Explainable Graph Neural Networks for Non-Invasive Assessment of Left-Atrial Posterior Wall Isolation

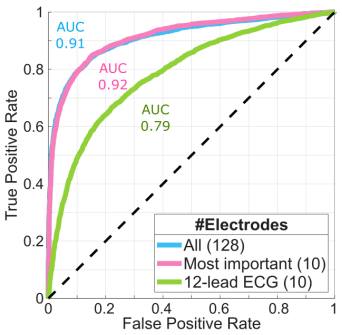
María Macarulla-Rodríguez, Jorge Sánchez, Carlos Fambuena-Santos, Clara Herrero-Martín, Raúl Moreno-López, Jorge Vicente, Rubén Molero, Ismael Hernández-Romero, Andreu M. Climent, María S. Guillem

Universitat Politècnica de València, ITACA Institute, Valencia, Spain

Ensuring complete posterior wall isolation (PWI) during atrial fibrillation (AF) ablation is essential for procedural success, but its verification currently depends on invasive techniques. In this study, we propose a graph neural network (GNN) to determine whether left atrial (LA) roof isolation has been successfully achieved using body surface potential maps (BSPM).

A dataset of 16,711 AF simulations was used to train a GNN using pre- and post-ablation BSPMs. The BSPM electrode configuration was modeled as a graph to capture spatial relationships. Model explainability was used to identify the most relevant electrodes contributing to the prediction. Based on this analysis, a reduced subgraph of the 10 most informative electrodes was defined and compared with both the full BSPM configuration and a standard 12-lead ECG layout. Performance was evaluated using the area under the receiver operating characteristic curve (AUC), which measures the ability to discriminate between complete and incomplete PWI across decision thresholds.

The proposed GNN achieved high performance using the full BSPM, with an AUC of 0.91. The reduced 10-electrode configuration preserved performance (AUC 0.92), demonstrating that a compact and task-specific electrode set can retain relevant spatial information. In contrast, the 12-lead ECG configuration showed lower performance (AUC 0.79), highlighting its limited spatial coverage for this task.



ROC curves.

These results indicate that BSPM combined with GNNs enables accurate, non-invasive detection of PWI completion, while explainability provides physiologically meaningful insights and supports electrode reduction. This approach may facilitate intra-procedural decision-making and post-ablation monitoring without relying on invasive techniques.