Effect of Reducing the Number of Leads in Body Surface Potential Mapping of Computer Models of Atrial Arrhythmias

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Introduction: Non-invasive identification and localization of arrhythmic driving sources using body surface potential mapping (BSPM) has been shown to be an important tool for patient's therapy planning. This study aims to quantify the impact of atrial tachycardia (AT), flutter (AFL) and fibrillation (AF) characterization by an aggressive reduction in the number of leads.

Methods: a realistic three-dimensional computer model of the atria was used to generate BSPM signals (4 AT, 4 AFL and 11 AF) with 567 leads (high resolution – HR), which were downsampled spatially to 64 leads (low resolution – LR). Both configurations were reshaped to 2D representations, interpolated to 30 x 65 grids and band-pass filtered (fc=2 and 20 Hz). Dominant frequency (DF) maps were generated combining Welch periodogram and activation detection with wavelet transform modulus maxima in each lead. Phase was obtained with Hilbert transform on signals filtered around the highest DF ($\pm$1Hz); dynamics of phase singularity points (SPs) were analyzed using histograms (heatmaps) and connecting SPs along time (filaments). HR vs. LR comparisons were made using Pearson's correlation (1D and 2D), sensitivity and precision of SP detection and structural similarity index (SSIM) between DF maps and heatmaps.

Results: filtered and unfiltered interpolated signals correlated well between LR and HR ($\rho > 0.97$). HR and LR DF maps correlated poorly ($\rho = 0.426 \pm 0.116$, 0.359 ± 0.149 and 0.702 ± 0.037 for AT, AFL and AF, respectively), but SSIM was high ($SSIM > 0.7$). SP detection was most affected by the downsample (sensitivity: 0.681 ± 0.113, 0.737 ± 0.158,0.767 ± 0.055, precision: 0.576 ± 0.131, 0.748 ± 0.183, 0.783 ± 0.064 for AT, AFL, and AF respectively) but heatmaps in LR and HR were similar ($SSIM > 0.7$). Filament analysis showed no significant differences between HR and LR, though each mechanism presented distinct behaviors.

SSIM for DF maps and heatmaps

SSIM	DF maps	Heatmaps
AT	0.86 ± 0.06	0.87 ± 0.03
AFL	0.94 ± 0.04	0.94 ± 0.02
AF	0.70 ± 0.08	0.73 ± 0.19

Conclusion: 64 leads results yield similar BSPM patterns to those observed with a higher lead number. Analyses will be extended to 32 and 16 leads.