Can We Trust the Force?

Frank Pelosi[1]

[1]University of Michigan Health Systems

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Frank Pelosi, Jr., MD, FHRS, FACC

Associate Professor of Medicine

Department of Internal Medicine

Cardiac Electrophysiology Section

University of Michigan Medical School

Ann Arbor, Michigan

Corresponding Author:

Frank Pelosi, Jr, MD, FACC, FHRS

1500 East Medical Center Drive

Ann Arbor MI. 48109

734-232-0112

fpelosi@med.umich.edu

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"For my ally is the Force, and a powerful ally it is." – Yoda

For over 40 years, delivering quality radiofrequency (RF) ablation lesions has been the unending quest for electrophysiology. The call from attending to fellow for "better contact" begins during training and forever echoes in an electrophysiologist's minds throughout their career. For straightforward pursuits such as AV node, slow pathway, or accessory pathway ablation, the reward for good contact is obvious and almost immediate. Electrophysiologists who trained with only electrograms and fluoroscopy regularly walked the precipice between contact and perforation guided only by electrograms, catheter movement and "feel".[1] As we embarked into the no-man's land of atrial fibrillation, we welcomed three-dimensional mapping systems that allowed us to use a focal ablation catheter to create complex lesion sets for both atrial and ventricular arrhythmias. But this blessing comes with the burden of ensuring both continuous and consistent ablation lesion quality to provide durable results. With only rudimentary geometry to guide us, we all knew that to overly trust this technology was at the peril of both patient and physician. The accuracy of three-dimensional mapping systems was vulnerable to patient movement or impedance changes, resulting in impressive images for our next conference, but inconsistent clinical outcomes. For many of us, the personal pride of creating beautiful left atrial lesion sets was eclipsed by the bewilderment of early atrial fibrillation recurrence or a more burdensome iatrogenic atrial tachycardia.

Seminal work on this subject showed that catheter contact was an important factor to RF lesion quality.[2] This led to technologies that could assist the operator to assess contact as means of improving RF lesion quality. The goal was simple: create a way to know how much we can advance a RF catheter against living myocardium without perforation. This required a system that could provide reliable feedback across a range of applied force, catheter angles, ablation energies, and tissue types. Introduced in 2008, contact force (CF) technologies have been widely adopted to create more consistent RF lesions and reduce fluoroscopy.[3] In this issue of the*Journal of Cardiovascular Electrophysiology* , Küffer and colleagues offer insight on the accuracy and the limits of contact force (CF) technology.[4]

The investigators used a novel experimental model to assess the accuracy and reliability of the four commercially available RF ablation catheters. They used a counterweight-based system with two low-friction pullies and a polymeric foam platform immersed in a temperature-controlled saline tank. The platform is suspended with wires guided through the pullies to a counterweight placed on a precision scale outside of the tank. As the RF catheter presses downward on the testing platform, upward force is applied to the counterweight causing a change in weight on the scale and then compared with the contact force measurement from the respective catheter's mapping system. The error was calculated from the difference between the two measurements. The investigators tested four available ablation catheters with contact-force technologies. Two catheters– Smarttouch SF (Biosense- Webster, Inc) and Stablepoint (Biosense Webster, Inc)– use machine precision springs to determine CF. Tacticath (Abbot, Inc) uses a beam of light and interferometers and AcQBlate Force (Biotronik, Inc) uses a single optical fiber and deformable parallelogram to determine CF. Each catheter was assessed at 4 different contact angles: perpendicular to the platform (0°), 30°, 45°, 60°, and parallel to the platform (90°). A minimum of 100 measurements were obtained at each angle with total of 6685 total measurements using three catheters for each of the four models.

The investigators found that the force derived from the catheter's mapping system was very accurate at lower contact force with a perpendicular catheter angle. When the angle was adjusted to 30°, 45°, and 60° degrees, there was more error, especially when higher force was applied. When more than 40g of force was applied, variance between the catheters were more marked, with some catheters (Smarttouch SF and AcQBlate Force) underestimating CF as compared with the precision scale and overestimated true CF when the catheter was applied parallel to the testing platform. Tacticath appeared to have better performance, but the study was not designed to compare the 4 models directly. The conclusions of the study were that at CF of 10-40g, measurements errors were low, but at CF of greater than 40g, combinations of catheter type and angle could either underestimate or overestimate CF by as much as 15g.

Küffer and colleagues should be commended for a novel, rigorous methodology to assess contact force. However, there are limitations in applying their observations to clinical practice. The model appears to be reliable, but other factors could affect its accuracy. CF applied to the intact, moving myocardium is dependent on the force applied and the properties of the tissue such as thickness and pliability. Therefore, a static polymeric foam platform may not be an appropriate surrogate for dynamic myocardial tissue. The investigators did not attempt to simulate other factors that could affect accuracy such as prolonged dwell time in the blood pool, measuring CF during ablation, or the effect of repeated ablations or catheter manipulation on the CF measurement components.

Other experimental models have shown similar results.[5,6] Therefore, we can have more confidence in*Küffer's, et al* methodology especially when the catheter is positioned parallel to testing platform. Both investigators observed that at higher CF measures, force is underestimated. Why is this important? Operators could have a false sense of security when advancing the catheter, but higher contact force pressure mitigates the effects of saline irrigation, resulting in lower RF ablation quality, more steam pops and catheter thrombus formation.[7,8]

Almost a generation of electrophysiologists have trained virtually exclusively with CF catheters and increasingly depend on it to reduce fluoroscopy and optimize contact. Ask some trainees to use a catheter without CF, and you may find that the once confident second-year fellow regresses to the uneasy, tentative trainee of early July. As contact force became widely adopted, several observational studies touted the promise of CF as a means of improving outcomes with reduced complications. This led many to trust CF as the standard of ensuring quality ablation to the point that some found the lack of faith by others disturbing. However, randomized studies in patients undergoing RF ablation for atrial fibrillation demonstrated no such improvement in clinical outcomes or perforations.[9,10] This could be due to the paucity of perforations for analysis or the variances in the rigor of ensuring CF-based quality lesions.

If there is one lesson that we can all learn it is that, like the previous advances before it, understanding CF's limitations allow us to better appreciate its capabilities. We do not know if CF is accurate when using an increasingly popular high-power short-duration strategy to create durable lesions, so we should look forward to technologies that give us a more direct tissue-level assessment of ablation quality as our strategies evolve.

From, *Küffer et al* ., we are reminded that the advice of another*Star Wars* character, Darth Vader, "Do not underestimate the force" can also apply to certain CF ablation catheters.

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