When Does 3D Echo Make A Difference?

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GUIDELINES AND STANDARDS

EAE/ASE Recommendations for Image Acquisition and Display Using Three-Dimensional Echocardiography

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GUIDELINES AND STANDARDS

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Practical Applications of 3D Echocardiography

<table>
<thead>
<tr>
<th>Recommended</th>
<th>Promising Clinical Trials</th>
<th>Areas of active Research</th>
</tr>
</thead>
</table>

Recommended

- LV Volumes
- MV anatomy
- MV Stenosis
- Guidance of Transcatheter Procedures
- + Tricuspid Valve Anatomy
Techniques for Integration

- 3DE Integration
- Cropping
- Multi-planar Reconstruction
- Automated Analysis Programs

Which is a true 4-chamber view?

A  B  C
LV Function Assessment

Tomographic Slices
LV Function Assessment
Tomographic Slices
LV Function Assessment

Tomographic Slices
LV Function Assessment
Improve Biplane LVEF Using 3D


True 3D LV Volumes
Increased Accuracy
3DE Changes 2DE Categorization

Table 1: Re-allocation to above or below ejection fraction (EF) threshold according to 2D EF

<table>
<thead>
<tr>
<th>2D EF band</th>
<th>No of 2D patients</th>
<th>Re-allocation according to a threshold EF 30% (%)</th>
<th>Re-allocation according to a threshold EF 40% (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 25%</td>
<td>32</td>
<td>2 (6.3)</td>
<td>1 (3.1)</td>
</tr>
<tr>
<td>26–35%</td>
<td>36</td>
<td>14 (38.9)</td>
<td>5 (13.9)</td>
</tr>
<tr>
<td>36–40%</td>
<td>13</td>
<td>1 (7.7)</td>
<td>7 (53.9)</td>
</tr>
<tr>
<td>41–45%</td>
<td>10</td>
<td>2 (20.0)</td>
<td>5 (50.0)</td>
</tr>
<tr>
<td>&gt; 45%</td>
<td>129</td>
<td>0 (0)</td>
<td>2 (1.6)</td>
</tr>
</tbody>
</table>


Feasibility, Accuracy, and Reproducibility of Real-Time Echocardiography for Measurement of Left Ventricular Volume and Systolic Function

Y = 6.8 + 0.88x, r = 0.86
Y = 0.3 + 0.99x, r = 0.97
Y = 4.9 + 0.85x, r = 0.93
Y = 16.0 + 0.76x, r = 0.92
Y = 36.9 + 0.69x, r = 0.88
Y = 21.0 + 0.78x, r = 0.85
Bias = -10.7, LOA = 17.5
Bias = -25.7, LOA = 32.7
Bias = -4.1, LOA = 6.1
Bias = -16.2, LOA = 24
Bias = -2%, LOA = 2.4%
Bias = -0.5%, LOA = 2.5%

Y = 29.1 + 0.7x, r = 0.90
Y = 0.68 + 0.98x, r = 0.98
Y = 9.2 + 0.8x, r = 0.96
Bias = -17.6, LOA = 26.7
Bias = -9.8, LOA = 17.9
Bias = -3%, LOA = 2.5%

ORIGINAL RESEARCH

Feasibility, Accuracy, and Reproducibility of Real-Time Echocardiography for Measurement of Left Ventricular Volume and Systolic Function

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Fully Automated Cardiac Chamber Quantification

Multi-planar Reconstruction
RV Size Assessment
MPR RV Size Assessment Increases Consistency

Surgeon’s View of the MV

Lesion Identification/Repair Complexity

MPR Localization

A1-P1  A2-P2  A3-P3
MV Quantification

What MVA would you report?

A

2D 1.66 cm²

B

3D 1.44 cm²
Rheumatic Mitral Stenosis

LA Perspective  
LV Perspective

MVA Planimetry by MPR

- 2D echo planimetry overestimates MVA
- 3D echo improves identification of the narrowest part of the MV orifice due to better alignment of the image plane at the mitral tips

Mitral Valve Quantification

Mitral Valvuloplasty Scoring
Wilkins ≤8

- Semi-quantitative
- Subject to observer variability
- Less reliable in classifying patients with scores within the mid-range
- Fibrosis vs calcification
- Uneven distribution of pathology
- Underestimates subvalve disease

http://www.csecho.ca/wp-content/themes/twentyeleven-csecho/cardiomath/?eqnHD=echo&eqnDisp=mvsmgh
Mitral Valvuloplasty Scoring

- Commissural morphology not assessed
- Post-procedural MR
- Important predictor of long-term outcome

Validation of a New Score for the Assessment of Mitral Stenosis Using Real-Time Three-Dimensional Echocardiography

<table>
<thead>
<tr>
<th>3DE Score</th>
<th>&lt;8</th>
<th>Mild</th>
</tr>
</thead>
<tbody>
<tr>
<td>8-13</td>
<td>Moderate</td>
<td></td>
</tr>
<tr>
<td>&gt; 14</td>
<td>Severe</td>
<td></td>
</tr>
</tbody>
</table>

Validation of a New Score for the Assessment of Mitral Stenosis Using Real-Time Three-Dimensional Echocardiography

- Feasible
- Reproducible
- Good intra- and inter-observer variability
- Better detection of calcification and commissural splitting


Subvalvular Assessment

[Images of ultrasound scans related to subvalvular assessment]
Percutaneous MV Balloon Valvuloplasty

En-face Left Ventricular View

Bileaflet Mechanical Valve
Thrombosed Mechanical Prosthesis

Location of Paravalvular Leaks

• Commonly located posteriorly because:
  1. Distal location in surgical field
  2. Protecting the circumflex artery
  3. Increase prevalence of calcium and fibrosis posteriorly
  4. Mitral fibrosa in anterior annulus tethers valve
Assessment of Paravalvular Leaks

- Size of leak

Percutaneous Repair of MV Dehiscence

Courtesy MA Garcia Fernandez
Atrial Septal Defects

ASD Size <38mm

- Waist diameter determines device size (range 4 – 38 mm)
Use of Biplane Imaging:
Incorrect Device Placement

Biplane Imaging:
Correct Device Placement
What is the mechanism of the TR?

Case 2
TV Imaging is Predominantly TTE

2D Echo TV Lesion Localization Is Plane Dependent

<table>
<thead>
<tr>
<th></th>
<th>Septal</th>
<th>Anterior</th>
<th>Posterior</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0%</td>
<td>100%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>100%</td>
<td>0%</td>
<td>100%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>92%</td>
<td>0%</td>
</tr>
</tbody>
</table>

3D TTE Can Identify Lead Position in 90% of Patients


TV Annular Enlargement

- There is a linear relation between tricuspid valve annulus diameter and regurgitant volume
- In secondary TR, annular dilatation is a marker of severity
  - >40 mm or 21 mm/m² in diastole 4-chamber view
- Mild TR can be seen in those with normal tricuspid valve leaflets and annular dimensions

Dreyfus GD et al. J Am Coll Cardiol 2015;65:2331–6
2D Echo Underestimates Tricuspid Annular Diameter

Badano et al. Eur J Echo. 2009;10;477-84

3D Tricuspid Annular Measurements

Tsang et al. JASE. 2012; 25(6): 879
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**Promising Clinical Trials**
- LV Mass
- RV Volumes/Function
- Ao Anatomy
- Ao Stenosis

**LV Mass Measurement**

- 2D biplane
- 3D-guided biplane

**MRI reference**

# RV Volumes/Function

## 3D ECHO ASSESSMENT OF THE RIGHT HEART

*Validation vs. Cardiac Magnetic Resonance*

<table>
<thead>
<tr>
<th>Study</th>
<th>Population characteristics</th>
<th>RV EDV mL (95%CI)</th>
<th>RV ESV mL (95%CI)</th>
<th>RV EF mL (95%CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shimada et al. (2010)</td>
<td>Meta-analysis (n=807)</td>
<td><strong>-13.3 (-17.7, -10.1)</strong></td>
<td><strong>-5.5 (-7.6, -3.4)</strong></td>
<td><strong>-0.9 (-1.8, -0.1)</strong></td>
</tr>
<tr>
<td>Grapsa et al. (2010)</td>
<td>Normal subjects (n=20)</td>
<td><strong>-1.3 (-4.57, 1.57)</strong></td>
<td><strong>0.80 (-1.35, 2.95)</strong></td>
<td><strong>-1.3 (-3.1, 0.5)</strong></td>
</tr>
<tr>
<td>Grapsa et al. (2010)</td>
<td>PAH (n=60)</td>
<td><strong>-3.7 (-10.96, 3.56)</strong></td>
<td><strong>-0.02 (-6.19, 6.15)</strong></td>
<td><strong>-1.3 (-3.07, 0.47)</strong></td>
</tr>
<tr>
<td>Sugeng et al. (2010)</td>
<td>Patients (n=28)</td>
<td><strong>-14 (-27.8, -0.2)</strong></td>
<td><strong>-9 (-19.2, 1.2)</strong></td>
<td><strong>-2 (-4.27, 0.27)</strong></td>
</tr>
<tr>
<td>van der Zwaan et al. (2010)</td>
<td>CHD (n=50)</td>
<td><strong>-34 (-43.26, -24.74)</strong></td>
<td><strong>-11 (-18.71, -3.29)</strong></td>
<td><strong>-4 (-5.91, -2.09)</strong></td>
</tr>
<tr>
<td>Leibundgut et al. (2010)</td>
<td>Patients (n=88)</td>
<td><strong>-10.2 (-14.63, -5.77)</strong></td>
<td><strong>-4.5 (-7.53, -1.47)</strong></td>
<td><strong>-0.4 (-1.97, 1.17)</strong></td>
</tr>
</tbody>
</table>

Elliptical Ao Annulus

Automated Aortic Root Assessment
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Areas of Active Research

| LV Shape | LV Dyssynchrony | LA Volumes | MV Regurgitation | Prosthetic Valves |

LV Shape

LA Volumes

LV Dyssynchrony

MV Regurgitation

Prosthetic Valves
Thank you for listening

### "Easy" Applications

<table>
<thead>
<tr>
<th>Technique</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cropping</td>
<td>• Display and understand the anatomy</td>
</tr>
<tr>
<td></td>
<td>• Tricuspid valve</td>
</tr>
<tr>
<td></td>
<td>• Mitral valve</td>
</tr>
<tr>
<td>Multi-planar reconstruction</td>
<td>• Improve measurements</td>
</tr>
<tr>
<td></td>
<td>• MV planimetry</td>
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<tr>
<td></td>
<td>• LVOT</td>
</tr>
<tr>
<td></td>
<td>• Improves LV and RV assessment</td>
</tr>
<tr>
<td>Automated Analysis Programs</td>
<td>• LV volumes</td>
</tr>
<tr>
<td></td>
<td>• LA volumes</td>
</tr>
<tr>
<td></td>
<td>• RV volumes</td>
</tr>
<tr>
<td></td>
<td>• SV measurement</td>
</tr>
<tr>
<td></td>
<td>• MV</td>
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