Electrogram Signatures of Functional Substrate Behaviour with Extra-Stimulus

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Background: Ventricular tachycardia (VT) substrate identification remains a clinical challenge. Extra-stimulus mapping is a method to assess dynamic substrate behaviour by revealing abnormal functional properties, two of which are decremental conduction and functional conduction block. Neither the exact tissue behaviour nor the optimal methodology to identify these phenomena from electrograms is known. Simulations were utilised to explore the functional substrate behaviour resulting in electrogram markers of decremental conduction and functional conduction block.

Methods: Two 1mm^3 electrodes with 2mm centre-to-centre spacing were positioned atop the centre of a protected isthmus consisting of a channel of borderzone tissue surrounded by non-conducting scar. Following a drive train (S1), single extra-stimulus (S2) was delivered at varying coupling intervals to induce slowed anterograde conduction, functional block with retrograde conduction, and functional conduction block at both mouths of the isthmus. Experiments were performed on small and large meshes between 50μm and 200μm resolution in bidomain and pseudo-bidomain simulations.

Results: Anterograde slow conduction displayed wide electrogram complexes, whilst functional block with retrograde conduction caused reversed polarity late components, consistent with clinical markers of decremental conduction. Slower conduction and larger scar produced more decrement. Block at both isthmus ends resulted in markedly shorter electrogram durations compared to other tissue behaviours. Electrogram morphology was dependent on mesh size but not resolution, with bath loading producing minimal effects.

Conclusion: Degree of decrement is dependent on surrounding tissue conduction velocity and size of the scar, with larger scar producing more decrement. Shortening of electrogram duration with extra-stimulus may indicate conduction block at multiple sites remote to the measurement site. Pseudo-bidomain with regular resolutions is sufficient to study these phenomena.

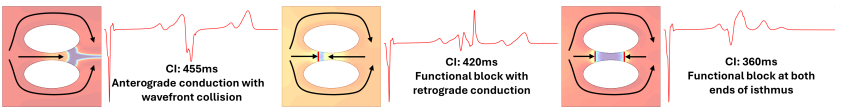

Figure 1. Tissue behaviours and electrograms at S2 coupling intervals (CIs). Black arrows show conduction pathways; red lines show functional block.