Obstetrical Doppler: How, when and why?

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Disclosure statement

- I do not have an affiliation, financial or otherwise, with a pharmaceutical company, medical device or communications organization.

- I have no conflicts of interest to disclose (i.e. no industry funding received or other commercial relationships).

- I have no financial relationship or advisory role with pharmaceutical or device-making companies, or CME provider.
Objectives

1. To discuss the indications of obstetrical Doppler testing in uterine, umbilical, and cerebral arteries
2. To describe the results and limitations of obstetrical Doppler in screening for fetal growth restriction and preeclampsia
3. To expose the methods of Doppler evaluation of fetal well-being for growth-restricted fetuses
“First we’re going to run some tests to help pay off the machine.”
Question 1

In case of fetal growth restriction due to severe placental insufficiency, the following Doppler pattern is more likely:

A- Increased cerebral and umbilical pulsatility
B- Increased cerebral velocity
C- Decreased cerebral and increased umbilical pulsatility
D- Reverse flow in cerebral artery
E- Reverse flow in umbilical vein

(answer: C)
Question 2

In case of severe fetal anemia, the following pattern is more likely:

A- Increased cerebral and umbilical pulsatility
B- Increased cerebral velocity
C- Decreased cerebral and increased umbilical pulsatility
D- Reverse flow in cerebral artery
E- Reverse flow in umbilical vein

(answer: B)
Question 3

At 18 weeks, a bilateral notch in the uterine artery Doppler can be:

A- a normal finding
B- associated with an increased risk of preeclampsia or IUGR
C- Should be repeated at 24-26 weeks
D- Requires an antihypertensive treatment
E- A+B+C are correct

(answer: E)
How to obtain a good Doppler signal?
Effect of angle

Figure 3: Effect of the Doppler angle in the sonogram. (A) higher-frequency Doppler signal is obtained if the beam is aligned more to the direction of flow. In the diagram, beam (A) is more aligned than (B) and produces higher-frequency Doppler signals. The beam/flow angle at (C) is almost 90° and there is a very poor Doppler signal. The flow at (D) is away from the beam and there is a negative signal.

Simple general rule: keep angle ≤ 45°

In some cases, as close as 0° as possible
Basic settings

- Gate size: adapt to vessel size
- Gain: adjust to obtain good signal/noise ratio
- PRF (Pulse repetition frequency) or scale: adjust to flow velocity
Wall filter

- Set too low: noise
- Set too high: you lose information or you create absent end-diastolic flow
Resistance index, pulsatility index, ratios ???

Figure 16: Flow velocity indices

Indices make you independent from insonation angles. \( PI \) gives the maximum of hemodynamic information.
PI, RI

**Resistance Index \( \frac{(S-D)}{S} \)**

**Umbilical Artery PI**

Harrington et al, Ultrasound Obstet Gynecol. 6(1995)
Role of Doppler in management of placental insufficiency

I. **Prediction** IUGR/preeclampsia (long term)
   - Uterine arteries (notch/increased resistance)
   - Objective: population screening / IUGR etiology

II. **Diagnosis/surveillance** (mid term)
   - Umbilical arteries
   - Objective: adjust frequency of monitoring

III. **Fetal well-being** (short term)
   - Umbilical arteries
   - Cerebral arteries
   - Other fetal Dopplers
     - Ductus Venosus, IVC
     - Aortic isthmus etc...
   - Objective: decide when to deliver a fetus with IUGR

http://www.fetalmedicine.com/fmf/online-education/03-doppler/
Uterine arteries

- Screening test
- 20-24 weeks
- PI or RI increased

- Protodiastolic NOTCH
- 60-90% sensitivity
- PPV 20-30%
Uterine arteries
Pulsatility index in the uterine artery with gestation (mean 95th and 5th centiles)
Normal uterine artery
Increased resistance to blood flow / loss of elasticity

Notch is characteristic of uterine artery

Normal in non-pregnant uterus and during 1st trimester
1st trimester uterine artery Doppler

30-60% have a protodiastolic notch
Mean PI = 1.6
Predictive value?
« Combined screening »

Down syndrome screening

90% detection for 5% FPR

70% detection for 5% FPR

50% detection for 5% FPR

Ultrasound

Biochemistry
Combined screening

Preeclampsia screening?

40% detection for 10% FPR?

50% detection for 10% FPR?

X% detection for Y% FPR?

Doppler

Biochemistry
Fetal surveillance

Fetal Monitor Patterns

Reassuring Pattern
Baseline fetal heart rate is 120-160 bpm, present both to level and long-term variability. Accelerations last for 15 or more seconds above baseline, and peak to 15 or more bpm.

Elevated Heart Rate: Tachycardia
Baseline fetal heart rate is above 160, possible onset of decreased variability. Usually due to fetal lacking nutritional blood supply, or neutral effects of some drugs.

Early Deceleration
The onset and return of the deceleration coincides with the onset and end of the contraction. Decelerations are associated with fetal movement, stimulation, and uterine contractions.

Late Deceleration with Preserved Variability
Fetal heart rate returns to baseline AFTER the contraction has ended. Late decelerations are associated with uteroplacental insufficiency, or decreased uterine blood flow.

Normal umbilical artery Elevated Doppler index Absent/reversed end-diastolic velocity

Early-onset FGR
Evolution over 4-6 weeks

Normal umbilical artery Elevated Doppler index Absent/reversed end-diastolic velocity

Late-onset FGR
Evolution over 6-9 weeks

Nonreactive FHR Declining A/F Loss of breathing
Umbilical Doppler

Umbilical artery
Umbilical artery Doppler

NORMAL

1- cardiac cycle

Systolic peak

End diastolic velocity

Continuous positive flow

Baseline
Progression of Abnormal Doppler Waveform of Umbilical Artery

Normal diastolic flow

Decreased diastolic flow

Very Bad

Absent diastolic flow

Bad

Reverse flow

Awful
Middle Cerebral Artery (MCA)

- Main branch of circle of Willis
- Carries 80% of blood supply
- Easy to identify
- Easy to repeat
Brain sparing effect

Fetal adaptation / response to hypoxemia

BRAIN, heart, adrenals

Vasodilatation
Ductus venosus

Ductus venosus flow reflects the cardiac response (right atrium) to hypoxia
Ductus venosus: «a» wave

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

Normal

Abnormal

Critical
Doppler evolution

Early IUGR (22-34 weeks)

Late IUGR (34-40 weeks)

Baschat AA, Ultrasound Obstet Gynecol 2011
When to deliver?

<table>
<thead>
<tr>
<th>Early</th>
<th>Late</th>
</tr>
</thead>
<tbody>
<tr>
<td>abnormal UA (EDV decreased)</td>
<td>absent / reversed UA EDV</td>
</tr>
<tr>
<td>redistribution of cardiac output (decreased CPR)</td>
<td>“Normalization”</td>
</tr>
<tr>
<td>brain sparing</td>
<td>abnormal precordial veins</td>
</tr>
<tr>
<td></td>
<td>UV-pulsation</td>
</tr>
<tr>
<td></td>
<td>DV-RAV</td>
</tr>
</tbody>
</table>

Fetal Death

- Delayed maturation of fetal behavioral states
- Delayed maturation of FHR control
- Increased baseline
- Absent reactivity
- Decreasing variation
- Variation loss
- Late decelerations

- Declining amniotic fluid volume
- Declining global activity
- Loss of breathing
- Loss of movement
- Loss of tone

Acid base

- $pO_2$
- $pH$

Baschat et al.
When to deliver IUGR? Aortic isthmus??

Brain sparing effect
Aortic isthmus

Abnormal isthmus flow predicts suboptimal neurodevelopment

JC Fouron Am J Obstet Gynecol 2005
Middle cerebral artery in Fetal Anemia: increased velocity

- Vmax >1.5 MoM
- Se=100% NPV=100%
- FP=12%
- PPV=65%

Indications: maternal antibodies, fetal hydrops, parvovirus exposure, etc...
perinatology.com

Expected Peak Velocity of Systolic Blood Flow in the MCA as a Function of Gestational Age

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) [ ]

Calculations:

The Median Peak Systolic Velocity for this age is [ ]
Your measurement is [ ] Multiples of Median

REFERENCES:

4. Pereira L, et al., Conventional management of maternal red cell alloimmunization compared with
Doppler ultrasound for the fetal assessment in high-risk pregnancies

- Reduction in perinatal deaths  RR=0.71
- Fewer inductions of labour
- Fewer admissions to hospital
- No report of adverse effects
- No difference for fetal distress in labour
- No difference in caesarean delivery
- No benefit proven in low-risk women

Cochrane Collaboration 2010
### Recommendation 5: Uterine Artery Doppler

<table>
<thead>
<tr>
<th>Previous obstetric history</th>
<th>Risk factors in current pregnancy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Previous early onset gestational hypertension</td>
<td>Pre-existing hypertension</td>
</tr>
<tr>
<td>Placental abruption</td>
<td>Gestational hypertension</td>
</tr>
<tr>
<td>Intrauterine growth restriction</td>
<td>Pre-existing renal disease</td>
</tr>
<tr>
<td>Stillbirth</td>
<td>Long-standing type I diabetes with vascular</td>
</tr>
<tr>
<td></td>
<td>complications, nephropathy, retinopathy</td>
</tr>
<tr>
<td></td>
<td>Abnormal maternal serum screening (hCG or AFP &gt; 2.0 MOM)</td>
</tr>
<tr>
<td></td>
<td>Low PAPP-A (consult provincial lab for norms)</td>
</tr>
</tbody>
</table>

1. Where facilities and expertise exist, uterine artery Doppler may be performed at the time of the 17 to 22 weeks’ gestation detailed anatomical ultrasound scan in women with the following factors for adverse perinatal outcome. (II-A)

2. Women with a positive uterine artery Doppler screen should have the following:
   - A double marker screen (for alpha-fetoprotein and beta hCG) if at or before 18 weeks’ gestation. (III-C)
   - A second uterine artery Doppler at 24 to 26 weeks. If the uterine artery Doppler is positive at the second scan, the woman should be referred to a maternal-fetal medicine specialist for management. (III-C)
Umbilical artery Doppler: SOGC guidelines

1. Should not be used as a screening tool in low-risk women

2. Should be performed in suspected IUGR or placental pathology (preeclampsia)

3. Abnormal Doppler is an indication for increased fetal surveillance or delivery, depending on other clinical factors