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Physiological assessment of stroke risk in atrial fibrillation using 4D-flow with cardiac magnetic resonance imaging

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Take Home Messages

- Stroke is the major cause of a loss in quality of life associated with atrial fibrillation.
- Internationally utilised risk scores such as CHA_2-DS_2-Vasc have limited predictive capacity.
- Physiological assessment of the left atrium using 4D-flow cardiac magnetic resonance is a promising advance in assessing intracardiac flow and thromboembolism risk.

Introduction.

Atrial fibrillation is the most common cardiac arrhythmia in the United Kingdom with a point prevalence of 2.5% [1]. The diagnosis of AF is associated with a five-fold increase in the risk of stroke [2]. These strokes are often more severe and confer a greater loss in quality of life when compared to non-AF strokes [3, 4]. Anticoagulation is offered to individuals deemed to be at a high risk of stroke, using internationally recognised risk scores such as CHA_2-DS_2-Vasc (now CHA_2-DS_2-VA), and reduces the risk of stroke by up to two-thirds [5] [6].

The problem.

Since the original validation study, CHA_2-DS_2-Vasc has become a widely accessible tool for clinical teams to estimate stroke risk [7]. However, CHA_2-DS_2-Vasc has several limitations. One, it is fundamentally a surrogate measure. CHA_2-DS_2-Vasc collates several known upstream risk factors for stroke and associates this with physiological risk of thrombus formation in the left atrium (LA) and LA appendage (LAA). While it

incorporates more risk factors than its predecessor, the CHADS2 score, it faces the same issue in that many stroke risk factors such as smoking and LA size are not included and it does not discriminate between types of AF [8, 9]. This is important, because although not fully understood, different types of AF are generally thought to have heterogenous stroke risk [10].

Therefore, CHA_2-DS_2-Vasc may have limited predictive capacity [11]. In a retrospective study of 167 individuals with non-valvular AF who underwent transoesophageal echocardiography, although CHA_2-DS_2-Vasc reported good sensitivity (92%), it had a moderate predictive capacity (c-statistic 0.554-0.883) and poor specificity (28.9%) for detecting LAA risk factors for thromboembolism such as thrombus and sludge [12]. Although CHA_2-DS_2-Vasc may be more sensitive when compared to the outgoing CHADS2 score (sensitivity of CHADS2: 81.3%), it was found to have lower specificity and poorer predictive value which are important considerations for clinical teams to guide shared decision making[12].

The original CHA_2-DS_2-Vasc study assessed 1084 individuals from the Euro Heart Survey [7]. However, the external validity of this study may have limitations [7]. In a systematic review of 34 studies, stroke rates stratified by CHA_2-DS_2-Vasc score varied dramatically between the individual cohorts being assessed [13]. For those with a CHA_2-DS_2-Vasc score of one, stroke rates varied from 0.2% to 6.64% per year; indicative of the significant heterogeneity in stroke risk that CHA_2-DS_2-Vasc may not capture [13].

4D-flow using cardiac MRI.

Three-dimensional time-resolved phase-contrast cardiac magnetic resonance (CMR) imaging (4D-flow) is a novel technique to assess flow in-vivo [14]. 4D-flow can determine velocity and visualise intracardiac flow in 3D, in addition to quantifiable assessments of pathological blood flow such as vortex size and stasis [15, 16]. 4D-flow on CMR can

provide a physiological assessment of flow in the LA and LAA, the critical site for thromboembolism in AF.

Whilst the technique has been more widely adopted in the evaluation of aortopathy, its use in the LA and correlation with stroke risk has been increasingly reported over the last decade. Using CMR 4D-flow, Markl et al showed that in 60 individuals with AF, increasing CHA_2-DS_2-Vasc was associated with reduced atrial flow velocities and greater flow stasis [17]. Surprisingly, only a weak correlation was identified between atrial flow dynamics and left ventricular ejection fraction [17]. As LAA is of particular interest for thrombus formation, it was thought that low-flow patterns would be greater in the LAA when compared to the LA. While the authors found this to be true in controls, this pattern was not observed in those with AF and they suggest that atrial myopathy in AF may cause more global flow dysfunction [17].

Garcia et al demonstrated that LA flow in AF may yet be more complicated [16]. They showed using 4D-flow that larger flow vortices were associated with increasing CHA_2-DS_2-Vasc which itself was associated with pulmonary vein inflow velocity and LA remodelling [16]. Importantly, studies have shown measures such as LA peak velocity and vorticity to be reproducible [18]. While these early studies are promising, future longitudinal outcome studies are needed.

The technique has limitations. Firstly, CMR, while increasingly adopted worldwide, is resource intense and access may be limited. Second, acquisition of images can be challenging, particularly for those in AF at the time of assessment. Third, as cardiac structure changes with time, it might be that individuals require serial assessment, and the time for which a single scan remains 'valid' is unclear.

Conclusion.

4D-flow assessed on CMR may be a promising development in the physiological assessment of stroke risk in AF. However, longitudinal outcome studies are needed to assess the role of 4D-flow as a potential risk stratification tool that could improve the precision by which we offer anticoagulation.

Disclosures.

I have no conflicts of interest to declare.

Figures(s).

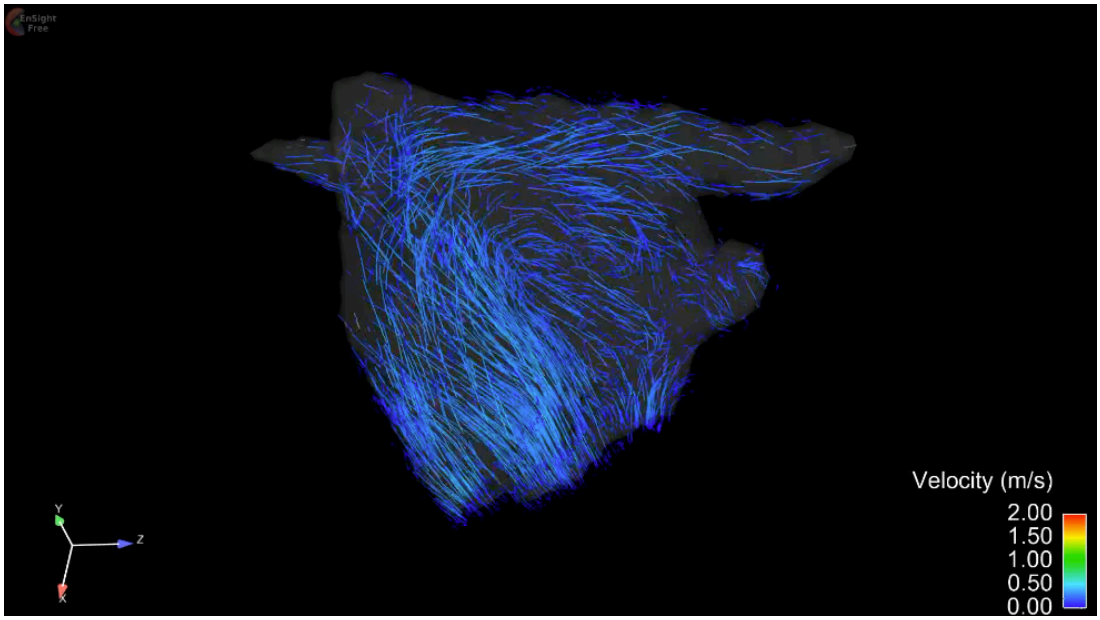

Figure 1 – 4D-flow of the left atria during sinus rhythm. Participant from the AFLETES-MRI study.

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