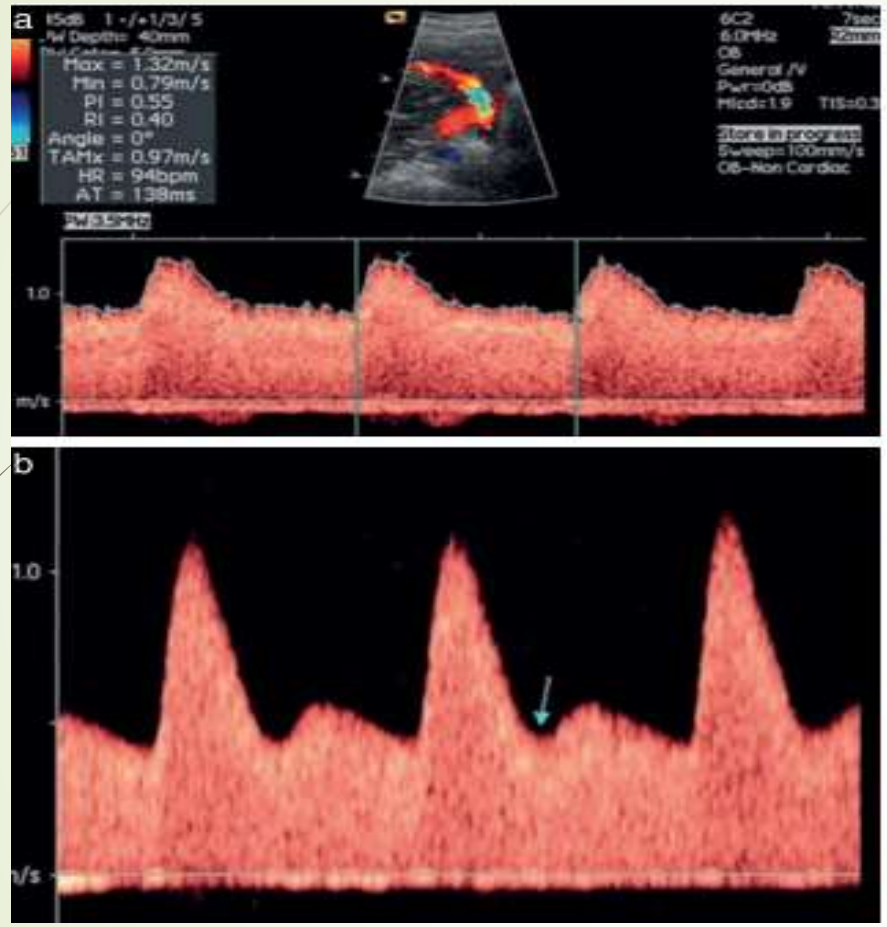
Second- and third-trimester uterine artery evaluation

1. Transabdominal technique

- The probe is placed longitudinally in the lower lateral quadrant of the abdomen, angled medially in the parasagittal plane.
- Color flow mapping is useful to identify the uterine artery as it is seen crossing the external iliac artery.
- The sample volume is placed 1 cm downstream from this crossover point.

2. Transvaginal technique

- empty her bladder
- Placed in the dorsal lithotomy position.
- The probe is placed in the lateral fornix and the uterine artery identified, using color Doppler, at the level of the internal cervical os.
- This should then be repeated for the contralateral uterine artery



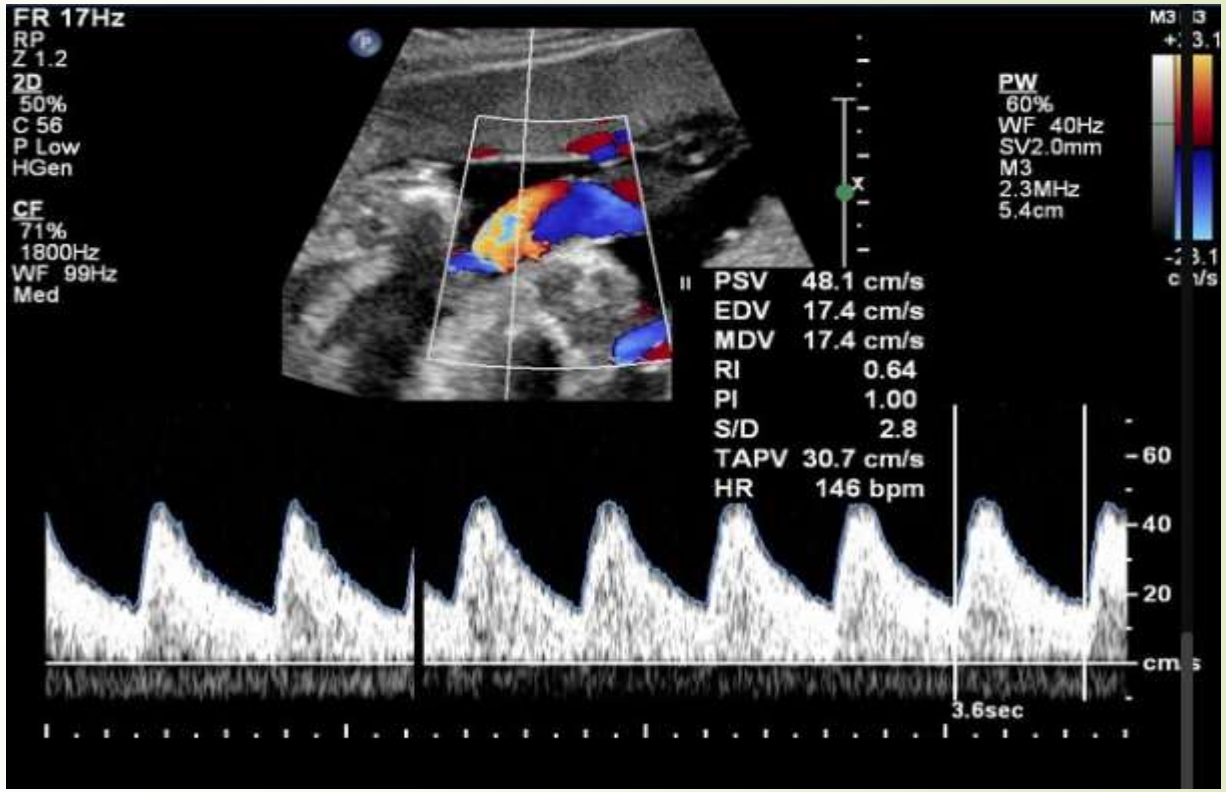
Waveforms from uterine artery obtained transabdominally in second trimester. Normal (a) and abnormal (b) waveforms; note notch (arrow) in Doppler

Umbilical artery Doppler waveforms

- Low-impedance circulation, with an increase in the amount of end-diastolic flow with advancing gestation.
- Reflect the status of the placental circulation
- The increase in end-diastolic flow seen with advancing gestation is a direct result of an increase in the number of tertiary stem villi that takes place with placental maturation.
- There is a significant difference in Doppler indices measured at the fetal end, in a free loop and at the placental end of the umbilical cord.
- Waveforms obtained from the placental end of the cord show more end-diastolic flow thus lower ratio values (resistive index [RI], systole/diastole [S/D] ratio).
- The impedance is highest at the fetal end, and absent/reversed EDV is likely to be seen first at this site.
- For the sake of simplicity and consistency, measurements should be made in a free cord loop.

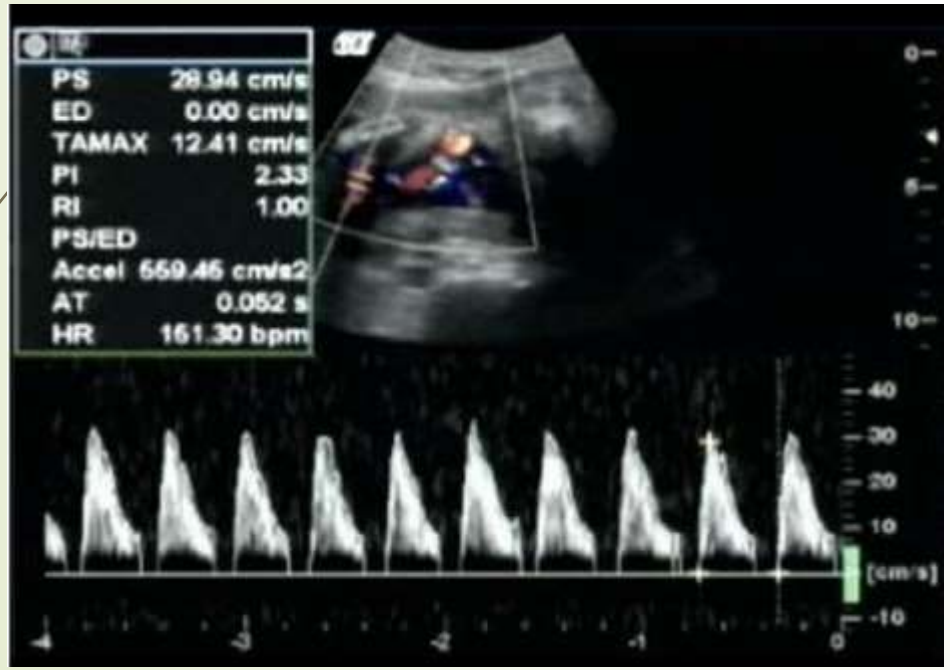
Waveform

- "sawtooth" pattern with flow always in the forward direction towards the placenta.
- An abnormal waveform shows absent or reversed diastolic flow.
- Before the 15th week, the absence of diastolic flow may be a normal finding.

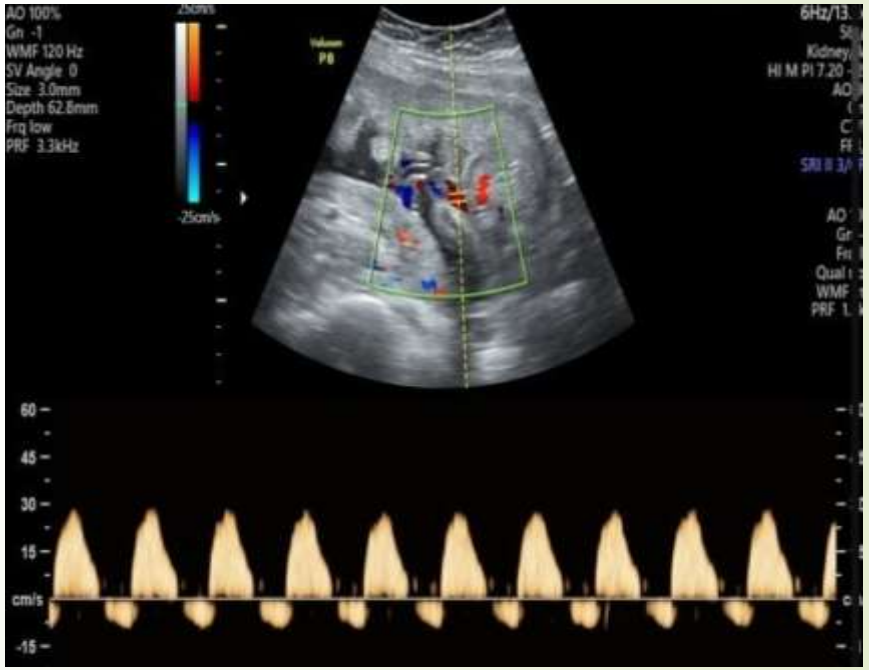


Waveform

- Reversed diastolic flow in the umbilical arterial circulation represents an advanced stage of placental compromise and is associated with more than 70% of placental arterial obliteration. The notation of absent or reversed end-diastolic flow in the umbilical artery is commonly associated with severe FGR and oligohydramnios.



Absent diastolic flow



Reversal of diastolic flow

Parameters

- The 95% confidence interval limit slowly decreases for both the resistive index (RI) and pulsatility index (PI) through the course of gestation due to progressive maturation of the placenta and increase in the number of tertiary stem villi.
- **Parameters**
- The commonly used parameters are:
- umbilical arterial S/D ratio (**SDR**): systolic velocity / diastolic velocity
- pulsatility index (**PI**) (Gosling index): (**PSV** - **EDV**) / **TAV**
- resistive index (**RI**) (Pourcelot index): (**PSV** - **EDV**) / **PSV**
- **PSV:** peak systolic velocity
- **EDV:** end-diastolic velocity
- **TAV:** time-averaged velocity

- The Doppler indices have been found to decline gradually with gestational age (i.e. there is more diastolic flow as the fetus matures):
- S/D ratio mean value decreases with fetal age
  - at 20 weeks, the 50th percentile for the S/D ratio is 4
  - at 30 weeks, the 50th percentile is 2.83
  - at 40 weeks, the 50th percentile is 2.18
- RI mean value decreases from 0.756 to 0.609
- PI mean value decreases from 1.270 to 0.967

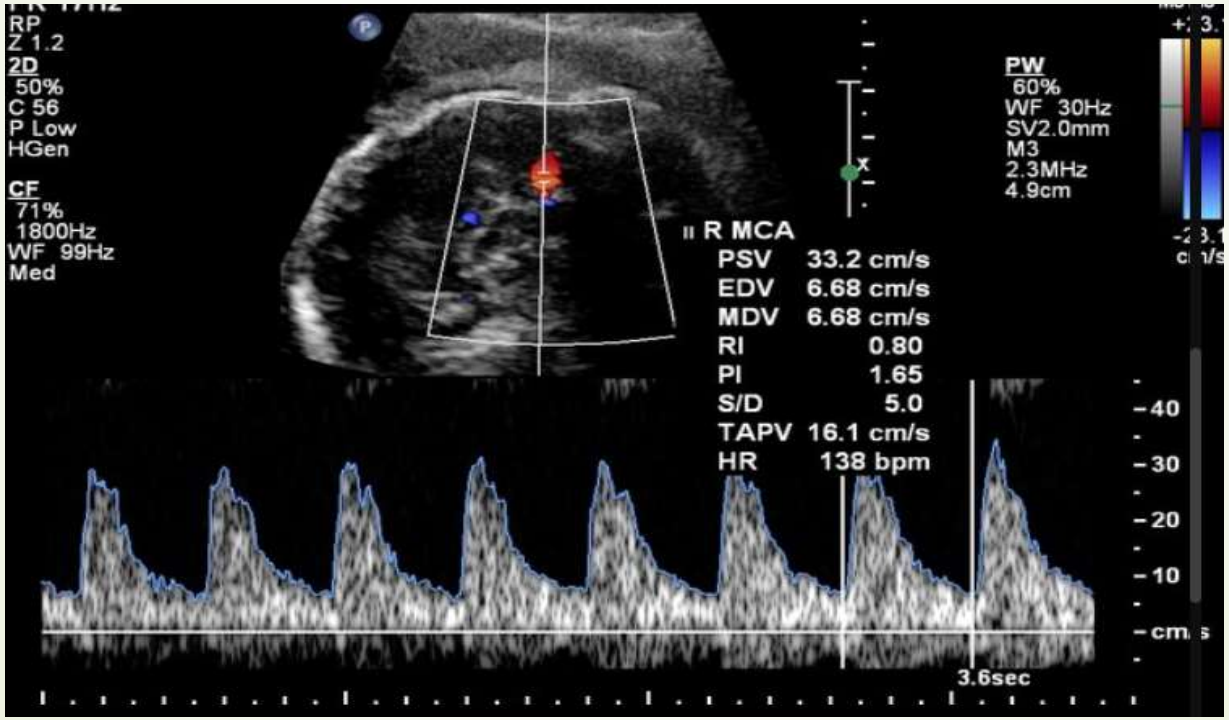
Middle cerebral artery Doppler assessment

- Important part of assessing fetal cardiovascular distress, fetal anemia or fetal hypoxia.
- An axial section of the brain, including the thalami and the sphenoid bone wings.
- Color flow mapping should be used to identify the circle of Willis and the proximal MCA, just caudal to the transthalamic plane
- The pulsed-wave Doppler gate should then be placed at the proximal third of the MCA, close to its origin in the internal carotid artery (the systolic velocity decreases with increasing distance from the point of origin of this vessel)
- Angle between the ultrasound beam and the direction of blood flow should be kept as close as possible to 0◦.
- Care should be taken to avoid any unnecessary pressure on the fetal head, as this may lead to increased PSV, decreased EDV and increased PI.

Parameters :

- fetal MCA pulsatility index (PI)
- fetal MCA peak systolic velocity (PSV): the highest velocity should be recorded
- fetal MCA systolic/diastolic (S/D) ratio: a normal fetal MCA S/D ratio should always be higher than the umbilical arterial S/D ratio
- cerebroplacental ratio (CPR): ratio of pulsatility index of MCA and umbilical artery

- In the normal situation the fetal MCA has a high resistance flow which means there is minimal antegrade flow in fetal diastole.
- Occasionally show end-diastolic flow reversal, a non-pathological finding that is usually due to increased intracranial pressure mostly by probe compression



MCA doppler

Cerebroplacental ratio

- **Cerebroplacental ratio (CPR)** is an obstetric ultrasound tool used as a predictor of adverse pregnancy outcome in both small for gestational age (SGA) and appropriate for gestational age (AGA) fetuses.
- **An abnormal CPR reflects redistribution of cardiac output to the cerebral circulation or** reflection of the arterial redistribution that occurs during preferential brain perfusion in response to fetal hypoxemia
- It is calculated by dividing the Doppler pulsatility index of the middle cerebral artery (MCA) by the umbilical artery (UA) pulsatility index:

An abnormal cerebroplacental ratio may result in the following conditions:

- low normal range MCA and upper normal range UA PI
- abnormal low MCA and normal UA PI
- abnormal low MCA and high UA PI

Foetal venous Doppler waveforms

- The ductus venosus (DV) connects the intra-abdominal portion of the umbilical vein to the left portion of the inferior vena cava, just below the diaphragm.
- The vessel is identified by visualizing this connection by 2D imaging, either in a mid-sagittal longitudinal plane of the fetal trunk or in an oblique transverse plane through the upper abdomen.

- The probe is ideally focused so sampling is done where the umbilical vein joins the ductus venosus
- A right ventral mid-sagittal view of the fetal trunk, color flow mapping used to demonstrate the umbilical vein, ductus venosus and fetal heart
- The image should be magnified enough for the fetal thorax and abdomen to occupy the whole screen
- The insonation angle should be 30° or less
- the sweep speed should be high (2-3 cm/s) so that the waveforms are spread allowing better assessment of the A wave

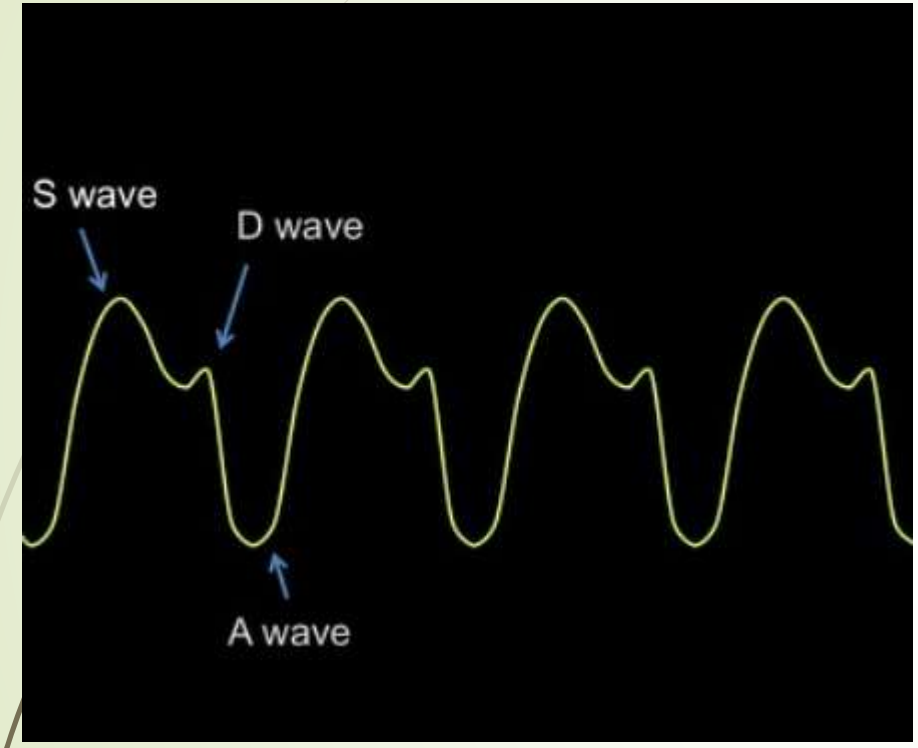
On Doppler ultrasound,

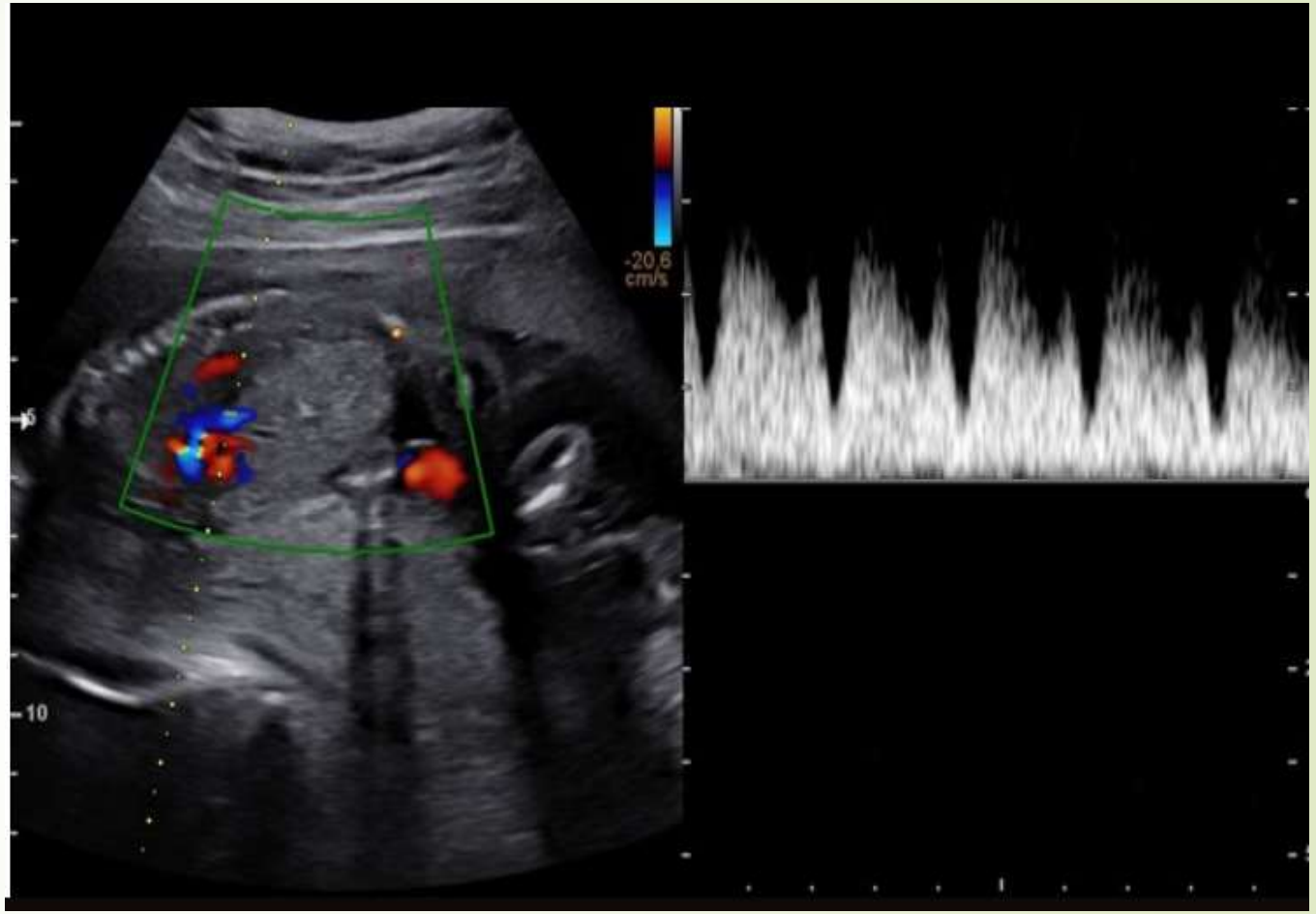
The flow in the ductus venosus has a characteristic triphasic waveform where in a normal physiological situation flow should always be in the forward direction [7] (i.e. towards the fetal heart).

This triphasic waveform comprises of:

- **S wave:** corresponds to fetal ventricular systolic contraction and is the highest peak
- **D wave:** corresponds to fetal early ventricular diastole and is the second highest peak
- **A wave:** corresponds to fetal atrial contraction and is the lowest point in the wave form still being in the forward direction
    - as above, reversal of the A wave (i.e. crossing the baseline) is always abnormal [10]

Normal ductus venosus waveform





THANK YOU