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Remote Magnetic Navigation

Human Experience in Pulmonary Vein Ablation

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Objectives We aimed at assessing the feasibility and efficacy of remote magnetic navigation (MN) and ablation in patients with atrial fibrillation (AF).

Background This novel MN system could facilitate standardization of the procedures, reducing the importance of the operator skill.

Methods After becoming familiar with the system in 48 previous patients, 45 consecutive patients with AF were considered for ablation using the Niobe II remote magnetic system (Stereotaxis, St. Louis, Missouri) in a stepwise approach: circumferential pulmonary vein ablation (CPVA), pulmonary vein antrum isolation (PVAI), and, if failed, PVAI using the conventional approach. Remote navigation was done using the coordinate or the wand approach. Ablation end point was electrical disconnection of the pulmonary veins (PVs).

Results Using the coordinate approach, the target location was reached in only 60% of the sites, whereas by using the wand approach 100% of the sites could be reached. After step 2 ablation, only 1 PV in 4 patients (8%) could be electrically isolated. Charring on the ablation catheter tip was seen in 15 (33%) of the cases. In 23 patients, all PVs were isolated with the conventional thermocool catheter, and in 22 patients only the right PVs were isolated with the conventional catheter. After a mean follow-up period of 11 ± 2 months, recurrence was seen in 5 patients (22%) with complete PVAI and in 20 patients (90%) with incomplete PVAI.

Conclusions Remote navigation using a magnetic system is a feasible technique. With the present catheter technology, effective lesions cannot be achieved in most cases. This appears to impact the cure rate of AF patients. (J Am Coll Cardiol 2007;50:868–74) © 2007 by the American College of Cardiology Foundation

Over the last decade, radiofrequency catheter ablation of atrial fibrillation (AF) has become an important and increasingly used therapy with good procedural success rates and long-term effectiveness. However, the procedure remains technically challenging, the results are difficult to replicate, and the operator's

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experience could have a significant impact on the success rate. Mapping of the cardiac chambers is performed with relatively stiff deflectable catheters that are manually moved by the operator, standing at the table. The operator navigates the catheter to the desired position guided by fluoroscopy or other imaging systems. Recently, a novel magnetic navigation (MN) system was introduced that allows the use of a soft ablation catheter that can be guided and positioned by directional magnetic fields to the desired site (1–6). If feasible, remote MN could facilitate standardization of the procedures, reducing the dependency on the operator's skill and allowing nonexperienced physicians to treat this arrhythmia. We report our initial experience with remote circumferential pulmonary vein ablation (CPVA) and pulmonary vein antrum isolation (PVAI) using MN in patients with symptomatic and drug-refractory AF.

Methods

After performing 48 procedures using MN, the following 45 consecutive patients were included in this study. The protocol was approved by the institutional review board and all patients gave a written informed consent.

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Catheter positioning. The patient arrived to the Electrophysiology and Pacing lab in a fasting state. Access was obtained in the right femoral vein. An 11-F intracardiac echocardiography (ICE) catheter was placed into the right atrium. A 4-mm Carto RMT catheter (Biosense-Webster, Diamond Bar, California) was used in conjunction with the Niobe II magnetic navigation system (Sterotaxis, St. Louis, Missouri) and biplane flat panel fluoroscopy system (Axion Artis, Siemens, Erlangen, Germany).

Remote magnetic navigation and ablation system. The remote MN system consists of 2 focused-field permanent magnets of a neodymium-iron-boron compound that are computer controlled inside a fixing housing and located on either side of the body (1,7). In the "navigate" position they create a relatively uniform magnetic field (0.08 T) of approximately 15 cm inside the chest of the patients. The mapping and ablation catheter are equipped with a small permanent magnet positioned at the tip that aligns itself with the direction of the externally controlled magnetic field to enable it to be steered effectively. By changing the orientation of the outer magnets relative to each other, the orientation of the magnetic field changes and thereby leads to deflection of the catheter. All magnetic field vectors can be stored and, if necessary, reapplied for automatic navigation of the magnetic catheter. In addition, a computer-controlled catheter advancer system (Cardiodrive unit, Stereotaxis) is used to allow truly remote catheter navigation without the need for manual manipulation. The video workstation (Navigant II, Stereotaxis) in conjunction with the Cardiodrive unit allows precise orientation of the catheter by 1-mm or larger increments and by 1-mm or larger steps in advancement or retraction. The system is controlled by coordinate or wand remote control of the ablation catheter from inside the control room. The wand remote control of the catheter allows a single hand control: the orientation of the tip of the catheter is manipulated by the joystick and the advancement or withdrawal can be done by the roller wheel on the side of the wand. The coordinate control of the catheter is a 2-hand remote control: with the joystick it is possible to advance or withdraw the catheter, and the mouse controls the orientation. The cursor is represented as an arrow (vectors) with a circle. A vector consists of a line with a circle at the starting point, and an arrow at the ending point of the vector. The circle contains a dot (representing the arrow tip) if the vector in the 3-dimensional space is pointing out of the screen and a cross (representing the crossed feathers of an arrow) if it is going away from the user into the screen. Vectors are indications of the direction of the magnetic field, as projected onto the respective X-ray image plane (Fig. 1). A vector is drawn to indicate the position from which the field strength should be set and the direction the magnetic field needs to point to orient the distal tip of the magnetic catheter or guidewire.

Using this system, radiofrequency (RF) ablation was performed with the 4-mm solid-tip magnetic ablation

Abbreviations and Acronyms

AF = atrial fibrillation
CPVA = circumferential pulmonary vein ablation
EGM = electrogram
ICE = intracardiac echocardiography
LA = left atrium/atrial
MN = magnetic navigation
PV = pulmonary vein
PVAI = pulmonary vein antrum isolation
RF = radiofrequency

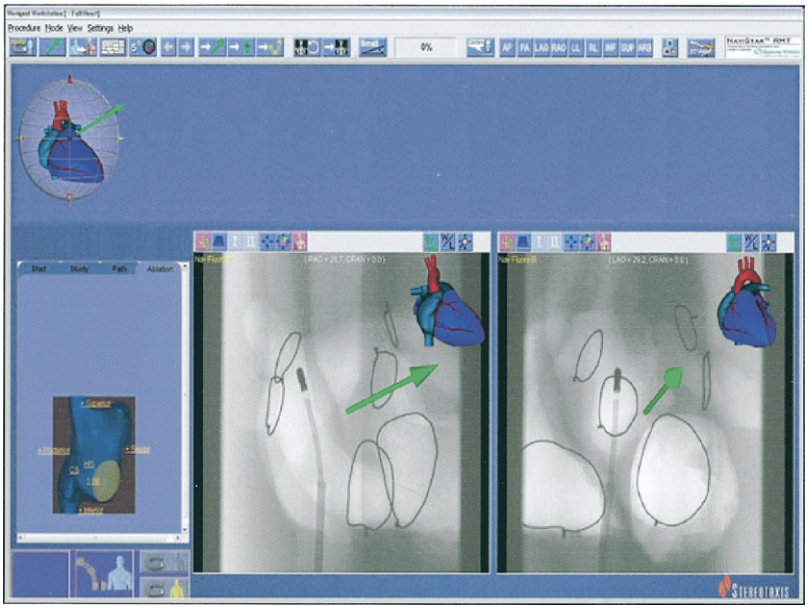

Figure 1 Magnetic Navigation Field Directions

The **green arrow** (vector) indicates the direction of the magnetic field, as projected onto the respective X-ray image plane.