Evaluation of Cardiac Function
Part 2:
Cardiac Function Using B-Mode, M-Mode and Pulsed Doppler

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Providence Tarzana Medical Center
Tarzana, CA

Director
Fetal Diagnostic Centers
Pasadena and Tarzana, CA
Real-Time B-Mode Ultrasound -Z-Scores-
Real-Time B-Mode Ultrasound
-Z-Scores-

M-Mode
Real-Time B-Mode Ultrasound
-Z-Scores-

M-Mode

Pulsed Doppler
Cardiac Z-Score Measurements
Development of Z-scores for fetal cardiac dimensions from echocardiography.

Schneider C, McCrindle BW, Carvalho JS, Hornberger LK, McCarthy KP, Daubeney PE.

Brompton Fetal Cardiology, Royal Brompton Hospital, London, UK.

The use of Z-scores in the analysis of fetal cardiac dimensions.

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fetalecho.com
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The standard score is

\[ z = \frac{x - \mu}{\sigma}, \]

where:

- \( x \) is a raw score to be standardized;
- \( \mu \) is the mean of the population;
- \( \sigma \) is the standard deviation of the population.

http://www.uark.edu/misc/lampinen/tutorials/normal.htm
http://en.wikipedia.org/wiki/Standard_score
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95% of values are within 1.98 SD of the mean.

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Z-Scores

Ventricular Measurements

BPD
FL
Weeks Gestation
Femur

BPD

Wks Gest

Development of Z-scores for fetal cardiac dimensions from echocardiography.

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Figure 3 Sample Z-score nomogram relating aortic valve to femur length (FL). This allows determination of the Z-score from knowledge of the size of the aortic valve and the FL. For further nomograms of other cardiac dimensions relating to FL, biparietal diameter and gestational age either use Equations 1 and 2 and Tables 1–3 or see Figure E2.
Z-scores for fetal cardiac dimensions

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Aortic Valve

Z-Scores

Femur Length
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Opinion

The use of Z-scores in the analysis of fetal cardiac dimensions
**Z-Scores**

**Figure 1** This is from the Microsoft Excel spreadsheet that can be downloaded from the journal's website. To view the computed Z-score, the user enters the biometric measurement (Step 1) and the measured cardiac structure (Step 2) and then reads the Z-score (Step 3).
### OUTFLOW TRACTS

#### Aortic Valve

<table>
<thead>
<tr>
<th>Enter Measured Biparietal Diameter in centimeters</th>
<th>LN of Biparietal Diameter</th>
<th>Multiplier M</th>
<th>Intercept C</th>
<th>Computed Ln of predicted STRUCTURE</th>
<th>Enter Measured STRUCTURE in centimeters</th>
<th>Computed Ln of Measured STRUCTURE</th>
<th>Root Mean Square</th>
<th>Z Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>1.386294381</td>
<td>1.030</td>
<td>-2.848</td>
<td>-1.4078</td>
<td>0.3</td>
<td>-1.2039728</td>
<td>0.1397</td>
<td>1.558281</td>
</tr>
</tbody>
</table>

#### Pulmonary Valve

<table>
<thead>
<tr>
<th>Enter Measured Biparietal Diameter in centimeters</th>
<th>LN of Biparietal Diameter</th>
<th>Multiplier M</th>
<th>Intercept C</th>
<th>Computed Ln of predicted STRUCTURE</th>
<th>Enter Measured STRUCTURE in centimeters</th>
<th>Computed Ln of Measured STRUCTURE</th>
<th>Root Mean Square</th>
<th>Z Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>1.386294381</td>
<td>1.126</td>
<td>-2.813</td>
<td>-1.2522</td>
<td>0.3</td>
<td>-1.2039728</td>
<td>0.1171</td>
<td>0.410416</td>
</tr>
</tbody>
</table>

#### Ascending Aorta

<table>
<thead>
<tr>
<th>Enter Measured Biparietal Diameter in centimeters</th>
<th>LN of Biparietal Diameter</th>
<th>Multiplier M</th>
<th>Intercept C</th>
<th>Computed Ln of predicted STRUCTURE</th>
<th>Enter Measured STRUCTURE in centimeters</th>
<th>Computed Ln of Measured STRUCTURE</th>
<th>Root Mean Square</th>
<th>Z Score</th>
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</thead>
<tbody>
<tr>
<td>4</td>
<td>1.386294381</td>
<td>1.06</td>
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<td>-1.2885</td>
<td>0.3</td>
<td>-1.2039728</td>
<td>0.1227</td>
<td>0.689121</td>
</tr>
</tbody>
</table>

#### Main Pulmonary Artery

<table>
<thead>
<tr>
<th>Enter Measured Biparietal Diameter in centimeters</th>
<th>LN of Biparietal Diameter</th>
<th>Multiplier M</th>
<th>Intercept C</th>
<th>Computed Ln of predicted STRUCTURE</th>
<th>Enter Measured STRUCTURE in centimeters</th>
<th>Computed Ln of Measured STRUCTURE</th>
<th>Root Mean Square</th>
<th>Z Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>1.386294381</td>
<td>1.144</td>
<td>-2.774</td>
<td>-1.1881</td>
<td>0.3</td>
<td>-1.2039728</td>
<td>0.1455</td>
<td>-0.10923</td>
</tr>
</tbody>
</table>
http://www.fetalecho.com/zscorepage
Case 1

Z-Score: Normal Size of Main Pulmonary Artery
Z-Score: Ascending Aorta
Decreased in Size (Z-score 1.83-2.28)
Case 1

Aortic Arch with Suggestion of Coarctation Shelf
Qualitative Assessment of Cardiac Function

Real-Time
Real-Time

Qualitative Assessment

Normal

Dilated RV and RA

Real-Time
Real-Time Qualitative Assessment

Normal Pericardial Effusion

Real-Time
Real-Time

Qualitative Assessment

Normal

Tricuspid Regurgitation

Real-Time
Quantitative M-Mode
Fetal echocardiography. IV. M-mode assessment of ventricular size and contractility during the second and third trimesters of pregnancy in the normal fetus.

DeVore GR, Siassi B, Platt LD.
Quantitative M-Mode

1 to 6: Diastolic Biventricular Outer Dimension
2 to 3: Diastolic Right Ventricular Inner Dimension
4 to 5: Diastolic Left Ventricular Inner Dimension
7 to 8: Tricuspid Valve Opening Excursion
9 to 10: Mitral Valve Opening Excursion
1 to 2: Diastolic Right Ventricular Wall Thickness
3 to 4: Diastolic Interventricular Septal Thickness
5 to 6: Diastolic Left Ventricular Wall Thickness
Quantitative M-Mode

Bi-Ventricular Outer Dimension

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Quantitative M-Mode

Left Ventricular Inner Dimension

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Quantitative M-Mode

Right Ventricular Inner Dimension

End Diastole

M-Mode

BPD

cm

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Quantitative M-Mode

Mitral Valve Opening Excursion

End Diastole

M-Mode

cm

BPD

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Mitral Valve Opening Excursion

Quantitative M-Mode

End Diastole

M-Mode

TV

MV

cm

BPD

0

0.375

0.75

1.125

1.5

4 5 6 7 8 9 10

95

50

05

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Quantitative M-Mode

Right Ventricular Wall Thickness

BPD

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Quantitative M-Mode

Left Ventricular Wall Thickness

M-Mode

End Diastole

TV

MV

cm

BPD

Monday, November 14, 11
Quantitative M-Mode

Interventricular Wall Thickness

M-Mode

End Diastole

BPD

cm

TV

MV

0.5

0.375

0.25

0.125

0

4

5

6

7

8

9

10

05

50

95

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Quantitative M-Mode

Coarctation of the Aorta

LV
RV

LV: 1.17 cm
RV: 1.62 cm
RV/LV: 1.38

FETAL CARDIAC FUNCTION

(a) BOD (cm)
(b) RVID (cm)
(c) LVID (cm)
(d) RVID (mm)

Femur length (cm)

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Fractional Shortening

Diastole-Systole

Diastole

RV: 32%
(5% CI: 25%, 95% CI: 40%)

LV: 33%
(5% CI: 26%, 95% CI: 41%)

The use of fetal echocardiography for predicting intrapartum fetal heart rate patterns in the post-term pregnancy


Department of Obstetrics and Gynecology, Division of Maternal-Fetal Medicine and Department of Pediatrics, LAC/USC Women’s Hospital, USC School of Medicine, Los Angeles, California, USA

Key words: Fetal echocardiography, Post-term pregnancy, Antepartum testing
Quantitative M-Mode

Postterm Pregnancies

> 40 Weeks

Probability of Abnormal FHR During Labor

RV/LV > 1.11
RV/LV < 1.11

LV: 1.17 cm
RV: 1.62 cm
RV/LV: 1.38


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%Abnormal Testing Associated with Abnormal Intrapartum Heart Rate Monitoring

- NST: 19%
- AFI: 28%
- RVID: 79%
- LVID: 33%
- BVOD: 63%
- RVID/LVID: 72%
- PE: 28%
- SD UA: 5%

* p<0.05
%Abnormal Testing Associated with Abnormal Intrapartum Heart Rate Tracing Requiring Emergency Delivery

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Newer Techniques for Measuring M-Mode Dimensions from 4D STIC Acquisitions Ultrasound
Pulsed Doppler Evaluation of Cardiac Function
Pulsed Doppler

- Sinoatrial Node
  - Anterior internodal tract
  - Middle internodal tract
  - Posterior internodal tract
- HIS bundle
- Right bundle branch
- Purkinje fibers
- Bachmann's bundle
  - Atrioventricular node
  - Left bundle branch
  - Left posterior fascicular branch
  - Left anterior fascicular branch

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Pulsed Doppler

Recording Doppler Waveforms

- **INFLOW**
- **LEFT OUTFLOW**
- **RIGHT OUTFLOW**

Monday, November 14, 11
Pulsed Doppler

Systolic Measurements

**Peak Velocity**
- How fast blood exits ventricle

**Velocity Time Integral (VTI)**
- How much blood exits ventricle

**Time to Peak Velocity**
- Measure of resistance to blood flow

Gestational Age
- 16
- 40
Systolic dysfunction prolongs the pre-ejection time (isovolumic contraction time) and a shortening of the ejection time.
Both systolic and diastolic dysfunction result in abnormality in myocardial relaxation which prolongs the relaxation period (isovolumic relaxation time).
Tei Index

Left Ventricular Myocardial Performance Index (LV MPI)

$$LV\ MPI = \frac{IVCT + IVRT}{LVET}$$


Computing the TEI Index
Tei Index

Left Ventricular Myocardial Performance Index (LV MPI)

\[
LV\ MPI = \frac{IVCT + IVRT}{LVET} = \frac{MCOT-LVET}{LVET}
\]

Tei C, Ling LH, Hodge DO, et al.
New index of combined systolic and diastolic myocardial performance: a simple and reproducible measure of cardiac function - a study in normals and dilated cardiomyopathy.
J Cardiol 1995;26:357-366.

Computing the TEI Index
Blood Flow Doppler

Blood Flow Doppler + Tissue Doppler

Tissue Doppler
Blood Flow Doppler

\[ \text{MPI or TEI} = \frac{A-B}{B} \]
Pulsed Doppler Recording From the Left Ventricle

Pulsed Doppler Waveform

Left Parasternal View

Left Ventricle
Computing the TEI Index
Pulsed Doppler Recording From the Right Ventricle

Diastolic Waveform

Systolic Waveform

Apex Up
4-Chamber View

Rotate

Three-Vessel View

TEI Index Right Ventricle
Clip of Acquiring the Right Ventricular Waveforms: Four-Chamber View
Pulsed Doppler Recording From the Right Ventricle

Clip of Acquiring the Right V Waveforms: Short-Axis View
Clip of Acquiring the Right Ventricular Waveforms: Short-Axis View
Problem of Identifying the END POINTS
Using the CLICKS as the reference points
Clip of Acquiring the Wall Motion
TEI Index = \frac{a-b}{b}
Simultaneous Blood Doppler and Wall Doppler Recording
Simultaneous Blood Doppler and Wall Doppler Recording
Simultaneous Blood Doppler and Wall Doppler Recording

Flow Velocity Waveform

S

IRT

ICT
Simultaneous Blood Doppler and Wall Doppler Recording
37 w 6 D

HC: 31.8 (4.9%)
AC: 30.8 (3.7%)
FL 7.0 (15%)
EFW: 2664 gms (<10%)
AFI < 2

MCA RI = 0.62
Normal is < 0.76
RVW

IUGR
37 W 6 D

Tei Index = \frac{26-14}{14} = 0.86

Normal is < 0.65
When the peak velocity of E wave of the blood velocity waveform is divided by the E' of the wall motion waveform increased values are an indication of heart failure or myocardial dysfunction.
This is result of decreased velocity of the wall motion (E') and an increased velocity of the blood entering the right ventricle (E). This suggests less motion of the right ventricular wall (E') and more blood entering the right ventricle (E).
The E/E' ratio does not change with gestational age (6.2 +/- 0.97 SD).
Fetal congestive heart failure

James C. Huhta
# Cardiovascular profile score (10 points = normal)

<table>
<thead>
<tr>
<th></th>
<th>Normal</th>
<th>-1 point</th>
<th>-2 points</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Hydrops</strong></td>
<td>None (2 pts)</td>
<td>Ascites or pleural effusion or pericardial effusion</td>
<td>Skin oedema</td>
</tr>
<tr>
<td><strong>Venous Doppler</strong></td>
<td>UV</td>
<td>UV Pulsations</td>
<td>UV Pulsations</td>
</tr>
<tr>
<td>(umbilical vein and ductus venosus)</td>
<td>DV (2 pts)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Heart size</strong></td>
<td>&gt;0.20 and &lt;0.35 (2 pts)</td>
<td>0.35–0.50</td>
<td>&gt;0.50 or &lt;0.20</td>
</tr>
<tr>
<td>(heart area/chest area)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Cardiac function</strong></td>
<td>Normal TV and MV RV/LV S.F. &gt;0.28</td>
<td>Holosystolic TR or RV/LV S.F. &lt;0.28</td>
<td>Holosystolic MR or TR dP/dt 400 or monophasic filling</td>
</tr>
<tr>
<td></td>
<td>Biphasic diastolic filling (2 pts)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Arterial Doppler</strong></td>
<td>UA (2 pts)</td>
<td>UA (AEDV)</td>
<td>UA (REDV)</td>
</tr>
<tr>
<td>(umbilical artery)</td>
<td></td>
<td></td>
<td></td>
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Thank You