Non-Invasive Localization of Atrial Cardiomyopathy Using Body Surface Potential Maps and Graph Neural Networks

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Atrial fibrillation (AF) is closely linked to atrial cardiomyopathy (ACM). The early and accurate detection of ACM is thus essential for treatment guidance and improving patient outcomes. Non-invasive methods, such as body surface potential maps (BSPM), are suitable for detection, while Graph Neural Networks (GNN) are convenient for accurately capturing complex spatial-temporal relationships among BSPM signals. This research focuses on non-invasive localization of ACM using simulated BSPM data and GNN.

The BSPMs are obtained from Eikonal simulations with ACM at six different locations on 10 atrial and 10 torso models. The locations are: inferior vena cava (IVC), superior vena cava (SVC), left pulmonary veins (LPV), right pulmonary veins (RPV), the right atrial septum (RAS), and the posterior left atrial wall (PLAW). The complete dataset consists of 9,504 BSPM. The data was divided into train, validation, and test sets, with a ratio of 80%, 10%, and 10% across the models (the combined atria and torsos), respectively. The metrics employed to analyze the performance of the GNN model are accuracy (ACC), specificity (SP), and sensitivity (SE).

The model for ACM localization achieved an ACC of 80% in validation, and 83% in test. The highest SE and SP were achieved in localizing ACM at SVC, IVC, and RPV, and the lowest SE and SP were at LPV.

		Predicted class					
		ICV	**SCV**	**LPV**	**RPV**	**RAS**	**PLAW**
True class	**ICV**	23		1			
	SCV		23	1			
	LPV	4	7	13			
	RPV	1			23		
	RAS		2		2	17	3
	PLAW	1	1			2	20

ACM localization confusion matrix.

This research demonstrates that ACM can be located in the atria using a non-invasive method such as BSPM and GNN. The findings of this research suggest that GNN hold significant potential to detect ACM and therefore, to assist in guiding treatment strategies, leading to more effective healthcare solutions.