

''Ülkemizden Yayınlananlar''



Dynamic Behavior of Left Atrial Low-Voltage Areas in Persistent Atrial Fibrillation: Implications for Substrate-Guided Ablation

Yunus Emre Özbebek ✉, Özcan Özdemir, Sinan Boz, Haluk Furkan Şahan, Engin Algül, Sinan İçsen, Hamza Sunman, Tolga Han Efe

ABSTRACT

Background

Low-voltage areas (LVAs) identified by electroanatomical mapping are commonly used to characterize the atrial substrate in persistent atrial fibrillation (PeAF). However, voltage measurements may vary according to rhythm and physiological state, and LVAs should not be considered synonymous with histological scar or fibrosis.

Objective

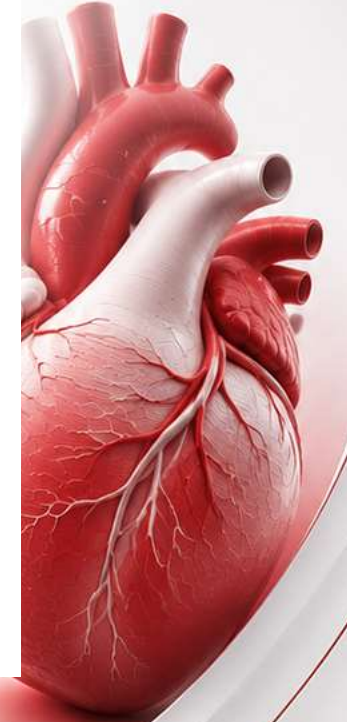
To evaluate rhythm- and physiological state-dependent changes in left atrial LVAs during atrial fibrillation (AF), early sinus rhythm after cardioversion (SR1), and sinus rhythm under isoproterenol infusion (SR2).

Methods

This retrospective observational study included 49 patients with persistent AF undergoing first-time catheter ablation. High-density left atrial voltage maps were acquired during AF, early sinus rhythm after electrical cardioversion (SR1), and sinus rhythm during isoproterenol infusion (SR2). Bipolar LVAs were defined as voltage amplitudes < 0.3 mV during AF and < 0.5 mV during sinus rhythm. Unipolar LVAs were defined using corresponding rhythm-specific thresholds of < 0.71 mV during AF and < 0.83 mV during sinus rhythm, whereas dense bipolar LVAs were defined as bipolar voltage amplitudes < 0.2 mV. Global and regional LVA burden was quantified, and complete paired global analyses included 48 patients.

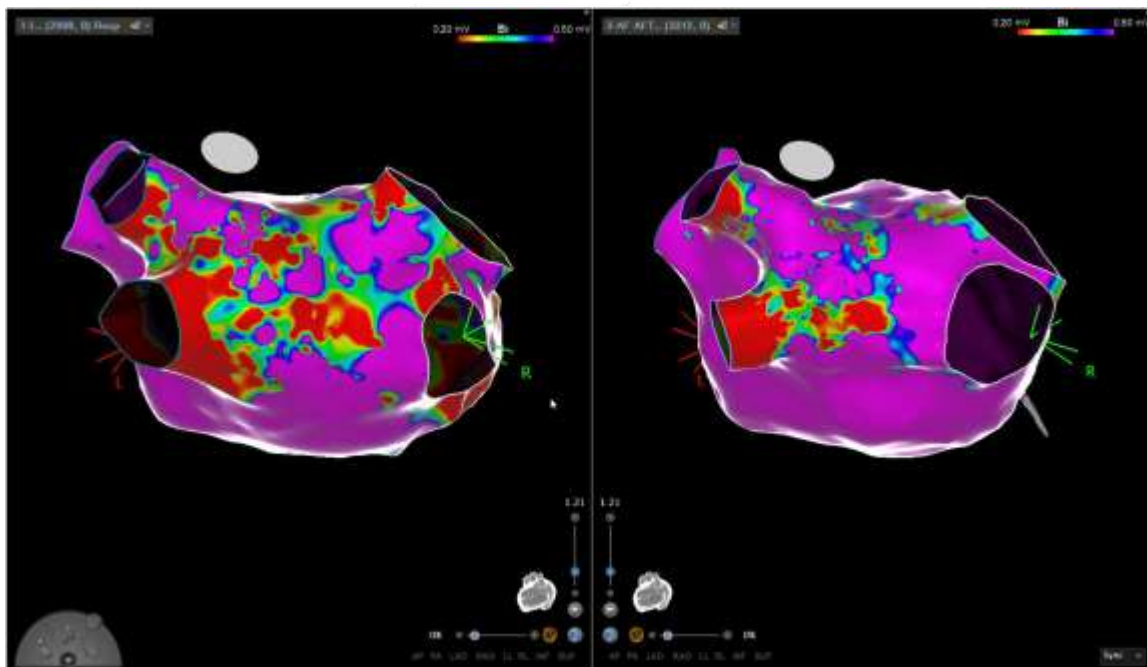
Results

Global LVA burden decreased stepwise across mapping conditions. Bipolar LVA ratio decreased from 17.25% (IQR, 11.40–31.76) during AF to 8.70% (IQR, 6.98–16.17) during SR1 and 5.20% (IQR, 2.60–10.93) during SR2 ($p < 0.001$). Similar reductions were observed for unipolar and dense bipolar LVA ratios (both $p < 0.001$). Regional analysis showed significant heterogeneity in bipolar LVA reduction, whereas unipolar and dense bipolar changes were more homogeneous. Larger left atrial volume was associated with less pronounced bipolar and unipolar LVA reduction. AF duration category was not significantly associated with LVA reduction.

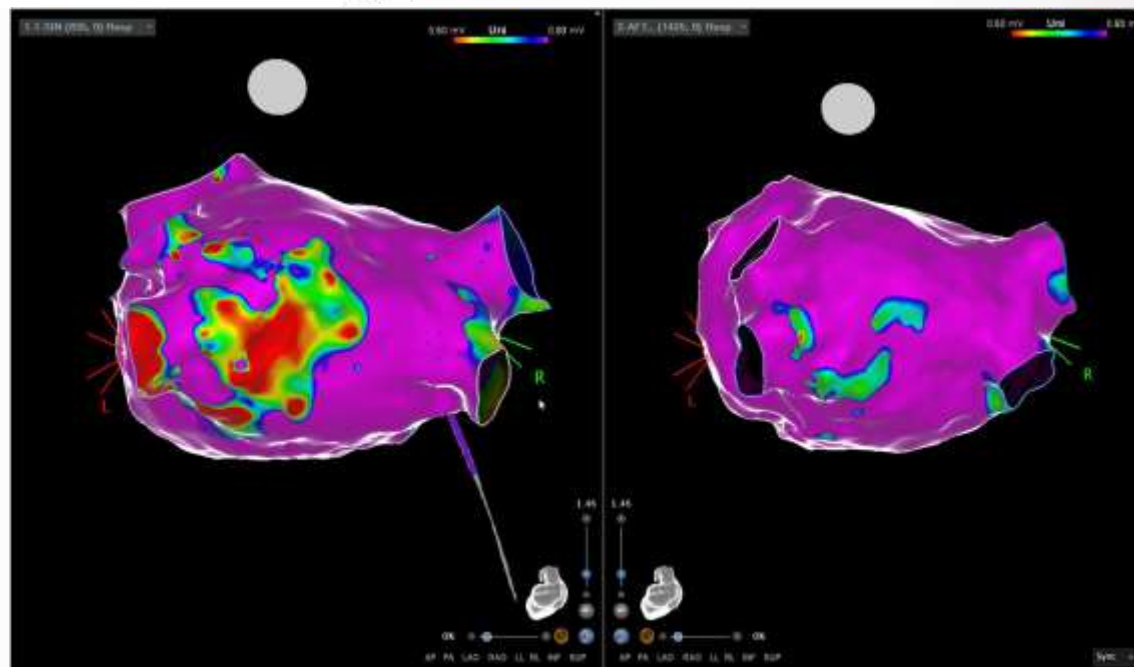


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Representative bipolar voltage maps. Representative left atrial bipolar voltage maps obtained in the same patient during early sinus rhythm after cardioversion (SR1, left panel) and during sinus rhythm under isoproterenol infusion (SR2, right panel). The maps demonstrate a reduction in bipolar LVA burden from SR1 to SR2.



Representative unipolar voltage maps. Representative left atrial unipolar voltage maps obtained in the same patient during early sinus rhythm after cardioversion (SR1, left panel) and during sinus rhythm under isoproterenol infusion (SR2, right panel). Unipolar LVAs were defined as areas with voltage amplitudes < 0.83 mV during sinus rhythm. The maps demonstrate a reduction in unipolar LVA burden from SR1 to SR2.

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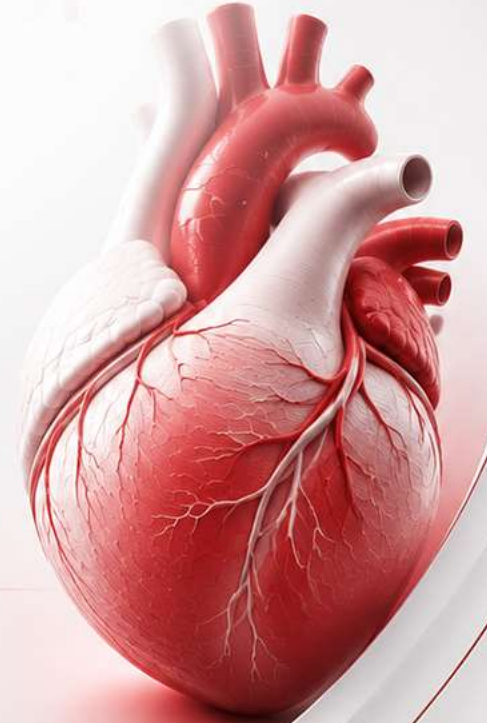
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Why This Study Matters

This study highlights that atrial substrate characterization based on a single static voltage map may provide an incomplete representation of the atrial substrate in patients with persistent AF. The findings emphasize that voltage-defined LVAs are not necessarily static and may vary according to rhythm and physiological state. Therefore, dynamic voltage assessment may offer complementary information beyond conventional single-condition mapping.

From a clinical perspective, these findings may help explain the inconsistent outcomes observed in LVA-guided ablation studies. Reliance on static low-voltage thresholds may result in both under-recognition of relevant electroanatomical substrate and overestimation of potential ablation targets. However, the present study was not designed to determine whether dynamic LVA assessment improves ablation outcomes, and the clinical implications should therefore be interpreted cautiously.

By demonstrating the dynamic behavior of LVAs during AF, after cardioversion, and following pharmacological modulation with isoproterenol, this study supports further investigation of individualized, physiology-based substrate assessment. Future studies should determine whether integrating rhythm-dependent voltage mapping and functional substrate evaluation can improve patient selection, refine ablation targets, and enhance outcomes in PeAF.



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