Echocardiography in arterial hypertension
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.
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} ♀; < 50 g/m^{2.7} ♂)

\[
LVM = 0.832 \times [(0.8 + 5.0 + 0.8)^3 - (5.0)^3] + 0.6 = 136 \text{ g}
\]
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 ($LVr$), where $LVr$ is 1/2 of LV internal diameter.

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

v.n. < 0.43
Distribution of LV geometry in the CSN registry

Adapted from Ganau A, de Simone G et al: JACC 1992;19:1550-1558
Campania Salute Network Registry - Unpublished
3D Echocardiography

Lembo M et al. J. Hypertens, 2018, in press
LV normal geometry by 3D but with concentric geometry by 2D-echo

LV concentric geometry by 3D but normal geometry by 2D-echo

LV concentric geometry by both 3D and 2D-echo

LV normal geometry by both 3D and 2D-echo

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?

Cumulative Hazard

Time of follow-up (months)

n=8,848

Acute MI
Stroke
Sudden death

LV chamber function and MBP

Adapted from de Simone G et al. J Hypertens 2015, 2015, 33:745–754
<table>
<thead>
<tr>
<th>LV Structures and Function</th>
<th>Healthy Group (n=48)</th>
<th>HTN Group (n=116)</th>
<th>HFrEF Group (n=49)</th>
<th>Trend P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Myocardial mechanics</strong></td>
<td></td>
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<tr>
<td>Longitudinal S, %</td>
<td>$-19.9 \pm 2.0$</td>
<td>$-17.8 \pm 1.8^*$</td>
<td>$-13.9 \pm 2.9^+$</td>
<td>$32%$</td>
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<td>$&lt;0.001$</td>
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<tr>
<td>Radial S, %</td>
<td>$45.4 \pm 10.3$</td>
<td>$37.1 \pm 11.7^*$</td>
<td>$26.2 \pm 10.4^+$</td>
<td>$42%$</td>
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<td>$&lt;0.001$</td>
</tr>
<tr>
<td>Circumferential S, %</td>
<td>$21.2 \pm 2.9$</td>
<td>$21.2 \pm 3.5$</td>
<td>$18.7 \pm 5.3^*$</td>
<td>$12%$</td>
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<td>$0.005$</td>
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<tr>
<td>Twist, °</td>
<td>$13.3 \pm 3.4$</td>
<td>$13.2 \pm 3.7$</td>
<td>$11.1 \pm 4.4^+$</td>
<td>$17%$</td>
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<td>$0.005$</td>
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*Kraigher-Krainer E et al. JACC 2014;63:447–56*
Hemodynamics in relation to LV geometry

Adapted from de Simone G et al. J Hypertens 2015, 2015, 33:745–754
$r = -0.74$
$p < 0.0001$
Rationale for the use of 2-element Windkessel model of arterial stiffness

Figure 5: Experimental relation between SV and PP in humans.

Representative result of SV, and baroreflex responses to wide range of disturbance in blood volume (0.5 L–6.5 L).

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)</td>
<td>.025</td>
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<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)</td>
<td>.0001</td>
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<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)</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>
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<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)</td>
<td>.0001</td>
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<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)</td>
<td>.011</td>
</tr>
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\( ^a \) Adjusted for baseline systolic BP, PP, LV mass, sex and treatment allocation.

\( ^b \) Adjusted for baseline systolic BP and treatment allocation.
Determination of LA volume

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

Ellipsoid model

$\nu_{E\text{lls}} = 2.323 \times LAd^{2.07}$

LA dilatation$^* =$

$>18.5$ mL/height in m$^2$ (men)
$>16.5$ mL/height in m$^2$ (women)


Scoring utility...

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

<table>
<thead>
<tr>
<th>CRITICAL</th>
<th>USEFUL</th>
<th>USELESS</th>
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Maurizio Galderisi,
Maria Angela Losi,
Grazie Canciello,
Bruno Trimarco,
Nicola De Luca,
Raffele Izzo,

Costantino Mancusi,
Roberta ESposito,
Maria Lembo,
Ciro Santoro,
Andrea D’Amato,
Richard B. Devereux.