Left atrial dimensions – Is left atrial volume calculation always necessary?

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ABSTRACT

Background: Left atrial size may increase with hypertension, diastolic dysfunction, atrial fibrillation, valvular disease, ischaemic heart disease and heart failure. Accurate measurement of left atrial size is important as it can help in the diagnosis and management of heart diseases. Recently, left atrial volume has been recommended for the accurate measurement of the left atrial size. These measurements are complex and sometimes controversial. In this study we sought to investigate when left atrial volume measurement may not be necessary.

Methods: One hundred echocardiographic studies were selected retrospectively according to the left atrial size - diameter and/or left atrial area. Twenty-five patients were included in each of the 4 groups: severe, moderate, mildly dilated and normal left atrium respectively, according to routine 2-dimesional (2D) echo measurements. Then, left atrial size was re-calculated and left atrial volume was computed and adjusted to the body size.

Results: Initial diagnosis of normal left atrial size and severely dilated left atrium were accurate in 100% of the evaluated studies, according to left atrial diameter and left atrial area. In patients with mild and moderate left atrial dilatation, the left atrial area was usually underestimated.

Conclusion: If normal, or severe, left atrial dilatation is found by simple measurements of antero-posterior diameter and area, further calculation of left atrial volume index may not be necessary. In all other cases left atrial volume index should be calculated to accurately grade left atrial dilatation.

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INTRODUCTION

Accurate assessment of the left atrial size is important. Larger left atrial size has been associated with thromboembolism,[1] stroke and death,[2] and hypertensive heart disease.[3] Left atrial volume was predictive for congestive heart failure,[4] cardiovascular events[5] and correlated with diastolic dysfunction.[6] Left atrial size was predictive for mortality in patients with dilated cardiomyopathy[7] and myocardial infarction.[8,9] For many years left atrial dimensions were determined according to simple linear and 2D measurements, with or without, correction for body size. Recent guidelines recommend, on routine assessment of the left atrial size, using calculation of left atrial volume.[10] The measurements, as obtained by different methods, are controversial and do not always provide similar results.[11,12] These measurements are complex and often prolong the time of echocardiographic exams in a busy echocardiography-lab.

In this work we contemplated to define, when calculation of left atrial volume may not be necessary.

METHODS

We reviewed our database of 9 000 digitally stored echocardiographic exams, performed during 2012 - 2013 at Assaf Harofeh Medical Center, and identified patients with normal, mild, moderate and severe left atrial dilatation according to the hospital records. Twenty-five studies with adequate imaging quality were randomly selected in each group. Group 1 - studies with normal left atrial size, group 2 - studies with mild left atrial dilatation, group 3 - studies with moderate left atrial dilatation and group 4 - studies with severe left atrial dilatation. Criteria for including patients into the different groups were based on the routine measurements of left atrial antero-posterior diameter and left atrial area, as performed by the original team who had performed and interpreted these studies, (Figures 1A and B), according to the recommendations.[13] If there was discrepancy between left atrial diameter and area, the parameter that was larger determined the final grading. These 100 examinations were then re-assessed for left atrial size, using calculation of the left atrial volume and left atrial volume index

adjusted to body surface area as recommended,[10] according to the formula 8/3π[(A1)(A2)/(L)], and as illustrated in Figures 2 A and B. Body Surface Area (BSA) was calculated according to Mosteller,[14] BSA=√(weight x height/3 600).

Our goal was to determine how often accurate volume calculation will change the definition of left atrial size based on simple 2D measurements.

RESULTS (Table 1, Figure 3)

In group 1 (normal left atrial size) left atrial volume index was within the normal range in all 25 echo exams.

In group 2, initially defined as mild left atrial dilatation, only 32% (8 patients) had mild left atrial dilatation according to the left atrial volume index. In 2 exams normal left atrial size was found. In the other 15 echo exams (60%) left atrial area was compatible with moderate dilatation.

In group 3, initially defined as moderate left atrial dilatation, calculated left atrial volume index changed the diagnosis in 96% (24 patients). In 1 patient left atrial size was changed to mild. In 23 patients true left atrial size, estimated according to the left atrial volume index, was compatible with severe dilatation.

In group 4, patients with severe left atrial dilatation, calculation of the left atrial volume index did not change the diagnosis in any of the 25 patients and severe left atrial dilatation was found by left atrial volume index.

Adjustment of the antero-posterior left atrial diameter to the body surface area diminished size of the left atrium to lower category in 7 exams (28%) of group 4, 17 exams (68%) of group 3 and 22 exams (88%) of group 2.

DISCUSSION

Our results revealed an underestimation of the left atrial size with routine unadjusted left atrial diameter and area in patients with mild and moderate left atrial dilatation. In patients with normal left atrial size and in patients with severe left atrial dilatation, calculation of the volume did not change the initial diagnosis, even without adjustment to the BSA. In all the groups

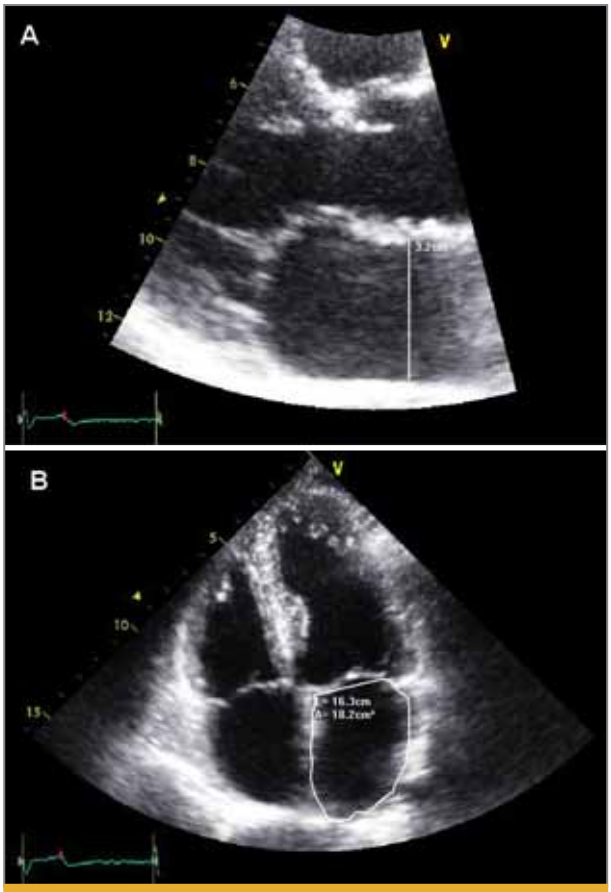

FIGURE 1: Routine initial 2D measurements of the left atrial size according to the antero-posterior left atrial diameter (A), and to the left atrial area (B).

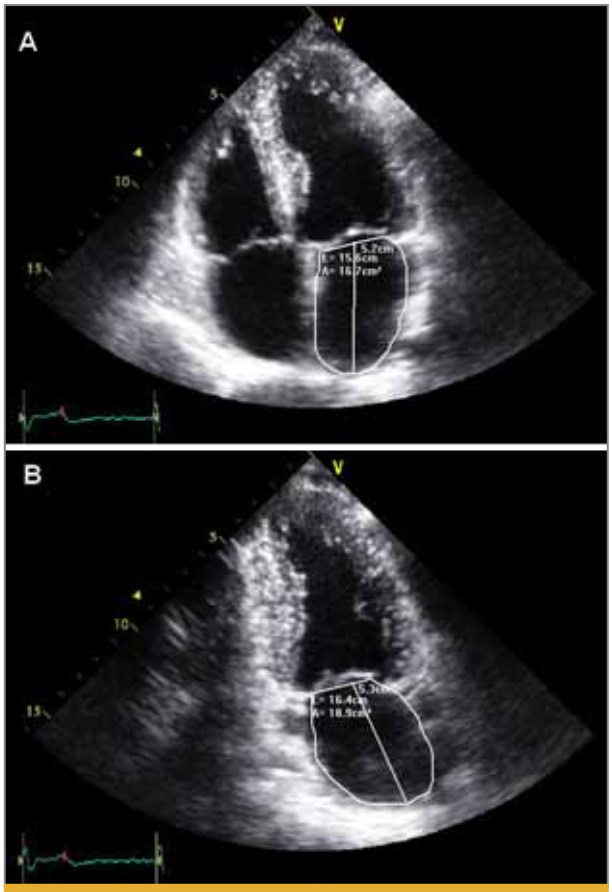

FIGURE 2: Measurements of left atrial area and length of the left atrium on 4-chamber view (A), and on 2-chamber view (B), that are necessary for the calculation of left atrial volume.

TABLE 1: Assessment of the left atrial size in 4 groups of echo exams with mild, moderate, severe and normal left atrial size.

LA size according to LAD with/or LA Area	Age	M/W*	LADI cm/m²	LAD cm	Area 4C cm²	Area 2C cm²	Mean Area cm²	Shortest L cm	LAV cm	LAVi cm³/m²	Height, cm	Weight, kg	BSA m²	BMI kg/m²	Initial Diagnosis Correct
Normal n=25	53±9	14/11	1.8±0.2	3.4±0.3	15±2	15±2	14.7±2	4.5±0.6	41±7.8	22±3.2	170±12	78±15	1.91±0.2	27±4	25 (100%)
Normal range**			**LAD men (3-4), women (2.7-3.8)**				**LADi (1.5-2.3)**		**Area (≤20)**		**LAV men (18-58), women (22-52), LAVi (22±6)**				
Mild n=25	54±13	12/13	2.1±0.2	4.1±0.2	22±2	20±2	22±4.6	5.4±0.3	68±7.6	35±4.2	169±10	83±14	2±0.2	29±4.6	8(32%)
Mild LA Dilatation**			**LAD men (4.1-4.6), women (3.9-4.2)**				**LADi (2.4-2.6)**		**Area (20-30)**		**LAV men (59-68), women (53-62), LAVi (29-33)**				
Mode-rate n=25	66±13	15/10	2.5±0.3	4.8±0.3	32±4	30±0.4	31±3.5	6.6±0.5	125± 24	65±15	170±11	82±22	2±0.3	29±6.5	1(4%)
Moderate LA Dilatation**			**LAD men (4.7-5.2), women (4.3-4.6)**				**LADi (2.7-2.9)**		**Area (30-40)**		**LAV men (69-78), women (63-72), LAVi (34-39)**				
Severe n=25	70±11	12/13	3.3±0.6	6.2±1	47±14	45±17	46±15	7.6±1.5	243±120	128±59	167±9	77±16	1.89±0.2	28±6	25(100%)
Severe LA Dilatation**			**LAD men ≥5.2, women ≥4.7**				**LADi ≥3**		**Area >40**		**LAV men ≥79, women ≥73, LAVi ≥40**				

LA: left atrium, LAD: antero-posterior left atrial diameter, LADi: left atrial diameter index adjusted for BSA, L: length of left atrial, LAV: left atrial volume, LAVi: left atrial volume index adjusted for BSA, BSA: body surface area, BMI: body mass index. M: men, W: women Reference range (10,11)***

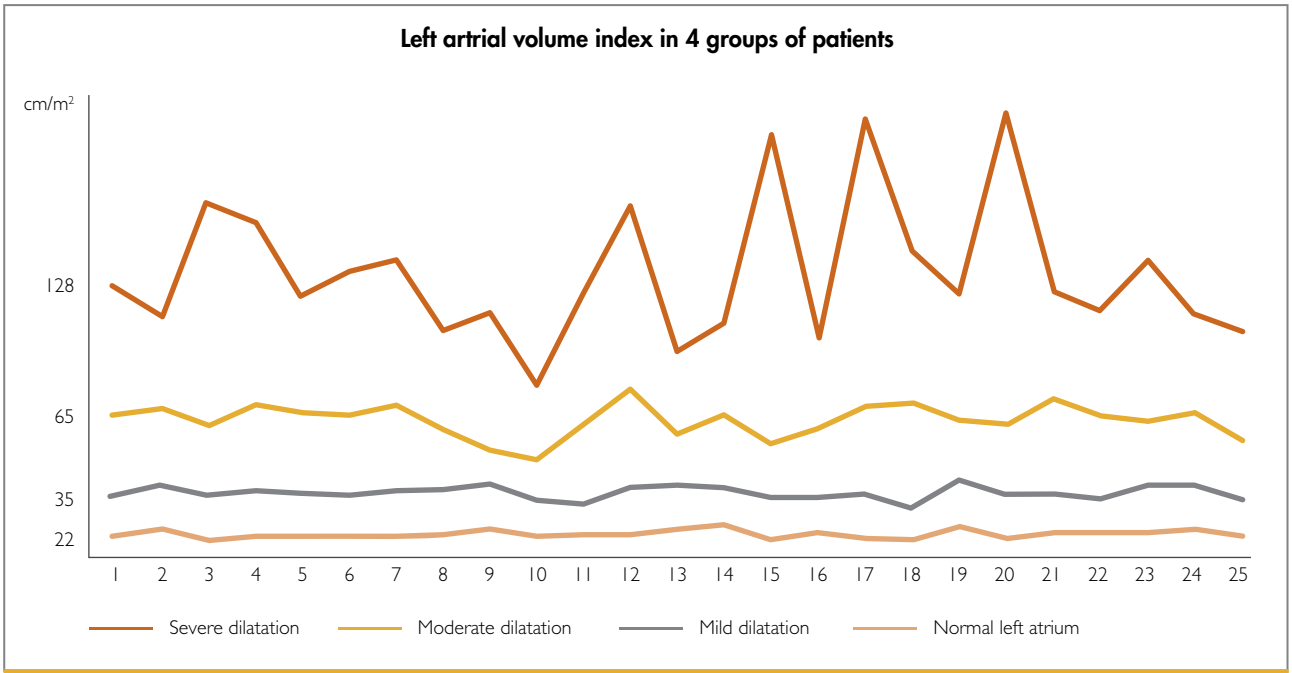

FIGURE 3: Left atrial volume index is represented graphically for all 4 groups of patients with initial diagnosis of normal left atrium, mild, moderate and severe left atrial dilatation.

BMI was elevated representing different BSAs, requiring adjustment to body surface area in most echo studies.

Until recently, linear left atrial dimensions have been used for estimation of left atrial size.[15,16,17] The 3-dimensional (3D) structure of the heart needed more accurate measurements of left atrial volume which were introduced in 2005 - 6,[13] and these have become the standard based on the recent guidelines.[10] Ellipsoidal formula underestimates left atrial volume.[12] Area-length method and biplane method of discs

(modified Simpson's rule) were recommended recently as well as a 3D data set.[10] With the development of echocardiographic speckle tracking imaging,[18] left atrial function assessment became possible[19] with calculation of segmental and average peak left atrial strain,[20,21] but this is time consuming and needs off-line analysis. Echocardiographic 3D data sets are usually obtained from the apical approach using a multi-beat full volume acquisition.[22,23] This algorithm is time consuming, needs post-processing and probably underestimates true left atrial volume in comparison with the gold standard magnetic resonance imaging (CMR).[24]

Left atrial size and volume can be evaluated with computerised tomography (CT), usually before radiofrequency ablation of atrial fibrillation,[25] and before closure of left atrial appendage.[26] For calculation of left atrial volume CT uses echocardiographic views and methods,[27] that include area length method, Simpson's method[28] and the ellipsoid technique.[29] Other views used in CT are different from those obtained with echocardiography and CMR.[30] 3D algorithm for left atrial volume calculation was also proposed,[27] internal contour of the left atrium should be delineated from the apical 4- and 2-chamber views. Cardiac CT is a rapid technique, but is associated with irradiation, injection of iodinated contrast and is relatively expensive.

Cardiac magnetic resonance can also be used for calculation of left atrial volume.[31] The same biplane echocardiographic techniques (area-length method and ellipsoid method) are used from 4-chamber and 2-chamber views similar, to echocardiography. Simpson's method, with thorough delineation of left atrial contour at each of the sequential short axis images, can be performed. 3D CMR algorithm also exists.[31] CMR acquisition time is 30 - 50 minutes, it is associated with the injection of gadolinium or a gadolinium like contrast, it is expensive and, unless shielded, cannot be performed in patients with pacemakers and defibrillators.[32]

Echocardiographic examination is a real-time imaging, it takes up to 30 minutes, has good spatial resolution, it is widely available and does not need contrast.[32]

Correct left atrial volume evaluation needs experience for optimal delineation of the left atrial area and length, avoiding foreshortening, excluding pulmonary veins and appendage and keeping at end systole. A small error in left atrial area will be magnified by the formula. Optimal imaging settings often take time, even for an experienced operator. In this light we suggest the initial use of standard simple 2D measurements – antero-posterior left atrial diameter and area of the left atrium. If these parameters are compatible with normal left atrial size, or with severely dilated left atrium, further calculations may not be necessary. In all other cases accurate grading of left atrial dilatation is obligatory. These findings can be of particular value in an outpatient echocardiography service with a large number of normal exams and limited time devoted to each echocardiography exam. It may be less applicable to large tertiary centers where most echocardiography studies are pathological.

CONCLUSION

If normal, or severely dilated, left atrial size is found by initial 2D measurements of antero-posterior diameter and left atrial area, calculation of left atrial volume index may not be necessary. In all other cases, left atrial volume index is necessary to accurately determine left atrial dimension.

LIMITATIONS

Although we re-evaluated and re-measured all digitally stored echocardiographic exams, the study is retrospective. In some cases, discrepancy between left atrial diameter and area exists. In our study the larger parameter of these 2 determined the final grading.

Conflict of interest: none declared.

REFERENCES

1. Stroke prevention in atrial fibrillation investigators. Predictors of thrombo-embolismin atrial fibrillation, II: Echocardiographic features of patients at risk. Ann Intern Med 1992;116:6-12.
2. Benjamin EJ, D'Agostino RB, Belanger AJ, et al. Left atrial size and the risk of stroke and death. The Framingham Heart Study. Circulation 1995;92:835e41.
3. Miller JT, O'Rourke RA, Crawford MH. Left atrial enlargement: An early sign of hypertensive heart disease. Am Heart J 1988;116:1048-51.
4. Takemoto Y, Barnes ME, Seward JB, et al. Usefulness of left atrial volume in predicting first congestive heart failure in patients 65 years of age with well-preserved left ventricular systolic function. Am J Cardiol 2005;96:832-6.
5. Tsang TS, Barnes ME, Gersh BJ, et al. Prediction of risk for first age-related cardiovascular events in an elderly population: The incremental value of echocardiography. J Am Coll Cardiol 2003;42:1199-205.
6. Tsang TS, Barnes ME, Gersh BJ, et al. Left atrial volume as a morphophysiologic expression of left ventricular diastolic dysfunction and relation to cardio-vascular risk burden. Am J Cardiol 2002;90:1284-9.
7. Modena MG, Muia N, Sgura FA, et al. Left atrial size is the major predictor of cardiac death and overall clinical outcome in patients with dilated cardio-myopathy: A long-term follow-up study. Clin Cardiol 1997;20:553e60.
8. Moller JE, Hillis GS, Oh JK, et al. Left atrial volume: A powerful predictor of survival after acute myocardial infarction. Circulation 2003;107:2207e12.
9. Beinart R, Boyko V, Schwammenthal E, et al. Long-term prognostic signifi-cance of left atrial volume in acute myocardial infarction. J Am Coll Cardiol 2004;44:327e34.
10. Lang RM, Badano LP, Mor-Avi V, et al. Recommendations for cardiac chamber quantification by echocardiography in adults: An update from the American Society of Echocardiography and the European Association of Cardiovascular Imaging. J Am Soc Echocardiogr 2015;28:1-39.
11. Jiamsripong P, Honda T, Reuss CS, et al. Three methods for evaluation of left atrial volume. Eur J Echocardiogr. 2008;9(3):351-5. Epub 2007 Jul 23.
12. Khankirawatana B, Khankirawatana S, Porter T. How should left atrial size be reported? Comparative assessment with use of multiple echocardiographic methods. Am Heart J. 2004;147(2):369-74.
13. Lang RM, Bierig M, Devereux RB, et al. Recommendations for chamber quantification. Eur J Echocardiography Eur J Echocardiography 2006;7: 79-108.
14. Mosteller RD. Simplified Calculation of Body Surface Area. N Engl J Med. 1987;317(17):1098(letter).
15. Di Tullio MR, Sacco RL, Sciacca RR, et al. Left atrial size and the risk of ischaemic stroke in an ethnically mixed population. Stroke 1999;30:2019e24.
16. Vaziri SM, Larson MG, Benjamin EJ, et al. Echocardiographic predictors of non rheumatic atrial fibrillation. The Framingham Heart Study. Circulation 1994;89:724e30.
17. D J Sahn, A DeMaria, J Kisslo et al. Recommendations regarding quantitation in M-mode echocardiography: results of a survey of echocardiographic measurements. Circulation. 1978;58:1072-1083.
18. Leitman M, Lysyansky P, Sidenko S, et al. Two-dimensional strain-a novel software for real-time quantitative echocardiographic assessment of myo-cardial function. J Am Soc Echocardiogr. 2004;17(10):1021-9.
19. Saraiva RM, Demirkol S, Buakhamsri A, et al. Left atrial strain measured by two-dimensional speckle tracking represents a new tool to evaluate left atrial function. J Am Soc Echocardiogr. 2010;23(2):172-80. doi:10.1016/j. echo.2009.11.003.
20. Cameli M, Lisi M, Reccia R, et al. Pre-operative left atrial strain predicts post-operative atrial fibrillation in patients undergoing aortic valve replacement for aortic stenosis. Int J Cardiovasc Imaging. 2014;30(2):279-86.
21. Cameli M, Lisi M, Righini FM, et al. Left atrial speckle tracking analysis in patients with mitral insufficiency and history of paroxysmal atrial fibrillation. Int J Cardiovasc Imaging 2012;28:1663-1670.
22. Montserrat S, Gabrielli L, Borras R, et al. Left atrial size and function by three-dimensional echocardiography to predict arrhythmia recurrence after first and repeated ablation of atrial fibrillation. Eur Heart J Cardiovasc Imaging. 2014;15(5):515-22.
23. Mor-Avi V, Yodwut C, Jenkins C, et al. Real-Time 3D Echocardiographic Quantification of Left Atrial Volume. J Am Coll Cardiol Img 2012;5:769 -7723.
24. Shimada YJ, Shiota T. Underestimation of left atrial volume by three-dimensional echocardiography validated by magnetic resonanceimaging: a meta-analysis and investigation of the source of bias. Echocardiography. 2012;29(4):385-90.
25. Cronin P, Sneider MB, Kazerooni EA, et al. MDCT of the left atrium and pulmonary veins in planning radiofrequency ablation for atrial fibrillation: A how-to guide. AJR Am J Roentgenol. 2004;183(3):767-78.
26. Lockwood SM, Alison JF, Obeyesekere MN, et al. Imaging the left atrial appendage prior to, during, and after occlusion. Am Col Cardiol Img 2011;(4)3:303-306.
27. Koka AR, Yau J, Why CV, et al. Underestimation of left atrial size measured with transthoracic echocardiography compared with 3D MDCT AJR,2010, 194: W375-381.
28. Takagi Y, Ehara S, Okuyama T, et al. Comparison of determinations of left atrial volume by the biplane area-length and Simpson's methods using 64-slice computed tomography. J Cardiol. 2009;53(2):257-64.
29. Mahabadi AA, Samy B, Seneviratne SK, et al. Quantitative assessment of left atrial volume by electrocardiographic-gated contrast-enhanced multi detector computed tomography. J Cardiovasc Comput Tomogr. 2009;3(2):80-7.
30. Gweon HM, Kim SJ, Kim TH, et al. Evaluation of left atrial volumes using multidetector computed tomography: Comparison with echocardiography. Korean J Radiol. 2010;11(3):286-294.
31. Nacif MS, Barranhas AD, Türkbey E, et al. Left atrial volume quantification using cardiac MRI in atrial fibrillation: Comparison of the Simpson's method with biplane area-length, ellipse, and three-dimensional methods. Diagn Interv Radiol. 2013;19(3):213-20.
32. To AC, Flamm SD, Marwick TH, Klein AL. Clinical utility of multi-modality LA imaging. Assessment of size, structure and function. J Am Coll Cardiol Img. 2011;4(7):788-798.