Chamber Quantification and Evaluation of Systolic Function

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Professor of Medicine
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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<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 y*</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 is recommended for primary prevention of SCD in selected patients with HF/EF at least 40 d post-MI with LVEF ≤30% and NYHA class I symptoms while receiving GDMT, who are expected to live &gt;1 y*</td>
<td>I</td>
<td>B</td>
<td>362, 597, 598</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, 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>Iib</td>
<td>No Benefit</td>
<td>595, 596, 612</td>
</tr>
<tr>
<td>CRT is not indicated for patients whose comorbidities and/or frailty limit survival to &lt;1 y</td>
<td>Iib</td>
<td>No Benefit</td>
<td>38</td>
</tr>
</tbody>
</table>

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.
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.
Interpretation of LV size

<table>
<thead>
<tr>
<th>LV dimension</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>LV diastolic diameter (cm)</td>
<td>4.2–5.8</td>
<td>3.8–5.2</td>
</tr>
<tr>
<td>LV diastolic diameter/BSA (cm/m²)</td>
<td>2.2–3.0</td>
<td>2.3–3.1</td>
</tr>
<tr>
<td>LV systolic diameter (cm)</td>
<td>2.5–4.0</td>
<td>3.2–3.4</td>
</tr>
<tr>
<td>LV systolic diameter/BSA (cm/m²)</td>
<td>1.3–2.1</td>
<td>2.2–2.3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>LV volume</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>LV diastolic volume (mL)</td>
<td>62–150</td>
<td>46–106</td>
</tr>
<tr>
<td>LV diastolic volume/BSA (mL/m²)</td>
<td>34–74</td>
<td>29–61</td>
</tr>
<tr>
<td>LV systolic volume (mL)</td>
<td>21–61</td>
<td>14–42</td>
</tr>
<tr>
<td>LV systolic volume/BSA (mL/m²)</td>
<td>11–31</td>
<td>8–24</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

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

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

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

Not ASE Recommended
LVEF: Modified Simpson’s Biplane

\[
LVEF = \frac{LVEDV - LVESV}{LVEDV} \times 100
\]
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>
<th>Condition</th>
<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>
<thead>
<tr>
<th></th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Normal range</td>
<td>Mildly abnormal</td>
</tr>
<tr>
<td>Septal wall thickness (cm)</td>
<td>0.6–1.0</td>
<td>1.1–1.3</td>
</tr>
<tr>
<td>Posterior wall thickness (cm)</td>
<td>0.6–1.0</td>
<td>1.1–1.3</td>
</tr>
<tr>
<td>LV mass/BSA (g/m²)</td>
<td>49–115</td>
<td>116–131</td>
</tr>
</tbody>
</table>

LV mass by 2D method

<table>
<thead>
<tr>
<th></th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Normal range</td>
<td>Mildly abnormal</td>
</tr>
<tr>
<td>LV mass (g)</td>
<td>96–200</td>
<td>201–227</td>
</tr>
<tr>
<td>LV mass/BSA (g/m²)</td>
<td>50–102</td>
<td>103–116</td>
</tr>
</tbody>
</table>

Classification of LV Geometry

Relative Wall Thickness

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

- **Concentric Remodeling**
  - Normal Geometry
  - \( \leq 95 \) (♀) \( \leq 115 \) (♂)
- **Concentric Hypertrophy**
  - \( > 95 \) (♀) \( > 115 \) (♂)
- **Eccentric Hypertrophy**
  - \( \leq 0.42 \)
- **Relative Wall Thickness (RWT)**
  - \( \leq 0.42 \)
  - \( > 0.42 \)
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)

- ≤ 95
- ≤ 115
- > 95
- > 115

Concentric Remodeling
Concentric Hypertrophy
Normal Geometry
Eccentric Hypertrophy

Relative Wall Thickness (RWT)

> 0.42
≤ 0.42
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 Szanto,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

All Cause Mortality

Cardiovascular Events

Questions & Discussion