Computer Simulations Outcomes of Left Atrial Arrhythmia Induction are Highly Sensitive to Scar and Fibrosis Determination

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Background: Personalized computational models are being used to guide ablation. While detailed cardiac mesh can be obtained, the extent of scar and fibrosis are less accurate and how it affects the results is unknown.
Objective: How does uncertainty in scar and fibrosis determination affect simulation outcome.
Methods: Two personalized left atrial models were generated for a de-novo and a redo atrial. The geometry was segmented from MRA images with CorView (University of Utah). In control setting scar and fibrosis were obtained by thresholding LGE-MRI images at 70%, and 60% of the maximum myocardial intensity, respectively. This was compared against segmentations, generated by dilating, or eroding the control segmentation by one pixel, increasing or decreasing the threshold by 5%. Simulations were performed using openCarp. Eight S1 stimulations were followed by a single S2, which ranged from 300ms to 160ms in 10ms steps at four different sites. The simulation was continued for 2sec or the end of activation. The outcomes were normal capture without further activity, extra beats with additional activity but not sustained, sustained arrhythmia with activity until the end of the simulation, and no capture.
Results: Normally captured beats were not affected in redo cases, but did change in de-novo ablation. However, extra beats were likely to change to arrhythmia when adding or subtracting scar. Sustained arrhythmia was sensitive to a reduction in scar size. While the point of losing capture was stable.
Conclusion: Our simulation outcomes showed high sensitivity to changes in scar determination. This reiterates that attention is need when determining appropriate thresholds for scar and fibrosis.

Redo Ablation

Observed in Control		Plus One Pixel				Threshold -5%				Minus One Pixel				Threshold +5%			
Scar[%] 3	Fibrosis[%] 31	Scar [%]	8	Fibrosis [%]	31	Scar [%]	10	Fibrosis [%]	31	Scar [%]	2	Fibrosis [%]	9	Scar [%]	1	Fibrosis [%]	21
		Normal Capture	Extra Beat	Sustained Arrhythmia	No Capture	Normal Capture	Extra Beat	Sustained Arrhythmia	No Capture	Normal Capture	Extra Beat	Sustained Arrhythmia	No Capture	Normal Capture	Extra Beat	Sustained Arrhythmia	No Capture
Normal Capture	14	14				14				14				14			
Extra Beat	16		1	13	2	2	1	11	2	2	1	11	2	2	8	6	
Sustained Arrhythmia	18		1	15	2	1	1	13	3	1	2	11	4		11	7	
no Capture	12				12			1	11			1	11			1	11
After Modification		14	2	28	16	17	2	25	16	17	3	23	17	16	19	14	11

First Time Ablation

Observed in Control		Plus One Pixel				Threshold -5%				Minus One Pixel				Threshold +5%			
Scar[%] 1	Fibrosis[%] 13	Scar [%]	2	Fibrosis [%]	26	Scar [%]	2	Fibrosis [%]	22	Scar [%]	0	Fibrosis [%]	4	Scar [%]	0	Fibrosis [%]	5
		Normal Capture	Extra Beat	Sustained Arrhythmia	No Capture	Normal Capture	Extra Beat	Sustained Arrhythmia	No Capture	Normal Capture	Extra Beat	Sustained Arrhythmia	No Capture	Normal Capture	Extra Beat	Sustained Arrhythmia	No Capture
Normal Capture	31	18		7	6	19	1	9		31				31			
Extra Beat	17	1	3	7	6		7	7	3	15	0		2	13	2		2
Sustained Arrhythmia	2			2				2		2		0		2		0	
no Capture	10				10				10	2			8		2		8
After Modification		19	3	16	22	19	10	18	13	50	0	0	10	46	4	0	10

No Change | Worse Outcome | Improved Outcome

Simulation outcome for one redo ablation and one first time ablation. Arrhythmia induction was tested with S1S2 pacing, where the S2 ranged from 300ms – 160ms, and was stimulated at 4 different positions resulting in 60 outcomes per test case. On the left in gray are the results from the control settings, results from the modified settings are found at the bottom in dark gray area. The middle area show the changes compared to the control that occurred due to the different settings. Green is no change, red indicates worse simulation outcome and blue indicates an improvement.