The unbearable futility of deriving the left atrial size from a single-linear dimension

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The assessment of the left atrial (LA) size is important, since LA enlargement has been established as a robust predictor of major adverse cardiovascular outcomes,1 including atrial fibrillation (AF).2,3 In addition, the LA size predicts cardiovascular events in patients with lone AF, likelihood of post-operative AF, and success of cardioversion or AF ablation.4 Therefore, current guidelines on the management of patients with AF recommend the assessment of the LA size and function by standard two-dimensional and Doppler echocardiography in the clinical work-up of all patients with AF.5

LA size assessment

Different imaging modalities are available to assess the LA size.6 However, among all cardiovascular imaging modalities, echocardiography is the most frequently used technique to measure LA volumes and phasic functions.7 Not only echocardiography is widely available, cheap, and harmless for both patients and healthcare professionals, but also has a higher temporal resolution than cardiac magnetic resonance (CMR) or multidetector computed tomography (MDCT).

Traditionally, the LA size has been estimated with echocardiography by measuring its anterior–posterior linear dimension, either from M-mode tracings or two-dimensional images. Despite the fact that this measurement is simple to obtain and has been extensively used in clinical routine and research work, it is now clear that LA anterior–posterior diameter is not representative of the true LA size since the LA has an asymmetric three-dimensional shape. Inaccuracy of the anterior–posterior linear dimension in reflecting the true LA size is particularly relevant in pathologic LA, when LA enlargement occurs non-uniformly (i.e. mainly along the superior–inferior and medial-lateral directions and less in anterior–posterior direction) the LA being constrained between the sternum and the spine.8 This may explain the relatively low agreement between LA anterior–posterior diameter and LA volumes and the closer relationship of LA volumes with cardiovascular morbidity and mortality.9

Therefore, the conclusions of the study by Sohns et al.10 that ‘LA volume measured by MDCT may be a better predictor of recurrence of AF after pulmonary vein ablation than echocardiographic LA diameter’ are neither surprising nor new. What it is actually surprising is that there are echocardiographic laboratories which still report the LA size using a single-linear measurement. Another methodological issue in the study by Sohns et al.10 is the way LA diameter has been quantified. Despite they claim that they have followed recommendations on cardiac chamber quantification issued by ASE and EAE,11 the authors reported that the LA diameter was measured ~1 cm above the mitral annulus in both apical four- and two-chamber views. This diameter represents an unconventional and never validated parameter which can hardly reflect the LA size particularly if enlarged (Figure 1).

Therefore, despite the main message of the paper10 that the LA volume measured by MDCT may be a predictor of recurrence of AF after pulmonary vein ablation is a useful clinical information, the comparison with echocardiography is both misleading (they used an echo parameter already known to be inaccurate) and unfair (they did not measure at least the anterior–posterior LA diameter, which was predictive of AF recurrence in previous studies).

This paper resumes the old and vexed issue of the competition among imaging techniques, to affirm the superiority of one technique over the others. This approach should have been overcome in 2013, since it does not help either the clinicians reading these papers or the patients who are managed accordingly. Much more useful for our patients and for tax payers is that clinicians are able to realize the pros and cons of the different imaging techniques and their clinical relevance/application, in order to use them in an evidence-based and cost-effective manner.6,7 With this open-mind approach, clinicians will be able to select the most useful technique(s) to image the LA, in order to address the specific clinical problem of each patient.

Echocardiography should remain the investigation of choice to assess the LA size and function in the clinical routine. Dedicated LA acquisitions with newer echocardiographic techniques, such as 3DE12,13 (Figure 2) and speckle-tracking,14 are entering the clinical arena and potentially provide valuable information on both LA size and myocardial mechanics. Future studies will demonstrate how these parameters should be clinically applied in patients undergoing LA interventions such as catheter ablation, where...
Figure 1  Typical example of a patient with severe left atrial enlargement in whom the left atrium assumes a trapezoidal shape in the apical four-chamber view. Transversal diameter measured below the mitral annulus (left panel) grossly underestimates the extent of LA dilation in comparison with LA three-dimensional maximal volume (right panel).

Figure 2  Acquisition of full-volume three-dimensional (3D) data sets allows accurate measurement of left atrial (LA) volume and phasic functions. LA volume increases during the reservoir phase to a maximum ($V_{\text{max}}$), followed by two phases of progressive emptying (conduit and active contraction phases) with the LA volume decreasing to pre-atrial contraction ($V_{\text{preA}}$) and then minimum LA volume ($V_{\text{min}}$). Accordingly, total LA stroke volume (Total SV) can be divided into passive and active components.
there is a need to assess the effects of such intervention on LA phasic functions, and to understand how such alterations to LA function may affect management decisions, such as anticoagulation and redo procedures.

MDCT remains the gold standard in obtaining a 3D data set for image integration in electrophysiology procedures pre-pulmonary vein ablation and in diagnosing complications from ablation such as pulmonary vein stenosis. Its more widespread application in studying LA size and function is largely limited by radiation exposure and need for contrast injection, which certainly prohibits its use in repeated routine follow-up studies.

At present, CMR is the least frequently used of the three modalities for assessing LA. However, this technique shows great promise. Its ability to visualize the anatomy of the LA and assess LA function at an acceptable temporal resolution, combined with its unique ability of imaging LA myocardial fibrosis makes CMR particularly useful for patients undergoing AF ablation. Further refinements in acquisition sequences are likely to improve image quality and make this technique applicable for more clinical indications.

Finally, reconstructed three-dimensional data sets obtained with MDCT and CMR can be combined with the online electrophysiological information acquired via mapping catheters positioned in the LA. Therefore, the ablation points can be marked on the acquired electroanatomical map to guide the actual ablation procedure.

**Conclusions**

The assessment of the LA size, anatomy, and function using the proper imaging technique and reliable parameters is important in the setting of AF treatment, since it provides important prognostic information and guides management.

Finally, there is much more to look at than maximal volume to assess LA size and function in a comprehensive and clinically useful way.

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**References**