Ultrasound: the window to the baby: what can it tell us?

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Editor: Obimages.net

Disclosures

The website obimages.net and internet video CME courses available on the website will be referred to in this talk.

Warnings

- Discussion will involve some principles of physics: Doppler effect, velocity
- (Stick with me, I will get you through it)
- The term baby versus fetus used interchangeably
Thank you for asking me to participate.
Manny Gaziano, 4/22/2017
Talk Outline

• Early pregnancy ultrasound findings and fetal viability
• Potential causes of stillbirth and ultrasound’s insight into cause

It all begins in the maternal ovary…

[Image of ultrasound showing Graaafian follicle and Cumulus oophorus]

[Image of ultrasound showing Vascular ring of fire and Corpus luteum]
Early pregnancy ultrasound and aspects of fetal viability will be reviewed. In addition, insights provided by ultrasound into the causes of stillbirth are considered.
Morula: 12 to 16 cell stage

Early gestational sac

Inner cell mass
cyto/blast
trophoblast
endothelial
Cardiac Motion: 5 5/7ths Weeks

Fetal Viability

- Errors exist in correctly assigning viability during early gestation.
- 4.4% of pregnancies are labeled not viable when in fact the pregnancy is viable.
Correct Viability Assignment: Ultrasound Task

Crown rump length
Fetal heart beat
Presence or absence of yolk sac
Results of interval scan
If uncertain viability, repeat in 11 to 14 days.

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“Estimate usefulness of diagnostic tests in work up of potential causes of stillbirth”

Diagnostic Tests for Evaluation of Stillbirth: Results From the Stillbirth Collaborative Research Network

Star-Tribune: Sunday March 19, 2017

After a stillbirth, tests help pinpoint cause
Potential Causes of Stillbirth (N=512)

- Useful diagnostic tests for evaluation:
  - Placental pathology
  - Fetal autopsy
  - Genetic testing
  - Antiphospholipid antibodies

Clinical Scenarios Associated with Cause of Stillbirth*

- Fetal growth restriction
- Hypertensive disorders
- Genetic testing
- Fetal-maternal hemorrhage
- Fetal anomalies
- Preterm labor

*Ultrasound provides antenatal information on each of these scenarios
Morbidity

FGR

Adverse outcomes:
- Asphyxial depression
- Stillbirth
- Fetal distress
- Neonatal hypoglycemia

Wigglesworth Classification: Stillbirth
By the Relative Condition at Death classification,
the most common condition: fetal growth restriction (43.0%).

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Fetal Growth Restriction

Fetal Growth Restriction

- Occurs in 3 to 10% of all pregnancies
- Disproportionate contribution to perinatal mortality and morbidity
- Greatest risk of adverse perinatal outcome in those who weights are ≤ 3rd percentile for gestational age

Manning, 1995/McIntire et al, 1999

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Fetal Growth Restriction

Fetal Growth Chart
Factors Complicating Diagnosis

- Multiplicity of causes for FGR
- Association with premature delivery
- Complexity of growth determinates

Accurate Pregnancy Dating

- Unless the pregnancy is accurately dated, it is difficult to suspect or diagnose fetal growth restriction.
- Early ultrasound is the best way to accurately date the pregnancy.

Estimated Fetal Weight

- Most common method to identify the growth restricted fetus
- Equations that incorporate AC, BPD, and FL provide estimates of fetal weight
- Charts vary widely in accuracy of prediction*
Estimated Fetal Weight

- Biparietal diameter
- Abdominal circumference
- Femur length

Most Common

- Underlying maternal hypertension, and some forms of growth restriction are reflected in placental changes which can be quantified by prenatal ultrasound.
Fetal Doppler

- Obstetrical Doppler: predicts placental pathology and may predict outcome
- We will briefly discuss 3 fetal blood vessels (Umbilical artery, Middle Cerebral Artery, and Ductus venosus)

Christian Andreas Doppler

Change in wave frequency that occurs when a wave source and receiver are in relative motion.

Doppler Effect
Fetal Doppler: The Beginning

Doppler Imaging

Velocity

- Doppler shift is directly proportional to velocity.
- Velocity: speed and direction of red blood cells.

Velocity can be expressed in 3 ways:

Non-invasive measurement of human fetal circulation using ultrasound: a new method
D R Fitzgerald, J E Drum
British Medical Journal, 1 December 1977
Spectral Doppler

Graphic
• Doppler shift: infer velocity
• For fetal assessment; evaluate a flow velocity waveform, a reflection of a complete heart cycle

Basics of Assessment of Fetal Circulation by Doppler
1. Each vessel has its own “signature” waveform
2. Arterial interrogation reflects downstream resistance to flow
3. Downstream from umbilical artery > Placenta

Umbilical Artery: From Normal to Abnormal

Normal
Abnormal
Critical
Umbilical Artery

Abnormal Doppler patterns (AED): occlusive lesions of the placental vasculature; small artery obliteration of tertiary villi

Salafia CM, Obstet Gynecol 90(5):1997

What do abnormal Doppler values in the umbilical artery tell us?

• Reflect placental function
• Associated with growth restriction
• Associated with karyotype abnormalities


Birth Weight (Grams)

Rev. Diastolic Flow
Zero Diastolic Flow
End Diastolic Flow

Doppler of the MCA

Middle Cerebral Arteries

Normal
Abnormal
Normal = "high" resistance diastole
Abnormal = "low" resistance diastole

Doppler: Ductus Venosus

Spectral Analysis
Venous Doppler: Ductus venosus

Venous patterns
- may be the best measure of deteriorating cardiac function as cardiac size & filling pressure increases

DV - Normal

DV - Abnormal
Inferences from Test Results

Umbilical Artery Doppler
Reflects downstream resistance to flow and placental insufficiency

Middle Cerebral Doppler
Reflects blood flow redistribution under conditions of stress

Venous Doppler
Reflects hemodynamic dysfunction

Abnormal Placenta

Umbilical artery: zero diastolic flow
MCA: increased diastolic flow
DV: reverse diastolic flow

Anemia: Middle Cerebral Artery

Circle of Willis
• Anterior
• Posterior
• Middle
Value of MCA Doppler

- Peak systolic velocity of MCA is associated with fetal anemia

Non-invasive diagnosis: fetal anemia

Measurement: peak systolic velocity
Noninvasive Diagnosis by Doppler Ultrasonography of Fetal Anemia Due to Maternal Red-Cell Alloimmunization

Giancarlo Mari, M.D. and The Collaborative Group for Doppler Assessment of the Blood Velocity in Anemic Fetuses

- Sensitivity for prediction of moderate or severe fetal anemia prior to first fetal blood sampling: 100%

Ultrasound and Genetics

- Ultrasound findings consistent with genetic abnormalities include a number of markers
- Absence of any marker reduces the a priori risk of some genetic syndromes by 60% to 80%.

Ultrasound and Genetics

- Markers present: women with and without fetuses with aneuploidy.
- 17% of women >35 years of age demonstrate markers
Ultrasound and Genetics

- Nuchal translucency (NT), 11-14 weeks. Effective marker

- Nuchal Fold (NT) >6 mm. abnormal. 45% of infants with Down syndrome

NT and Outcome

NT and Adverse Pregnancy Outcome

Adverse outcomes: fetal malformations (heart), dysplasia, deformations, disruptions and genetic syndromes
Significant when NT is > 3.5 mm (>90th percentile)
No increased risk with survival to the mid-trimester plus no abnormalities on targeted scan

Ultrasound and Genetics

- Nasal bone (NB): absent or hypoplastic, detection rate 57% for aneuploidies

- Renal pelvis dilatation: 17% to 25% detection rate for aneuploidies
Ultrasound and Genetics

- Echogenic bowel: detection 3.7 to 27%; also, CF, infections, bowel obstruction

- Dilatation of brain ventricles: 7.5 to 21% detection rate.

Lethal Genetic Syndromes

- Trisomy 13
  - Chiari malform
  - VSD

- Trisomy 18
  - Bilateral hydronephrosis
  - Holoprosencephaly

- Trisomy 13
  - Hydrocephalus
  - Bilateral hydronephrosis
DNA Testing of Mother’s Blood

Cell-free DNA testing of Maternal Plasma

- Test maternal blood: common aneuploidies (trisomies 21, 13, and 18)
- Detection rates, high-risk populations: 99% with false positive rate of 0.1%
- Low risk population: similar high detection rates with false positive rates of 0.6% compared to 3.6% for those undergoing routine testing.

Fetal Anomalies

Non-Chromosomal Anomalies: 11 to 14 week scan

- Anomalies Potentially
- CNS: (acrania, alobar holoprosencephaly, exencephaly)
- Abdomen or related: (gastrochisis, megacystis, and many others necessary)
- Others: (50% diaphragmatic hernia and 50% lethal severe infections)
- Undetected: (agenesis of corpus callosum, cerebellar hypoplasia)

Cardiac Anomalies

- Congenital heart defects: (CHDs) or abnormalities
  - Common Malformations
    - About 2% of infants
    - Major cardiac defects: about 1% of births
Problem

- In routine screening over 50% of cardiac malformations are missed.

Complexity of Diagnosis

Other anomalies

- Most Common Defects:
  - Venous return defects
  - Atrial septal defects
  - Tetralogy of fallot
  - Hypoplastic left heart syndrome
Tetralogy of Fallot

Preterm Labor Risk

ULTRASOUND in Obstetrics & Gynecology

Ability of a preterm surveillance clinic to triage risk of preterm birth: a prospective cohort study

Triage Clinics

High risk asymptomatic women screened at 22 to 28 weeks.

Screening thresholds:
- Risk for preterm birth
- Fetal fibronectin (>50 μg/mL)
- Cervical length (<15 mm)

Triage Clinics for Preterm Birth

Using screening thresholds:
- 4% of asymptomatic women admitted to hospital
- Cervically identified as high risk for adverse outcome
Invasive Fetal Procedures

- Congenital diaphragmatic hernia (CDH)
- Defects in the diaphragm through which intra-abdominal organs become present within the fetal chest

FETO

Congenital Diaphragmatic Hernia

- Open fetal surgery
- Endoscopic thoracic endoscopic closure (ETEC)

The Future

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Summary

- Ultrasound has a useful role in assessing some of the scenarios associated with stillbirth
- Fetal Doppler assessment is key to understanding the role of the placenta in adverse outcome
- Maternal blood DNA supplants the role of ultrasound in the diagnosis of certain genetic syndromes
- Refinement of ultrasound cervical length may help to modify the risks of preterm labor

Desired Outcome For All

Thank you!