Echocardiography in arterial hypertension

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Structural and functional parameters of potential clinical utility.

1. LV geometry (*LV mass, relative wall thickness, chamber size*)
2. LV pump performance (*stroke volume, stroke work, cardiac output*)
3. LV systolic chamber function (*ejection fraction, fractional shortening of minor axis*)
4. Output impedance (*pulse pressure/stroke volume, peripheral resistance*)
5. LA size (*LA volume, LA dimension*)
6. Diastolic function (*E/e’, E/A ratio, IVRT, DTE, MDI*)
7. LV wall mechanics (*midwall shortening, strain*)
8. Myocardial afterload (*circumferential end-systolic stress*)
9. Myocardial contractility (*afterload-adjusted shortening*)
10. LA function (*LA systolic force, LA ejection fraction, strain*)
11. Aortic size.
12. RV geometry and function........
Imaging techniques for LV quantification.

We recommend concurrent measurement of blood pressure for estimating functional parameters.

GDS/2018
Reasons for which 2D echocardiography is still the method of reference for arterial hypertension.

- Widespread available facilities
- Cost/effectiveness
- Available epidemiological evidence
- Consolidated cut-points for identification of high-risk phenotypes
- Number of parameters that can be obtained by the same simple procedure.
LVMi = 30.9 g/m^{2.7}
(n.v. < 47 g/m^{2.7} \, \text{♀};
< 50 g/m^{2.7} \, \text{♂})

LVM = 0.832 \times [(0.8 + 5.0 + 0.8)^3 - (5.0)^3] + 0.6 = 136 \, g
Comparing geometric models for LV mass

Relation between necropsy left ventricular weight (x axis) and left ventricular mass calculated with the thick-wall American Society of Echocardiography (ASE)-measured ellipsoidal model. Continuous lines are the regression line and the average values for both variables. The broken line is the line of identity. $r = 0.92$, $P < 0.0001$. 

Relative wall thickness (RWT)

This is the wall thickness (W) expressed per unit of LV minor axis radius (LVIr), where LVIr is ½ of LV internal diameter:

$$ RWT = \frac{W}{LVIr} $$

v.n. <0.43

LVMi = 61.3 g/m²

LVM = 0.832 \times [(0.9 + 6.2 + 1.1)^3 - (6.2)^3] + 0.6 = 261 \text{ g}
Distribution of LV geometry in the CSN registry

Campania Salute Network Registry - Unpublished
3D Echocardiography

Lembo M et al. J. Hypertens, 2018, in press
Lembo M et al. J. Hypertens, 2018, in press
2-tiered or 4-tiered patterns of LVH?

2-tiered or 4-tiered patterns of LVH?

\[ n = 8,848 \]
LV chamber function and MBP

Adapted from de Simone G et al. J Hypertens 2015, 2015, 33:745–754
Strain imaging for refined assessment of LV systolic function

Kraigher-Krainer E et al. JACC 2014;63:447–56

<table>
<thead>
<tr>
<th>LV Structures and Function</th>
<th>Healthy Group (n=48)</th>
<th>HTN Group (n=116)</th>
<th>HFP EF Group (n=49)</th>
<th>Trend P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Myocardial mechanics</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Longitudinal S, %</td>
<td>-19.9±2.0</td>
<td>-17.8±1.8*</td>
<td>-13.9±2.9**</td>
<td>32%</td>
</tr>
<tr>
<td>Radial S, %</td>
<td>45.4±10.3</td>
<td>37.1±11.7*</td>
<td>26.2±10.4**</td>
<td>42%</td>
</tr>
<tr>
<td>Circumferential S, %</td>
<td>21.2±2.9</td>
<td>21.2±2.5</td>
<td>18.7±5.3*</td>
<td>12%</td>
</tr>
<tr>
<td>Twist, °</td>
<td>13.3±3.4</td>
<td>13.2±3.7</td>
<td>11.1±4.4**</td>
<td>17%</td>
</tr>
</tbody>
</table>
Hemodynamics in relation to LV geometry

Adapted from de Simone G et al. J Hypertens 2015, 2015, 33:745–754
3D SV (ml) vs. 3D LVM/EDV ratio

$r = -0.74$

$p < 0.0001$

Lembo M et al. J. Hypertens, 2018, in press
Rationale for the use of 2-element Windkessel model of arterial stiffness

A representative result of SV, BP, and baroreflex responses to a wide range of perturbation in blood volume (3.5 L–6.5 L).


Figure 5: Experimental relation between SV and PP in humans.
# PP/SVi in the LIFE echo-substudy

Table 4. Relative unadjusted and adjusted hazard rate for primary cardiovascular end-point, cardiovascular mortality, stroke, myocardial infarction, hospitalization for heart failure and total mortality for baseline PP/SVi.

<table>
<thead>
<tr>
<th>Endpoints</th>
<th>No. of events</th>
<th>Unadjusted HR (95% CI)</th>
<th>p value</th>
<th>Adjusted HR (95% CI)</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary cardiovascular end-point</td>
<td>83</td>
<td>1.31 (1.05–1.64)</td>
<td>.019</td>
<td>1.38 (1.04–1.84)&lt;sup&gt;a&lt;/sup&gt;</td>
<td>.025</td>
</tr>
<tr>
<td>Cardiovascular mortality</td>
<td>19</td>
<td>2.10 (1.45–3.03)</td>
<td>.0001</td>
<td>2.35 (1.59–3.48)&lt;sup&gt;b&lt;/sup&gt;</td>
<td>.0001</td>
</tr>
<tr>
<td>Stroke</td>
<td>49</td>
<td>1.42 (1.08–1.89)</td>
<td>.013</td>
<td>1.45 (1.06–1.99)&lt;sup&gt;b&lt;/sup&gt;</td>
<td>.021</td>
</tr>
<tr>
<td>Myocardial Infarction</td>
<td>34</td>
<td>1.13 (0.78–1.65)</td>
<td>.507</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Hospitalization for heart failure</td>
<td>23</td>
<td>2.20 (1.55–3.06)</td>
<td>.0001</td>
<td>2.15 (1.48–3.12)&lt;sup&gt;b&lt;/sup&gt;</td>
<td>.0001</td>
</tr>
<tr>
<td>Total mortality</td>
<td>45</td>
<td>1.35 (1.01–1.81)</td>
<td>.044</td>
<td>1.52 (1.10–2.09)&lt;sup&gt;b&lt;/sup&gt;</td>
<td>.011</td>
</tr>
</tbody>
</table>

<sup>a</sup>Adjusted for baseline systolic BP, PP, LV mass, sex and treatment allocation.

<sup>b</sup>Adjusted for baseline systolic BP and treatment allocation.

Determination of LA volume

LA dilatation = >34 mL/m²
Determination of LA volume

Ellipsoid model

\[ v_{Ells} = 2.323 \times LAd^{2.07} \]

LA dilatation* =

>18.5 mL/height in m² (men)
>16.5 mL/height in m² (women)


Echocardiography should be considered in hypertensive patients when awareness of LV geometry and function will influence decision-making.
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