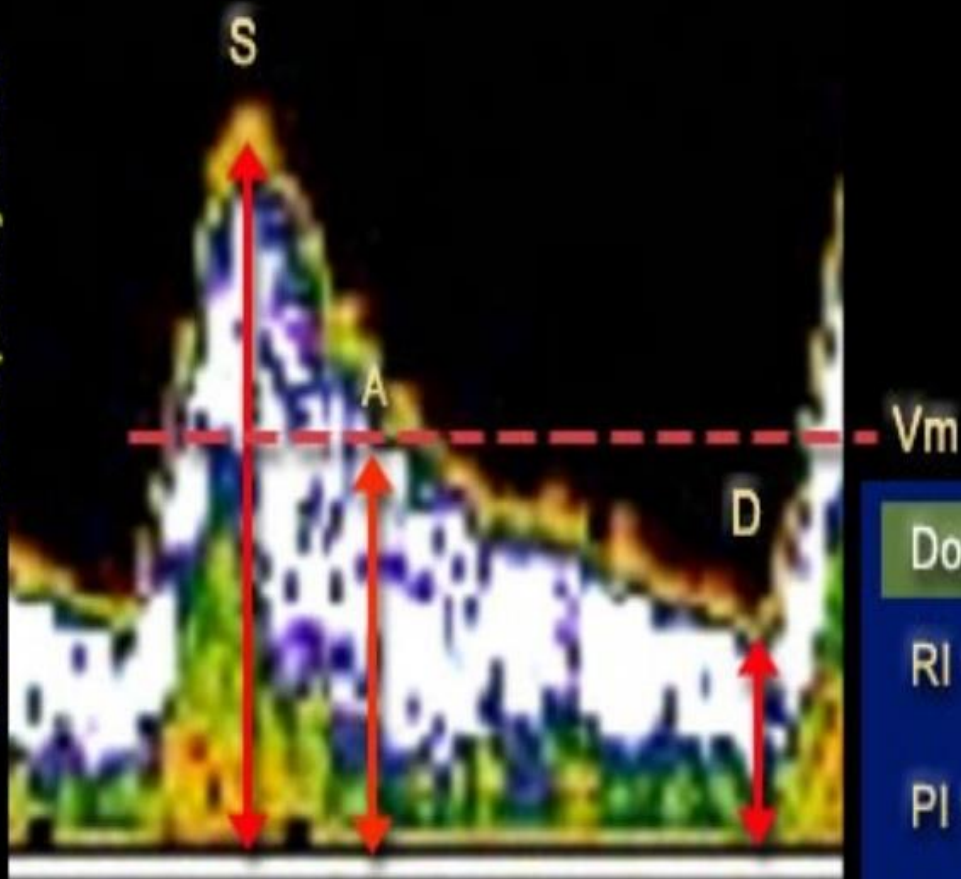


Doppler in pregnancy

- سونو کالر داپلر روشی برای اندازه گیری جریان خون در شریانها و عروق خونی است
- با تغییر فرکانس یا طول موج بر اثر حرکت (جریان خون) عمل می کند . در شریانها در هر سیکل ضربان قلب بوجود می آید یک موج ایجاد می کند که با سیستول شروع میشود و در انتهای دیاستول خاتمه می یابد
- برای ارزیابی جریان خون در عروق ایندکسهای زیر مورد بررسی قرار میگیرد
- PI : pulsatility index
- S/D Ratio :Systol - diastolic ratio
- RI :resistivity index
- عروق مورد بررسی داپلر شامل شریانهای رحمی ،شریان نافی،ورید نافی ،آئورت شکمی جنین،شریان سربرال میانی جنین و داکتوس ونوزوس است.

Maximum Frequency Shift



S = systolic peak (max. velocity)

D = end diastolic flow

Vm = mean velocity

A = Temporal average frequency over 1 cardiac cycle

Doppler Indices

$$RI = (S - D) / S \text{ (Pourcelot, 1974)}$$

$$PI = (S - D) / A \text{ (Gosling, 1976)}$$

$$S/D \text{ Ratio} = S/D \text{ (Stuart \& Drumm, 1980)}$$

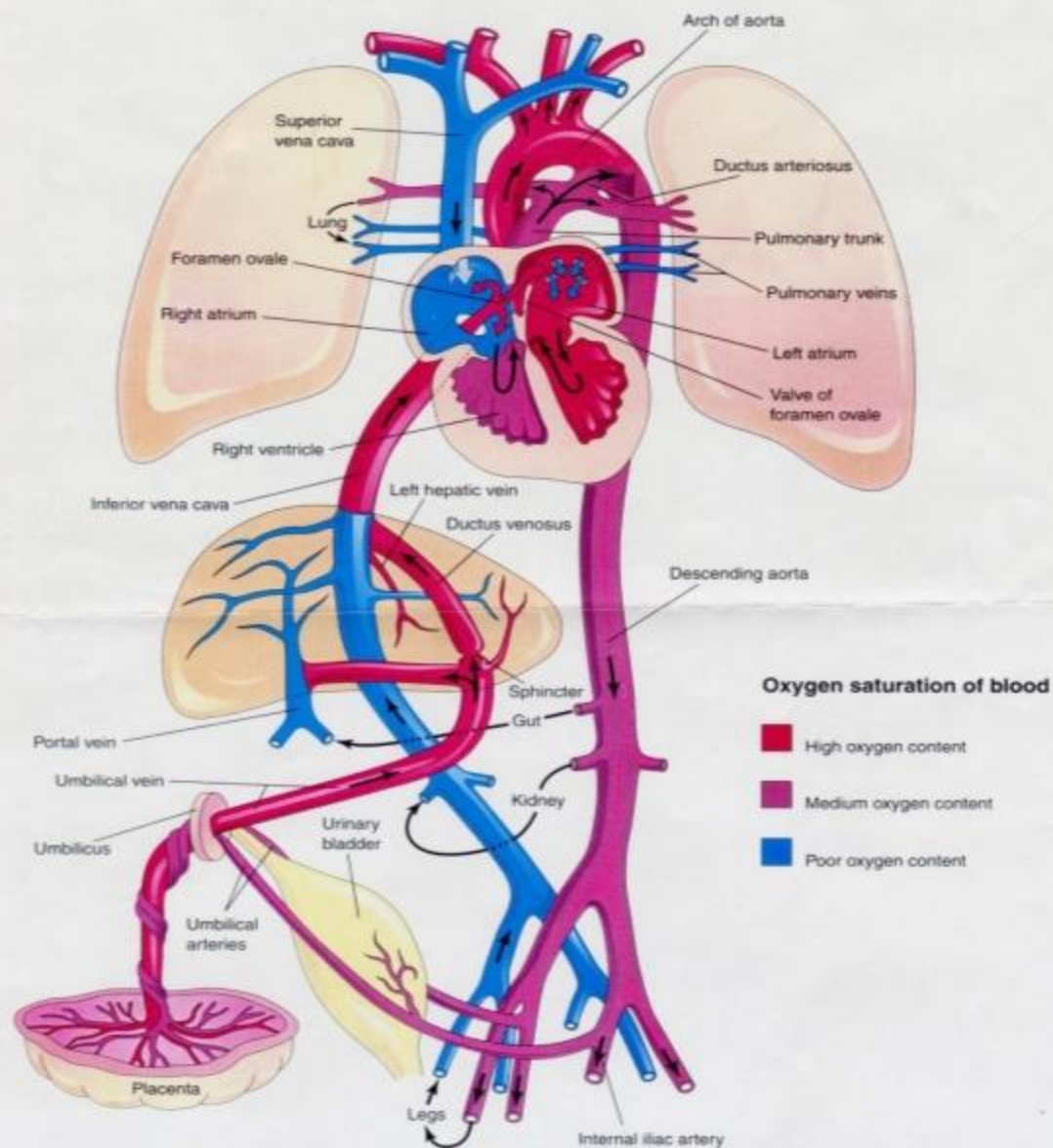



FIGURE 24-43. Schematic illustration of the fetal circulation. The colors indicate the oxygen saturation of the blood, and the arrows show the course of the blood from the placenta to the heart. Observe that three shunts permit most of the blood to bypass the liver and lungs: (1) ductus venosus, (2) foramen ovale, and (3) ductus arteriosus. The poorly oxygenated blood returns to the placenta for oxygen and nutrients through the umbilical arteries. (From Moore KL, Persaud TVN. *Before We Are Born: Essentials of Embryology and Birth Defects*, 5th ed. Philadelphia, W.B. Saunders, 1998.)



Color Doppler ultrasound Obstetric and Gynaecology

Doppler ultrasound has three view of applying in the Obs & Gynae field.

- Direct view for example in ovarian torsion or detecting vascularity of a fibroma.
- Easy conceptual view for example to differentiating a benign ovarian mass from malignant one.
- Deep conceptual view for example in detecting fetal hypoxia & acidosis in pregnancy , congenital anomalies and tumors , multiple pregnancies, follow fetal growth.



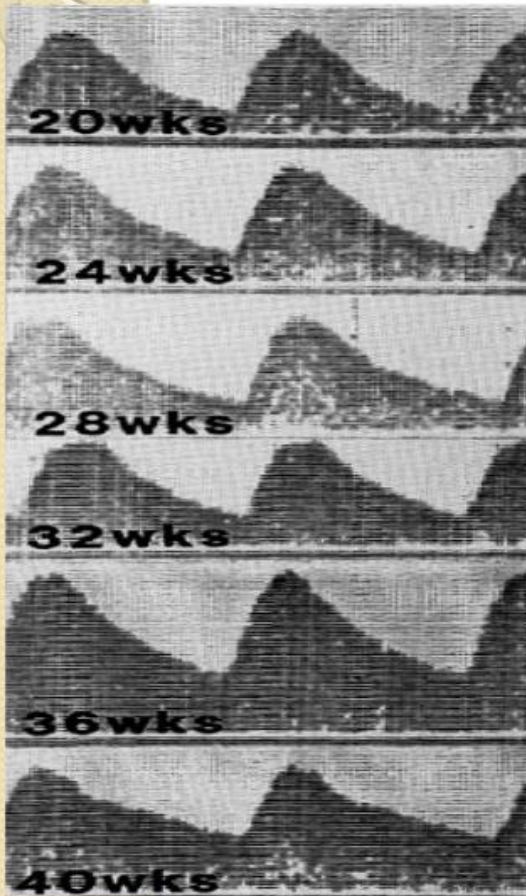
Vessels need to be examined

- Umbilical artery
- Middle cerebral artery
- Uterine artery
- Thoracic aorta
- IVC
- Ductus venosus
- Umbilical vein



Umbilical artery doppler

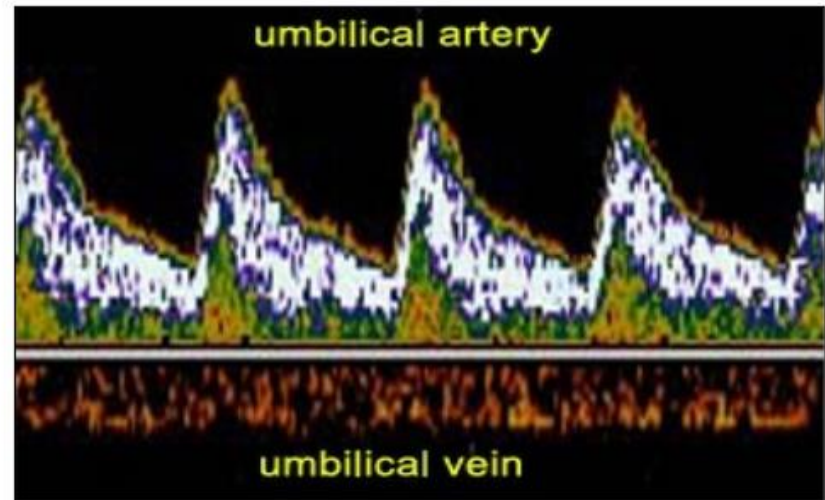
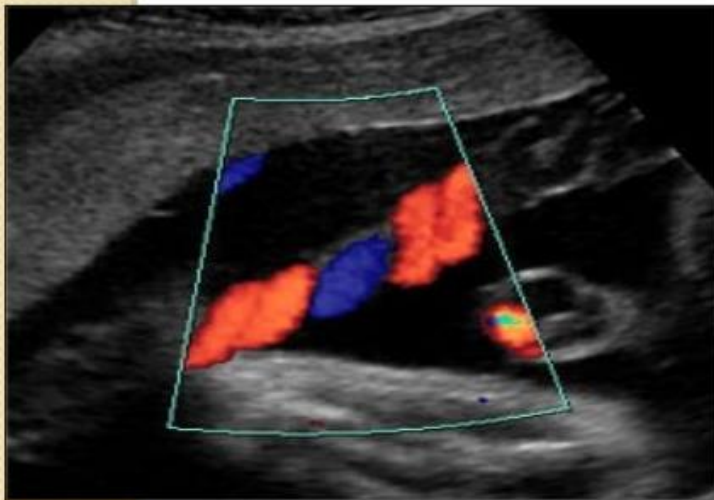
Basic Principles



- Umbilical arteries arise from allantoic arteries.
- End diastolic flow is often absent in first trimester.
- The high vascular impedance detected in the first trimester gradually decreases.
- It is attributed to growth of placental unit and increase in the number of the functioning vascular channels

UMBILICAL ARTERY FLOW

Characteristic **saw-tooth appearance of arterial flow** in one direction and **continuous umbilical venous blood flow** in the other.



Normal Umbilical Artery Doppler indices

PI {2nd trimester = 2 to 1.5}

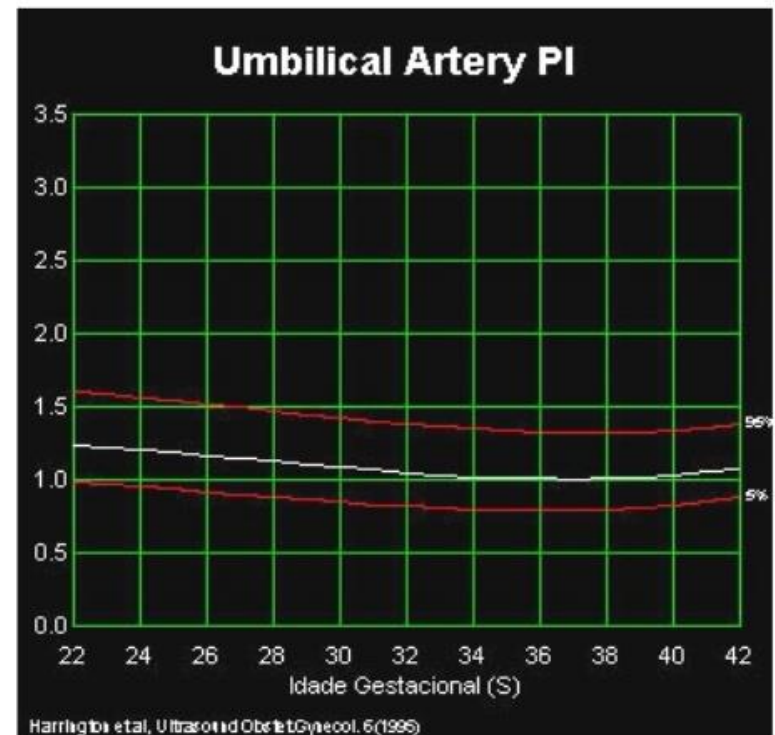
PI { 3rd trimester = 1.5 to 1 }


S/D RATIO = Decrease as pregnancy advance

Before 28 week <5

28 to 34 week <4

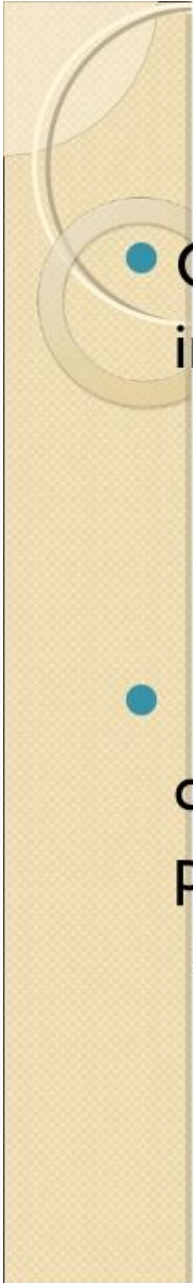
From 34 week to term
<3 to 3.5

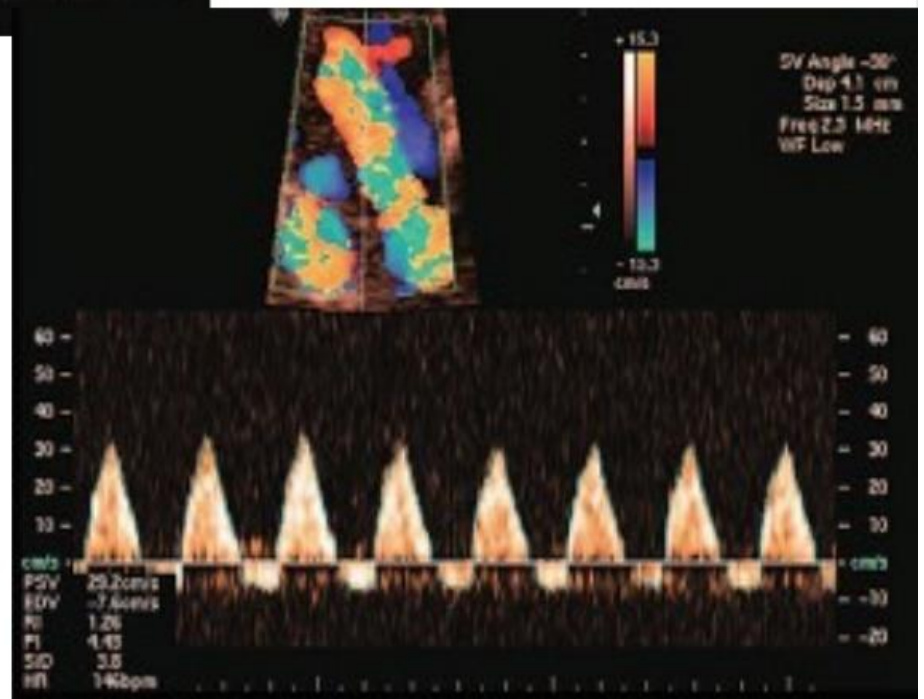
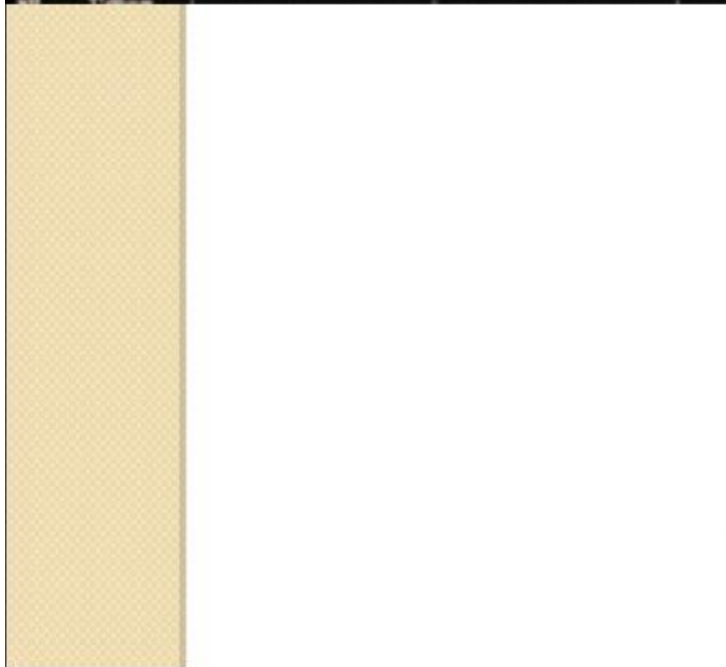
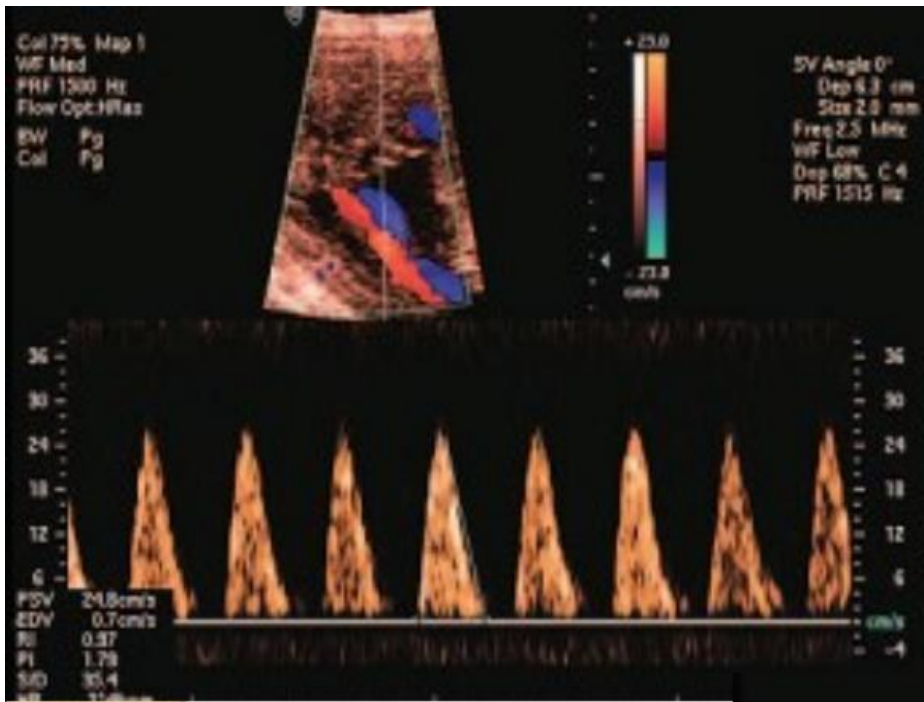



- 
- In IUGR, defective trophoblastic invasion of vessels- Increased placental vascular resistance -decreased forward flow in UA-decreased diastolic flow.
 - SD ratio, PI and RI all increase
 - Eventually diastolic flow reaches zero=Absent End Diastolic Flow(normal in <16 wks)
 - Further increase in vascular resistance causes flow reversal in diastole= Reversed EDF

- UA waveforms are slightly different at the fetal abdominal wall and at the placental insertion, with indices higher at the wall than the insertion.
- Though placental insertion is preferred site for measurement as not influenced by fetal movement.
- In practice, the UA is best examined in a segment of free floating umbilical cord.

- If there is reversed flow, the UA is reexamined close to the placental insertion, because this segment of the UA is the last part to develop reversed flow.
- Waveforms should be taken in semilateral position to eliminate forced respiratory and body movements ,as they can lead to abnormal waveforms.

- 
- Chasing the cord in grey scale will lead to inadvertently large angles of insonation and the wrong impression of reduced or even absent EDF.
 - Magnification of a cord segment followed by use of colour doppler ,detecting flow velocity in vertical plane ,allows the pulsed doppler gate to be placed in each artery with a minimum angle of insonation.

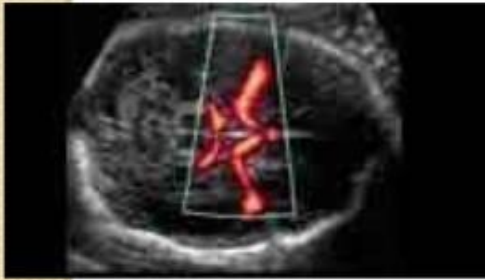


- 
- UA doppler is the “tip of iceberg “with respect to fetal hemodynamic state
 - Doppler shouldn't be done in fetuses with normal growth
 - Decisions regarding IUGR are not based on doppler alone, others factors to be considered are;
 - Gestational age
 - Interval growth and amniotic fluid volume
 - Nonstress testing and biophysical profile
 - Maternal factors

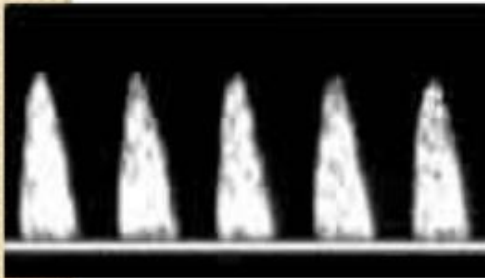


Middle cerebral artery doppler

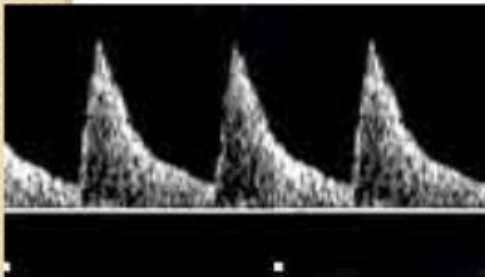
Normal MCA waveforms



Circle of willis



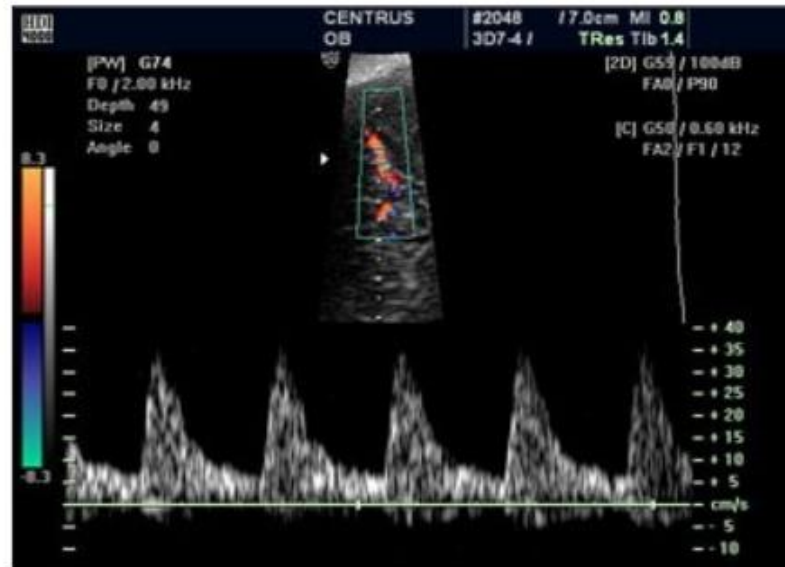
Normal impedance to flow in first trimester



Normal impedance to flow in second trimester

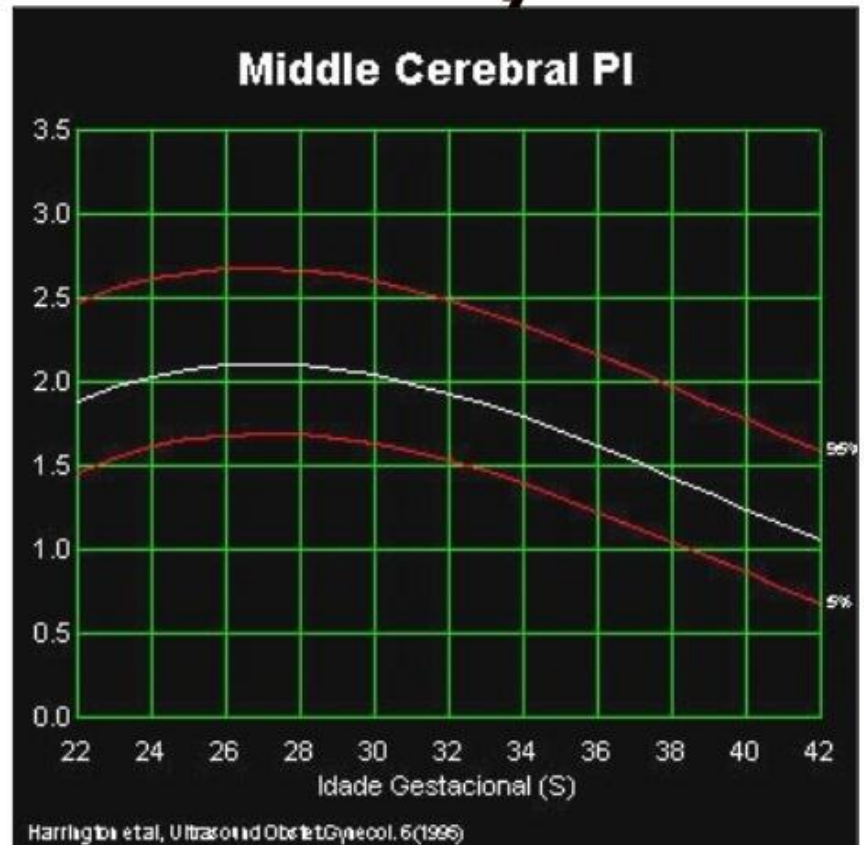
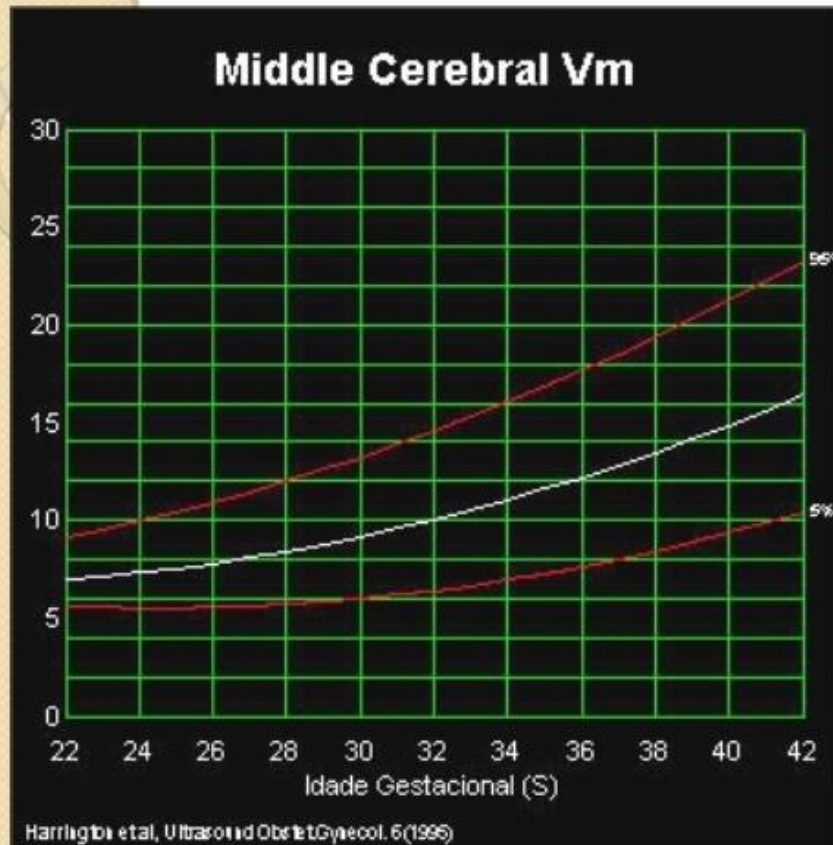
Middle cerebral artery

The possible doppler velocimetry sites

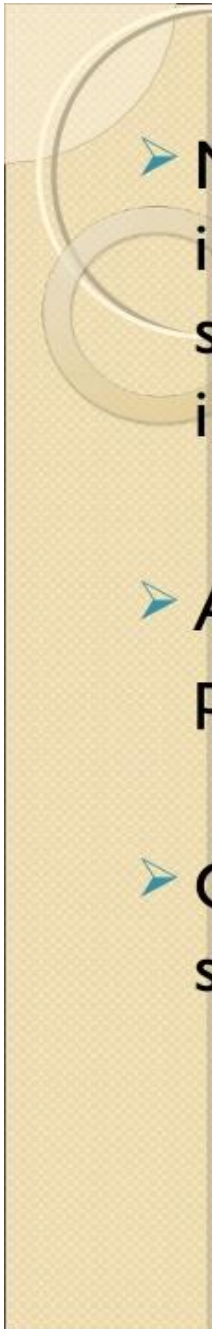



Using color flow imaging, the middle cerebral artery can be seen as a major lateral branch of the circle of Willis, running anterolaterally at the borderline between the anterior and the middle cerebral fossa


Middle cerebral artery



The blood velocity increases with advancing gestation, and this increase is significantly associated with the decrease in PI

- 
- MCA is the vessel of choice because it is easy to identify, is highly reproducible and can be easily studied with an angle of 0 degrees providing information on the true velocity of the blood flow
 - Average of both MCAs must be calculated for more precise result.
 - Obtain an axial section of the head at the level of sphenoid bone.

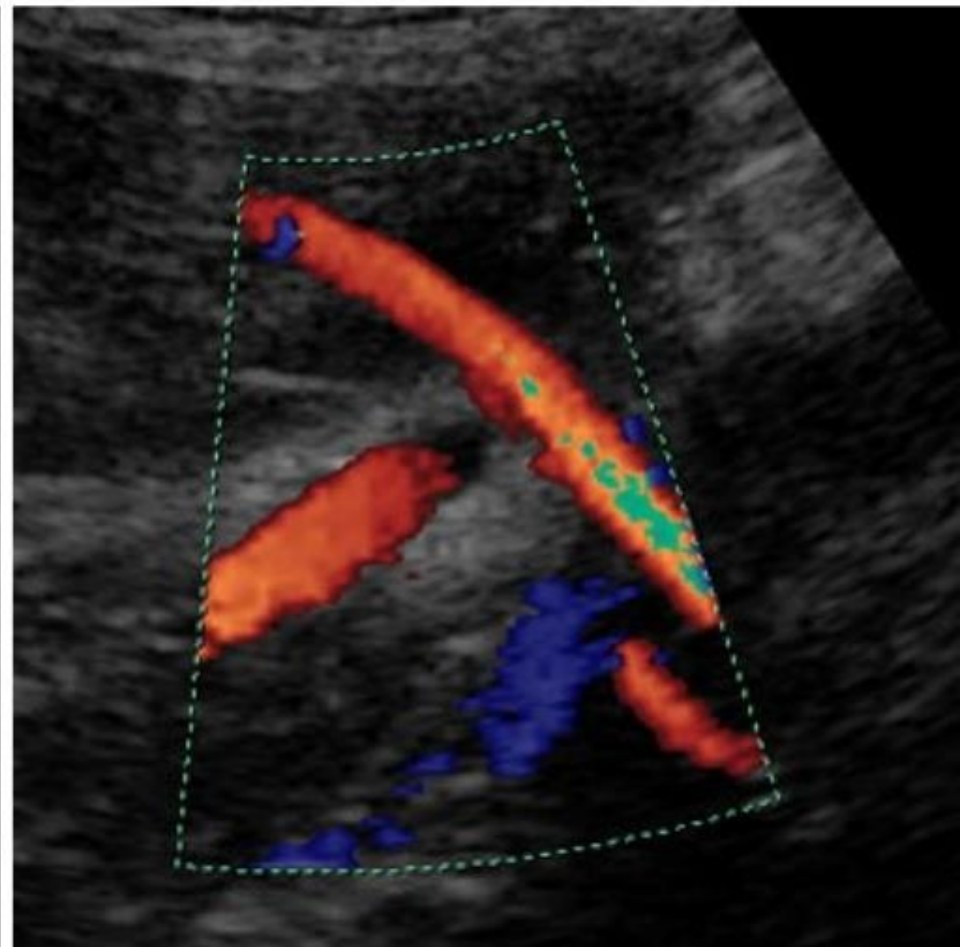
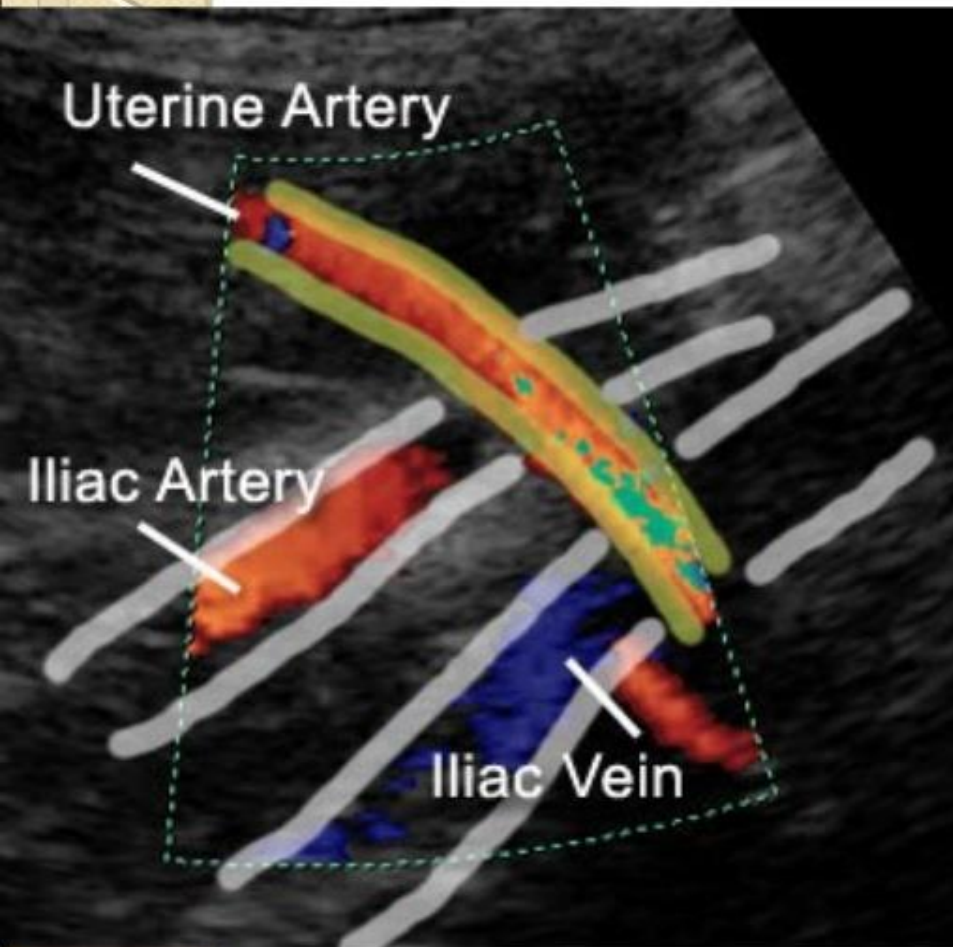
- 
- S/D ratio of MCA should be $>$ S/D ratio of UA throughout gestation
 - In IUGR ,hypoxia leads to autoregulation in fetal circulation causing increased flow towards brain, heart and adrenals and decreased towards kidney, placenta and peripheries.
 - Autoregulation leads to;
 - Increase in peak systolic velocity (PSV)
 - Decrease in S/D ratio,PI,RI ,values
 - Reversal of S/D ratio (UA $>$ MCA) in IUGR is called “head sparing” pattern

- 
- Apparent improvement in MCA PI and S/D ratio following sustained hypoxia may occur due to brain edema causing reversal of head sparing pattern.
 - So prediction of perinatal mortality is better done via MCA PSV rather than MCA PI as PSV shows sustained increase and tends to show slight decrease but values are maintained well above the upper limit of normal until a few hours before delivery or fetal demise.
 - Simultaneous improvement of UA tracing towards normal is better indicator.

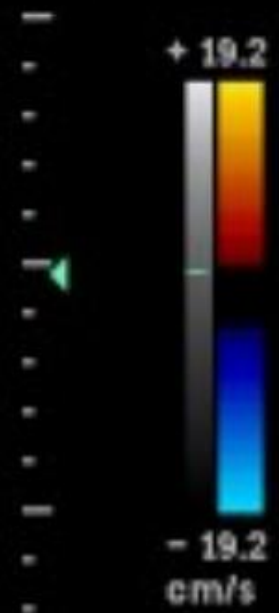


UTERINE ARTERY DOPPLER

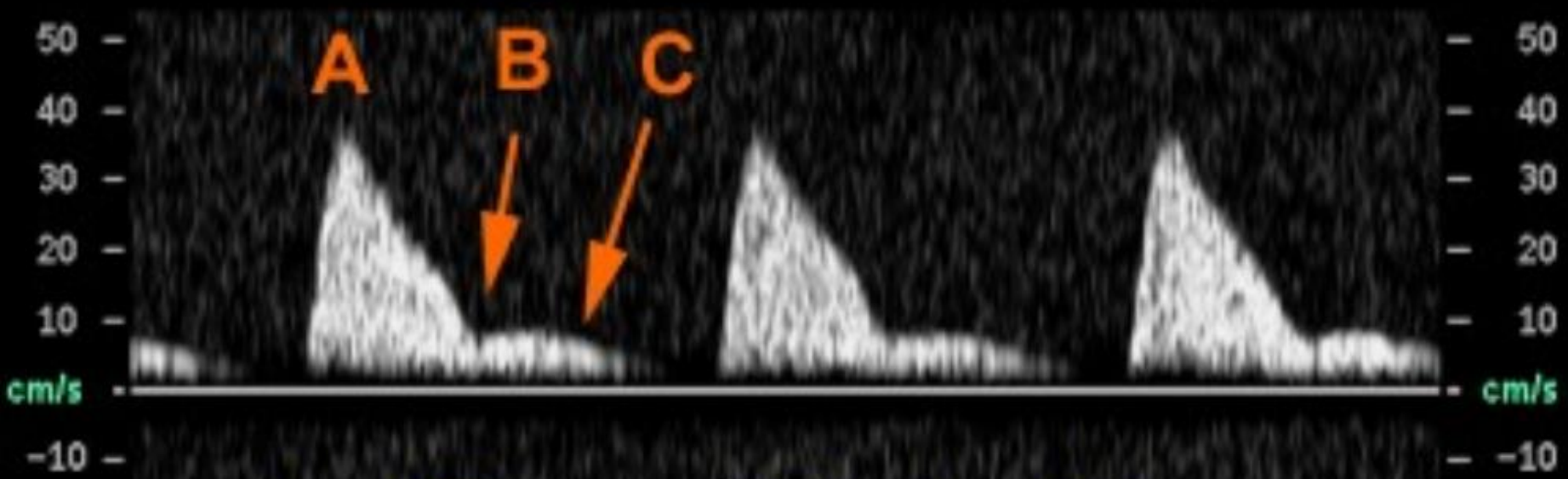
Uterine artery



Col 79% Map 7
WF Max
PRF 2000 Hz
Flow Opt: Med V

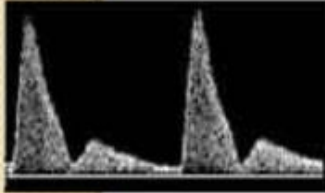


SV Angle 0°
Dep 4.2 cm
Size 2.0 mm
Freq 4.0 MHz
WF Low
Dop 86% Map 3
PRF 3731 Hz

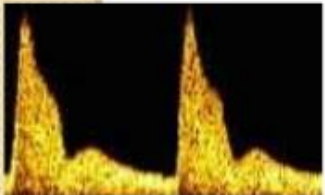


Non-Pregnant Uterine Artery

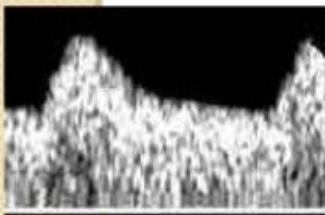
Normal uterine artery waveforms



Normal impedance to flow the uterine arteries in 1^o trimester



Normal impedance to flow the uterine arteries in early 2^o trimester



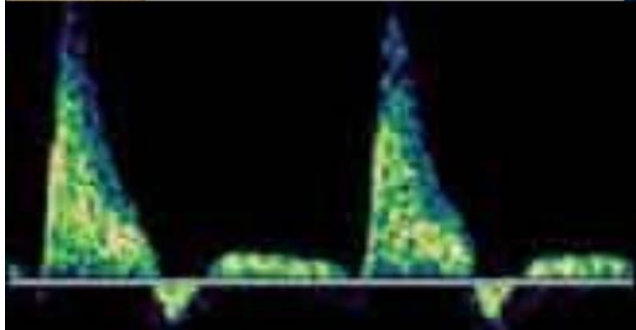
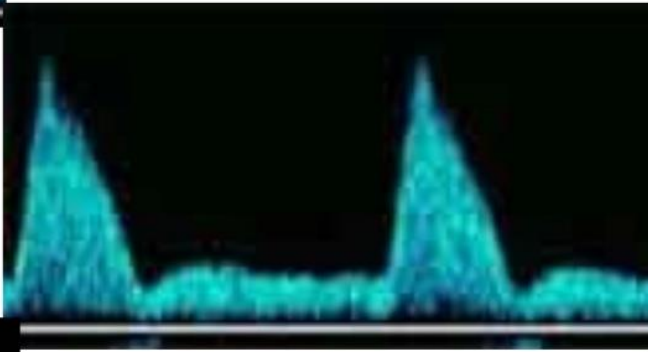
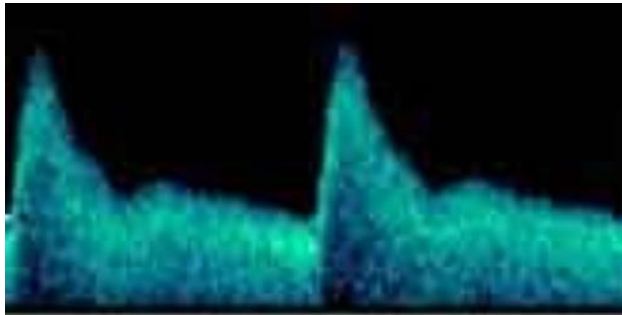
Normal impedance to flow the uterine arteries in late 2^o and 3^o trimester

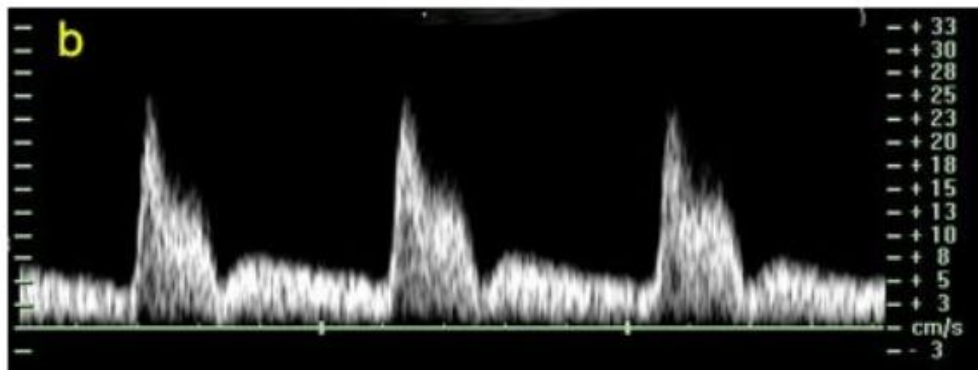
USES

- Ut artery doppler has more of predictive value for IUGR and PRE-ECLAMPSIA.
- Early diastolic notching and reduced or absent diastolic flow is normal in first trimester.
- But endovascular trophoblastic invasion of spiral arteries leads to decrease in placental vascular resistance, so after 16 wks of gestation there is progressive increase in diastolic flow throughout gestation
- So PI,RI and S/D ratio remain low.

- Early diastolic notch should disappear by 25th wk of gestation.
- Abnormal UA doppler reveals information about fetal side while abnormal Ut artery doppler tells about maternal side.
- Both Ut arteries are assessed just after crossing the iliac vessels and average measurement is taken, both are taken to avoid biases due to lateral placental implantation (lower PI and RI values on ipsilateral side).

Uterine artery





Doppler spectra of uterine artery flow. (a) The colour flow image allows beam/flow angle visualization. The sonogram shows high velocities throughout the cardiac cycle, indicating low distal resistance. (b) The sonogram shows a pulsatile flow waveform with low diastolic velocities. This is indicative of high distal resistance



Indications for Ut artery doppler

- Previous history of preeclampsia
- Previous history of child with IUGR
- Unexplained high maternal serum AFP level
- Unexplained high HCG levels

Uses of uterine artery doppler

- *IN VITRO FERTILIZATION*

If Ut A PI > 3.26, very low chance of achieving pregnancy, tells about receptivity of endometrium for implantation

- *RISK ASSESSMENT FOR PRE-ECLAMPSIA AND IUGR*

If the PI values of both uterine arteries are normal, the patient can be informed that she most likely will not develop preclampsia or have an IUGR fetus, as there is >99% negative predictive value

but if both are abnormal, patients are followed with more frequent clinic visits and ultrasounds for growth because the test has got only 50-75% positive predictive value.

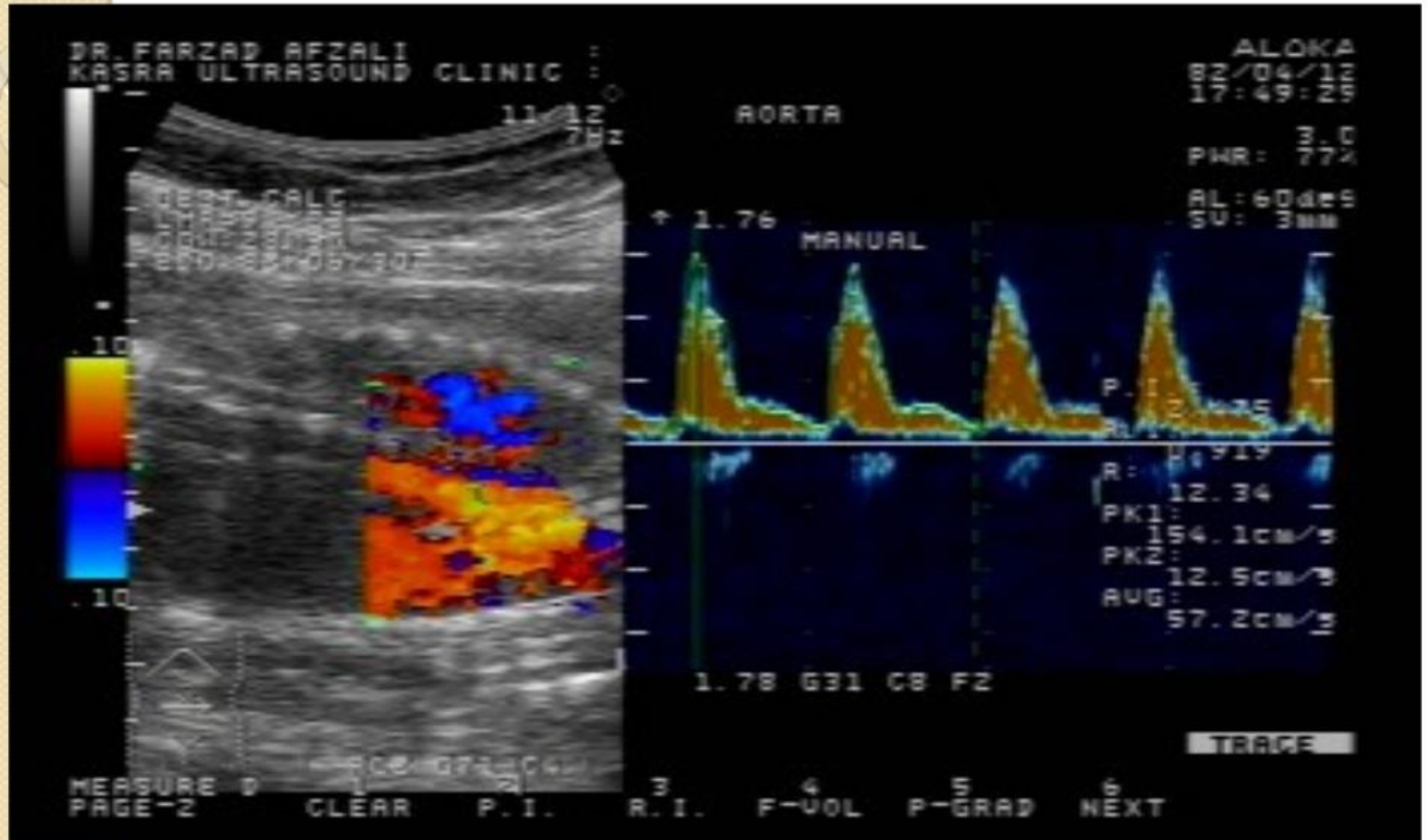
NORMAL VALUES

VESSELS	PI	RI
Umbilical artery	Early 2 nd trimester (1.5-2) Term = 1 (1-1.5)	<0.7
Middle cerebral artery	At 28-32 wks (>1.45) Term = 1	0.7-0.9
Uterine artery	18-22 wks(<1.2) If PI >1.45 with b/l notching then it indicates severe ischaemia.	0.33-0.55



THORACIC AORTA DOPPLER

FETAL AORTA



Comment

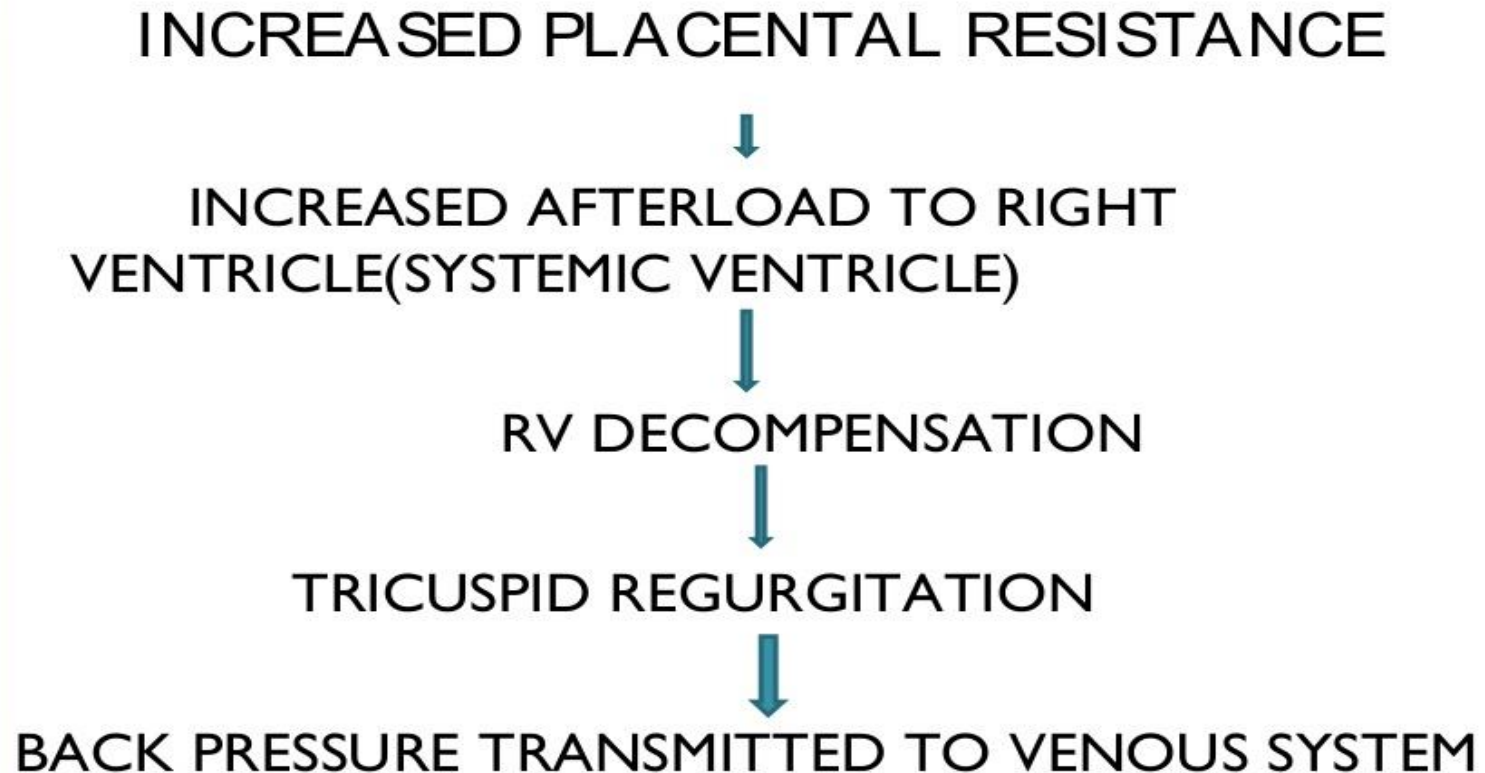
- Acidosis causes peripheral arterial spasm & rises PI of femoral arteries, consequently increases thoracic aorta PI.
- If fetal acidosis has an intrinsic cause, it will be expected that femoral artery PI will be effected more than umbilical PI.

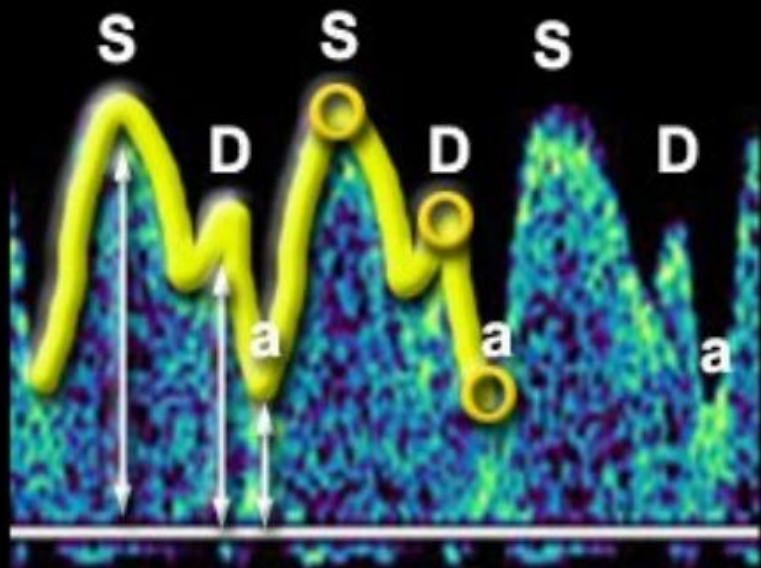
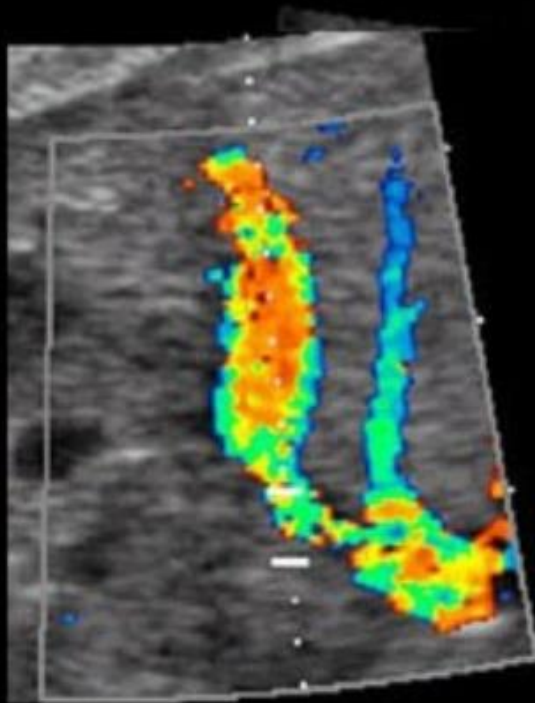
- PI of the descending aorta remains relatively constant throughout gestation because placental and renal resistance decreases while lower extremity vascular resistance increases with advancing gestation.
- It's normal for diastolic flow to decline at the end of pregnancy k/a “term effect”.
- In severe IUGR ,there is reversed flow in descending aorta.




DUCTUS VENOSUS DOPPLER

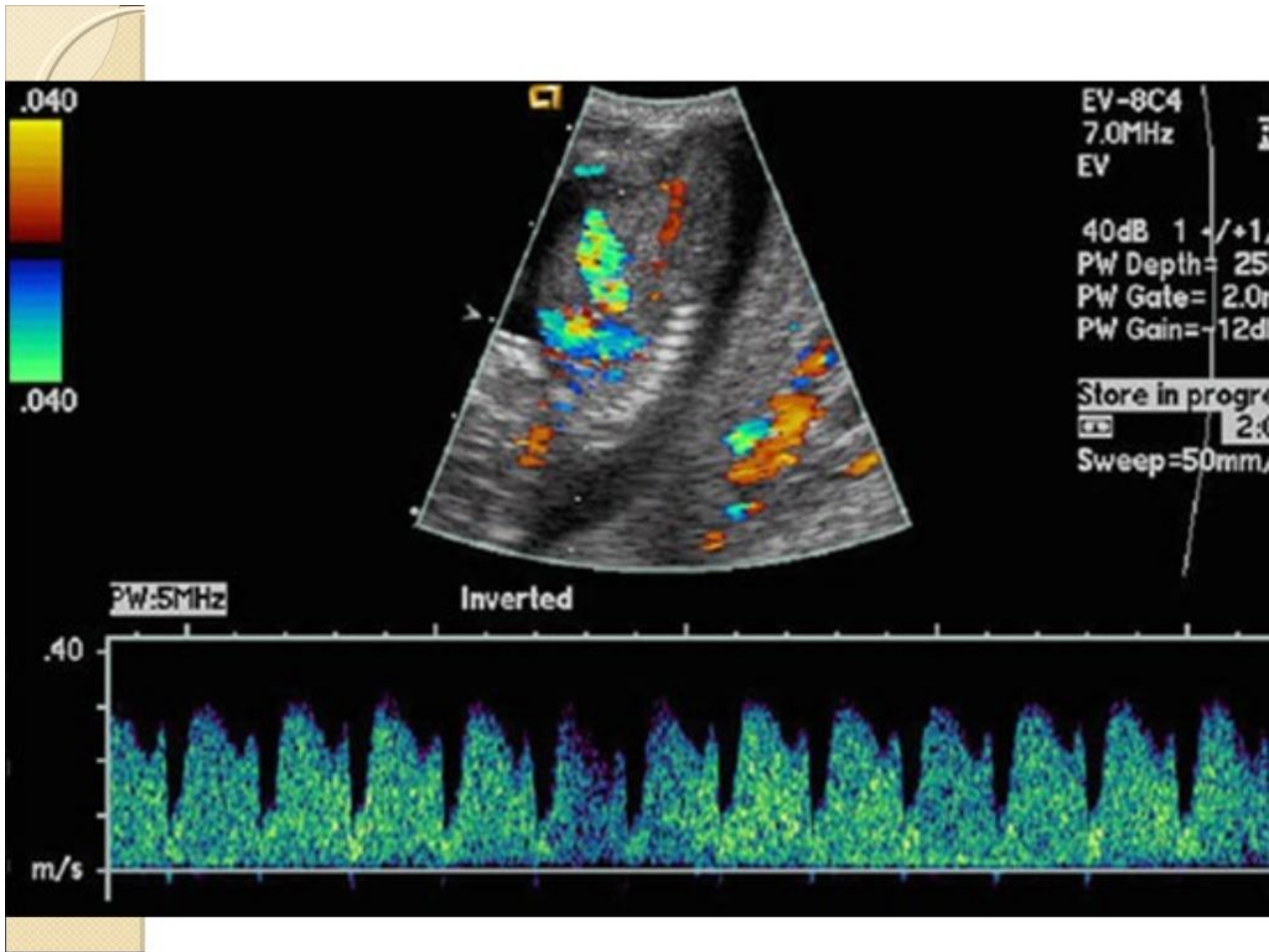
Pathological changes in venous flows with FGR

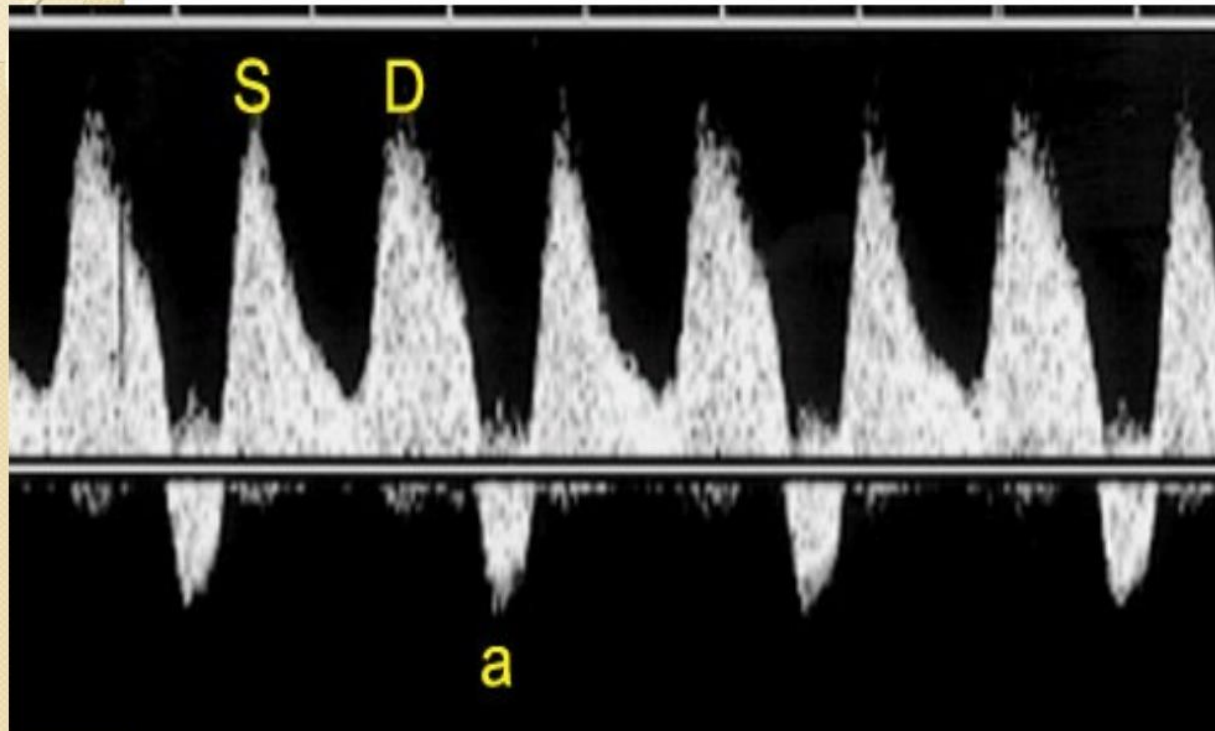




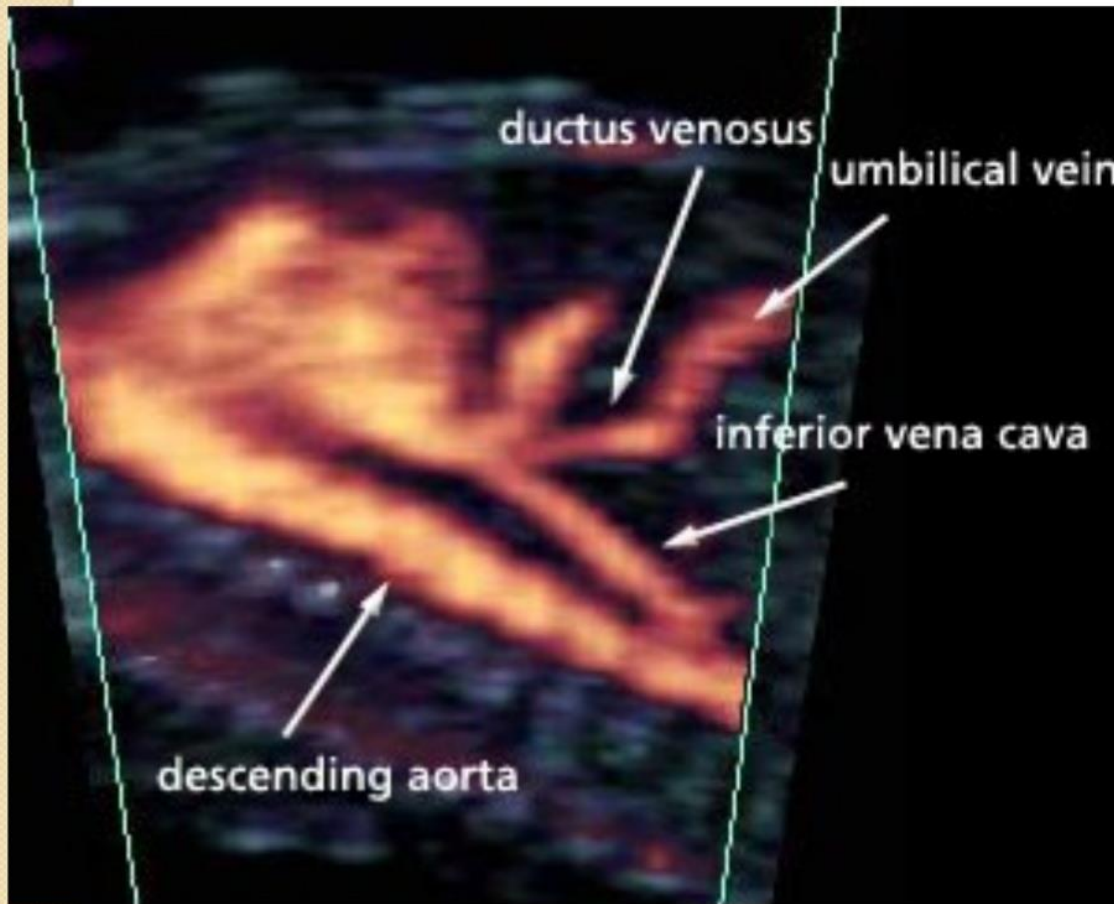
S = Ventricular systole
D = early diastole
a = atrial contraction

- 
- ❖ Ductus venosus is vascular connection from umbilical vein to IVC .
 - ❖ It is funnel shaped.
 - ❖ Ductus venosus develops at 7 wks gestation and shows minimal increase in diameter as a result, diameter of DV is approx 1/3 of umbilical vein after first trimester so blood coming through umbilical vein accelerates in DV and this high velocity flow gets directed towards left atrium from Rt atrium via foramen ovale .





DV waveforms showing reversal of 'a' wave





OTHER USES

**Abnormal DV waveforms in first trimester
should arise suspicion for**

- Presence of aneuploidy
- Risk of CHD even if chromosomal study is normal

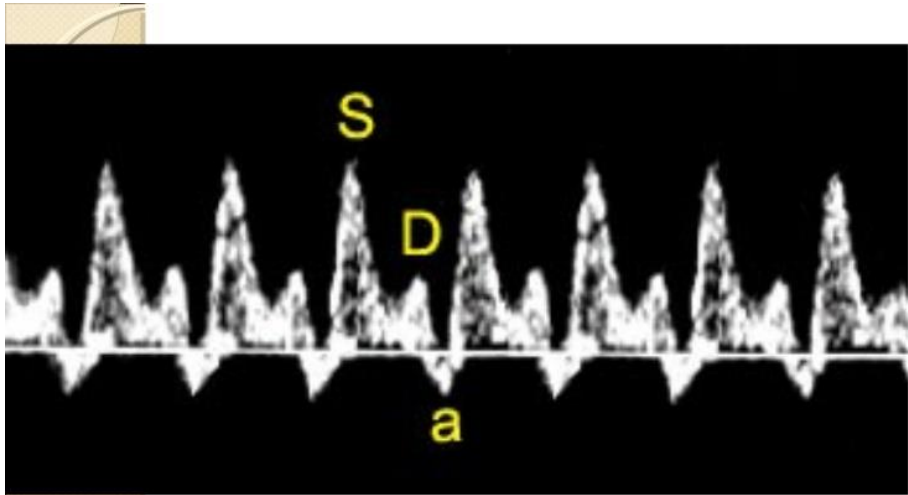


Umbilical vein doppler

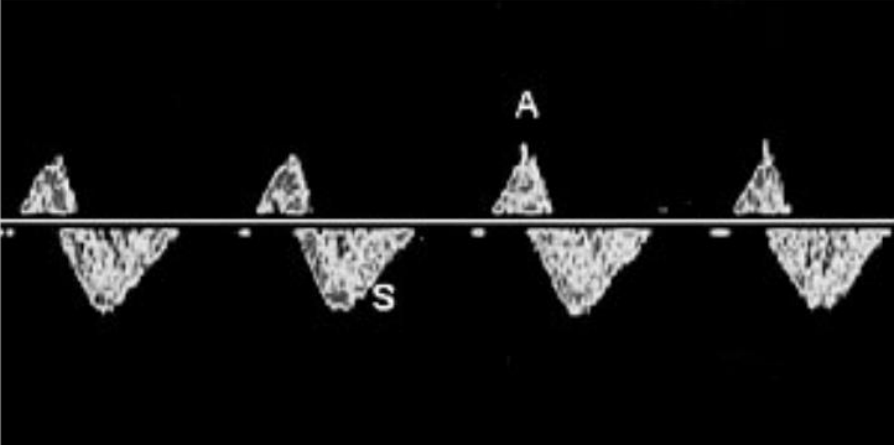
- Umbilical vein shows monophasic , continous non-pulsatile flow after first trimester in uncomplicated pregnancy.
- It shows pulsatile waveforms at the portal sinus.
- Fetuses with pulsations in the free floating umbilical vein in the second and third trimester have a higher morbidity and mortality, even in the setting of normal UA blood flow.
- Single pulsations correlate with cardiac systole while double pulsations result from significant cardiac insufficiency



IVC DOPPLER



IVC



COMPARISON

NORMAL PATTERN

IVC shows triphasic pulsatile waveforms

- first forward wave during ventricular systole
- second forward wave during early diastole
- third wave characterised by reversed flow in late diastole due to atrial contraction

ABNORMAL PATTERN

In IUGR fetuses the IVC shows increase in reversed flow during atrial contraction

OTHER USES OF DOPPLER IN OBS.

- ***In multiple pregnancy***
- ***Fetal anomaly***
- ***Effect of medicines on maternal and fetal circulation***
- ***Chronic maternal diseases such as nephropathy, autoimmune disease, coagulation disorders, diabetes and hypertension***

OTHERS

FETAL ANOMALIES

Doppler used to asses;

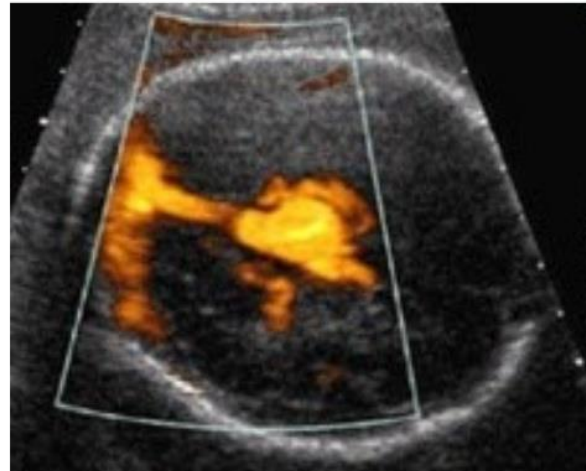
- Vein of galen malformation*
- Renal agenesis*
- Sacrococcygeal teratoma*
- Sequestration of lung*
- Congenital diapharamatic hernia*
- Assesment of a two or three vessel umbilical cord*

EFFECT OF DRUGS

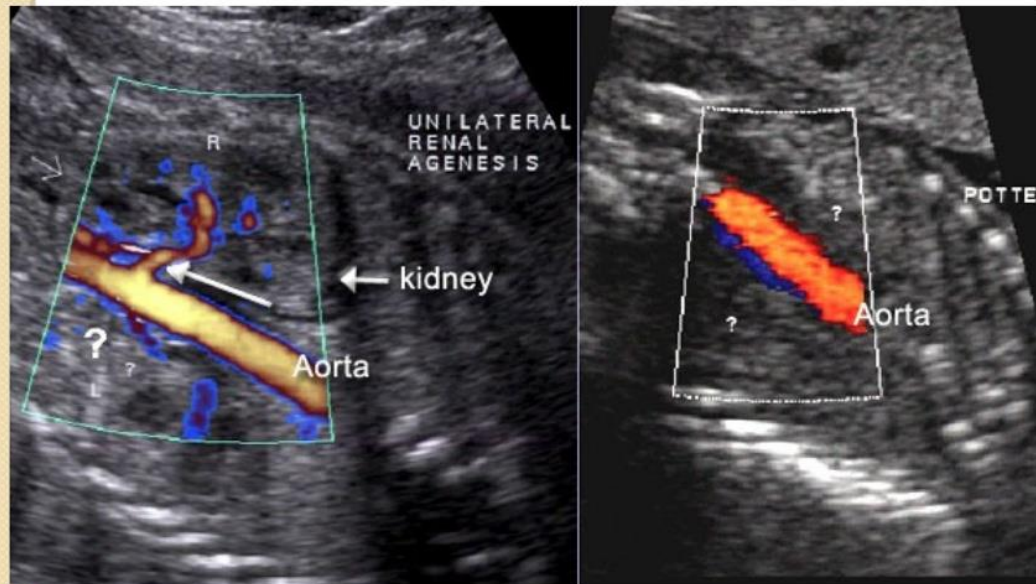
Changes in ductus arteriosus doppler after use of indomethacin for preterm labour and polyhydramnios(with increasing severity)

- raised PSV*
- raised EDV*
- features of TR*

VEIN OF GALEN ANEURYSM



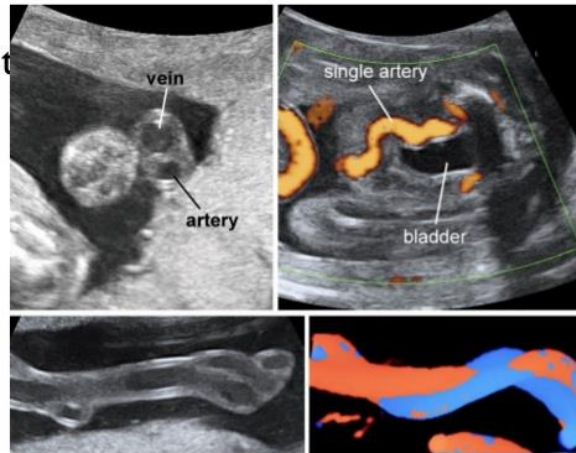
RENAL AGENESIS



SINGLE UMBILICAL ARTERY

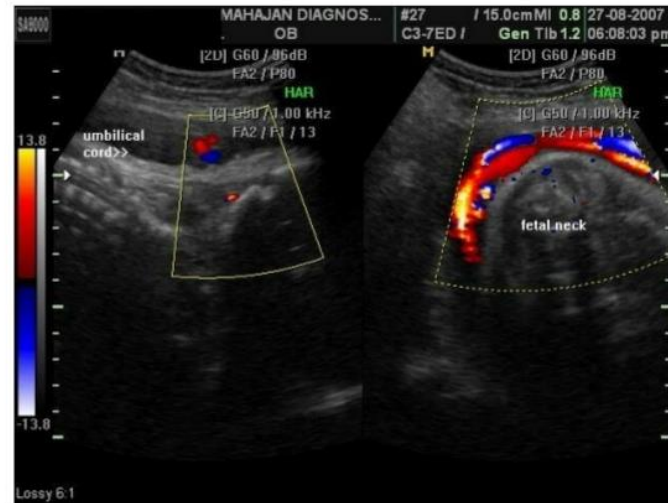
➤ It is diagnosed by imaging the origin of umbilical artery adjacent to fetal urinary bladder.

- ASSOCIATIONS:
1. Chromosomal defects (autosomal trisomies)
 2. Cardiac and renal anomalies
 3. Normal variant (1%)



CORD COILING AROUND NECK

Generally harmless.
Multiple(>2) loops of nuchal cord observed in 3rd trimester are relevant especially in breech presentation because then External Cephalic Version is contraindicated



3 FOLD NUCHAL CORD

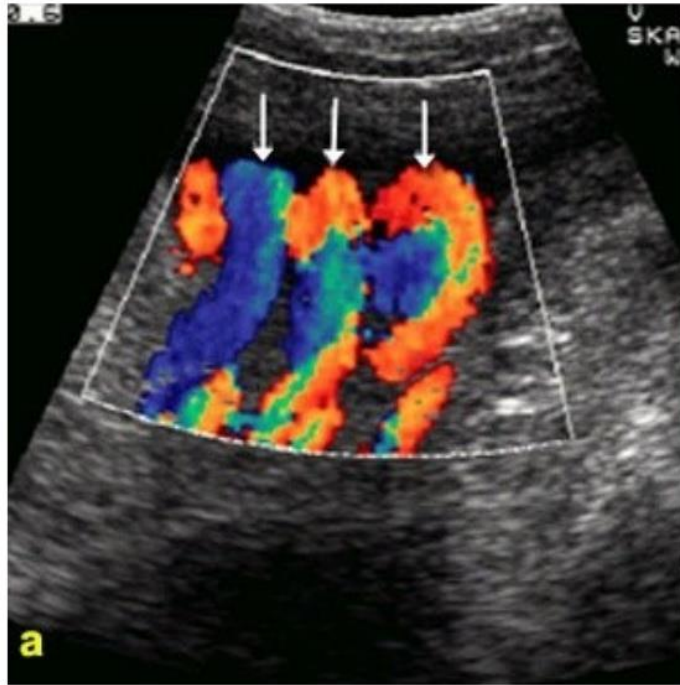
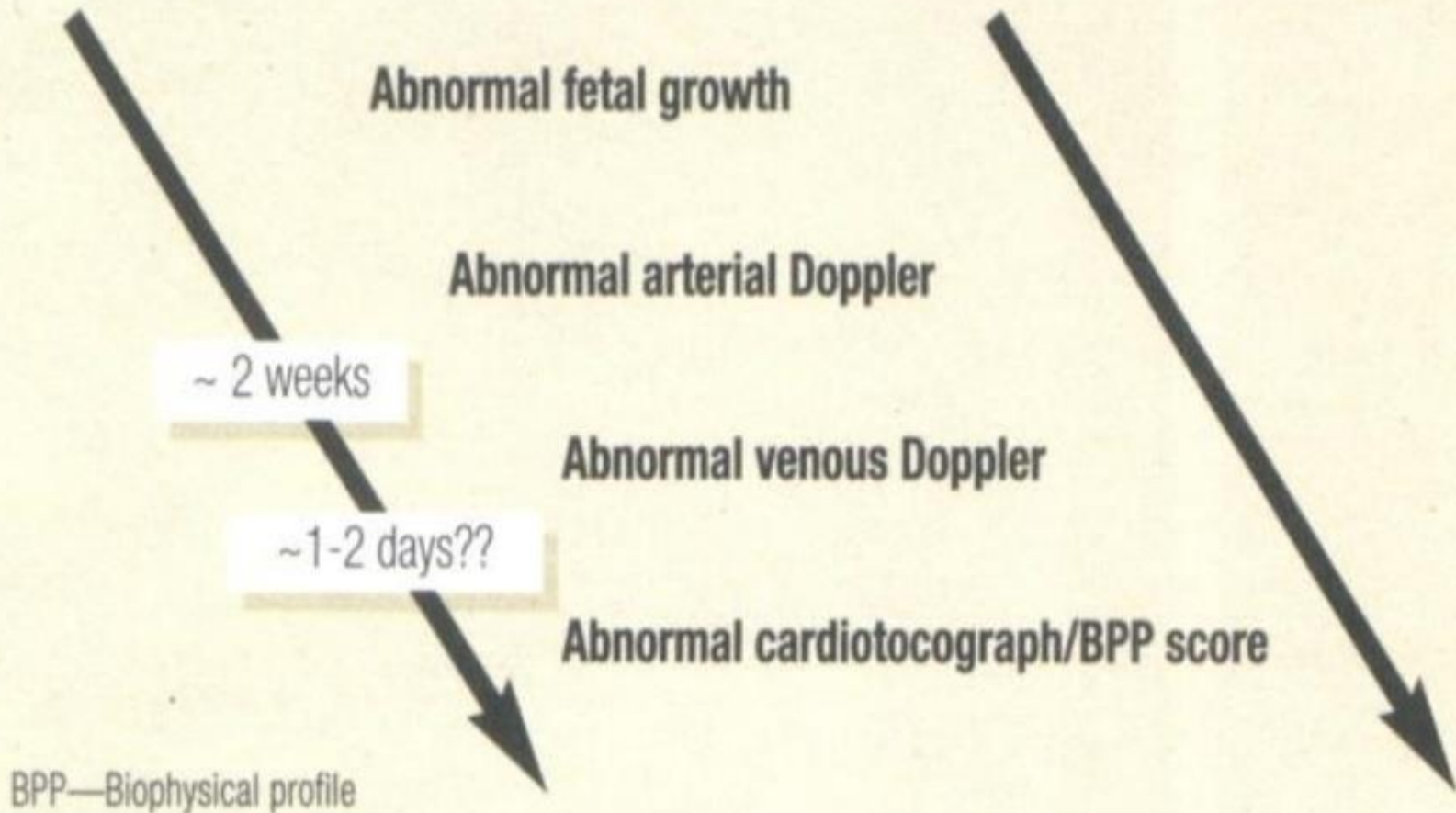


FIGURE 8. Timeline for fetal hypoxemia



- The best predictor of fetal hypoxia is PI of MCA. BPP has a limited role for assessing fetal well being before 32 gestational weeks.
- Doppler ultrasound can predict fetal distress sooner than BPP.
- The best predictor for fetal acidemia is PI of thoracic aorta.
- Reverse flow in the umbilical artery, along with pathologic waveform in the venous system are the best predictor of severe fetal distress, so termination of pregnancy must be considered as soon as possible.

Conclusion

- Doppler US assessment of the UA has become a standard of care for fetuses with IUGR, which helps to decrease the perinatal mortality in high risk pregnancies .
- Doppler US of the MCA has become the standard care for the diagnosis of fetal anaemia, thus avoiding unnecessary invasive procedures.



THANK YOU





BPP

▶ مدت انجام تست : ۳۰-۶۰ دقیقه

▶ بیوفیزیکیال پروفایل اصلاح شده :

NST + شاخص مایع آمنیون AFI

▶ مدت انجام تست بیوفیزیکیال اصلاح شده ۱۰ دقیقه می باشد.

▶ اگر خیلی نگران جنین هستید (مثلا Gold baby) تست ارجح BPP

▶ است.



چه مواردی در BPP ارزیابی می شوند

چه مواردی ارزیابی میشوند	ری اکتیو	نان ری اکتیو
تن جنین	مساوی و بیش از ۱ حرکت رفت و برگشت اندام در عرض ۳۰ دقیقه	
تنفس	مساوی و بیش از ۱ تنفس به شرط اینکه بیش از ۳۰ ثانیه طول نکشد در عرض ۳۰ دقیقه	
حرکت جنین	مساوی و بیش از ۳ حرکت در عرض ۳۰ دقیقه	
حجم مایع آمنیون (بزرگترین پاکت عمودی)	بیش از ۱ cm	مساوی و کمتر از ۱ cm



- ▶ تن جنين ، هفته ۸ حاملگی شروع میشود.
- ▶ حرکات جنين ، هفته ۹ حاملگی شروع میشود.
- ▶ تنفس جنين ، هفته ۲۱ حاملگی شروع میشود.



▶ معیاری که با تاخیر از بین می‌رود ، تن جنین است.

▶ زمانی که تن جنین از بین می‌رود ، PH اسیدی شده است.

▶ برادیکاردی و دیرشن تنفسی زمانی ایجاد می‌شود که اسیدوز جنین مشخص شده باشد.

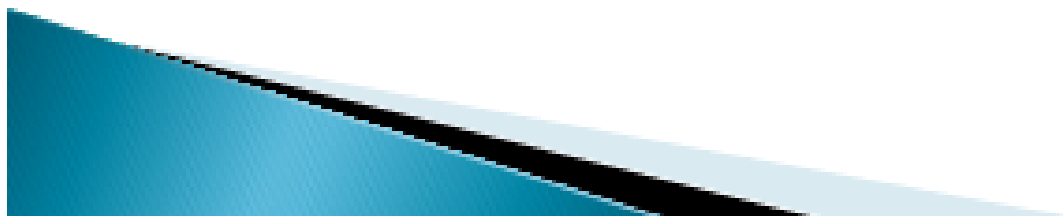
▶ اولین چیزهایی که ممکن است دچار افت شوند ولی جنین خوب است: (به ترتیب)

▶ کاهش حجم مایع آمنیون

▶ کاهش حرکت جنین

▶ حرکت تنفسی

▶ حرکت اندام جنین



- ▶ معیارهایی که با تاخیر دچار افت می شوند: (به ترتیب)
- ▶ کاهش تن جنین (مهمترین)
- ▶ کاهش حرکات جنین
- ▶ کاهش حرکات تنفسی
- ▶ کاهش NST (کم اهمیت ترین)

نتایج و اقدامات در BPP



۱۰ ۱۰	طبیعی بدون آسفکسی	تکرار تست هر هفته به جز موارد پست ترم و دیابت (۲ بار در هفته)	
۸ ۱۰	توجه به حجم مایع آمنیون کنید :	نرمال : ← مثل بالا عمل کنید.	
۶ ۱۰	آسفکسی نسبتا احتمالی جنین (با توجه به حجم مایع)	نرمال ← ← ←	<p>(۱) سن حاملگی مساوی و بیش از ۳۷ و CX مناسب باشد ختم حاملگی</p> <p>(۲) در غیر اینصورت تکرار تست همان روز اگر جواب مساوی و کمتر از ۶ بود ختم حاملگی</p> <p>(۳) بیش از ۶ طبق پروتکل</p>
۴ ۱۰	آسفکسی احتمالی جنین	کاهش ←	ختم حاملگی
۰-۲ ۱۰	آسفکسی تقریبا حتمی	تکرار تست همان روز ← ←	<p>(۱) مساوی و کمتر از ۶ بود ختم حاملگی</p> <p>(۲) بیش از ۶ بود طبق پروتکل</p>
۰-۲ ۱۰	آسفکسی تقریبا حتمی	ختم حاملگی	

▶ شایعترین علت مرگ جنین در BPP طبیعی :

(۱) خونریزی جنینی- مادری

(۲) حوادث بندناف

(۳) دکولمان جفت

نکات BPP

- (۱) اگر همه شاخص های BPP طبیعی بود می توان از NST صرف نظر کرد.
- (۲) اگر همه شاخص های BPP نرمال بود اما حجم مایع آمنیون غیرطبیعی باشد بررسی بیشتر میخواهد (یعنی اگر بزرگترین پاکت مایع آمنیون مساوی یا کمتر از ۲cm باشد)
- (۳) مهمترین شاخص BPP ، حجم مایع آمنیون است.
- (۴) حجم مایع آمنیون به تنهایی یکی از تست های ارزیابی سلامت جنین است.

Fetal Scalp Stimulation



Gently stroke or massage fetal scalp for 15 sec. during a vaginal examination ▶

Assess fetal tracing for signs of ▶
accelerations of 15 bpm for 15 sec.

This is a sign of fetal well-being ▶

تحریک ویبروآکوستیک

▶ مدت انجام تست : ۱۵ دقیقه

▶ در NST معمولی جنین را تحریک نمی کنیم .

▶ اما در تحریک ویبروآکوستیک، تحریک صوتی جنین ۱۰۰-۱۰۵

دسی بل در فاصله ۲۰ cm شکم مادر به مدت ۱-۲ ثانیه به منظور

حرکت جنین و تسریع FHR استفاده می شود.

▶ تفسیر همانند NST است.

▶ ویبروآکوستیک معادل :

۱. جیغ مادر در لیب است.

۲. نمونه PH خون پوست سر جنین است.

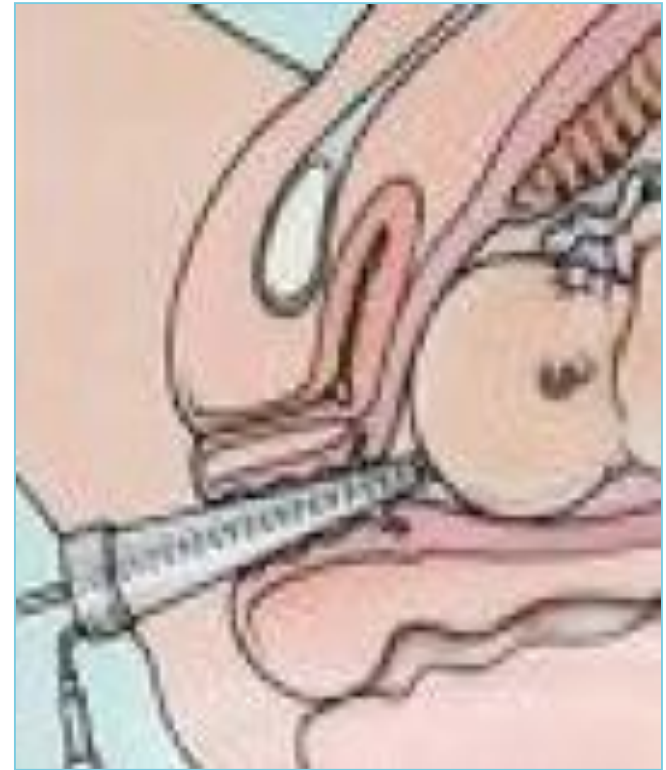
Fetal Acoustic Stimulation Test- FAST



Fetal Scalp Blood Sampling

Requires rupture of ▶
membranes

Acidosis is present if ▶
the pH is less
than 7.20



- ▶ برای نظارت قبل از زایمان پست ترم ها NST و بررسی حجم مایع آمنیون کافی است.
- ▶ برای ارزیابی قبل از زایمان سلامت جنین در دوقلویی از NST یا BPP استفاده میکنیم.
- ▶ بررسی سونوگرافی سریال برای کل سه ماهه سوم دوقلویی توصیه می شود (برای بررسی حجم مایع و میزان رشدجنین)