Constructing Realistic Canine Bilayer Biatrial Mesh for Atria Fibrillation Simulations

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Background: Understanding the mechanisms of atrial fibrillation (AF) is essential for improving the diagnostic and therapeutic management of patients. This understanding requires full and detailed access to the geometry of the atria. This is extremely expensive and difficult to implement in an experimental or clinical configuration.

Objective: Here we propose the first anatomical accurate high-resolution canine atrial computational bilayer model for AF studies.

Method: Initially inspired by the method recently used to develop human patient-specific models, a CT-scan of a 5 year old dog (24.8kg) was performed using a Siemens Definition Flash scanner. The obtained imaging data (Fig.a) were segmented and used to distinctly reconstruct 3 main layers representing Bachmann's bundle (BB), the left atrium (LA) and right atrium (RA) and also the coronary sinus (CS). The LA is dilated to obtain the second layer. The RA endocardial layer consists of the sinus node (SAN), the pectinate muscles (PM) and the crista terminalis (CT). All these parts were combined together and the Ramirez-Courtemanche-Nattel's canine cell model was used to simulate the propagation. Activation time (AT) and action potential duration (APD) were computed.

Results: The obtained bilayer mesh (Fig.b) has 1179133 nodes, 2346395 triangular elements and the average edge length of 276.25±57.55um. It contains 5 pulmonary veins (PVs), the 4 usual PVs plus one in the middle left. The action potential propagation from the SAN was visually realistic and its path on the realistic long CS presumes an important role of the CS on the initiation and maintenance of rotors during AF, in agreement with clinical studies. The propagation time from SAN to PVs was ~240.53ms (Fig.c) and the APD90 was 254.39±17.23ms as illustrated in Fig.d.

Conclusion: This new bilayer model with realistic CS and BB, combined with experimental approaches, will help to better understand AF and its underlying mechanisms, in order to develop better diagnostic and therapeutic options.