RECURRENCE PERIOD DENSITY ENTROPY- A PHASE SPACE METHOD FOR TRACKING PIVOT POINT OF A NUMERICALLY SIMULATED MEANDERING ROTOR

Anjani Muthyala[1], Suganti Shivaram[2], Divaakar Siva Baala Sundaram[3], Rogith Balasubramani[4], Susan Karki[1], Kyla M. Hagen[5] and Shivaram P. Arunachalam[2]

[1]Department of Cardiovascular Medicine, Mayo Clinic, Rochester, MN 55905
[2]Department of Radiology, Mayo Clinic, Rochester, MN 55905
[3]Department of Information Technology, Mayo Clinic, Rochester, MN 55905
[4]Department of ECE, Velalar College of Engineering and Technology, Thindal, Erode, TN, INDIA
[5]Department of Biomedical Engineering, University of Minnesota, Minneapolis, MN 55445

ABSTRACT

Introduction: Atrial Fibrillation is the most common sustained cardiac arrhythmia that may cause stroke, heart failure and even death. Rotor's which are stable electrical sources of cardiac excitation are believed to cause AF. The pivot points of rotor are believed to be good ablation targets to terminate AF in patients. Current mapping methods such as Local Activation (LAT) map, Complex Fractionated Atrial Electrograms (CFAE)- mean map, Dominant Frequency (DF) map and Phase Analysis maps are inadequate to identify the rotor pivot zones due to various noises, misleading phase and activation times. **Hypothesis**: A phase space method such as recurrence period density entropy (RPDE) technique can accurately track the pivot point of a numerically simulated meandering rotor.

Methods: Electrical activity in a 30x30mm human atrial tissue was simulated using an extended bi-domain model that incorporates both fibroblasts and myocytes in a bi-layer scheme. Also, incorporation of diffuse fibrosis allowed easy control over the extent of rotor meandering. The numerically simulated meandering rotor data was obtained with 100x100 pixel resolution at 1000 frames per second. Pixel locations are labeled at the rotor pivot point and the periphery at a particular time frame for reference purposes. Custom MATLAB software was written to compute 2D RPDE map with scale factor $\tau = 2$ and 2D Shannon Entropy map to track rotor pivot point for comparison.

Results: The 2D RPDE map demonstrated accurate tracking of the rotor pivot point verified with visual inspection with higher RPDE values at the reference pixel locations at the rotor core compared to the periphery. Validation of this technique with meandering rotors at different diffuse fibrosis levels can further demonstrate the efficacy of RPDE approach.

Conclusions: RPDE based mapping technology accurately tracked pivot point of a numerically simulated meandering rotor.

Keywords: atrial fibrillation, cardiac arrhythmia, recurrence period density entropy, numerical modelling, rotor, ablation, Shannon entropy.

INTRODUCTION

Cardiac arrhythmias are known to cause heart failure and subsequent death by affecting the pumping capacity of the heart [1]. The understanding etiology of the complex mechanisms that cause and maintain