

ULTRASOUND LECTURE SERIES

— Presented by —

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Ultrasound Evaluation of Abnormal Fetal Weight

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Sonographic Diagnosis of Intrauterine Growth Restriction (IUGR)

Calculation of fetal weight:

Formulas that use measurements of a variety of fetal body parts (up to 3: head circumference, abdominal circumference, and femur length).

The predicted weight will fall within 15% to 18% of the actual weight in 95% of cases.

Sonographic Diagnosis of IUGR

Calculation of fetal weight:

Gestational age and fetal weight are assessed in relation to one another to determine the weight percentile for gestational age.

Biparietal Diameter (BPD)



The measurement is obtained at the level of the thalami, the septum cavum pellucidum, and the third ventricle by placing the calipers at the outer echo-dense side of the proximal parietal bone to the inner echo-dense side of the distal parietal bone.

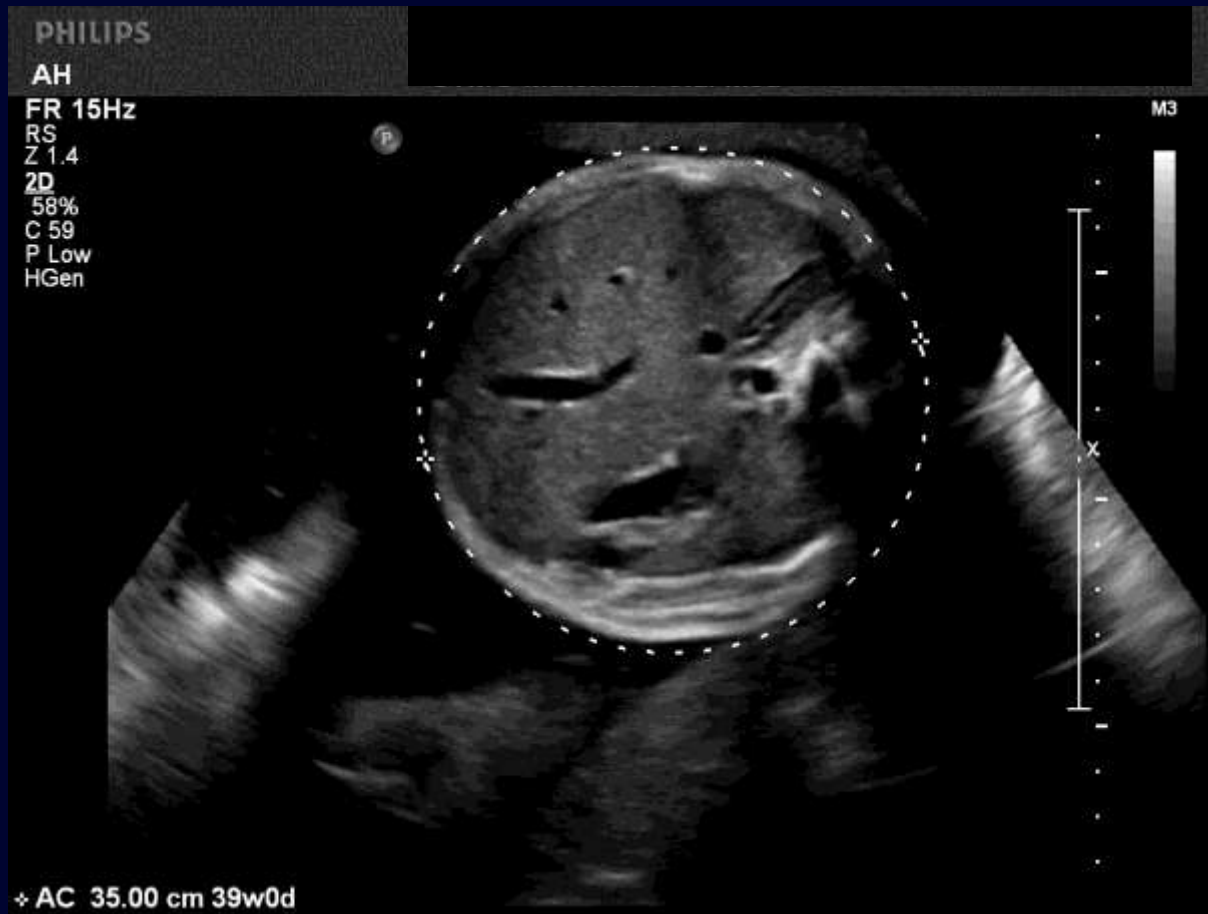
Head Circumference (HC)



This is calculated using the measurement of the BPD and occipitofrontal diameter (OFD), or it can be measured directly:

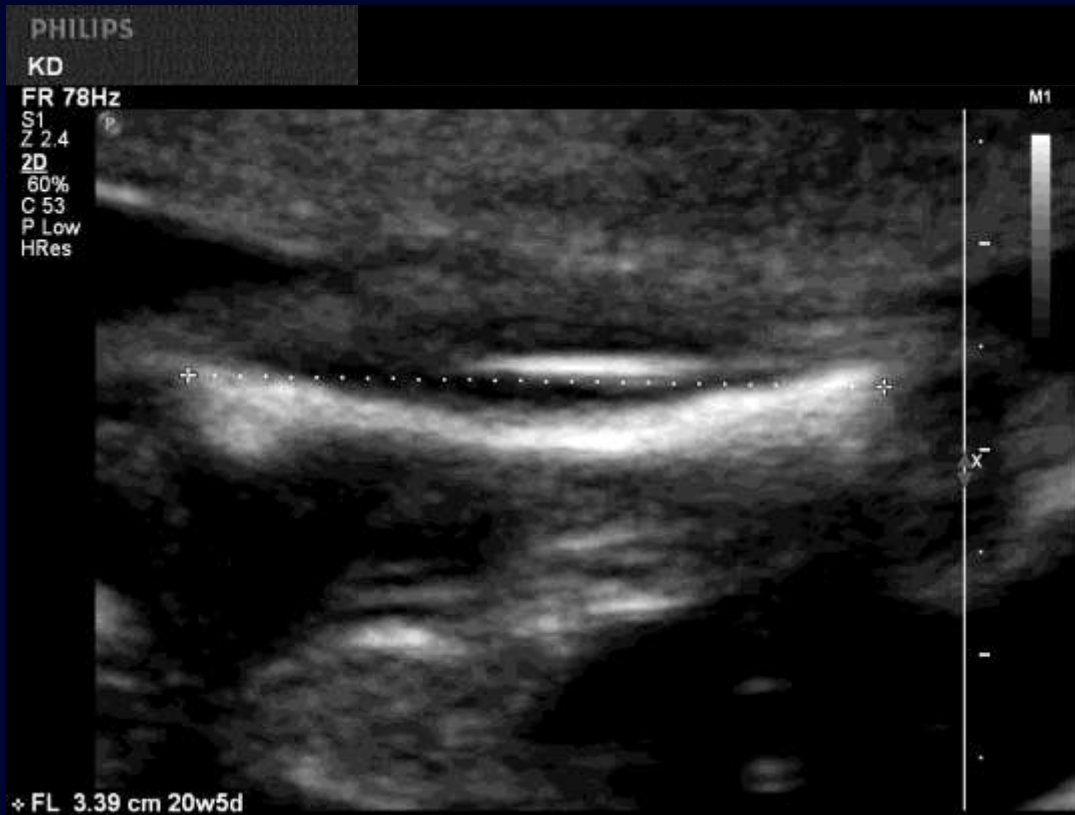
$$HC = (BPD = OFD) \times 1.57$$

Abdominal Circumference (AC)



The umbilical vein does not have to be visualized for its entire length; otherwise, it is an oblique section.

Femur Length (FL)



Only the long axis of the femur is measured.

Commonly Used Sonographic Formulas

$$\text{Gestational age (GA)} = 10.61 + 0.00175 \text{ BPD} \times \text{FL} + 0.0297 \text{ AC} + 0.071 \text{ FL}$$

(Hadlock et al, 1984)

$$\text{Ln(GA)} = 2.38631 + 0.0050012 \text{ BPD} + 0.0090476 \text{ FL} + 0.00048293 \text{ AC}$$

(Doubilet et al, 1993)

IUGR

IUGR is the consequence of disturbances of fetal growth.

IUGR fetuses have an increased risk of perinatal morbidity and mortality.

IUGR

Prenatal diagnosis of this condition can aid in decision making concerning the timing and route of delivery, thereby reducing perinatal mortality.

IUGR

Lubchenco et al, in 1963, plotted neonatal birth weights against gestational age at delivery. Their analysis revealed increased perinatal morbidity and mortality in infants with birth weights \leq 10th percentile.

IUGR

In 1966, Scott and Usher reported that the perinatal death rate was 8 times higher when the weight was between the 10th and 3rd percentile and 20 times higher when the weight fell below the 3rd percentile

Tests Used When Estimated Fetal Weight Is <10th Percentile

- Non-stress test (NST)
- Amniotic fluid volume
- Biophysical profile
- Doppler velocimetry

Non-Stress Test

A test is considered reactive when at least two accelerations of the fetal heart rate of 15 beats per minute (bpm) amplitude and 15 seconds' duration are observed in 20 minutes of monitoring (the most widely applied definition).

Before 32 weeks' gestation, another definition considers 10 bpm amplitude and 15 seconds' duration.

Amniotic Fluid Index (AFI)

The AFI is determined by the summation of the vertical diameter of the largest pocket in each of the 4 quadrants.

Phelan JP, et al. J Reprod Med 1987; 32:601-604

Largest Vertical Pocket for One Quadrant



Biophysical Profile

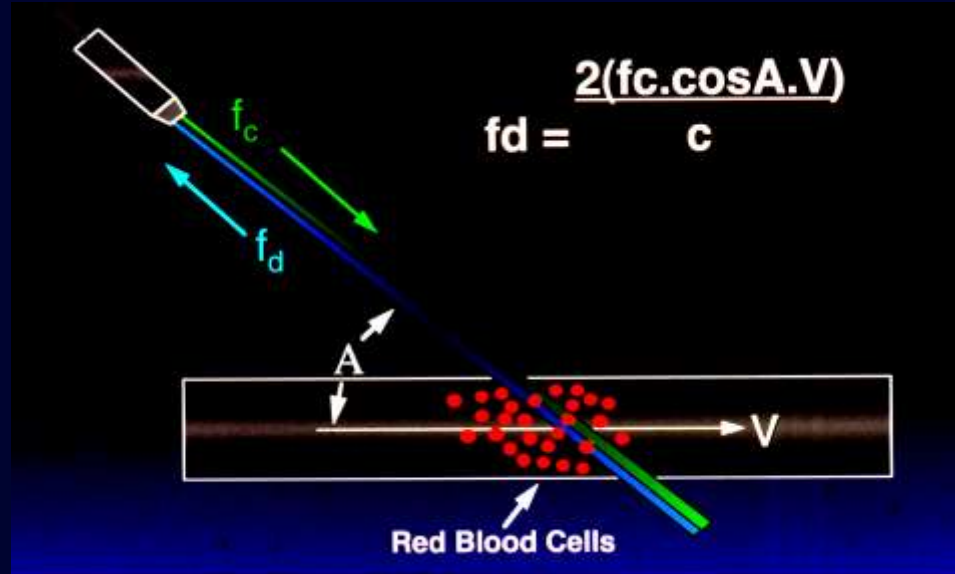
- 5 components:
 1. NST (it can be omitted if all the other components are normal).
 2. Fetal breathing movements (1 or more episodes of rhythmic breathing movements of 30 seconds or more within 30 minutes).
 3. Fetal movement (3 or more discrete body or limb movements within 30 minutes).
 4. Fetal tone (1 or more episodes of extension of a fetal extremity with return to flexion, or opening or closing of a hand).
 5. Determination of the amniotic fluid volume (a single vertical pocket of amniotic fluid exceeding 2 cm is considered evidence of adequate amniotic fluid).

Manning FA, et al. Am J Obstet Gynecol 1987; 156:709-712

Basic Doppler Velocimetry

- Umbilical artery
- Middle cerebral artery

Doppler Effect: Application to Obstetrics

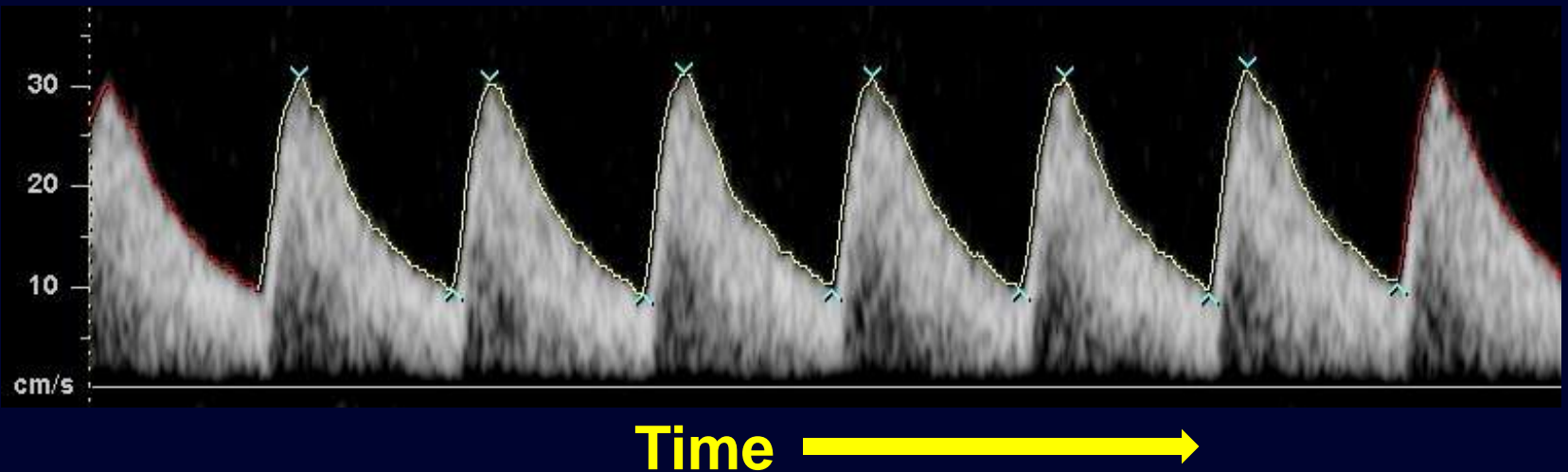


From a transducer, ultrasounds are emitted at a frequency **F_c**.

When they hit a structure that moves (for example, blood flow), they are backscattered and return to the transducer at a different frequency .

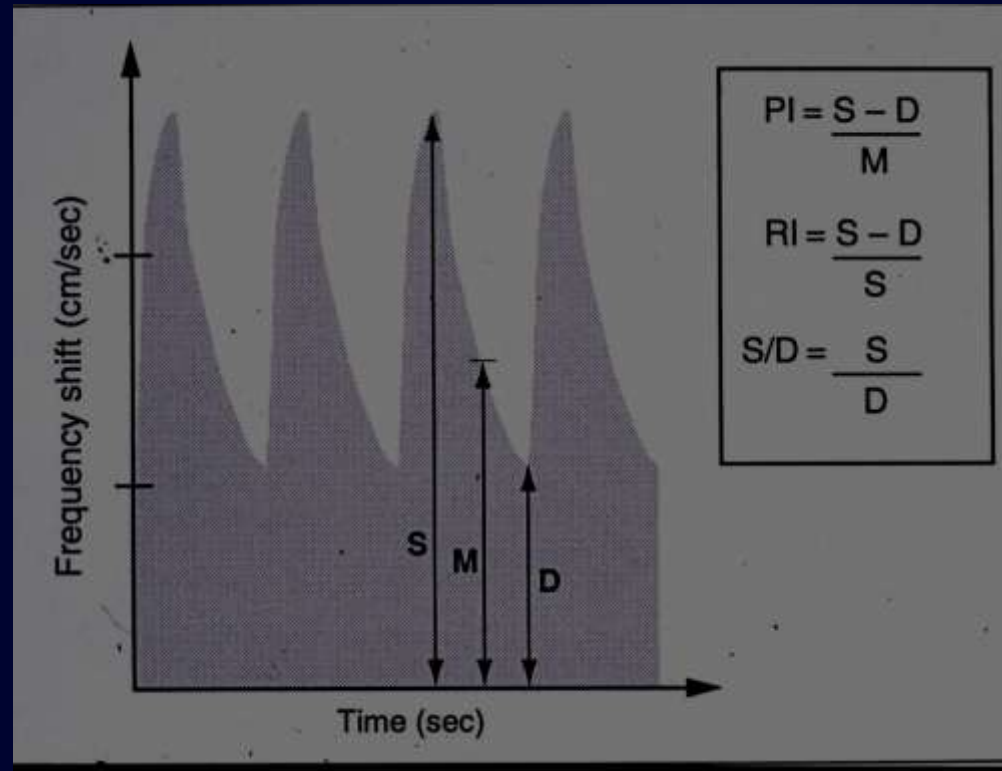
This different frequency is the Doppler shift (**F_d**). The Doppler shift increases as the velocity of the blood flow increases (**V**) and as the **cosine** of the angle (**A**) between the ultrasound beam and the direction of the blood flow increases. **C** is a constant (velocity of the ultrasound in water: 1540 m/s).

The **Doppler shift** arrives to the transducer. The information is analyzed and it is presented as **waveforms**.



On the y-axis, there is the velocity value. Some of the old ultrasound equipment reported the Doppler shift on the y-axis.

Angle-Independent Indices



PI = pulsatility index

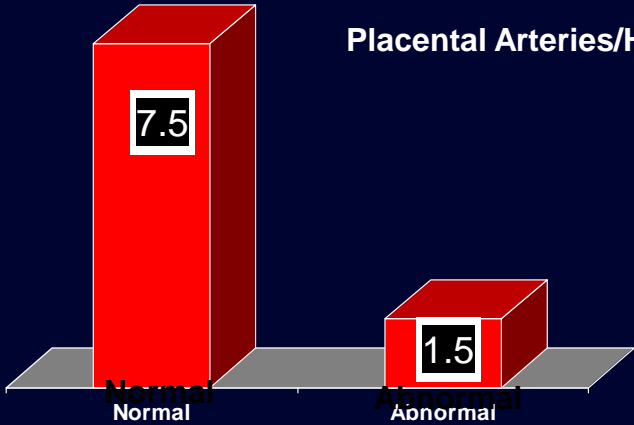
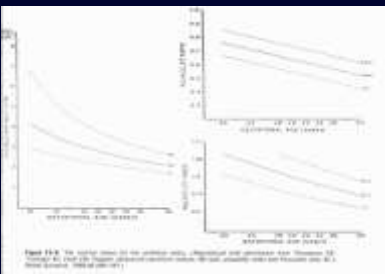
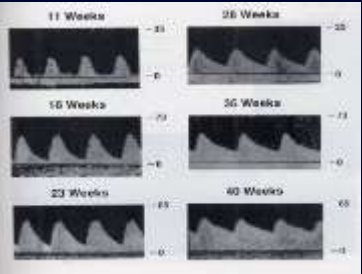
RI = resistance index

S = peak systolic velocity

D = end-diastolic velocity

M = mean velocity

Umbilical Artery



Giles WB, et al. Br J Obstet Gynecol 1985; 92:31



A



B



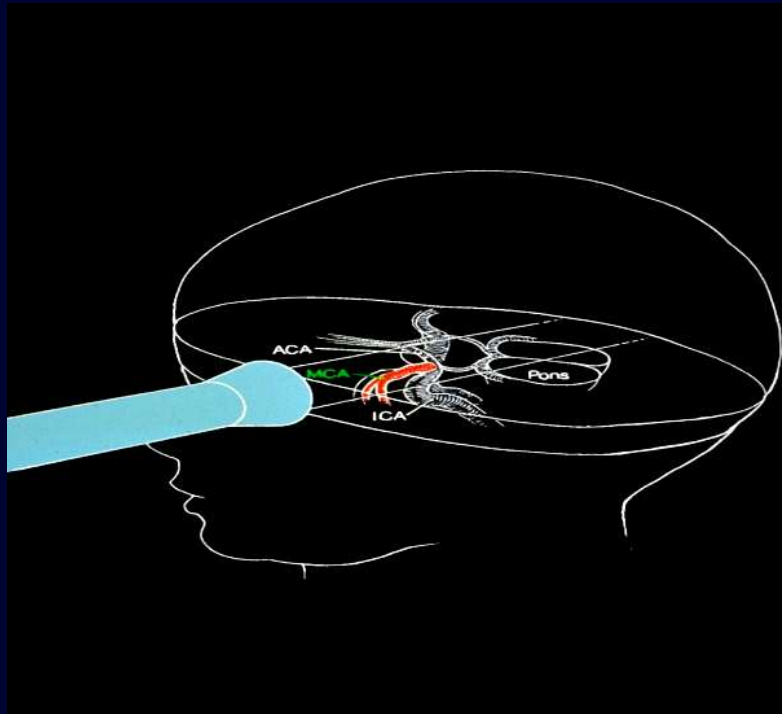
C

In cases of high placental vascular resistance (see IUGR), the umbilical artery diastole decreases (A), it becomes absent (B), and in the most severe cases, there is reversed flow (C).

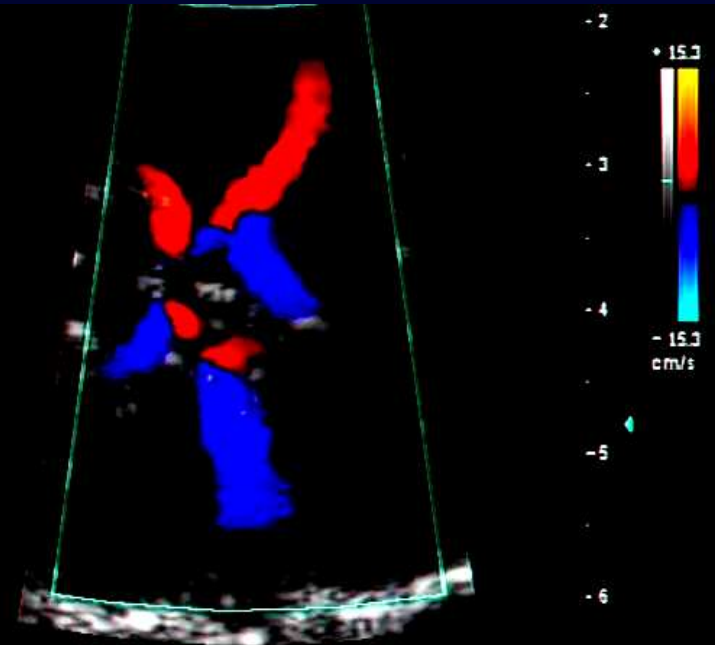
Umbilical Artery Doppler and Outcomes

- **Reduces perinatal death and unnecessary induction of labor in the preterm growth restricted fetus.**
- **A meta-analysis revealed that the use of Doppler ultrasonography reduced the odds of perinatal death by 38% (95% confidence interval, 15-55).**

Circle of Willis



Map 3
170dB/C 3
Persist Med
2D OptHGen
Col 73% Map 1
WF Low
PRF 1000 Hz
Flow Opt: Med V
BW 0 Pg 0
Col 0 Pg 0



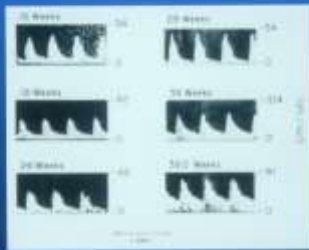
The most studied artery of the Circle of Willis is the middle cerebral artery (MCA).

Mari G, et al. Am J Obstet Gynecol 1989; 160:698

Middle Cerebral Artery

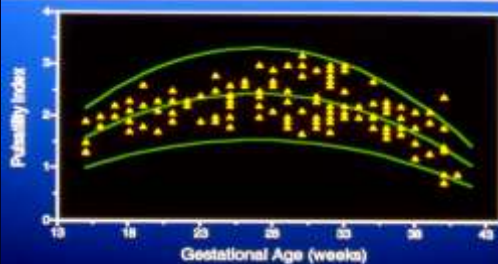


Fetal middle cerebral artery velocimetry

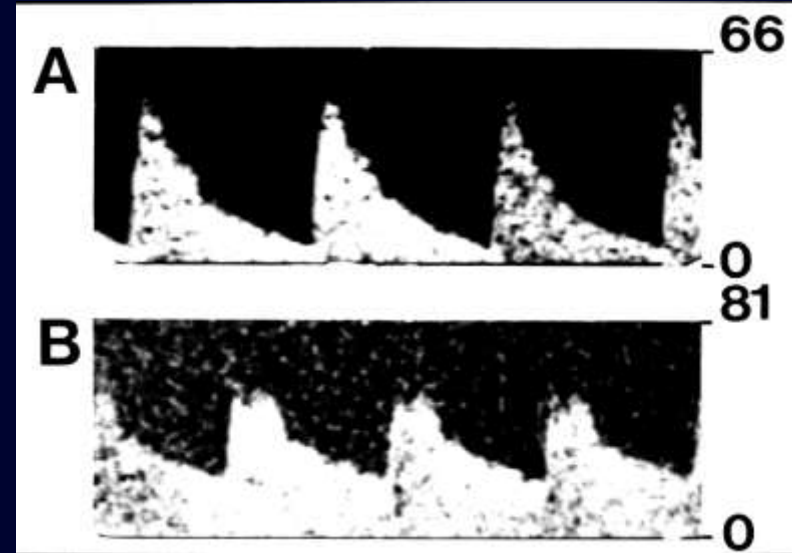


MIDDLE CEREBRAL ARTERY

Cross-Sectional Study

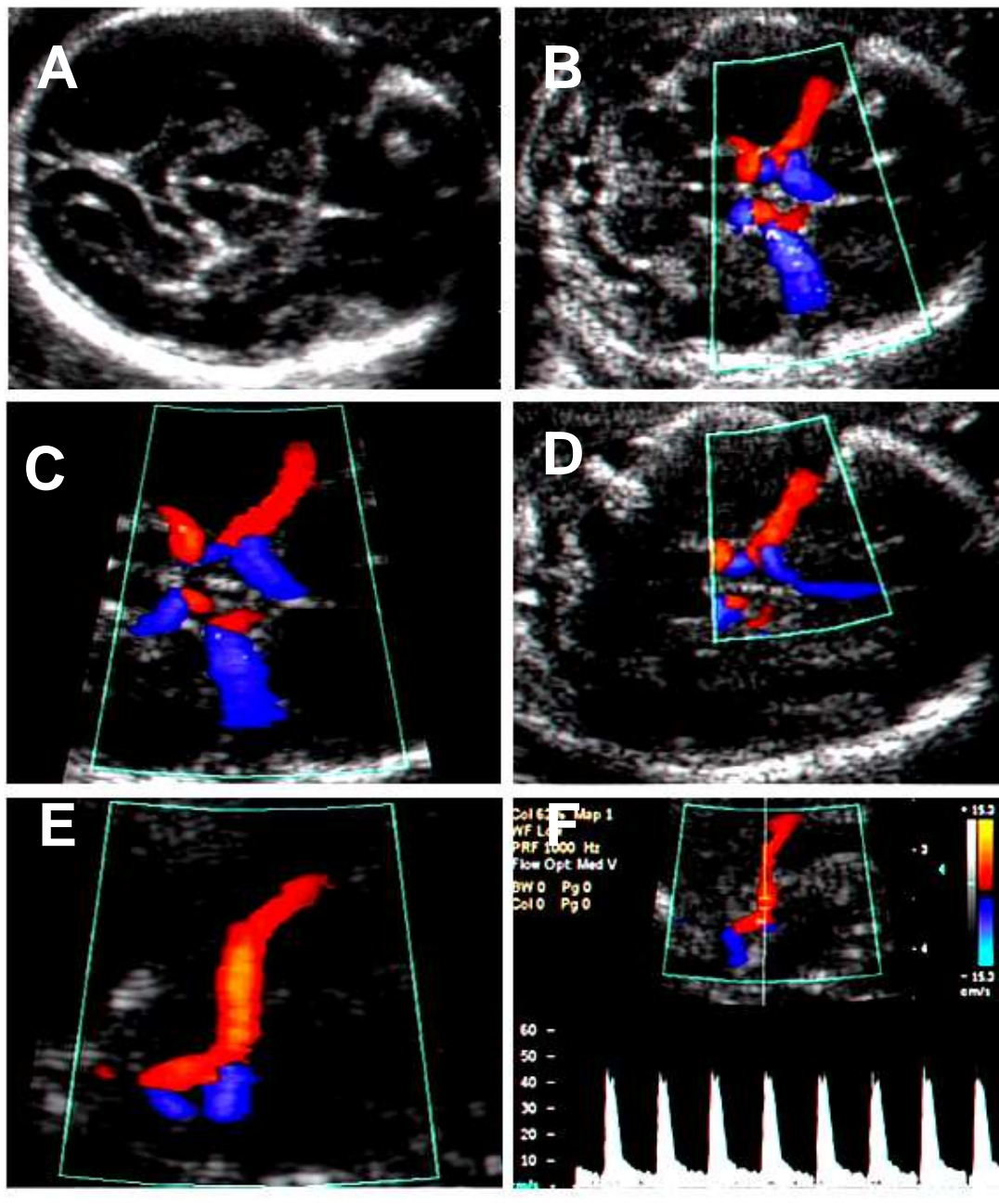


24 Weeks' Gestation



A = Normal

B = "Brain-sparing effect"

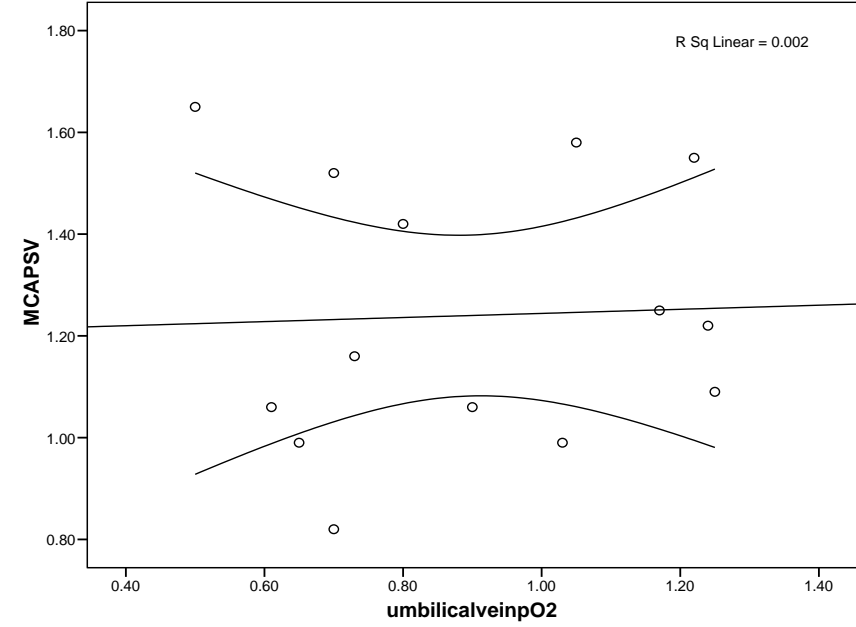
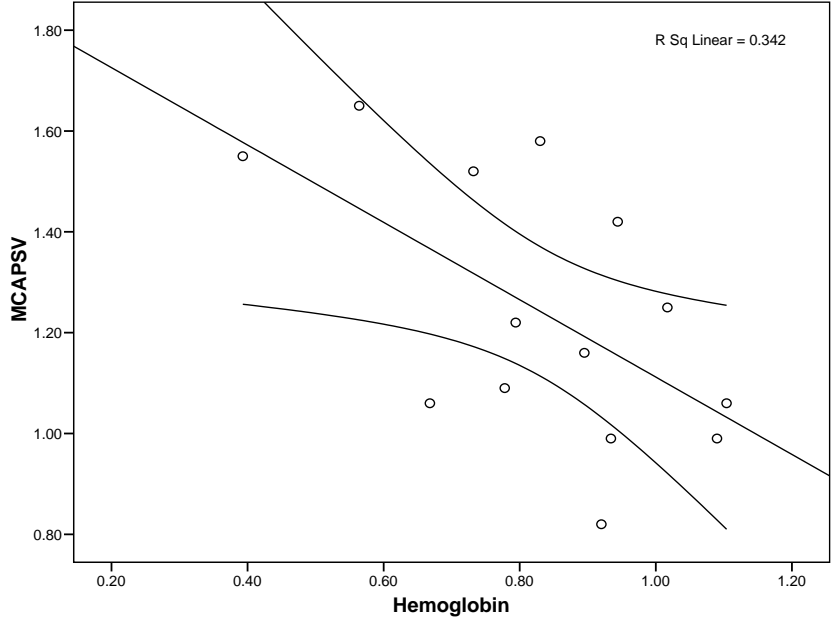


It is easy to sample the MCA with an angle of 0° , which allows for the real velocity of the blood flow to be determined.

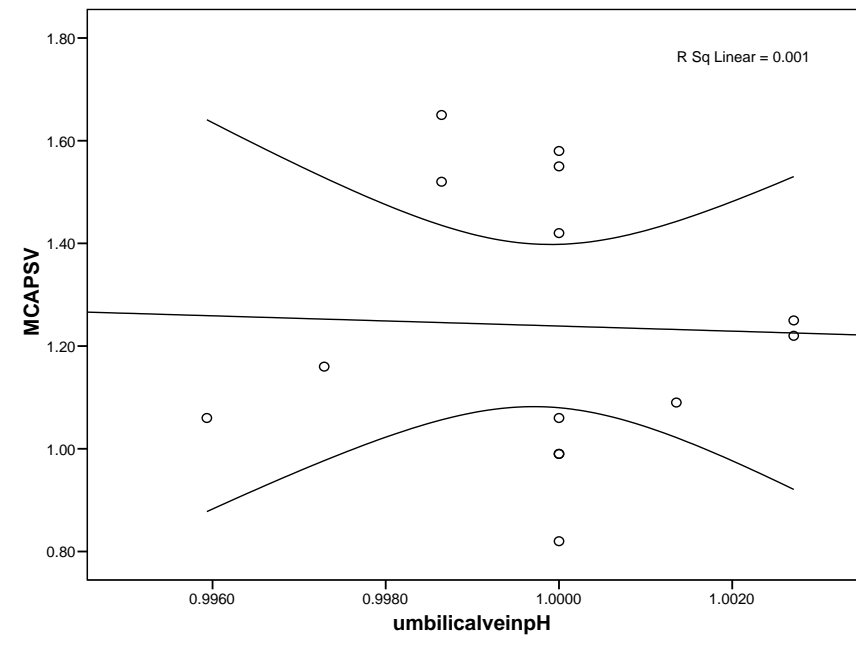
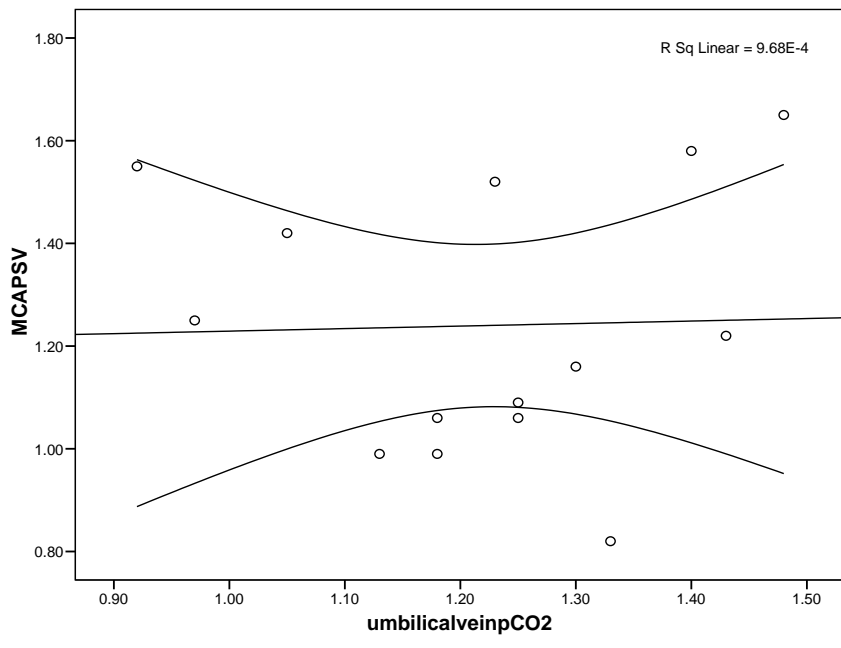
These are the steps for the correct sampling of the middle cerebral artery peak systolic velocity. The use of an angle corrector increases the intra- and inter-observer variability; therefore, its use is not recommended.

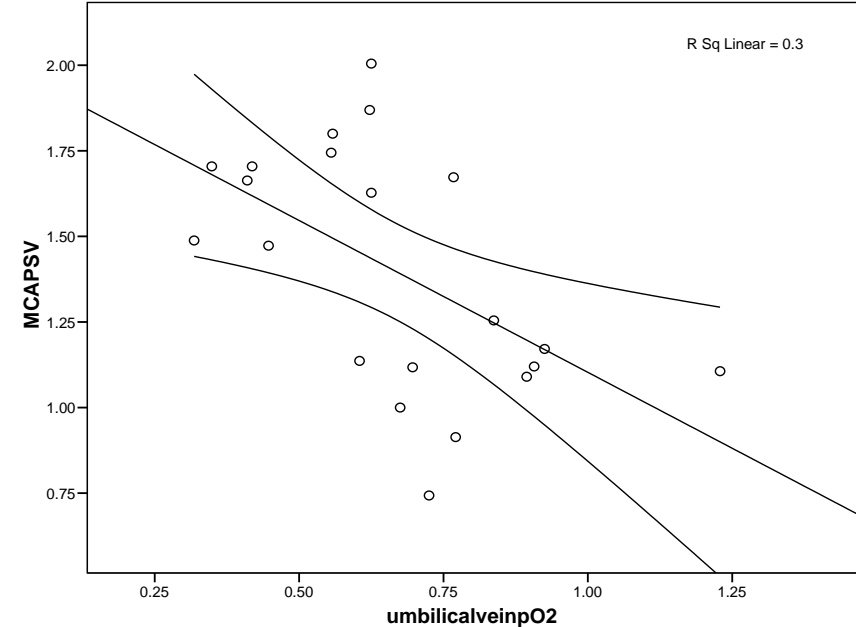
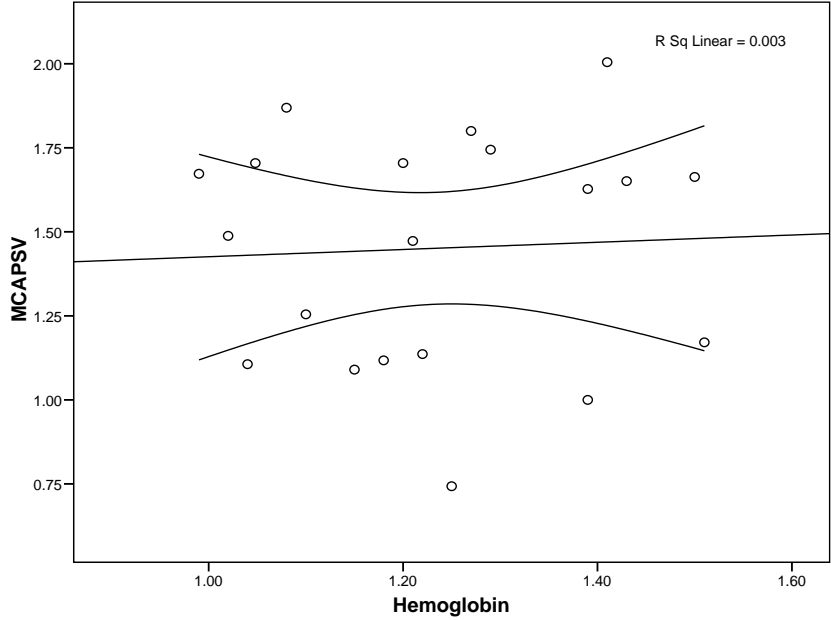
MCA PSV in IUGR Fetuses

- The middle cerebral artery peak systolic velocity (PSV) is increased in IUGR fetuses.
- IUGR fetuses more often than not are not anemic. The question that arises is why is the velocity increased in IUGR fetuses?
- The next 2 slides show that the mechanisms of high velocity are different in anemic and IUGR fetuses.

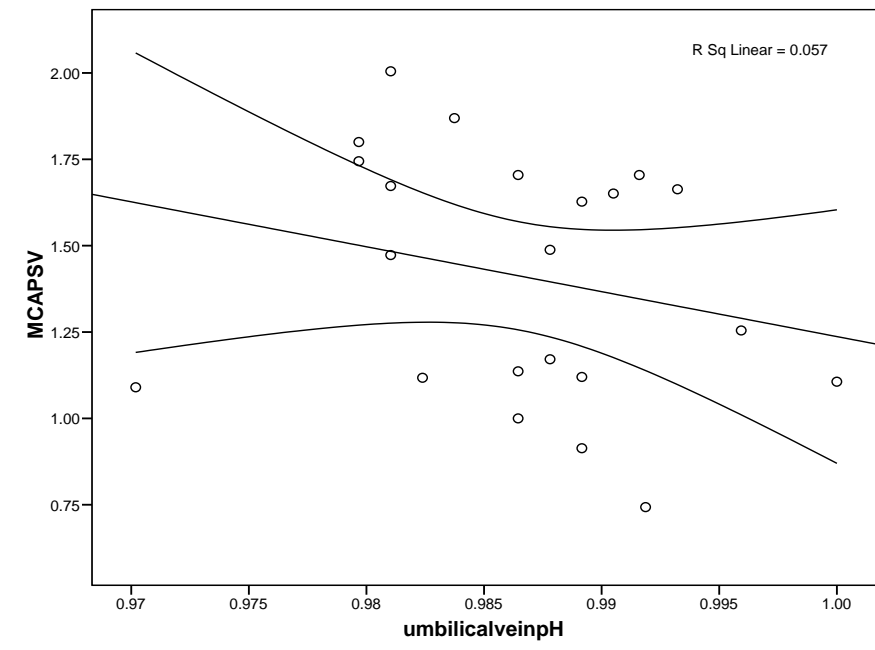
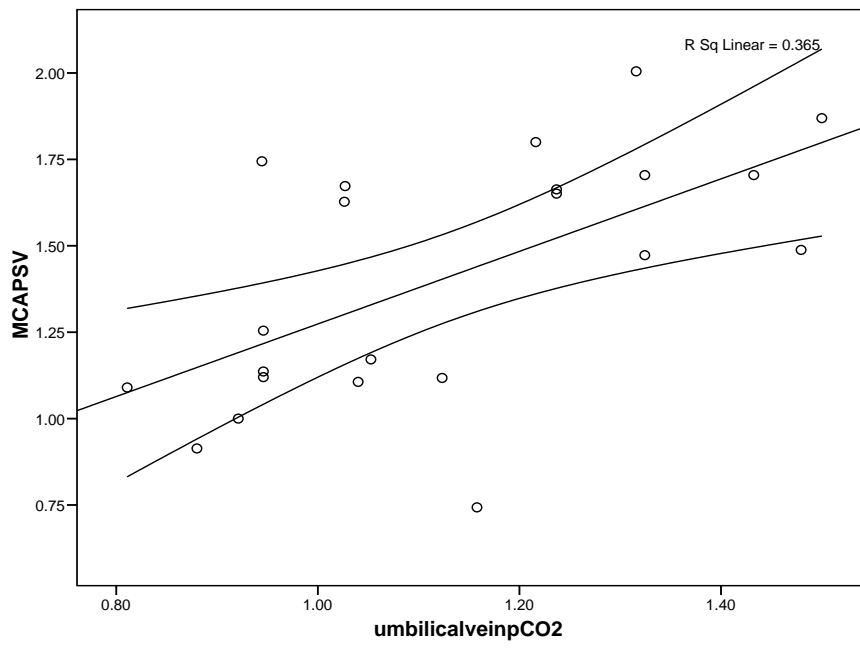


Anemia





IUGR



IUGR

**PubMed search on March 1, 2009:
13,309 papers (10,779 in English)**

Definition of IUGR

Despite the large volume of studies published, the definition of IUGR and the management of IUGR fetuses varies in different areas of the world.

Definition of IUGR

Several classifications of IUGR have been reported. A simple classification recently proposed includes:

- Biometry
- Gestational age
- Doppler ultrasonography
- Amniotic fluid volume
- Maternal pathology
- Fetal condition

Definition of IUGR

- Biometry
- Estimated fetal weight less than 10th percentile

Definition of IUGR

- Gestational age:
 - A. Very early IUGR (<29 weeks)
 - B. Early IUGR (29-32 weeks)
 - C. Late IUGR (>32 weeks)

Doppler Staging

Stage I

Abnormal umbilical artery (UA) or MCA pulsatility index (PI)

Stage II

UA absent/reversed end-diastolic velocity or abnormal ductus venosus (DV) PI or umbilical vein pulsation

Stage III

DV reversed flow of tricuspid regurgitation

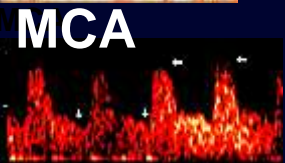
Doppler Staging

I

- Umbilical artery
- Middle cerebral artery
- Ductus venosus
- Umbilical vein
- Tricuspid valve

II

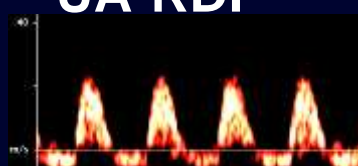
III



UA-aEDV



UA-RDF



UV



DV-PI



DV-RF



TR



UV

TR

UV

Amniotic Fluid Index

< 5



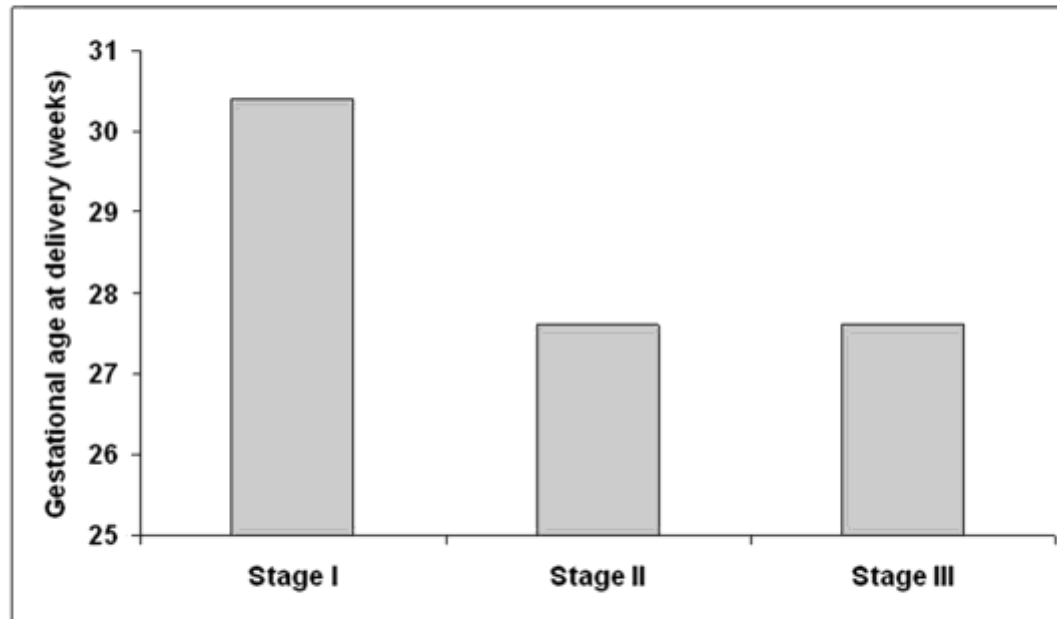
A

> 5

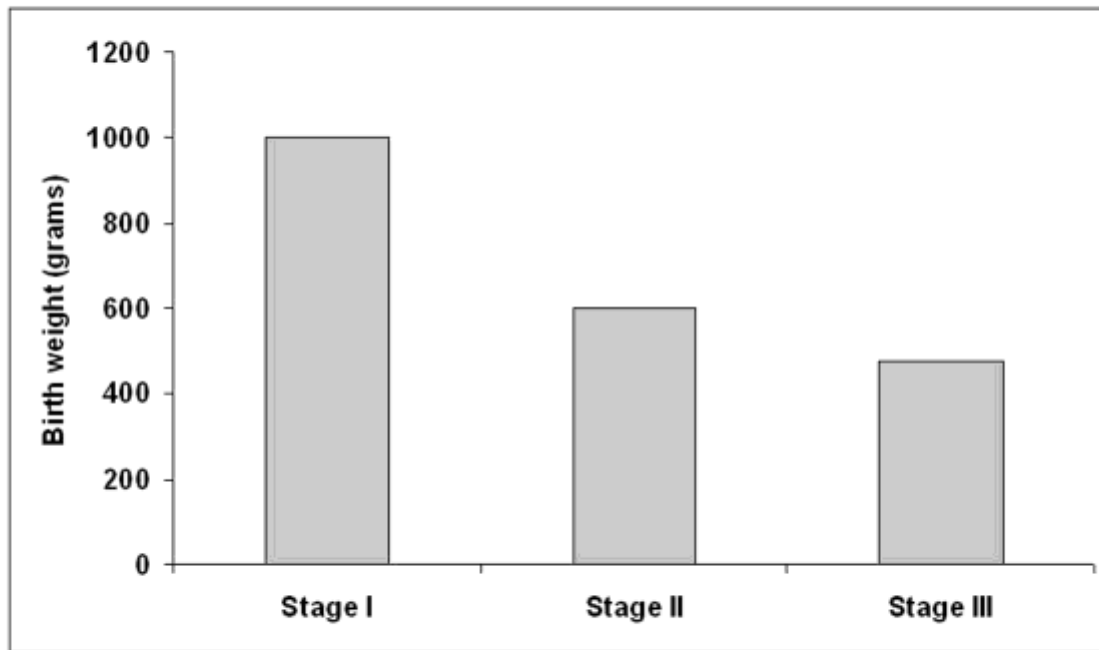


B

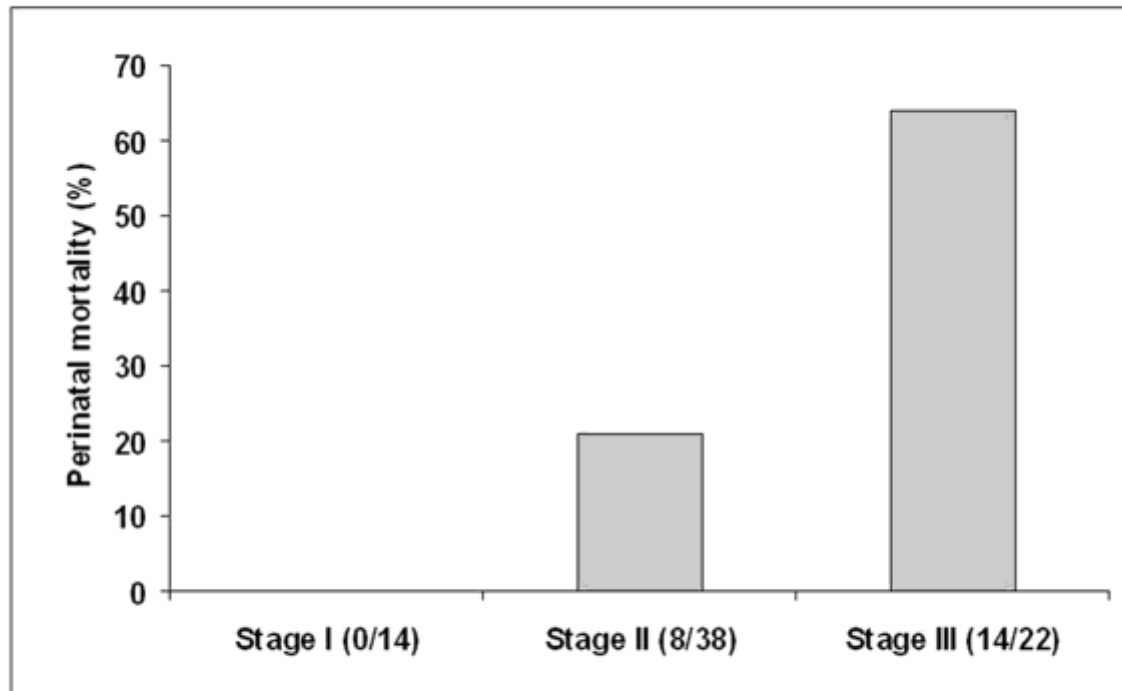
Staging



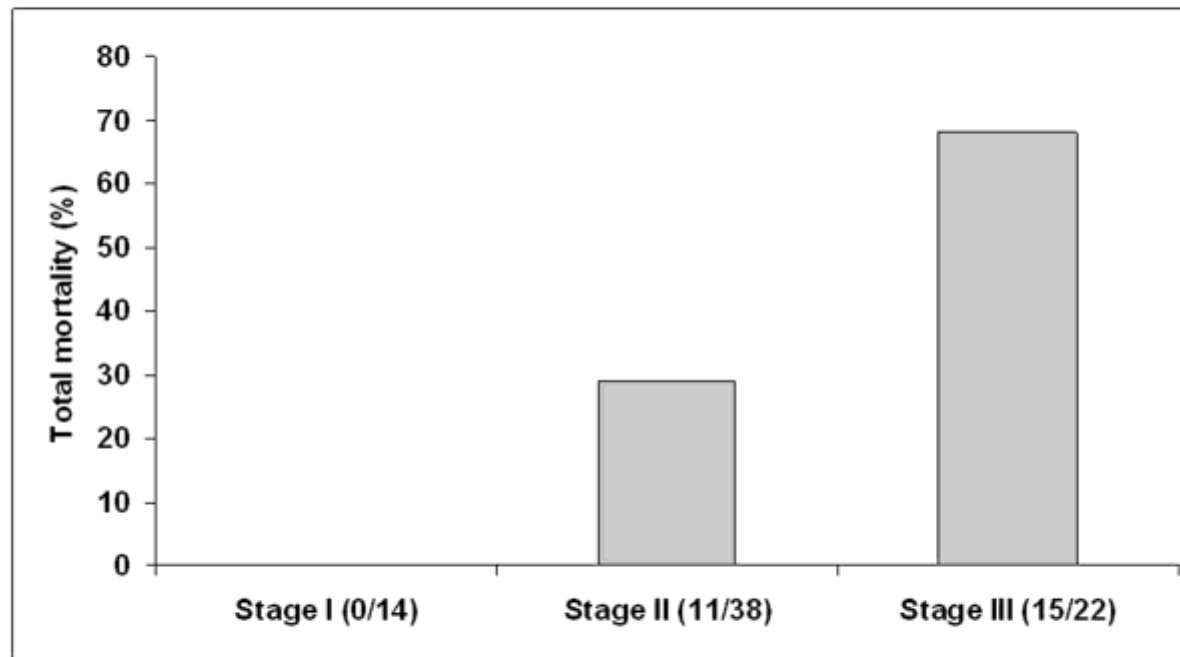
IUGR Staging



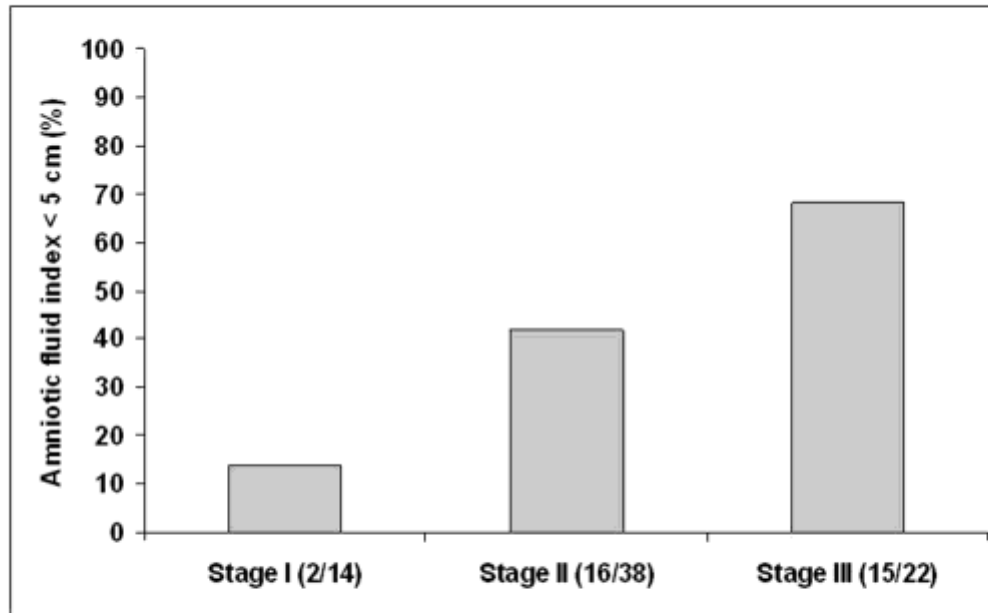
IUGR Staging



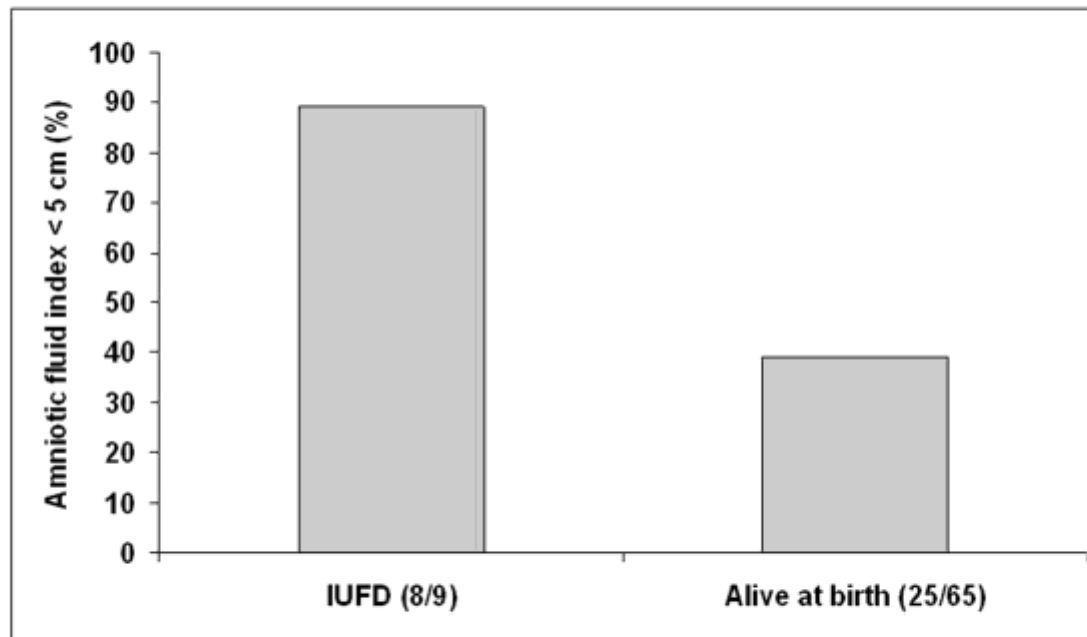
IUGR Staging



IUGR Staging



IUGR Staging



IUGR Classification Example I

- Estimated fetal weight (EFW) <10th percentile
 - Abnormal UA PI
 - Amniotic fluid index >5 cm
 - No maternal-fetal pathology
 - 26 weeks' gestation

**IUGR Stage IB, 26 weeks' gestation,
idiopathic**

IUGR Classification: Example II

- EFW <10th percentile
 - Ductus venosus RF
- Amniotic fluid index: 3 cm
 - Down syndrome
 - 26 weeks' gestation

IUGR Stage IIIA, 26 weeks gestation, Down syndrome

There is no robust data on how to manage and when to deliver IUGR fetuses.

Therefore, the management of IUGR fetuses is often subjective.

Management of IUGR Fetuses: Important Consideration

IUGR fetuses have been considered a homogeneous group, and this has hampered our understanding of the IUGR process.

Management of IUGR Fetuses: Important Consideration

Placental insufficiency is not the cause of IUGR.

Assali defined placental insufficiency as “an umbrella that we use to cover our ignorance in terms of etiology and pathogenesis of a disease process that often we do not understand.”

Management of IUGR Fetuses: Important Consideration

IUGR should be stratified by gestational age and by maternal or fetal disease. The IUGR diagnosed at 24 weeks' gestation in a patient with no pathology is different than the IUGR diagnosed in a patient with preeclampsia.

Management of IUGR Fetuses: Important Consideration

- If delivery occurs at less than 25 weeks' gestation, no IUGR survives.
- If delivery occurs after 29 weeks' gestation, mortality is rare.

Management of IUGR Fetuses: Important Consideration

Between 25 and 29 weeks' gestation, for each week the fetus remains in utero, the perinatal mortality decreases by 48%.

Management of IUGR Fetuses: Important Consideration

The biophysical profile does not predict survival in the next 24 hours in IUGR fetuses at less than 28 weeks' gestation.

Management of IUGR Fetuses

The following is a suggestion as to how to manage IUGR fetuses:

Management of IUGR Fetuses

When EFW <10th percentile and there is an abnormal UA PI or MCA PI, the patient should be referred to a perinatologist with experience in the management of IUGR fetuses.

Management of IUGR Fetuses

Between 24 and 34 weeks' gestation:

If (a) there is no maternal pathology, (b) the UA PI is abnormal (the diastole is present), (c) there is abnormal MCA PI, or (d) the AFI is >5 , the patient can be managed as an outpatient by a perinatologist, with an NST, a biophysical profile, and Doppler sonography of the umbilical artery performed every other day. Steroids should be administered.

Management of IUGR Fetuses

Following 34 weeks' gestation:

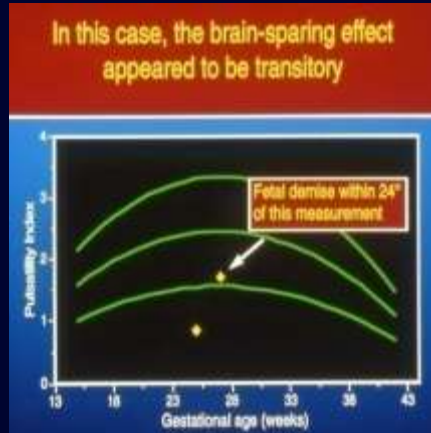
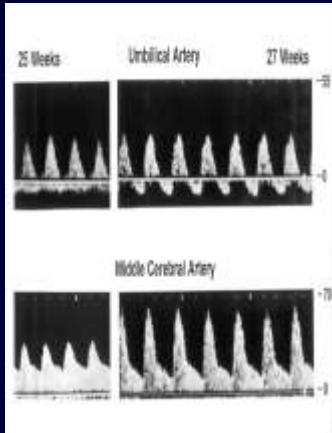
If there is no maternal pathology and the UA diastole is absent, the patient should be admitted to the hospital, and, in the presence of a reassuring NST, Doppler sonography should be repeated within 24 hours. If results confirm, perform delivery by cesarean section.

Management of IUGR Fetuses: Important Consideration

It is assumed that in a patient with no pathology that if a severe early IUGR is diagnosed, the patient will develop preeclampsia. This is not always true because the fetus may die earlier and the patient will not develop preeclampsia.

When Should IUGR Fetuses be Delivered?

Sequential Doppler Changes in IUGR



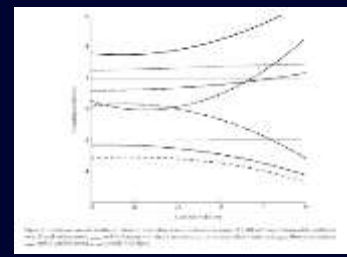
Mari G, Wasserstrum N. Am J Obstet Gynecol 1991; 164:776

This case report suggested that more than 1 Doppler study is better than a single study.

Sequential Doppler changes preceding late decelerations.

Arduini D, et al. Obstet Gynecol 1992; 79:605

- ???
- CCTG and BPP
 - Htn
 - DV
 - Delivery
 - AF



Ferrazzi E. et al. Ultrasound Obstet Gynecol 2001;18:564

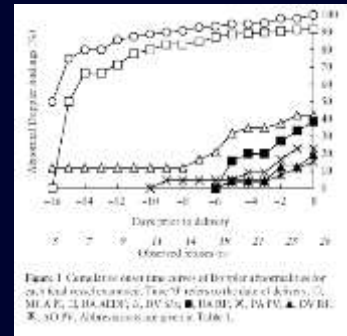


Figure 1. Graph illustrating the course of Doppler abnormalities for various fetal vessels: (□) MCA PI, (○) UA PI, (△) UA RI, (◇) UA S/D, (■) UA RI, (×) UA PI, (▲) DV RI, (●) S/D PI. (Adapted from reference 1, Table 1).

Hecher K. et al. Ultrasound Obstet Gynecol 2002;19:140

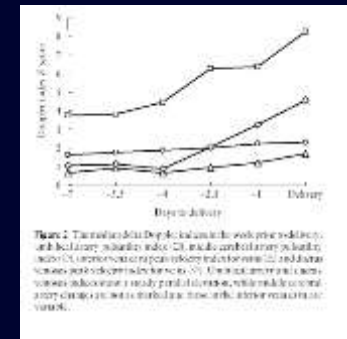
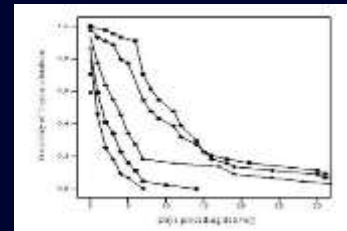


Figure 2. The median fetal Doppler index in the week prior to delivery and the delivery, in healthy babies (□), in babies with late decelerations (○), in babies with early decelerations (△), and in babies with severe fetal decelerations (◇) (n=20). An increase in the S/D ratio was observed in a steady parallel manner, while multiple abnormal early decelerations were associated with a decrease in the S/D ratio in the week prior to delivery.

Baschat A. et al. Ultrasound Obstet Gynecol 2001; 18: 57

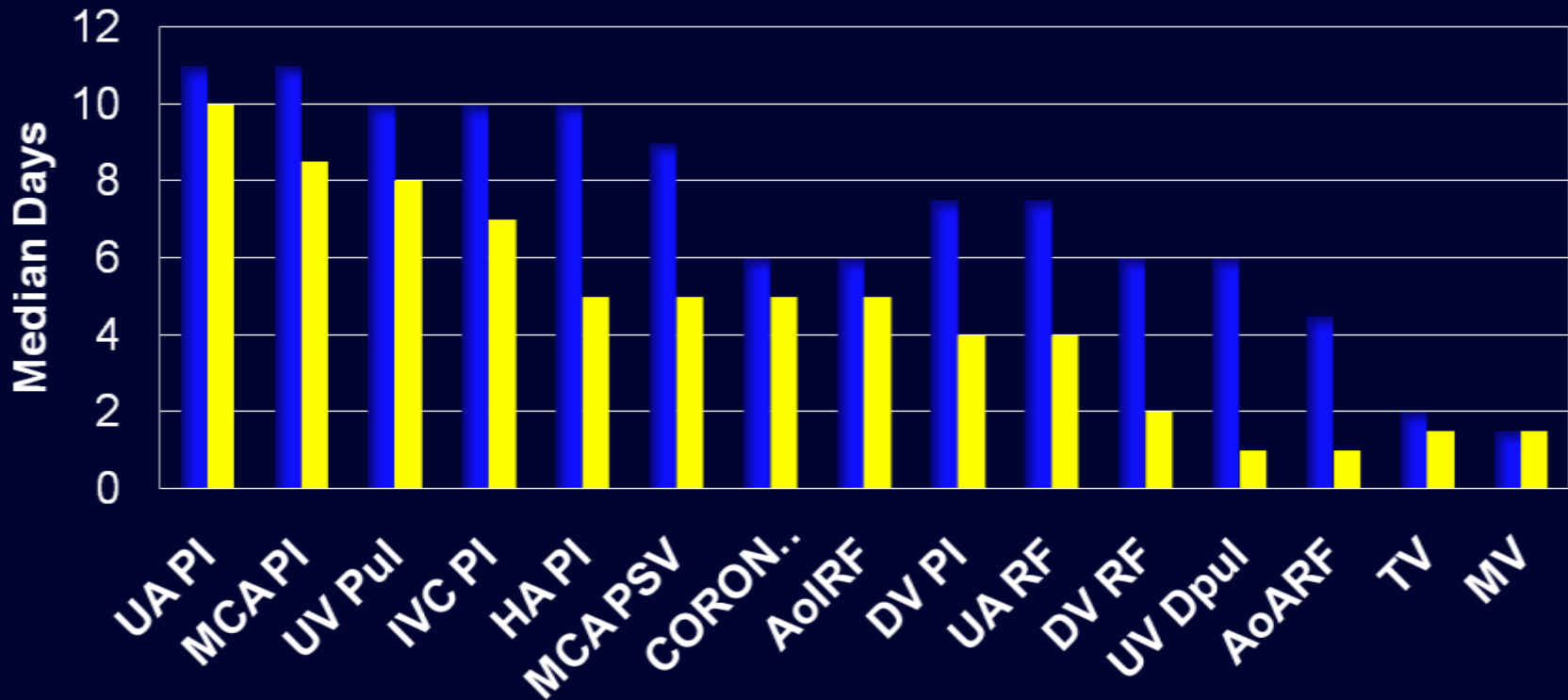


**Can we Predict Doppler Changes
in IUGR Fetuses Based on
Maternal History, Fetal Anatomy,
and Initial Doppler Findings?**

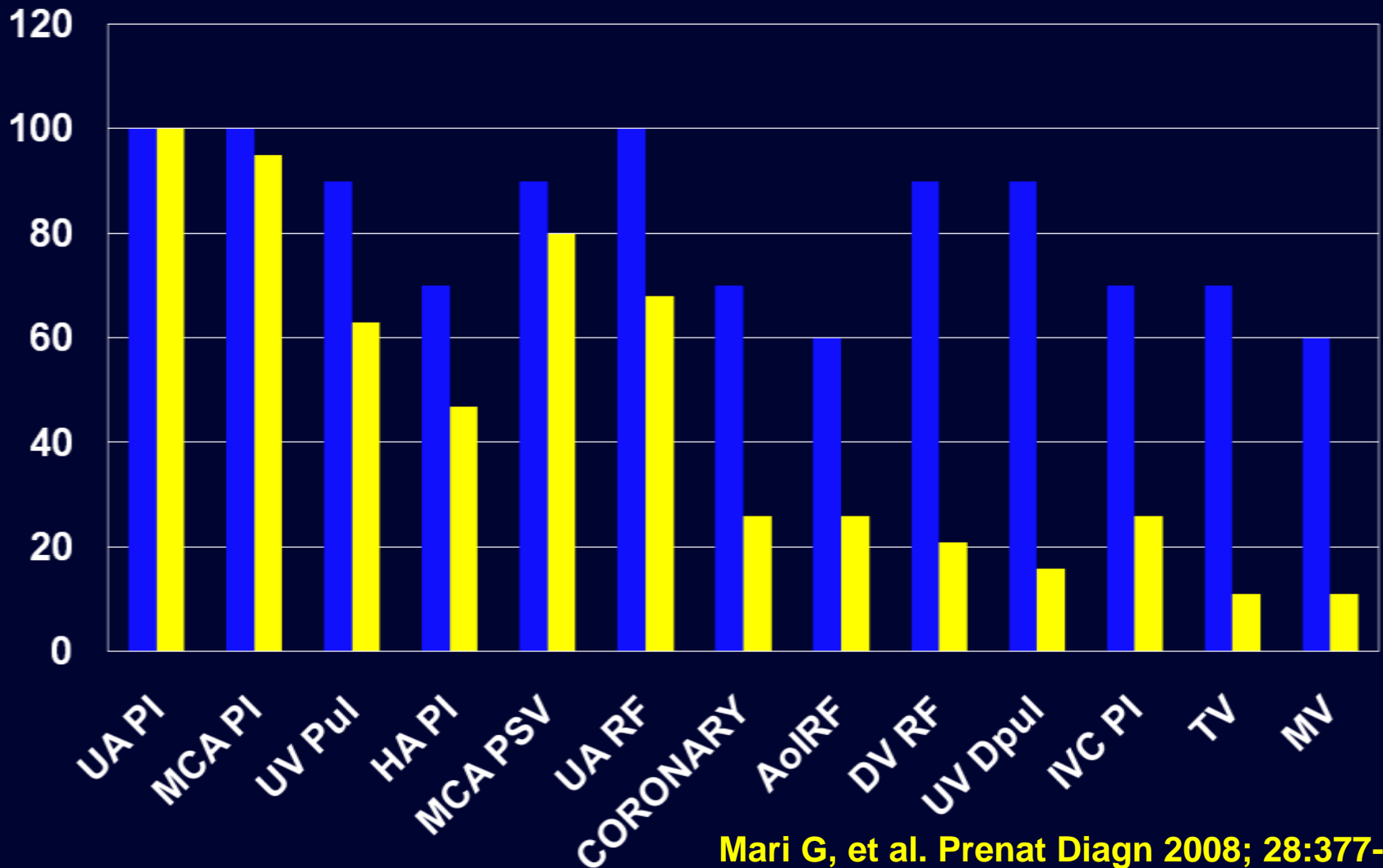
YES.

Time Interval Between Occurrence of Pathologic Findings and Delivery

Idiopathic (Blue)
Preeclampsia (Yellow)



Percent of Abnormal Parameters in the 2 Groups



Management of IUGR Fetuses

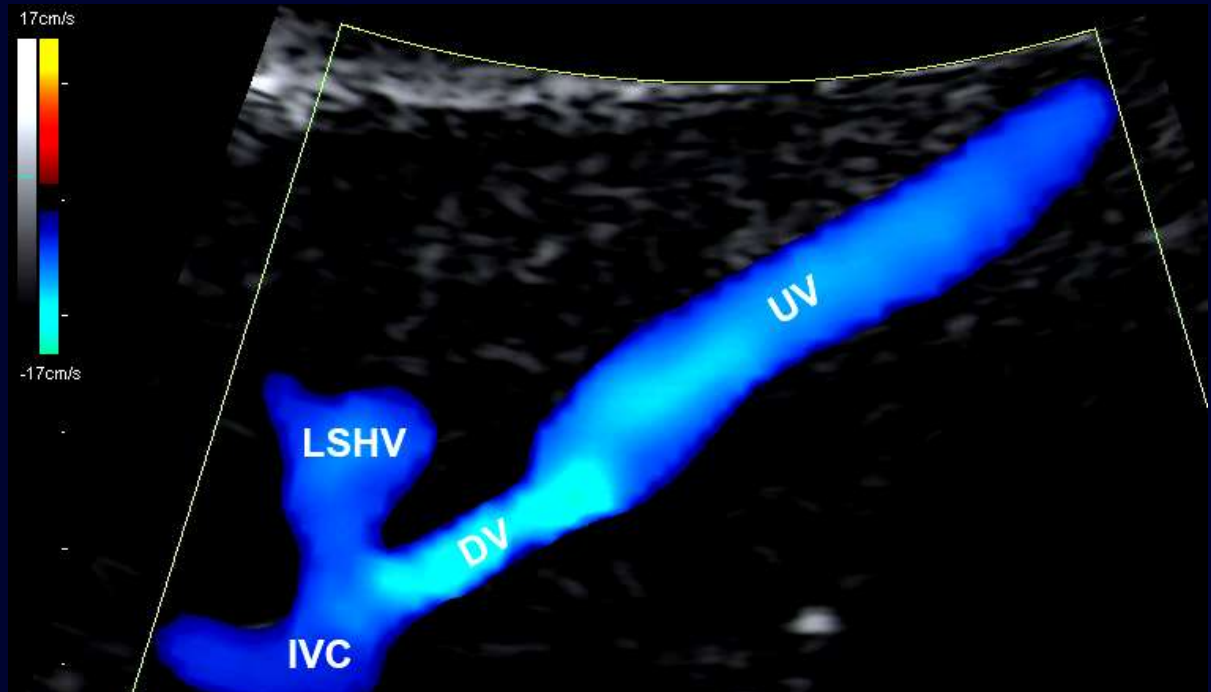
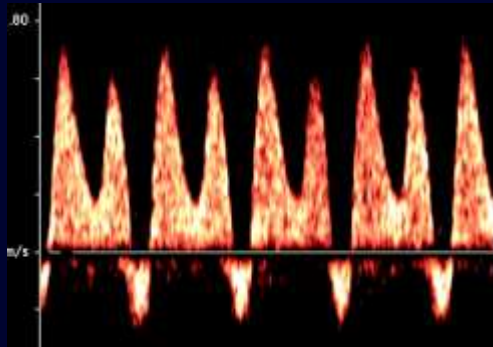
The 2 previous slides suggest that in idiopathic IUGR fetuses, the changes are predictable; therefore, a fetal demise can be avoided and timing of delivery can be optimized.

Future Studies

Doppler ultrasonography may play an important role in the management of IUGR fetuses. However, a prospective longitudinal study to understand the natural history of IUGR fetuses is what we most need at this time.

Question 1

Several investigators feel that ductus venosus reversed flow should prompt delivery. Is this justified?



Several investigators feel that ductus venosus reversed flow should prompt delivery. Is this justified?

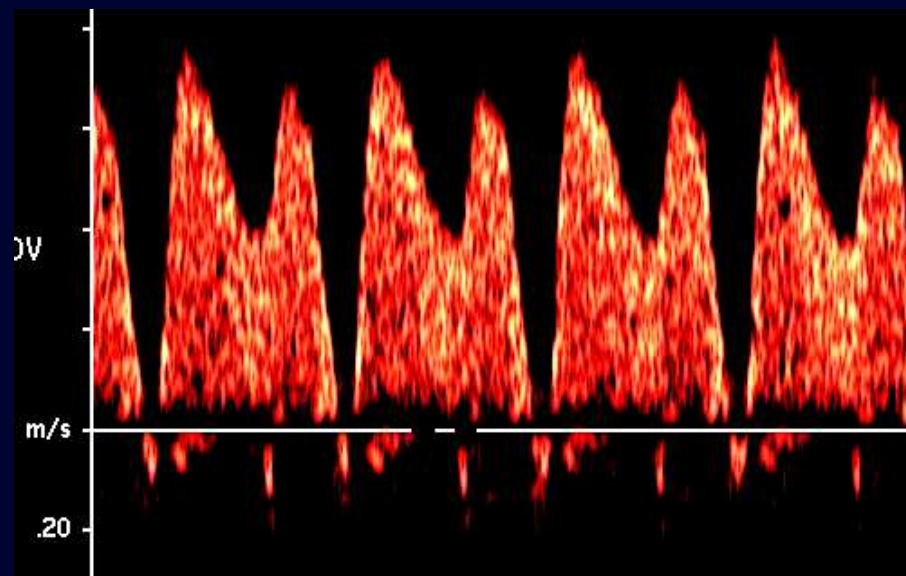
It is not justified for 3 main reasons:

A. The evidence is lacking at this time.

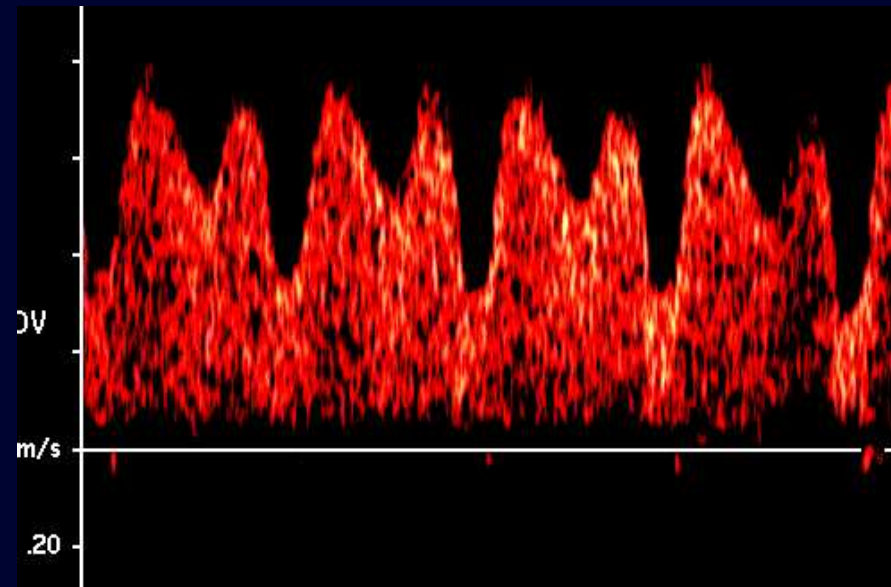
B. There is a transitional phase for the reversed flow.

C. There are several types of ductus venosus reversed flow.

DV Transitional Phase



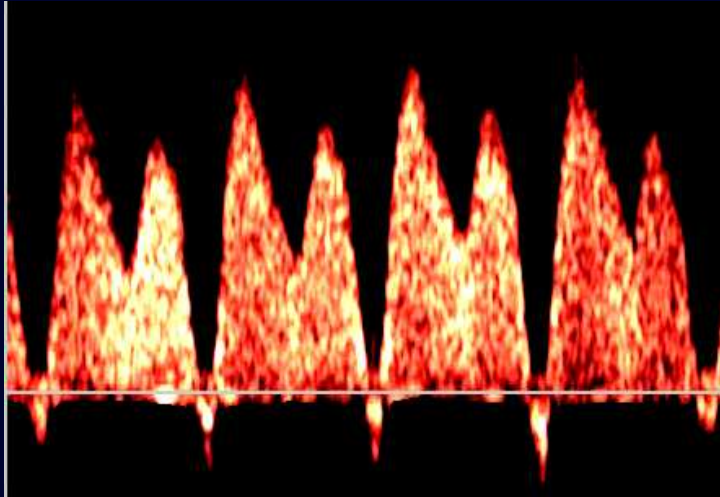
DV RF



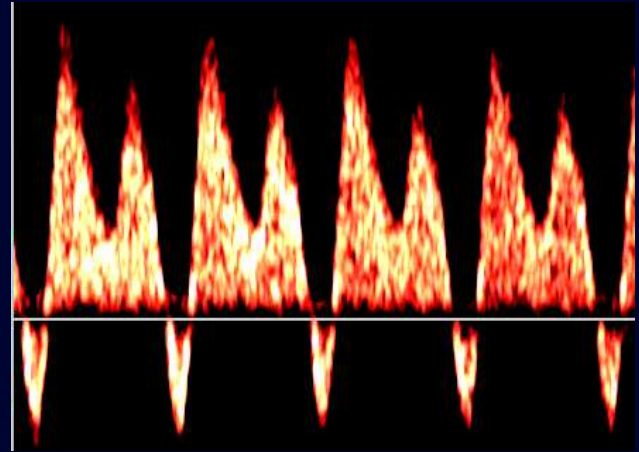
1 hour later

Ductus Venosus

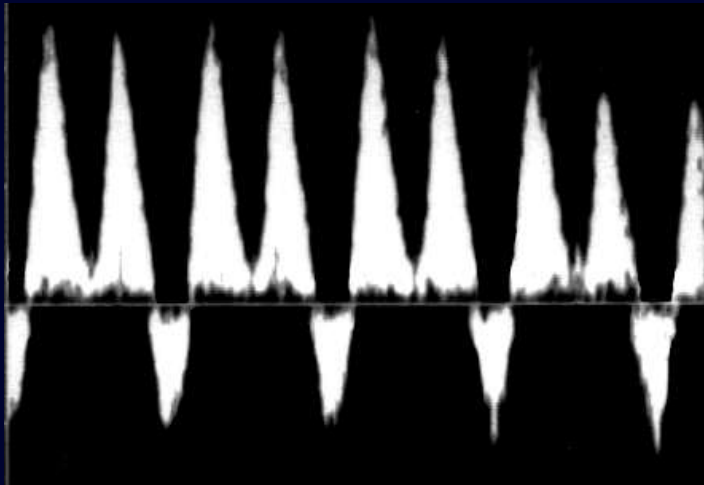
A



B



C

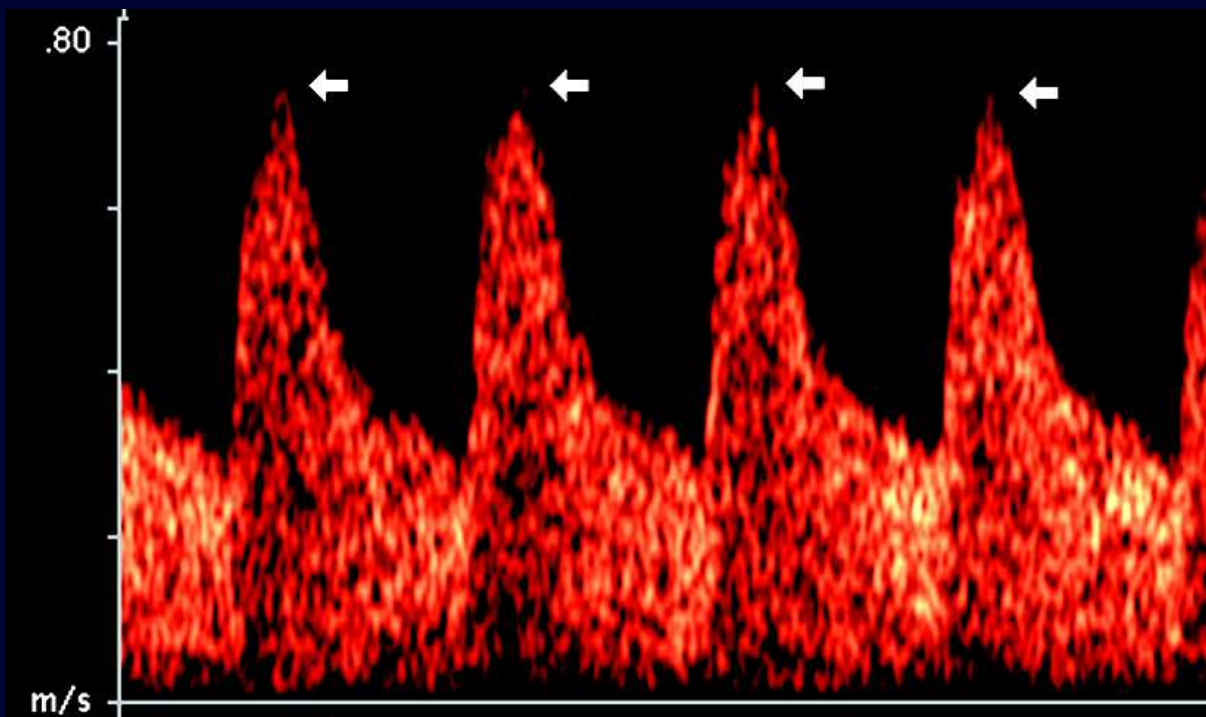


Question 2

MCA at 26 Weeks' Gestation

A. What is abnormal with these waveforms?

B. What do the arrows indicate?



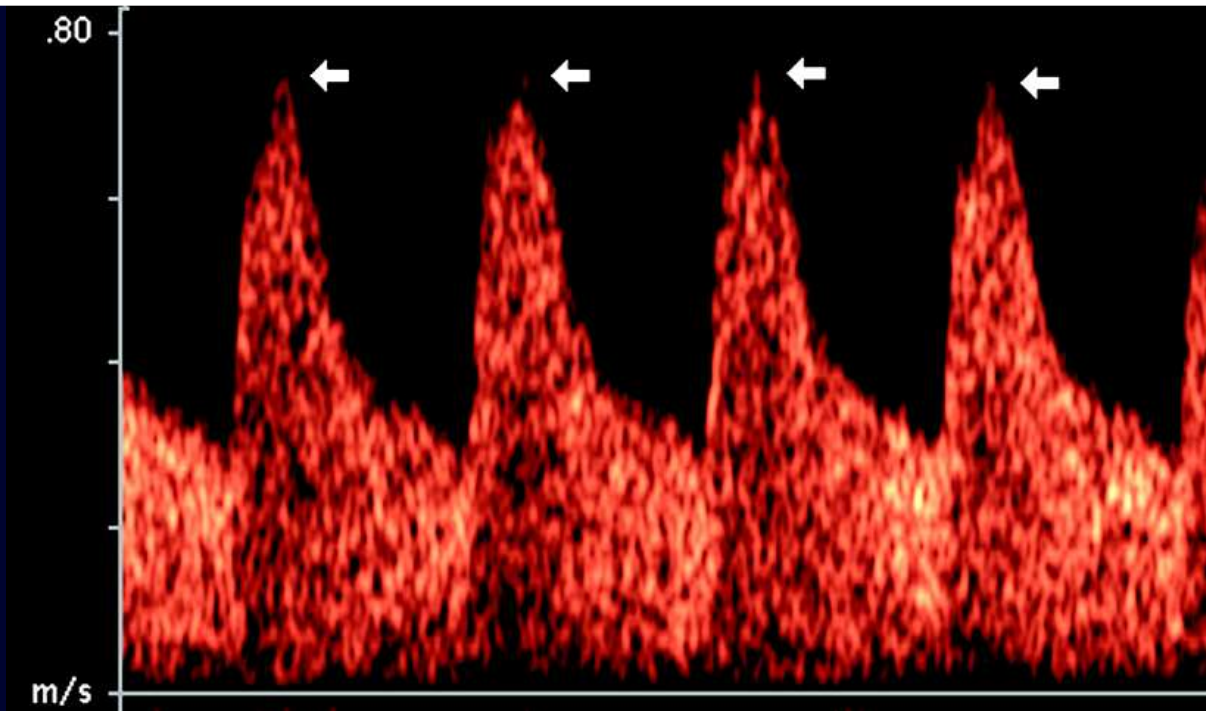
PI = 1.05

PSV = 77 cm/s

MCA at 26 Weeks' Gestation

A. What is abnormal with these waveforms?

B. What do the arrows indicate?



PI = 1.05

PSV = 77 cm/s

A. Pulsatility index and peak systolic velocity.

Question 3

How would you summarize the following?

A. Estimated fetal weight <10th percentile at 26 weeks' gestation.

B. Abnormal umbilical artery pulsatility index.

C. Amniotic fluid is 7 cm.

D. The mother has preeclampsia.

How would you summarize the following?

- A. Estimated fetal weight <10th percentile at 26 weeks' gestation.**
- B. Abnormal umbilical artery pulsatility index.**
- C. Amniotic fluid is 7 cm.**
- D. The mother has preeclampsia.**

Stage IB, 26 weeks, preeclampsia.

Question 4

**In a very early IUGR fetus, is
a biophysical profile of 8/8
reassuring for the next 24
hours?**

**In a very early IUGR fetus, is
a biophysical profile of 8/8
reassuring for the next 24
hours?**

No.

Question 5

What is the meaning of a low middle cerebral artery pulsatility index in an IUGR fetus?

What is the meaning of a low middle cerebral artery pulsatility index in an IUGR fetus?

It suggests vasodilatation. The reason is that an IUGR fetus redistributes its blood flow from the periphery and the liver to the brain.

THANK YOU.