Experience with the RPM Mapping Technology

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Over the past year or so, the EP Laboratory at Methodist Hospital in Indianapolis has worked with the Boston Scientific RPM (Real-time Position Management) mapping technology. From solid but somewhat limited beginnings, it has swiftly morphed into a premiere, highly flexible product that facilitates mapping and ablation with extraordinary ease, speed and accuracy. It continues to evolve rapidly. The technology has many features that will ensure further evolution and adaptation.

For mapping, RPM uses three catheters: two reference catheters and the mapping/ablation catheter. Each has several microcrystals arrayed along its distal 8-10 cm. Each crystal emits and receives high-frequency intracardiac ultrasound signals. Each crystal locates itself relative to its fellow crystals on the same catheter as well as all the crystals on the other two.

Typically, one catheter is placed in the coronary sinus (CS) and another in the right ventricular apex. Each of those has four crystals spaced approximately 20 mm apart. When so placed, those two catheters are ideally positioned at key cardiac locales, and their "fields of vision" are all-encompassing. The catheters are roughly at right angles to each other, an arrangement that facilitates triangulation, which is the basis for the spatial reckoning. The third catheter is the steerable mapping catheter that is configured additionally for ablation. Similar to the other catheters, it has echo crystals, although three rather than four. Its tip electrode, however, is configured for delivery of radiofrequency (RF) energy.

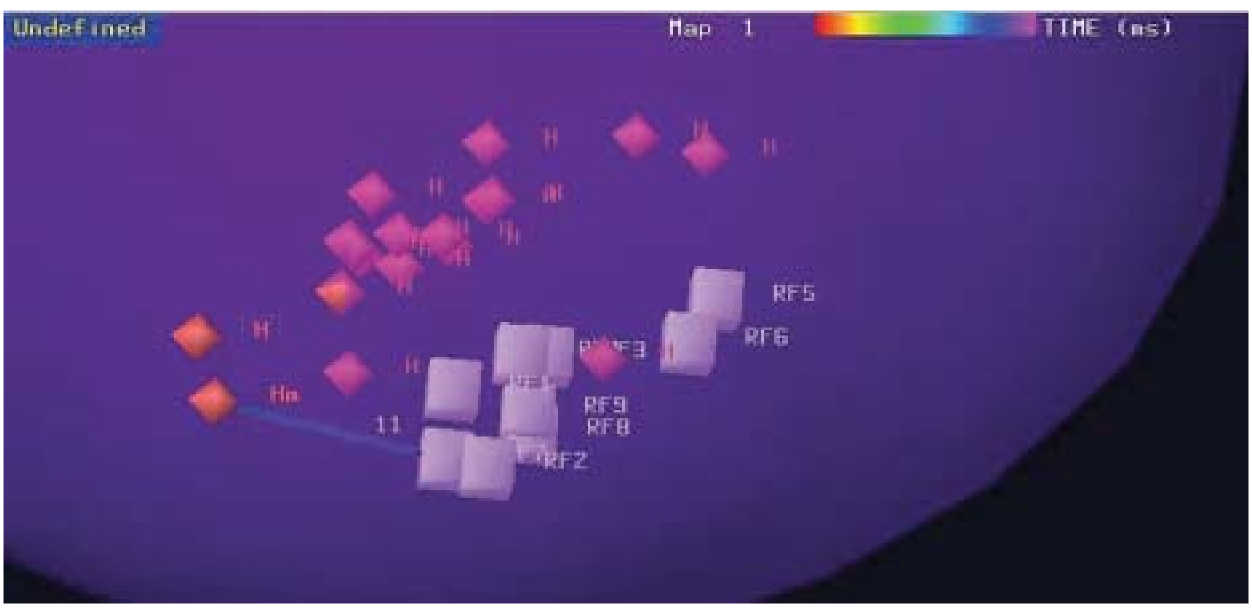

Figure 1. RAO view of recorded His cloud (red cubes) in a patient with AVNRT. The white cubes are sites of RF lesions for slow pathway ablation.

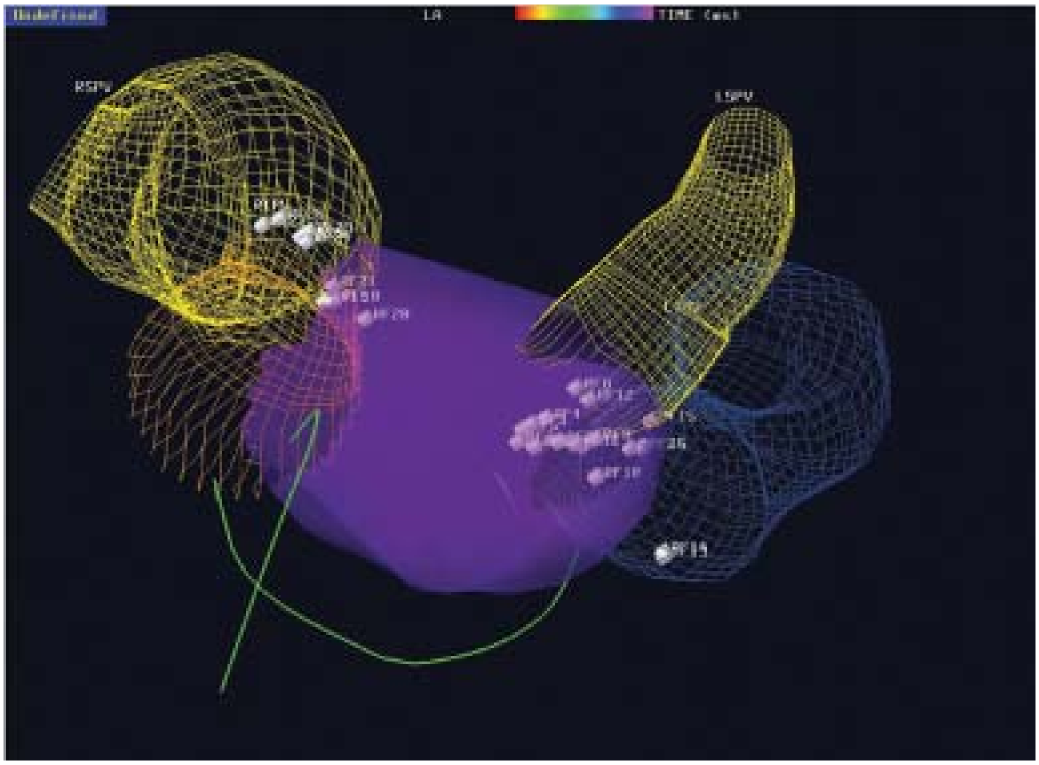

Figure 2. AP view of left atrium with pulmonary veins. The white cubes are sites of RF lesions to ablate mural potentials.

In addition to the echolocation crystals, each catheter has all the characteristics of conventional electrophysiologic catheters, i.e. the ability to record high-quality electrograms from various intracardiac locations.

The physics of triangulation bring tremendous precision to the mapping process. In real-time, the spatial orientation of the catheters is displayed in three dimensions to millimeter accuracy. Within the heart's computerized images, the colored catheters are clearly visible and move with it synchronically. The moving image of the heart with the three catheters and all recorded map points can be zoomed in and out and rotated in any direction. Thus, any area of interest can be seen up close and in action.

By simply moving the mapping catheter, the cardiac chambers and great vessels are mapped in short order. The boundaries of any chamber or vessel are rendered by movement of the mapping catheter tip. As the catheter moves against the chamber walls, the three-dimensional confines of the structure are delineated. If the catheter's movements reach the limits of the structure, those limits are easily reconfigured, and are further adjusted by any subsequent catheter movements outside the previous boundary. For example, while mapping the right atrium, the catheter might not enter every nook and cranny. If at some later time a new nook is entered, the chamber is updated and reconfigured with the new dimensions. If the catheter overreaches the limits of the structure, the overreach is easily undone. For example, while mapping the right atrium, the catheter might inadvertently prolapse into the right ventricle. If so, the map can be reset to the arrangement that predated the prolapse.

Without doubt, one of the RPM technology's greatest strengths is its full integration with the acclaimed EP MedSystems WorkMate recording system. Between the two, there is total linkage of electrographic and anatomic data. Instantaneously, one sees the electrograms from any mapped point and vice versa, i.e. sees the anatomic origin of any recorded electrogram. The data displays are side-by-side and fully correlated. All varieties of mapping (isochronal, voltage and scar) are available. Colorized map displays appear instantly and can be viewed in static or dynamic states.

The system has a Windows feel and is highly intuitive. That is decidedly valuable. Our EP Laboratory is staffed by well-trained, exceedingly capable nurses and technicians. These individuals now use the RPM technology routinely without having to rely upon the availability of company representatives. With one electrophysiologist, the nurses/technicians collect the data needed for all types of mapping including pulmonary vein mapping. Our laboratory is an RPM test site, and we have encountered a spectrum of experienced, savvy EP visitors who invariably note that RPM is, by far, the most user-friendly mapping system they have encountered.

We have used the technology to map and ablate virtually every type of atrial and ventricular arrhythmia. As time has passed and we've become more familiar with the system's precision and reliability, the fluoroscopy time has steadily shortened. With enough experience and confidence in the technology, one inevitably reaches a point where much catheter movement, especially fine movement, is done rather exclusively with RPM and where fluoroscopy is used adjunctively.

Here are three clinical examples of RPM utilization that should provide a "hands-on" sense of its utility. Of note, some of these data were acquired with earlier RPM iterations. With the contemporary iteration, results would be even better.

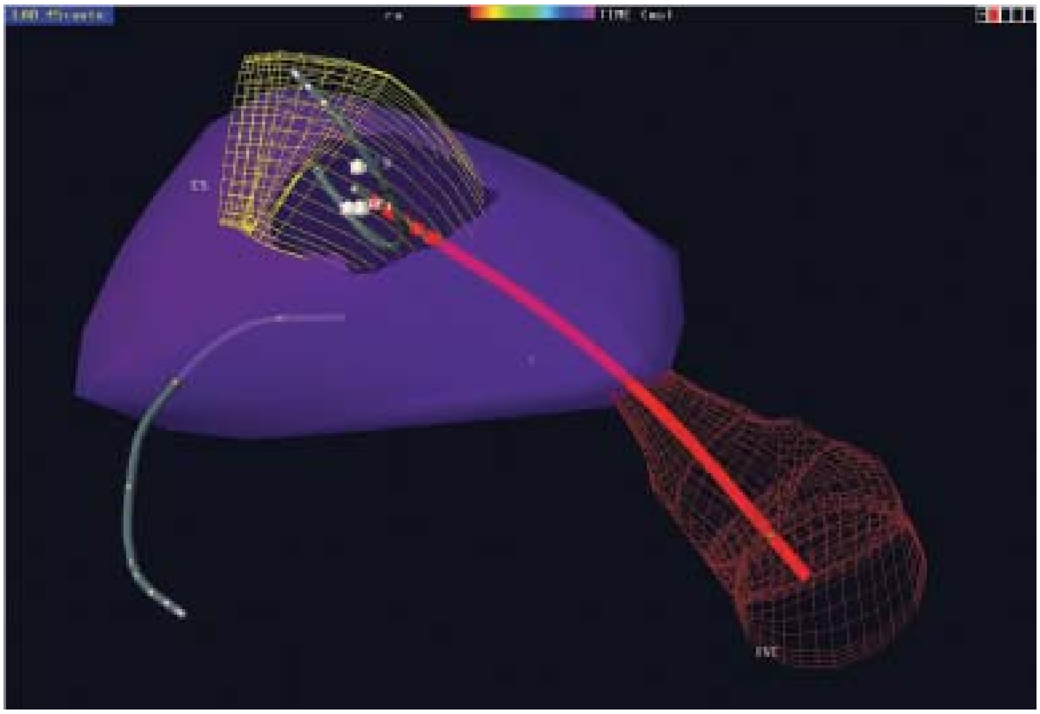

Figure 3. RAO view of coronary sinus os in a patient with AVRT and a posteroseptal accessory pathway (AP).

Figure 1 shows the map of a 46-year-old woman with typical, slow-fast atrioventricular nodal reentrant tachycardia (AVNRT). She had a previous AV node modification without benefit of RPM assistance. The arrhythmia was seemingly abolished, but later recurred. At the time of this repeat study, it was quickly apparent that successful ablation mandated energy delivery extremely close to the AV node. This time, RPM was used to map the His cloud in stunning detail. RPM can create enormous magnification and exactitude. The catheter tip and adjacent areas can be enlarged enough to fill virtually an entire monitor screen. In this example, the red cubes are the cloud of recorded His potentials and demarcate the underlying location of that structure in detail. Knowing that, lesions were successfully delivered without timidity but in close proximity to the His bundle. For an idea of RPM's precision, note that the blue line connecting the white and orange cubes measures the two as exactly 11 mm apart. Amidst the delivered lesions (white cubes), there is a red cube that is obviously spurious. In the context of all the points in the cloud, the odd one is an unambiguous outlier and can be ignored. The outlier is instructive and remains in this map, but could be deleted if so desired. For this patient, the second AV node modification was fully successful, and she has had zero recurrence.

RPM has proven of great value in ablating paroxysmal atrial fibrillation by pulmonary vein isolation. In our laboratory, the preferred mapping is with a 64-electrode basket catheter positioned sequentially within the proximal segments of each pulmonary vein. Mural potentials are seen in striking detail. RPM is used to define the left atrium and also each pulmonary vein emanating from it. With the new version 2.0 software, each vein appears real-to-life as a colored tubular structure connecting to the atrium. Such a structure can be displayed as a solid tube or a wire mesh. Sites of mural potentials, the potentials themselves and delivered lesions are recorded and displayed in pinpoint fashion.

Figure 2 demonstrates a left atrial map with all four pulmonary veins rendered in mesh. In this patient, there was rather a profusion of potentials in the left inferior and right superior veins. The white cubes exhibit sites at which lesions were delivered to abolish the potentials. Similar mapping was also obtained in the superior vena cava.

Figure 3 is from a patient with atrioventricular reentrant tachycardia (AVRT) predicated upon a posteroseptal accessory pathway. Detailed RPM mapping demonstrated there was a good chance of successful ablation at the os of the coronary sinus. Figure 3 focuses on the green CS catheter originating from the left subclavian vein and the red ablation catheter from the inferior vena cava. Figure 4 is a further magnification of the CS os and shows where only three, pinpoint, 20-second lesions were required to ablate the pathway and do so safely.

Obviously the technology is extraordinarily capable. Despite its wide-ranging capabilities, however, it has a small footprint since the mapping data are ollected within the heart itself. A small amplifier and some junction boxes are lightweight, fit easily at the end of the table and are readily accessible. There is cable linkage to the recording system. In our laboratory, the entire system is kept in close proximity to the patient and the electrophysiologist — the integrated mapping/recording systems are on a computer console approximately six feet from the patient.

We have used the RPM technology for somewhat longer than a year. Over that time, it has evolved rapidly to include the ability to map tubular structures and do so with lightning speed. Those advances result from the solid physical principles upon which the technology is based, inspired engineering, astute software writing and a creative collaboration between Boston Scientific and EP MedSystems. In a short time, the technology has acquired an impressive array of assets and a compelling momentum with a number of additional advances in the works. The current technology and its upcoming advances bode well for the future of electrophysiologic mapping and ablation.

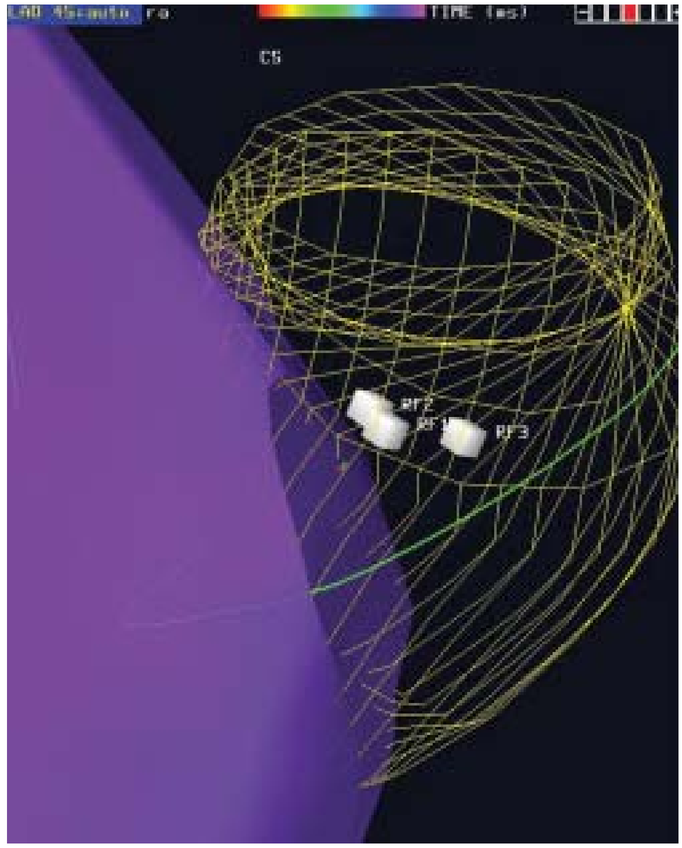

Figure 4. LAO magnified view of CS os. The white cubes are sites of lesions that interrupted the AP.