Practical Doppler Ultrasound in Obstetrics
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Doppler in OB US - Objectives

- Objectives
  - Apply appropriate Doppler evaluation to clinical obstetric practice
  - Perform obstetric Doppler exams using optimal settings and technique
  - Interpret and evaluate obstetric Doppler results to optimize clinical management

Doppler Equation

\[
\Delta F = \left(\frac{2 \times F_t \times V \times \cos \theta}{C}\right)
\]

Doppler Frequency Shift is Influenced by:
- \( F_t \): Frequency of insonant US beam
- \( V \): Velocity of target RBCs
- \( \theta \): Angle of insonation \( \rightarrow \cos 0^\circ = 1, \cos 90^\circ = 0 \)

2nd & 3rd Trimester OB US
Cord insertion site: central, eccentric marginal, velamentous


2nd & 3rd Trimester OB US

Cord (funic) presentation. Obligate cord presentation.

www.aium.org

Specialized Exam. ... might include fetal Doppler US ...
**Diagnosis: Vasa Previa**

**Vasa Previa**

Estimated incidence 1 in 2500 deliveries

Complications: hemorrhage, fetal exsanguination

Improved outcomes depend on:

- Prenatal US diagnosis & Planned C-section before ROM
- Perinatal mortality 56% when NOT recognized prenatally

* BUT 97% SURVIVAL WITH Prenatal US diagnosis!

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**OB Ultrasound - Size & Dates**

**PRACTICE BULLETIN**

Clinical Management Guidelines for Obstetricians–Gynecologists

**Fetal Growth Restriction**

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**Ultrasonographic Diagnosis and Evaluation**

"If the ultrasonographically estimated fetal weight is below the 10th percentile for gestational age, further evaluation should be considered, such as...

**Doppler blood flow studies of the Umbilical Artery.**

The utility of Doppler velocimetry evaluation, especially of the umbilical artery, has been studied and reviewed extensively in cases of fetal growth restriction."

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**Role of Doppler US in IUGR**

- Indications
- Technique
- Normal & Abnormal findings
- Pitfalls. “TIPS ➔”
- Utility. Role in OB management
UA Doppler: Placental and Fetal growth

Umbilical artery (UA) Systolic/Diastolic (S/D) ratio
- defined as: Peak-systole ÷ End-diastole
- reflects status of placental circulation
- high in early pregnancy, decreases during gestation
- in 2nd trimester, trophoblastic invasion
- increase in villous surface area, lower resistance circuit
- as gestation advances, lower placental resistance,
more forward flow during diastole → lower S/D ratio
- at >30 weeks, S/D < 3

Resistive Index (RI)
- defined as: (Peak-systole – End-diastole) ÷ Peak-systole
Pulsatility Index (PI)
- defined as: (Peak-systole – End-diastole) ÷ Mean

First Trimester UA Doppler

Late 2nd/Early 3rd Trimester UA Doppler

TIP:
→ IF discrepant/variable UA Doppler tracings are seen
Consider:
• Normal variability / fluctuations
• Fetal heart rate
• Filter settings
• Location along umbilical cord: at placenta or fetus?
In setting of IUGR:
- Lowered fetal cerebral vascular resistance
- Increase in diastolic flow in MCA
- Decrease in S/D ratio
- Referred to as “brain sparing”

Fetal Middle Cerebral Artery (MCA) Doppler

With increased resistance (placental insufficiency), forward flow in diastole decreases, with increase in S/D ratio. May develop absent or, eventually, reversed end-diastolic flow.

Fetal Middle Cerebral Artery (MCA) Doppler

Higher resistance circulation
Decreased diastolic flow
Increased S/D ratio
Normal S/D ratio in MCA > 4
MCA S/D always > UA S/D

MCA S/D Ratio: 4.7

Neurobehavioral outcomes in preterm, growth-restricted infants with and without prenatal advanced signs of brain-sparing
Preterm infants (<34 weeks), n=126
64 controls. 62 IUGR (BW<10th %ile). 33 w/abn MCA
Abnormal neurobehavioral scores (at 40 weeks) - higher in IUGR than AGA infants - higher in IUGR with “brain sparing” abn MCA Doppler
“Abnormal MCA Doppler findings are predictive of neurobehavioral impairment among preterm newborns with IUGR . . . suggests that this reflects advanced stage of brain injury with higher risk of abnormal neurological maturatation.”

Abnormal UA Doppler in IUGR

- Reversed diastolic flow in UA (increased placental resistance)
- Ominous sign of fetal compromise/hypoxemia

Doppler Interrogation of the Ductus Venosus


Doppler Interrogation of the Ductus Venosus


Doppler Interrogation of the Ductus Venosus

lyceum.algonquincollege.com

Doppler Interrogation of the Ductus Venosus

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


Abnormal Doppler of Ductus Venosus

www.ultrasound-images.com.br


Abnormal Doppler of Ductus Venosus

Phasic venous flow
- Hybrid of continuous monophasic umbilical/portal venous and hepatic venous waveforms
- Continuous forward flow (toward heart) throughout cardiac cycle, referred to as “forward a-wave flow”
Abnormal DV Doppler in IUGR

- Increased after-load causes deepening of a-wave
- Poor cardiac function leads to retrograde flow
- Reversed a-wave flow in DV
- Sign of severe hypoxia/RV dysfunction/fetal compromise
- High morbidity and mortality

TIP:
Technique for interrogation of DV.
→ If variable DV waveforms, consider:
  - Inadvertent sampling of HVs
→ If DV cannot be seen/interrogated, consider:
  - Sampling umbilical vein

Abnormal DV waveform with reversed a-wave flow
If DV cannot be seen, consider Doppler evaluation of umbilical vein
Abnormal phasic UV waveform

Arterial / Venous Doppler in IUGR

Arterial Doppler: indirect assessment of placental resistance
Venous Doppler: indirect assessment of fetal cardiac function

Progression of Doppler Findings in IUGR

- Abnormal increase in UA S/D ratio
- Decrease in MCA S/D ratio ("brain sparing")
- Absent/Reversed umbilical artery EDF
- Ductus venosus (DV) a-wave flow reversal
- Umbilical vein pulsation

Abnormal Doppler Findings in IUGR

- Umbilical artery resistance reflects placental resistance
- As placental resistance increases (loss of 30% of villous vasculature), diastolic velocities fall (95/D ratio) and eventually disappear (AEDF: 60-70% loss of vasculature)
- An elastic component induces reversed end-diastolic flow when rigid placental circulation recoils after being distended by pulse pressure
  - OR of 5.3 for perinatal death compared with absent flow

Vasconcelos et al. Fetal Diagn Ther 28:160, 2010

n = 1116 fetuses, IUGR defined as EFW < 10th centile
312 (28%) admitted to NICU and 58 (5.2%) affected by adverse perinatal outcome
Presence of abnormal umbilical artery Doppler [absent or reversed end-diastolic flow or PI > 95th] was significantly associated with adverse outcome, irrespective of EFW or AC measurement

Perinatal mortality risk in IUGR fetuses:
- Elevated S/D ratio in UA only: 5.6%
- Absent or reversed diastolic flow in UA: 11.5%
- Abnormal DV waveform: 39%

Cochrane Review: use of Doppler US in high-risk preg
18 studies, >10,000 infants
- 29% reduction in perinatal deaths
  • (1.2% vs 1.7%, NNT: 203)
- 10% reduction in inductions and Cesarean sections

Alfirevic et al, Cochrane Database of Systematic Reviews 2010
Baschat et al, Ultrasound Obstet Gynecol 2003

Role of Doppler US in ? Fetal Anemia

- Indications
- Technique. MCA-PSV
- Normal & Abnormal findings
- Pitfalls. “TIPS”
- Utility. Role in OB management

Mari G. J Ultrasound Med 24:697, 2005

Doppler of MCA PSV: Data/Evidence

- Doppler measurement of MCA-PSV accurately estimates Hgb in fetuses at risk for anemia
- Initially demonstrated in cases of red cell alloimmunization, later extended to other types of anemia
- Becomes more accurate as severity of anemia increases
- Effective US parameter in non-invasive management
- Minimal, “clinically acceptable” inter-observer variability
- 2005: “not yet” standard of care b/c possible “incorrect use” by inexperienced operator. Attn: angle correction


Doppler assessment of the fetus with intrauterine growth restriction.
SMFM Clinical Guideline. www.AJOG.org

Absence or reversed end-diastolic flow in the UA
is associated with increased risk of perinatal mortality.
Rate of perinatal death is reduced by as much as
29% when UA Doppler velocimetry is added to standard antepartum testing in setting of fetal growth restriction.
TIP:
→ Optimal sampling / measurement of MCA velocity

Consider:
• Location within middle cerebral artery
• MCA vs anterior cerebral artery (ACA)
  □ θ = 0° or angle correction
• Optimize scale settings: color, spectral
• Reproducibility?
• If variable, use highest peak MCA obtained


To assess for possible fetal anemia in setting of maternal alloimmunization
Fetal MCA PEAK Systolic Velocity Measurement

The middle cerebral artery is examined close to its origin in the internal carotid artery.
The angle of the ultrasound beam and the direction of blood flow should be zero degrees.
The risk of anemia is highest in fetuses with a pre-transfusion peak systolic velocity of 1.5 times the median or higher.

ENTER:
Gestational age (weeks)
Observed MCA Peak Systolic Velocity (cm/sec)
Calculate
Clear Form

Calculations:
The Median Peak Systolic Velocity for this age is
Your measurement is
Multiples of Median

Fetal intervention prompted by MCA PSV > 1.5 MoM

In Summary
• Role of Doppler US in OB
• Applications: Vasa previa, IUGR, ? Fetal anemia
• Technical considerations
  – S/D ratio in UA, MCA. Waveform in DV.
  – Peak systolic velocity in MCA
• Optimize settings
• Address/reconcile discrepant info


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