Identifying Potential Re-entrant Circuit Locations From Atrial Fibre Maps

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Abstract

Anatomical micro re-entrant circuits have been identified as potential drivers of atrial fibrillation (AF), and may play a particularly important role in persistent AF. In this proof of concept work, we develop a novel computational framework which identifies the locations in the atria most susceptible to the formation of re-entrant circuits.

The framework identifies risk regions by generating continuous fibre tracts across the atrial tissue using high resolution fibre orientation data acquired from a sheep heart. Fibre tracts are coupled together according to their proximity, and the resulting network is analysed for the presence of closed loops corresponding to potential re-entrant circuits. This occurs when adjacent muscle fibres decouple, through the action of interstitial fibrosis or otherwise, such that a closed loop is formed with path length greater than the effective refractory wavelength. If the distance within which fibres are coupled is large, closed loops are small and not capable of facilitating a circuit. If the distance is too small, the network if completely decoupled and closed loops do not form. At intermediate distances, closed loops initially appear around the pulmonary veins, the posterior left atrium and the left atrial appendage. These locations are believed to play important roles in AF. As fibres decouple further, a large fraction of the atrial tissue is susceptible to the formation of re-entrant circuits, and hence, circuits are no longer confined to a small region easily targeted by ablation. This may partially explain the failure of existing ablation strategies in a large number of patients with persistent AF.

If these methods can be adapted for use with lower resolution fibre orientation data that can be acquired clinically, future versions of the framework may identify personalised risk regions for individual patients, and may inform an optimum ablation strategy on a case by case basis.

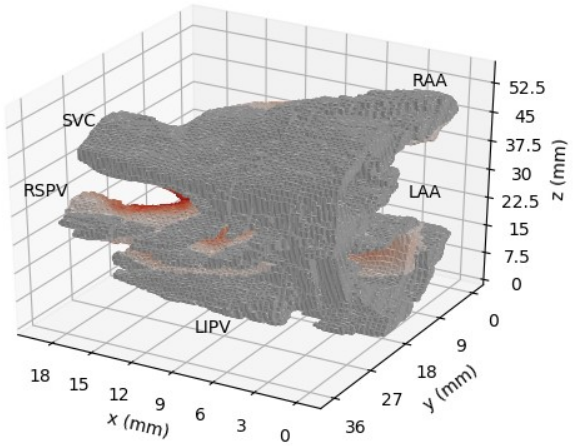

Figure 1. A model of a sheep atrium showing regions susceptible to the formation of re-entrant circuits in red. RSPV: right superior pulmonary vein, LIPV: left inferior pulmonary vein, SVC: superior vena cava, RAA: right atrial appendage, LAA: left atrial appendage.

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