



Doppler in pregnancy – What a sonographer needs to know

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7th September 2024

Doppler in Pregnancy

Aims:

- Recommend scanning technique for performing Doppler studies
- The correct interpretation of Doppler findings
- Appropriate reporting of normal and abnormal Doppler studies

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Doppler gives us information on:

Placentation:

- trophoblastic invasion of spiral arteries

Fetal well-being:

- hypoxia
- acidosis
- chromosomal anomalies
- anaemia
- MC twins
- post-term pregnancies

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An abnormal Doppler waveform is a result of either:

- Maternal disease
- Pathological conditions, which cause utero-placental insufficiency.



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Maternal disease and utero-placental insufficiency can cause:

- pre-eclampsia
- fetal growth restriction (FGR)
- perinatal death/stillbirth

Doppler assessment can determine the risk and severity of these obstetric complications.

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Who is at risk of FGR?

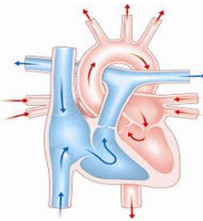
- Previous FGR
- Previous stillbirth
- Low BMI (<18)
- Maternal addiction
- Reduced fetal movements
- Pregnancy induced complications
- Maternal disease

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Maternal diseases:

- Heart disease

The partial pressure of oxygen in the maternal blood may be decreased.



- Pre-existing Insulin-dependent diabetes

Diabetic vasculopathy



- Gestational diabetes

Fetal macrosomia



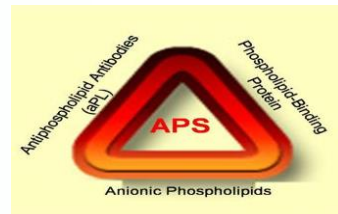
- Autoimmune disease (SLE)

Fetal loss at 10% in 2nd and 3rd Trimester due to placental dysfunction



- Antiphospholipid antibody syndrome

arterial and venous thrombosis of the utero-placental vasculature and placental infarction.



- Chronic renal impairment

Renal impairment can cause increased maternal blood pressure, which can lead to pre-eclampsia and FGR.



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Doppler plays a vital role in differentiating between:

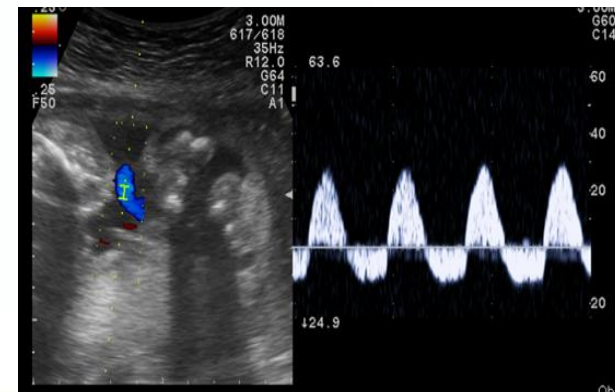
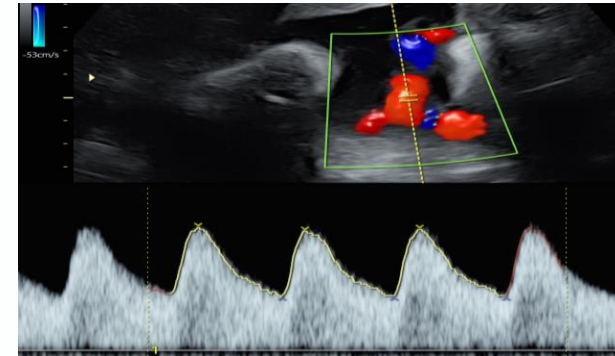
Small for Gestational Age (SGA)

(constitutionally small fetus)

VS.

Fetal Growth Restriction (FGR)

(placental insufficiency, fetal starvation)



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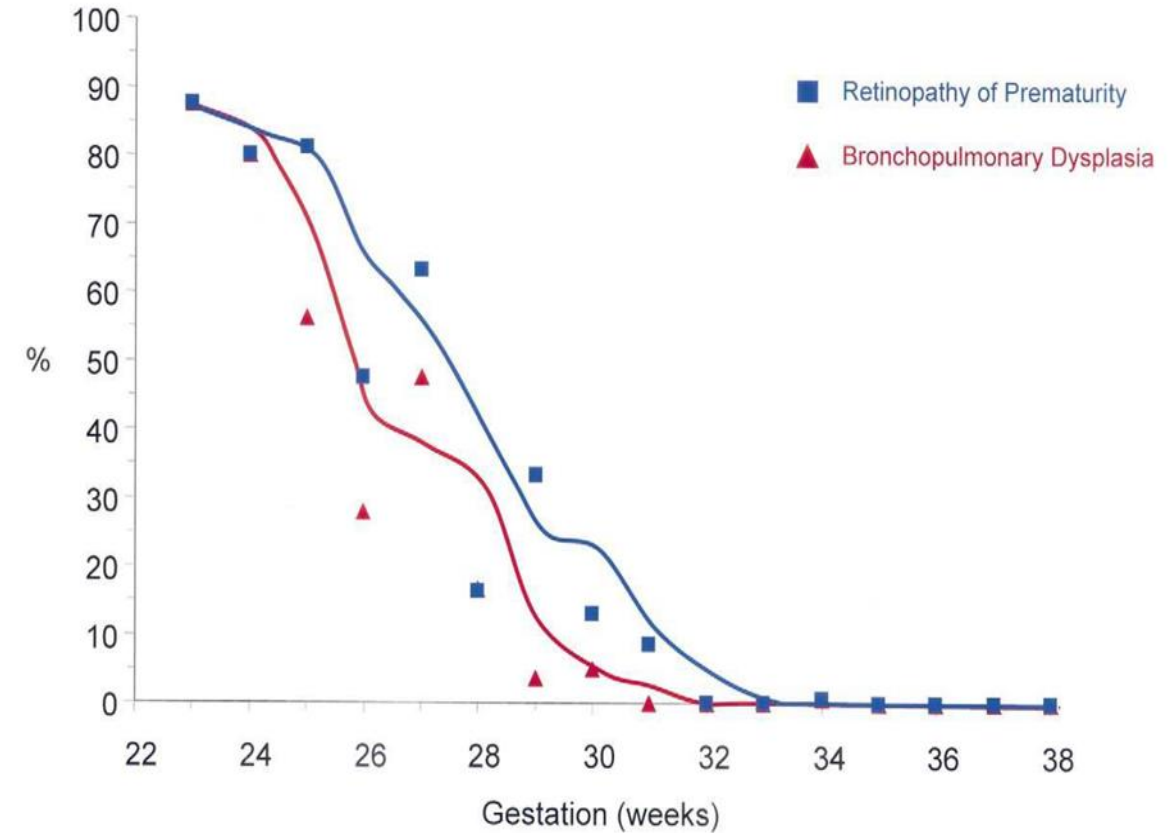
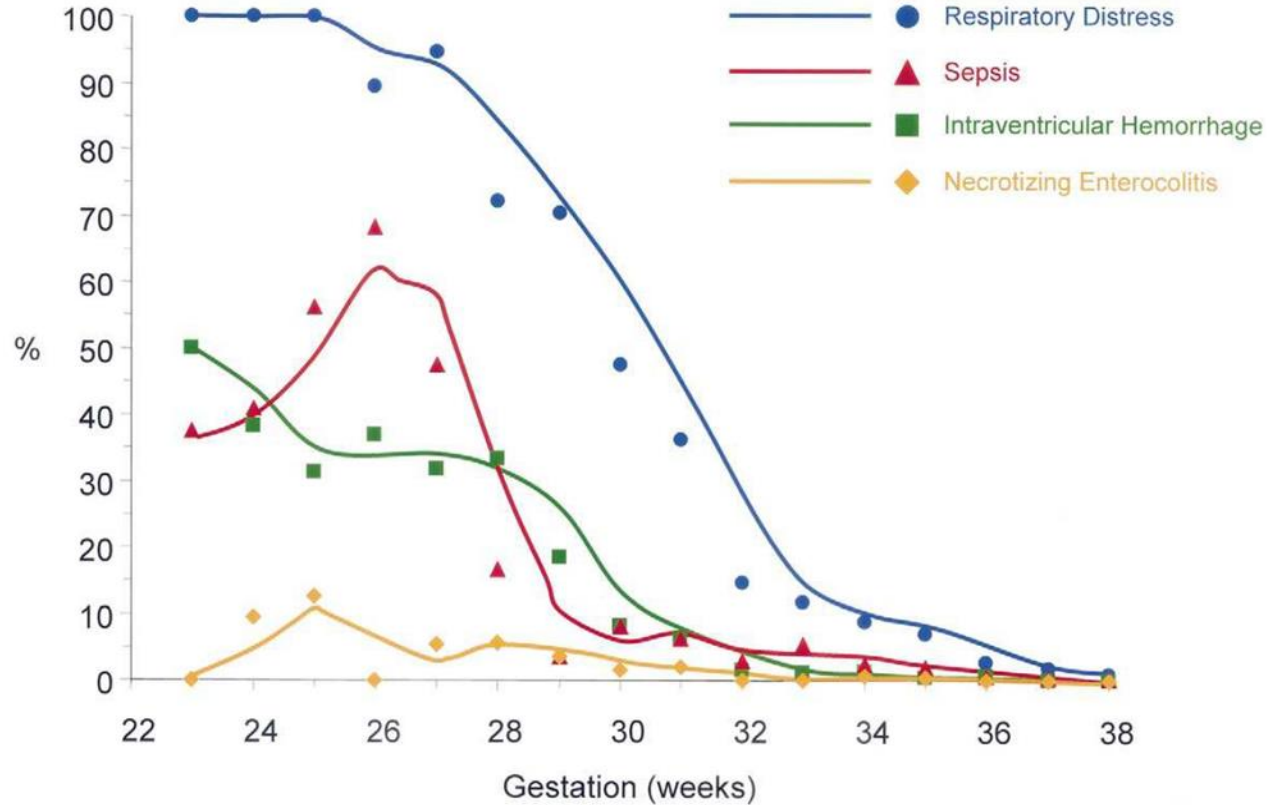
Doppler Studies should help:

- Reduce perinatal mortality and morbidity.
- Decision-making:
 - further diagnostic studies
 - more intense monitoring
 - treatment plans
 - timing of delivery



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Risk factors of prematurity:



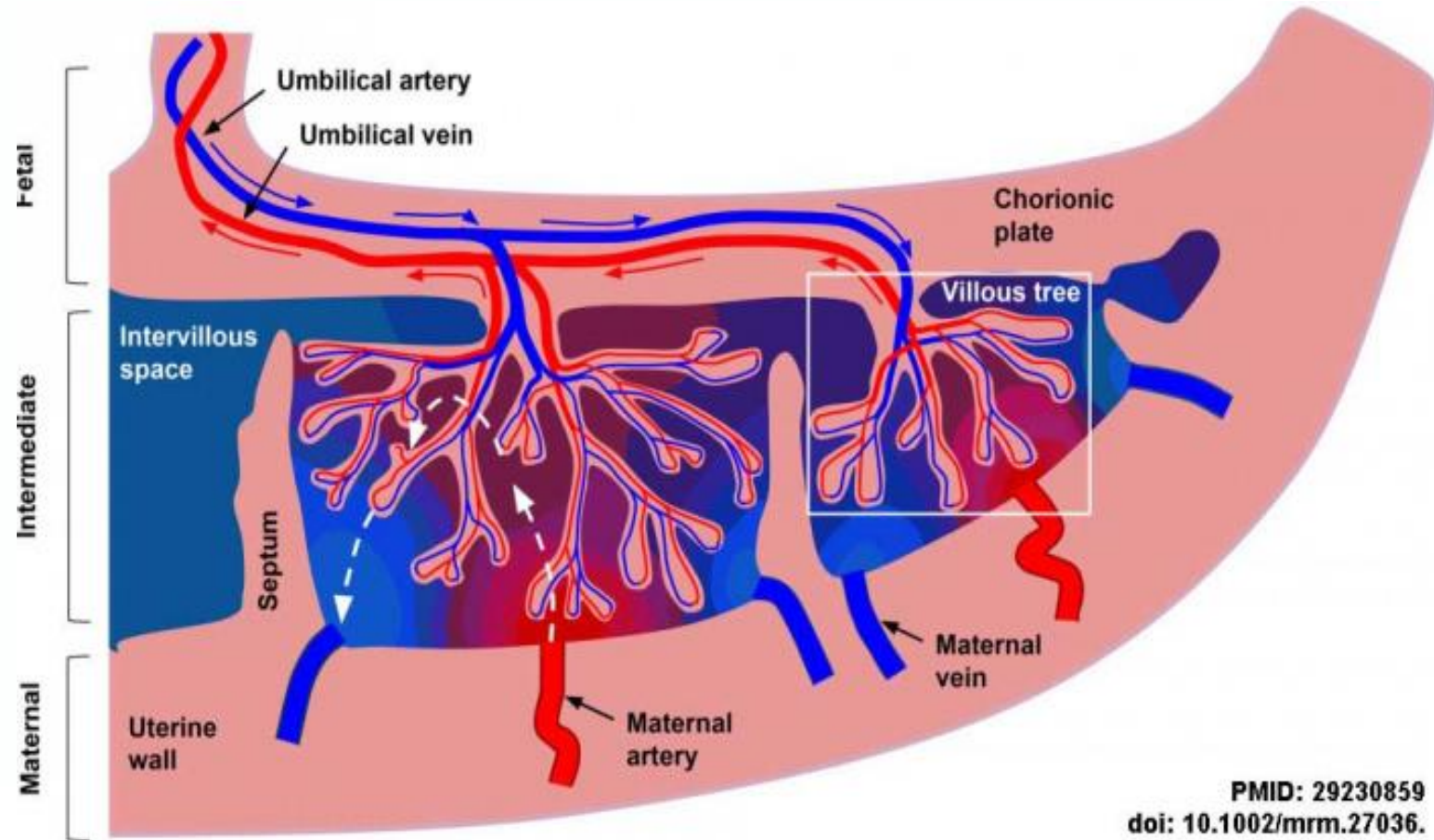
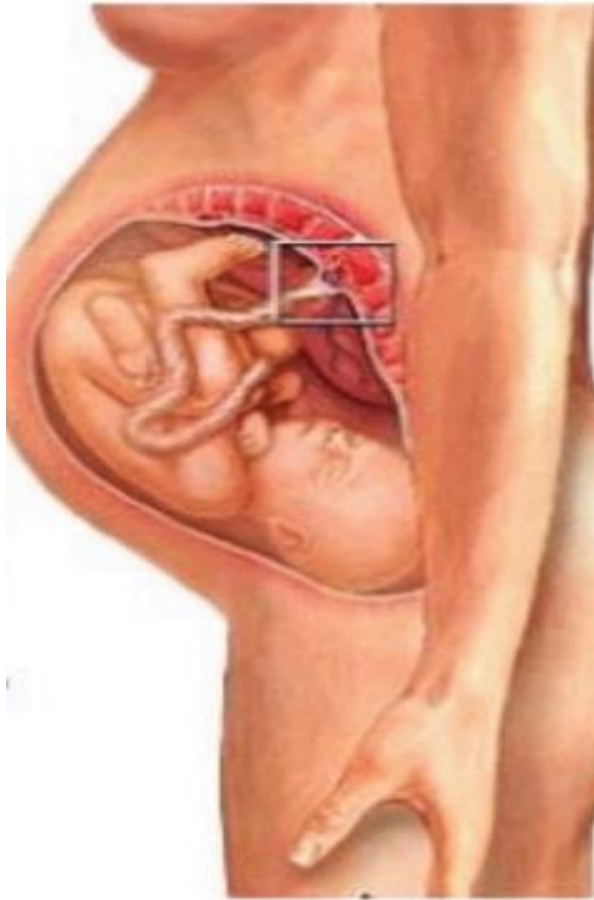
Mercer Treatment of Preterm PROM, *Obstet Gynaecol* 2003

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Obstetric Doppler ultrasound can interrogate four circulations:

- Utero-placental circulation: uterine arteries
(Maternal blood flow via the uterus to the placenta)
- Fetal-placental circulation: umbilical arteries
(Fetal blood flow from fetus to placenta)
- Fetal arterial circulation: middle cerebral arteries
(Blood flow within the fetal brain)
- Fetal venous circulation: ductus venosus
(A shunt that allows blood in the umbilical vein to bypass the liver)

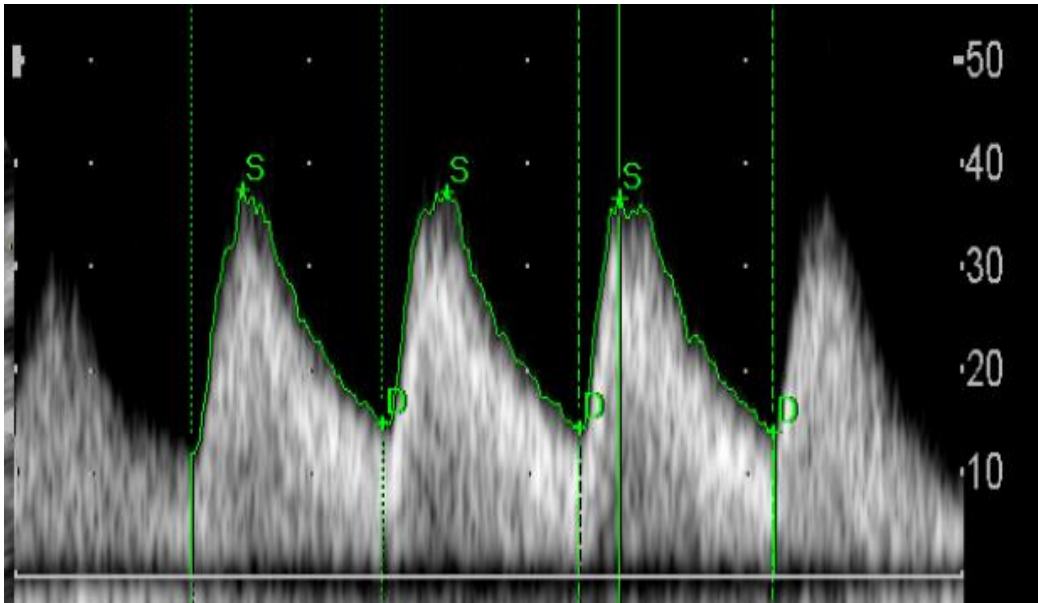
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PMID: 29230859
doi: 10.1002/mrm.27036.

Doppler in Pregnancy

Understanding the Doppler waveform:

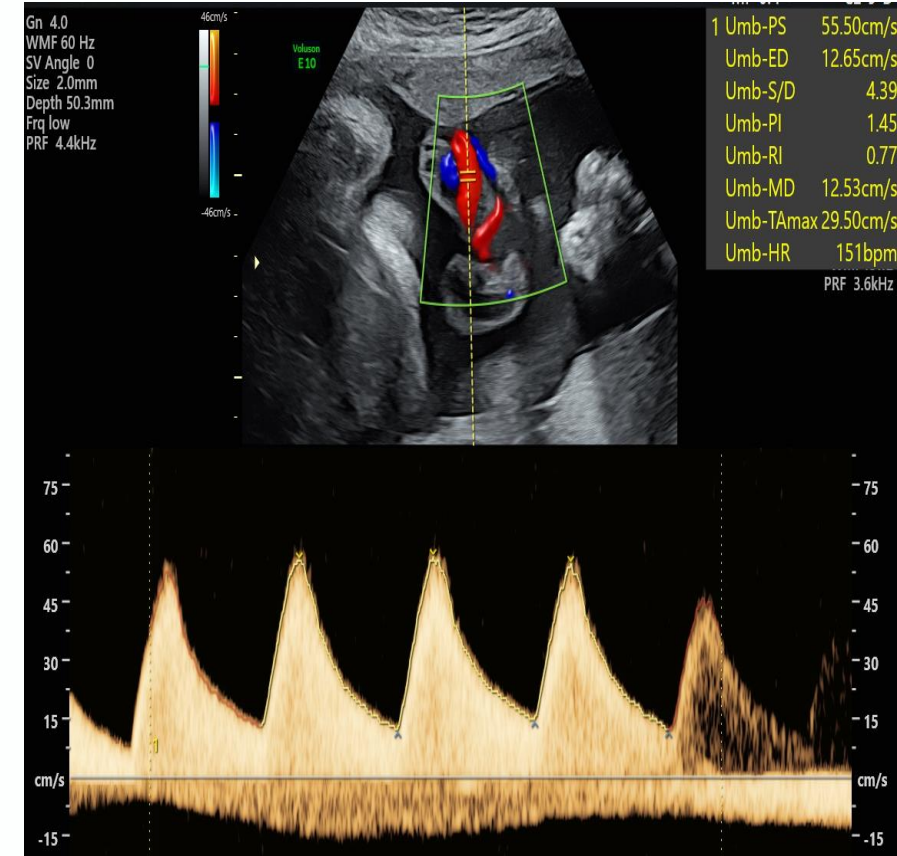


- S = Systolic peak
- D = diastolic flow
- The diastolic flow of the Doppler waveform is a measure of the vascular resistance downstream.

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Qualitative Information:

- Presence/absence of flow
- Direction of flow
- Quality of flow: laminar or turbulent
- Waveform shape:
 - low resistance
 - high resistance
 - absent end diastolic flow
 - reversed end diastolic flow

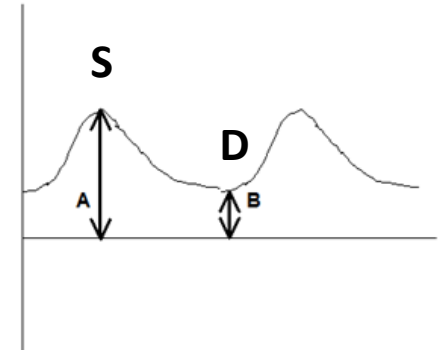


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Quantitative Information:

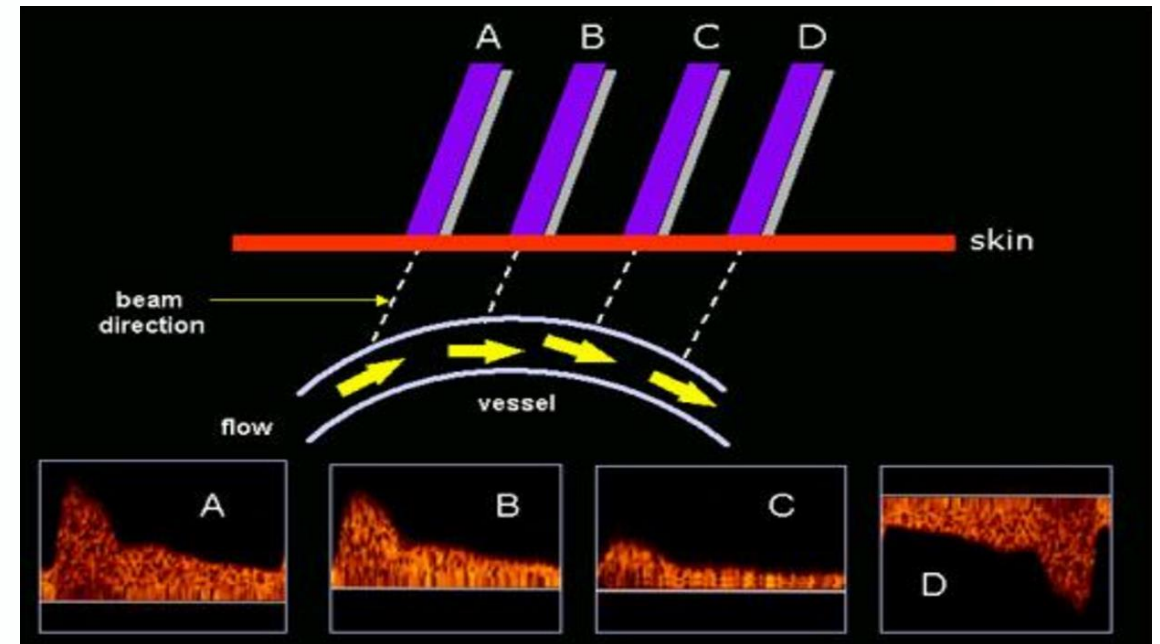
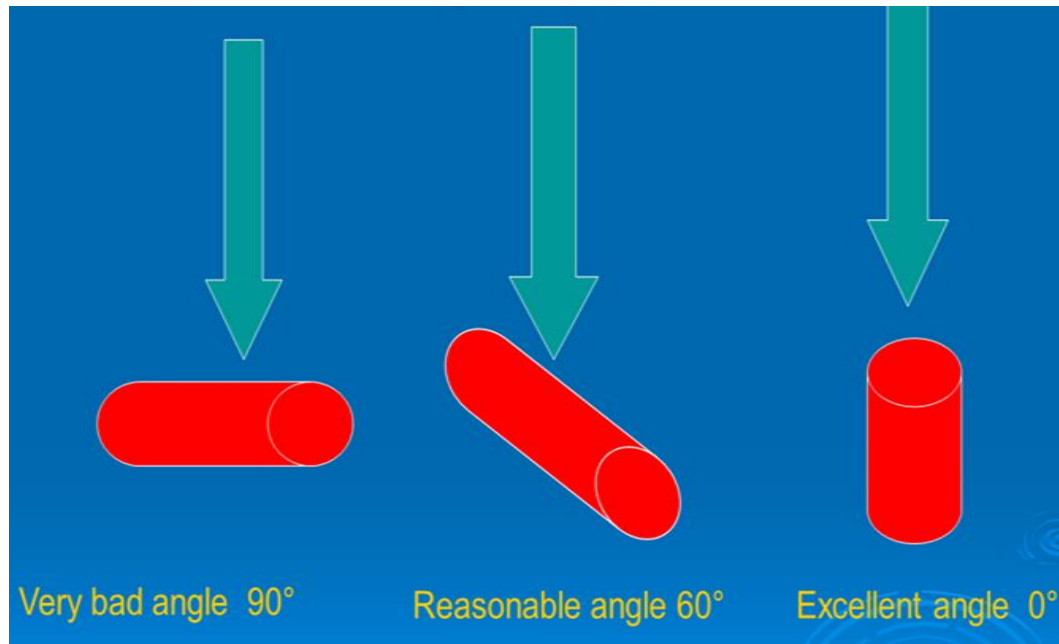
The best three known indices are:

- Pulsatility index (PI): $\frac{(\text{peak systole} - \text{minimum diastole})}{\text{mean systole}}$
- Resistance index (RI): $\frac{(\text{peak systole} - \text{minimum diastole})}{\text{peak systole}}$
- Systolic / Diastolic ratio: $\frac{\text{peak systole}}{\text{minimum diastole}}$



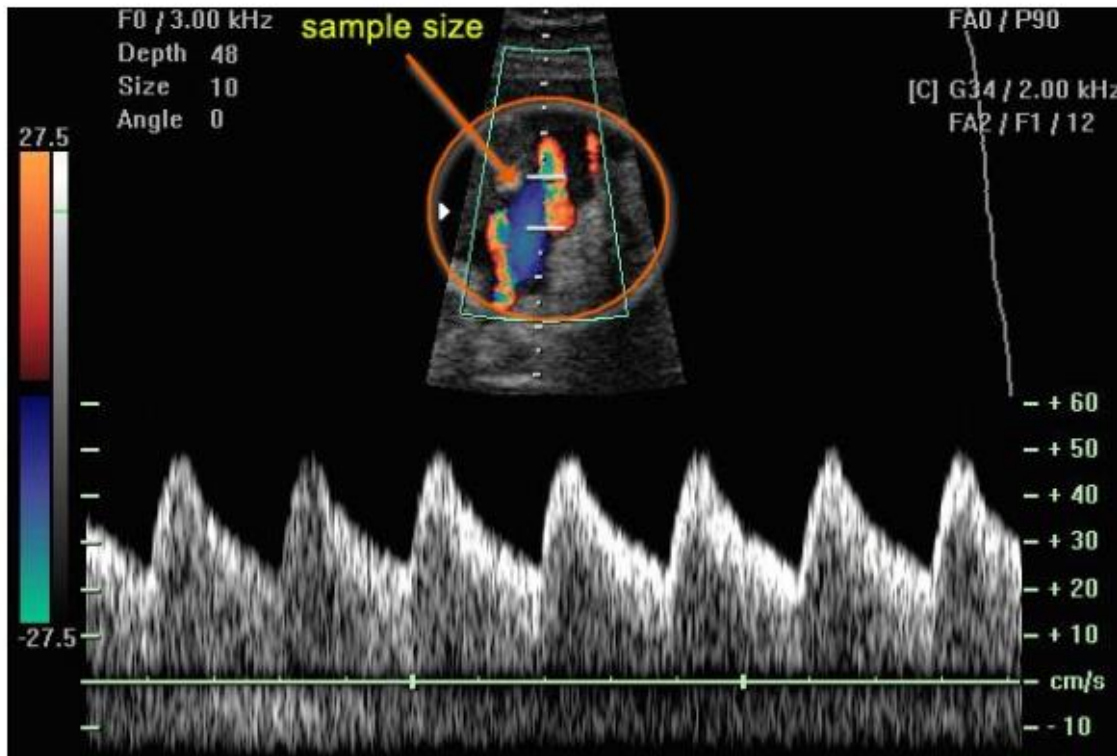
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- **Basic rules:** the angle of insonation should be 0° (or less than 30°).



[Doppler Ultrasound - Principles and practice \(fetalmedicine.org\)](http://fetalmedicine.org)

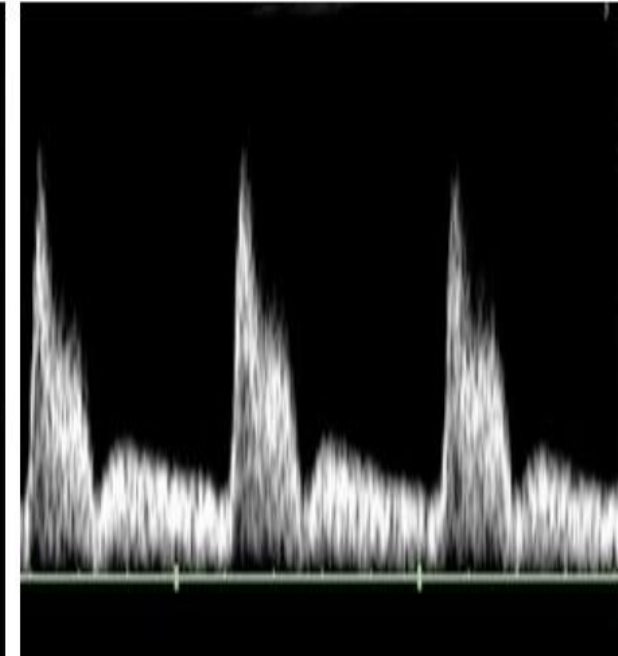
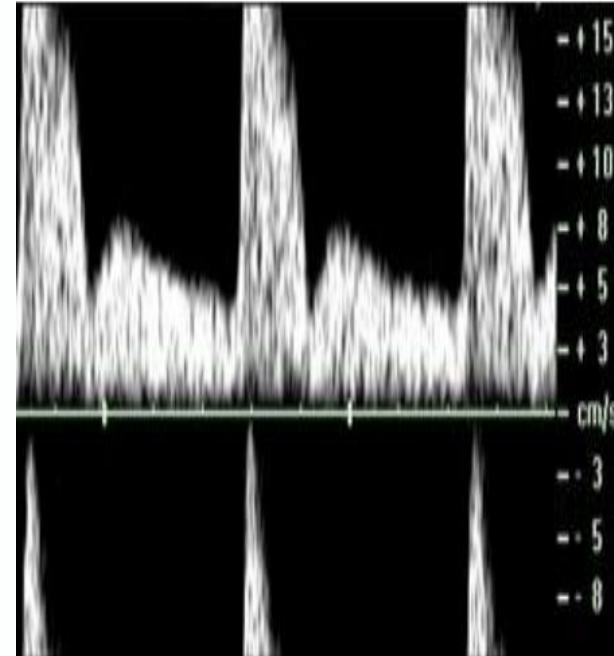
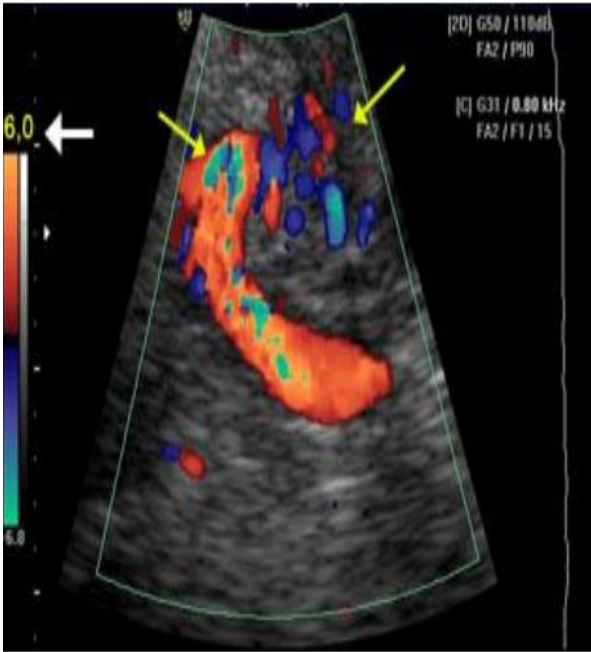
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- Sample gate should be placed in the centre of the vessel.
- Sample gate should fill 2/3 of vessel size.
- Make sure gate size is not too big, as it will then include signals from adjacent vessels.

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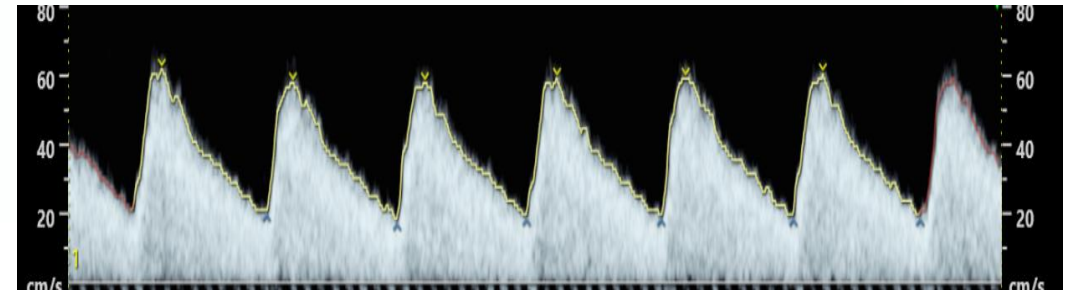
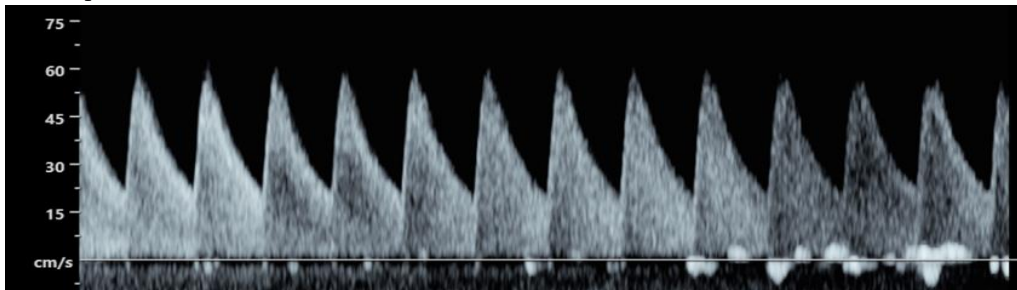
Be aware of aliasing:



Doppler in Pregnancy

Basic rules:

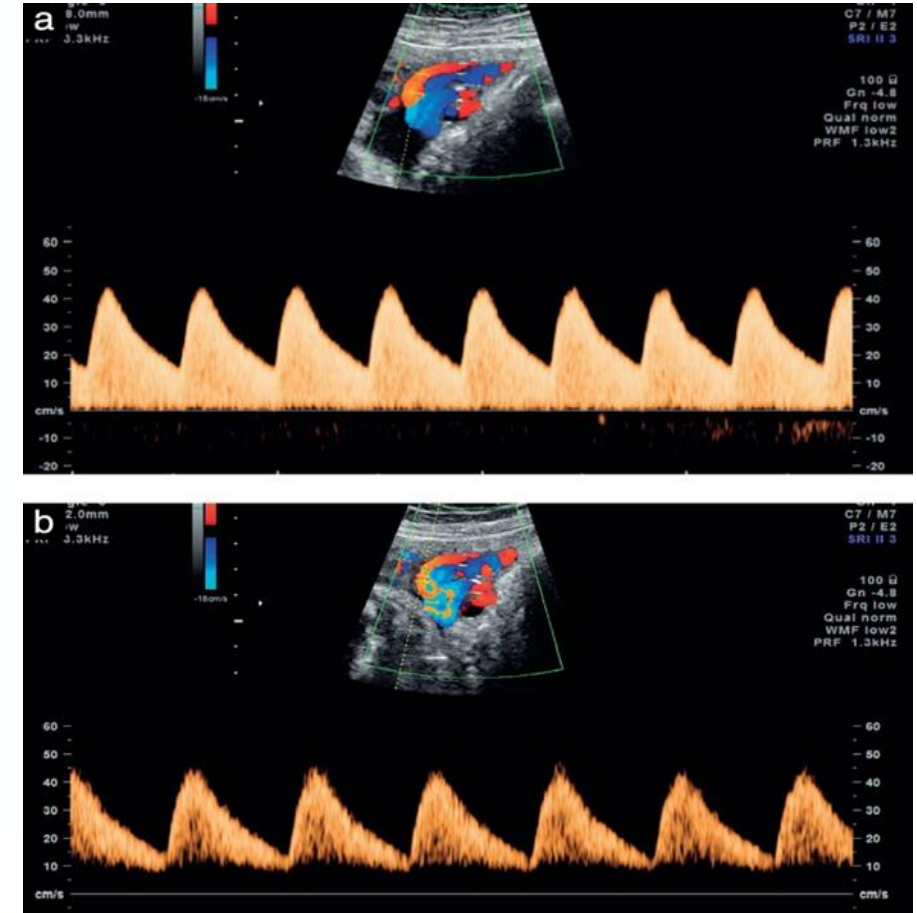
- Obtain Doppler waveform during absence of fetal breathing and fetal movements.
- Doppler horizontal sweep speed should be fast enough to separate successive waveforms.



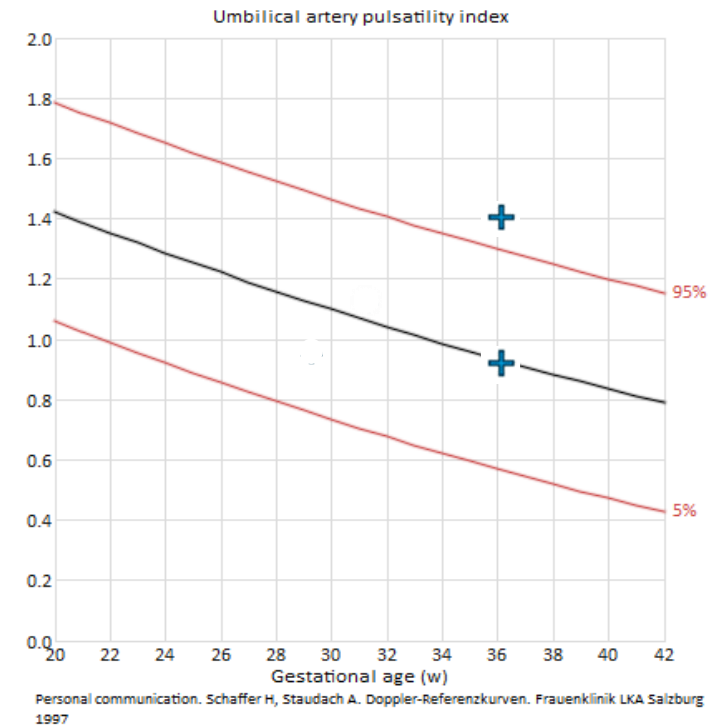
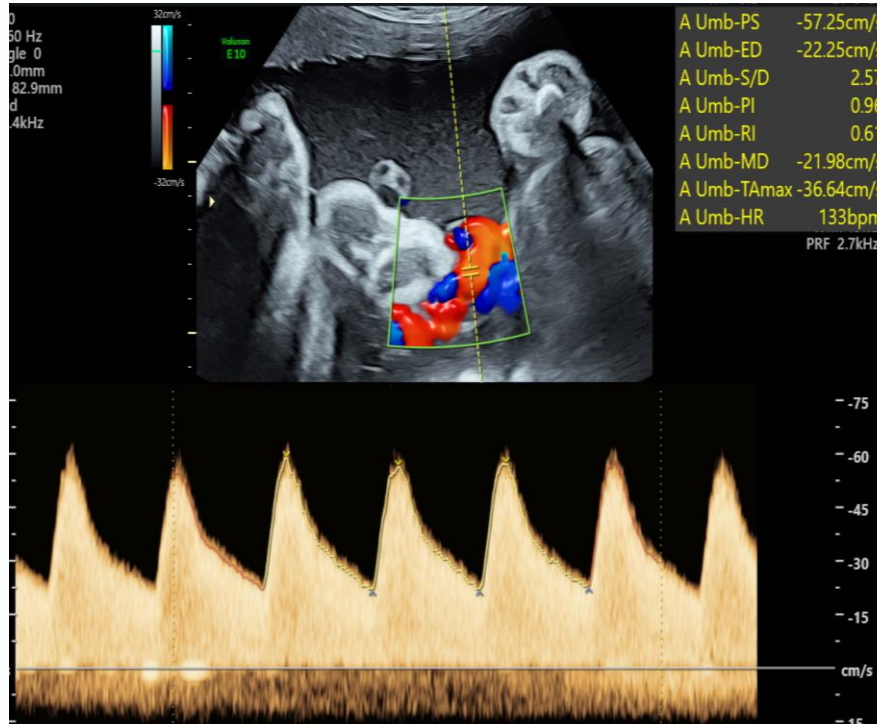
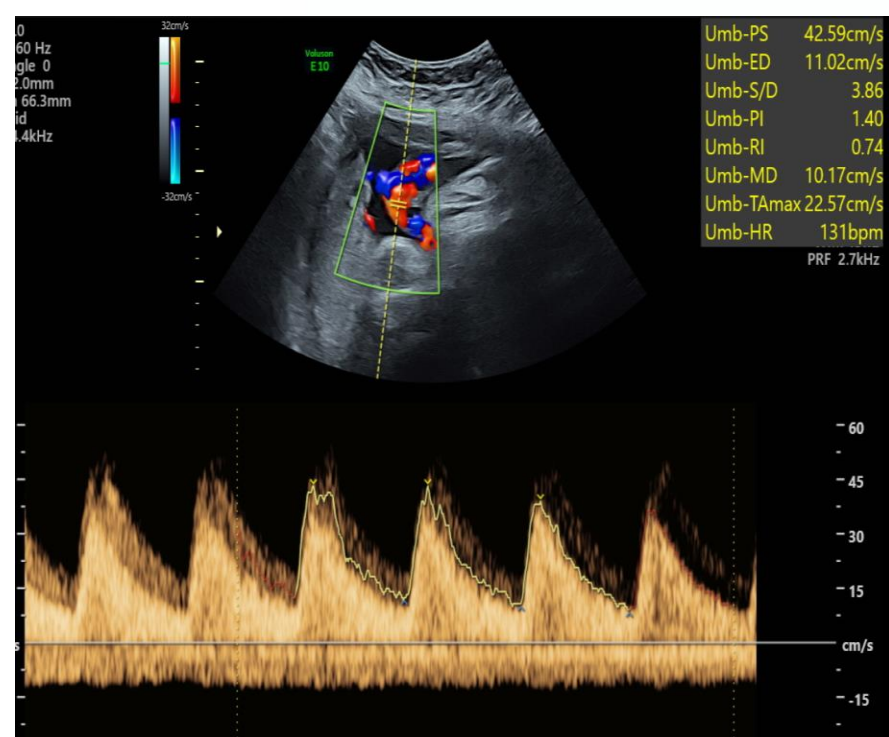
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Basic rules:

- Generate a Maximum Velocity Envelope (MVE) measurement to show the whole spectral Doppler waveform.
- Make sure your wall motion filter (WMF) is not too high or too low.
- Make sure the Doppler waveform fills 75% of the screen.



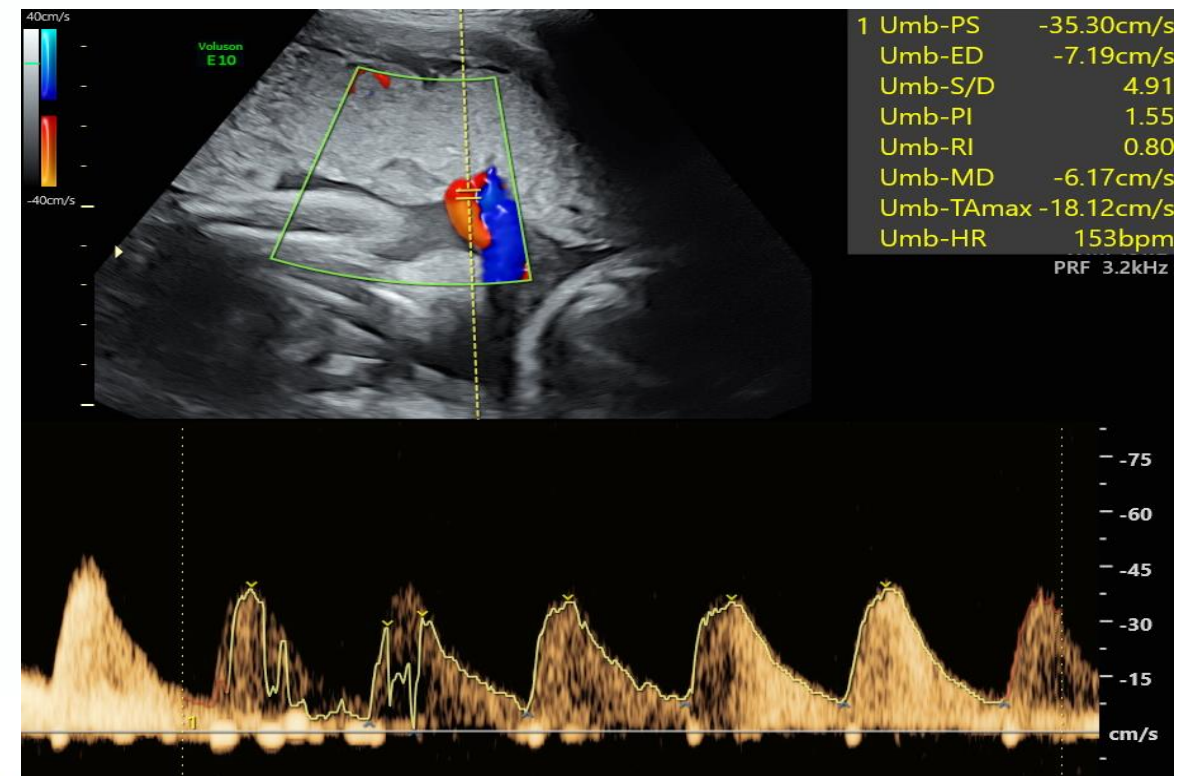
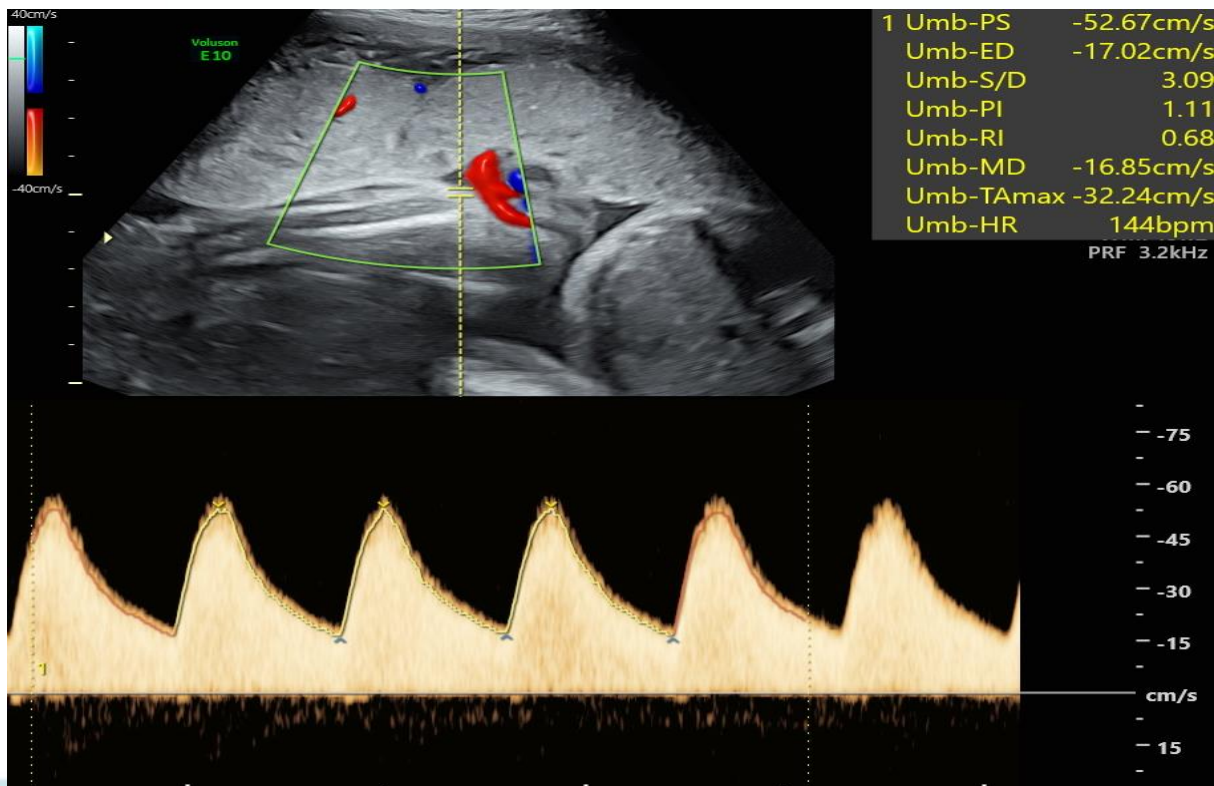
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Doppler in Pregnancy

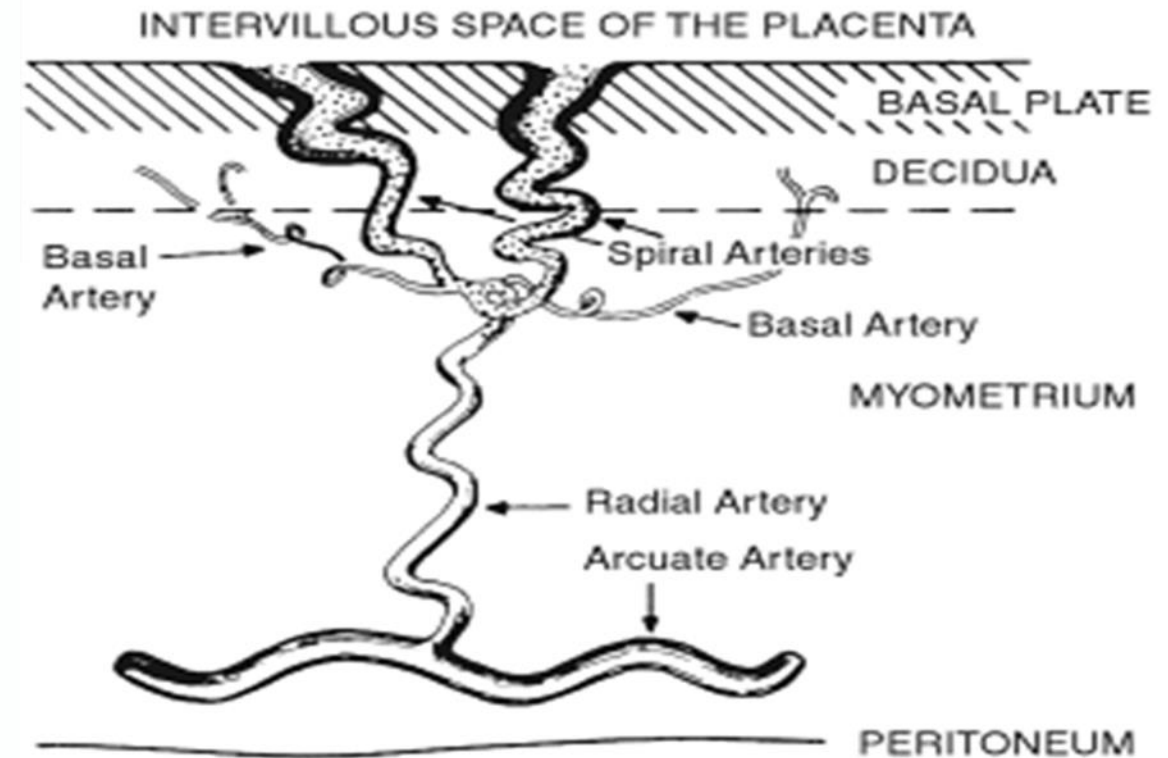
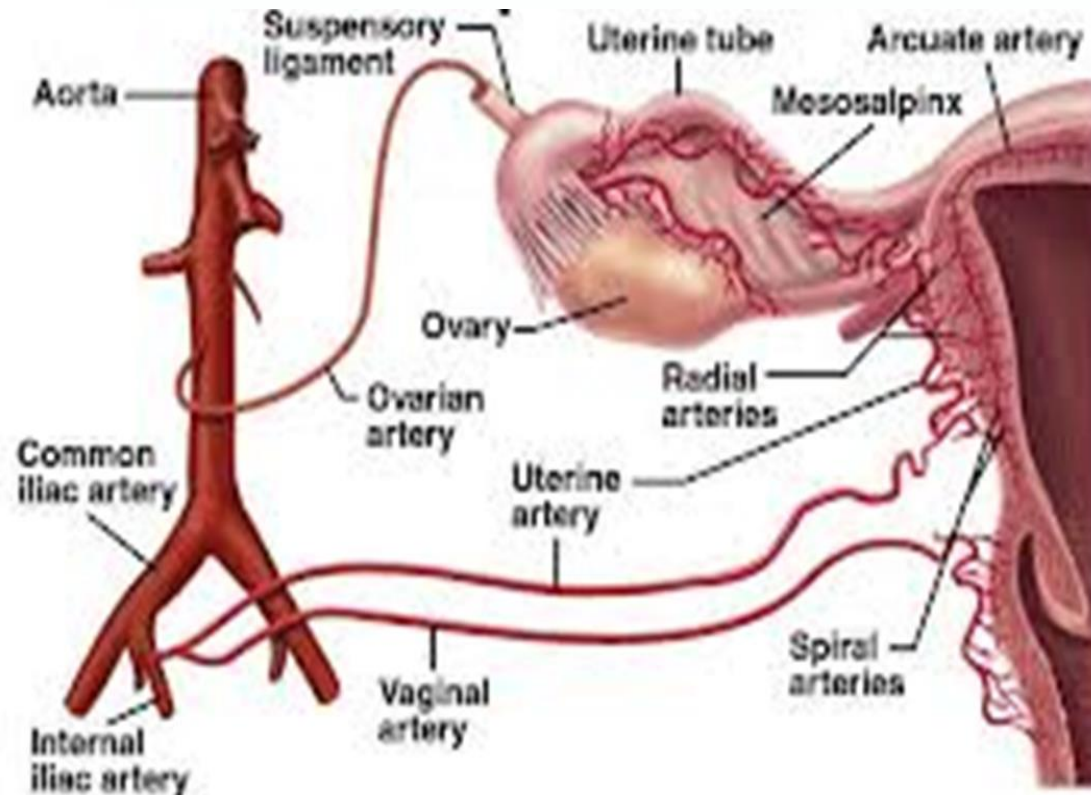
Basic rules:

Measure the best three waveforms.

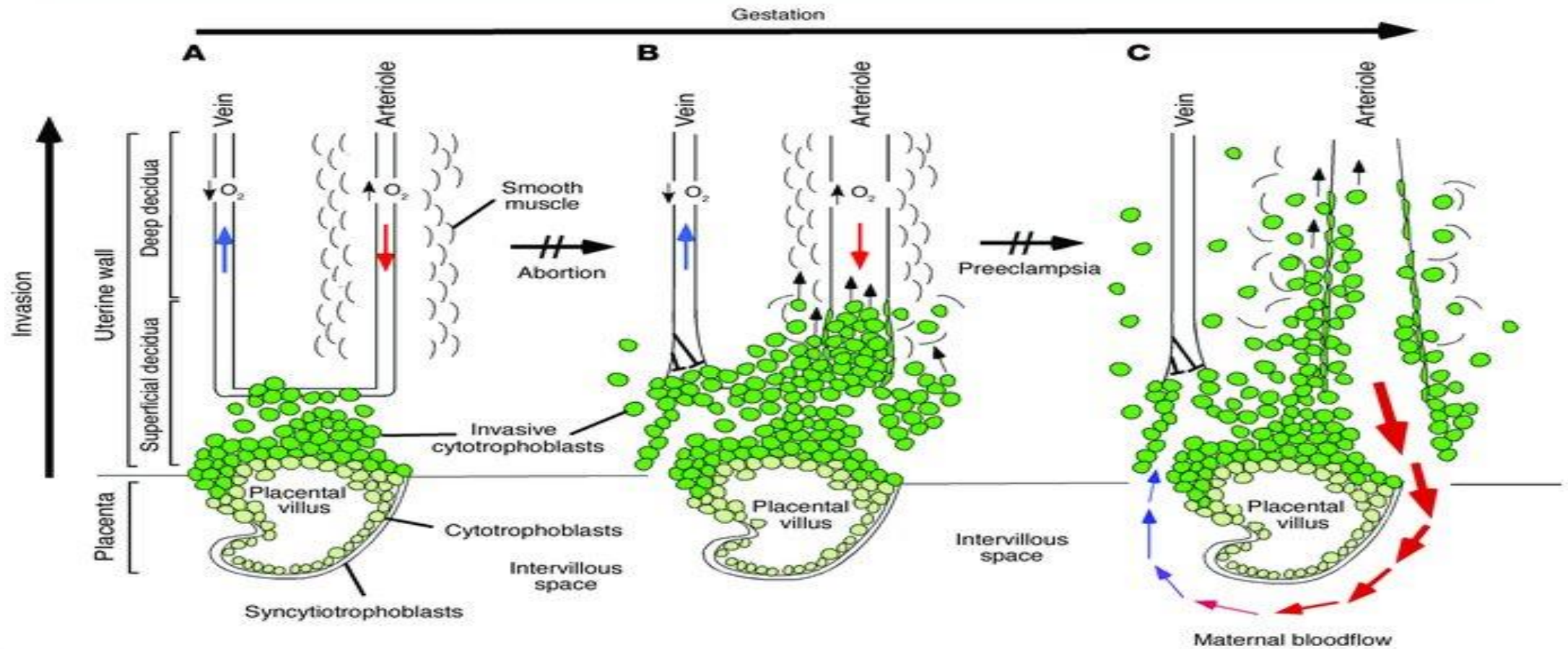


Utero-Placental Circulation: Uterine arteries

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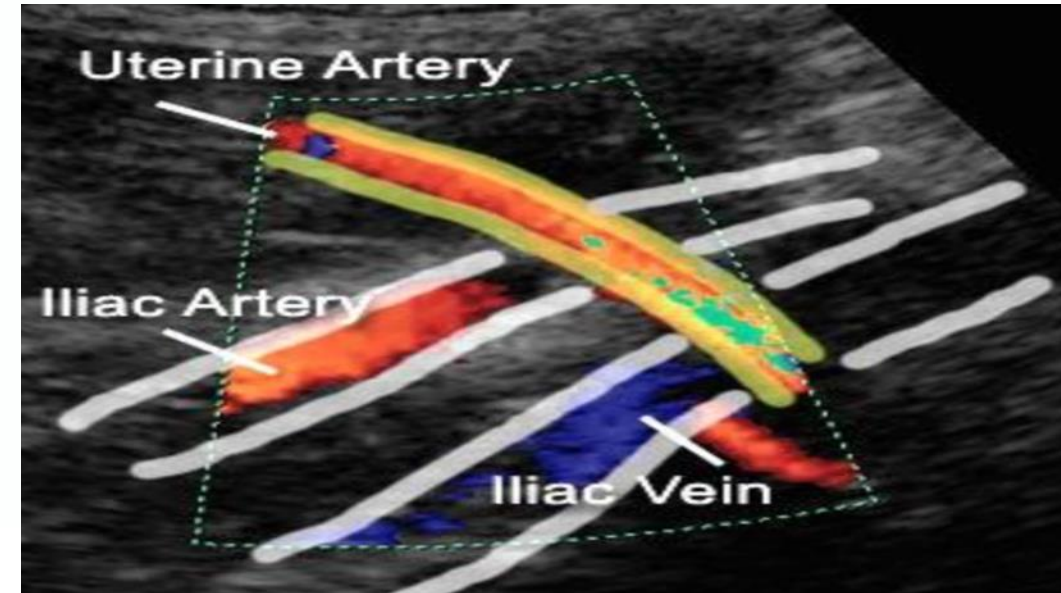
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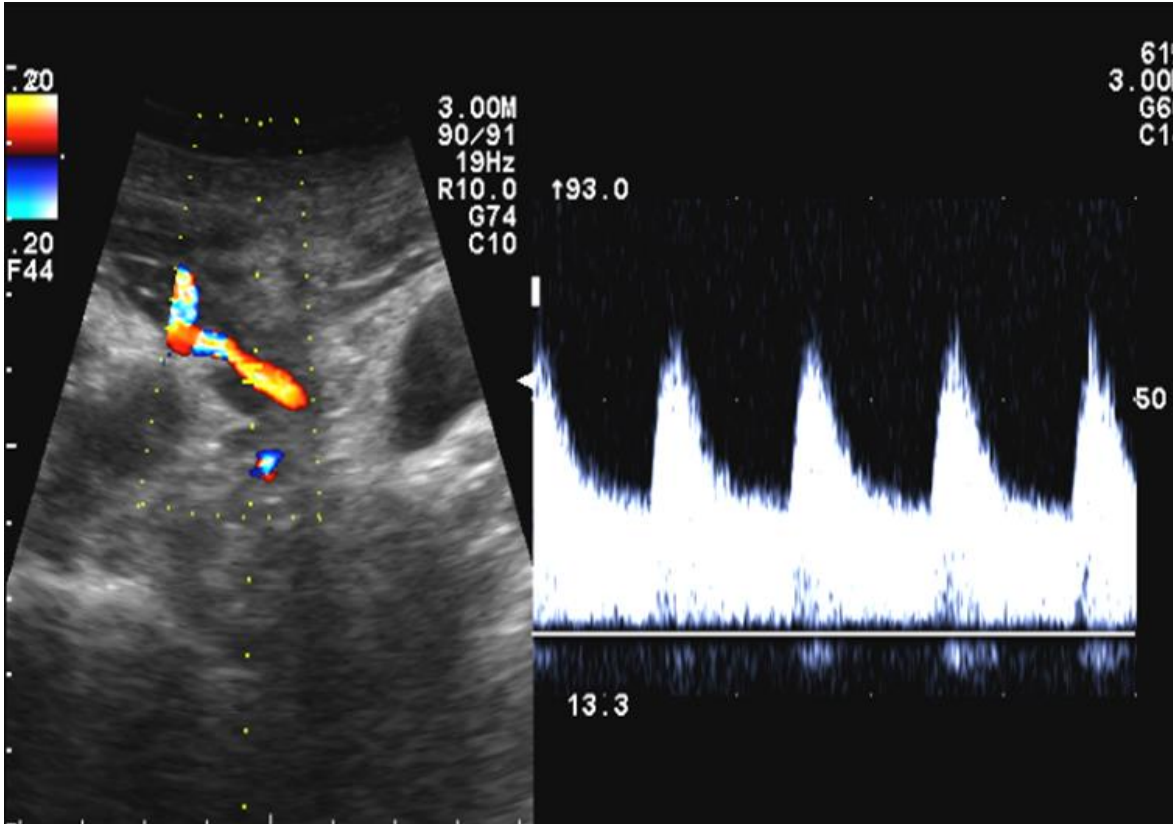
Uterine artery technique:

Ultrasound image with colour Doppler showing the uterine artery and the external iliac artery.



Isuog.org (2013)

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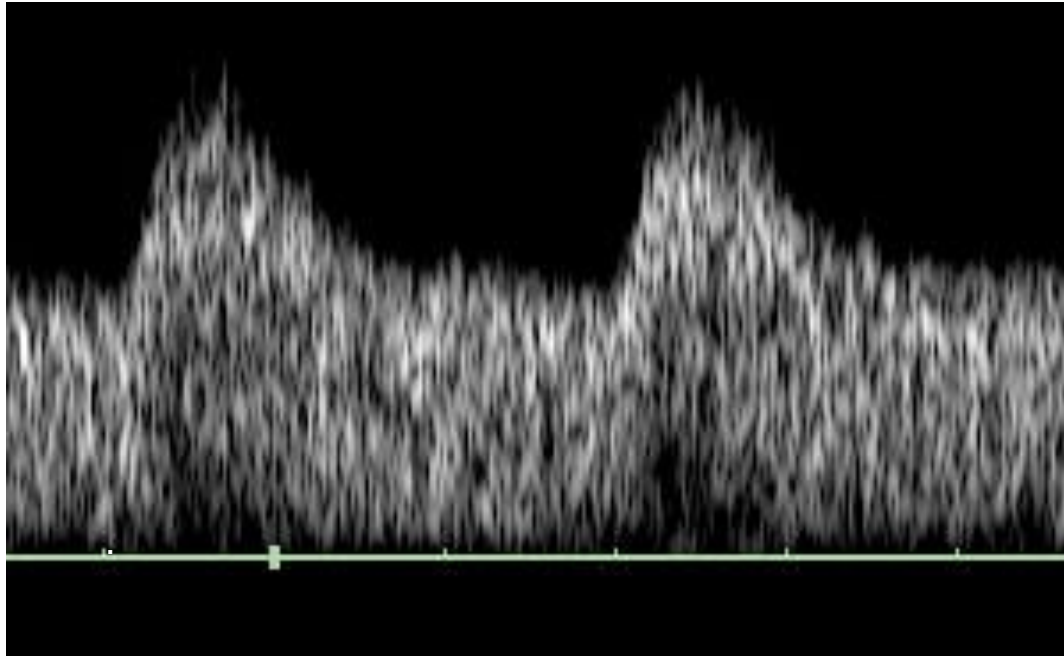


Uterine artery Doppler assessment:

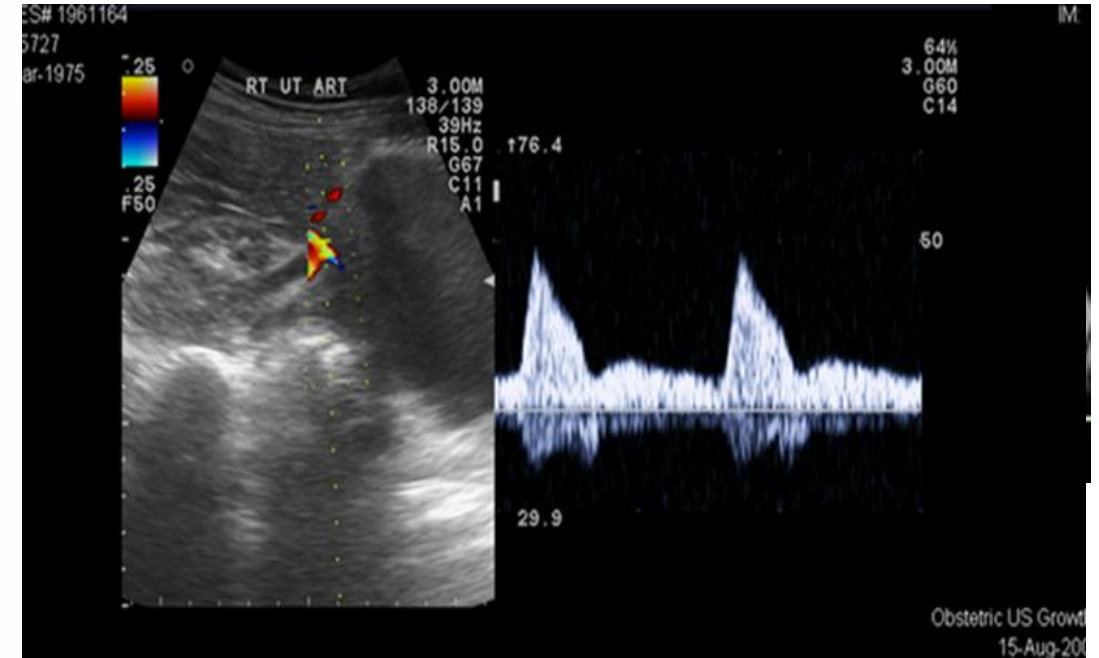
- Scan both left and right uterine arteries
- Measure the best 3 waveforms.
- Three separate spectral traces should be measured and evaluated.
- Report the mean P.I.

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Normal Uterine Artery Doppler



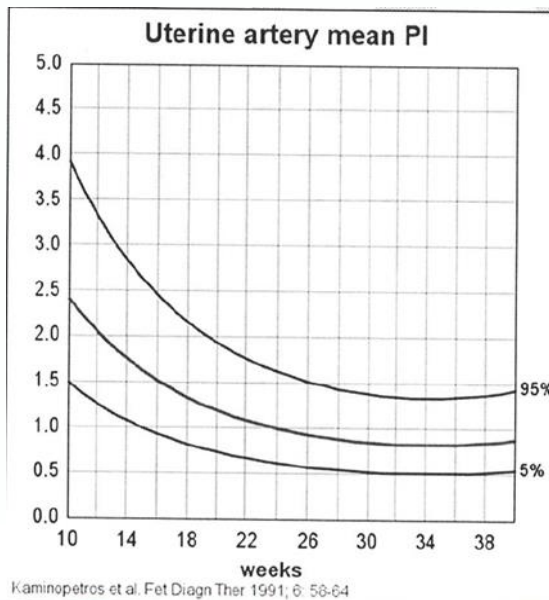
Abnormal Uterine Artery Doppler



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Abnormal findings of the uterine artery Doppler:

- Mean Uterine Artery P.I. above the normal range



Ultrasound Obstet Gynecol 2003; 21: 170-173

Published online in Wiley InterScience (www.interscience.wiley.com). DOI: 10.1002/uog.30

Comparison of color Doppler uterine artery indices in a population at high risk for adverse outcome at 24 weeks' gestation

G. ALBAIGES^{*}, H. MISSFELDER-LOBOS^{*}, M. PARRA^{*}, C. LEES[†], D. COOPER[†] and K. H. NICOLAIDES^{*}

^{*}Harris Birthright Centre for Fetal Medicine, King's College Hospital and [†]Department of Statistics, King's College School of Medicine, London, and [‡]Division of Maternal-Fetal Medicine, The Rosie Hospital, Addenbrookes NHS Trust, Cambridge, UK

“This removes the operator dependent assessment of a notch, and allows an objective method of calculating a woman's individual level of risk for adverse outcome.”

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Uterine Artery Doppler:

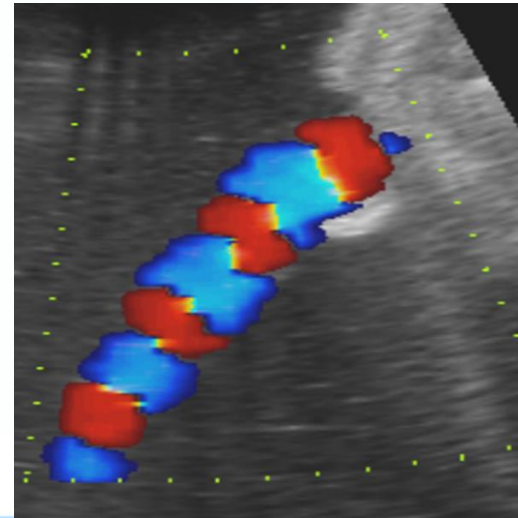
- A mean PI above average are possible indicators of abnormal outcome. It is seen in about 5% of the population.
- Abnormal uterine artery Doppler waveform: 50% of patients will develop severe complications .
- Normal uterine artery Doppler waveform: less than 2% of patients will develop severe complications.

Feto-Placental Circulation: Umbilical Artery Doppler

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Umbilical artery Doppler:

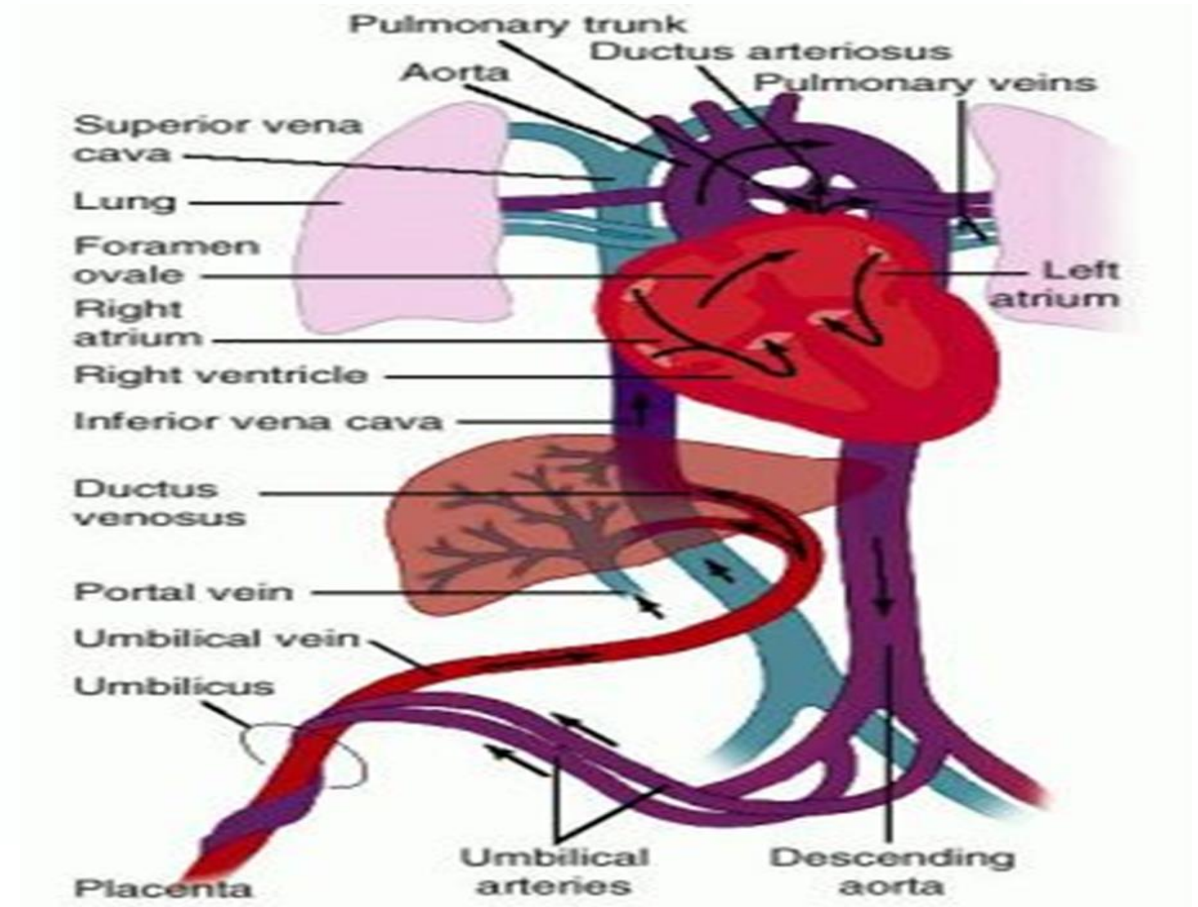
- The umbilical cord is the life-line for the fetus. The umbilical artery Doppler is a placental function test and overall measure of fetal health.
- It provides important diagnostic and prognostic information in the detection of FGR.

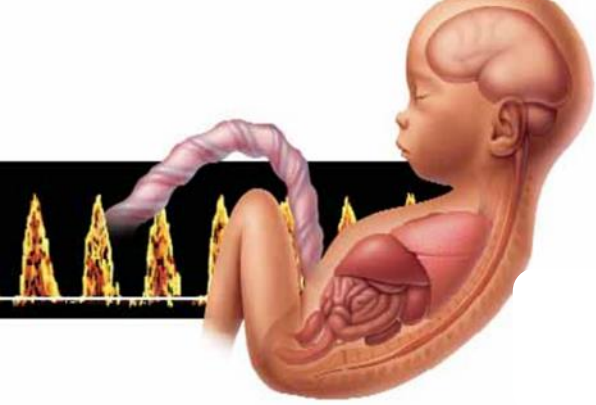


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Umbilical artery Doppler:

- 1 umbilical vein: carries oxygenated blood from placenta to fetus
- 2 umbilical arteries: carry deoxygenated blood from fetus to placenta

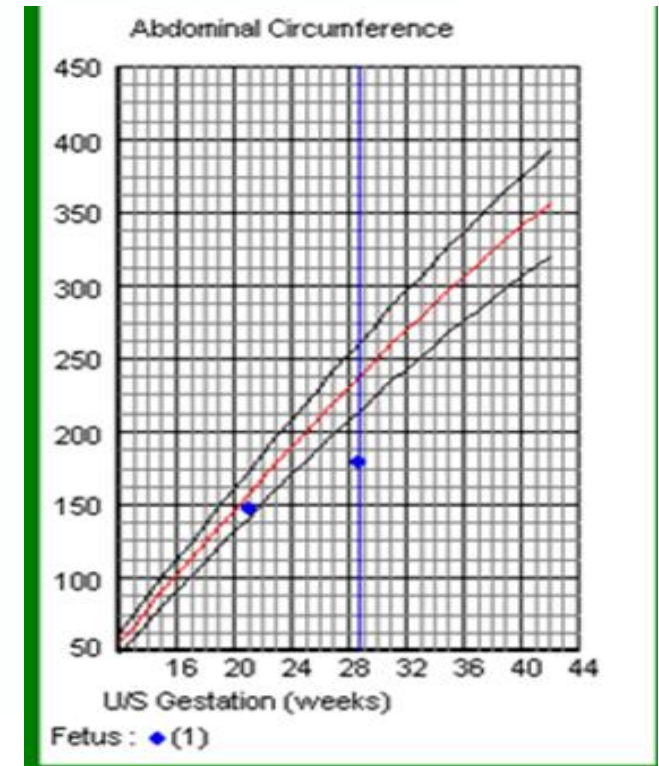




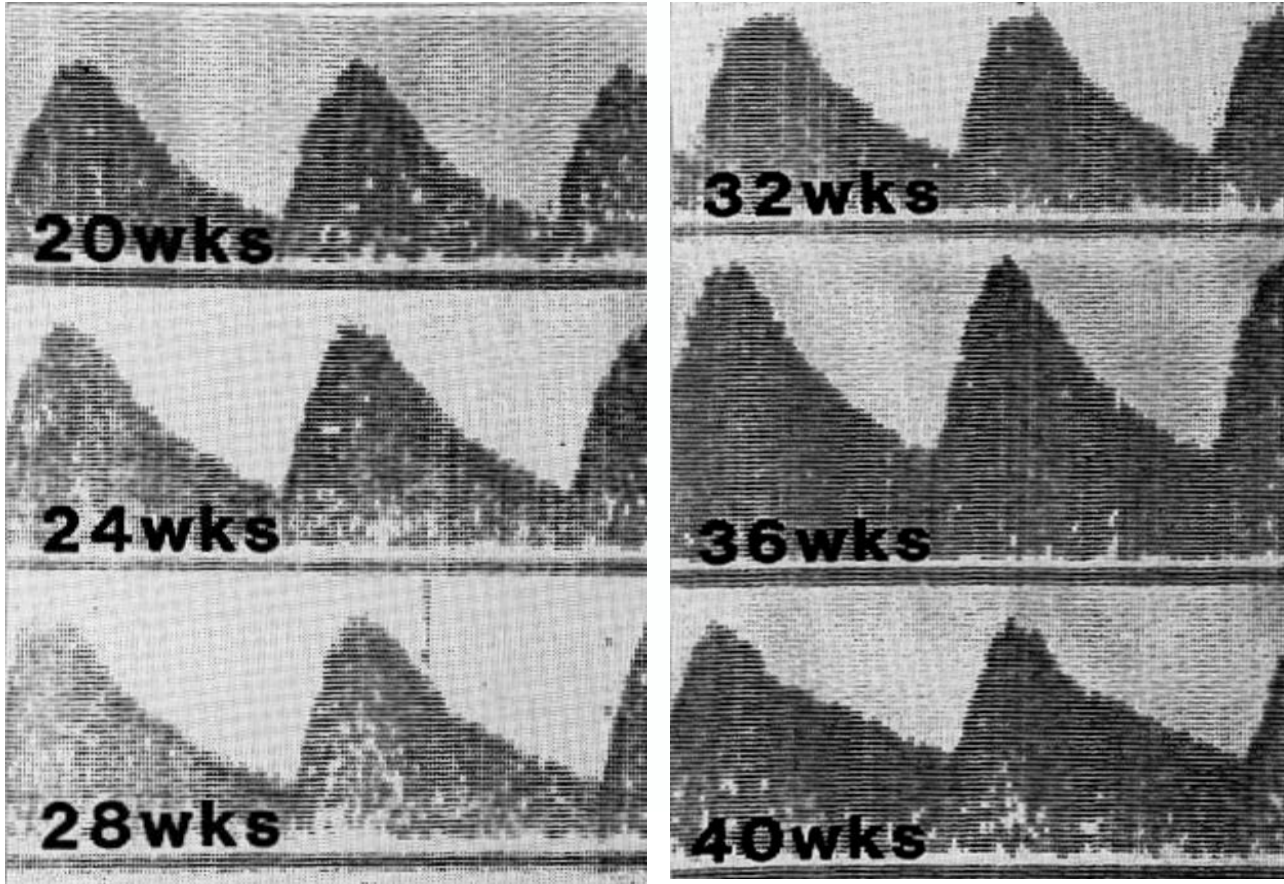
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When to perform umbilical artery Doppler:

- Reduction in growth velocity of AC by scan
- Suspected or confirmed FGR
- Small Gestational Age baby ($< 10^{\text{th}}$ centile)
- Oligohydramnios
- Previous stillbirth



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- Normally the resistance in the placenta decreases throughout pregnancy, with a resultant increase in the diastolic velocity.
- This is due to continuing development of the placental vascular system throughout the pregnancy.

Doppler in Pregnancy

Consensus definitions for early and late fetal growth restriction (FGR) in absence of congenital anomalies
(ISUOG September 2016)

EARLY FGR GA < 32 WEEKS	LATE FGR GA>32 WEEKS
<ul style="list-style-type: none">• <i>Scan Findings:</i> Reduced AC & abnormal Umbilical artery Doppler.• Prematurity related risks are high.	<ul style="list-style-type: none">• <i>Scan findings:</i> Reduced AC & abnormal Middle Cerebral Artery Doppler.• Unanticipated stillbirth is the primary issue.
<ul style="list-style-type: none">• <i>Solitary finding:</i> AC/EFW < 3rd centile or Umbilical Artery Doppler absent EDF.	<ul style="list-style-type: none">• <i>Solitary finding:</i> AC/EFW < 3rd centile.

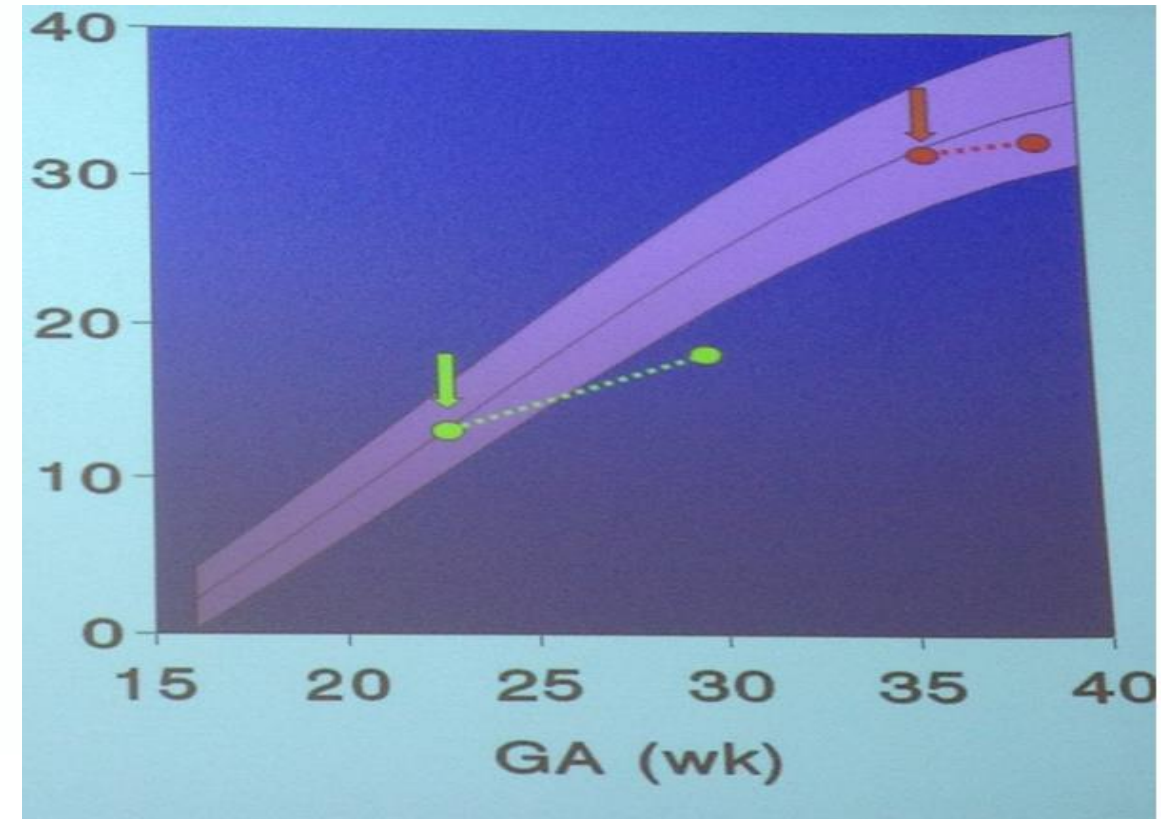
Doppler in Pregnancy

EARLY PLACENTAL FAILURE

- FGR a cardinal feature
- Low metabolic needs
- Long latency to demise

LATE PLACENTAL FAILURE

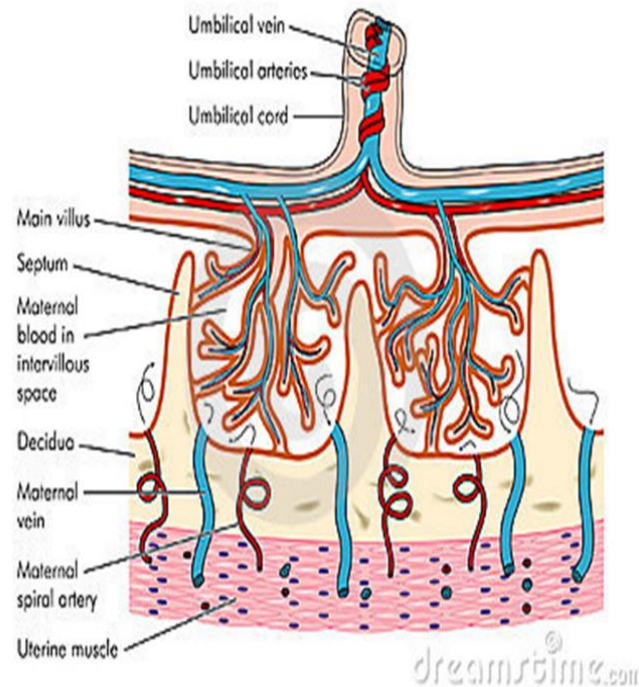
- High metabolic demands
- Short latency to demise/ unexpected stillbirth a risk



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Causes of early FGR

- **Villous changes:**
 - villous infarcts
 - small terminal villi
 - chronic villitis



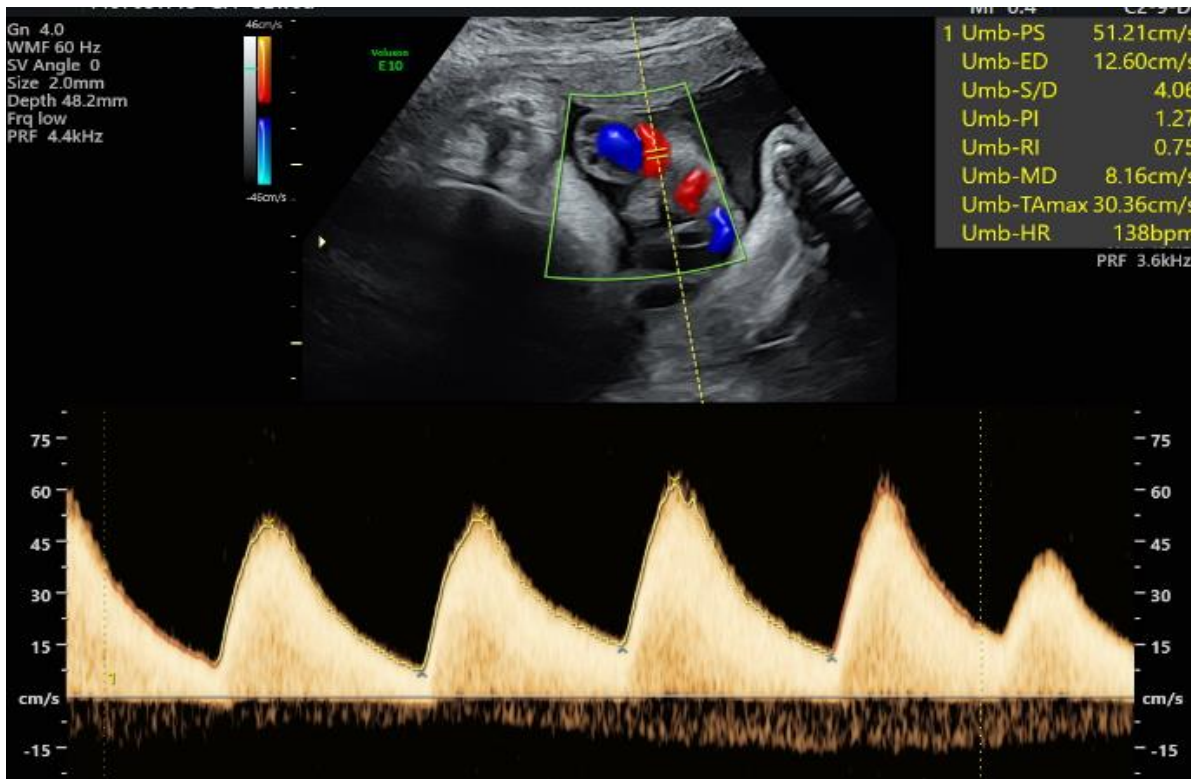
Causes of late FGR

A lack of oxygen to the placenta can result in spasms which cause:

- Occlusion by fibrinoid necrosis
- Placental ischaemia
- Acute atherosclerosis
- Atheromatous changes

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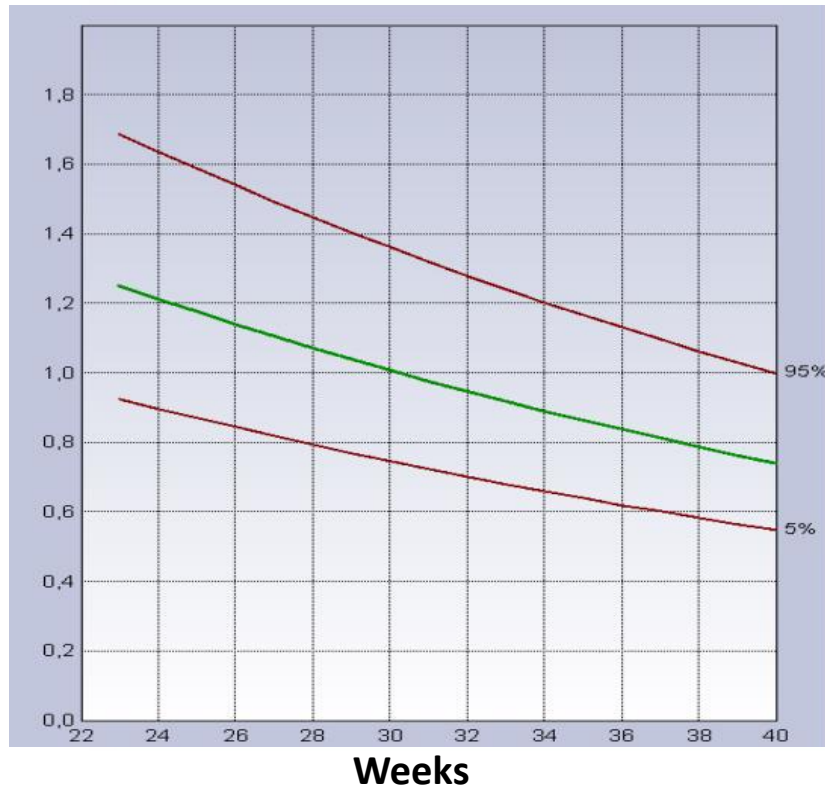
Good Doppler technique:



- Use correct angle of insonation.
- Use correct WMF and sweep speed.
- Measure the P.I.
- Evaluate the end diastolic flow (EDF).
- Measure the best three waveforms.
- Take three separate spectral traces.

Doppler in Pregnancy

Umbilical artery PI

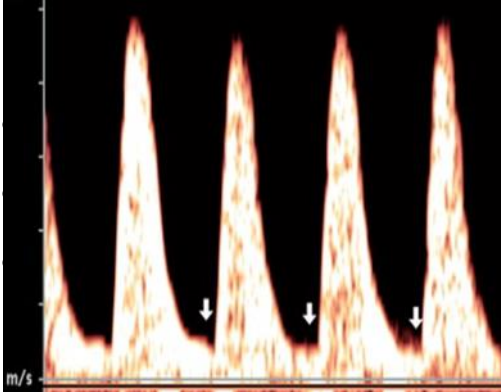


- Pulsatility index in the umbilical artery with gestation (mean, 95th and 5th centiles)
- The lower the P.I. the better.

Parra, Lees et al.: Fetal arterial and venous Doppler pulsatility index and time averaged velocity normal ranges, 2001

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High PI



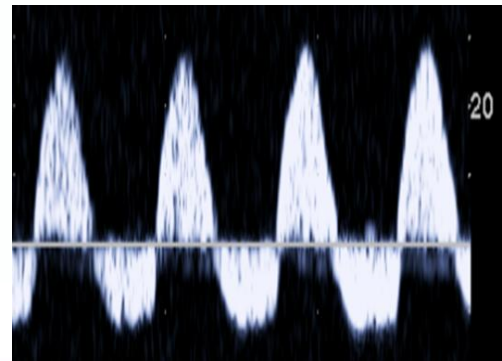
- 30% of placental circulation affected
- Risk of fetal hypoxia: 12-40%

Absent End Diastolic Flow (EDF)



- 50% of placental circulation compromised
- 85% hypoxia in utero
- 50% acidotic in utero

Reversed EDF



- 70% of placental circulation compromised
- Poorer prognosis than absent EDF with a tenfold increase in perinatal mortality.
- A pre-terminal condition

Fetal Arterial Circulation: Middle Cerebral Artery Doppler

Doppler in Pregnancy

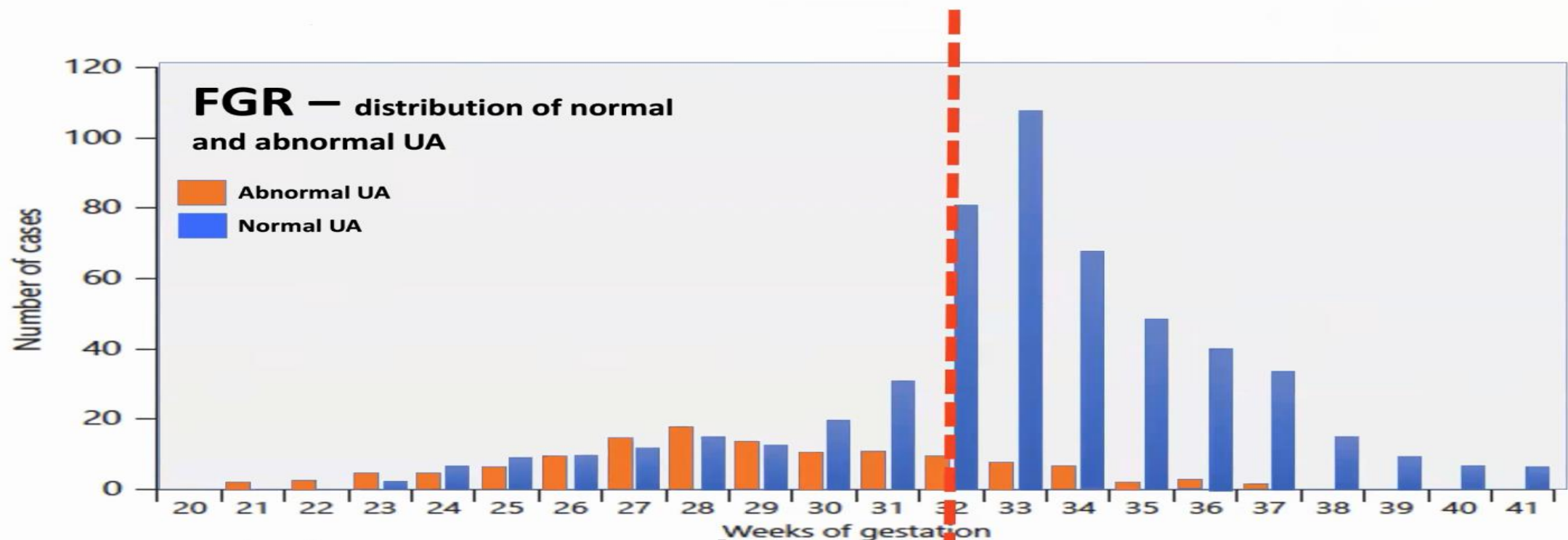
Middle Cerebral Artery Doppler:

Perform when:

- The AC is reduced and the umbilical artery Doppler is abnormal.
- The AC is reduced and the umbilical artery Doppler is normal after 32 weeks.

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Characteristics of Late Fetal Growth Restriction

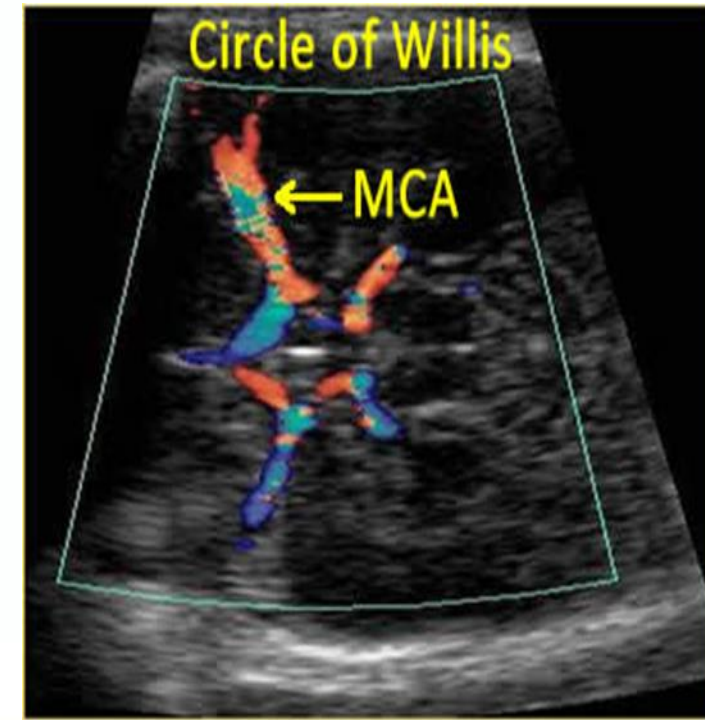
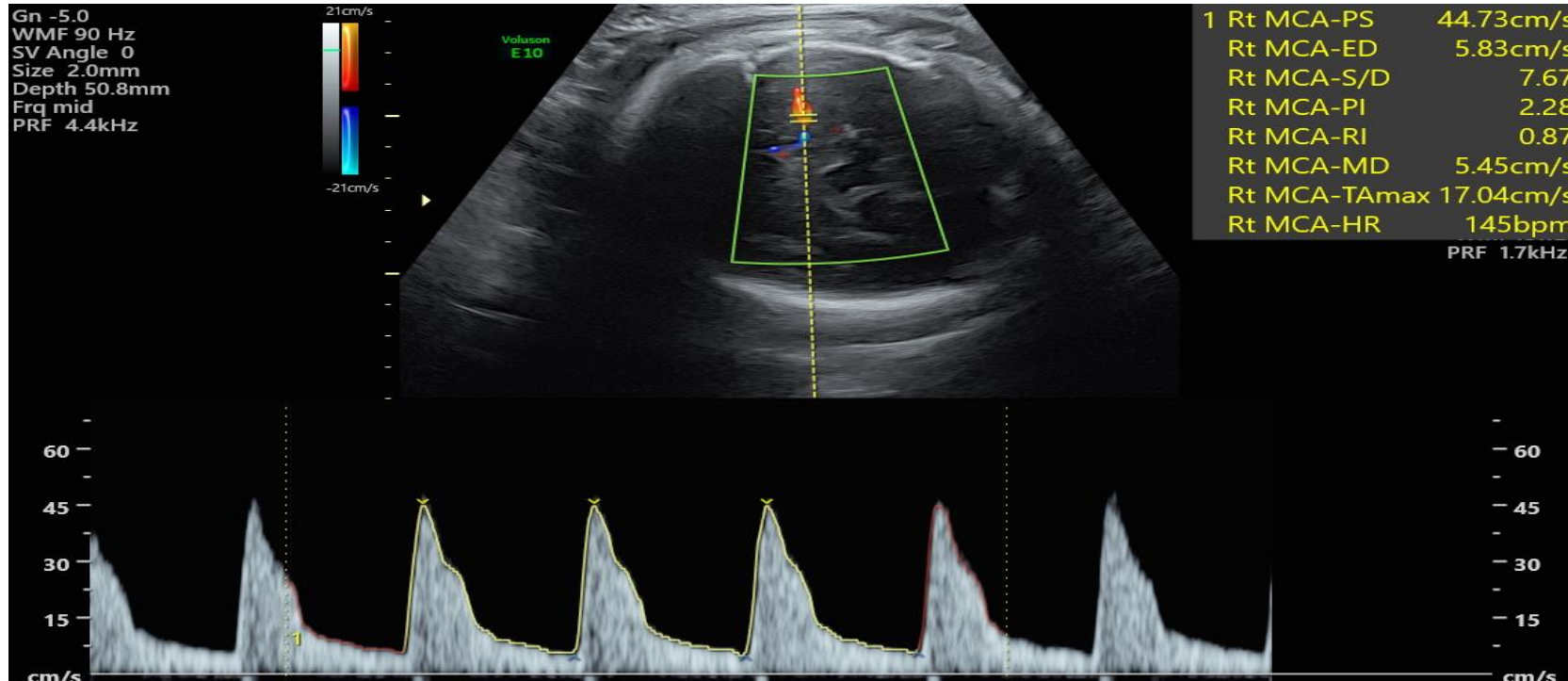


Fetal Diagn Ther 2014; 36:99-105

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Middle cerebral artery Doppler:

- Normal MCA will have a high resistance waveform

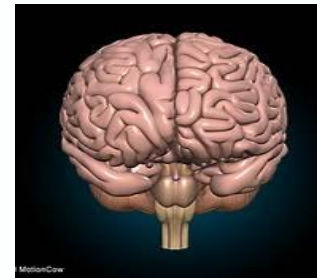


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Middle cerebral artery Doppler:

- Fetal 'arterial redistribution of blood flow' causes an increase of blood flow to the:-

- 1) Heart
- 2) Brain
- 3) Adrenal glands

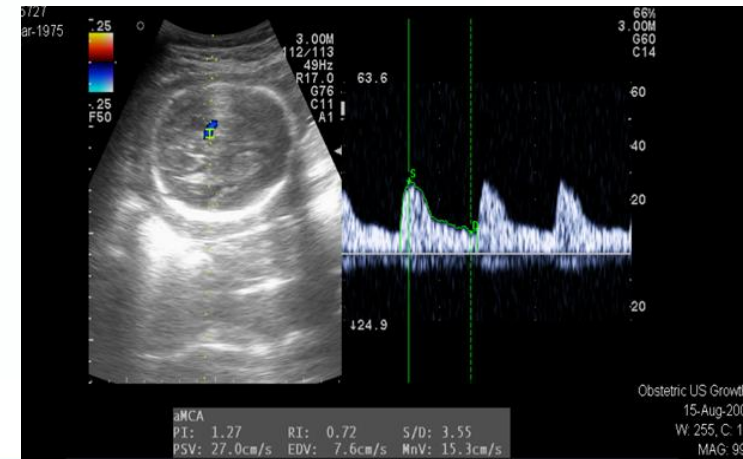


- The fetus redistributes blood away from the peripheral circulation, gastrointestinal tract and liver.

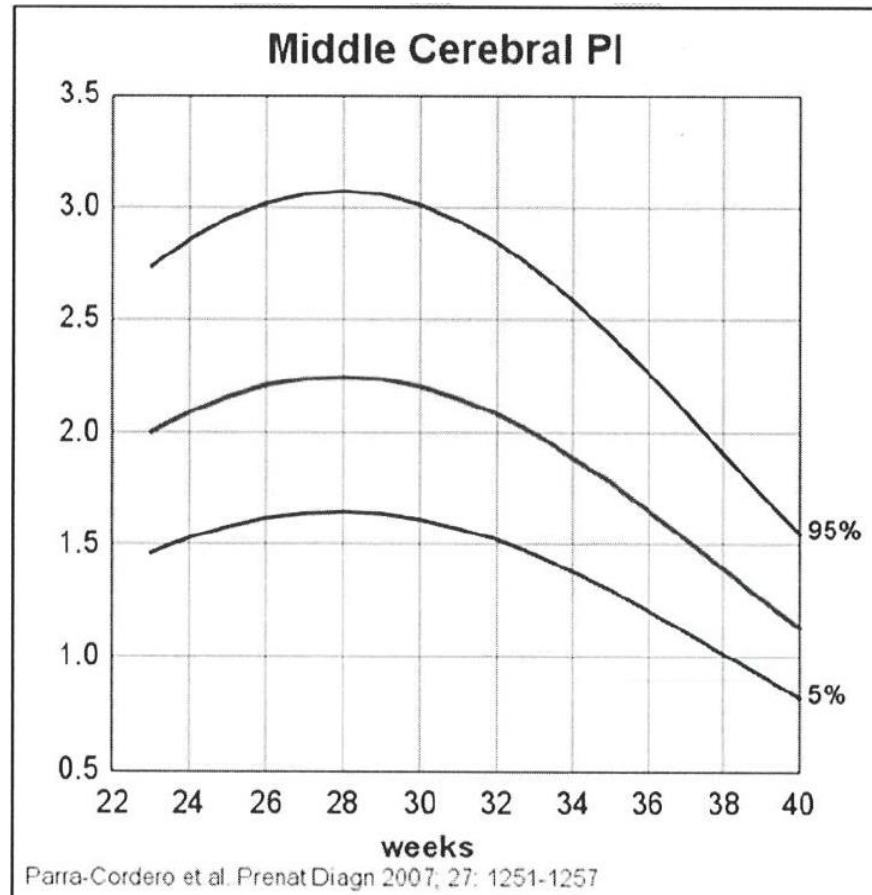
Doppler in Pregnancy

Middle cerebral artery Doppler:

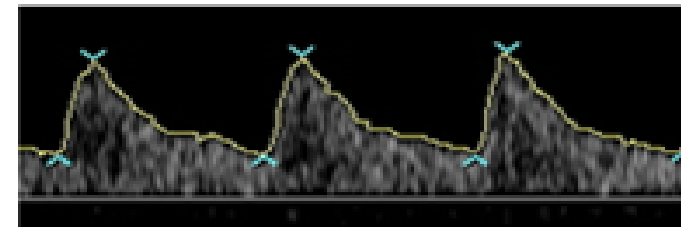
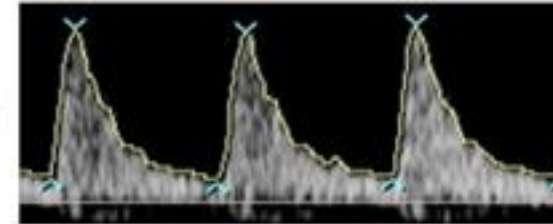
- Initial response to hypoxia: MCA will dilate
- Dilated MCA results in a low resistance waveform
- Low resistance is due to the increased flow of blood through the MCA to the brain.
- This is called the 'Brain Sparing Effect' and is a strong indicator for hypoxia.



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Middle cerebral arteries



'Brain-sparing effect'

Fetal Arterial Circulation:

Ductus venosus

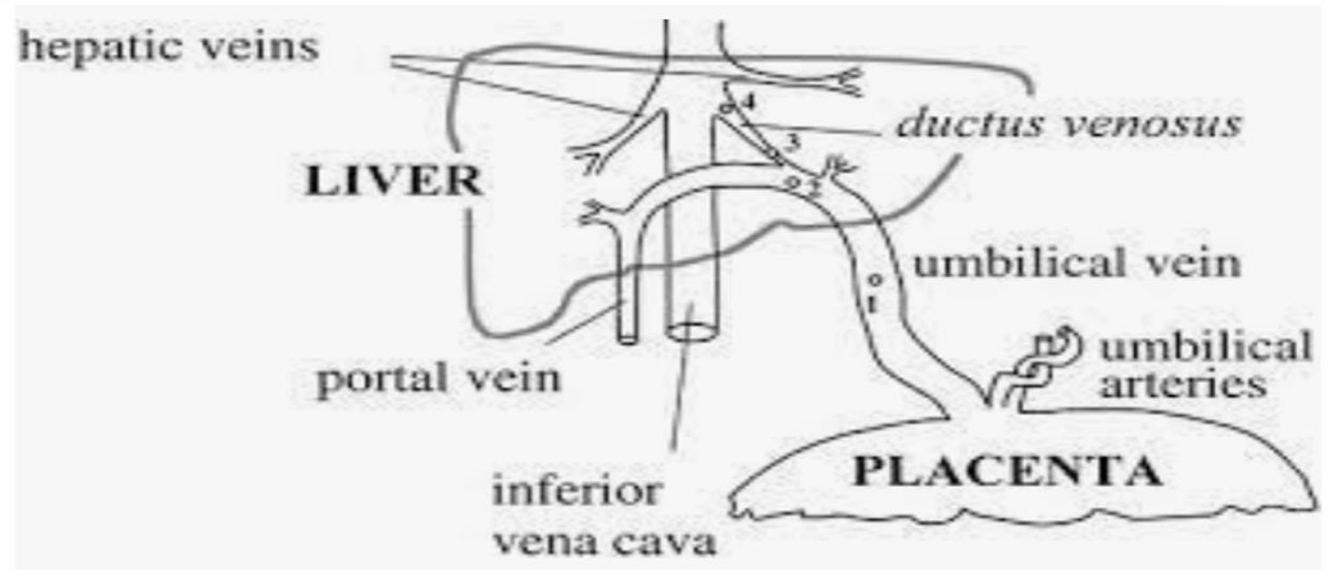
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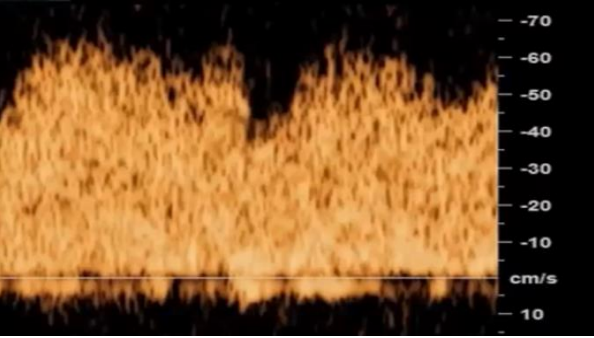
When there is evidence of arterial redistribution by the MCA Doppler, then perform:

- Ductus Venosus

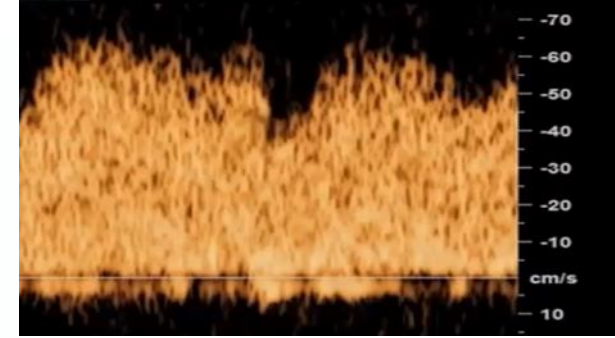
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- The ductus venosus is a shunt that allows oxygenated blood in the umbilical vein to bypass the liver and travel straight to the right atrium via the inferior vena cava. It is essential for normal fetal circulation.





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Ductus venosus:

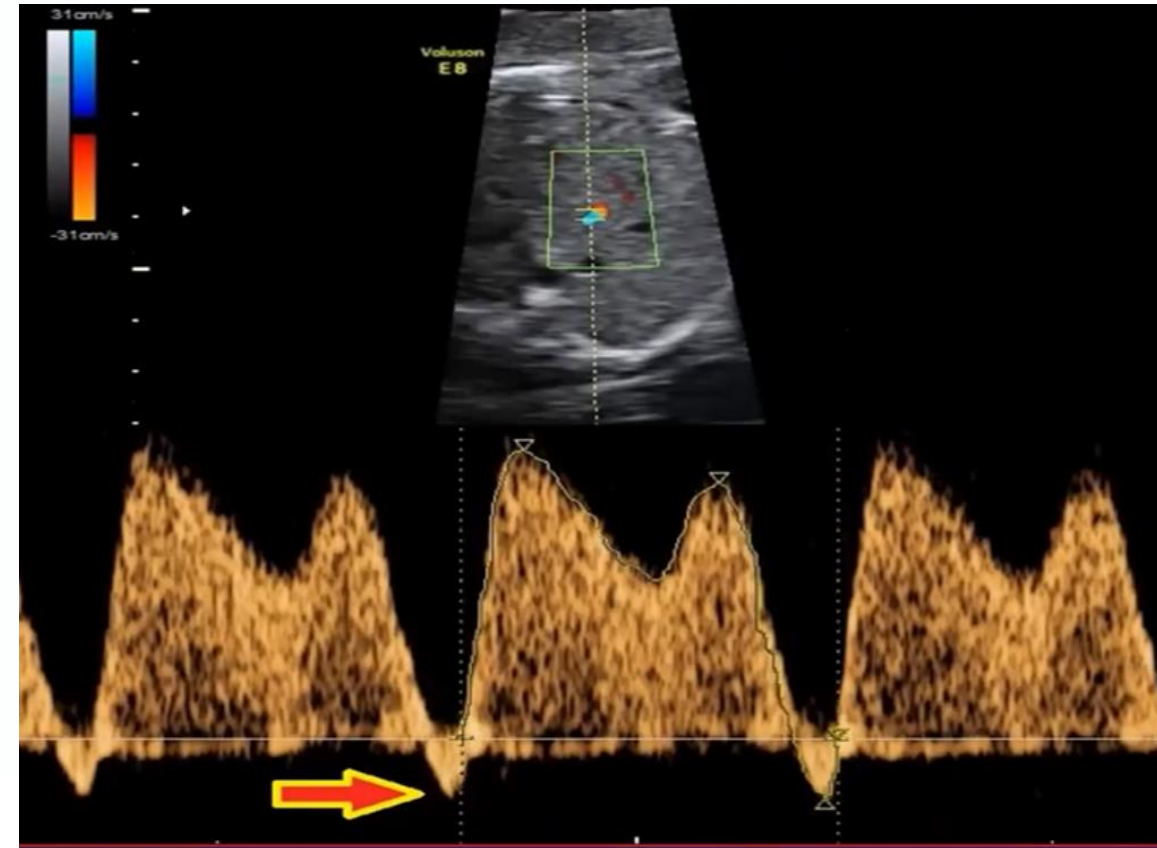
- Very useful in late stage fetal compromise and fetal growth restriction.
- Provide important cardiac data about stressed fetal circulation.
- Normal venous flow suggests continuing fetal compensation by arterial redistribution.

Doppler in Pregnancy

Normal ductus venosus with a positive a-wave

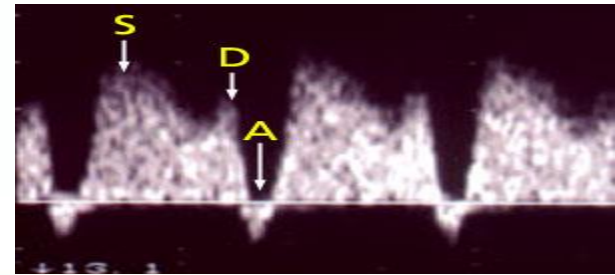


Abnormal Ductus Venosus with a reversed a-wave



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- Abnormal ductus venous waveforms have retrograde flow and an 'a-wave' which indicates the breakdown of haemodynamic compensatory mechanisms.
- When the fetal condition becomes critical, highly oxygenated umbilical vein blood passes exclusively through the ductus venosus to the fetal heart.
- If there is an increasing right ventricular afterload heart failure occurs.



Doppler in Pregnancy

Remember Doctors and sonographers have different skill sets.

- Educate sonographers to write accurate ultrasound reports to best help the Doctors provide effective clinical management.
- Spell out to the Doctors what is normal and what is not.



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Management dilemmas:

- Some fetuses will never reach a viable weight.
- Some fetuses will reach a viable weight, but delivery will not improve outcome.
- Waiting for maturity versus risk of IUD.
- Timing of steroids/delivery.
- Long-term stay on SCBU and long-term problems should be discussed with the parents.



Doppler in Pregnancy



Take home messages:

- Obstetric Doppler studies give information about fetal and pregnancy patho-physiology.
- Doppler can indicate abnormal placentation, fetal hypoxia, fetal anaemia and impending heart failure.
- Ultrasonographers should perform Doppler examinations with expertise and understand its potentials, limitations and what the waveforms mean.
- Audit sonographers' Doppler technique to ensure good practice.

Doppler in Pregnancy

***Helping one person might not change the whole world,
but it could change the world for one person.***



Thank you for listening!



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