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Does size still matter? The prognostic significance of left atrial shape in catheter ablation of atrial fibrillation

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Take Home Messages

- Cross sectional imaging and advancement in computational techniques have led to the development of new metrics for assessing left atrial (LA) geometry over and above LA diameter.
- These include LA asymmetry index, LA sphericity, and shape scores derived from statistical shape analysis.
- These measures provide valuable prognostic information on risk of AF recurrence following catheter ablation.

Introduction

As early as the 1970s, left atrial (LA) geometry was recognized as a mechanistically important factor in the development of atrial fibrillation (AF). Whilst quantitative assessment was limited to crude echocardiographic measurements of LA diameter as a marker of dilatation, it represented a valuable tool in risk stratification and patient selection for treatments such as electrical cardioversion (1).

Following these initial observations, the concept of "AF begets AF" became a key component in our understanding of its pathophysiology (2). Experimental evidence demonstrated that sustained AF had structural effects on the myocardium, leading to increase in atrial cell size and overall atrial dilation. In turn, a dilated atria had a greater propensity to sustain AF (3,4).

About the author

Alexander Sharp graduated from Imperial College London in 2015. Subsequently, he completed the Academic Foundation Programme in West Midlands Central Deanery, before moving to East of England Deanery for his Academic Clinical Fellowship. He has continued his clinical training here as a Cardiology Specialty Registrar with a sub-speciality interest in electrophysiology and cardiac devices. Currently, he is a Clinical Research Fellow working with Professor Tim Betts' Cardiac Rhythm Management Group in Oxford.

Contemporarily, catheter ablation is a key tool in our arsenal for managing AF. Guidelines emphasize the importance of patient selection, with consideration given to risk of recurrence (5). Variables such as age, sex, and nature of AF are established risk factors (6,7) and common to multiple scoring systems designed to aid the clinician (DR-FLASH, ATLAS, CAAP-AF) (5). Yet our regard of LA geometry remains simplified, with LA diameter >40-47 mm the metric used in the majority of these risk calculators (5).

Our understanding of the correlation of LA geometry with AF risk has progressed significantly in recent years. More sophisticated echocardiographic techniques and cross-sectional imaging with CT and MRI have improved our ability to accurately capture raw geometry. Alongside improvements in the computer sciences, we can now analyse not only LA size through LA diameter or LA volume, but LA shape using entirely novel metrics (**Table 1**). In this editorial I will discuss three in more detail and use each to highlight a possible explanation for why LA deformation is anisotropic.

Asymmetry index

Recognizing that LA dilatation occurs within the confines of anatomical constraints such as the spine and sternum, Nedios proposed the measure of asymmetry index (ASI) (8–10). This is a calculation of the ratio between anterior LA volume and total LA volume, the LA being divided by a cutting plane running parallel to the posterior wall, between the pulmonary vein ostia and left atrial appendage (**Figure 1**). In longstanding persistent AF, they observed a significant increase in ASI, without further increase in overall LA volume. In turn, it was correlated with poorer outcomes following catheter ablation in this cohort, proving a more valuable predictor than total LA volume. Clinically, this would suggest that ablative treatment may be advocated in patients with persistent AF and greater LA volumes if associated with a low ASI.

Table 1. Size and shape assessment of the left atrium.

	Parameter	Imaging modality	Method	Association with AF
LA size	LA diameter	2D TTE	Anteroposterior diameter in PLAX view	Larger atria associated with recurrence following catheter ablation
	LA volume	2D TTE 3D TTE CMR CT	Biplane Disk-summation 3D volumetry	
LA geometry	Asymmetry index	3D TTE CMR CT	Ratio of anterior LA volume to total LA volume	Higher ASI associated with recurrence following catheter ablation (8-10)
	LA sphericity		How closely atria resemble a best fit sphere	More spherical atria associated with recurrence following catheter ablation (11-14)
	Statistical shape analysis		Statistical analysis of geometric properties of cohort of shapes	"Shape scores" to predict ablation outcomes (18-21)

ASI = asymmetry index; CMR = cardiac magnetic resonance; CT = computerized tomography; LA = left atrium; PLAX = parasternal long axis; TTE = transthoracic echocardiography.

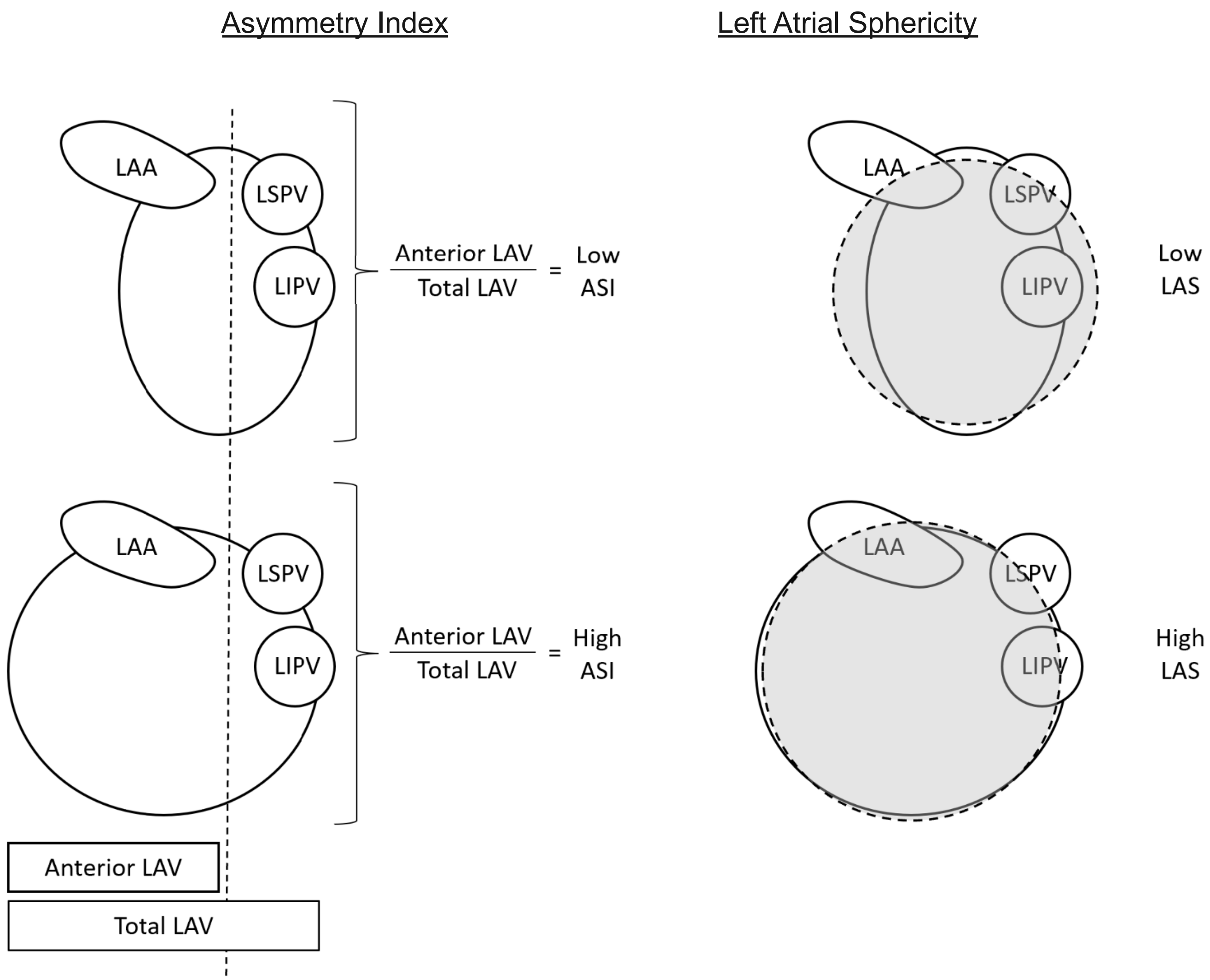

Figure 1. Diagrammatic representation of LA from left lateral view, demonstrating novel measures of left atrial geometry.
Left: ASI is the ratio of anterior LAV to total LAV, the LA being divided by a cutting plane parallel to the posterior wall, between pulmonary vein ostia (LSPV and LIPV) and LAA.
Right: LAS is a measure of how closely a patient's LA correlates with a best fit sphere (grey, dashed outline), higher values indicating a more spherical atrium.
ASI = asymmetry index; LA = left atrium; LAA = left atrial appendage; LAV = LA volume; LIPV = left inferior pulmonary vein; LSPV = left superior pulmonary vein.

Left atrial sphericity

A sphere has the smallest surface area to volume ratio of any geometric shape. As such, Bisbal hypothesized that as left atrial volumes increase in AF, spherical remodelling will occur to lessen wall stress (11). Whilst exact methods of calculation vary, fundamentally it is a measure of how closely a patient's LA geometry corresponds with a best fit sphere, higher values representing a more spherical LA (**Figure 1**). Multiple studies have demonstrated an association between left atrial sphericity (LAS) and AF recurrence following catheter ablation, with it proving either superior to LA volume and LA diameter, or an additional independent predictor (11–14).

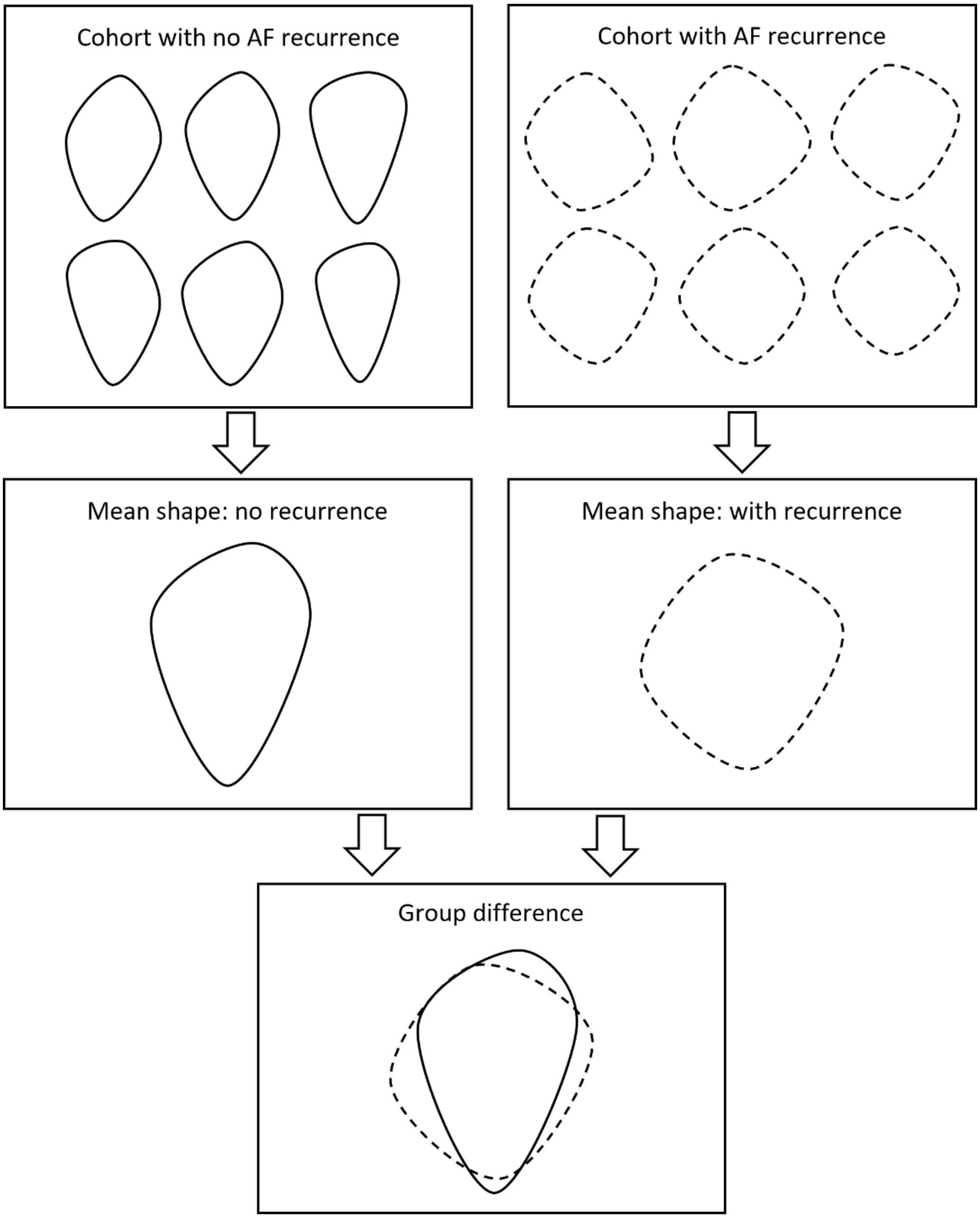

Figure 2. Statistical shape analysis facilitates statistical comparison of left atrial geometries from two different patient cohorts, one with atrial fibrillation recurrence following ablation, the other with no recurrence.

Statistical shape analysis

Given the heterogenous mechanisms underlying AF, it stands to reason that resulting atrial remodelling is equally heterogenous (4,15). Rather than any individual morphological descriptor, statistical shape analysis (SSA) refers to the technique of analysing geometric properties of a cohort of shapes using statistical methods. An average LA shape can be derived from a group of patients and compared with another group or individual. Shape variation can be quantified, with the advantage that the entire LA geometry is considered (**Figure 2**). Geometries can also be normalized with respect to scale, enabling comparison of shape independent of LA volume.

Results of studies utilizing such techniques support the notion of remodelling in persistent AF leading to a more spherical LA (16) and increased LAS being associated with AF recurrence (17) (18). However, most promisingly, they have enabled the development of "shape scores" for predicting AF recurrence by identifying differences between cohorts of patients with and without AF recurrence, with multiple examples of these proving excellent independent predictors (18–21).

Conclusions

The strive towards personalized medicine is universal across all aspects of healthcare. A greater appreciation of individual LA geometry and its correlation with predicting outcome represents a crucial step in achieving this goal in the field of AF management. In particular, ablation outcomes in persistent AF remain suboptimal; it is here initially, where I believe geometric measures in addition to simple LA diameter are ready for translation into clinical practice.

Disclosures

Noting to declare.

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