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In Vitro Validation of the Lesion Size Index to Predict Lesion Width and Depth After Irrigated Radiofrequency Ablation in a Porcine Model

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ABSTRACT

OBJECTIVES In an in vitro model, the authors tested the hypotheses that: 1) lesion dimensions correlate with lesion size index (LSI); and 2) LSI could predict lesion dimensions better than power, contact force (CF), and force-time integral (FTI).

BACKGROUND When performing radiofrequency (RF) catheter ablation for cardiac arrhythmias, reliable predictors of lesion quality are lacking. The LSI is a multiparametric index incorporating time, power, CF, and impedance recorded during ablation.

METHODS RF lesions were created on porcine myocardial slabs by using an open-tip irrigated catheter capable of real-time monitoring of catheter-tissue CF. Initially, 3 power settings of 20, 25, and 30 W were used with a fixed CF of 10 *g*. A fixed power of 20 W was then set with a CF of 20 and 30 *g*, thereby yielding a total of 5 ablation groups. In each group, LSI values of 5, 6, 7, and 8 were targeted. Sixty RF lesions were created by using 20 ablation protocols (3 lesions for each protocol).

RESULTS Lesion width and depth were not correlated with power or CF, but the results significantly correlated with FTI ($p < 0.01$) and LSI ($p < 0.0001$). Four steam pops occurred with power set at 30 W; no pops were noted with 20 or 25 W even when high LSI values were targeted.

CONCLUSIONS In this in vitro model, FTI and LSI predicted RF lesion dimensions, whereas power and CF did not. The LSI predictive value was higher than that of FTI. Steam pops occurred only using high ablation power levels, regardless of the targeted LSI. (J Am Coll Cardiol EP 2017;3:1126–35) © 2017 by the American College of Cardiology Foundation.

Radiofrequency (RF) catheter ablation is the therapy of choice for several cardiac arrhythmias. During ablation, proper RF delivery is crucial both to obtain an effective lesion and to avoid excessive heating that can possibly lead to thrombus formation, steam pop, and/or perforation. Parameters such as RF power, catheter tip temperature, and impedance drop are commonly monitored during RF delivery. However, these parameters display limited accuracy in assessing lesion quality, and more reliable indexes are needed. Conversely, the biophysics of RF lesion formation is known to be the result of a complex interplay of many factors, namely RF delivery time, catheter contact force (CF), power delivered, and tissue impedance.

Recently, a novel, externally irrigated-tip catheter has been developed, allowing real-time monitoring of in vivo catheter tissue CF by means of optical fibers (1). This catheter offers the opportunity to obtain novel ablation indexes, such as force-time integral (FTI) (2).

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FTI was shown to correlate with lesion size in an in vitro model (3) and to predict lesion size and steam pop occurrence in the beating canine heart (4). The lesion size index (LSI) is another multiparametric index that incorporates time, power, CF, and impedance data recorded during RF ablation in a weighted formula; it could therefore more precisely describe the complexity of in vivo ablation biophysics and help to predict the extent of myocardial tissue lesions (5,6).

In the present study, an in vitro model tested the hypotheses that: 1) lesion dimensions correlate with LSI; and 2) LSI could be a better predictor of lesion dimensions than power, CF, and FTI. As a secondary endpoint, we investigated if 1 of these variables could help to predict the occurrence of steam pops.

METHODS

FORCE-SENSING CATHETER. A 7-F, 3.5-mm open-tip irrigated TactiCath Quartz (St. Jude Medical, St. Paul, Minnesota) ablation catheter was used for the experiment. As previously described (3), this catheter has a force sensor incorporated into its distal part, which consists of a deformable body and 3 optical fibers that use infrared laser light to measure microdeformations caused by forces applied to the tip of the catheter.

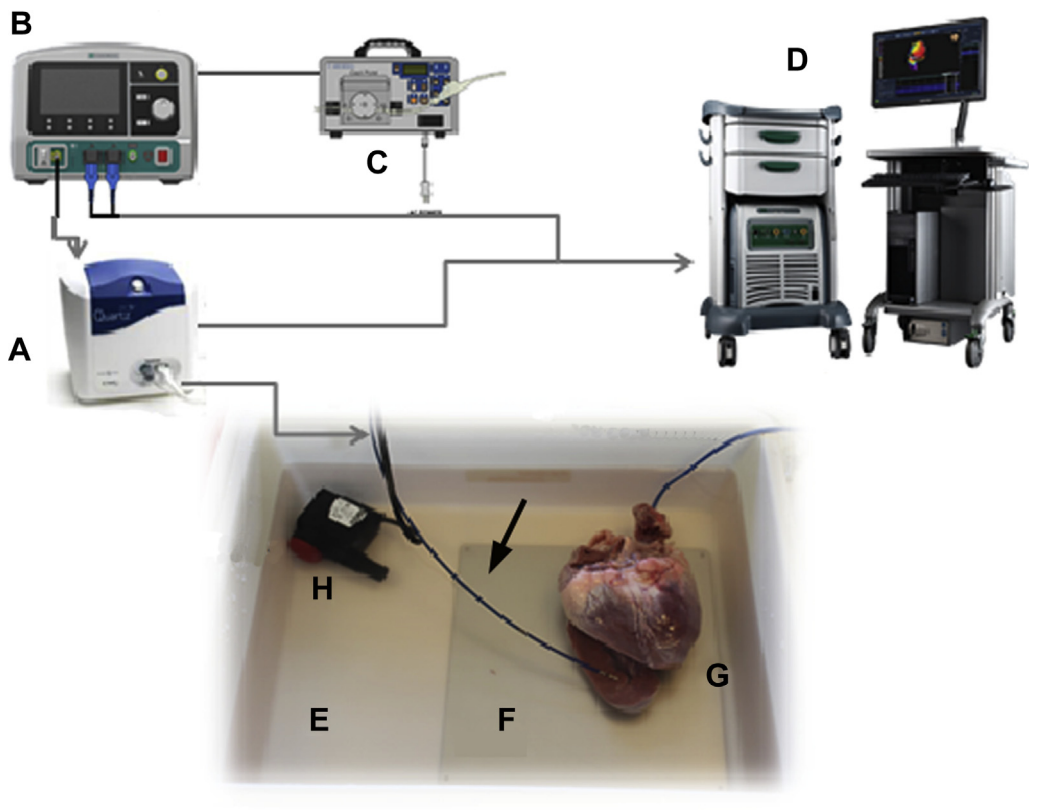
FORCE-TIME INTEGRAL. FTI is defined as the total area under the CF curve (contact FTI) applied during RF application, as previously described (3). FTI was found to predict the clinical outcomes in patients with paroxysmal atrial fibrillation after pulmonary vein isolation (5). FTI is derived from a simple multiplication of CF by time and does not take into account the important role of power delivery.

LESION SIZE INDEX. LSI is a novel ablation index that incorporates CF between the ablation tip and target tissue, impedance, power applied, and

ABBREVIATIONS AND ACRONYMS

CF = contact force
FTI = force-time integral
LSI = lesion size index
RF = radiofrequency

FIGURE 1 In Vitro Experimental Setup



(A) Contact force catheter interface. **(B)** Ampere RF generator (St. Jude Medical, St. Paul, Minnesota). **(C)** CoolPoint irrigation pump (St. Jude Medical). **(D)** NavX electroanatomic mapping system (Endocardial Solutions, St. Jude Medical). **(E)** Saline bath. **(F)** Ground platform. **(G)** Porcine heart. **(H)** Non-pulsatile pump. **(Arrow)** TactiCath ablation catheter (St. Jude Medical).