What can we learn from a novel “Global Positioning System” in persistent atrial fibrillation?

Kenton J. Zehr, MD

From the Division of Cardiac Surgery, Department of Surgery, The Johns Hopkins Hospital, Baltimore, Md.

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Address for reprints: Kenton J. Zehr, MD, Division of Cardiac Surgery, Department of Surgery, The Johns Hopkins Hospital, 1800 Orleans St, Zayed 7107, Baltimore, MD 21287 (E-mail: zehr@jhmi.edu).

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Kenton J. Zehr, MD

Central Message

The noninvasive ECVUE mapping system, which works somewhat like a GPS for the heart to map cardiac dysrhythmias, demonstrates why a biatrial cut-and-sew lesion set best addresses persistent atrial fibrillation.

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In this issue of the *Journal*, Ehrlich and colleagues¹ introduce a new noninvasive technology to the surgical world. Electrophysiologists have validated this ECVUE system (Medtronic, Minneapolis, Minn) in patients to map atrial and ventricular dysrhythmias for more than 5 years.² The article of Ehrlich and colleagues¹ gives insight into the surgical lesion set that is required to address persistent atrial fibrillation (AF) successfully. After all, if we are opening the chest, the freedom from AF must be high to claim a successful operation.

Faith in the mapping system can be gained by looking at the Global Positioning System (GPS).³ In the 1950s, the US Department of Defense found that tracking the position of satellites could be used to track fixed bodies on the surface of the earth. The Navstar GPS satellite constellation research project started in 1973 and launched the first 4 satellites in 1978. During the next several decades, integrated circuitry and mass production reduced the price of receivers to the \$100 range. GPS has 24 operational satellites orbiting 20,200 km above the surface of the earth in 6 different orbits. The satellites are spaced so that there are at least 4 available to a user any point on earth. With algorithms to correct for general relativity's time speed difference, the wobble of the earth's orbit, ionospheric and tropospheric wave speed differences, and signal refraction, the system has a potential for resolution down to less than an inch. Applications have been used to track people, animals, vehicles, weather balloons, and model rockets. GPS has particularly been used to understand how people interact with their environment, whether free-living activity, active transportation, or sport and recreation.⁴ After looking at this analogy, it is not a stretch to believe that placing a 252-electrode vest several inches from the heart and using gated computed tomographic scanning to establish atrial topography in relation to vest electrodes can allow accurate mapping of atrial dysrhythmias.

Ehrlich and colleagues¹ mapped 10 patients with persistent AF requiring open-chest heart surgery for other cardiac

pathology. Mapping was rapid, requiring no more than 23 seconds. Mapping was successful in all patients. All subjects had biatrial pathology, and all had rotor activity in both atria. The number of rotors was highly variable, ranging from 18 to 92. All patients underwent a Cox-maze III or IV procedure, and 9 patients were discharged in sinus rhythm.

This article underscores several points that the literature bears out. Persistent AF is a biatrial disease. Catheter ablation's less than optimal long-term outcomes underscore this. Lim and associate⁵ used the ECVUE mapping system in 105 patients with a 20 second mapping acquisition.⁵ Persistence of AF was associated with increasing rotor and focal activity and increasing atrial regions beyond pulmonary vein areas. The right atrium was involved in nearly 50% of patients. The AFACART (Non-Invasive Mapping of Atrial Fibrillation) study⁶ used the ECVUE system to look at 118 patients with persistent AF in 8 European centers.⁶ On average, 4.9 driver sites were found per patient. The left atrium was involved in 53% of patients, the right atrium in 27%, and the anterior interatrial groove in 20%. In the catheter ablation world of persistent AF, increasing time spent in AF and complexity of AF translate to poor ablation results. In the study of Lim and associates,⁵ in the group that presented with sinus rhythm, there was a 91% termination of AF; if the persistent AF was present less than 12 months, the rate was 69%; and if AF was present for more than 12 months, the rate was 14%. In the

AFACART study,⁶ driver ablation was successful in 64% of patients and additional pulmonary vein lines were required in 10 more patients, for a total AF termination in 77%. Of the patients with terminated AF, however, 49% had at least 1 episode of atrial tachycardia requiring antiarrhythmic drugs, cardioversion, or a repeat procedure. Rostock and colleagues⁷ adopted a sequential lesion approach for persistent AF termination. First a pulmonary vein isolation was performed, then defragmentation of the left atrium, coronary sinus, and right atrium. Of 88 patients, 68 patients (77%) had AF termination, the left atrium in 37 (55%) and the right atrium in 18 (26%). Fifty-four patients required at least 1 redo ablation. A total of 154 redo ablations were performed. In the more invasive world of cardiac surgery, these would be unacceptable surgical lesion sets for this disease with disappointing results.

In persistent AF, it appears to matter to have a complete lesion set addressing all 7 atrial regions. On the basis of the persistent AF mapping results, Ehrlich and colleagues¹ performed either a Cox-maze III or IV on the 10 patients included in the study. The surgical literature bears out that best results for termination of AF are achieved when the surgeon performs a biatrial lesion set. The number of rotors identified in the study patients add data as to why this is true. In a meta-analysis of 5 studies comparing a biatrial maze lesion set with left atrial maze lesions, Phan and co-workers⁸ reported freedoms from AF at 1 year in the 326 patients in the biatrial group versus the 385 patients in the left atrial group to be 78% and 71%, respectively. In a large single-institution study, Kim and colleagues⁹ reported on 199 patients undergoing a biatrial lesion set compared with 85 patients with a left atrial lesion set alone. All had associated mitral valve disease. The 2-year cumulative incidences of AF were 14% in the biatrial group and 26% in the left atrial group.

In fact, it is pretty clear that the closer the surgeon gets to performing a pure cut-and-sew Cox-maze III operation, the better is the freedom from AF. In one of the early comparisons of 56 patients undergoing the Cox-maze IV lesion set primarily with radiofrequency ablation for linear lesions with 56 matched patients undergoing a cut-and-sew Cox-maze III operation, Stulak and associates¹⁰ reported freedoms from AF at 15 months of 61% and 91%, respectively. And in a 20-year look at the Mayo experience¹¹ comparing various lesion sets and ablation techniques with an 80% follow-up of rhythm data (891 of 1115 patients), at every time point the cut-and-sew Cox-maze III procedure was superior to the Cox-maze IV and various other lesion sets. At 5 years, the freedom from AF without antiarrhythmic drugs was 80% for the cut-and-sew Cox-maze III procedure, compared with 61% for other procedures, including the Cox-maze III lesion set performed with alternative

energy sources. In a recent single-surgeon randomized prospective series¹² of 130 patients with rheumatic mitral disease comparing a cut-and-sew Cox-maze procedure III to no maze, there was a 90% freedom from AF in the Cox-maze III group. There was a significant survival advantage at 1 year of 94% versus 86% as result of stroke and anticoagulation problems in the no maze group. This was despite oversewing of the left atrial appendage in the no maze groups. These results are no small wonder in light of these data from Ehrlich and colleagues¹ documenting the complexity of drivers in patients with persistent AF. The likelihood of transmural ablation is 100% with a cut-and-sew approach, and the other well-documented driver of persistent AF, left atrial size, is significantly reduced by sewing up the pulmonary vein–encircling incision. The Cox-maze III operation as originally described by James L. Cox and his group¹³ remains appropriate for these patients with persistent AF.

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