# Robustness of ECG Imaging of Focal Ventricular Activation for Lead-Reduced Systems

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**Introduction:** Currently available commercial ECG imaging (ECGI) systems are based on multi-channel ECG recordings with up to 240 leads. In the present work, we assess ECGI robustness with respect to a reduced number of electrodes and investigate how the best electrode positions correlate across the patients.

**Methods:** ECGI with Tikhonov regularization was performed for 30 consecutive cardiac resynchronization therapy (CRT) patients with left- and right-ventricular (LV and RV) isolated pacing and for seven pacemaker patients with RV pacing only. The number of ECG leads was 197 (130; 240) median (min; max). First, we randomly excluded 10 to 90% of the electrodes with a 10% step, whereby for each step 150 random exclusion combinations were analyzed. For all patients and electrode configurations, we calculated ECGI localization errors (LEs) between non-invasively reconstructed and CT-based pacing lead locations. For every patient, median LEs within each lead setup were created from the 150 samples. From these individual median values, we computed median (min; max) LEs across all considered patients. Afterwards, we analyzed the highest incidence rates for the electrodes resulting in minimal LEs. Finally, we determined a reduced 16-lead system optimal in terms of resulting LEs.

**Results:** Excluding 10, 50, and 90% of originally available electrodes resulted in 18 (1; 74), 18 (1; 74), 19 (2; 74) mm median accuracy, respectively. The electrode clusters located on the upper middle and right back together with the precordial clusters exhibited the highest incidence rates in the individually best 90%-exclusion setups. The identified 16-leads setup resulted in 7 (1; 23) mm LE across the patients.

**Conclusions:** ECGI based on multi-channel (more than 200 leads) ECG recordings is robust against random drop-off of up to 90% of the available electrodes, making this technology suitable for further adjustments to serve the needs of everyday clinical EP work.