Advances in Ultrasound in Obstetrics and Gynecology

Saturday, October 15, 2016
Omni Shoreham Hotel • Washington, DC
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**Symposia At Sea**

**Practical Approach to Ultrasound in Obstetrics and Gynecology**

Book By March 26, 2017
LIABILITY IN
OB/GYN ULTRASOUND:
MINIMIZING RISK AND
IMPROVING OUTCOMES

James M. Shwayder, M.D., J.D.
Professor and Chair
Department of Obstetrics and Gynecology
University of Mississippi Medical Center
Jackson, MS
Liability in Ob-Gyn Ultrasound: Minimizing Risk and Improving Outcomes

James M. Shwayder, M.D., J.D.
Professor and Chair
Department of Obstetrics and Gynecology
University of Mississippi Medical Center
Jackson, Mississippi

Outline

• Malpractice, as it relates to ultrasound
• Areas that pose the greatest risk with ultrasound
• Most common errors that lead to litigation
• Practices that can help reduce your exposure to litigation
• Case examples

Legal Concept

Malpractice

Elements of Negligence
1. Duty
2. Breach of that duty
3. Proximate cause of injury
4. Damages

Burden of Proof

Medical malpractice
• Civil action
• Burden of proof = "preponderance of the evidence"
• Something > 50%

Cases by Specialty Area

Types of Errors

- Perception errors
- Interpretation errors
- Failing to suggest the next appropriate procedure
- Failure to communicate


Perception Errors

The abnormality is seen in retrospect but it is missed when interpreting the initial study.

- Error rate in radiology is ~ 30%¹
- Question: Was it below the standard of care for the physician not to have seen the abnormality.²
- Most suits are settled – 80% are lost if cases go to jury verdict


Missed Diagnosis New Jersey

- Four ultrasounds performed during pregnancy
- Images lacked clear anatomic landmarks, thus no accurate measurements of fetus made
- Physician reviewed one ultrasound
- Sonographer reported on three ultrasounds
  - “Structural irregularities that require further evaluation”
- Physician told the patient the “ultrasounds were completely normal”

Missed Diagnosis New Jersey

- Midline facial defect
- Cleft palate
- Club foot
- Lower-limb anomalies
- Limited cognitive and communication skills

Missed Diagnosis

- Suit against physician
- Suit against professional group he owned
  - Performs ultrasounds
  - Settlement = $1.98 million

**Ultrasound - Liability**

- Failure to conduct additional testing upon inability to visualize all four chambers of the heart during a routine sonogram
  - $4,200,000
- Failure to detect meningomyelocele on ultrasound at 15 weeks. Ultrasound reported as normal. (coupled with lack of AFP testing)
  - $4,350,000
- Failure to detect severe hydrocephalus
  - $5,500,000

**Delay in Diagnosis**

**North Carolina**

- 46 year old patient presented with abnormal uterine bleeding
- Physician assistant saw patient
- No biopsy performed
- Ultrasound = negative
  - Subsequently could not produce photograph taken at the time of ultrasound

**Delay in Diagnosis**

**North Carolina**

- 18 months later presented with persistent bleeding
- Physician assistant again saw patient
- No biopsy performed
- Ultrasound = negative
  - Photograph for second ultrasound found: showed existence of tumor

**Delay in Diagnosis**

**North Carolina**

- After another 10 months, sought care from another physician
- Physician performed biopsy
- Endometrial carcinoma
- Patient died from disease

**Delay in Diagnosis**

**North Carolina**

- Suit filed against 1st physician
  - After defendant physician’s deposition
  - No expert testimony required
- Settled for $800,000
**Legal Concepts**

- **Res ipsa loquitur**
  - But for the failure to exercise due care the injury would not have occurred
  - Delay in diagnosis and subsequent death

- **Respondeat superior**
  - An employer is liable for the wrong of an employee if it was committed within the scope of employment

**Ultrasound Examination**

- **Personnel**
  - Training
  - Supervision
- **Performance of the study**
  - AIUM guidelines
  - Appropriate Images

**Interpretation Errors**

The abnormality is perceived but incorrectly described

- Most often occur due to lack of knowledge or faulty judgment
  - Malignant lesion called benign
  - Normal variant is called abnormal
- The best defense is an appropriate differential diagnosis, preferably including the correct diagnosis
- Lawsuits involving interpretation errors
  - 75% are won if cases go to jury verdict

**Vaginal Bleeding**

- 36 y.o. G3P2002
- Seen in ED on 5/29/10 (Saturday)
- c/o spotting on Thursday and Friday
- No LMP noted

**Vaginal Bleeding**

- Examination
  - VSS
  - Point tenderness in the RLQ and suprapubic region
  - No vaginal bleeding
  - No CMT. No adnexal fullness

- hCG = 209
- H/H = 12.7/35.9
ED visit 6/04/10

- ED: RLQ Pain
- Rating: 8
- No vaginal bleeding
- Exam: Abdomen: Mild tender, no tenderness in the right inguinal area. There is no abdominal tenderness. No guarding or rebound.
- NOTE: No pelvic performed in the ED

Lab

- hCG = 2399
- H/H = 12.6/36.0
Physician’s office 6/07/10

• 36 yo. f/u from ED
• No bleeding
• Menstrual-like cramping
• “Seen in ER for pain.”
• “Last hCG – 2399”
• “RT OVARIAN CYST WAS SEEN, NO FF”
• VSS
5/30/10  209
6/04/10  2,399
6/07/10  Methotrexate given
6/07/10  6,484

Physician's office 6/14/10

6/19/10
hCG summary

- 5/30/10  209
- 6/04/10  2,399
- 6/07/10  Methotrexate given
- 6/07/10  6,484
Performance

• Incomplete study
• Poor image quality

Equipment

• Contemporary equipment
• Proper maintenance (PM)
• Image capture and retention

Image Retention

• Preferably digital capture and retention
• Maintain for the specific SOL for your state (jurisdiction)

Interpretation Errors

• Fluid within the endometrium
• Cyst in right ovary
• Did not review the prior images when interpreting the current study

Interpretation Errors

8/01/05
• LMP = 6/09/05
• EGA = 7w5d
• EDD = 3/16/06
Ultrasound
• Small fetal pole with cardiac activity
• EGA = 5w2d
• EDD = 3/29/06
Interpretation Errors

9/06/05
- EGA = 12w5d (dates); 10w5d (US)
- Ultrasound
  - No images were documented
  - No formal report
  - Written note
    - "1x1 cm yolk sac. No fetal pole. No CA"

9/26/05
- LMP = 6/09/05
- EGA = 15w5d (dates)
- EGA = 13w4d (ultrasound)
- No physical examination documented
- "Offered expectant management vs. D&C."
- "Rx: Cytotec"

Interpretation Errors

9/30/05
- Passed 61 gm male fetus
- 13-16 weeks with no grossly evident congenital abnormalities

Interpretation Errors

Settlement

$600,000

Interpretation Errors

9/06/05
- EGA = 12w5d (dates); 10w5d (US)
- Ultrasound
  - No images were documented
  - No formal report
  - Written note
    - "1x1 cm yolk sac. No fetal pole. No CA"

Recommendations

- Clinician
  - Was the 1x1 gestational sac a Nabothian cyst?
- Avoid “quick peeks” with the ultrasound
- Confirm findings that do not correlate with prior findings
- Document properly
- Examine patients
Image Retention

- Preferably digital capture and retention
- Maintain for the specific SOL for your state (jurisdiction)

Misdated Fetus

28 y.o. G3P2002 (Prior C/S x 2)
- LMP = 7/05/08
- EDC = 4/12/09
- Oligomenorrhea

Misdated Fetus

10/31/08
- EGA = 16w4d
- PE: Unable to palpate fundus due to body habitus. FHT's 160

Misdated Fetus

11/02/08 Ultrasound
- Small for dates
- EGA (dates) = 17 weeks
- "Live, intrauterine pregnancy with a gestational age of 9w4d ± 6 days. The EDD is 4/10/09."
- EGA (US) = 9w4d
- EDD (US) = 6/03/09

Misdated Fetus

12/14/08
- Office visit for abdominal pain
  - 15 5/7 weeks by ultrasound
  - 23 2/7 weeks by dates
- Exam: "Uterus is normal"

Misdated Fetus

4/05/09 Elective repeat C-Section
- 39 2/7 weeks by dates
- 31 6/7 weeks by ultrasound
- Male
  - Weight = 1710 gm
  - Apgar = 9,9
  - Ballard 31 weeks
Newborn Course

- Prematurity
- Respiratory distress syndrome
- Necrotizing enterocolitis

Misdated Fetus

- Deposition
- Review of records
  - FH < EGA on a consistent basis
- Settled $980,000

Failure to Communicate

1. Final written report is considered the definitive means of communicating the results of an imaging study or procedure.
2. Direct or personal communication must occur in certain situations:
   - Document communication
3. Cause of action: Failure to communicate in a timely and clinically appropriate manner

Failure to Suggest the Next Appropriate Procedure

The prudent radiologist/physician will suggest the next appropriate study or procedure based upon the findings and the clinical information.

- The additional studies should add meaningful information to clarify, confirm or rule out the initial impression.
- The recommended study should never be for enhanced referral income.
- Generally, the radiologist is not expected to follow up on the recommendation.
  - Exception: Beware of reinterpreting images on multiple occasions.

Recommendations

- Sonologist
  - Make specific recommendations when appropriate
- Clinician
  - Read the entire radiology report, not just the summary diagnosis
  - Correlate the radiologic diagnosis with the clinical findings

Failure to suggest next procedure

Failure to communicate

- 33 y.o. G3P2002
- Quad screen at 15 weeks
  - Risk of Down Syndrome = 1/1100
- US performed at 19w1d in radiology
- Reported as “normal”
  - No mention of subtle findings
    - UPJ = 4.3 and 4.4
    - EIF noted


Likelihood Ratios for DS with Isolated Markers

<table>
<thead>
<tr>
<th>Marker</th>
<th>AAURA</th>
<th>Nyberg</th>
<th>Bromley</th>
<th>Smith-Bindman</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nuchal fold</td>
<td>18.6</td>
<td>11</td>
<td>12</td>
<td>17</td>
</tr>
<tr>
<td>Hyperechoic bowel</td>
<td>5.5</td>
<td>6.7</td>
<td>NA</td>
<td>6.1</td>
</tr>
<tr>
<td>Short humerus</td>
<td>2.5</td>
<td>5.1</td>
<td>5.8</td>
<td>7.5</td>
</tr>
<tr>
<td>Short femur</td>
<td>2.2</td>
<td>1.5</td>
<td>1.2</td>
<td>2.7</td>
</tr>
<tr>
<td>EIF</td>
<td>2.0</td>
<td>1.8</td>
<td>1.4</td>
<td>2.8</td>
</tr>
<tr>
<td>Pyelectasis</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.9</td>
</tr>
<tr>
<td>Normal</td>
<td>0.4</td>
<td>0.36</td>
<td>0.22</td>
<td>??</td>
</tr>
</tbody>
</table>

Isolated Marker

- EIF
  - LR = 1.4 – 2.8
  - Adjustment
- Risk of Down’s
  - Originally 1 in 1100
  - Adjusted 1 in 392-785
- No amnio

Pyelectasis

- 7400 patients
- 25% of patients with Down’s had pyelectasis
- Incidence of Down’s = 3% if pyelectasis is present
- Abnormal:
  - 15-20 weeks > 4 mm
  - 20-30 weeks > 5 mm
  - > 30 weeks > 7 mm

Isolated Marker

- UPJ = 4.3 and 4.4
- Pyelectasis
  - LR = 1.5 – 1.9
  - Adjustment
- Risk of Down’s
  - Originally 1 in 1100
  - Adjusted 1 in 579-733
- No amnio

Prevalence of Markers and Likelihood Ratios

<table>
<thead>
<tr>
<th># Markers</th>
<th>DS = 164</th>
<th>Nml = 656</th>
<th>LR</th>
</tr>
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<tbody>
<tr>
<td>0</td>
<td>32</td>
<td>575</td>
<td>0.2</td>
</tr>
<tr>
<td>1*</td>
<td>32</td>
<td>66</td>
<td>1.9</td>
</tr>
<tr>
<td>2</td>
<td>20</td>
<td>13</td>
<td>6.2</td>
</tr>
<tr>
<td>3</td>
<td>40</td>
<td>2</td>
<td>80</td>
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</tbody>
</table>

* Individual LR better


Failure to Communicate

- 33 y.o. G3P2002
- Quad screen at 15 weeks
  - Risk of Down Syndrome = 1/1100
- 2 markers: LR = 6.2
- Adjusted Risk for DS = 1/177

Failure to Communicate

Defense
- Radiologist
  - They round to the nearest whole number.
  - This patient's UPJ's were thus 4 and WNL
  - The UPJ dilation was < 5 mm, which is "normal" in their lab
  - EIF is a worthless marker and of no consequence
  - It is the obstetrician's duty to recommend amniocentesis to the patient

Obstetrician
- The radiologist's report was "normal" with no mention of subtle markers for DS.
- I had no reason to recommend amniocentesis
- Had I known of the subtle findings I would have recalculated the patient's risk and would have recommended amniocentesis

Radiologist
- The UPJ dilation was < 5 mm, which is "normal in their lab"
- EIF is a worthless marker. We don't even mention it.
- Misinterpreted the images
- Duty to report the findings to the obstetrician. If he had done so, the duty for further counseling, evaluation, and treatment would have transferred to the obstetrician.

Verdict
- Plaintiff Verdict
  - Failing to appropriately communicate the findings to the obstetrician resulted in the continuation of an abnormal pregnancy that the patient, had she known of the abnormality, would have terminated.
Wrongful Birth

Reed v. Campagnolo

The court ruled that “… parents may maintain an action for wrongful birth if the physician fails to disclose the availability of tests which would have detected birth defects present in the fetus and if the woman would have had an abortion had she known the fetus’s deformities.”


Ultrasound Examination

- AIUM Accreditation
- Establishes policies and procedures – “Best Practices”

Equipment

- Contemporary equipment
- Proper maintenance (PM)
- Image capture and retention

Ultrasound Examination

- Performance of the study
- Interpretation of the study
- Communication of results
- Documentation

Defensibility

- If the components of a complete examination are documented, appropriately interpreted, and communicated the case is more defensible.
- The lack of any component places the case at risk.

Keepsake Ultrasounds
“Keepsake” Malpractice

Any malpractice claim concerning keepsake video production will be a case of first impression.

Entertainment Ultrasound

Case of First Impression

Colorado 2009
- Down’s Syndrome
- Alleged missed anomaly during “Keepsake Ultrasound” in the 3rd trimester

Entertainment Ultrasound

Case of First Impression

- Shorten femur at 31 weeks
- Termination is available up to 34 weeks in Boulder, Colorado

Entertainment Ultrasound

Case of First Impression

- Entertainment ultrasound is not an approved medical practice
- Question
  - Was this medical malpractice?
  - Was this a case of commercial negligence?
  - Was this a breach of an entertainment agreement?

COPIC Insurance Co.

Coverage Limitations

“Your professional liability policy covers acts of negligence in the course of providing medical care. This type of activity may fall outside this definition; therefore you may be denied coverage.”

Copiscope, No. 114, July 2003.

Entertainment Ultrasound

- Settled for undisclosed amount, rumored to be $1 M
Liability Risks
Different scenarios

- Untrained technician-no physician oversight
- RDMS sonographer-no physician oversight
- RDMS sonographer-physician oversight
  - No prior physician-patient relationship
- Current patient

Outline

- Malpractice
- Most common errors that lead to litigation
- Practices that can help reduce your exposure to litigation

Thank You
THREE AND FOUR DIMENSIONAL ULTRASOUND IN OBSTETRICS

Jude P. Crino, M.D.
Assistant Professor, Maternal-Fetal Medicine
Director, Perinatal Ultrasound
Department of Gynecology and Obstetrics
Johns Hopkins University School of Medicine
Baltimore, MD

Contribution Not Received in Time for Inclusion.
Fetal Growth Restriction: Diagnosis and Management

Alfred Abuhamad, M.D.
Professor and Chairman
Department of Obstetrics and Gynecology
Vice Dean for Clinical Affairs
Eastern Virginia Medical School
Norfolk, VA
Fetal Growth Restriction: Diagnosis & Management

Alfred Abuhamad, MD.
Eastern Virginia Medical School

Fetal Growth Restriction

Complex Problem:

• Various published definitions
• Poor detection rates
• Limited preventive or treatment options
• Multiple associated morbidities
• Increased likelihood of perinatal mortality

FGR

Treatment:

• Bed rest
• Aspirin
• Nutrient supplements with Calcium/Zinc
• Maternal oxygenation
• Heparin
• Plasma volume expansion
• Calcium channel blockers
• Hormonal therapy
• Smoking cessation

No Benefit

ACOG IUGR bulletin 2000. Reaffirmed 2010

Fetal Growth Restriction

NICHD Fetal Imaging Forum 2
May 2015

• Multisociety representation

To develop a consensus on the diagnosis and optimal management of the singleton pregnancy with fetal growth restriction (FGR).

Definition

• Fetal Growth Restriction (FGR) is sonographically estimated fetal weight (SEFW) <10% for GA (PRENATAL STATUS)

• Small for gestational age (SGA) is actual birth weight (BW) < 10% for GA (POSTNATAL STATUS)

ACOG PB 2013; RCOG GG 2013; SOGC 2013; RCPI 2014

Definition

Other diagnostic criteria:

• SEFW < 5%
• SEFW < 3%
• AC < 10%
• AC < 5%
• Ac < 3%
**Risk Factors for FGR**

<table>
<thead>
<tr>
<th>Maternal</th>
<th>Fetal</th>
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<tr>
<td>Advanced maternal age</td>
<td>Multiple gestation</td>
</tr>
<tr>
<td>Chronic medical diseases</td>
<td>Birth defects</td>
</tr>
<tr>
<td>Diabetes</td>
<td>Congenital anomalies</td>
</tr>
<tr>
<td>Chronic hypertension</td>
<td>Cesarean section</td>
</tr>
<tr>
<td>Congenital heart disease</td>
<td>Fetal death</td>
</tr>
<tr>
<td>Pre-gestational diabetes</td>
<td>Insulin requiring diabetes</td>
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<tr>
<td>Fetal death</td>
<td>Genetic syndromes</td>
</tr>
<tr>
<td>Hypertension</td>
<td>Chromosomal abnormalities</td>
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<tr>
<td>Medication exposure</td>
<td>Trisomy 18</td>
</tr>
<tr>
<td>Polyhydramnios</td>
<td>Trisomy 13</td>
</tr>
<tr>
<td>Macrosomia</td>
<td>Transient tachypnea</td>
</tr>
<tr>
<td>Prematurity</td>
<td>Congenital heart defects</td>
</tr>
</tbody>
</table>

**Screening – ACOG Opinion**

- All pregnant women should be screened for risk factors (medical and obstetric history)
- Fundal height measured at each visit > 24 weeks
  - If fundus cannot be palpated, e.g. obesity, multiple gestation, sonography is preferred
- Sonographic screening may be used in the presence of risk factors
- No evidence that routine sonography, serum analytes, or uterine artery Doppler improve outcomes

ACOG PB 134, 2013

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**Poor effectiveness of antenatal detection of fetal growth restriction and consequences for obstetric management and neonatal outcomes: a French national study**

- Singleton births, all French maternity units in 2010, over 1 week period
- Routine US between 30 and 35 weeks
- 22% of SGA infants were suspected of FGR (but outcome was not better if FGR was suspected)
- 50% of infants suspected of FGR were not SGA (increased risk of provider-initiated early delivery in this group)

ACOG IUGR bulletin 2000. Reaffirmed 2010
J Obstet Gynecol 1996;16:77

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**Fetal Growth Restriction**

- Undetected in 30 - 50% of cases
- Incorrectly diagnosed in 50% of cases

ACOG IUGR bulletin 2000. Reaffirmed 2010
J Obstet Gynecol 1996;16:77

---

**Diagnosis**

- Small EFW
- Small EFW with abnormalities

ACGN-Fetal Imaging Forum 2 – May 2015

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**Fetal Growth Restriction**

- FGR vs. SGA, single or distinct entity?
- Should we rethink approach to FGR?
  - Small EFW
  - Small EFW with abnormalities

Formulas for SEFW

A systematic review of the ultrasound estimation of fetal weight

N. J. Dudley
Medic/Physics Department, Nottingham City Hospital, Nottingham, UK

- Review of studies employing 7 different regression equations for EFW

Formulas for SEFW

- No consistently superior method of assessment emerged
- Similar systematic and random errors between formulas
- Wide intra and inter-observer variability identified
- Use average of multiple measurements
- Improvement in image quality
- Uniform calibration of equipment
- Regular audits for quality assurance

Dudley N, UOG 2005

Weight Percentiles

- Population Norms
  - "One size fits all"
  - Unadjusted for factors that affect fetal size
- Customized Norms
  - "One size does not fit all"
  - Adjusted for factors that affect fetal size (fetal gender, ethnicity, parity, parental size, altitude, maternal co-morbidity)

Racial/ethnic standards for fetal growth: the NICHD Fetal Growth Studies

Intergrowth-21

- Multicenter international study – 7 countries
- Longitudinal growth 4321 low-risk pregnant women from 14 weeks to 42 weeks
- Biometric charts for BPD, HC, OFD, AC and FL were developed
- Goal is to describe how fetuses SHOULD grow, as opposed to traditional charts that describe how fetuses DO grow
- Question: outcome studies to confirm superiority over current existing charts

Papageorghiou AT, Lancet, 2014

Fetal Growth Restriction

Outcome:

- Low Apgar scores & cord pH < 7.0
- Increased NICU admissions & sepsis
- Increased stillbirth and neonatal mortality
- Increased learning disabilities
- Increased adult onset cardiovascular disease

ACOG IUGR bulletin 2000. Reaffirmed 2010
SGA: Morbidity and Mortality

- Hypoglycemia
- Hyperbilirubinemia
- Hypothermia
- IVH
- NEC
- Seizures
- Sepsis
- RDS
- Cerebral Palsy
- Neonatal death

Fetal Assessment

Non-invasive tests:
- Fetal kick counts
- Non-stress test
- Biophysical profile
- Doppler assessment

Invasive tests:
- Amniocentesis
- Cordocentesis

No ideal test for all growth restricted fetuses.

Cardiovascular Adaptation of FGR

Early Changes / FGR

Arterial Redistribution

Brain Sparing Reflex

- ↑ impedance in UA (↑S/D)
- ↓ impedance in MCA (↓ PI)

Value of CPR

Fetal Hypoxemia

Blood Flow Redistribution

Brain Sparing Reflex

Increased
- Heart
- Brain
- Adrenal
- Spleen

Decreased
- Lungs
- GI
- Skeletal
- Other

Risk of cerebral palsy in term-born singletons according to growth status at birth

- Medical Birth Registry in Norway
- Singletons, born 1996-2006
- 398 children with CP, 490,022 normally developed
- Low birth weight and HC correlates with increased risk of CP
Umbilical Arteries

Normal Waveform
Abnormal Waveform

Umbilical Artery

AEDF
REDF

Fetal Hypoxemia / FGR

UA ↑ Impedance

• Obliteration of small muscular arteries in tertiary stem villi
• For A/REDF, need > 70 % placental obliteration

Ultrasound Obstet Gynecol 1997;9:271
AJOG 1989;161:1055

Fetal Hypoxemia / FGR

UA ↑ Impedance

• Meta-analysis of 18 trials (> 10,000 women), concluded that use of UA Doppler in high-risk women reduced perinatal death & obstetric interventions

Syst Rev 2010(1):CD007529

Should Doppler be performed in low-risk women as a screening test?

Meta-analysis of 4 trials found no difference in outcome
**Cerebral Vasculature**

**Middle Cerebral Artery**
- Most accessible cerebral vessel
- Carries 80% of cerebral flow
- Constant 3% - 7% of CO
- Excellent reproducibility

_AOG 1993;169:1393_

**Circle of Willis**

**Middle Cerebral Artery**

Normal Waveform  Abnormal Waveform

_Cerebral Placental Ratio (CPR)**
- Ratio of MCA PI to UA PI
- Used to assess brain sparing
- Blood flow centralization present if CPR < 5% for GA or < 1.08 (similar accuracy) – associated with adverse perinatal outcome
- Can identify FGR fetuses at risk of cesarean sections for NRFHR

_Bahado-Singh RD, AOG, 1999_  
_Cruz-Martinez R, Obstet Gynecol, 2011_  
_Dalibo A, JUM, 2005_

---

**The role of brain sparing in the prediction of adverse outcomes in intrauterine growth restriction: results of the multicenter PORTO Study**

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Adverse perinatal outcome</th>
<th>Sensitivity</th>
<th>Specificity</th>
</tr>
</thead>
<tbody>
<tr>
<td>UA PI (≥ 90th centile)</td>
<td>85% (35/41)</td>
<td>54% (45/84)</td>
<td></td>
</tr>
<tr>
<td>UA PI (&lt; 90th centile, AEDF, REDF)</td>
<td>90% (37/41)</td>
<td>54% (45/83)</td>
<td></td>
</tr>
<tr>
<td>CPR (PI)</td>
<td>66% (27/41)</td>
<td>65% (72/110)</td>
<td></td>
</tr>
</tbody>
</table>

_CPR = MCA PI / UA PI_
_Am J Obstet Gynecol 2014;211:288_

---

**Late Changes / FGR**

**Elevated Central Venous Pressure**

- ↑ EDP in RV (↑ afterload)
- ↑ Cardiac stiffness

_Ultrasound Obstet Gynecol 1996;7:401_

---

**Cardiac Decompensation**

Table of Contents
Early Changes
• Biometric changes
• Arterial Doppler

Late Changes
• Venous Doppler
• Heart rate tracing

Fetal Hypoxemia / FGR

Table of Contents
In high-risk pregnancies with suspected FGR UA Doppler assessment significantly decreases likelihood of IOL, cesarean delivery and perinatal death.

UA Doppler surveillance should be started when fetus is viable and FGR suspected.

DV, MCA and other vessels Dopplers have some prognostic value for FGR fetuses, but currently lack of RCT showing benefit and they should be reserved for research protocols.

Importantly, the myocardial performance index is raised in small for gestational age fetuses before the arterial and venous Doppler abnormalities that characterize hypoxia are evident.

Perinatal morbidity and mortality in early-onset fetal growth restriction: cohort outcomes of the trial of randomized umbilical and fetal flow in Europe (TRUFFLE)

Fetal outcome was better than expected

Perinatal death was uncommon (8%)

70% survived without severe neonatal morbidity.
Perinatal morbidity and mortality in early-onset fetal growth restriction: cohort outcomes of the trial of randomized umbilical and fetal flow in Europe (TRUFFLE)

Poor Prognostic Factors:
- Presence and severity of maternal hypertensive conditions
- Gestational age at diagnosis
- Gestational age at delivery

PORTO vs. ULTRA TOT

<table>
<thead>
<tr>
<th></th>
<th>PORTO</th>
<th>ULTRA TOT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hypertensive diseases/ preeclampsia</td>
<td>12% (134)</td>
<td>28% (232)</td>
</tr>
<tr>
<td>GA at enrollment</td>
<td>30.1±3.9</td>
<td>31.3±5.7</td>
</tr>
<tr>
<td>GA at delivery</td>
<td>37.8 ± 3.0</td>
<td>35.7 ± 3.6</td>
</tr>
<tr>
<td>Birth weight (grams)</td>
<td>2495 ± 671</td>
<td>2039 ± 675</td>
</tr>
<tr>
<td>NICU admission</td>
<td>28% (321)</td>
<td>24% (196)</td>
</tr>
<tr>
<td>Apgar&lt;7 at 5 min.</td>
<td>1% (13)</td>
<td>7.4% (62)</td>
</tr>
<tr>
<td>Stillbirth</td>
<td>4 (1,280)</td>
<td>N/A</td>
</tr>
<tr>
<td>Neonatal death</td>
<td>4 (1,280)</td>
<td>19 (1,44)</td>
</tr>
</tbody>
</table>

Ultrasound Obstet Gynecol 2013; 42: 400-408

Unterscheider et al 2013 – EVMS 2015

Timing of Delivery?

Stillbirth
Neonatal morbidity and mortality

Risk of stillbirth after 37 weeks in pregnancies complicated by small-for-gestational-age fetuses

- Cumulative risk of stillbirth increases for each week after 37 weeks
- The increased risk becomes significant at 39 weeks for FGR < 10%
- FGR <5% there is a significant over 2-fold risk of stillbirth at 38 weeks compared to 37 weeks

Delivery Timing with Abnormal Dopplers

Table of Contents
Induction of Labor vs. Expectant Management in FGR?

**DIGITAT Trial**
- No significant differences
  - Primary composite adverse neonatal outcome
  - Rate of operative delivery or cesarean
  - MAIN scores
- No fetal or neonatal deaths in either group
- No difference in developmental or behavioral outcomes at 2-year follow up
- IOL before 38 weeks associated with > NICU admit
- Either strategy acceptable

Boers KE, AOG, 2012
Van Wyk L, AOG, 2012

**Summary: Delivery Timing**
Uncomplicated FGR (nl UA Dopplers)
1. EFW 5-10% - delivery at 39 weeks
2. EFW < 5% - delivery at 37 weeks

Complicated FGR (abnormal UA Dopplers)
1. Elevated UA Dopplers (DEDF) - 37 weeks
2. AEDF: corticosteroids → delivery if > 34 weeks
3. REDF: corticosteroids → delivery if ≥ 32 weeks

**FGR – Mode of Delivery**
- No RCTs for MOD for FGR
- Several small observational studies
  - Demonstrate that FGR is a risk factor for cesarean
- No evidence to suggest VD (or IOL) is contra-indicated for FGR
- Even with abnormal UA Dopplers, a reasonable chance for VD

Horowitz, EM et al. J MFH 2014
Cherbutzola, PR et al. Int J Gyneco Obstet 2015
Makovev, S et al. Arch Gyne Obstet 2009
Viechtb, H et al. J Mat 2014

**Conclusion**
- FGR is poorly detected & Incorrectly diagnosed
- FGR is associated with increased neonatal morbidity & mortality
- Abnormal arterial Doppler substantially increases adverse outcomes in FGR
- Abnormal cardiac function is seen before conventional Doppler abnormalities in FGR
- Presence of hypertensive conditions increases adverse outcomes in FGR
Case Presentations of Genetic Syndromes

Elena Sinkovskaya, M.D., Ph.D.
Assistant Professor
Director of Research
Division of Maternal-Fetal Medicine
Department of Obstetrics & Gynecology
Eastern Virginia Medical School
Norfolk, VA
ULTRASOUND IN THE EVALUATION OF ABNORMAL UTERINE BLEEDING

James M. Shwayder, M.D., J.D.
Professor and Chair
Department of Obstetrics and Gynecology
University of Mississippi Medical Center
Jackson, MS
Ultrasound in the Evaluation of Abnormal Uterine Bleeding

James M. Shwayder, M.D., J.D.
Professor and Chair
Obstetrics and Gynecology
University of Mississippi School of Medicine
Jackson, Mississippi

Learning Objectives

• Understand the relative value of different methods of evaluating the endometrium in patients with abnormal uterine bleeding
• Be able to better predict the presence of significant pathology in different age groups
• Be able to describe the unique capabilities of ultrasound
• Take home pearls in the evaluation of AUB with ultrasound

Endometrial Evaluation
Histologic Evaluation

• Options
  • Endometrial biopsy
  • Dilatation and curettage
• Diagnosis best made by tissue biopsy
  • Hormonal dysregulation
  • Endometritis
  • Endometrial hyperplasia
  • Diffuse malignancy

Endometrial Evaluation
Visual Evaluation

• Options
  • Hysteroscopy
  • Transvaginal sonography (TVS)
  • Saline-infusion sonohysterography (SIS)
  • 3D Ultrasound/SIS
• Diagnosis best made by visualizing the endometrial cavity for local anatomic causes
  • Polyps
  • Submucous myomas
  • Focal malignancy


PALM-COEIN

Abnormal Uterine Bleeding (AUB)
• Heavy menorrhea bleeding (AUB-HM)
• Intermenstrual bleeding (AUB-I)

PALM Structural Cases
• Polyp (AUB-P)
• Adenomyosis (AUB-A)
• Leiomyoma (AUB-L)
• Submucosal myoma (AUB-Lm)
• Other myoma (AUB-L)
• Malignancy & hyperplasia (AUB-H)

COEN Nonstructural Cases
• Cystic hyperplasia (AUB-C)
• Ovarian dystrophy (AUB-O)
• Endometrial (AUB-E)
• Intrasubmucous (AUB-I)
• Not yet classified (AUB-N)
Does age affect the likelihood that the cause of AUB is amenable to a sonographic diagnosis?

## Age-Based Findings at Hysteroscopy

<table>
<thead>
<tr>
<th>Age Group (#)</th>
<th>Normal</th>
<th>Abnormal</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 29</td>
<td>14</td>
<td>9</td>
</tr>
<tr>
<td>30–39</td>
<td>58</td>
<td>36</td>
</tr>
<tr>
<td>40–49</td>
<td>105</td>
<td>44</td>
</tr>
<tr>
<td>50–59</td>
<td>43</td>
<td>12</td>
</tr>
<tr>
<td>&gt; 60</td>
<td>18</td>
<td>6</td>
</tr>
<tr>
<td>Total</td>
<td>238</td>
<td>107</td>
</tr>
</tbody>
</table>


## Age-Based Findings at SIS (filling defects)

<table>
<thead>
<tr>
<th>Age       (#)</th>
<th>Normal</th>
<th>Abnormal</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 29</td>
<td>38</td>
<td>26</td>
</tr>
<tr>
<td>30–39</td>
<td>80</td>
<td>50</td>
</tr>
<tr>
<td>40–49</td>
<td>152</td>
<td>104</td>
</tr>
<tr>
<td>50–59</td>
<td>43</td>
<td>26</td>
</tr>
<tr>
<td>&gt; 60</td>
<td>28</td>
<td>17</td>
</tr>
<tr>
<td>Total</td>
<td>341</td>
<td>223</td>
</tr>
</tbody>
</table>

Brown and Shwayder, AIUM Annual Meeting 2007

## Age-Based Findings at Surgery (filling defects)

<table>
<thead>
<tr>
<th>Age       (#)</th>
<th>Normal</th>
<th>Abnormal</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 29</td>
<td>38</td>
<td>28</td>
</tr>
<tr>
<td>30–39</td>
<td>80</td>
<td>54</td>
</tr>
<tr>
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<td>152</td>
<td>107</td>
</tr>
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<td>50–59</td>
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<td>29</td>
</tr>
<tr>
<td>&gt; 60</td>
<td>28</td>
<td>18</td>
</tr>
<tr>
<td>Total</td>
<td>341</td>
<td>236</td>
</tr>
</tbody>
</table>

Brown and Shwayder, AIUM Annual Meeting 2007

## Timing of Studies

### 13 y.o. G0 with AUB

- Began menses age 11
- Heavy bleeding x 10 months
- hCG = negative
Adolescent Females

- "Immature" pituitary-hypothalamic axis
- First 2 - 3 years following menarche
- Coagulation Disorders
  - 19% of adolescent patients with AUB
  - 25% if initial Hb < 10 gm/dL
  - 50% if hospitalization required


13 y.o. G0 with AUB

- Coagulation evaluation: WNL
- Minimal response to oral contraceptives
- hCG = negative
- Referred for ultrasound

13 y.o. G0 with AUB

G0P0
LMP=2/15/2011
BC: NONE
SURGERY: NONE

2/20/11

Advantage

- Preop diagnosis
- Preparation for surgery
  - Appropriate equipment
  - Preop medications

Table of Contents
24 y.o. G1 P1001

- Presents with irregular, heavy bleeding for 8 months
- Delivered 1 year previously
- Breast fed x 2 months
- On oral contraceptives before pregnancy
- hCG: negative

Additional history
- Finds bruises on her thighs frequently
- Has bloody noses ~ 2 x a month
- Her mother had a hysterectomy for heavy bleeding

Pathogenesis of AUB
Coagulopathies – Who to Evaluate?

History of 2 or more of the following:
- Bruising of > 5 cm 1-2 times/month
- Epistaxis 1-2 times per month
- Frequent gum bleeding with flossing or brushing teeth
- Family history of bleeding symptoms

• Heavy menstrual bleeding since menarche
  - One of the following conditions:
    - Postpartum hemorrhage
    - Surgery-related bleeding
    - Bleeding associated with dental work
  - Two or more of the following conditions:
    - Epistaxis, 1 to 2 times per month
    - Frequent gum bleeding
    - Family history of bleeding symptoms

115 women with menorrhagia
Age 35.4 ± 11.9 years (13-53)

Age

<table>
<thead>
<tr>
<th>Abnormality</th>
<th>Total</th>
<th>&lt; 19</th>
<th>20-44</th>
<th>&gt; 45</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Platelet aggregation</td>
<td>44</td>
<td>44</td>
<td>48</td>
<td>32</td>
<td>.46</td>
</tr>
<tr>
<td>Von Willebrand’s factor</td>
<td>7</td>
<td>4</td>
<td>8</td>
<td>8</td>
<td>.76</td>
</tr>
<tr>
<td>Coagulation factor</td>
<td>5</td>
<td>8</td>
<td>6</td>
<td>0</td>
<td>.34</td>
</tr>
<tr>
<td>Any abnormality</td>
<td>47</td>
<td>48</td>
<td>52</td>
<td>32</td>
<td>.32</td>
</tr>
</tbody>
</table>

Values are percentages

28 y.o. - Menometrorrhagia
LMP = 9/01/15 (Study on 9/08/15)
BC: Pills
Surgery: None
BMI = 69

Pathology

**ENDOMETRIUM, BIOPSY:**
- Simple glandular hyperplasia without cytologic atypia.

PCO and Endometrial Cancer

- Chronic anovulation
  - RR = 3.1 (1.1 – 7.3)
- Obesity
  - RR = 2.6 to 3.0

Endometrial CA and Age < 45

- **6.3**
- **10.5**
- **13.2**


24 y.o. with Oligomenorrhea/ Menorrhagia

- G0
- Long-standing oligomenorrhea, now with menorrhagia
- BMI 73.2 kg/m²

**Table of Contents**
Endometrial Biopsy

- Well-differentiated adenocarcinoma of the endometrium

Endometrial Evaluation

- Histologic Evaluation

- Options
  - Endometrial biopsy
  - Dilatation and curettage
  - Diagnosis best made by tissue biopsy
    - Hormonal dysregulation
    - Endometritis
    - Endometrial hyperplasia
    - Diffuse malignancy

Postmenopausal Bleeding

- 58 yo G1P1001 with persistent postmenopausal bleeding
- Endometrial biopsy x 3
  - Tissue insufficient for diagnosis

Table of Contents
Pipelle endometrial sampling. Sensitivity in the detection of endometrial cancer.

<table>
<thead>
<tr>
<th>Author</th>
<th>Year</th>
<th>#</th>
<th>Sens</th>
<th>Journal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zorlu</td>
<td>1994</td>
<td>26</td>
<td>95%</td>
<td>Gyn Ob Invest</td>
</tr>
<tr>
<td>Stovall</td>
<td>1991</td>
<td>40</td>
<td>97.5%</td>
<td>Obstet Gyn</td>
</tr>
<tr>
<td>Guido</td>
<td>1995</td>
<td>65</td>
<td>83%</td>
<td>J Reprod Med</td>
</tr>
<tr>
<td>Van den Bosch</td>
<td>1995</td>
<td>140</td>
<td>44.6%</td>
<td>Obstet Gyn</td>
</tr>
</tbody>
</table>

Evidence: II-1


A comparison of Pipelle device and the Vabra aspirator

25 Patients scheduled for hysterectomy

- Percent surface area sampled
  - Pipelle 4.2% ± 0.92%
  - Vabra Aspirator 41.6% ± 5.7% (p<0.0001)
- Mean number of quadrants sampled (4 ant/4 post)
  - Pipelle 2.4 ± 0.41
  - Vabra aspirator 7.4 ± 0.42 (p < 0.0001)

A comparison of Pipelle device and the Vabra aspirator

<table>
<thead>
<tr>
<th>Patients scheduled for hysterectomy</th>
<th>Percent surface area sampled</th>
<th>Vabra Aspirator 41.6% ± 5.7% (p&lt;0.0001)</th>
<th>Pipelle 4.2% ± 0.92%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean number of quadrants sampled</td>
<td>(4 ant/4 post)</td>
<td></td>
<td>Pipelle 2.4 ± 0.41</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Vabra aspirator 7.4 ± 0.42 (p&lt;0.0001)</td>
</tr>
</tbody>
</table>


How should we investigate women with postmenopausal bleeding?

76 Postmenopausal women
- Pipelle in outpatient clinic
- TVS prior to outpatient hysterectomy/D&C
  - Abnormal: Endometrial thickness > 5 mm
- Hysteroscopy and Curettage


How should we investigate women with postmenopausal bleeding?

- Pipelle
  - Successful: 70%
  - Sensitivity: 70%
- TVS
  - Sensitivity: 83%
  - Specificity: 77%
  - Positive predictive value: 54%
- Detected 5 ovarian tumors
  - (3 missed on pelvic exam, 2 malignant)


Postmenopausal Bleeding

- 61 yo G3P1021 with postmenopausal bleeding
- Spotting x 2 months


Postmenopausal Bleeding

- 63 yo G2P1011 with postmenopausal bleeding
  - For 3 days
  - 3 weeks ago

Papillary serous cystadenocarcinoma
ACOG COMMITTEE OPINION

The Role of Transvaginal Ultrasonography in the Evaluation of Postmenopausal Bleeding

- Endometrial thickness < 5 mm
  - 82% could have a biopsy performed
  - 27% had adequate tissue
  - 73% had TIFD

ACOG Committee Opinion, Number 440, August 2009

Endometrial Thickness and Postmenopausal Bleeding

<table>
<thead>
<tr>
<th>Reference</th>
<th>ET (mm)</th>
<th>#</th>
<th># CA</th>
<th>NPV (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Karlsson 1995</td>
<td>≤ 4</td>
<td>1168</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>Ferrazzi 1996</td>
<td>&lt; 4</td>
<td>930</td>
<td>2</td>
<td>99.8</td>
</tr>
<tr>
<td>Gull 2000</td>
<td>&lt; 4</td>
<td>163</td>
<td>1</td>
<td>99.4</td>
</tr>
<tr>
<td>Epstein 2001</td>
<td>&lt; 5</td>
<td>97</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>Gull 2003</td>
<td>&lt; 4</td>
<td>394</td>
<td>0</td>
<td>100</td>
</tr>
</tbody>
</table>

Risk of Cancer = 1/917

Postmenopausal Bleeding

- Endometrium = 3.9 mm
- Option A
  - No further bleeding
- Option B
  - Repeat episode of bleeding 8 months later

Can Ultrasound Replace D&C?

- 394 postmenopausal women referred for PMB (1987-1990)
- Menopausal if > 1 year w/o bleeding
- Ultrasound and D&C
- 10 year follow-up (n = 339)

Göteborg, Sweden

ACOG COMMITTEE OPINION

Initial evaluation may be with either EMB or TVS
- Endometrial thickness > 4 mm should trigger further evaluation
  - EMB
  - Sonohysterography
  - Hysteroscopy
- EMB with TIFD requires additional evaluation
Recurrent PMB - None

<table>
<thead>
<tr>
<th>Endometrial Thickness</th>
<th>#</th>
<th>CA</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤ 4 mm</td>
<td>134</td>
<td>0</td>
</tr>
<tr>
<td>5-7 mm</td>
<td>31</td>
<td>0</td>
</tr>
<tr>
<td>&gt; 8 mm</td>
<td>22</td>
<td>0</td>
</tr>
<tr>
<td>Unmeasurable</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>TOTAL</td>
<td>191</td>
<td>0</td>
</tr>
</tbody>
</table>


Recurrent PMB - Yes

<table>
<thead>
<tr>
<th>Endometrial Thickness</th>
<th>#</th>
<th>CA</th>
<th>Hyper</th>
<th>CA or Hyperp</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤ 4 mm</td>
<td>28</td>
<td>0</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>5-7 mm</td>
<td>9</td>
<td>3</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>≥ 8 mm</td>
<td>28</td>
<td>4</td>
<td>5</td>
<td>9</td>
</tr>
<tr>
<td>Unmeasurable</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>TOTAL</td>
<td>66</td>
<td>7</td>
<td>8</td>
<td>15</td>
</tr>
</tbody>
</table>

Sonohysterography

38 y.o. G2P1011

- c/o of irregular and heavy bleeding
- Myomectomy 2009
- Hysteroscopic myomectomy 10/11/10
- C-section x 1
Sonobiopsy

- Evacuate fluid from catheter and syringe prior to biopsy
- Can be done with ultrasound guidance
- Withdraw the ultrasound probe prior to doing biopsy with Goldstein sonobiopsy catheter
Endometrial Aspiration at SIS
Age > 50

- 603 patients
- Indication
  - PMB 73.8%
  - Thickened endometrium 15.3%
  - Suspected polyp 9.3%
  - Abnormal Pap 1.7%


Endometrial Aspiration at SIS

- Simultaneous
  - Endometrial aspiration in all cases
- Sequential
  - Endometrial aspiration only if SIS is abnormal
    - Polyps
    - Focal lesion
    - Thickened endometrium


Endometrial Aspiration at SIS

If proliferative endometrium = Normal
- Screen positive = surgery 4.5%
- Missed hyperplasia or cancer 13.3%

If proliferative endometrium = Abnormal
- Screen positive = surgery 13%
- No missed hyperplasia or cancer


Conclusions

- Ultrasound is a reasonable first step in evaluation in patients with AUB
- ~1/3 will have an endometrial polyp or submucous myoma regardless of age

Conclusions

- Consider coagulopathies in patients based on historical information
- Consider endometrial biopsy as first-line evaluation in obese patients with long-standing oligo/amenorrhea

Conclusions: Endometrial Thickness < 4

- TVS endometrial thickness < 4 mm is a reasonable threshold to avoid initial endometrial biopsy or SIS
- Recurrent abnormal vaginal bleeding requires further evaluation
Conclusions: Proliferative Endometrium

- Postmenopausal bleeding
- Proliferative endometrium on EMB may be abnormal
- May warrant further evaluation

Thank You
James Shwayder, MD, JD
Professor and Chair
Obstetrics and Gynecology
University of Mississippi
Jackson, Mississippi
Wiser Hospital for Women and Infants
Adnexal Masses: What’s Benign and What’s Malignant?

Alfred Abuhamad, M.D.
Professor and Chairman
Department of Obstetrics and Gynecology
Vice Dean for Clinical Affairs
Eastern Virginia Medical School
Norfolk, VA
Adnexal Masses: What’s benign & What’s Malignant?

Alfred Abuhamad, MD
Eastern Virginia Medical School

www.openultrasound.com

Free download – open access

25 year old, referred with left pelvic pain, US of left adnexa

25 year old, referred with left pelvic pain, US of left adnexa

Table of Contents
31 year old – 12 weeks pregnant

41 year old - referred with Rt sided fullness, large mass on exam

41 year old - referred with Rt sided fullness, large mass on exam

24 year old, at 20 weeks gestation, referred for evaluation of midline pelvic mass

24 year old, at 20 weeks gestation, referred for evaluation of midline pelvic mass

Table of Contents
54 year old, enlarged right ovary

54 year old, enlarged right ovary

75 year old, complex mass discovered on CT scan in right adnexa

75 year old, complex mass discovered on CT scan in right adnexa
65 year old, history of postmenopausal bleeding x 1 about 3 months ago

65 year old, history of postmenopausal bleeding x 1 about 3 months ago

65 year old, history of postmenopausal bleeding x 1 about 3 months ago

65 year old, history of postmenopausal bleeding x 1 about 3 months ago
85 year old, referred due to an intrauterine mass - asymptomatic

42 year old, left adnexal mass – pain left lower quadrant

42 year old, left adnexal mass – pain left lower quadrant
Ultrasound in the Evaluation of Ectopic Pregnancy and PUL

James M. Shwayder, M.D., J.D.
Professor and Chair
Department of Obstetrics and Gynecology
University of Mississippi School of Medicine
Jackson, Mississippi

Learning Objectives

- Nomenclature regarding pregnancy of unknown location (PUL)
- Alternative approaches the diagnostic dilemma of evaluating a patient with a possible ectopic pregnancy.
- Understand the value of various diagnostic tests.
- Gain insight into the ultrasound findings in patients with an ectopic pregnancy

Consensus Nomenclature

1. Definite ectopic pregnancy (EP)
   - Extrauterine gestational sac with yolk sac and/or embryo (with or without cardiac activity)
2. Probable EP
   - Inhomogeneous adnexal mass or extrauterine sac-like structure
3. PUL
4. Probable intrauterine pregnancy
5. Definite IUP

Consensus Nomenclature

• PUL
  – no signs of either EP or IUP


Pregnancy of Unknown Location


Case Presentation

• 28 y.o. G1P0 presents with pelvic pain and scant vaginal spotting.
• LMP ~ 4-5 weeks ago
• + UPT at home
• Exam: VSS
  Uterus AV, NT, TNS
  Adnexa: NT, without masses
• hCG = 874 IU/L

Increase in hCG in early pregnancy

Sampling Interval (days) % Increase
1 29
2 66
3 114
4 175
5 255

Kadar et. al. Obstet Gynecol 1981; 58: 162 (Yale)

Increase in hCG in early pregnancy

Doubling time = 2.98 days
15% of normal pregnancies had abnormal ß-hCG increases

Kadar et. al. Obstet Gynecol 1981; 58: 162 (Yale)

Increase in hCG in early pregnancy

Table: Days Range Median
1 1.24 – 1.81 1.50
2 1.53 – 3.28 2.24
3 1.88 – 5.94 3.35
4 2.33 – 10.76 5.00
7 4.38 – 63.88 16.73

Case Presentation

Day 1  hCG = 874 IU/ml
Day 3  hCG = 1,056 IU/ml
Day 5  hCG = 1,110 IU/ml

Threshold vs. Discriminatory Levels

Threshold level
• Lowest β-hCG level at which a normal intrauterine pregnancy can be detected

Discriminatory level
• The level of β-hCG above which all normal intrauterine pregnancies should be seen

Threshold vs. Discriminatory Levels

Threshold level
• β-hCG = 400-500 mIU/mL (1st IRP)

Discriminatory level
• β-hCG = 1000-1500 mIU/mL (1st IRP)

Dependencies
• Transducer frequency, uterine position, body habitus, operator experience/ability

Evidence Against the hCG Discriminatory Level

• January 1, 2000 - December 31, 2010
• TVS and β-hCG on same day
• No intrauterine fluid collection
• Subsequent embryonic or fetal cardiac activity

Doubilet and Benson, J Ultrasound Med 2011; 30:1637-1642

Evidence Against the hCG Discriminatory Level

<table>
<thead>
<tr>
<th>hCG (3-4th IS)</th>
<th># (202)</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;1000</td>
<td>162</td>
<td>80.2</td>
</tr>
<tr>
<td>1000-1499</td>
<td>19</td>
<td>9.4</td>
</tr>
<tr>
<td>1500-1999</td>
<td>12</td>
<td>5.9</td>
</tr>
<tr>
<td>2000</td>
<td>9</td>
<td>4.5</td>
</tr>
</tbody>
</table>

Doubilet and Benson. J Ultrasound Med 2011; 30:1637-1642

Reevaluation of Discriminatory and Threshold Levels

• 651 patients
• TVS and β-hCG within 6 hours of each other
• Known intrauterine pregnancies
• Findings visualized 99% of the time
• 1st, 3rd, or 4th International Standard – 2nd I.S.~ ½ that of others

Reevaluation of Discriminatory and Threshold Levels

<table>
<thead>
<tr>
<th>hCG (mIU/mL)</th>
<th>Gestational Sac</th>
<th>Yolk Sac</th>
<th>Embryo</th>
</tr>
</thead>
<tbody>
<tr>
<td>Threshold level</td>
<td>390</td>
<td>1094</td>
<td>1394</td>
</tr>
<tr>
<td>Discriminatory level</td>
<td>3510</td>
<td>17,716</td>
<td>47,685</td>
</tr>
</tbody>
</table>


Case Presentation

- TVS
  - Uterus
  - No evidence of IUP
  - Ovaries
  - Corpus luteum - left
  - Adnexa
  - No definite adnexal pathology
- Current terminology: PUL
- Treatment: MTX 50 mg/m²

Reevaluation of Discriminatory and Threshold Levels

Case Presentation

- 24 y.o. G2P0010 presents with scant vaginal spotting and pain
- LMP ~ 5 weeks ago
- Exam: VSS
  - Uterus: NS, NT; Adnexa: NT
- Initial: hCG = 710 IU/L
- Repeat in 2 days: hCG = 980 IU/L
### Endometrial Thickness in Ectopic Pregnancy when hCG < Discriminatory Zone

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Mean (mm)</th>
<th>Range (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intrauterine pregnancy</td>
<td>13.42</td>
<td>± 0.68</td>
</tr>
<tr>
<td>Spontaneous abortion</td>
<td>9.28</td>
<td>± 0.88</td>
</tr>
<tr>
<td>Ectopic pregnancy</td>
<td>5.95</td>
<td>± 0.35</td>
</tr>
<tr>
<td>Abnormal pregnancy (97%)</td>
<td>≤ 8</td>
<td></td>
</tr>
</tbody>
</table>

Case Presentation - #3

- 28 y.o. G1P0 presents with pelvic pain and scant vaginal spotting.
- LMP ~ 7 weeks ago
- Exam: VSS
  - Uterus TNS;
  - Mild adnexal discomfort
- hCG = 4,634 IU/L
Intrauterine Fluid with Ectopic Pregnancy

229 patients with ectopic

- No intrauterine fluid 191 83.4
- Intrauterine fluid 38 16.6
  - Adnexal mass 33 86.8


Intrauterine Fluid with Ectopic Pregnancy

38 patients

- Type A 31 81.6
  - Pointy edged 30 78.9
  - Echoes 28 73.7
  - Located with the cavity 21 55.3
- Type B 7 18.4
  - Smooth walled
  - Located in decidua or uncertain


Conclusions

- Findings
  - A smooth-walled anechoic intrauterine cystic structure
  - No adnexal mass
- Probability
  - Intrauterine pregnancy 99.8%
  - Ectopic pregnancy 0.02%

TVS for Diagnosing Ectopics

Reviewed 10 studies

- 2216 patients
- Ectopic = 565 25.5%
- No ectopic = 1651 74.5%


**Inclusion criteria**

- Clinical suspicion of ectopic pregnancy
- All patients underwent TVS
- All cases of EP were surgically confirmed
- No adnexal masses were excluded, except simple cysts

**TVS Criteria for Ectopic Pregnancy**

<table>
<thead>
<tr>
<th>TVS Finding</th>
<th>Likelihood of Ectopic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extrauterine embryo + heartbeat</td>
<td>100%</td>
</tr>
<tr>
<td>Adnexal mass with yolk sac or embryo without heartbeat</td>
<td>100%</td>
</tr>
<tr>
<td>Tubal ring</td>
<td>95%</td>
</tr>
<tr>
<td>Complex or solid adnexal mass</td>
<td>92%</td>
</tr>
<tr>
<td>No tubal ring, yolk sac, embryo</td>
<td></td>
</tr>
</tbody>
</table>


---

**TVS for Diagnosing Ectopics**

**Criteria for ectopic pregnancy**

A: Adnexal embryo with heartbeat
B: Adnexal mass containing yolk sac or embryo
C: Adnexal mass with central anechoic area and hyperechoic rim ("tubal ring")
D: Any adnexal mass other than a simple cyst or an intraovarian lesion

Diagnosing Ectopic Pregnancy
Six Strategies

- Ultrasound followed by quantitative hCG
- Quantitative hCG followed by ultrasound
- Progesterone followed by ultrasound and quantitative hCG
- Progesterone followed by quantitative hCG and ultrasound
- Ultrasound followed by repeat ultrasound
- Clinical examination

Diagnosing Ectopic Pregnancy
Six Strategies—Recommendations

- Ultrasound followed by hCG
- hCG followed by ultrasound
- Either progesterone protocol
  - More missed ectopic pregnancies
- Ultrasound followed by repeat ultrasound
  - May be applicable in poorly compliant patient
- Clinical exam only—NOT recommended

Garcia and Barnhart. Obstet Gynecol 2001; 97: 464-70

Case Presentation

- 41 G2P0010 with LMP 3 weeks ago
- c/o vaginal bleeding and abdominal pain
- Unprotected intercourse x 10 years
- + UCG

Ectopic Pregnancy
hCG Dynamics with Spontaneous Resolution of Ectopic

Helsinki, Finland
118 patients
Entry criteria
- Decreasing or stable hCG
- No signs of rupture/intraperitoneal hemorrhage
- Adnexal mass < 4 cm
- No cardiac activity

Korhonen, Stenman, Ylostalo. Fertil Steril 1994; 61: 632-36 (Finland)
Ectopic Pregnancy

hCG Dynamics with Spontaneous Resolution of Ectopic

Rate of Spontaneous Resolution
- hCG < 200 IU/L: 88%
- hCG > 2000 IU/L: 25%


Initial hCG

Case Presentation
- 38 y.o. G3P0020 seen in ER with c/o slight spotting and mild abdominal discomfort
- Uterus: Mid-position, TNS
- Adnexa: No definite masses
- hCG = 357 IU/L
- Hct = 36.4
- D/C home with F/U 2 days in WCC

Case Presentation
- WCC – c/o increasing pain and weakness

BLOOD

hCG = 465 IU/L
Serum hCG and Tubal Rupture

<table>
<thead>
<tr>
<th>ß-hCG (IU/L)</th>
<th>Unruptured</th>
<th>Ruptured</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 100</td>
<td>9.2%</td>
<td>11.4%</td>
</tr>
<tr>
<td>100 - 999</td>
<td>47.3%</td>
<td>38.6%</td>
</tr>
<tr>
<td>1000 - 9,999</td>
<td>38.2%</td>
<td>38.6%</td>
</tr>
<tr>
<td>&gt; 10,000</td>
<td>5.3%</td>
<td>11.4%</td>
</tr>
</tbody>
</table>

Saxon et al. Obstet Gynecol 1997; 90: 46
(McGill, Cleveland Clinic)

Case presentation

• 28 y.o. G2P0010
• Presents with pelvic pain and vaginal spotting
• LMP = 7 weeks ago
• hCG: positive

Ultrasound Diagnosis of Interstitial Pregnancy

- Empty uterine cavity
- Chorionic sac > 1 cm from the lateral edge of the uterine cavity (endometrium)
- Thin (<5 mm) layer of myometrium surrounding the chorionic sac

Terminology

- **Interstitial pregnancy**
  - Embryo implants in the interstitial or intramural portion of the Fallopian tube
- **Cornual pregnancy**
  - Pregnancies that occur in a rudimentary horn, unicornsate uterus, cornual region of a septate uterus, a bicornuate uterus, or a uterus didelphys
- **Angular pregnancy**
  - Embryo implants in one of the lateral angles of the uterine cavity, medial to the utero-tubal junction

Case Presentation

- 23 y.o. G2P1001
- Enters c/o slight spotting and cramping
- LMP = Unknown
- UCG = positive
- hCG = 2,392
Consensus Nomenclature

- Pregnancy of unknown location (PUL)
  - Possible IUP
  - Increased endometrial thickness

Quantitative hCG

12/30/10    2392
1/01/11    7721

hCG = 7721

01/04/11
hCG = 16,371

01/18/11
FHR = 140 bpm
Ectopic Pregnancy-Summary

- Ultrasound can be justified prior to obtaining a quantitative hCG
  ~ 50% of ruptured ectopics had hCG levels below the discriminatory zone (<1000 IU)
- Endometrial thickness when hCG < discriminatory level
  - An endometrial thickness < 8 mm is associated with an abnormal pregnancy 97% of the time

- The discriminatory level has changed
  - It may be as high as 2500-3500 IU/L
  - A cystic structure within the endometrium, in the absence of an adnexal mass
  - Is associated with an IUP in > 99% of patients

- Finding an IUP r/o ectopic pregnancy
  - Exception: heterotopic pregnancy
    - (1:667-1:30,000)
  - Finding of embryo + heart beat or yolk sac in adnexa
    - Diagnostic of ectopic pregnancy
  - No IUP. Complex/solid mass, sep from ovary
    - 92% likelihood of ectopic

Thank You
HANDS ON SCANNING
DEMONSTRATION:
THE PELVIC ULTRASOUND
EXAMINATION

James M. Shwayder, M.D., J.D.
Professor and Chair
Department of Obstetrics and Gynecology
University of Mississippi Medical Center
Jackson, MS
CARDIAC IMAGING:
TIPS TO IMPROVE
DIAGNOSIS OF CHD

Alfred Abuhamad, M.D.
Professor and Chairman
Department of Obstetrics and Gynecology
Vice Dean for Clinical Affairs
Eastern Virginia Medical School
Norfolk, VA
The Approach to Fetal Cardiac Imaging in Early Gestation

Alfred Abuhamad M.D.

Chronology of Cardiac Development

<table>
<thead>
<tr>
<th>Feature</th>
<th>Weeks of development (from fertilization)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Angiogenic clusters</td>
<td>Early 3</td>
</tr>
<tr>
<td>Formation of heart tubes</td>
<td>Early 3</td>
</tr>
<tr>
<td>Cardiac looping</td>
<td>Early 3</td>
</tr>
<tr>
<td>Fusion of heart tubes</td>
<td>Early 3</td>
</tr>
<tr>
<td>Looping of heart tube</td>
<td>Mid 3</td>
</tr>
<tr>
<td>Appearance of interventricular septum</td>
<td>Mid 4th week</td>
</tr>
<tr>
<td>Septum primum</td>
<td>End Early 4</td>
</tr>
<tr>
<td>Appearance of endocardial cushions</td>
<td>End 4</td>
</tr>
<tr>
<td>Conotruncal ridge</td>
<td>Late 6th week</td>
</tr>
<tr>
<td>Conotruncal septum</td>
<td>Early 6th week</td>
</tr>
<tr>
<td>Septum secundum</td>
<td>Late 6th week</td>
</tr>
<tr>
<td>Fusion of endocardial cushions</td>
<td>Early 6</td>
</tr>
<tr>
<td>Obliteration of membranous septum</td>
<td>Mid 7th week</td>
</tr>
</tbody>
</table>

End of 9th menstrual week

From Practical Guide To Fetal Echocardiography – Abuhamad, Chaoui – 2nd Edition

Cardiac Imaging in Early Gestation

- Caution in detailed anatomic cardiac evaluation at less than 10 weeks gestation

9 Weeks Gestation

Color Doppler helps but still

NT and CHD

Approach to Examination

- Transvaginal
- Transabdominal
Cardiac Imaging in Early Gestation

*Transvaginal*

- Better resolution of probe
- Inconvenience to patients
- Limited probe range of motion
- Requires expertise

Cardiac Imaging in Early Gestation

*Transvaginal*

- Most optimal < 13 weeks
- Fetus in transverse lie

---

**13 Weeks**

*Transabdominal Approach*

- 4CV
- PV

---

**13 Weeks**

*Transabdominal Approach*

- 4CV
- Cardiac axis
- Left PV

---
**Early Fetal Echocardiography**

**Indications (10 - 14 weeks)**

- Increased NT
- Reverse flow in Ductus Venosus
- Tricuspid / mitral regurgitation
- Abnormal cardiac axis
- Other (suspected abnormality)

---

**Early Fetal Cardiac Imaging**

**TABLE 16.1** Optimization of Grayscale Examination in Early Cardiac Scan

- Place in decubitus position (NT position)
- Magnify image
- Narrow sector width
- Filter to occupy one-third of ultrasound screen
- Use high-contrast image setting
- Use mid-to-high-resolution transducer
- Image from apical to right lateral of fetal heart

---

**TABLE 16.2** Optimization of Color Doppler Examination in Early Cardiac Scan

- Start with grayscale optimization before achieving color Doppler
- Use a narrow color Doppler box
- Use mid to high color Doppler range
- Use mid to high sensitivity
- Use low color Doppler gain
- Use low power output
- Use bidirectional Doppler if available

---

**Color Doppler in Early Echo**
From Practical Guide To Fetal Echocardiography – Abuhamad, Chaoui – 2nd Edition
Ebstein Anomaly

Aortic Stenosis

Coarctation of Aorta

Coarctation Aorta

Common Arterial Trunk

Tetralogy of Fallot
Ventricular Septal Defect
13 Weeks

Ventricular Septal Defect
12 Weeks

3VT in Early Gestation

Cardiac Axis in the First Trimester

Cardiac Axis
11 0/7 to 14 6/7 Weeks

Cardiac Axis
4 Chamber View

2D 2D+color Doppler 2D+HD-color Doppler
Cardiac Axis

12 Weeks

9 Weeks - 52 days

197 fetuses with CHD and 394 controls

Cardiac Axis in Early Gestation

Left Deviation

DORV, 12-6 weeks

MVP stress with DORV 11-6 weeks

TOF, 11-4 weeks

Cardiac Function

Table of Contents
4D Ultrasound and Early Fetal Echocardiography

Mitral Atresia – 4D

Coarctation Aorta-4D

AV- Canal – 4D

PATIENT: 33 year old - G2P0

REASON FOR REFERRAL: Detailed 1st trimester ultrasound with enlarged nuchal translucency noted on the outside scan

GA AT PRESENTATION: 12+0 weeks
CHD: Tetralogy of Fallot with pulmonary stenosis - ARSA
Small omphalocele
Two vessel umbilical cord

**DIAGNOSIS**

**Genetic Counseling:**
*Work up for chromosomal anomalies*

**Fetal Karyotype:** 46XX,del(4)(p15.2) - Wolf-Hirschhorn syndrome

**Pregnancy outcome:** termination at 15+1 weeks
Early Fetal Imaging

National Guidelines - AIUM

d. Embryonic/fetal anatomy appropriate for the first trimester should be assessed.

http://www.aium.org/resources/guidelines/obstetric.pdf - 2013

Early Fetal Imaging

ISUOG Guidelines

First trimester ultrasound remains indication driven. If a late first trimester US is performed – evaluation of
in some experienced centers, detection of major fetal anomalies in first trimester is possible

http://www.isuog.org - 2013

Early Fetal Imaging

National Guidelines

NICHD Consensus on fetal imaging - 2013

Early Fetal Imaging

Spectral Doppler Safety - AIUM

The use of Doppler ultrasound during the first trimester is currently being investigated as a valuable diagnostic aid for
dermatology practitioners.

http://www.aium.org/officialStatements/42 - 2011

Early Fetal Imaging

Spectral Doppler Safety - ISUOG

ISUOG statement on the safe use of Doppler in the 11 to 13 + 6-week fetal ultrasound examination

http://www.aium.org/officialStatements/42 - 2011
Cardiac Imaging in Early Gestation

**Spectrum of CHD**

- More complex abnormalities
- Higher association with aneuploidy
- Higher association with hydrops

**My Recommendations**

- It is easier than you think!
- Adjust your US presets (NT+Fetal Echo)
- Attempt to look on every scan
- Look at cardiac axis (measure?)
- High definition color optimal
- Look at 3-Vessel-Trachea View
THE ROLE OF THE 3 VESSEL TRACHEA VIEW IN SCREENING AND DIAGNOSIS FOR CONOTRUNCAL ANOMALIES

Elena Sinkovskaya, M.D., Ph.D.
Assistant Professor
Director of Research
Division of Maternal-Fetal Medicine
Department of Obstetrics & Gynecology
Eastern Virginia Medical School
Norfolk, VA
The Role of the Three-vessel Trachea View in Screening and Diagnosis for Conotruncal Anomalies?

Elena Sinkovskaya MD, PhD
Division of Maternal-Fetal Medicine
Eastern Virginia Medical School

What is conotruncus?
CONOTRUNCUS = Conus Cardis + Truncus Arteriosus

Embryogenesis of conotruncus
5th – 8th week

What are the conotruncal anomalies?
- Common arterial trunk
- Tetralogy of Fallot
- Transposition of the great arteries
- Double outlet right ventricle
- Double outlet left ventricle
- Interrupted aortic arch
- Aortopulmonary window

Ultrasound Views:
4-chamber view LVOT view RVOT view 3 vessel–trachea view

Differential Diagnosis – common features
CARDIAC AXIS
may be displaced to the left
Differential Diagnosis – common features

Perimembranous VSD

Differential Diagnosis – common features

Vessel overrides the IVS

Tetralogy of Fallot

Taussig-Bing anomaly

Common arterial trunk

ALWAYS follow the vessels

Transverse and paratransverse views of the fetal upper thorax

1. 4-chamber view
2. 5-chamber view
3. 3-vessel view
4. View of ductus arteriosus
5. View of aortic arch
6. 3-vessel-trachea view

Three-vessel view

Arterial duct view

Aortic arch view

From: "Echocardiographic anatomy in the fetus." Chiappa E.M et al.
Three-vessel-trachea view

How to read three-vessel view?
Assessment of anatomic components of the 3VTV should include analysis of:

- Number of vessels
- Size of vessels
- Alignment of vessels
- Arrangement of vessels
- Relation to the trachea
- Pattern of blood flow

Normal 3VTV

1. Number of vessels: three
   - ductal arch;
   - aortic arch;
   - superior vena cava
2. Vessel size: DA > AoA > SVC
3. Vessels aligned along oblique line: DA is most anterior, SVC is most posterior
4. Vessels arrangement from left to the right: DA, AoA, SVC
5. Both arches are on the left to the trachea
6. The confluence of the ductal and aortic arches with the same direction of the blood flow - "V shape"

Common Arterial Trunk (CAT)

1. Pulmonary artery originates from CAT
2. Single vessel overriding IVS (CAT) (usually has 4 leaflets)
3. Large ventricular septal defect

Common Arterial Trunk
4-chamber view

Normal Heart
CAT

Common Arterial Trunk
Cardiac axis
Common Arterial Trunk

Outflow tracts

NORMAL HEART
• Two crossing great vessels
• PA arises from RV, Ao - from LV
• IVS is intact

CAT
• Single great vessel - trunk
• PA/Ao arises from trunk
• Malalignment VSD

Blood flow to CAT from both ventricles - "Y" sign

Common Arterial Trunk

Outflow tracts

NORMAL HEART
• Ao - transverse
• PA - longitudinal
• Ao/V with 3 leaflets

CAT
• Single vessel - transverse
• Valve has 1-6 (usually 4) leaflets

Common Arterial Trunk

3 vessel trachea view

NORMAL HEART
• 3 vessels (PA, Ao, SVC)
• V - shape

CAT
• 2 vessels (trunk, SVC)
• Variable appearance

Common Arterial Trunk

3 vessel view
Common Arterial Trunk
3 vessel view

Common Arterial Trunk
3 vessel trachea view

Common Arterial Trunk
3 vessel trachea view

Spectrum of CAT

Tetralogy of Fallot
1. Large ventricular septal defect
2. Right ventricle outflow tract obstruction:
   - Infundibular stenosis (2a) - 70%
   - Pulmonary valve atresia - 30%
   - Absent pulmonary valve - <1%
3. Enlarged aorta overriding VSD
4. Right ventricular hypertrophy

Tetralogy of Fallot
Embryology

From www.PedHeart.com
**Tetralogy of Fallot**

**4-chamber view**

- Normal Heart
- ToF

**Cardiac axis**

Blood flow to Ao from both ventricles - "Y" sign

**LVOT view**

- Normal Heart
- ToF

- Aorta arises wholly from LV
- Ventricular septum intact
- Aorta arises from both ventricles
- Subaortic VSD

**RVOT view**

- Normal Heart
- ToF

- PA normal in size
- PV opens and closes freely
- PA is small
- Stenosis of PV and/or RVOT

**3 vessel view**

- Normal Heart
- ToF

- PA> Ao > SVC
- PA < Ao
Tetralogy of Fallot

3 vessel view

NORMAL HEART
- Normal vessel alignment

ToF
- Abnormal vessel alignment

II. Abnormal vessel size:
PA is smaller than Ao

Tricuspid atresia

III. Abnormal vessel relationship:
abnormal relation to the trachea

"U shape"
Right-sided Aortic Arch + left-sided Ductus Arteriosus

Spectrum of ToF

Pulmonary Stenosis ~ 70%
Pulmonary Atresia ~ 30%
Absent pulmonary valve ~ 1%

From www.PedHeart.com
Transposition of Great Arteries

- Ao arises anteriorly and from RV;
- PA arises from LV;
- TGA results in complete separation of the pulmonary and systemic circulations;

Concomitant cardiac anomalies:
- Ventricular septal defect - 40%
- LVOR obstruction - 5%
- VSD+LVOT obstruction - 10%
- Anomalies of coronary arteries - 50%

From www.PedHeart.com
Transposition of Great Arteries
3VTV views

Spectrum of TGA

Diagnosis ????

Spectrum of DORV

Double Outlet Right Ventricle
1. Ao and PA arise from RV
2. Large ventricular septal defect
   - subaortic
   - subpulmonary
   - subarterial (doubly committed)
   - non-committed (remote)
3. Obstruction
   - subpulmonary
   - subaortic

Double Outlet Right Ventricle
4-chamber view

NORMAL HEART or DORV ???

Double Outlet Right Ventricle

**LVOT view**

- **NORMAL HEART**
  - Aorta arises wholly from LV
  - Ventricular septum intact
  - Ao-mitral continuity present

- **DORV**
  - One of the vessels overrides IVS
  - Malalignment VSD
  - Ao-mitral continuity absent

Double Outlet Right Ventricle

**ToF type**

- Blood flow to Ao from both ventricles - “Y” sign

Double Outlet Right Ventricle

**TGA type**

- Blood flow to Ao from both ventricles - “Y” sign

Double Outlet Right Ventricle

**TGA type**

- Taussig-Bing anomaly
NORMAL HEART
- Ao - transverse
- PA - longitudinal
- PA is anterior

DORV
- Ao and PA - transverse
- Ao and PA are side by side

III. Abnormal vessel relationship:
abnormal alignment

What’s the diagnosis?
What’s the diagnosis?

1. Interrupted Aortic Arch type A
2. Common arterial trunk type A1 + right AoArch
3. Hemitruncus (one of PA from Aorta) + right AoArch
4. Aortopulmonary window + right AoArch

Take-home message

The 3VTV is an essential component to fetal echocardiography as it adds significantly to the complete diagnosis of heart defects

Echocardiography

Prenatal

Postnatal

Thank You
Case Presentations of Fetal Cardiac Malformations

Elena Sinkovskaya, M.D., Ph.D.
Assistant Professor
Director of Research
Division of Maternal-Fetal Medicine
Department of Obstetrics & Gynecology
Eastern Virginia Medical School
Norfolk, VA
THE ROLE OF ULTRASOUND IN THE DIAGNOSIS OF PLACENTA ACCRETA

Alfred Abuhamad, M.D.
Professor and Chairman
Department of Obstetrics and Gynecology
Vice Dean for Clinical Affairs
Eastern Virginia Medical School
Norfolk, VA
The Role of Ultrasound in the Diagnosis of Placenta Accreta

Alfred Abuhamad, MD.
Eastern Virginia Medical School

Lecture Outline

- Placenta previa
- Vasa previa
- Placental abruption
- Morbidly adherent placenta

Placenta Previa

Fetal Imaging Consensus Meeting

- Diagnosis of placenta previa is overestimated at less than 16 weeks of gestation
- At > 16 weeks, if the placental edge is > 2 cm from the internal os, the placental location should be reported as normal

- If the placental edge is < 2 cm from the internal os, but not covering the internal os, the placenta should be labeled as low-lying
- If the placental edge covers the internal cervical os, the placenta should be labeled as placenta previa
- The terms partial previa, marginal previa and complete previa should be abandoned

Fetal Imaging Consensus Meeting

- For all low-lying placentas and placenta previas, follow-up is recommended at 32 weeks
- if still low-lying or previa at 32 weeks, a follow-up ultrasound is recommended at 36 weeks
- Color Doppler is recommended to rule-out vasa previa for low-lying placentas in the third trimester and resolving previas
- Transvaginal ultrasound should be used for the diagnosis when placenta previa is suspected

JMM May 2014 33:745-757
Vasa Previa

Placental Abruption

Placenta Accreta

- US findings in First Trimester
- US Findings in Second & Third Trimesters
- MRI Findings
- Recent Literature - controversy
- Optimizing your US Diagnosis

Novel Pathologic Entity

- First described in the 20th century
- First reports in 1930’s
- Suggest that the entity did not exist or was quite rare before the 1930’s

Terminology

- Morbidly adherent placenta: abnormal implantation of the placenta into the uterine wall
- Placenta accreta: placental villi adhere directly to the myometrium
- Placenta increta: placental villi invade into the myometrium
- Placenta percreta: placental villi invade through the myometrium and into the serosa

Frequency

- Placenta accreta: 75%
- Placenta increta: 18%
- Placenta percreta: 7%

Surgery Gynecol Obstet 1937;64:178-200

Am J Obstet Gynecol 1997;177:210-214
**Pathogenesis**

**Three Theories**

- Primary defect of trophoblast function, leading to excessive invasion of myometrium
- Secondary basalis defect due to failure of normal decidualization in area of uterine scar allowing an abnormally deep trophoblastic infiltration
- An abnormal vascularization resulting from the scaring process after surgery with secondary localized hypoxia leading to both defective decidualization and excessive trophoblastic invasion


**Incidence**

- Overall is around 3/1000 deliveries
- Increase over past several decades
- Estimated at 1/10,000 in the 1960’s
- Main reason for increase is change in cesarean section rates


**Risk Factors**

**Cesarean Section/Placenta Previa**

- No previa
- Placenta Previa


**Risk Factors**

<table>
<thead>
<tr>
<th>TABLE 8.5 Risk Factors for Placenta Accreta</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Placenta previa and prior cesarean section</td>
</tr>
<tr>
<td>- Advanced maternal age</td>
</tr>
<tr>
<td>- Multiparity</td>
</tr>
<tr>
<td>- Prior uterine surgery</td>
</tr>
<tr>
<td>- Prior uterine irradiation</td>
</tr>
<tr>
<td>- Endometrial ablation</td>
</tr>
<tr>
<td>- Asherman’s syndrome</td>
</tr>
<tr>
<td>- Leiomyomas</td>
</tr>
<tr>
<td>- Uterine anomalies</td>
</tr>
<tr>
<td>- Hypertensive disorders in pregnancy</td>
</tr>
<tr>
<td>- Smoking</td>
</tr>
</tbody>
</table>

Abuhamed A - Ultrasound in Obstetrics and Gynecology: A Practical Approach

**Ultrasound Parameters**

<table>
<thead>
<tr>
<th>TABLE 8.6 Ultrasound Diagnostic Findings in Placenta Accreta</th>
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Abuhamed A - Ultrasound in Obstetrics and Gynecology: A Practical Approach

**Sonographic Findings**

**First Trimester**

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Sonographic Findings

**First Trimester**

- Sac implanted in lower segment (Prior CS)
- Multiple irregular vascular spaces

Ultrasound Obstet Gynecol 2006;28:178-182

Sonographic Findings

**Gestational Sac Location**

- Database of 90,435 births
- Placenta accreta in 20
- First trimester scan in 7/20
- Sac in lower segment in 6/7

J of Ultrasound in Med 2003;22:19

Gestational Sac Location

Table 1. Summary of Patients

<table>
<thead>
<tr>
<th>Pt</th>
<th>Prex Cad</th>
<th>GA Scan wk</th>
<th>Scan Location</th>
<th>Procedure</th>
<th>Pathologic</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>6.5</td>
<td>Low</td>
<td>Laparotomy</td>
<td>Placenta</td>
<td>Yes</td>
</tr>
<tr>
<td>2</td>
<td>4</td>
<td>6</td>
<td>Low</td>
<td>Laparotomy</td>
<td>Accreta</td>
<td>No</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
<td>6</td>
<td>Low</td>
<td>Laparotomy</td>
<td>Accreta</td>
<td>Yes</td>
</tr>
<tr>
<td>4</td>
<td>2</td>
<td>6</td>
<td>Low</td>
<td>Laparotomy</td>
<td>Accreta</td>
<td>Yes</td>
</tr>
<tr>
<td>5</td>
<td>2</td>
<td>10</td>
<td>Low</td>
<td>Laparotomy</td>
<td>Accreta</td>
<td>Yes</td>
</tr>
<tr>
<td>6</td>
<td>2</td>
<td>6</td>
<td>Low</td>
<td>Laparotomy</td>
<td>Accreta</td>
<td>Yes</td>
</tr>
<tr>
<td>7</td>
<td>0</td>
<td>10</td>
<td>Laparotomy</td>
<td>Placenta</td>
<td>Accreta</td>
<td>Yes</td>
</tr>
</tbody>
</table>

GA indicates gestational age at first scan, C/I, iPhone scan unit, NA, not applicable, Prex Cad, previous cesarean delivery, Placenta, Accreta, Accreta (uterine scar), Hemoperitoneum (blood within the peritoneal cavity).
Cesarean Scar Pregnancy
Post Treatment with MTX into Sac (10 days)

Sonographic Findings
Second & Third Trimester
15 – 20 Weeks

Sonographic Findings
Multiple vascular lacunae within placenta at 15 – 20 weeks

Sonographic Findings
Multiple vascular lacunae within placenta at 15 – 20 weeks

Sonographic Findings
Multiple vascular lacunae within placenta at 15 – 20 weeks

Sonographic Findings
Second & Third Trimester
Beyond 20 Weeks

Table II Sensitivity and positive predictive value of ultrasound diagnostic criteria for placenta accreta at 15 to 20 weeks of gestational age

<table>
<thead>
<tr>
<th>Diagnostic criteria</th>
<th>Sensitivity</th>
<th>Specificity</th>
<th>Positive predictive value</th>
</tr>
</thead>
<tbody>
<tr>
<td>14/14</td>
<td>10/10</td>
<td>90%</td>
<td>90%</td>
</tr>
<tr>
<td>13/12</td>
<td>9/9</td>
<td>90%</td>
<td>90%</td>
</tr>
<tr>
<td>12/11</td>
<td>8/8</td>
<td>90%</td>
<td>90%</td>
</tr>
<tr>
<td>11/9</td>
<td>7/7</td>
<td>90%</td>
<td>90%</td>
</tr>
<tr>
<td>10/8</td>
<td>6/6</td>
<td>90%</td>
<td>90%</td>
</tr>
<tr>
<td>9/7</td>
<td>5/5</td>
<td>90%</td>
<td>90%</td>
</tr>
<tr>
<td>8/6</td>
<td>4/4</td>
<td>90%</td>
<td>90%</td>
</tr>
<tr>
<td>7/5</td>
<td>3/3</td>
<td>90%</td>
<td>90%</td>
</tr>
<tr>
<td>6/4</td>
<td>2/2</td>
<td>90%</td>
<td>90%</td>
</tr>
<tr>
<td>5/3</td>
<td>1/1</td>
<td>90%</td>
<td>90%</td>
</tr>
<tr>
<td>4/2</td>
<td>0/0</td>
<td>90%</td>
<td>90%</td>
</tr>
</tbody>
</table>

*Details from one abnormal finding that was not confirmed by a follow-up scan.

Multiple vascular lacunae within placenta

*Personal Observation*
Multiple vascular lacunae have very high predictive power in association with a placenta previa
Pathogenesis of Placental Lacunae

Placental tissue alterations resulting from long-term exposure to pulsatile blood flow

Lacunae – Blood Flow

Gray Scale

Lacunae – Blood Flow

Color Doppler

Lacunae – Blood Flow

Lacunae in Placenta Accreta

Table 3. Utility of lacunae in the diagnosis of PAD

<table>
<thead>
<tr>
<th>Study</th>
<th>Sensitivity (%)</th>
<th>Specificity (%)</th>
<th>PPV</th>
<th>NPV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cali et al. 35</td>
<td>73</td>
<td>86</td>
<td>60</td>
<td>90</td>
</tr>
<tr>
<td>Cornstock et al. 34</td>
<td>93</td>
<td>93</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wong et al. 39</td>
<td>100</td>
<td>28</td>
<td>21</td>
<td>100</td>
</tr>
<tr>
<td>Yang et al. 37, Gr. 1</td>
<td>86.9</td>
<td>78.6</td>
<td>76.9</td>
<td>88</td>
</tr>
<tr>
<td>Yang et al. 34, Gr. 2</td>
<td>100</td>
<td>97.2</td>
<td>93.8</td>
<td>100</td>
</tr>
<tr>
<td>Gr 1 = grade 1 (one to three lacunae), Gr. 2 = grade 2 (four to six lacunae)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Sonographic Findings

Multiple vascular lacunae within placenta (# Lacunae)

Table 2. Distribution of adherent placentas according to lacunar grade

<table>
<thead>
<tr>
<th>Adherent placenta</th>
<th>Grade 0 (n = 25)</th>
<th>Grade 1 (n = 10)</th>
<th>Grade 2 (n = 11)</th>
<th>Grade 3 (n = 5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>22</td>
<td>6</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Accreta</td>
<td>3</td>
<td>4</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Incresa</td>
<td>—</td>
<td>—</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Percuta</td>
<td>—</td>
<td>—</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>25</td>
<td>10</td>
<td>11</td>
<td>5</td>
</tr>
</tbody>
</table>

**Sonographic Findings**

**Loss of hypoechoic retroplacental zone**

Also referred to as loss of clear space between placenta and uterus

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**Normal hypoechoic retroplacental zone**

---

**Loss of hypoechoic retroplacental zone**

---

**Loss of Hypoechoic Retroplacental Zone in Placenta Accreta**

<table>
<thead>
<tr>
<th>Author</th>
<th>Sensitivity (%)</th>
<th>Specificity (%)</th>
<th>PPV</th>
<th>NPV</th>
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<td>Cornstock et al.</td>
<td>73</td>
<td></td>
<td>14</td>
<td></td>
</tr>
<tr>
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<td>100</td>
<td>35</td>
<td>20</td>
<td>100</td>
</tr>
<tr>
<td>Calli et al.</td>
<td>90.2</td>
<td>80.8</td>
<td>57</td>
<td>96.7</td>
</tr>
</tbody>
</table>

*BJOG 2014;121:171–182*
Loss of hypoechoic retroplacental zone

- False positive rate of 21% or higher
- Should not be used alone
- Angle dependent, can be absent in normal anterior placentas

Sonographic Findings

- Abnormality of the uterine serosa-bladder interface
  - Interruption of line
  - Thickening of line
  - Irregularity of line
  - Increased vascularity on color Doppler

Normal uterine serosa-bladder interface

Abnormality of the uterine serosa-bladder interface
Bladder Wall in Placenta Accreta

Table 2. Utility of interrupted bladder line in the diagnosis of PAD

<table>
<thead>
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<th>Study</th>
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<th>Specificity (%)</th>
<th>PPV</th>
<th>NPV</th>
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<tbody>
<tr>
<td>Cali et al.</td>
<td>70</td>
<td>99</td>
<td>96</td>
<td>92</td>
</tr>
<tr>
<td>Corstocck et al.</td>
<td>20</td>
<td>75</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wong et al.</td>
<td>11</td>
<td>100</td>
<td>100</td>
<td>88</td>
</tr>
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BJOG 2014;121:171–182

3D Ultrasound - Bladder

Sonographic Findings

Other Signs

- Retroplacental myometrial thickness of < 1 mm
- Turbulent blood flow through the lacunae on Doppler ultrasonography
- Abnormal bridging vessels on color Doppler

Prenatal identification of invasive placenta using ultrasound: systematic review and meta-analysis

F. D’ANTONIO, C. IACOVELLA and A. BHIDE

| MRI Findings |
| Uterine bulging |
| Heterogeneous signal intensity within the placenta |
| Dark intra-placental bands on T2-weighted images |
| Abnormal placental vascularity |
| Focal interruptions in the myometrial wall |
| Tenting of the bladder |
| Direct visualization of invasion of near organs |

AJR 2011:197:1549–1551
MRI Findings
Direct visualization of invasion of near organs

Clinical Radiology 2009; 64:511-516

Prenatatal identification of invasive placentation using magnetic resonance imaging: systematic review and meta-analysis

Ultrasound Obstet Gynecol 2014;44:8-16

MRI & Accreta

Fetal Imaging Forum - 2013

MRI may be useful in determining
- Extent of invasion and involvement of structures when percreta is suspected
- When there is increased suspicion for placenta accreta based on clinical factors but the ultrasonography is nondiagnostic.


Accuracy of ultrasound for the prediction of placenta accreta
Zachary S. Bowman, MD, PAHA, Alphonse G. Ellis, MD, Anam M. Kamelev, MD, War, DO, Douglas S. Richarz, MD, Thomas G. Volpe, MD, MA, Paula L. Novinian, MD, Robert M. Silver, MD

Am J Obstet Gynecol 2014;211:177

Why Such Disparity?

How do I optimize my ultrasound diagnosis?

- Placental lacunae (OR 1.4 – 95% CI, 1.3-1.6)
- Loss of retroplacental space (OR 2.2 – 95% CI, 1.6-3.0)
- Irregular bladder wall (OR 1.3 – 95% CI, 1.0-1.6)
- Color Doppler abnormalities (OR 1.3 – 95% CI, 1.1-1.4)

Am J Obstet Gynecol 2014;211:177
How to Optimize US Diagnosis?

1-Understand Relevance of a-Priori Risk

| NIPT | NIPT + T18 |

Ultrasound Parameters

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Abuhamad A. - Ultrasound in Obstetrics and Gynecology: A Practical Approach

How to Optimize US Diagnosis?

2-Optimize Ultrasound Imaging

- Always use the transvaginal approach
- Evaluate placenta in real time
- Always add color Doppler in low velocity
- Carefully assess the lower segment / cervical area (look for cervical invasion)
- Develop expertise

Ultrasound predictors of placental invasion: the Placenta Accreta Index

<table>
<thead>
<tr>
<th>Parameter</th>
<th>OR 90% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade-3 lacunae</td>
<td>10.8 1.4–83</td>
</tr>
<tr>
<td>No. of cesarean deliveries</td>
<td>9.6 2.5–37.1</td>
</tr>
<tr>
<td>Placental location</td>
<td>3.9 1.1–14.1</td>
</tr>
<tr>
<td>Grade-2 lacunae</td>
<td>2.9 0.6–12.7</td>
</tr>
<tr>
<td>Bridging vessels</td>
<td>2.3 0.6–8.7</td>
</tr>
<tr>
<td>Sagittal smallest myometrial thickness</td>
<td>1.0 0.8–1.2</td>
</tr>
</tbody>
</table>

Am J Obstet Gynecol 2014

Invasion of Cervical Stroma

Ultrasound Marker for PPH

SMFM Pregnancy Meeting 2015 – Poster # 261

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Risk for Accreta?

How to Optimize US Diagnosis?

- Until we have large prospective data on US diagnosis,

How to Optimize US Diagnosis?

- High-risk for bleeding
- Intermediate-risk for bleeding
- Low-risk for bleeding

High-risk for Bleeding

Low Risk for Bleeding

Intermediate Risk for Bleeding
Intermediate Risk for Bleeding

Ultrasound predictors of placental invasion: the Placenta Accreta Index
Martins W. Y. Kai, MD and S. Braun, MD C; Andrew Wells, MD, Yvonne Necheles, MD; Ronald D. McIntire, PhD, Diane M. Yauk, MD

<table>
<thead>
<tr>
<th>Risk</th>
<th>Sensitivity</th>
<th>Specificity</th>
<th>Positive Predictive Value</th>
<th>Negative Predictive Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>25%</td>
<td>75%</td>
<td>60%</td>
<td>70%</td>
</tr>
<tr>
<td>Medium</td>
<td>60%</td>
<td>50%</td>
<td>70%</td>
<td>60%</td>
</tr>
<tr>
<td>High</td>
<td>75%</td>
<td>60%</td>
<td>80%</td>
<td>50%</td>
</tr>
</tbody>
</table>

Am J Obstet Gynecol 2014

How to Optimize US Diagnosis?

5-Be Conservative

- High-index of suspicion
- When in doubt – call intermediate risk
- False + results are OK

Management

EVMS Accreta Clinic

- Diagnosis is based on probability; low risk – moderate risk – High risk
- Patients seen in one clinic – Accreta Clinic
- Protocol for preoperative coordination of care
- Check list to ensure adequate preoperative preparation & counseling
- Multidisciplinary team – MFM, Ob Anesthesia, Intervention radiology, Urology All
- All surgery in main OR
- ICU postop care

Multidisciplinary Care Team

- Experienced pelvic surgeon /maternal – fetal medicine
- Skilled nursing team
- Blood bank team
- Experienced anesthesia team
- Skilled urologist
- Experienced intensivist
- Experienced interventional radiologist

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Multidisciplinary Care Team

Planned Delivery

• 93% of patients with placenta accretas report hemorrhage after 35 weeks

Planned Delivery

• Associated with shorter OR times
• Lower frequency of transfusions
• Lower ICU admission

Planned Delivery

Massive Transfusion

• Recommend a 1:1 ratio of pRBC to FFP

Surgical Management

• Consider transfer to a tertiary center
• Consider ultrasound mapping of placental implantation site preoperatively
• Cesarean hysterectomy with placenta left in situ
• Staged surgical approach (intervention radiology)
• Conservative management
Conservative Treatment
Placenta left in situ

Total cases 167
Successful conservative management 131 (78%)
Spontaneous placental resorption 87 (75%)
Severe maternal morbidity 10 (6%)
Practical Approach to Ultrasound in Obstetrics and Gynecology

June 24 – July 1, 2017

Canada North East Discovery aboard Ms. Veendam Holland America
Sail from Boston, Massachusetts to Montreal, Canada

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