ECGI–Derived Left Ventricular Activation Time Predicts Response to Cardiac Resynchronization Therapy with Left Bundle Branch Pacing

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Introduction: Cardiac resynchronization therapy (CRT) is a cornerstone for heart failure (HF) management, yet conventional biventricular pacing suffers from a 30% non-responder rate. Left bundle branch area pacing (LBBAP) has emerged as a physiological alternative by directly engaging the native conduction system. However, variable patient response underscores the need for reliable, real-time predictors of procedural success.

Purpose: To evaluate the utility of real-time, imageless Electrocardiographic Imaging (ECGI) in identifying intraprocedural predictors of echocardiographic response to LBBAP-CRT.

Methods: Two-centre study including 42 HF patients undergoing LBBAP-CRT. Ventricular activation was mapped using imageless ECGI during the LBBAP procedure, gathering data at baseline and post-implantation. ECGI metrics included Total Activation Time (TAT), Left Ventricular Activation Time at the 95th percentile (LVAT95), LV dyssynchrony index (LVDI), and Ventricular Electrical Uncoupling (VEU). Clinical response was defined as an absolute increase in Left Ventricular Ejection Fraction (LVEF) >5 points at 6-month follow-up.

Results: At 6 months, 26 patients (62%) were responders. Baseline clinical characteristics were balanced between groups. Likewise, at baseline, QRS duration (QRSd) and ECGI metrics were comparable between groups. Post-implant, however, responders achieved a superior electrical activation profile despite having a final QRSd nearly identical to non-responders. Univariate analysis showed that final TAT, LVAT95, and LVDI were significantly associated with response. In the multivariate model, post-implant LVAT95 was the sole independent predictor; each 1-ms increase in LVAT95 was associated with a 14% higher risk of non-response (OR 1.14; 95% CI 1.07–1.25; p=0.0006). ROC analysis for LVAT95 yielded an AUC of 0.89 (95% CI: 0.80–0.99), with an optimal threshold of 57.6 ms providing 87% sensitivity and 85% specificity.

Conclusion: Imageless ECGI provides objective, real-time characterization of ventricular activation during LBBAP. Among all predictors tested, final LVAT95 was the strongest predictor of CRT response, highlighting its potential to optimize procedures, potentially reducing implantation time and improve clinical outcomes.

Final LVAT95 comparison between responders and non-responders to LBBAP-CRT