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STATE-OF-THE-ART REVIEW

Role of Contact Force Sensing in Catheter Ablation of Cardiac Arrhythmias

Evolution or History Repeating Itself?

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JACC: CLINICAL ELECTROPHYSIOLOGY CME/MOC

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CME/MOC Objective for This Article: Upon completion of this activity, the learner should be able to: 1) identify and compare the strengths and limitations of using surrogate markers of tissue contact; 2) describe the impact that contact force has on lesion size, ablation safety and efficacy; and 3) discuss the impact of contact force quality metrics on ablation efficacy.

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ABSTRACT

Adequate catheter-tissue contact facilitates efficient heat energy transfer to target tissue. Tissue contact is thus critical to achieving lesion transmurality and success of radiofrequency (RF) ablation procedures, a fact recognized more than 2 decades ago. The availability of real-time contact force (CF)–sensing catheters has reinvigorated the field of ablation biophysics and optimized lesion formation. The ability to measure and display CF came with the promise of dramatic improvement in safety and efficacy; however, CF quality was noted to have just as important an influence on lesion formation as absolute CF quantity. Multiple other factors have emerged as key elements influencing effective lesion formation, including catheter stability, lesion contiguity and continuity, lesion density, contact homogeneity across a line of ablation, spatiotemporal dynamics of contact governed by cardiac and respiratory motion, contact directionality, and anatomic wall thickness, in addition to traditional ablation indices of power and RF duration. There is greater appreciation of surrogate markers as a guide to lesion formation, such as impedance fall, loss of pace capture, and change in unipolar electrogram morphology. In contrast, other surrogates such as tactile feedback, catheter motion, and electrogram amplitude are notably poor predictors of actual contact and lesion formation. This review aims to contextualize the role of CF sensing in lesion formation with respect of the fundamental principles of biophysics of RF ablation and summarize the state-of-the-art evidence behind the role of CF in optimizing lesion formation. (J Am Coll Cardiol EP 2018;4:707–23)

Efforts at refining ablation technology are driven by the modest success rates of catheter ablation procedures for atrial and ventricular arrhythmias. Pulmonary vein (PV) isolation (PVI) is the paradigm that illustrates the deficiencies of contemporary radiofrequency (RF) ablation technology. Although electrical disconnection of the PV from the left atrium (LA) can be achieved almost universally by the end of the procedure, long-term efficacy remains modest, with single- and multiple-procedure success rates of 54% and 79% for paroxysmal atrial fibrillation (AF) over long-term follow-up (≥3 years) (1). Resumption of PV-LA conduction is the chief mechanism of AF recurrence after catheter ablation of paroxysmal AF (2–4). Achieving durable PVI is thus the ultimate goal in enhancing procedural efficacy. Even in an arrhythmia with a well-defined mechanism, such as typical cavotricuspid isthmus (CTI)-dependent atrial flutter, recurrent conduction can be seen in up to 23% of patients at late restudy (5), with single-procedure success of 92%, which suggests incomplete lesion efficacy with contemporary technologies (6). When myocardial thickness increases and the substrate for arrhythmia becomes more complex, such as with ventricular tachycardia, ablation efficacy is even lower, with ventricular tachycardia–free survival achievable in only 50% to 88% with ischemic cardiomyopathy and 41% to 53% in nonischemic cardiomyopathy, often with multiple procedures (7).

Current research on enhancing the efficacy of RF ablation has focused on understanding the influence of catheter-tissue contact force (CF) on lesion formation. The contribution of CF to the creation of effective lesions and the ultimate success of a catheter ablation procedure were recognized more than 2 decades ago (8). The inability to measure imparted CF meant that for decades, operators used indirect

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