Prognostic Value of Left Atrial Size and Function

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Conflicts: None
Now, that’s a BIG Atrium!

Almost a liter!
Atrial Volume in a Normal Adult Population by Two-dimensional Echocardiography*

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Left atrial (LA) and right atrial (RA) volumes were calculated from two-dimensional echocardiography (2D echo) in 54 normal volunteers, of whom 23 were nonathletic men and 25 nonathletic women; 6 additional men had a history of athletic training. Ages ranged from 20 to 66 years (average nonathletic group, 38 years; athletic men, 35 years). The LA volume was measured by single-plane area-length algorithm from apical 2-chamber (2CH) and 4-chamber (4CH) views and from their combination by means of Simpson's rule. The RA volume was analyzed only in the 4CH view. Mean LA volume was larger for men than women; for nonathletic men, 46 ± 14 ml for 2CH view and 38 ± 10 ml for both the 4CH view and for Simpson's rule combination of the apical views. For women it was 36 ± 11 ml for the 2CH view, 34 ± 12 ml for the 4CH view, and 32 ± 10 ml by Simpson's rule. Right atrial volume was 39 ± 12 ml in nonathletic men and 27 ± 7 ml in women. In the six athletic men, LA volume and volume index, but not RA volume and volume index, were significantly larger than in nonathletes. These findings in this small sample suggest that caution should be exercised in interpreting atrial enlargement in athletes. There were no significant correlations between atrial volumes and age, although individuals over 65 years with normal hearts were not represented. In evaluating LA volume in a given patient, it is advisable to use specific values for each apical view and algorithm and to correct for either sex or body surface area (BSA) but not for both. In the RA it is necessary to correct for both sex and BSA.
Assessment of LA Size

Recommendations from ASE Guidelines

M-mode

Simpson’s rule

Area-length

Left Atrial Volume = \frac{8}{3\pi}[(A_1)(A_2)/(L)]

* (L) is the shortest of either the A4C or A2C length

Lang et al. JASE 2005; 18: 1440
Assessment of LA Size

Recommendations from ASE Guidelines

Table 9 Reference limits and partition values for left atrial dimensions/volumes

<table>
<thead>
<tr>
<th></th>
<th>Women</th>
<th></th>
<th>Men</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Reference range</td>
<td>Mildly abnormal</td>
<td>Moderately abnormal</td>
</tr>
<tr>
<td>Atrial dimensions</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LA diameter, cm</td>
<td>2.7–3.8</td>
<td>3.9–4.2</td>
<td>4.3–4.6</td>
</tr>
<tr>
<td>LA diameter/BSA, cm/m²</td>
<td>1.5–2.3</td>
<td>2.4–2.6</td>
<td>2.7–2.9</td>
</tr>
<tr>
<td>RA minor-axis dimension, cm</td>
<td>2.9–4.5</td>
<td>4.6–4.9</td>
<td>5.0–5.4</td>
</tr>
<tr>
<td>RA minor-axis dimension/BSA, cm/m²</td>
<td>1.7–2.5</td>
<td>2.6–2.8</td>
<td>2.9–3.1</td>
</tr>
<tr>
<td>Atrial area</td>
<td>≤20</td>
<td>20–30</td>
<td>30–40</td>
</tr>
<tr>
<td>Atrial volumes</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>LA area, cm²</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LA volume, mL</td>
<td>22–52</td>
<td>53–62</td>
<td>63–72</td>
</tr>
<tr>
<td>LA volume/BSA, mL/m²</td>
<td>≤22 ± 6</td>
<td>29–33</td>
<td>34–39</td>
</tr>
</tbody>
</table>

Normal: 22±6 ml/m²

Lang et al. JASE 2005; 18: 1440
423 pts (317 in SR) followed 3.5 ± 2.3 years for 1st AF, CHF, CVA/TIA, MI, revascularization, CV death

All size parameters were significant predictors of events, but volume index was superior

Tsang et al. JACC 2006; 47: 1018-23
LA Volume and Prognosis

- **Independent prognostic index**
  - **Heart failure** (Rossi A et al J Am Coll Cardiol 2002;40:1425)
  - **MI** (Beinart R et al J Am Coll Cardiol 2004;44:327)
  - **Mitral regurgitation** (Messika-Zeitoun et al Eur Heart J 2007;28:1773)

**Figure 3.** Kaplan-Meier survival curves of patients with left atrial (LA) volume index ≥32 ml/m² and for patients with LA volume index >32 ml/m². The log-rank test was used to compare survival curves. \( p = 0.0001 \)

Beinart R et al J Am Coll Cardiol 2004;44:327
LA Volume Predicts Incidence of AF

- 1655 pts without AF followed 4.0 ± 2.8 years
- 189 (11.4%) developed AF
- LA size strongly associated with incidence of AF
- Cumulative risks of AF by quartiles of LA volume were 3%, 12%, 15%, and 26%, respectively

Tsang et al. Mayo Proc 2001; 76: 467-75
LA Size Predicts AF Recurrence

Results from AFFIRM

- 2474 pts in SR at risk for recurrent AF
- Overall 46% recurred at 1 year, 84% at 5 years
- Recurrence associated with LA diameter (1.21, 1.16, 1.32 for 4.1-4.5 cm, 4.6-5.5 cm and >5.5 cm)

Olshansky et al. JACC 2005; 45: 2026-33
Indexed LA Volume More Predictive of AF Recurrence

n = 411, at least 6 month f/u

ROC curve area: LA diameter = 0.59 vs 0.84 for iLAV, p<0.001

Marchese et al. EJE 2011; 12: 214-21
LA Size Predicts Outcome in MR

• LA size predicts post-operative survival and incidence of a fib

Figure 3. Unadjusted survival curves stratified according to left atrial size. See text for details. LA, left atrium.

LA Volume and MR

• **LA volume predicts occurrence of a fib and combined end-point of death or surgery**

Messika-Zeitoun et al Eur Heart J 2007;28:1773
LA Size and Function

3D Echo vs MRI

LA volume 2D vs. 3D

- Correlation between LA volume measured by these two methods are modest (Muller H et al Echocardiography 2007; 24:960).

Maximum LA volume by RT3DE

Association with Diastolic Dysfunction

- **Positive correlation with:**
  - LV mass, E velocity, E/A ratio, and E/E` ratio

- **Negative correlation with:**
  - LV EF and A` velocity

De Castro et al Am J Cardiol 2008;101:1347
Atrial Systolic Function
Complicated by Having Two Outlets and No Isovolumic Period

Mitral Valve

Pulmonary Vein
Three Components of Atrial Function

- **Pump**
- **Conduit**
- **Reservoir**
LA Pressure & Volume
Reservoir, Conduit, and Pump

Bauer et al. JASE 2005; 18: 795-801
LA elastance & stiffness

Bauer et al. JASE 2005; 18: 795-801
Left Atrial Elastance

Active Component Much Smaller than LV

Alexander Circ Res. 61:209;1987
LA Pressure-Diameter in Acute Mitral Regurgitation

Sasayama et al. Circ. 60:177;1979
LA pressure-volume loops

LAD occlusion

LCx occlusion

Bauer et al. JASE 2005; 18: 795-801
LA elastance & stiffness

**LAD occlusion**
- Equation: $y = 1.9x - 2$
- Correlation: $r = 0.98$
- Equation: $y = 5.8e^{0.025x}$
- Correlation: $r = 0.96$

**LCx occlusion**
- Equation: $y = 1.4x - 3$
- Correlation: $r = 0.89$
- Equation: $y = 0.8x - 2$
- Equation: $y = 4.2e^{0.043x}$
- Correlation: $r = 0.98$
- Equation: $y = 4.2e^{0.027x}$

Bauer et al. JASE 2005; 18: 795-801
Atrial Function in AF

• **Pump function**
  – Effectively zero, except for tiny fibrillatory waves

• **Reservoir and conduit function**
  – These remain, but because of loss of pump function, mean LA pressure increases, moving passive LA loop upward and to the right and onto steeper PV curve

• **Left atrial appendage function**
  – Marker for LA systolic potential
Why Is This Important??

Atrial Fibrillation

- LAA velocity is often **lower** post DCC than pre
- Thus, patients are at **higher** risk for LAA clot following DCC
- Even if cleared by TEE, patients need anticoagulation following DCC

Sinus Rhythm

Grimm et al. JACC 1997; 29: 582-589
Left Atrial Appendage Stunning Resolves Within Two Weeks of Ablation

n = 16

Takami et al. JACC 2003; 41: 2207-11
The Pseudorestrictive Pattern of Transmitral Doppler Flow Pattern after Conversion of Atrial Fibrillation to Sinus Rhythm: Is Atrial or Ventricular Dysfunction to Blame?

Hirotugu Yamada, MD, PhD, Erwan Donal, MD, Yong-Jin Kim, MD, Deborah A. Agler, RCT, RDCS, Youhua Zhang, MD, Neil L. Greenberg, PhD, FACC, Todor N. Mazgalev, PhD, FACC, James D. Thomas, MD, FACC, and Richard A. Grimm, DO, FACC,

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Yamada et al. JASE 2004;17:813
Recovery of LA Pressure and Function After 3 Hours of Pacing-Induced AF

Yamada et al.  JASE 2004;17:813
Recovery of Transmitral Flow After 3 Hours of Pacing-Induced AF

Yamada et al. JASE 2004;17:813
Recovery of LV Function After 3 Hours of Pacing-Induced AF

Yamada et al. JASE 2004;17:813
LA Function and Prognosis

- **Reduced total LA emptying fraction linked to increased risk for first episode of atrial fibrillation in the elderly population**

Figure 3. Age-adjusted associations between LA emptying fraction and indexed maximum LA volume for the prediction of AF or atrial flutter.

Abhayaratna WP et al. Am J Cardiol 2008;101:1626
LA Remodeling vs Recurrence

Results from GISSI-AF

- 340 pts post DCC
- Overall 54% recurred at 1 year
- Analyzed for groups with no recurrence and tertiles of AF duration (1-6d, 7-58d, and 59+d)

Pt with less AF had favorable remodeling

No impact of valsartan treatment

Staszewsky et al. Circ Img 2011; 4: 711-8
LA Strain and Strain Rate
Application of Speckle Tracking

Saraiva et al. JASE 2010; 23: 172-80
Age-dependence of positive and negative strain

Saraiva et al. JASE 2010; 23: 172
Speckle Tracking for Left Atrial Strain

498 Patients with Negative Stress Echo

4 chamber view  2 chamber view

Speckle Tracking for Left Atrial Strain

Prediction of Functional Capacity

Left atrial function

