Doppler Ultrasound in the Management of Fetal Growth Restriction

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For your convenience a copy of this lecture is available for review and download at http://onyeije.net/present

Terminology

Intrauterine Growth Restriction - IUGR

Small for Gestational Age - SGA

Fetal growth restriction - FGR

Definitions

- Intrauterine growth retardation (IUGR)
  - Fetus is at or below the 10th percentile for EGA
  - Fetus is subjected to pathology that restricts its ability to grow.
- Small for Gestational Age:
  - A "small" but otherwise healthy fetus.
- Low Birth weight (LBW)
  - Birth weight of less than 2500 gms which could be due to IUGR or prematurity

Traditional Classification of IUGR

Symmetrical

Fetal head and body are proportionately small.
Occurs with early developmental problems.

Asymmetrical

Fetal brain is abnormally large when compared to the body
Occurs when the fetus experiences a problem during later development

In a normal infant, the brain weighs about three times more than the liver. In asymmetrical IUGR, the brain can weigh five or six times more than the liver.

Functional Classification

Normal Small Fetus

Abnormal Small Fetus

Growth Restricted Fetus

Functional Classification

Normal Small Fetus:

- No Structural abnormality. Normal umbilical Doppler. Normal AFI.
- Less than 10th percentile.
- Good prognosis. No increased risk. No special care provided.

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Functional Classification

Abnormal Small Fetus:

- Chromosomal abnormality or structural defect with small size.
- Poor prognosis.

Functional Classification

Growth Restricted Fetus:

- Small due to placental dysfunction
- Variable prognosis.
- Appropriate and timely treatment can improve outcome.

Maternal Risk Factors

- Multiple gestation
- Drug exposure
- Cardiovascular disease
- Kidney disease
- Chronic infections
  - UTI, Malaria, TB, genital infections
- Autoimmune disease

Fetal Risk Factors

- TORCH infections
- Fetal anomalies
- Aneuploidy
- Skeletal Dysplasia
- Hypoxia

Placental Factors

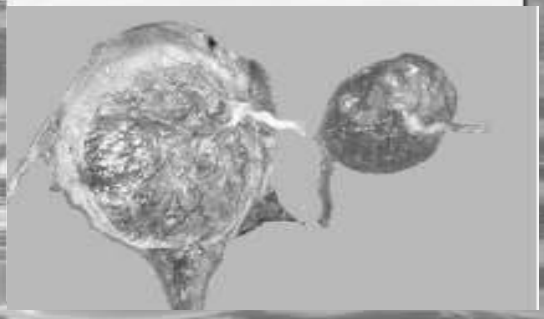
- Uteroplacental insufficiency
  - Improper placentation in the first trimester.
  - Abnormal insertion of placenta.
  - Reduced maternal blood flow to the placenta.
- Fetoplacetal insufficiency due to-.
  - Vascular anomalies of placenta and cord.
  - Decreased placental functioning mass-.
    - Small placenta, abruptio placenta, placenta previa, postdates

Diagnosis of IUGR

- Difficult diagnosis
- Need to evaluate risk factors
- Serial ultrasounds important
- Dating is important
- Ultrasound signs
  - Inadequate fetal interval growth.
  - Reduced AFI.
  - Placental calcification.

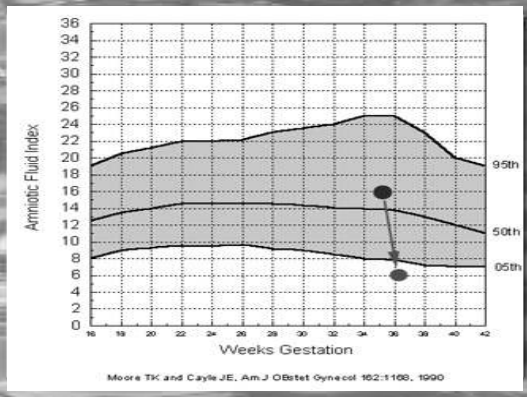
The Growth Restricted Neonate

The Growth Restricted Placenta



Surveillance

- **Duration:** Until delivery occurs
- **Reason**: To identify further progression of the disease process that would jeopardize the fetus.
- **Modalities**: NST, AFI, Doppler, BPP



Doppler In IUGR

Doppler ultrasonography was first used to study flow velocity in the fetal umbilical artery in 1977

DOPPLER WORKS LIKE AN ECHO

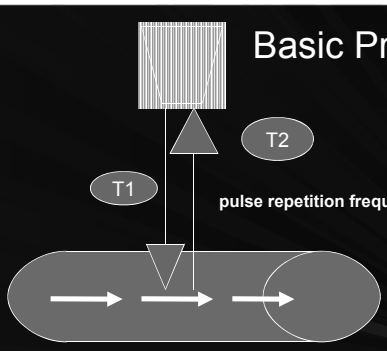
T1 : time of omitted signal .
T2 : time of returned signal .

T2 – T1 = ***time difference or phase shift .***

The Doppler frequency is obtained from phase shift.

AS TIME DIFFERENCE DECREASE THE DOPPLER FREQUENCY INCREASE.

Basic Principals



(T2 –T1) *phase shift* **with known beam / flow angle can calculate flow velocity .**

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Basic Principles

The time difference or phase shift can be processed to produce either **colorflow display** or a **Doppler sonogram**

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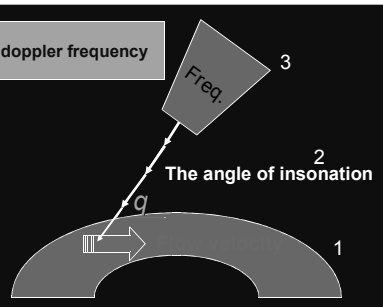
Factors affecting doppler frequency



The angle *q* between the beam and the direction of flow is VERY important in the use of Doppler ultrasound.

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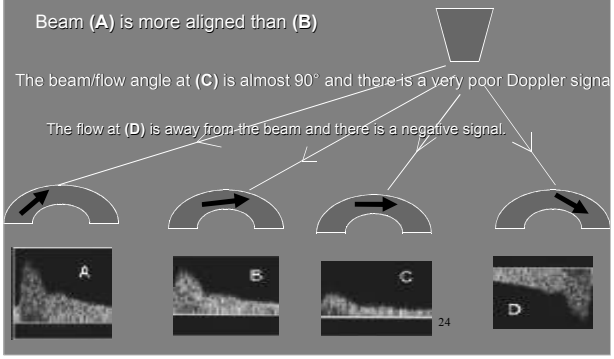
Why the Different Waveforms?

Beam **(A)** is more aligned than **(B)**

The beam/flow angle at **(C)** is almost 90° and there is a very poor Doppler signa

The flow at **(D)** is away from the beam and there is a negative signal.



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Aliasing

If a second pulse is sent before the first is received, the receiver cannot discriminate between the reflected signal from both pulses and aliasing occur.

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Aliasing

So to eliminate aliasing The pulse repetition frequency or scale is set appropriately for the flow velocities

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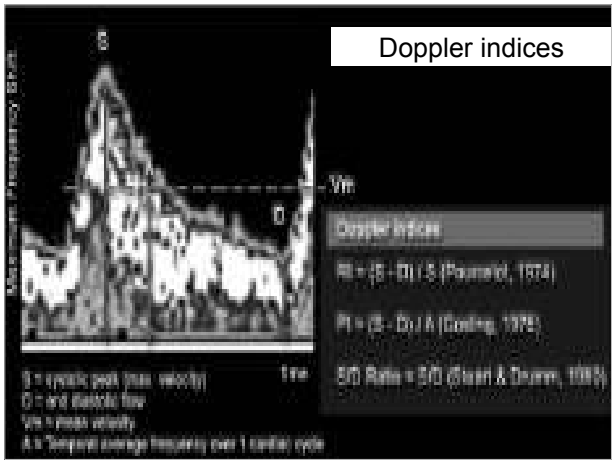
Umbilical artery Doppler

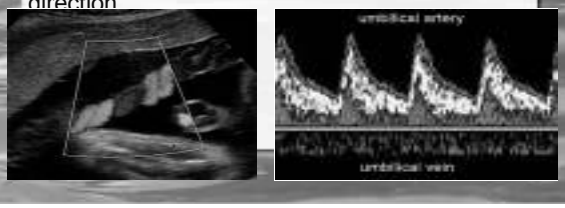


Umbilical artery

UMBILICAL ARTERY FLOW

Arterial flow has a saw-tooth pattern of arterial flow in one direction

Venous blood flow is continuous in the other direction

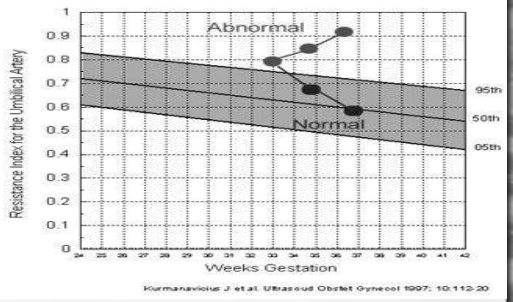


FACTORS AFFECTING UMBILICAL ARTERY DOPPLER FLOW VELOCITY WAVEFORMS*

Gestational age	EDFV ratio increases with advancing gestational age[13]
Fetal heart rate	EDFV decreases with decreasing fetal heart rate[39]
Fetal breathing movements	Increases variability in the measurements[14]
Site of measurement	EDFV is higher near the umbilical cord insertion into the fetal abdomen than near the placental insertion[47]
Equipment used: continuous Doppler versus pulsed Doppler	Continuous Doppler is more a "blind technique" compared with pulsed Duplex Doppler, allowing 2D real time ultrasound[48]
User experience	Reliability increases with increasing experience[49]
Radius of the umbilical artery	Decreasing radius (vasoconstriction) increases EDFV[50]
Impedance to pulsatile flow propagation	Increasing vascular impedance increases EDFV[50]
Downstream vascular resistance within the microcirculation	Increasing vascular resistance decreases EDFV[50,51]
Angle of the fetal Doppler insonation	Best if less than 45°[52], <15° for MCA absolute peak systolic flow velocity[53,54]

*EDFV = end diastolic flow velocity; MCA = middle cerebral artery.

Doppler of the Umbilical Artery

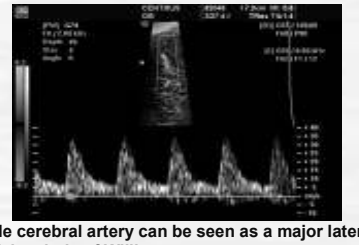


Kurmanavicius J et al. Ultrasound Obstet Gynecol 1997; 10:112-20

An increasing trend in Doppler suggests . deteriorating condition

Middle cerebral artery doppler

Middle cerebral artery



The middle cerebral artery can be seen as a major lateral branch of the circle of Willis

It runs anterolaterally at the borderline between the anterior and the middle cerebral fossae

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Middle cerebral artery

Redistribution of blood flow occurs as an early stage in fetal adaptation to hypoxemia

(brain-sparing reflex)

Increased blood flow to protect the brain, heart, and adrenals

Reduced flow to the peripheral and placental circulations

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MCA Doppler wave form of early stage of fetal hypoxemia

increased end-diastolic flow in the middle cerebral artery (lower MCA **pulsatility index** or resistance **index**)

Average of both MCAs must be calculated for more precise result

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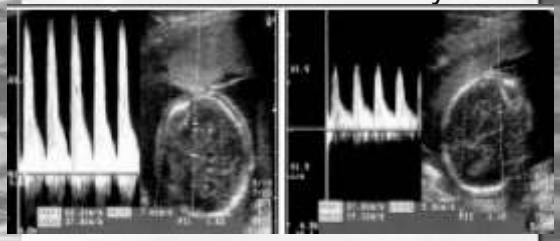
Middle Cerebral Artery



Flow velocity waveform in the fetal middle cerebral artery in a severely anemic fetus at 22 weeks (left) and in a normal fetus (right). In fetal anemia, blood velocity is increased

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Middle Cerebral Artery

When the fetus is hypoxic, the cerebra arteries tend to become dilated in order to preserve the blood flow to the brain and The systolic to diastolic ratio will decrease (due to an increase in diastolic flow)

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Doppler ultrasound for the fetal assessment in high-risk pregnancies

- A reduction in perinatal deaths.
- Fewer inductions of labour .
- Fewer admissions to hospital .
- no report of adverse effects .
- No difference was found for fetal distress in labour .
- No difference in caesarean delivery .

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Site of measurement	EDFV is higher near the umbilical cord insertion into the fetal abdomen than near the placental insertion[67]
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User experience	Reliability increases with increasing experience[69]
Radius of the umbilical artery	Decreasing radius (vasoconstriction) increases EDFV[70]
Impedance to pulsatile flow propagation	Increasing vascular impedance increases EDFV[70]
Downstream vascular resistance within the microcirculation	Increasing vascular resistance decreases EDFV[70–72]
Angle of the fetal Doppler insonation	Best if less than 45°[73]; <15° for MCA absolute peak systolic flow velocity[62,64]

*EDFV = end diastolic flow velocity; MCA = middle cerebral artery.