Evaluation of a novel high-resolution mapping technology for ablation of recurrent scar-related atrial tachycardias

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BACKGROUND Rhythmia is a new technology capable of rapid and high-resolution mapping. However, its potential advantage over existing technologies in mapping complex scar-related atrial tachycardias (ATs) has not yet been evaluated.

OBJECTIVE The purpose of this study was to examine the utility of Rhythmia for mapping scar-related ATs in patients who had failed previous ablation procedure(s).

METHODS This multicenter study included 20 patients with recurrent ATs within 2 years after a previous ablation procedure (1.8 ± 0.7 per patient). In all cases, the ATs could not be adequately mapped during the index procedure because of scar with fractionated electrograms, precluding accurate time annotation, frequent change in the tachycardia in response to pacing, and/or degeneration into atrial fibrillation. These patients underwent repeat mapping and ablation procedure with Rhythmia.

RESULTS From a total of 28 inducible ATs, 24 were successfully mapped. Eighteen ATs (75%) terminated during radiofrequency ablation and 4 (16.6%) with catheter pressure or entrainment from the site of origin or isthmus. Two ATs that were mapped to the interatrial septum slowed but did not terminate with ablation. In 21 of 24 ATs the mechanism was macroreentry, while in 3 of 24 the mechanism was focal. Interestingly, in 5 patients with previously failed ablation of an allegedly "focal" tachycardia, high-resolution mapping demonstrated macroreentrant arrhythmia. The mean mapping time was 28.6 ± 17 minutes, and the mean radiofrequency ablation time to arrhythmia termination was 3.2 ± 2.6 minutes. During a mean follow-up of 7.5 ± 3.1 months, 15 of 20 patients (75%) were free of AT recurrences.

CONCLUSION The Rhythmia mapping system may be advantageous for mapping complex scar-related ATs.

KEYWORDS Atrial tachycardia; Mapping; Scar; Ablation; Multielectrode catheters

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Introduction

Pulmonary vein isolation (PVI) is the cornerstone of atrial fibrillation (AF) ablation and is associated with a reasonable clinical outcome in patients with paroxysmal AF. However, in patients with persistent AF, PVI is less effective and additional substrate ablation is frequently performed.[1] This approach not uncommonly results in the development of organized postablation, scar-related atrial tachyarrhythmias.[2–4]

The mechanism of these arrhythmias is usually reentry involving preexisting or iatrogenic ablation-related scar tissue.[5] These circuits can be challenging to map because of significant scar with fractionated multicomponent electrograms, limiting accurate time annotation. In addition, entrainment and post-pacing interval mapping techniques may be difficult to perform and interpret because of high-output pacing, lack of capture in areas of scar, and/or change in the tachycardia in response to pacing.

The Rhythmia mapping system is a new system capable of rapid and high-resolution electroanatomic and activation mapping.[6] Recent publications have reported the feasibility to use this technology for mapping atrial arrhythmias, including for PVI.[7] However, whether this mapping technology has advantages over existing systems for mapping

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complex atypical atrial tachycardias (ATs) has not yet been determined. The aim of this study was to examine the utility of Rhythmia for mapping and ablation of complex scar-related ATs in patients who had failed previous ablation procedure(s) for ATs.

Methods

Patient selection

This multicenter prospective study included 20 consecutive patients with recurrent AT within 2 years (range 0–15 months; median 5 months) after a previously failed ablation procedure. In all previous procedures, the arrhythmia could not be adequately mapped and was ultimately terminated with empiric ablation lines or electrical cardioversion. Inadequate mapping was attributed to the presence of scar with highly fractionated electrograms, precluding accurate time annotation, frequent changes in the tachycardia in response to pacing, and/or degeneration into AF. These patients underwent repeat mapping and ablation procedure with Rhythmia. The institutional review board of the 3 participating institutions approved the study protocol.

Initial mapping and ablation procedure

The methodology of the initial ablation procedures is detailed in the online supplemental material. In brief, mapping of the ATs were performed using either CARTO 3 (Biosense Webster, Johnson & Johnson) or NavX (EnSite Velocity, St. Jude Medical) using circular multielectrode or PentaRay catheters. Ablation was performed using an open irrigated tip catheter.

Mapping and ablation with Rhythmia

All procedures were performed using Rhythmia with its Orion basket catheter (Boston Scientific, Cambridge, MA). The procedures were performed under conscious sedation or general anesthesia according to center and operator preference. Unfractionated heparin was administered before the transspetal punctures to maintain an activated clotting time of 300–400 seconds for the duration of the procedure. Diagnostic catheters were placed in the right atrium and coronary sinus. Intracardiac ultrasound catheter (Acuson, Malvern, PA) was placed in the right atrium to guide transspetal puncture. In addition, a catheter was often placed in the inferior vena cava to serve as an indifferent unipolar electrode. Activation was determined on the basis of the combination of bipolar and unipolar electrograms and timed at the maximum (−)dV/dt of the local unipolar electrogram. Specifically, at sites with multiple and/or fractionated bipolar potentials, the activation time was determined by the maximum (–)dV/dt of the corresponding unipolar electrograms (Figure 1). Data acquisition during AT was automated with the following beat acceptance criteria: (1) tachycardia cycle length (TCL) stability (±5 ms); (2) time stability of a reference electrogram positioned at the coronary sinus; (3) beat-to-beat electrogram consistency; and (4) ≥3 consecutive beats with similar electrogram morphology and timing. Bipolar electrograms were filtered at 30 and 300 Hz. Unipolar electrograms were filtered at 1 and 300 Hz.

The *mechanism of the tachycardia* was defined as macroreentry or focal (or microreentry) on the basis of the activation map. Macroreentrant circuits had a well-defined entrance site, common pathway (isthmus), and exit site. The *entrance* was defined as the site at which the orthodromic wavefront enters the common pathway, while the *exit* was defined as the site at which the orthodromic wavefront exits the common pathway. Focal tachycardias had a point source with centrifugal activation from this center. Mapping of a macroreentrant AT was considered complete when (1) ≥90% of the TCL was mapped; (2) a channel of conduction consistent with an "isthmus" was identified; and (3) mapping density at zones of slow conduction was adequate (limiting data interpolation between points to ≤5 mm). Ablation of AT was guided by the activation map alone. While entrainment and post-pacing interval mapping was performed in some selected cases for the validation of the activation map, ablation was guided by activation mapping alone. The ablation catheter used was a nonmagnetic open-irrigated catheter (Celsius, ThermoCool, Biosense Webster). Visualization of the catheter on the Rhythmia mapping system was based on impedance tracking.

Follow-up

Patients were monitored by 7- to 14-day Holter recordings immediately after the procedure and at 3 month (±2 weeks), 6 months (±4 weeks), and 12 month (±4 weeks) postprocedure. A 12-lead electrocardiogram was assessed at every follow-up clinic visits at 1, 3, 6, and 12 months. Additional monitoring was performed on the basis of symptoms. Antiarrhythmic drugs were not routinely resumed after the ablation procedure, only in cases of arrhythmia recurrence. *Freedom from atrial tachyarrhythmia* was defined as the absence of AF and/or organized AT lasting >30 seconds without a blanking period.

Statistical analysis

Descriptive statistics are reported as mean ± SD for continuous variables and as absolute frequencies and percentages for categorical variables. Comparisons between the linear and multielectrode mapping data were performed using the unpaired Student *t* test. A *P* value of <.05 was considered statistically significant. Analyses were conducted using SPSS Statistics 20.0 (Chicago, IL).

The authors had full access to and take full responsibility for the integrity of the data. All authors have read and agree to the manuscript as written.

Results

Patient characteristics and previous ablation procedures

Patient characteristics and previous ablation data are listed in Online Supplemental Table 1. The mean age of the cohort was 62 ± 7.3 years. The mean left atrial size was 54 ± 4.6