Learning Objectives

- Describe how Doppler ultrasound can be used adjunctively with other management tools, i.e., non-stress test and biophysical profile, in the assessment of fetal condition
- Describe how Doppler ultrasound can be used to pinpoint fetal growth restriction
- Describe how the assessment of the fetal venous system can determine time of delivery
- Develop an algorithm for management of IUGR
Complications of IUGR that can be averted

- Fetal death
- Morbidity
  - Short term - neonatal encephalopathy
    - Necrotizing enterocolitis
  - Longer term - developmental delay
  - Long term - diabetes, hypertension
Does identification of SGA fetuses improve their outcome?

- Data from 1990 - 1998 involving 26,968 pts
  - Identified SGA’s - 681
  - Unidentified SGA’s - 573
- SGA’s followed with serial Dopplers
- End points of neonatal morbidity included
  - Low Apgar’s (<4 at 5 mins)
  - Encephalopathy
  - Convulsions
  - pH <7.0
  - CP
  - Mental retardation
  - Death

Does identification of SGA fetuses improve their outcome?

- Unidentified SGA - neonatal morbidity and mortality was 4.1 fold greater (11.7% v. 5.0%)

Diagnosis Made by EFW or AC

Advantages of Each
Abdominal Circumference

- Liver size
- Liver is the largest intra-abdominal organ that is most affected by aberrant growth
  - Growth restriction and macrosomia
- AC < 2 5th percentile: sensitivity > 95%
  - Most sensitive
  - Most scientifically applicable

Which definition is most clinically applicable
Management of IUGR

- Severe IUGR due to placental dysfunction
  - Progressive
  - No treatment to reverse or halt the process
- Timing of Delivery
  - Risks: prematurity vs. continued intrauterine life
- Objective:
  - Buy time to reduce prematurity risks, but deliver prior to brain damage
- Question: *Can this be accomplished?*
- Answer: DOPPLER
In IUGR, umbilical artery waveform is the way to start assessing fetal condition.
RCT meta-analysis shows a halving of perinatal mortality rate when Doppler is added to the diagnostic mix

- Divon
- Neilson
- Alfrevic
UmA FWV Across Gestation

14 weeks
22 weeks
31 weeks
35 weeks
40 weeks
IUGR Case  Normal
The umbilical artery tells us about the adequacy or vascularization in the villus circulation
Development of the Placental Circulation
The Three Stages of Fetal Circulation

- **First Trimester**
  - Mesenchymal villi develop (framework) - primary, secondary and tertiary stem villi

- **Second Trimester**
  - Stem villi branch into 10-15 generations of immature, intermediate stem villi and mature intermediate stem villi - “branching” angiogenesis

- **Third Trimester**
  - Intermediate mature stem villi sprout many terminal villi - “non-branching” angiogenesis
Doppler in IUGR

- The middle cerebral artery simply reflects the extent of fetal “brain sparing”
Doppler Velocimetry: Middle Cerebral Artery

- Normally a high impedance bed with low end-diastolic flow
- Increase in diastolic flow velocities:
  - Early sign of fetal hypoxemia
    - (Gudmundsson, 1996)
  - Sign of re-distribution of fetal blood flow in chronic hypoxemia
    - (Wladiminoff, 1986; Mari 1991; Gramellini 1992)
MCA Doppler in IUGR

Circle of Willis
Circle of Willis
IUGR  Normal
When blood is shuttled to the brain, there are some drawbacks:

**Short Term**
- Oligohydramnios (Arduini)

**Long Term**
- Necrotizing enterocolitis (Campbell)

**Very Long Term**
- Diabetes (Barker)
  - Cardiovascular disease (Barker)
The ductus and the IVC indirectly reflect the efficiency of the fetal heart and seem to correlate with the presence or absence of metabolic acidosis.
Ductus Venosus

Normal

Abnormal
Ductus Venosus Progressive Changes - Case Example

HD #4  HD #7  HD #10

S/a ratio
3.8  5.9  6.1
Ductus Venosus

HD #12
Venous back flow during atrial contraction is most reflective of fetal metabolic acidemia.

- **Ductus Venous**

- **Inferior Vena Cava**
- Metabolic acidosis, not necessarily hypoxia, correlates with neurological outcome in the infant
What are our goals in IUGR?

1. To prevent fetal death
2. To prevent neonatal death
3. To prevent neonatal damage
Is there a predictable sequence of events in IUGR?

It depends on whether it occurs early or late.
Early IUGR

1. Often abnormal uterine arteries
2. Often hypertension or thrombophilia
3. Early plateauing of fetal growth
4. Fetal femur falls off as early as AC
5. Sometimes echogenic bowel
6. High risk for perinatal death and disability
Late IUGR

1. AC falls off curve first (>32 weeks)
2. Sneaks up because EFW < 10th % late
3. Low risk for perinatal death
4. Higher rate for fetal distress, C Sx, and some increase in neurological fall out
Timeline in early IUGR

1. Decreased EDF in umb artery
2. MCA shows brain sparing
3. Absent EDF in umb artery
4. Ductus - decreased flow during AC
5. BPP <= 6 or NR NST
Timeline in late IUGR

1. MCA shows brain sparing
2. Umb artery shows decreased EDF
3. BPP is non reassuring of NR NST
## FHR Tracings, Umb A Doppler, and the early IUGR Fetus

<table>
<thead>
<tr>
<th>Group</th>
<th>FHR Tracing</th>
<th>Umb A Doppler</th>
<th>Hypoxia / Acidemia</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>normal</td>
<td>normal</td>
<td>none</td>
</tr>
<tr>
<td>II</td>
<td>normal</td>
<td>abnormal</td>
<td>&lt; 5.0%</td>
</tr>
<tr>
<td>III</td>
<td>abnormal</td>
<td>abnormal</td>
<td>60%</td>
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Monitoring of fetuses with intrauterine growth restriction: a longitudinal study

K. HECHER, C. M. BILARDO*, R. H. STIGTER†, Y. VILLE‡, B. J. HACKELÖER, H. J. KOK*, M. V. SENAT‡ and G. H. A. VISSE†

The sequence of changes in Doppler and biophysical parameters as severe fetal growth restriction worsens

A. A. BASCHAT, U. GEMBRUCH* and C. R. HARMAN

Temporal sequence of abnormal Doppler changes in the peripheral and central circulatory systems of the severely growth-restricted fetus

E. FERRAZZI*, M. BOZZO*, S. RIGANO*, M. BELLOTTI*, A. MORABITO*, G. PARDI†, E. C. BATTAGLIA‡ and H. L. GALAN§
Temporal Sequence of Doppler Changes in Severe IUGR

Ferrazzi et al. Usg Obstet Gynecol; 2002
Temporal Sequence of Doppler Changes in Severe IUGR

Ferrazzi et al. Usg Obstet Gynecol; 2002
## Abnormal Doppler and Perinatal Outcome

<table>
<thead>
<tr>
<th></th>
<th>Death and/ or CNS damage (14 cases)</th>
<th>Alive &amp; no CNS damage (12 cases)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>UA &amp; MCA PI</td>
<td>100%</td>
<td>100%</td>
<td>n.s.</td>
</tr>
<tr>
<td>UA AEDF</td>
<td>13 (93%)</td>
<td>10 (83%)</td>
<td>n.s.</td>
</tr>
<tr>
<td>DV S/a</td>
<td>10 (71%)</td>
<td>2 (17%)</td>
<td>0.004</td>
</tr>
<tr>
<td>PA PV</td>
<td>5 (35%)</td>
<td>1 (8%)</td>
<td>0.09</td>
</tr>
<tr>
<td>UA REDF</td>
<td>9 (64%)</td>
<td>1 (8%)</td>
<td>0.002</td>
</tr>
<tr>
<td>DV RF</td>
<td>5 (36%)</td>
<td>0</td>
<td>0.01</td>
</tr>
<tr>
<td>Ao PV</td>
<td>4 (28%)</td>
<td>0</td>
<td>0.03</td>
</tr>
</tbody>
</table>

Percent of Abnormal Doppler Findings in Individual Vessels and Incidence of BPP Score < 6

Trends over time of variables in relation to time before delivery and reference ranges (±2 SD)

Hecher et al. Ultrasound Obstet Gynecol 2001;18:564-570
# FHR Tracings, Umb A Doppler, and the IUGR Fetus

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Pardi et al. Diagnostic value of blood sampling in fetuses with growth retardation. NEJM 1993; 328: 692-696
Late IUGR

- SGA fetuses with normal umb artery waveform
- 98 SGA and 101 AGA controls
- Abnormal neural behavioral testing
- Motor: 36% with abn MCA vs 20% with normal MCA
- State organization: 17.5% vs <5%
How do we reconcile all the different variables in order to determine the best timing for delivery?

- gestational age
- EFW/birth weight
- Dopplers
  - arterial
  - venous
  - sequence/pattern
- oligohydramnios
- FHR tracing
- BPP
- acid-base status
Algorithm for the Management of IUGR
Diagnosis: USG EFW < 10th percentile

Well Dated

Yes

• Review menstrual cycle
• Measure cerebellum
• Assess fetal PI (FL/AC)
• Assess UmA Doppler

Re-dated & normal size

No

Excluded: fetal anomalies, aneuploidy & congenital infection

Treatment: rest in lateral position, increase fluid, intake,
stop smoking, (aspirin?)

Begin Fetal Surveillance

Yes

• Normal pregnancy
• Interval growth scan
Fetal Surveillance:

- FACs BID & Serial growth scans (q 2 weeks)
- Biophysical testing (NST/AFI 2X/week or BPP weekly)
- Doppler velocimetry (UmA, MCA, ± DV)
- Deliver at 36-37 weeks if testing remains reassuring

UmAAEDF
Oligohydramnios

<34 weeks

- Hospitalize, BP testing, BMZ, NICU consultation
- Daily UmA & Venous Doppler velocimetry
- Search for etiology of ischemic placental disease

24-28 wks

- Abnl NST/BPP
- RF DV?

28-32 wks

- Abnl NST/BPP
- RF in DV
- Absent “a” in DV?

32-34 wks

- Abnl NST/BPP
- A or RF in DV; RFUA
- Arrested fetal growth
- oligo or +FLM

DELIVER

>34 weeks
Intrauterine Growth Restriction: Key Points

- The use of umbilical artery Doppler as an adjunct to APT reduces mortality
- As the IUGR fetus decompensates, there are progressive Doppler velocimetry changes
- These Doppler changes tend to follow a consistent pattern and largely occur prior to abnormalities in biophysical testing
Intrauterine Growth Restriction: *Key Points*

- Umbilical vein pulsations are a late sign of fetal compromise.
- Venous Doppler velocimetry may allow delivery prior to marked acidosis and potentially minimize morbidity particularly in extreme prematurity.
- RCTs are needed to test the utility of venous Doppler in the management of IUGR.