

# Sonographic Assessment of Fetal Growth

## 2018 Gottesfeld Hohler Memorial Foundation Resident Ultrasound Course

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# Learning Objectives

1. Understand how to perform sonographic biometric measurements
2. Understand the utility and limitations of biometric measurements as a tool to assess the GA & EFW
3. Be familiar with the approaches for fetal size assessment
4. Discuss specific clinical scenarios of abnormal fetal growth
5. Be familiar with Doppler studies used in monitoring fetuses with growth restriction

# Importance of Fetal Biometry

- **Pregnancy Dating**
  - Pre-term Vs post-term
- **Fetal Growth**
  - FGR Vs Macrosomia



# Sonographic Criteria for Dating Pregnancies

## Why is it needed?



The American College of  
Obstetricians and Gynecologists  
WOMEN'S HEALTH CARE PHYSICIANS

The association for medical ultrasound  
**aium**  
AMERICAN INSTITUTE OF ULTRASOUND IN MEDICINE

 Society for  
Maternal-Fetal  
Medicine

## COMMITTEE OPINION

Number 611 • October 2014

(See also Committee Opinion No. 579)

### Method for Estimating Due Date

Committee on Obstetric Practice  
American Institute of Ultrasound in Medicine  
Society for Maternal-Fetal Medicine

*This document reflects emerging clinical and scientific advances as of the date issued and is subject to change. The information should not be construed as dictating an exclusive course of treatment or procedure to be followed.*



# Limitations of Menstrual Age (LMP)

- Do not recall:
  - Only 71% could accurately recall LMP

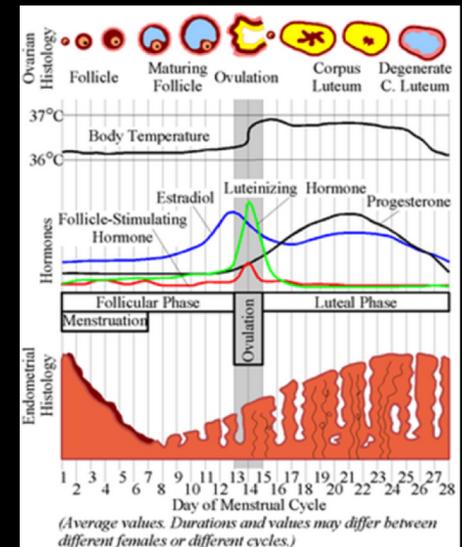
*Anderson HF et al. Am J ObstetGynecol 1981; 140: 770–4*

- Misunderstand the question

- Unreliable / Irregular

- Oligomenorrhea
- AUB
- OCP
- Smoking
- Ovulating early/ late

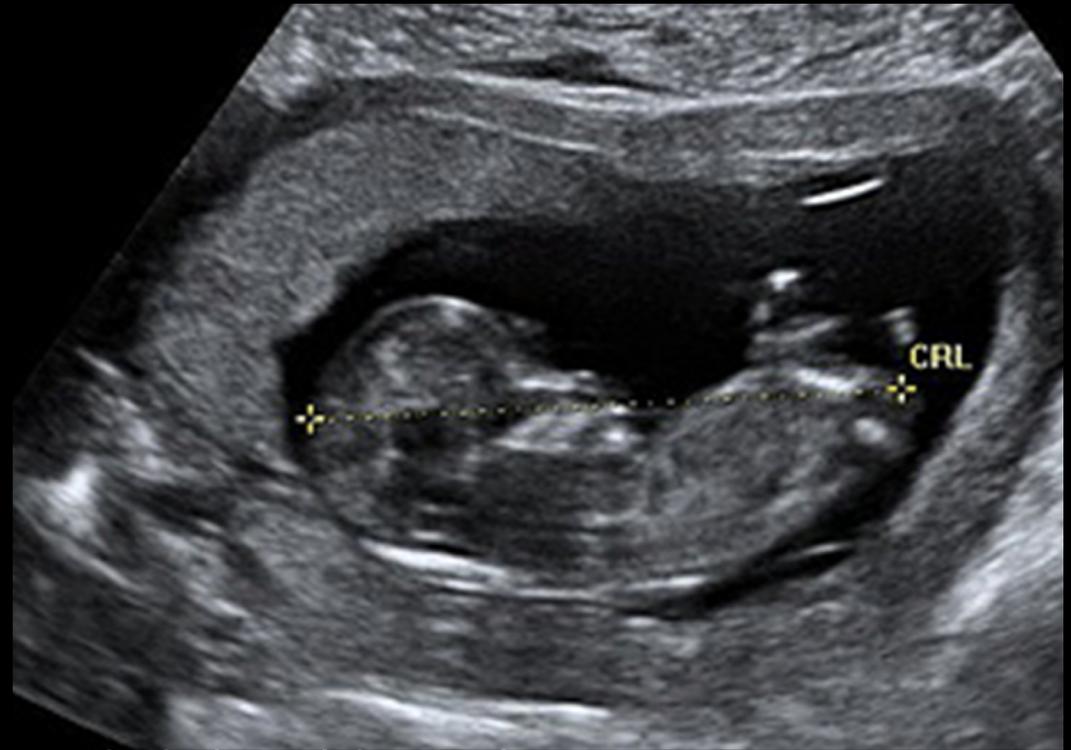
- “Early or late ovulation occurs in 20% of the population.”



J Jpn Obstet Gynecol Soc. 1962 Jun;14:523-41

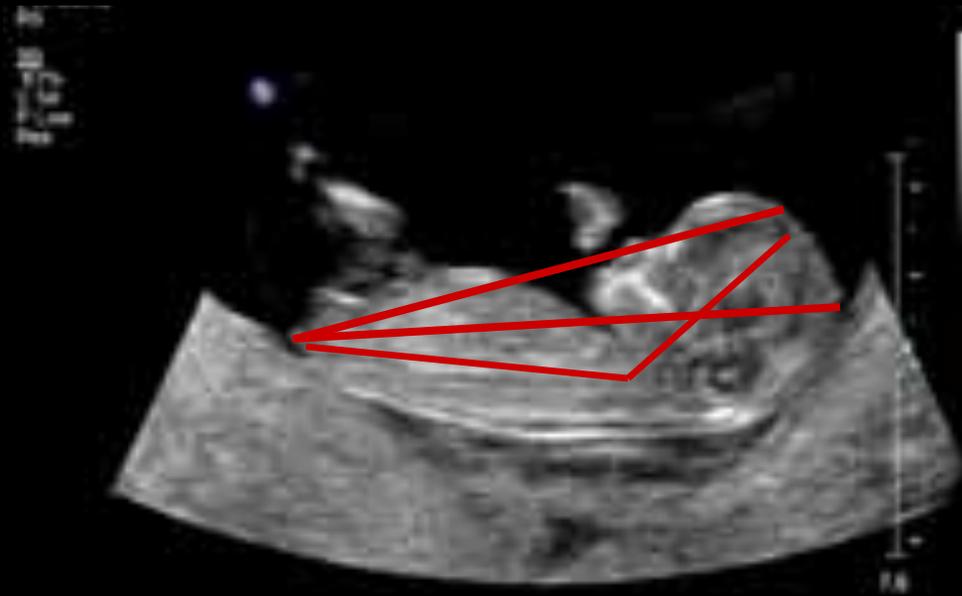
# Accurate Dating is Crucial for Assessment of GA & Fetal Growth

- Most accurate dating: Crown rump length (CRL) at 7-14 weeks
  - Maximum length
  - Use average of 3
  - +/- 5-7 days



- If ART: age of embryo and date of transfer

# Crown-Rump Length = Longest straight line



- Outer margin of the cephalic pole to the rump

# **2<sup>nd</sup> /3<sup>rd</sup> Trimester Estimated Fetal Weight**

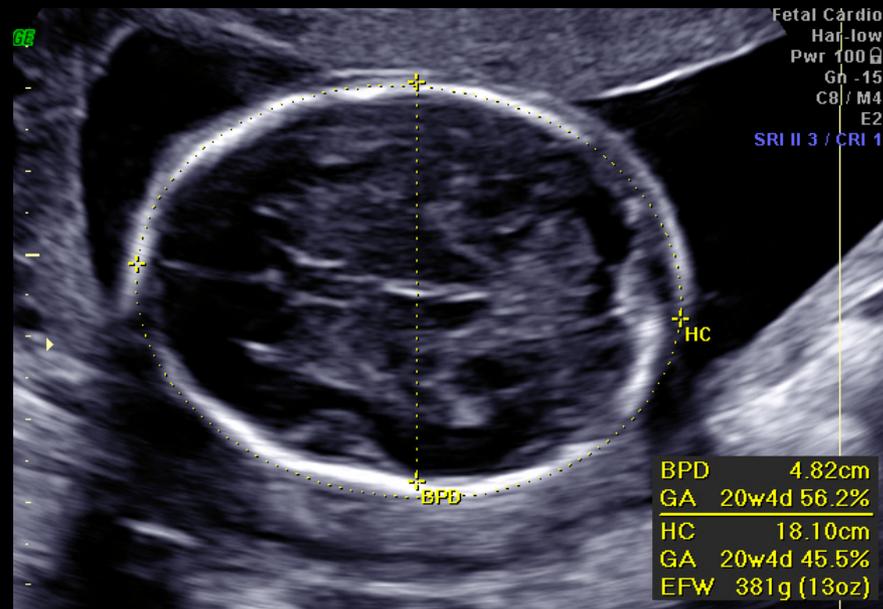
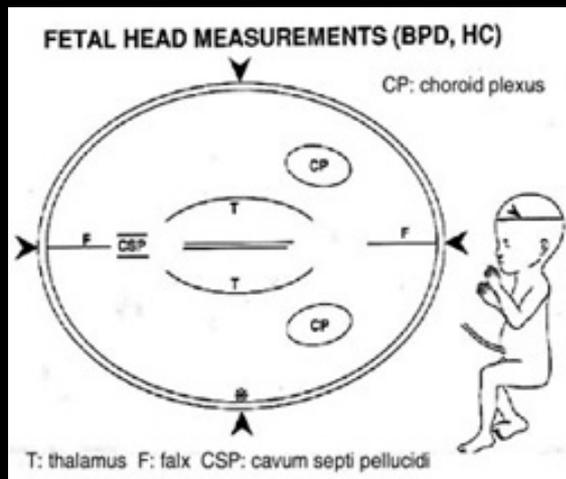
- **> 14 weeks CRL replaced by Calculation of EFW based on formulas that use measurements of a variety of fetal body parts**
  - **Biparietal diameter (BPD)**
  - **Head circumference (HC)**
  - **Abdominal circumference (AC)**
  - **Femur length (FL)**
  
  - **The predicted weight  $\approx$  +/- 15% of the actual weight in most cases**

# How to Perform Biometric Measurements

- **Proper technique**
- **Good image**
- **Average of three**

# 2<sup>nd</sup> /3<sup>rd</sup> Trimester: BPD/ HC

- Axial/transverse plane (symmetrical calvaria)
- Perpendicular to the parietal bones
- Plane includes: 3rd ventricle, thalami, CSP
- Outer to inner echo-dense parietal bone
- Skin excluded

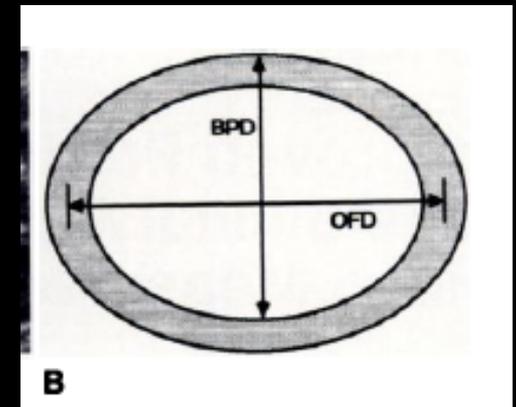
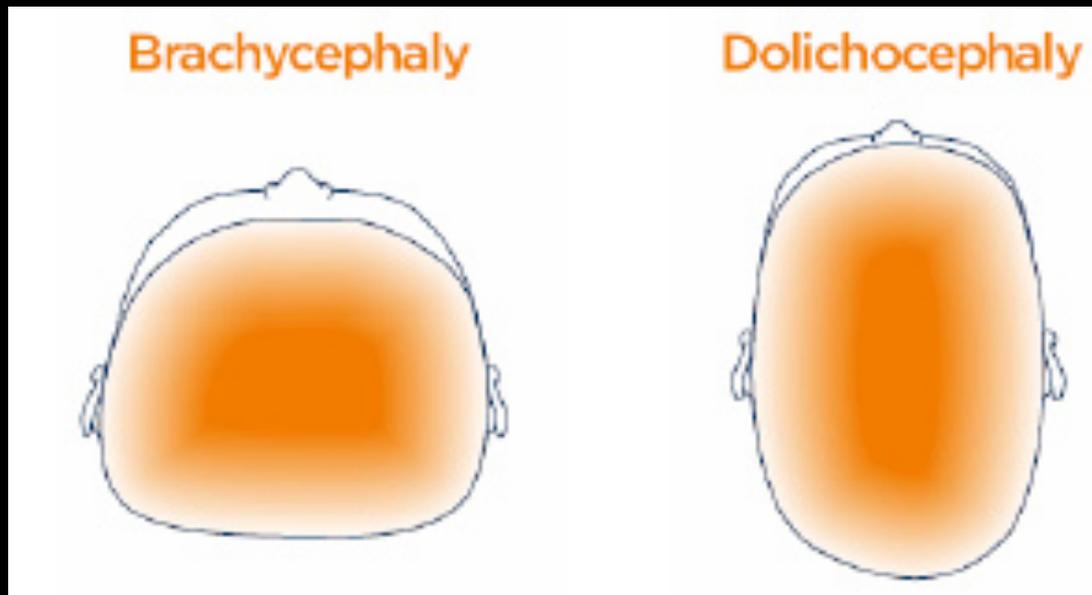


# Biparietal Diameter (BPD)

- The BPD is the most studied biometric parameter
  - Between 14 and 20 weeks of gestation age: accuracy of  $\pm 7$  days
  - Test performance diminishes as the gestation progresses: mid to late third trimester, the margin of error is 3-4 weeks

# Head Shape & BPD

- Breech presentations
- Oligohydramnios
- PPRM
- Neural tube/ cranial abnormalities



# Head Circumference

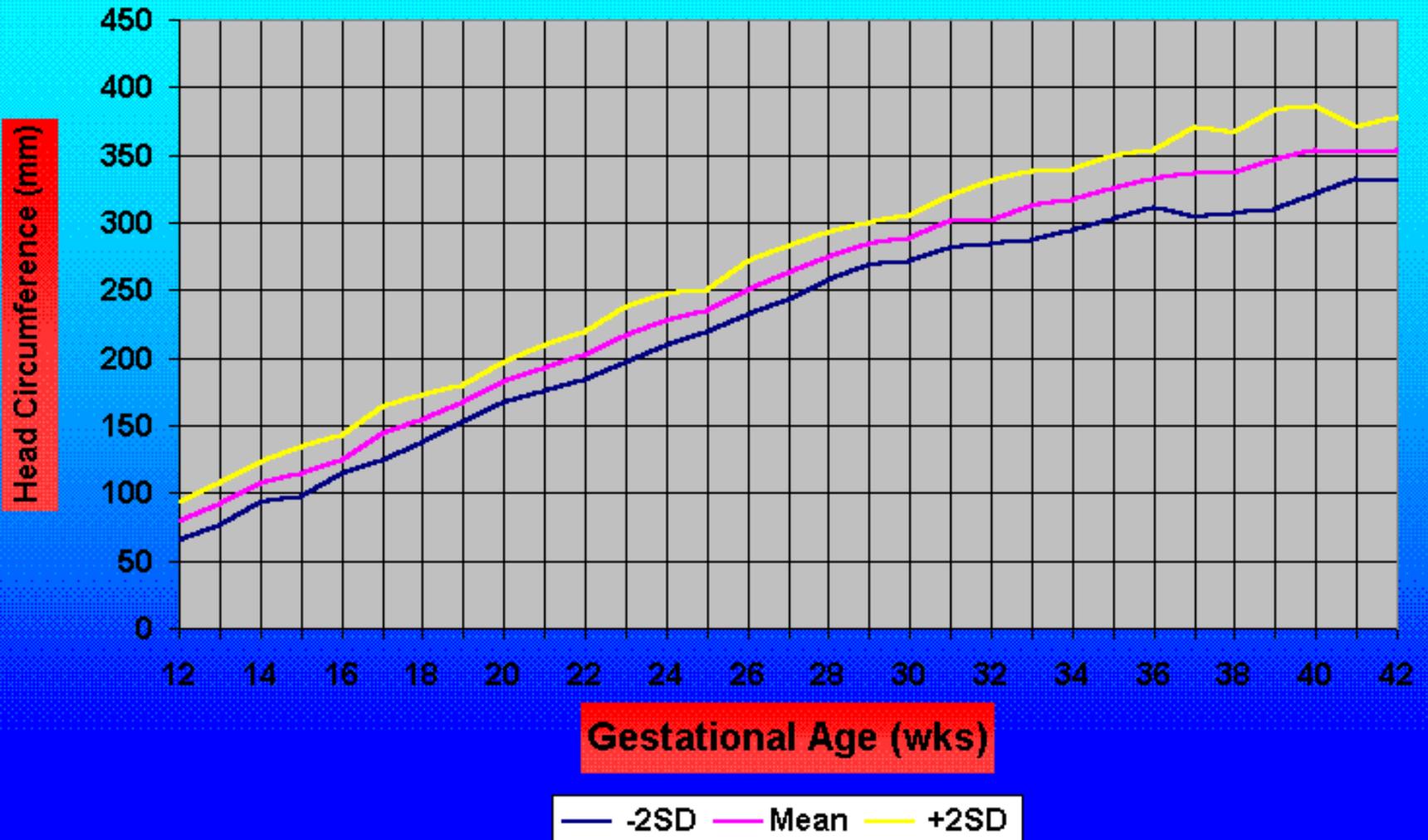
- Independent of head shape
  - Superior to BPD
- Same plane as BPD
- Cursor on the outer margins of calvarium bilaterally
- Skin excluded



Measured directly or calculated  $HC = (BPD + OFD) \times 1.57$

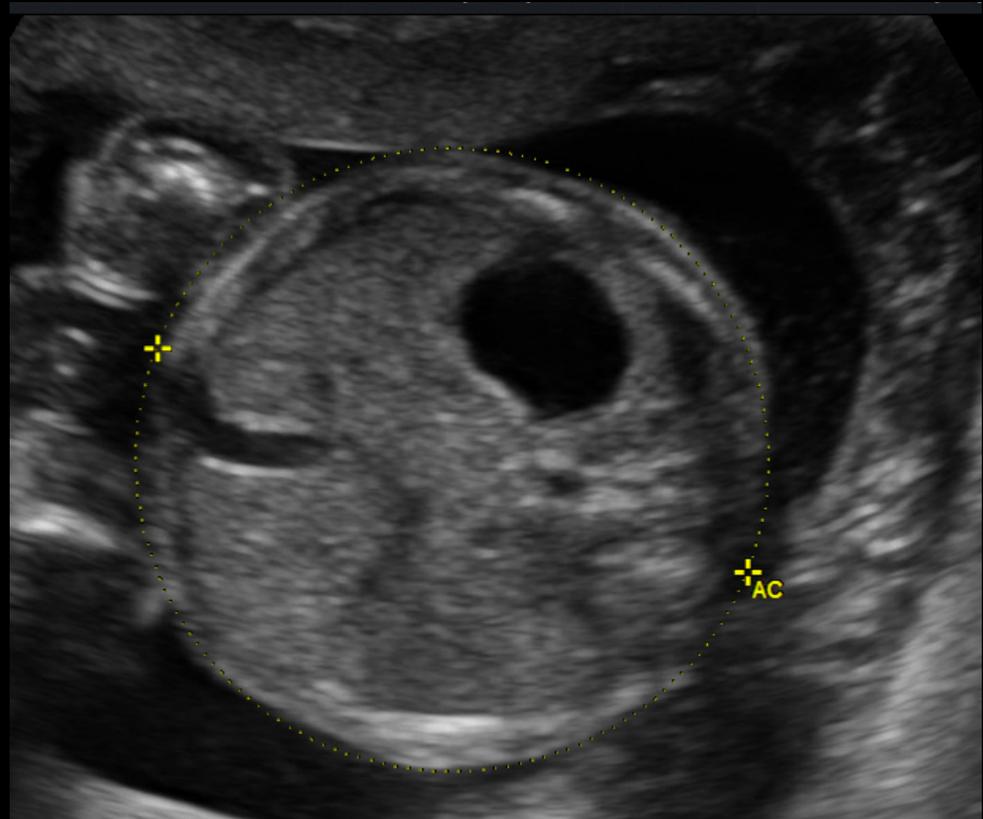
# Head Circumference

Chervenak FA et.al. Ultrasound in Obstetrics and Gynecology 1992;Table A1-3;pg 1778. Boston: Little, Brown and Company.

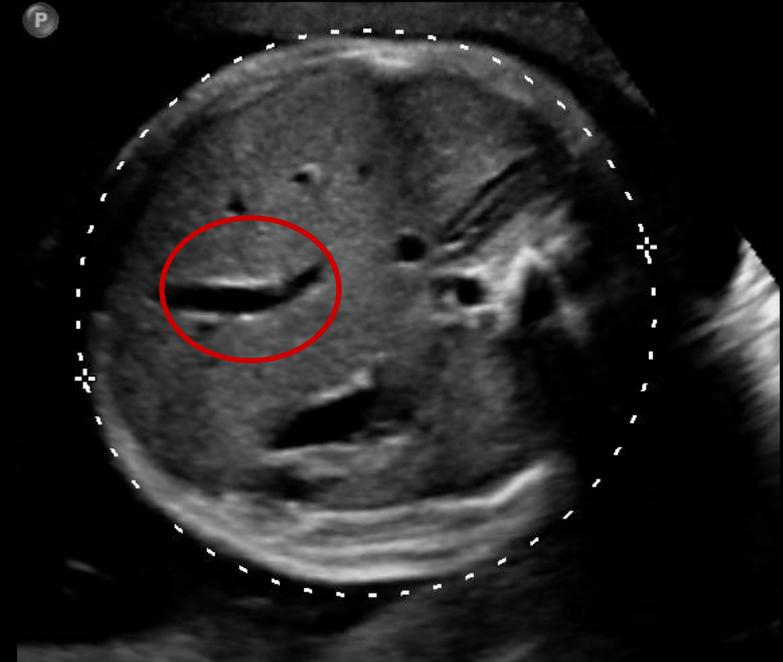


# Abdominal Circumference

- Perpendicular to abdominal wall
- True transverse plane (complete ribs)
- Measured at the largest diameter of the liver
- Level of umbilical vein & fetal stomach
- Include the skin edges



# Abdominal Circumference

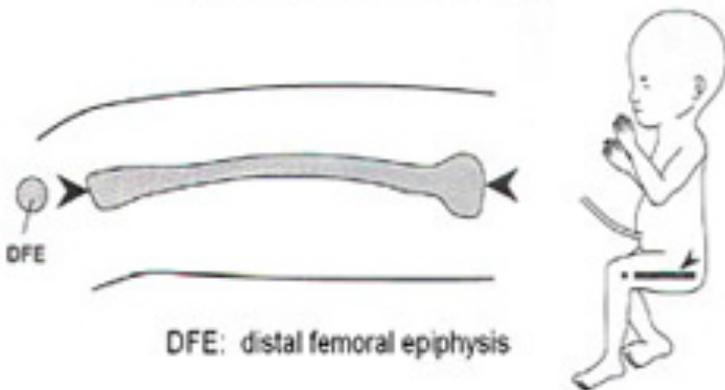


- The image is taken at the level of the largest diameter of the fetal liver: the point of union of the right and left portal veins, which has a "hockey stick" appearance

# Femur Length

- Transducer perpendicular to the long axis of femur
- Measure the longest ossified femur portion (exclude the distal femoral epiphysis)

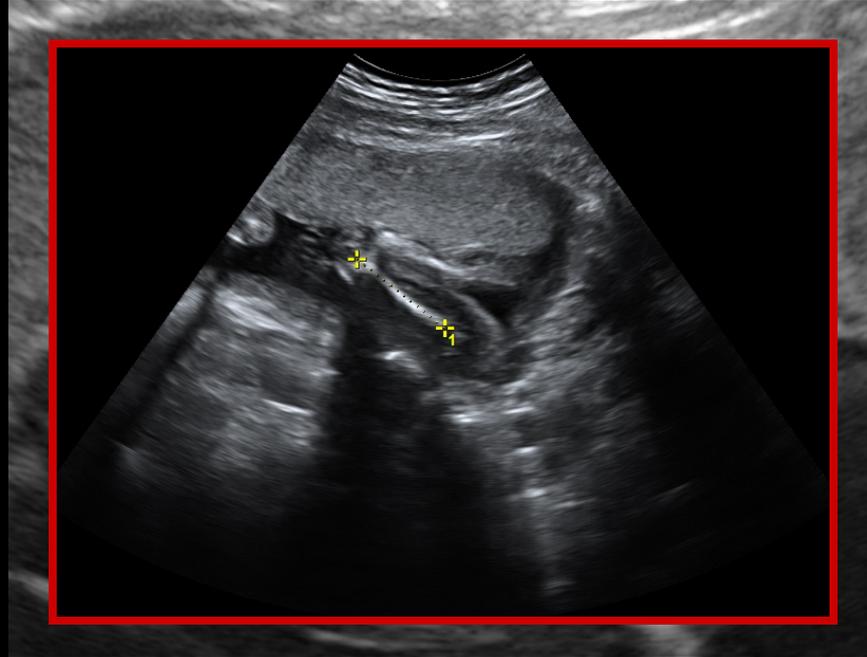
## FETAL FEMUR LENGTH



Source: Callen, Peter, "Ultrasonography in Obstetrics and Gynecology", 3<sup>rd</sup> edition, 1994, WB Saunders Company, Philadelphia.

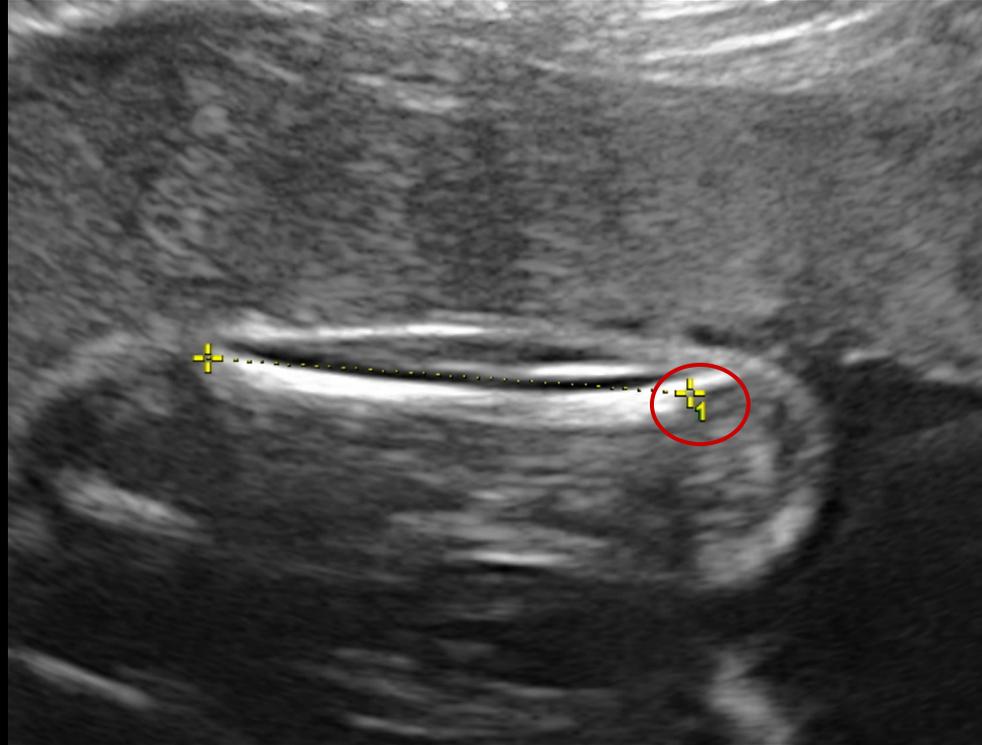


# Femur Length



- **Transducer aligned perpendicular to the long axis of the bone**

# Femur Length



- **The longest femoral length should be accepted**
- **Calipers at the junction of bone and cartilage to measure only ossified bone**
- **Exclude the distal femoral epiphysis**

# Biometry Variability

Parameter	20-26 wks	26-32 wks	32-42 wks
BPD	$\pm 2.1$	$\pm 3.8$	$\pm 4.1$
HC	$\pm 1.9$	$\pm 3.4$	$\pm 3.8$
AC	$\pm 3.7$	$\pm 3.0$	$\pm 4.5$
FL	$\pm 2.5$	$\pm 3.1$	$\pm 3.5$

Adapted from Hadlock FP. AJR Am J Roentgenol 138:649, 1982

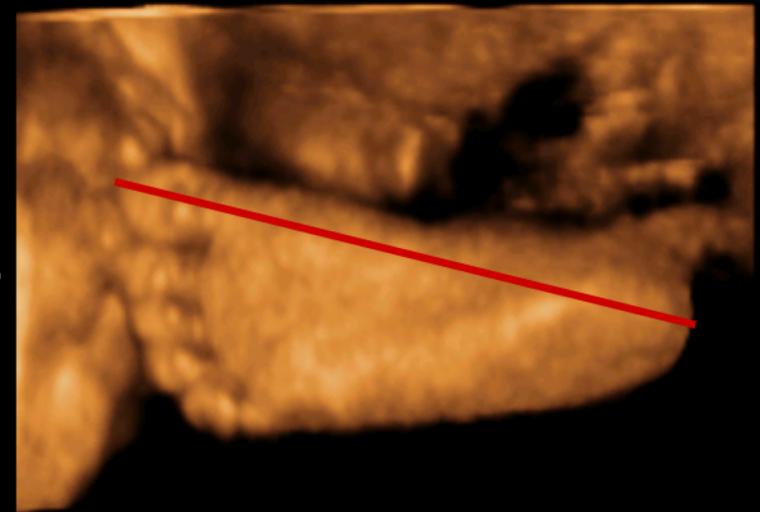
# ACOG/SMFM/AIUM

## Guidelines for Dating Based on Ultrasonography

Menstrual Age Range	Method of Measurement	Re-Dating Criteria US vs LMP Discrepancy
<b>13 6/7 wk</b> $\leq 8\ 6/7\ wk$ 9 0/7 - 13 6/7 wk	CRL	$> 5\ days$ $> 7\ days$
14 0/7 - 15 6/7 wk	BPD, HC, AC, FDL	$> 7\ days$
16 0/7 - 21 6/7 wk	BPD, HC, AC, FDL	$> 10\ days$
22 0/7 - 27 6/7 wk	BPD, HC, AC, FDL	$> 14\ days$
<b><math>&gt; 28\ 0/8\ weeks</math></b> <small>ACOG Committee Opinion No. 611. Obstet Gynecol 2014;124:863-6</small>	BPD, HC, AC, FDL	$> 21\ days$

# Non-traditional Measurements

- Unknown date in advanced gestation (late 2nd/3<sup>rd</sup> trimester)
- Distinguish between IUGR & dating errors
  - **Trans-cerebellar diameter**
  - Fetal foot
  - Long bones
  - Outer & inner orbital distance
  - Kidney length



# Transcerebellar Diameter

- **Axial view**
- **Outer, lateral edges**



- **Not affected by race**
- **Not affected by head shape**
- **Not affected by FGR**

# Fetal Transcerebellar Diameter Measurement for Prediction of Gestational Age at the Extremes of Fetal Growth

*Martin R. Chavez, MD, Cande V. Ananth, PhD, MPH,  
John C. Smulian, MD, MPH, Anthony M. Vintzileos, MD*

**Fetal transcerebellar diameter measurement with particular emphasis in the third trimester: A reliable predictor of gestational age**

Martin R. Chavez, MD,<sup>a</sup> Cande V. Ananth, PhD, MPH,<sup>b</sup> John C. Smulian, MD, MPH,<sup>a</sup> Lami Yeo, MD,<sup>a</sup> Yinka Oyelese, MD,<sup>a</sup> Anthony M. Vintzileos, MD<sup>a</sup>

- **“Reliable and accurate in predicting gestational age, even extremes of fetal growth.”**

# Estimation Fetal Weight

- The biometric parameters are used for EFW calculation by comparison to a **population-based standard**
- Multiple models
- Several population based formulas

**Table 1.** Formulas Selected for the Study

Parameters	Reference <sup>a</sup>	Formula
AC, BPD	Thurnau et al <sup>7</sup>	$BW = (BPD \times AC \times 9.337) - 229$
	Shepard et al <sup>16</sup>	$\text{Log}_{10} BW = 0.166(BPD) + 0.046(AC) - 0.002546(AC)(BPD) - 1.7492$
	Hadlock et al, A <sup>11</sup>	$\text{Log}_{10} BW = 1.1134 + 0.05845(AC) - 0.000604(AC)^2 - 0.007365(BPD)^2 + 0.000595(BPD)(AC) + 0.1694(BPD)$
AC, HC	Vintzileos et al <sup>8</sup>	$\text{Log}_{10} BW = 1.879 + 0.084(BPD) + 0.026(AC)$
	Warsof et al <sup>9</sup>	$\text{Log}_{10} BW = 0.144(BPD) + 0.032(AC) - 0.000111(BPD)^2(AC) - 1.599$
	Weiner et al, A <sup>10</sup>	$\text{Log}_{10} BW = 1.6575 + 0.04035(HC) + 0.01285(AC)$
AC, FL, BPD	Hadlock et al, B <sup>11</sup>	$\text{Log}_{10} BW = 1.182 + 0.0273(HC) + 0.07057(AC) - 0.00063(AC)^2 - 0.0002184(HC)(AC)$
	Hadlock et al, C <sup>12</sup>	$\text{Log}_{10} BW = 1.335 - 0.0034(AC)(FL) + 0.0316(BPD) + 0.0457(AC) + 0.1623(FL)$
	Combs et al <sup>15</sup>	$BW = 0.23718(AC)^2(FL) + 0.03312(HC)^3$
AC, FL, HC	Hadlock et al, D <sup>12</sup>	$\text{Log}_{10} BW = 1.326 - 0.00326(AC)(FL) + 0.0107(HC) + 0.0438(AC) + 0.158(FL)$
	Weiner et al, B <sup>10</sup>	$\text{Log}_{10} BW = 1.6961 + 0.02253(HC) + 0.01645(AC) + 0.06439(FL)$
	Ott et al <sup>13</sup> (BW in kg)	$\text{Log}_{10} BW = -2.0661 + 0.04355(HC) + 0.05394(AC) - 0.0008582(HC)(AC) + 1.2594(FL/AC)$
AC, FL, BPD, HC	Hadlock et al, E <sup>12</sup>	$\text{Log}_{10} BW = 1.3596 + 0.0064(HC) + 0.0424(AC) + 0.174(FL) + 0.00061(BPD)(AC) - 0.00386(AC)(FL)$
AD, FL, BPD	Rose and McCallum <sup>14</sup>	$\text{Ln} BW = 0.143(BPD + AD + FL) + 4.198$

AD indicates abdominal diameter.

<sup>a</sup>Letters were assigned to formulas if more than 1 formula was evaluated from the reference.

# Estimation Fetal Weight

## Sonographic Fetal Weight Estimation

Which Model Should Be Used?

*Nir Melamed, MD, MSc, Yariv Yogev, MD, Israel Meizner, MD,  
Reuven Mashiach, MD, Ron Bardin, MD, Avi Ben-Haroush, MD*

26 different birth weight prediction models

3,705 sonographic EFW < 3 days delivery

For most models, estimates were within 15% of actual BW in more than 80% of cases.

# Estimation Fetal Weight

- Considerable variation among different models, although most showed good overall accuracy.
- Models with 3 -4 biometric indices were better than models with only 1 or 2
- Accuracy decreased at BW extremes
  - Overestimation in low-BW
  - underestimation for BW > 4000 g

# Customized Birth Weight Standards

## Paediatric and Perinatal Epidemiology

Affiliated to the Society for Pediatric and Perinatal Epidemiologic Research

doi: 10.1111/j.1365-3016.2010.01155.x

1

## The case against customised birthweight standards

Jennifer A. Hutcheon<sup>a</sup>, Xun Zhang<sup>b</sup>, Robert W. Platt<sup>b,c</sup>, Sven Cnattingius<sup>d</sup> and Michael S. Kramer<sup>b,c</sup>

*<sup>a</sup>Department of Obstetrics & Gynaecology, University of British Columbia, Vancouver, Canada, <sup>b</sup>Department of Pediatrics, and <sup>c</sup>Department of Epidemiology, Biostatistics, and Occupational Health, McGill University, Montreal, Canada, <sup>d</sup>Clinical Epidemiology Unit, Department of Medicine, Karolinska Institutet, Stockholm, Sweden*

“Maternal characteristics accounted for only a small percent of total factors influencing BW. The best estimate of BW remains close to the population average, explaining the ineffectiveness of adjusting for maternal characteristics.”

# Individualized Growth Assessment

2nd ▲ growth velocities provide estimates of growth potential and predict 3rd TM size trajectories

- Each fetus serves as it's own control
- Biological variability is substantially reduced

# Fetal Growth Restriction

- Abnormal fetal growth- does not fulfill its growth potential
- Several definitions using arbitrary cutoffs:
  - EFW < 10<sup>th</sup> %ile ; AC < 5<sup>th</sup> %ile
- Not all growth restricted fetuses fall < 10<sup>th</sup> %ile
- Not all fetuses < 10<sup>th</sup> %ile are growth restricted
  - FGR Vs. Constitutionally small fetus?
- Multiple factors impact normal and abnormal fetal growth (maternal, placental, fetal)

# FGR Etiology: Maternal Conditions

- **Reduced utero-placental perfusion (Doppler studies)**
  - Hypertension
  - Renal disease
  - Cardiovascular disease
  - Diabetes
  - Collagen vascular disease
  - SLE
  - Antiphospholipid syndrome
  - Preeclampsia
- **Chronic Hypoxemia:**
  - Pulmonary disease
  - Cardiovascular disease
  - Severe Anemia
  - Hemoglobinopathies
  - High Altitude
- **Poor nutrition**
  - Low pre-pregnancy weight and weight gain
    - Celiac disease untreated
    - Starvation
- **Substance or Toxins**
  - Alcohol
  - Cocaine, narcotics
  - Smoking
  - Medications
  - Caffeine
  - Radiation
- **Maternal and Fetal Hormones**
  - Hypothyroidism (poor control)
- **Uterine malformations (unicornuate)**

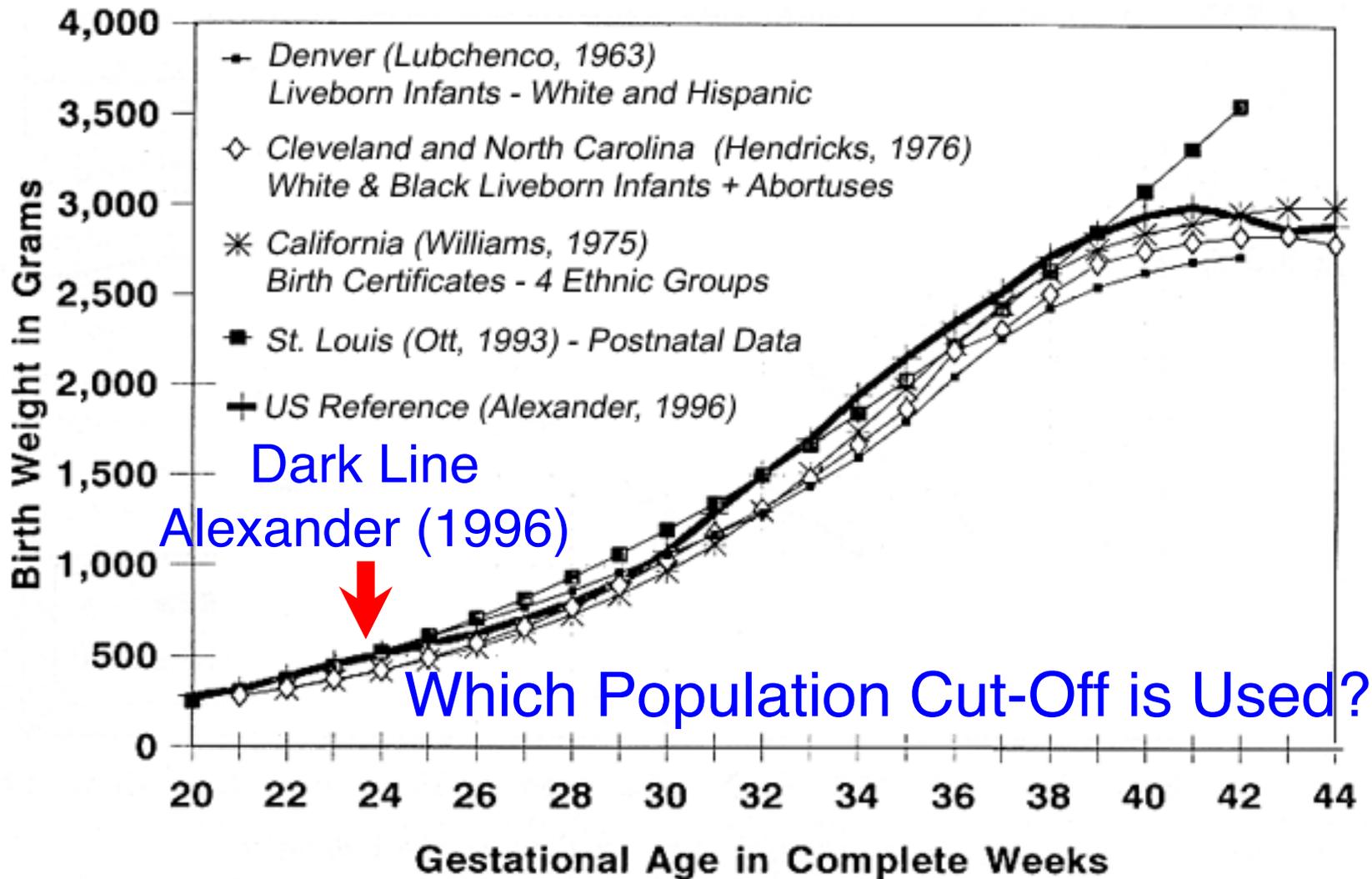
# FGR Etiology: Placental Factors

- **Impaired placental function (nutritional/ respiratory)**
  - Histological placental lesions (parenchymal or vascular)
  - Abnormal development, narrowing or obstruction of placental vessels
  - Separation at the placental maternal interface
  - Abnormal placentation
- **Confined placental mosaicism**
  - Infarcts & vasculopathy
  - 10% of idiopathic FGR placentas (0.5-1% in controls from CVS).
  - FGR depends on the chromosomes involved, level mosaicism, and presence of UPD
  - Normal long-term development (limited data)
- **Preeclampsia**
  - failure of trophoblast invasion of the spiral arteries (atherosis, occlusion, and infarction)
- **Gross placental/ cord anomalies (mild association)**
  - Single umbilical artery
  - Velamentous cord insertion
  - Bilobed placenta
  - Circumvallate placenta
  - Placental hemangioma
  - Placenta previa
- **Genetic**
  - Upregulation of leptin, CRH and IGF-binding protein-1 seen in microarray analysis of FGR placentae

# FGR Etiology: Fetal Factors

- **Genetic factors**
- **Congenital malformations**
- **Congenital infection**
  
- **Multiple gestations**

# Variable Definitions - FGR



# Adapted from Engl J Med 1999;340:1234-8

## BIRTH WEIGHT IN RELATION TO MORBIDITY AND MORTALITY AMONG NEWBORN INFANTS

DONALD D. MCINTIRE, PH.D., STEVEN L. BLOOM, M.D., BRIAN M. CASEY, M.D., AND KENNETH J. LEVENO, M.D.

12,317 singleton infants (1988-1996)  $\geq$  37 weeks gestation

Birth Weight %	$\leq$ 3rd	4th-5th	6-10th	11-15th	16-25th	26th-75th
Number of Infants	3184	2065	5254	5400	10,857	55,601
Apgar $\leq$ 3, 5 min	<b>7 (0.2)*</b>	1 (<0.1)	6 (0.1)	5 (0.1)	9 (0.1)	38 (0.1)
UA Cord pH $\leq$ 7.0	<b>28 (0.9)*</b>	12 (0.6)	28 (0.5)	27 (0.5)	37 (0.3)	212 (0.4)
Intubation Del Rm	<b>70 (2.2)*</b>	11 (0.5)	39 (0.7)	39 (0.7)	70 (0.6)	317 (0.6)
Seizures (1st 24 hrs)	<b>14 (0.4)*</b>	4 (0.2)	<b>14 (0.3)*</b>	9 (0.2)	16 (0.1)	68 (0.1)
Sepsis (+ blood cult)	<b>15 (0.5)*</b>	6 (0.3)	12 (0.2)	15 (0.3)	28 (0.3)	125 (0.2)
Death (1st 28 days)	<b>9 (0.3)*</b>	2 (0.1)	2 (<0.1)	3 (0.1)	3 (<0.1)	18 (<0.1)

\*  $p < 0.05$  refers to data compared to  
26th-75th percentile

# SGA Infant - Postnatal Sequelae

- IUFD
- neonatal morbidity
  - hypoglycemia
  - hyperbilirubinemia
  - hypothermia
  - IVH
  - NEC
  - Seizures, CP, Hearing loss
  - sepsis
  - RDS
- neonatal death
- cognitive delays & learning disabilities
- adult diseases (Barker's hypothesis)



# Detection of FGR by Ultrasound

Screening for fetal growth restriction with universal third trimester ultrasonography in nulliparous women in the Pregnancy Outcome Prediction (POP) study: a prospective cohort study

*Ulla Sovio, Ian R White, Alison Dacey, Dharmindra Pasupathy, Gordon C S Smith*

Prospective Cohort Study (2008-2012)

- 4,512 nulliparous Women
- fetal biometry at 20, 28, 36 weeks gestation

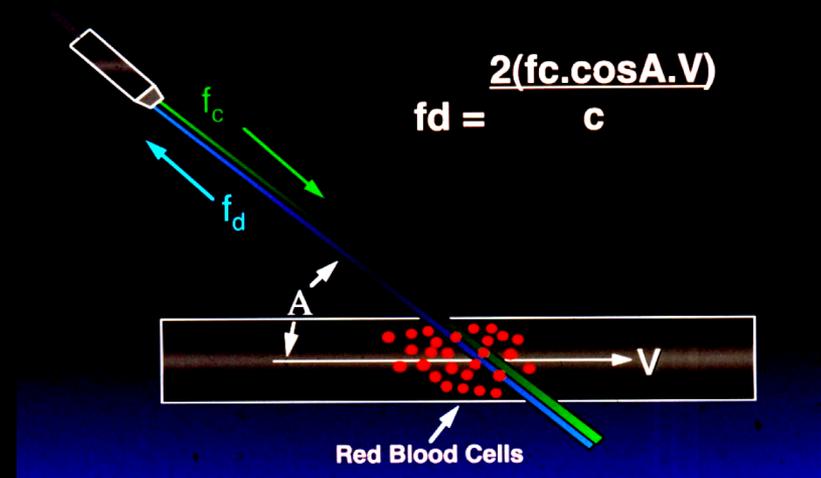
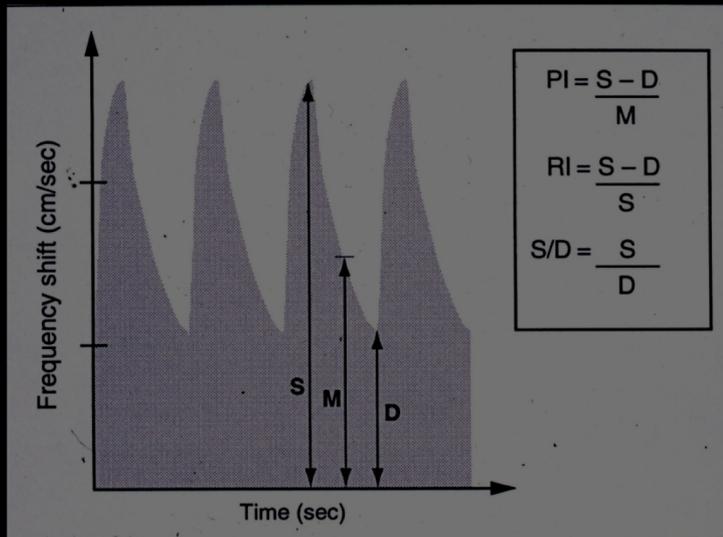
Universal 3rd trimester fetal biometry roughly tripled detection of SGA infants

# Tests Used When Estimated Fetal Weight Is <10th Percentile

- Non-stress test (NST)
- Amniotic fluid volume
- Biophysical profile
- Doppler velocimetry
  
- Frequency, in vs outpatient, Timing of delivery varies with clinical scenario

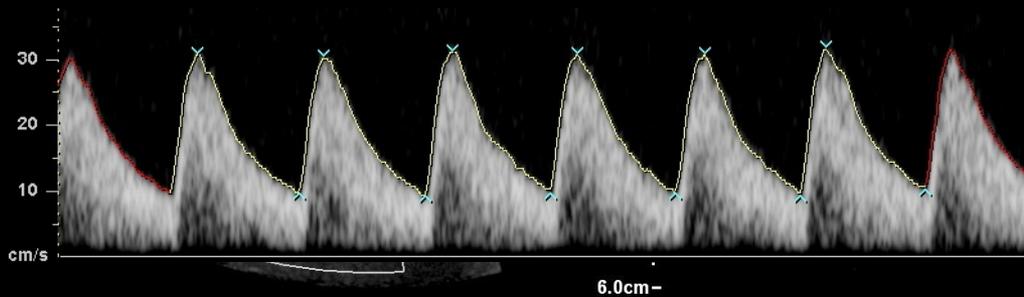
# Fetal Doppler

- Doppler frequency shift: The change in frequency observed which is proportional to the speed of RBC movement
- Using **Doppler**, the information on blood flow velocity in a vessel is calculated and presented as **waveform**
- Non invasive mode of assessing the fetal circulation

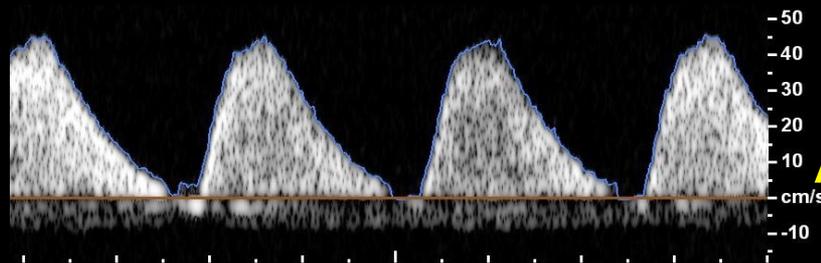


# Umbilical Artery Doppler

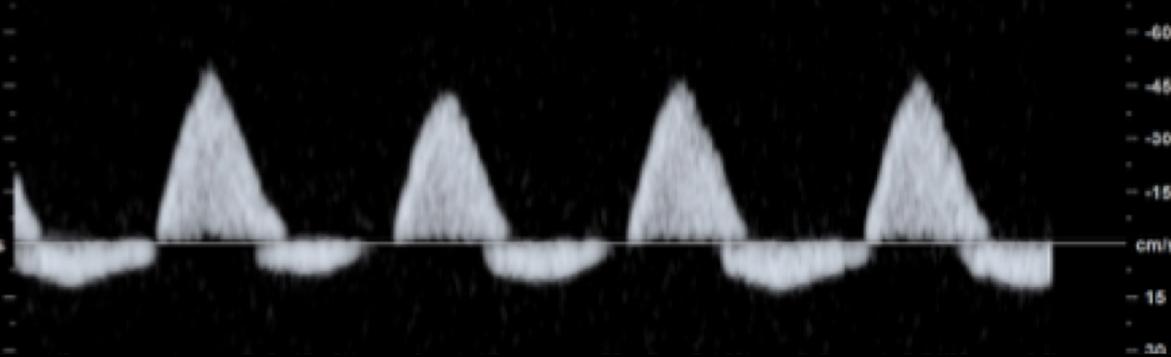
- Measure of placental resistance
- Indirect assessment of placental function



Normal S/D ratio



AEDF: Absent End Diastolic Flow

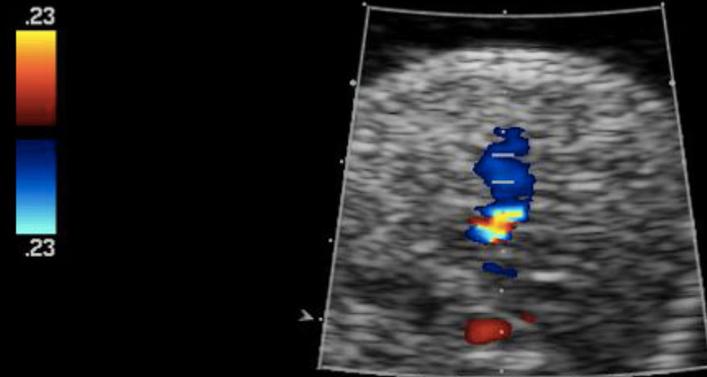


REDF

# Ominous Doppler Findings in FGR

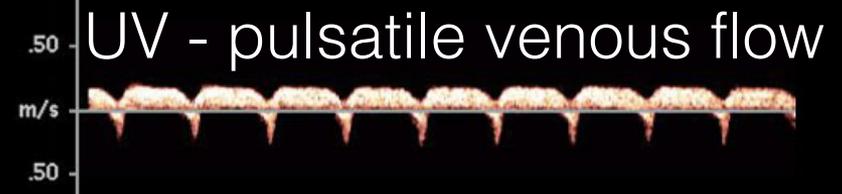


UA - reversed diastolic flow

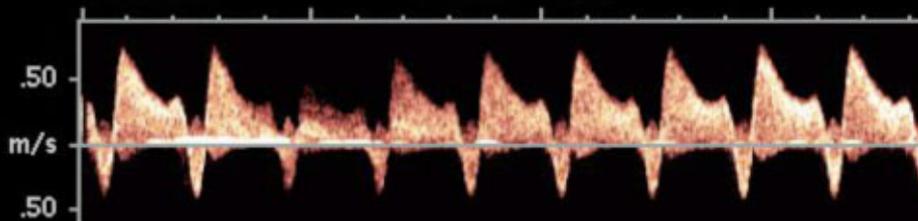


PW:3.5MHz

Inverted



UV - pulsatile venous flow



Ductus venosus - reversed diastolic flow

# Fetal Macrosomia

- Excessive fetal growth
- LGA: BW  $\geq$  90<sup>th</sup> %ile for given GA
- Macrosomia: BW  $\geq$  4000gm at any GA



## Fetal Risks:

- cesarean delivery
- shoulder dystocia
- clavicular fracture
- brachial plexus injury

# Fetal Macrosomia Prediction

- **“The diagnosis of fetal macrosomia is imprecise. For suspected macrosomia, the EFW using ultrasound biometry is no better than obtained with clinical palpation.” (Level A)**
- **The true value of ultrasonography in the management of suspected macrosomia may be its ability to rule out the diagnosis, which may help to avoid maternal morbidity (Level B)**

# Summary

- Ultrasound is a useful tool in assessing GA & EFW
  - 1<sup>st</sup> ▲ CRL
  - 2<sup>nd</sup>/3<sup>rd</sup> ▲ EFW based on measurements of several parameters
- Biometry & population based models predict birth weight with 15% accuracy
- Ultrasound plays a central role in both the diagnosis of FGR as well as monitoring FGR for fetal well being
  - BPP/ AFI/ Doppler studies
- Detection of macrosomia by ultrasound is imprecise

# Thank You

**Eran Bornstein, MD**  
**Director of Obstetrics,**  
**Maternal Fetal Medicine**  
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