Evaluating Cardiac Function of the Four-Chamber View in Fetuses with IUGR: New Perspectives

We shall not cease from exploration. And the end of all our exploring will be to arrive where we started and know the place for the first time.

T.S. Eliot
What Should Be Evaluated?

1. Shape and Size of the 4-Chamber View

2. Shape, Size and Contractility of the Ventricles

**Shape and Size of the 4-Chamber View**

**GSI**

Length/Width

Mean: 1.2

SD: 0.09

5th Centile: 1.08

**Size of the 4-Chamber View**

**Fetal Heart Size**

A comparison between the point-to-point trace and automated ellipse methods between 20 and 40 weeks' gestation.

2016
Ventricular Evaluation

Shape, Size and Contractility of the Ventricles

What Would Be The Characteristics of the Ideal Measurement Tool to Evaluate the Right and Left Ventricles?
The Ideal Diagnostic Tool

1. Measure the Size of the Ventricles
2. Measure the Shape of the Ventricles
3. Measure the Contractility of the Ventricles
4. Simultaneously Make All of the Above Measurements
5. Be Angle Independent of the Position of the 4-Chamber View
6. Provide Results of Actual Measurements, Z-Scores, and Centiles Using Different Independent Variables of Fetal Biometry and Gestational Age
7. Take Less Than 4 Minutes

Speckle Tracking Analysis Meets All of the Previous Criteria

What is Speckle Tracking Analysis?

The “Deep Dive”
The “Deep Dive”

Software Divides the Ventricular Chamber Into 24 Equal Segments From the Base to the Apex

End-Diastolic Measurements and End-Systolic Measurements

What is Speckle Tracking Analysis?

Identification of the Endocardium of the Ventricles

Exported Research Data
Data Export

What Can Be Measured?

New Concepts

24-Segment End-Diastolic and Systolic Measurements
Measuring the Size of the Ventricles

Evaluation of the right and left ventricles: An integrated approach measuring the area, length, and width of the chambers in normal fetuses. 

Measuring the RV/LV 24-Segment Ratios

## Measuring the RV/LV 24-Segment Ratios

### Comprehensive Evaluation of Fetal Cardiac Ventricular Widths and Ratios Using a 24-Segment Speckle Tracking Technique

G. Esplin, R. Devore, D. L. Gumin

Table 1. The 24-Segment Right to Left Ventricular Ratios

<table>
<thead>
<tr>
<th>Segment</th>
<th>Mean</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.02</td>
<td>0.002</td>
</tr>
<tr>
<td>2</td>
<td>1.02</td>
<td>0.002</td>
</tr>
<tr>
<td>3</td>
<td>1.02</td>
<td>0.002</td>
</tr>
<tr>
<td>4</td>
<td>1.02</td>
<td>0.002</td>
</tr>
<tr>
<td>5</td>
<td>1.02</td>
<td>0.002</td>
</tr>
<tr>
<td>6</td>
<td>1.02</td>
<td>0.002</td>
</tr>
<tr>
<td>7</td>
<td>1.02</td>
<td>0.002</td>
</tr>
<tr>
<td>8</td>
<td>1.02</td>
<td>0.002</td>
</tr>
</tbody>
</table>

### Measuring the Shape of the Ventricles

#### Measuring the Shape of the Ventricles

Sphericity Index: Length/Width

- Basal
- Mid
- Apical

#### Sphericity Index: Length/Width

Ultrasound Obstet Gynecol 2018; 51: 650–658

Right and left ventricular 24-segment sphericity index is abnormal in small-for-gestational-age fetuses

G. R. Devore, M. Zaretsky, D. L. Gumin, and J. C. Horbins

Right ventricular segment

Ultrasound Obstet Gynecol 2018; 52: 245–249
Measuring the Contractility of the Ventricles

GLOBAL

- LV
- RV

FAC = \frac{\text{End-Diastolic Area} - \text{End-Systolic Area}}{\text{End-Diastolic Area}} \times 100
Measuring Longitudinal Contractility

Annular Plane Systolic Excursion

Speckle Tracking of the Basal Lateral and Septal Wall Annular Plane Systolic Excursion of the Right and Left Ventricles of the Fetal Heart

6

Annular Plane Systolic Excursion
6 Annular Plane Systolic Excursion

 Speckle Tracking of the Basal Lateral and Septal Wall Annular Plane Systolic Excursion of the Right and Left Ventricles of the Fetal Heart

 LV
 RV

 Lateral Wall Comparison
 Septal Wall Comparison

 7 Longitudinal Annular Displacement Fractional Shortening

 Longitudinal Annular Systolic Displacement Compared to Global Strain in Normal Fetal Hearts and Those With Cardiac Abnormalities

 End-Diastole - End-Systole End-Diastole x 100

 8 Longitudinal Global Strain

 Global Longitudinal Strain

 End-Systolic Length - End-Diastolic Length End-Diastolic length x 100 NEGATIVE VALUE
**Longitudinal Displacement Fractional Shortening Vs Global Strain**

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>LV longitudinal displacement</td>
<td>21.05</td>
</tr>
<tr>
<td>fractional shortening, %</td>
<td></td>
</tr>
<tr>
<td>RV longitudinal displacement</td>
<td>22.94</td>
</tr>
<tr>
<td>fractional shortening, %</td>
<td></td>
</tr>
<tr>
<td>LV global strain, %</td>
<td>-22.93</td>
</tr>
<tr>
<td>RV global strain, %</td>
<td>-22.70</td>
</tr>
</tbody>
</table>

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**Table 4. Global Strain of the LV From Published Studies**

<table>
<thead>
<tr>
<th>Author</th>
<th>Year</th>
<th>No. Studied</th>
<th>Gestational Age, wk</th>
<th>Analysis Program</th>
<th>Study Mean</th>
<th>Study SD</th>
<th>ΔZ Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dr. Sato</td>
<td>2008</td>
<td>100</td>
<td>20–22</td>
<td>GE</td>
<td>25.9</td>
<td>4.0</td>
<td>-0.59</td>
</tr>
<tr>
<td>Dr. Sato</td>
<td>2008</td>
<td>100</td>
<td>20–32</td>
<td>Siemens</td>
<td>28.4</td>
<td>4.0</td>
<td>-0.82</td>
</tr>
<tr>
<td>Kato et al.</td>
<td>2013</td>
<td>64</td>
<td>30–34</td>
<td>Siemens</td>
<td>24.2</td>
<td>3.9</td>
<td>-0.12</td>
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<tr>
<td>Morimoto et al.</td>
<td>2010</td>
<td>93</td>
<td>14–39</td>
<td>GE</td>
<td>23.3</td>
<td>1.8</td>
<td>0.42</td>
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<tr>
<td>Marui et al.</td>
<td>2013</td>
<td>146</td>
<td>14–39</td>
<td>Siemens</td>
<td>25.0</td>
<td>3.7</td>
<td>0.47</td>
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<tr>
<td>Zhu et al.</td>
<td>2012</td>
<td>20</td>
<td>35–40</td>
<td>Siemens</td>
<td>20.7</td>
<td>2.2</td>
<td>0.98</td>
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<tr>
<td>Van Weeghe et al.</td>
<td>2013</td>
<td>19</td>
<td>15–36</td>
<td>GE</td>
<td>18.5</td>
<td>6.8</td>
<td>1.03</td>
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<tr>
<td>Ozgul et al.</td>
<td>2015</td>
<td>57</td>
<td>14–39</td>
<td>Siemens</td>
<td>21.7</td>
<td>4.5</td>
<td>1.59</td>
</tr>
<tr>
<td>Trojan et al.</td>
<td>2013</td>
<td>54</td>
<td>15–35</td>
<td>Siemens</td>
<td>17.9</td>
<td>3.4</td>
<td>1.52</td>
</tr>
<tr>
<td>Eienenberger et al.</td>
<td>2017</td>
<td>103</td>
<td>14–39</td>
<td>Toshiba</td>
<td>20.46</td>
<td>4.15</td>
<td>1.53</td>
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<tr>
<td>Suh et al.</td>
<td>2012</td>
<td>80</td>
<td>30–42</td>
<td>Siemens</td>
<td>16.0</td>
<td>3.3</td>
<td>1.61</td>
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<tr>
<td>Bokol et al.</td>
<td>2009</td>
<td>33</td>
<td>17–38</td>
<td>Siemens</td>
<td>17.4</td>
<td>6.4</td>
<td>4.53</td>
</tr>
</tbody>
</table>

NR indicates not reported.

*1.2.3.4.5.6.7.*

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**Measuring Left Ventricular Function**

**Table 5. Global Strain of the LV From Published Studies**

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NR indicates not reported.

*1.2.3.4.5.6.7.*

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**Evaluation of Fetal Left Ventricular Size and Function Using Speckle-Tracking and the Simpson Rule**

<table>
<thead>
<tr>
<th>Stroke Volume</th>
<th>Cardiac Output</th>
<th>Cardiac Output/kg</th>
<th>Ejection Fraction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simpson's Rule</td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

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**J Ultrasound Med 2018; 37:1159–1171 | 0276-4297**
Measuring **Left Ventricular Function**

Evaluation of Fetal Left Ventricular Size and Function Using Speckle-Tracking and the Simpson Rule

Greggory R. DeVore, MD; Diane L. Gumina, MS; John C. Hobbs, MD

Simpson's Rule

Abnormal Fetal Growth <10th Centile

Original Research

**OBSTETRICS**

Assessment of ventricular contractility in fetuses with an estimated fetal weight less than the tenth centile

Greggory R. DeVore, MD; Diane L. Gumina, MS; John C. Hobbs, MD

Consensus definition of fetal growth restriction: a Delphi procedure

S. J. GORDIJN*, I. M. BEUNE*, B. THILAGANATHAN‡, A. PAPAGEORGIOU‡, A. A. BASCHAT†, P. N. BAKER‡, R. M. SILVER‡, K. WYNIA** and W. GANZEVOORT††
50 Fetuses EFW <10th Centile

25 Normal UAPI and CPR
Small for Gestational Age
Not At Risk for Adverse Outcome?

25 Abnormal UAPI and/or CPR
Fetal Growth Restriction
At Risk for Adverse Outcome

Small for Gestational Age
Any Abnormality of Contractility of the RV and LV

ABNORMAL FOR ONE OR BOTH VENTRICLES 84%
ABNORMAL RIGHT VENTRICLE 80%
ABNORMAL LEFT VENTRICLE 56%

Global Contractility

24-Segment Transverse Fractional Shortening
LEFT VENTRICLE 40%
RIGHT VENTRICLE 40%

LEFT VENTRICLE 36%
RIGHT VENTRICLE 68%

24 Segment Fractional Shortening

Fractional Area Change

Longitudinal Contractility

ABNORMAL RIGHT VENTRICLE 44%
ABNORMAL LEFT VENTRICLE 36%
GIRSEN STUDY NO
SIGNIFICANT DIFFERENCE
IN CARDIAC FUNCTION
TESTS BETWEEN CONTROLS
AND GROUP I (SGA) FETUSES

Control vs Fetuses EFW<10th and Normal Doppler UAPI and CPR

ATRIAL TYPE NATRIURETIC PEPTIDE (VOLUME LOADING) WAS
SIGNIFICANTLY HIGHER IN FETUSES
WITH EFW <10TH CENTILE
THAN CONTROLS

Fetal Growth Restriction

-Absent or Reversed Umbilical Artery Doppler Flow-

51 Fetuses with EFW <10th Centile

13 Perinatal Deaths

38 Alive

Collaboration with the Perinatal Research Branch
National Institutes of Health
Detroit, MI

4-Chamber View

-Percent of Fetuses-

No Significant Difference
Ventricular Wall Thickness >95th Centile -Percent of Fetuses-

Perinatal Death: 92%
Alive: 74%
Perinatal Death: 77%
Alive: 71%

No Significant Difference

Ventricular Area <5th Centile -Percent of Fetuses-

Alive: 26%
Perinatal Death: 16%

Unique to Alive Fetuses

Perinatal Deaths Did Not Have Ventricular Areas <5th Centile

Left Ventricular 24-Segment Transverse Widths <5th Centile -Percent of Fetuses-

Segments 1-8: 29%
Segments 9-16: 16%
Segments 17-24: 24%

Unique to Alive Fetuses
Left Ventricular 24-Segment Transverse Widths <5th Centile - Percent of Fetuses -

Perinatal Deaths Did Not Have Widths <5th Centile

Unique to Alive Fetuses

Segment 1-8: 29% (Alive), 26% (Perinatal Death)
Segment 9-16: 16% (Alive), 18% (Perinatal Death)
Segment 17-24: 3% (Alive), 2% (Perinatal Death)

Left Ventricular 24-Segment Transverse Widths >95th Centile - Percent of Fetuses -

Unique to Perinatal Death Group

Segment 17-24: 24% (Perinatal Death)

Comparing Mean Z-Scores

- Perinatal Death: -3.34
- Alive: -1.38
- Perinatal Death: -2.8
- Alive: -2.8

P-values:
- Perinatal Death vs Alive: P=0.05
- Perinatal Death vs Perinatal Death: P=0.97

Perinatal Deaths: 40% Segment 17-24
Alive: 20% Segment 17-24
Comparing Mean Z-Scores

<table>
<thead>
<tr>
<th>Perinatal Death</th>
<th>Alive</th>
</tr>
</thead>
<tbody>
<tr>
<td>-5.6</td>
<td>-1.68</td>
</tr>
<tr>
<td>&lt;1 Centile</td>
<td>5th Centile</td>
</tr>
</tbody>
</table>

LV Ejection Fraction

P<0.03

Fractional Shortening Percentile

-LEFT VENTRICLE-

Conclusions

- Cardiomegaly is common for both groups of fetuses.
- Ventricular wall thickness is common for both groups of fetuses.
- A smaller left ventricular area is present in those who did not have a perinatal death.
- A larger left ventricle was present in fetuses who had a perinatal death.
- Decreased LV Contractility was present in fetuses with Perinatal Deaths as represented by the following:
  - LV Ejection Fraction
  - LV Fractional Area Change
  - LV 24 Segment Fractional Shortening

We shall not cease from exploration. And the end of all our exploring of the Four-Chamber View will be to arrive where we started and know the place for the first time.

T.S. Eliot
Thank You