Three Dimensional Ultrasound in Obstetrics

Alfred Abuhamad, M.D.
Eastern Virginia Medical School

Outline
• What is 3D ultrasound?
• How to optimize your 3D image?
• Provide you with 10 compelling clinical advantages of 3D ultrasound in the Ob practice?
• Highlight the scientific evidence for 3D over 2D in Obstetric ultrasound?
• Present my view into the future of 3D ultrasound?

What is 3D ultrasound?

2D US
3D US

3D Ultrasound

Volume of Data
Infinite # of Planes

Volume Sonography
How to Optimize Your 3D Image?

• Minimize the depth on the screen
• Narrow the sector width
• Adjust the focal zone to the target level
• Avoid shadowing by skeleton
• Enhance 2D image first
• Place your acquisition box close to target organ
• Maximize speed of acquisition

How to Optimize Your 3D Image?

• In general, the darker the amniotic fluid – the better your 3D volume (surface rendering and resolution in planes B and C)
How to Optimize Your 3D Image?

What The Experts Don’t Tell You:

• The quality of 3D is so much dependent on the quality of 2D imaging in all its aspects –
• Major limitation of current 3D ultrasound

What the advantages of 3D US?

Advantages of 3D Ultrasound

1- Review Planes Unobtainable by 2D Ultrasound

Review Planes Unobtainable by 2D US

Coronal view of uterus - Septate

Surface rendering – cardiac valves
Mid-Sagittal plane of fetal brain

- 3D median planes are more easily obtained
- Allow for accurate diagnosis of anomalies
- Valuable approach for rapid assessment of corpus callosum and cerebellar vermis

Fetal cranial sutures

- Patterns of normal and abnormal development described
- Premature closure of coronal sutures in Apert syndrome
- Development of sutures in Trisomy 21 described

Fetal lip and palate
Fetal Cleft Lip / Palate

- Flipped face view
- Reverse face view
- Underside view
- 30° inclined axial view

Prospective study, low risk
1856 second trimester pregnancies
Diagnosis at first scan:
87% (3D) vs 78% (2D)

Table 2. Diagnostic Accuracy of 3D/4D US and 2D US in Detecting 131 Anomalies in Fetuses With Trisomy 18

<table>
<thead>
<tr>
<th>Anomalies</th>
<th>3D/4D US</th>
<th>2D US</th>
<th>PPV</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHD</td>
<td>96.15</td>
<td>89.71</td>
<td>90</td>
</tr>
<tr>
<td>Anoemn</td>
<td>92.40</td>
<td>85.77</td>
<td>88.67</td>
</tr>
<tr>
<td>Esophagus</td>
<td>96.3a</td>
<td>88.15</td>
<td>86.66</td>
</tr>
<tr>
<td>Cleft</td>
<td>90</td>
<td>89.21</td>
<td>90</td>
</tr>
<tr>
<td>Other</td>
<td>95</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Total</td>
<td>93.89</td>
<td>73.28</td>
<td>88.61</td>
</tr>
</tbody>
</table>

PPV indicates positive predictive value.
*P = .05
Review Planes Unobtainable by 2D US

Incidence of absent ribs in low-risk fetuses is 6%.

Fetal skeletal system

Ultrasound Obstet Gynecol 2008;32:506-509

Advantages of 3D Ultrasound

2 - Review Topographic Anatomy (skin)

Review Topographic Anatomy

Review Topographic Anatomy

Review Topographic Anatomy

Review Topographic Anatomy

Review Topographic Anatomy

Fetal Ears

Fetal Extremities
Review Topographic Anatomy

Fetal Extremities

Fetal Chest

Advantages of 3D Ultrasound

3- Rotate Volumes To View All Sides

Normal Fetal Face

Advantages of 3D Ultrasound

4- Highlight Elements Within Volumes

Table 2: Diagnostic Accuracy of 3D/4D US and 2D US in Detecting 131 Anomalies in Fetuses With Trisomy 18

<table>
<thead>
<tr>
<th>Anomalies</th>
<th>Sensitivity %</th>
<th>PPV %</th>
</tr>
</thead>
<tbody>
<tr>
<td>CNS</td>
<td>96.11</td>
<td>65.23</td>
</tr>
<tr>
<td>Facial</td>
<td>96.11</td>
<td>65.38</td>
</tr>
<tr>
<td>Multifocal</td>
<td>55.86</td>
<td>85.21</td>
</tr>
<tr>
<td>Overall</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

% = 95
PPV indicates positive predictive value.
Highlight Elements Within Volumes

Fetal Achondrogenesis

Highlight Elements Within Volumes

Prune Belly Syndrome

Highlight Elements Within Volumes (Inverse Mode)

Prune Belly Syndrome

Advantages of 3D Ultrasound

5- Better Display of Vasculature within Volumes or Organs

Display of Vasculature

11 wks

4-Chamber View - Normal

Display of Vasculature

True Knot in Cord – Loose Knot
True Knot in Cord – Tight Knot

Conjoined Twins

Conjoined Twins - Vasculature

CAT – Inverse mode

DORV

TGA
Coarctation of the aorta

6- Enhanced Accuracy of Organ Volume Measurements

- 3D US had best diagnostic accuracy
- PPV: 100%, NPV: 92%
- Superior to 2D biometric parameters

Prenat Diagn, 2007 Mar;27(3):216

7- Enhanced Estimation of Fetal Weight

Ultrasound Obstet Gynecol, 2011; 38:613-619
3D Ultrasound

Estimation of Fetal Weight

- Fractional limb volume (EFW)
- Upper arm volume (IUGR)

J Ultrasound Med. 2001 Dec;20(12):1283

Advantages of 3D Ultrasound

8- Display of Multiple Planes in One View

Display of Multiple Planes in One View

TOF - TUI

Advantages of 3D Ultrasound

9- Enhanced Display of 2D Ultrasound

Enhance Display of 2D Planes

Pentalogy of Cantrell
Enhance Display of 2D Planes

Dandy Walker – 11 weeks

Sinkovskaya Abouhamad, Prenat Diag 2012

Enhance Display of 2D Planes

Tuberous Lesions - Brain

Enhance Display of 2D Planes

Tuberous Lesions - Brain

Submit 3D Volumes for Review

CNS Anomalies

Advantages of 3D Ultrasound

10- Ability to submit Volumes for Remote Expert Review

3D Ultrasound

What is My View of the Future of 3D Ultrasound?
2 Important Concepts in 3D Sonography

**3D Ultrasound**

**Concept 1:**
Acquired volume of a structure contains all the anatomical 2D planes for a complete evaluation of this structure.

**Concept 2:**
For every organ, 2D anatomical planes that are needed for a complete evaluation are organized in a constant anatomic relationship to each other.

**3D Ultrasound**

Obtain a volume of an organ

Computerized program to automatically display all 2D planes that are required for a complete evaluation of this particular organ.

**Automated Sonography**

**Standardization**
3D Ultrasound

Will Lead to:
- Standardization
- Simplification
- Automation

of the ultrasound examination

3D Ultrasound

- Optimization of display of 3D ultrasound is dependent on the quality of the 2D image
- Several 3D ultrasound clinical applications exist in advanced obstetrical imaging
- Future of 3D technology is promising especially in the field of ultrasound automation