Maximum Fibrosis Affects Reentry Morphology in 3D Ventricular Models

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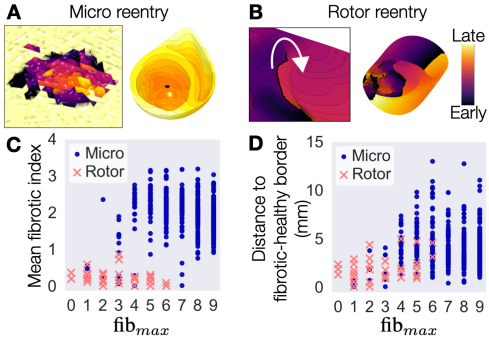
Background: Late gadolinium-enhanced (LGE) MRI has been used to generate models to predict arrhythmogenesis in fibrotic hearts. However, LGE MRI lacks information about microstructure and absolute quantification of fibrosis. The goal of this study is to investigate how density of fibrotic microstructure affects reentry morphology in 3D ventricular models of non-ischemic cardiomyopathy (NICM).

Method: LGE MRI of 5 NICM patients were segmented and fibrotic regions assigned an index 1-4 representing LGE intensity (0.01-25, 25-50, 50-75, 75-100%). Fibrosis was represented as reduced conductivity, ionic changes and non-conducting clefts between elements in fibrotic regions. The amount of clefts was determined by a probability that depends on the local LGE intensity and a scaling parameter related to the maximum fibrosis (fib_{max}). 10 different fib_{max} values were used resulting in 50 models. We induced arrhythmia by programmed stimulation at 17 different sites. For each reentry induced, initiation site was automatically found using graph analysis. To quantify local features associated with reentry, we calculated mean fibrotic index within 5 mm of initiation sites and measured the sites' distances to the fibrotic-healthy border. Student's t-test was performed.



Results: We observed 616 micro-reentries, involving slow zig-zag propagation between clefts (Fig. A), and 35 rotors (Fig. B). Increasing fib_{max} from 0 to 10 resulted in reentry morphology changing from 100% rotors to 100% micro-reentries (Fig. C, D). Micro-reentries are initiated in areas of higher mean fibrotic index than rotors (1.96 ± 0.53 vs 0.23 ± 0.18, $p < 0.01$, Fig. C). Rotors are initiated closer to fibrotic-healthy borders than micro-reentries (1.90 ± 1.25 vs 3.93 ± 1.99 mm, $p < 0.01$, Fig. D).

Conclusion: Modulating the level of fibrosis within hyperenhanced LGE regions significantly affects the induced reentry type and location.