OB/GYN Ultrasound Symposium 2018

Why Is Fetal Soft Tissue Assessment Important?

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Course Director

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Why is Fetal Soft Tissue Assessment Important?

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Learning Objectives

After completing this presentation, the participant should be able to:

1. Describe the rationale for evaluating fetal soft tissue
2. Discuss conventional approaches for soft tissue assessment using 2DUS
3. Explain how 3DUS can be used to measure fractional limb volume
4. Summarize advantages and limitations for using FLV to improve the precision of estimated fetal weight

Financial Disclosures

I have no relationships with commercial companies that could be perceived as a conflict of interest although the following relationships are disclosed:

- Samsung: Limited Research Support
- Toshiba: Technology Consultant
- Philips Ultrasound: Technology Consultant
Why is Fetal Soft Tissue Important?

- Fetal growth is a complex process and should be characterized using a combination of skeletal and soft tissue parameters.
- Soft tissue assessment improves precision of EFW and now adds another key nutritional component to the weight estimation process.

159 Healthy Term and Preterm Newborns
87 boys and 72 girls

Dual-energy X-ray Absorptiometry (DXA)

Term Infants:
42.9% of newborns < 10% body fat were classified as AGA
9.9% AGA newborns had < 10% body fat
Fetal Soft Tissue Parameters using Ultrasonography

- Fetal thigh circumference
- Subcutaneous tissue - arm and leg
  Jeanty P, et al. (1985)
- Fetal thigh and calf circumferences
  Vintzileos A, et al. (1985)
- Fetal limb fat and lean body mass
  Bernstein IM, et al. (1997)
- Fetal abdomen subcutaneous tissue
- Cheek-cheek diameter
- Fetal buttocks
- Fetal thigh soft tissue thickness

In animal studies, regardless of the model used, FGR fetuses are unable to deposit normal fat stores in late gestation. When FGR babies are examined after delivery, they show all the clinical signs of reduced fat stores.

Thus, if fat concentration could be estimated fairly precisely during fetal life with ultrasonographic estimates of fat-to-lean ratios in various sites, this might help distinguish the “normal small” from the FGR fetuses.

Battaglia, FC. NeoReviews 2003; 4:e91

Neonatal Nutrition Score - Dr. Reba Hill
Fetuses with intrauterine growth restriction have reduced subcutaneous fat and lean body mass compared to normal controls.

Subcutaneous fat concentrations decreases are greater when compared to decreases in lean body mass.
Neonatal Thighs

Growth Restriction - 2845 grams
39.7 weeks, menstrual age

Macrosomia - 4368 grams
38.4 weeks, menstrual age

Fetal Thigh 2D Soft Tissue Parameters - NICHD
Mid-Point of Diaphysis Defined Using 3D Multi-Planar Imaging

Red Dot Marks Cross Sectional View of Femur Diaphysis
Limb Tracing for ThC and Mid-Thigh Area (MTA)

Calculations

\[ MTFM = MTA - MTLM \]
\[ MTLM = MTA - MTFM \]

\[ ThC = \text{Mid-Thigh Circumference (cm)} \]
\[ MTA = \text{Mid-Thigh Area (Fat area + Lean Mass Area; cm}^2) \]
\[ MTFM = \text{Mid-Thigh Fat Mass (Subcutaneous Fat; cm}^2) \]
\[ MTLM = \text{Mid-Thigh Lean Mass (Muscle and Bone; cm}^2) \]
\[ MTSCTT = \text{Maximum Thigh Subcutaneous Tissue Thickness; cm} \]

Fractional Limb Volume

Limb Subvolume based on 50% of long bone diaphysis length

Fractional Arm Volume
Fractional Thigh Volume

Fractional Limb Volume - Technical Considerations

Edges of the Long Bones Have Shadowed Soft Tissue Borders

Use Color Filter for Soft Tissue Contrast

Use Adequate Acquisition Sweep Angle

Avoid Motion Artifacts!
Fractional Limb Volume
Fetal Soft Tissue Development

Fractional limb volume – a soft tissue parameter of fetal body composition: validation, technical considerations and normal ranges during pregnancy


Objective of fetal imaging, Department of Obstetrics and Gynecology, William Beaumont Hospital and University of Michigan. William Beaumont Hospital Research Committee. Equal risk, NIH, Department of Obstetrics and Gynecology, Harper College of Medicine, Detroit, MI. (Reproduction Research Branch, National Institute of Child Health and Human Development, National Institutes of Health, Department of Health and Human Services, Bethesda, MD) and Department of Obstetrics and Gynecology, Wayne State University, Detroit, MI. 2004

Fractional Limb Volume - Reproducibility Study

**Fractional Arm Volume - Normal Ranges**


**Fractional Thigh Volume - Normal Ranges**


**obsono.org**

Innovative Resources for Prenatal Limited Volume, Multi-View Sonography, and Individual Growth Assessment

**Welcome to the Ob Sono Website**

The purpose of this website is to disseminate innovative approaches for sonoanatomic evaluation of the fetus. Special emphasis has been placed on the use of forearm and arm parameters. First, fractional arm (FAV) or thigh (FTV) volumes are important fetal tissue parameters that can be directly measured, combined with other parameters to improve the prediction of intrauterine growth retardation, or used for individual growth assessment (IGA). Second, new forearm and arm reference ranges can be calculated and graphed for fetal heart measurements that include aortic and pulmonary valve diameters, cross-sectional areas, and cardiac circumferences. This is based on the analysis of 174 fetal ultrasound images from a single institution. A new computer program called fetal infant growth assessment (FIGA) is now available for fetal infant growth assessment (FIGA). The software and video tutorial (free and complete) can be obtained via the free download at www.obsono.org.

The content contained in this website is based on what is published in the medical literature and is provided for informational and educational purposes only.

**Fractional Limb Volume - Percentiles and Z-Scores**

Calculate percentiles and scores of fractional arm volume (FAV) and fractional thigh volume (FTV) measurements in comparison with normal ranges. The software can be downloaded for free at www.obsono.org.

**EFW Using 3D Biometry with Fractional Limb Volume**

Calculate estimated fetal weight based on sonoanatomic measurements, such as abdominal circumference, as well as other parameters such as...
**Fractional Limb Volume**

Fetal Weight Estimation

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**Three-Dimensional Ultrasound-Assessed Fetal Thigh Volumetry in Predicting Birth Weight**

FONG-MING CHANG, MD, REN-ING LIANG, MD, HUEI-CHEN KO, PhD, BOR-LIN YAO, MD, CHI-HSIN CHANG, MD, AND CHEN-HSIANG YU, MD

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Obstet Gynecol 1997; 90: 331-9
Most prediction models do not include soft tissue parameters for fetal weight estimation...

- soft tissue parameters difficult to standardize
- 3DUS fetal limb measurements can be time consuming
- soft tissue borders poorly visualized at ends of long bones

Air Displacement Plethysmography

Two Compartment Model

\[ \text{Density} = \frac{\text{Mass}}{\text{Volume}} \]

- Fat
- Fat-Free Mass

Two Compartment Model

- Fat
- Fat-Free Mass


J Nutri 2009;139:1772-8

- 47 mother-infant pairs studied
- pregnant women scanned (33-38 weeks)
- infant body composition study (24 - 72 hrs)
We conclude that fetal growth biometrics determined by 2D US do not provide a reliable assessment of % BF in term infants.

Best EFW precision (lowest random error) occurred with volume-based weight models. 2013

<table>
<thead>
<tr>
<th>Fetal Weight Estimation Model</th>
<th>Birth Weight All Infants (g)</th>
<th>Birth Weight &lt; 2000 g (n = 158)</th>
<th>Birth Weight 2000-4000 g (n = 28)</th>
<th>Birth Weight &gt; 4000 g (n = 100)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BPD, AC, FDL Original Hadlock (OH2)</td>
<td>4.9 ± 8.8*</td>
<td>4.9 ± 10.6*</td>
<td>4.4 ± 8.2*</td>
<td>6.7 ± 8.6*</td>
</tr>
<tr>
<td>BPD, AC, FDL Modified Hadlock (MH2)</td>
<td>1.1 ± 8.4</td>
<td>1.0 ± 10.0</td>
<td>1.2 ± 8.0</td>
<td>0.5 ± 8.3</td>
</tr>
<tr>
<td>BPD, AC, TVol New Model 6</td>
<td>1.9 ± 6.6*</td>
<td>0.4 ± 7.8</td>
<td>1.5 ± 6.4*</td>
<td>4.3 ± 5.8*</td>
</tr>
</tbody>
</table>

* systematic error significantly different from zero, one sample t-test

Sonographically based fetal limb volumes, especially fractional thigh volume, reflect neonatal fat mass and are better correlated with birth weight.


Comparison of Estimated Fetal Weights Using Volume and 2-Dimensional Sonography and Their Relationship to Neonatal Markers of Fat

Nattinee Srisutai MD*, Phutthas Champrapap MD*, Chulalak Komthib Dr PH**

* Division of Maternal-Fetal Medicine, Department of Obstetrics and Gynecology, Faculty of Medicine, Siriraj Hospital, Mahidol University, Bangkok, Thailand
** Division of Research Development, Faculty of Medicine, Siriraj Hospital, Mahidol University, Bangkok, Thailand

Model Derivation Group (n = 100)

BW = 774.744 + 32.568 x TVol

Model Validation Group (n = 50)

Mean % Difference

Hadlock  -3.1 ± 7.8%
New Model  0.2 ± 5.5%


Birth weight prediction using three-dimensional sonographic fractional thigh volume at term in a Chinese population

F. Yang†, K.-Y. Leung‡, Y.-W. Hou§, Y. Yuan* and M. H.-Y. Tang†

*Department of Obstetrics and Gynaecology, University of Hong Kong, Hong Kong; †Department of Obstetrics and Gynaecology, Queen Elizabeth Hospital, Hong Kong; ‡Department of Statistics, College of Economics, James University, Guangzhou, China; §Department of Ultrasound, Queen Elizabeth Hospital, Hong Kong.

Prospective Study (n = 190)

<table>
<thead>
<tr>
<th>Model</th>
<th>Mean % Difference</th>
<th>EFW ± 5%</th>
<th>EFW ± 10%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Modified Hadlock (BPD, HC, AC, FL)</td>
<td>-2.5 ± 6.9%</td>
<td>46.8</td>
<td>83.7</td>
</tr>
<tr>
<td>Volume Based Model (BPD, AC, TVol)</td>
<td>-0.4 ± 4.8%</td>
<td>74.2</td>
<td>95.8</td>
</tr>
</tbody>
</table>

"strong correlation between 3D thigh volume measurements at 33 weeks gestation and birth weight"

"adding TVol measurements to EFW at 38 weeks at 38 weeks improves accuracy and reduces error rate"

Longitudinal prospective cohort study of 115 unselected pregnancies

"Fractional thigh volume measurements offer some improvement over 2-dimensional biometry for the detection of late-onset fetal growth restriction at 34-36 weeks."

Semi-Automated Fractional Limb Volume Measurements

5D Limb Vol Tool

Automated Fractional Limb Volume Demo

Semi-Automated FLV With Manual Editing
Prospective Study - Samsung WS80 with Elite Computer Assisted Fractional Limb Volume

Menstrual Age (n = 50)

Semi-Automated Fractional Limb Volume
Bland-Altman Analysis

Time Required to Complete FLV Measurements
Manual vs Automated Fractional Limb Volume (n = 10)
Automated Fractional Limb Volume Measurements Improve the Precision of Birth Weight Predictions in Late Third-Trimester Fetuses

Lauren M. Maye, RDMS, MPH, Song Yaw Kim, MS, Sangmee Lee, MS
Halim Song Habibzadeh, PhD, Wesley Lee, MD

- 50 third-trimester fetuses scanned within 4 days of delivery
- Hadlock (BPD, AC, FDL) compared to Lee (BPD, AC, TVol) BW predictions
- 5D Limb Vol technology - Samsung WS80

J Ultrasound Med 2017; 36: 1649-1655

Most accurate weight predictions results - Hadlock Model
Most precise weight predictions results - Lee Model

Mean BW = 3335 grams at 39.4 ± 1.3 weeks gestation

Automated Fractional Limb Volume
Correction Factors for Systematic Errors

AVol = 1-(-0.0907) = 1.0907
TVol = 1-(-0.0523) = 1.0523
Automated Fetal Weight Estimation: A Multicenter Validation Using Fractional Limb Volume

Prospective study of 600 pregnancies

Primary Objective - Compare the accuracy and precision of BW predictions based on 3D Limb Vol technology in pregnant women as compared to 2D BW prediction models.

Secondary Objective - Characterize the performance of BW predictions based on 3D Limb Vol technology in pregnant women with suspected growth abnormalities.

a. Baylor College of Medicine at Texas Children's Hospital Pavilion for Women (Houston, USA)
b. Magee Womens Hospital, Pittsburgh PA
c. Beijing Obstetrics and Gynecology Hospital, (Beijing, China)
d. Erlangen University Hospital (Hanover, Germany).

Fractional Limb Soft Tissue - Summary

Fetal soft tissue assessment requires development of ultrasound parameters that are reproducible and for which reference ranges have been established.

Fractional limb volume, when used with 2D biometry, improves the precision of EFW and now adds a soft tissue component to the weight estimation procedure.

The clinical value of fractional limb volume - either as a directly measured soft tissue parameter or for fetal weight estimation requires further investigation.