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EDITORIAL COMMENT

# Power- Versus Temperature-Guided Radiofrequency Ablation

## Have We Found the Perfect Catheter?*

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Catheter ablation is widely performed using radiofrequency (RF) energy, which is a form of alternating electrical current that can create myocardial lesions by transforming electromagnetic energy into thermal energy (i.e., 50°C isotherm of irreversible tissue injury). Ablation lesions are formed by direct resistive heating and heat conduction of the tissue involved (**Figure 1**). High temperatures at the catheter tip initially limited creation of large lesions, but development of cooled-tip catheters has largely resolved this problem. These catheters deliver higher power to create RF lesions with larger depth and volume. These catheters decrease char and coagulum formation, but they have a higher risk of steam pops. These catheters are used in power-controlled mode because temperature feedback at the catheter tip is obscured by substantial saline irrigation.

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In this issue of the *Journal*, Iwasawa et al. (1) sought to prove the efficacy of a novel irrigated RF ablation catheter designed with a diamond-embedded tip (for rapid cooling) and 6 surface thermocouples to reflect tissue temperature. The investigators evaluated the preclinical and clinical performance of this catheter during pulmonary vein (PV) isolation. The ablation was performed in temperature-controlled mode (60°C/50 W) with the goal of achieving ~80% reduction in high-resolution electrogram (EGM) amplitude. Patients who underwent PV isolation with this catheter were scheduled for PV remapping after 3 months, regardless of symptoms. The study had a retrospective control group, which underwent PV isolation with a standard force-sensing ablation catheter (Thermocool SmartTouch, Biosense-Webster, Diamond Bar, California). In a porcine model, the investigators showed lesion transmurality in 92.7% of the cases using this new catheter. In patients treated with this novel irrigated RF ablation catheter, all PVs were successfully isolated during the procedure. At 3 months, 23 patients underwent remapping. In 17 of 23 patients (73.9%), PVs remained durably isolated.

As elegantly demonstrated in the landmark study by Haïssaguerre et al. (2), the PVs play an important role in the initiation of atrial fibrillation (AF). Consequently, special attention should still be paid to obtain long-lasting entrance and exit blocks to completely isolate these structures from the left atrium (LA). Iwasawa et al. (1) should be applauded for attempting to overcome preclusion of temperature feedback during RF ablation with irrigated-tip catheters. It has long been established that in the absence of substantial heat loss due to convective cooling, lesion size is best predicted by electrode–tissue interface temperature. Nonetheless, we believe that in clinical practice, the cooling effect of circulatory blood, especially in places of brisk blood flow, might limit the benefit and accuracy of the temperature-controlled mode.

The goal during catheter ablation of AF is to create transmural lesions to avoid conduction recovery, regardless of the ablation mode used. Good

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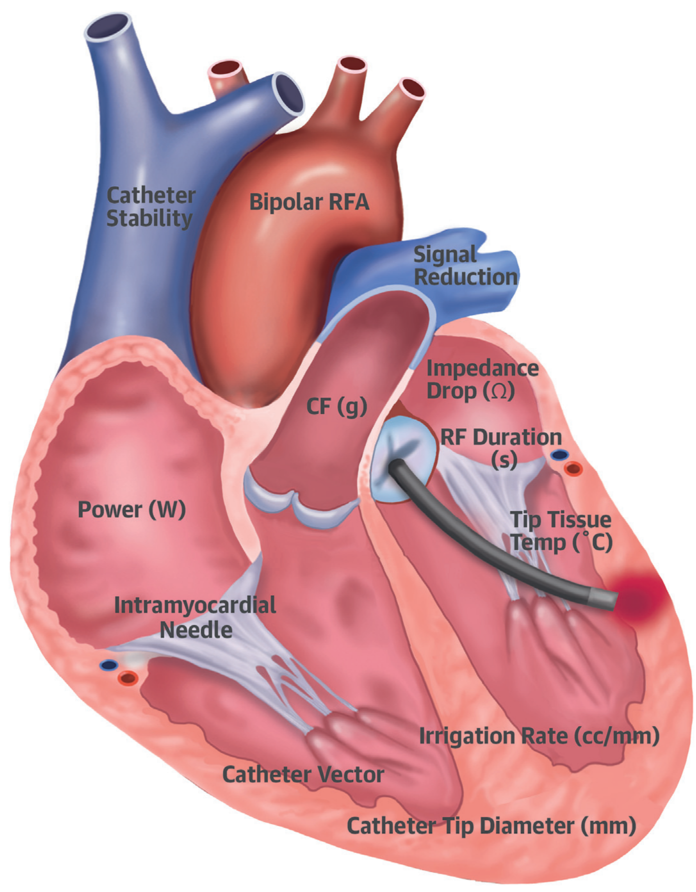
catheter–tissue contact force (CF) is critical to achieve this. Several indirect parameters used as surrogates for CF include tactile feedback, local EGM amplitude and morphology changes, catheter-tip imaging with fluoroscopy or intracardiac echocardiography, and catheter-tip impedance monitoring (**Figure 1**). Catheter stability also plays a critical role in lesion formation because dramatic tip cooling occurs with catheter tip sliding. More recently, with the development of CF-sensing catheters, we have considerably improved the quality of our ablation lesions, particularly when trying to achieve long-term complete PV isolation. Results from the prospective multicenter SMART-AF (Thermocool Smarttouch Catheter for the Treatment of Symptomatic Paroxysmal Atrial Fibrillation) trial, which was the first trial conducted to evaluate the safety and effectiveness of an irrigated CF-sensing catheter in patients with drug-refractory paroxysmal AF, found that when the CF used was between investigator-selected working ranges >80% of the time during catheter ablation, clinical outcomes were 4.3 times more likely to be successful ($p = 0.0054$) (3). The contribution of real-time CF sensing to catheter ablation outcomes was demonstrated by the significantly higher success rate of 81% versus 66% on 12-month freedom from all atrial arrhythmia recurrence when investigators stayed within >80% of their selected CF range, suggesting that consistent, stable catheter–tissue contact is necessary to create effective transmural lesions (3). This study also used the SmartTouch catheter with an average CF per procedure of $18 \pm 9g$ (4,5). Similar results were obtained with a different CF ablation catheter in the multicenter randomized TOCCASTAR (TactiCath Contact Force Ablation Catheter Study for Atrial Fibrillation) trial (6).

**FIGURE 1** **RF Lesion Formation**




Numerous factors are involved in creating long-lasting transmural lesions with radiofrequency ablation; a combination of most of these parameters will eventually help in delivering radiofrequency energy effectively and safely into the myocardial tissue. CF = contact force; RF = radiofrequency; RFA = radiofrequency ablation.

Unfortunately, the catheter used by Iwasawa et al. lacks this feature, rendering its use in clinical practice less appealing. The investigators reported that the contact level was assessed by traditional indirect parameters (e.g., EGM voltage, catheter motion, proximity to the electroanatomical map surface, and intracardiac ultrasound imaging) because CF measurement was not available with this new catheter. We consider this a pitfall of this technology because CF has clearly demonstrated to improve clinical outcomes and has been an instrumental tool for less experienced operators and for clinical electrophysiology fellows in training at academic institutions. The CF technology has improved not only the safety of RF delivery but also catheter manipulation safety.

The investigators used ~80% reduction in the amplitude of the composite-tip EGM as a surrogate of transmurality. It is well-known that tissue heating during catheter ablation application produces an impedance decline at the catheter tip. Reichlin et al. (7) originally proved the concept that the initial impedance decrease during catheter ablation in AF patients was higher when greater CF was achieved, and suggested that monitoring the initial impedance drop was a CF indicator and might help improve formation of durable ablation lesions. Subsequently, the same group showed that PV isolation guided by an initial impedance decrease was feasible and resulted in PV isolation concurrent with or before completion of the ablation ring in 94% of patients. Single-procedure efficacy was 84% after 1-year follow-up (8). The average impedance drop in the current study by Iwasawa et al. was $13 \pm 4\ \Omega$, but only 76% of individual lesions had an impedance drop of $>10\ \Omega$, which might explain the low rate of PV isolation at