Chamber Quantification and Evaluation of Systolic Function

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ACC Latin America
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Disclosures

• No relevant financial disclosures
Overview

• Assessment of LV size
• Assessment of LV function
• Assessment of LV mass and geometry
GUIDELINES AND STANDARDS

Recommendations for Cardiac Chamber Quantification by Echocardiography in Adults: An Update from the American Society of Echocardiography and the European Association of Cardiovascular Imaging

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### Recommendations

<table>
<thead>
<tr>
<th>Recommendations</th>
<th>COR</th>
<th>LOE</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICD therapy is recommended for primary prevention of SCD in selected patients with HF/EF at least 40 d post-MI with LVEF ≤35% and NYHA class II or III symptoms on chronic GDMT, who are expected to live &gt;1 year</td>
<td>I</td>
<td>A</td>
<td>355, 593</td>
</tr>
<tr>
<td>CRT is indicated for patients who have LVEF ≤35%, sinus rhythm, LBBB with a QRS ≥150 ms, and NYHA class II, III, or ambulatory IV symptoms on GDMT</td>
<td>I</td>
<td>A (NYHA class III/IV)</td>
<td>38, 78, 116, 594</td>
</tr>
<tr>
<td>CRT can be useful for patients who have LVEF ≤35%, sinus rhythm, a non-LBBB pattern with QRS ≥150 ms, and NYHA class III/ambulatory class IV symptoms on GDMT</td>
<td>Ila</td>
<td>A</td>
<td>78, 116, 594, 596</td>
</tr>
<tr>
<td>CRT can be useful for patients who have LVEF ≤35%, sinus rhythm, LBBB with a QRS 120 to 149 ms, and NYHA class II, III, or ambulatory IV symptoms on GDMT</td>
<td>Ila</td>
<td>B</td>
<td>78, 116, 594–596, 599</td>
</tr>
<tr>
<td>CRT can be useful in patients with AF and LVEF ≤35% on GDMT if a) the patient requires ventricular pacing or otherwise meets CRT criteria and b) AV nodal ablation or rate control allows near 100% ventricular pacing with CRT</td>
<td>Ila</td>
<td>B</td>
<td>600–605</td>
</tr>
<tr>
<td>CRT can be useful for patients on GDMT who have LVEF ≤35% and are undergoing new or replacement device implantation with anticipated ventricular pacing (&gt;40%)</td>
<td>Ila</td>
<td>C</td>
<td>155, 602, 606, 607</td>
</tr>
<tr>
<td>An ICD is of uncertain benefit to prolong meaningful survival in patients with a high risk of nonsudden death such as frequent hospitalizations, frailty, or severe comorbidities*</td>
<td>IIb</td>
<td>B</td>
<td>608–611</td>
</tr>
<tr>
<td>CRT may be considered for patients who have LVEF ≤35%, sinus rhythm, a non-LBBB pattern with a QRS duration of 120 to 149 ms, and NYHA class II/ambulatory class IV on GDMT</td>
<td>IIb</td>
<td>B</td>
<td>596, 612</td>
</tr>
<tr>
<td>CRT may be considered for patients who have LVEF ≤35%, sinus rhythm, a non-LBBB pattern with QRS ≥150 ms, and NYHA class II symptoms on GDMT</td>
<td>IIb</td>
<td>B</td>
<td>595, 596</td>
</tr>
<tr>
<td>CRT may be considered for patients who have LVEF ≤30%, ischemic etiology of HF, sinus rhythm, LBBB with QRS ≥150 ms, and NYHA class I symptoms on GDMT</td>
<td>IIb</td>
<td>C</td>
<td>595, 596</td>
</tr>
<tr>
<td>CRT is not recommended for patients with NYHA class I or II symptoms and non-LBBB pattern with QRS &lt;150 ms</td>
<td>III: No Benefit</td>
<td>B</td>
<td>595, 596, 612</td>
</tr>
</tbody>
</table>

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Assessment of LV Size
LV Dimensions

• Measure in PLAX view.

• Measure at or immediately below mitral valve leaflet tips.

• 2D images are preferred to avoid oblique sections of the ventricle

• Representative of LV size only in normally shaped ventricles
LV Volumes

- Calculation of LV volumes from linear dimensions is no longer recommended.
- May be inaccurate due to assumption of a fixed geometric LV shape which does not apply in a variety of pathologies.
LV Volumes

• Should routinely be assessed by using the biplane method of disks summation technique.

• Should be measured from apical 4- and 2-chamber views.

• Avoiding foreshortening and aim to maximize LV areas
Tips

• Avoiding foreshortening

• LV lengths should be comparable between views

• Exclude trabeculations and papillary muscle
Contrast Echocardiography

- Should be used when two or more contiguous LV segments are poorly visualized in apical views.
- Contrast-enhanced images may provide larger volumes than unenhanced images.
3D Echocardiography

- More accurate and reproducible
- No geometrical assumptions
- 3D LV volume measurement is recommended when feasible depending on image quality.
Jenkins C et al. Left ventricular volume measurement with echocardiography: a comparison of left ventricular opacification, three-dimensional echocardiography, or both with magnetic resonance imaging. Eur Heart J. 2009;30:98-106.
Interpretation of LV size

<table>
<thead>
<tr>
<th></th>
<th>Male</th>
<th></th>
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<th></th>
<th>Female</th>
<th></th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Normal range</td>
<td>Mildly abnormal</td>
<td>Moderately</td>
<td>Severely</td>
<td>Normal range</td>
<td>Mildly abnormal</td>
<td>Moderately</td>
</tr>
<tr>
<td><strong>LV dimension</strong></td>
<td></td>
<td></td>
<td></td>
<td>abnormal</td>
<td>abnormal</td>
<td></td>
<td></td>
<td>abnormal</td>
</tr>
<tr>
<td>LV diastolic diameter</td>
<td>4.2-5.8</td>
<td>5.9-6.3</td>
<td>6.4-6.8</td>
<td>&gt;6.8</td>
<td>3.8-5.2</td>
<td>5.3-5.6</td>
<td>5.7-6.1</td>
<td>&gt;6.1</td>
</tr>
<tr>
<td>LV diastolic diameter/BSA</td>
<td>2.2-3.0</td>
<td>3.1-3.3</td>
<td>3.4-3.6</td>
<td>&gt;3.6</td>
<td>2.3-3.1</td>
<td>3.2-3.4</td>
<td>3.5-3.7</td>
<td>&gt;3.7</td>
</tr>
<tr>
<td>LV systolic diameter</td>
<td>2.5-4.0</td>
<td>4.1-4.3</td>
<td>4.4-4.5</td>
<td>&gt;4.5</td>
<td>2.2-3.5</td>
<td>3.6-3.8</td>
<td>3.9-4.1</td>
<td>&gt;4.1</td>
</tr>
<tr>
<td>LV systolic diameter/BSA</td>
<td>1.3-2.1</td>
<td>2.2-2.3</td>
<td>2.4-2.5</td>
<td>&gt;2.5</td>
<td>1.3-2.1</td>
<td>2.2-2.3</td>
<td>2.4-2.6</td>
<td>&gt;2.6</td>
</tr>
<tr>
<td><strong>LV volume</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LV diastolic volume</td>
<td>62-150</td>
<td>151-174</td>
<td>175-200</td>
<td>&gt;200</td>
<td>46-106</td>
<td>107-120</td>
<td>121-130</td>
<td>&gt;130</td>
</tr>
<tr>
<td>LV diastolic volume/BSA</td>
<td>34-74</td>
<td>75-89</td>
<td>90-100</td>
<td>&gt;100</td>
<td>29-61</td>
<td>62-70</td>
<td>71-80</td>
<td>&gt;80</td>
</tr>
<tr>
<td>LV systolic volume/BSA</td>
<td>11-31</td>
<td>32-38</td>
<td>39-45</td>
<td>&gt;45</td>
<td>8-24</td>
<td>25-32</td>
<td>33-40</td>
<td>&gt;40</td>
</tr>
</tbody>
</table>

Rvol MR 105 cc/beat  
2D LVEDD 54 mm  
2D LVESD 40 mm  
Volumetric LVEF 54%  
LA index 75 cc/m2  
Biplane LV EDD Vol 225 cc  
Biplane LV EDD Vol/index 137 cc/m2
Assessment of LV Function
Methods

• Fractional Shortening
• Ejection Fraction
• Stroke Volume
• Global Longitudinal Strain
• Regional Wall Motion Analysis
LVEF: Modified Quinones Method

\[
LVEF_{\text{calc}} = \frac{LVEDD^2 - LVESD^2}{LVEDD^2}
\]

\[
EF = LVEF_{\text{calc}} + [(1 - LVEF_{\text{calc}}) \times \%\Delta L]
\]

Where anapitotic factor (\%\Delta L) is:
- 15 Normal
- 5 Hypokinetic
- 0 Akinetic
- -5 Dyskinetic
- -10 Aneurysmal

Not ASE Recommended
LVEF: Modified Simpson’s Biplane

\[
\text{LVEF} = \frac{\text{LVEDV} - \text{LVESV}}{\text{LVEDV}} \times 100
\]
Assessment of LV Volumes by Echo

Jenkins C et al. Left ventricular volume measurement with echocardiography: a comparison of left ventricular opacification, three-dimensional echocardiography, or both with magnetic resonance imaging. Eur Heart J. 2009;30:98-106.
# LV Ejection Fraction

<table>
<thead>
<tr>
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<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>52 – 72 %</td>
<td>54 – 74 %</td>
</tr>
<tr>
<td>Mildly Abnormal</td>
<td>41 – 51 %</td>
<td>41 – 51 %</td>
</tr>
<tr>
<td>Moderately Abnormal</td>
<td>30 – 40 %</td>
<td>30 – 40 %</td>
</tr>
<tr>
<td>Severely Abnormal</td>
<td>&lt; 30 %</td>
<td>&lt; 30 %</td>
</tr>
</tbody>
</table>

Assessment of LV Mass and Geometry
Question

• 64 year old white female presents with a 16 year history of hypertension, she initially was managed with diuretics alone but has been managed with two drug therapy with ACE inhibitor and diuretics for the last 7 years.
Question

• She describes NYHA class II DOE, no orthopnea or PND. Denies chest pain or other cardiac symptoms.

• Exam
  • 165cm  82 Kg
  • BP 137/81  HR 67
  • Lungs Clear
  • CV soft S1 paradoxically split S2, 1/6 holosystolic blowing murmur at apex
  • No Edema
Question

• Echocardiogram demonstrates enlarged left ventricle with global hypokinesis, LVEF 23%, Moderate mitral regurgitation

  • LVEDD  79mm    LVESD 74 mm
  • Septal wall 9 mm  Posterior wall 9 mm
  • LV Mass 121 gm/m2
Question

• Which best describes the remodeling of the left ventricle
  1. Concentric remodelling
  2. Normal geometry
  3. Concentric hypertrophy
  4. Eccentric hypertrophy
Interpretation of LV Mass

<table>
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</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Normal range</td>
<td>Mildly abnormal</td>
</tr>
<tr>
<td>LV mass by linear method</td>
<td>0.6–1.0 cm</td>
<td>1.1–1.3 cm</td>
</tr>
<tr>
<td>Septal wall thickness (cm)</td>
<td>88–224 g</td>
<td>225–258 g</td>
</tr>
<tr>
<td>LV mass (g)</td>
<td>49–115 g/m²</td>
<td>116–131 g/m²</td>
</tr>
<tr>
<td>LV mass/BSA (g/m²)</td>
<td>96–200 g</td>
<td>201–227 g</td>
</tr>
<tr>
<td>LV mass by 2D method</td>
<td>50–102 g/m²</td>
<td>103–116 g/m²</td>
</tr>
</tbody>
</table>

Classification of LV Geometry

Relative Wall Thickness

RWT = \frac{2 \times PWT_d}{LVID_d}

<table>
<thead>
<tr>
<th>Relative Wall Thickness (RWT)</th>
<th>Concentric Remodeling</th>
<th>Concentric Hypertrophy</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; 0.42</td>
<td>≥ 95 (♀)</td>
<td>≤ 115 (♂)</td>
</tr>
<tr>
<td>≤ 0.42</td>
<td>≤ 95 (♀)</td>
<td>&gt; 115 (♂)</td>
</tr>
</tbody>
</table>

Left Ventricular Mass Index (g/m²)
Question

• Calculate relative wall thickness (RWT)

\[
RWT = \frac{2 \times PWT_d}{LVID_d}
\]

\[
RWT = \frac{2 \times 9}{79}
\]

• RWT = 0.22

• Plot on 2 by 2 table
Relative Wall Thickness

Left Ventricular Mass Index (g/m²)

Relative Wall Thickness (RWT)

> 0.42

≤ 0.42

Concentric Remodeling

Concentric Hypertrophy

Normal Geometry

Eccentric Hypertrophy

≤ 95 (♀️)

≤ 115 (♀️)

> 95 (♀️)

> 115 (♀️)
Question

• Which best describes the remodeling of the left ventricle

1. Concentric remodelling
2. Normal geometry
3. Concentric hypertrophy
4. Eccentric hypertrophy
LV Mass: A Marker of Prognosis

Comprehensive characterisation of hypertensive heart disease left ventricular phenotypes

Jonathan C L Rodrigues,¹,² Antonio Matteo Amadu,¹,³ Amardeep Ghosh Dastidar,¹,⁴ Gergley V Szancho,¹,⁵ Stephen M Lyen,¹,⁶ Cattleya Godsave,⁷ Laura E K Ratcliffe,⁸ Amy E Burchell,⁴,⁸ Emma C Hart,²,⁸ Mark C K Hamilton,⁶ Angus K Nightingale,⁴,⁸ Julian F R Paton,²,⁸ Nathan E Manghat,¹,⁶ Chiara Bucciarelli-Ducci¹,⁴


Conclusions Myocardial interstitial fibrosis varies across hypertensive LV phenotypes with functional consequences. Eccentric LVH has the most fibrosis and systolic impairment. Concentric remodelling is only associated with abnormal aortic function. Understanding these differences may help tailor future antihypertensive treatments.
LV Geometry: Clinical Implications

Questions & Discussion