Prevalence of fractionated electrograms in the coronary sinus: Comparison between patients with persistent or paroxysmal atrial fibrillation and a control population

Andrew W. Teh, MBBS,* Jonathan M. Kalman, MBBS, PhD,* Peter M. Kistler, MBBS, PhD,*†‡ Geoffrey Lee, MB ChB,* Fiona Sutherland, RN,* Joseph B. Morton, MBBS, PhD,* Jitendra K. Vohra, MD,* Paul B. Sparks, MBBS, PhD*

*From the *Department of Cardiology, Royal Melbourne Hospital and the Department of Medicine, University of Melbourne, Melbourne, Australia, †Department of Cardiology, The Alfred Hospital, Melbourne, Australia, and ‡The Baker IDI, Melbourne, Australia.*

BACKGROUND Complex fractionated atrial electrograms (CFAEs) are often identified as targets for radiofrequency ablation in the coronary sinus (CS) of patients with atrial fibrillation (AF).

OBJECTIVE The purpose of this study was to determine whether similar features are present in a normal control population.

METHODS Twenty-four patients with AF (12 paroxysmal, 12 persistent) were compared with 12 controls (undergoing radiofrequency ablation for supraventricular tachycardia) in whom at least 1 minute of AF was induced by rapid atrial pacing. Electrogram comparisons during sinus rhythm and AF were made offline. A random 10-second window of AF was used for analysis of fractionation and dominant frequency.

RESULTS The three groups were age matched. CFAEs during AF were less prevalent in the control versus the AF groups (control = 30% ± 28%, paroxysmal AF = 63% ± 34%, persistent AF = 62% ± 29%, $P = .01$). This difference was significant for the proximal to mid-CS only. Conduction velocity within the CS was slower in AF versus control patients (paroxysmal AF = 51 ± 6 cm/s, persistent AF = 52 ± 6 cm/s, control = 73 ± 11 cm/s, $P < .001$). Minimum AF cycle length was shorter in the AF groups versus the control group (paroxysmal AF = 132 ± 34 ms, persistent AF = 127 ± 34 ms, control = 168 ± 30 ms, $P = .01$). No differences in dominant frequency or prevalence of sinus rhythm CFAE was seen among the three groups.

CONCLUSION AF patients have a higher prevalence of CFAE and short cycle length activation within the proximal CS than control patients with nonclinical AF. CFAE are associated with slowed CS conduction in AF patients. No difference in the dominant frequency during AF was seen. CS CFAEs are common in a control population with induced AF and are unlikely to signify clinically important AF drivers in this setting.

KEYWORDS Atrial fibrillation; Coronary sinus; Dominant frequency; Fractionated electrogram

ABBREVIATIONS **AF** = atrial fibrillation; **CFAE** = complex fractionated atrial electrogram; **CS** = coronary sinus

(Heart Rhythm 2010;7:1200–1204)

Introduction

Nademanee et al[1] were the first to demonstrate that complex fractionated atrial electrograms (CFAEs) could be targeted for successful ablation of atrial fibrillation (AF). Since that seminal observation, CFAE ablation has been incorporated into a range of ablation procedures for treatment of both paroxysmal and persistent AF, with varying success.[2–6] The coronary sinus (CS) has been identified as a common site of fractionated electrograms, and in many centers extensive CS ablation is an integral part of the procedure for persistent AF ablation.[2–4,7] However, the significance of fractionated electrograms is unclear, and whether they represent recordings from active drivers in the AF process or are simply passive is uncertain. Simultaneous recording of signals from CS musculature and adjacent left atrium further confuses this analysis. In the current study, we compared the prevalence of fractionated CS electrograms in paroxysmal and persistent AF populations with a control supraventricular tachycardia population in whom AF was induced during electrophysiologic study. This control population had not previously experienced a clinical episode of AF.

Dr. Teh is the recipient of a postgraduate research scholarship from the National Heart Foundation of Australia. Dr. Lee is the recipient of a postgraduate research scholarship from the Cardiac Society of Australia and New Zealand. Drs. Teh and Lee are the recipients of a cardiovascular and lipid research grant from Pfizer. Dr. Kistler is supported by a Research Investigatorship from the Cardiac Society of Australia and New Zealand.
Address reprint requests and correspondence: Dr. Jonathan M. Kalman, Department of Cardiology, Royal Melbourne Hospital, Melbourne, Australia 3050. E-mail address: Jon.kalman@mh.org.au. (Received March 10, 2010; accepted May 6, 2010.)

Methods

Study population

Twelve patients with paroxysmal AF and 12 patients with persistent AF were compared with 12 age-matched control

1547-5271/$ -see front matter doi:10.1016/j.hrthm.2010.05.011

patients undergoing radiofrequency ablation for supraventricular tachycardia in whom AF of at least 1-minute duration was induced by rapid atrial pacing.

All patients provided written informed consent according to a study protocol approved by the Melbourne Health research and ethics committee. With the exception of amiodarone, all antiarrhythmic medications were withheld at least five half-lives prior to the procedure.

Electrophysiologic study

Intracardiac catheters were positioned as follows: (1) 10-pole CS catheter (2-5-2-mm interelectrode spacing) with the proximal bipole positioned at the CS ostium; (2) His-bundle electrogram/right ventricular catheter; and (3) mapping and ablation catheter. Bipolar intracardiac electrograms and 12-lead surface ECG were recorded simultaneously on a computerized digital amplifier system (EPMed Systems, West Berlin, NJ, USA). Intracardiac electrograms were filtered between 30 and 500 Hz. Offline analysis was performed with onscreen digital calipers at 200 mm/s sweep speed. Induction of AF in control patients was achieved by rapid pacing in the right atrium at 200-ms cycle length with an output of 20 mA and pulse width of 2.0 ms for 10 seconds. A representative recording of AF induced in a control patient is shown in Figure 1.

Atrial conduction

Atrial conduction was assessed by averaging linear conduction over 10 consecutive beats along the CS catheter between the proximal bipole (9,10) and the distal bipole (1,2) during CS pacing. Conduction velocity was estimated by dividing the linear distance between the proximal and distal bipoles (37 mm) over the conduction time.

P-wave duration was measured from surface ECG lead II and averaged over 10 consecutive sinus rhythm beats.

Atrial fibrillation cycle length

Mean AF cycle length was calculated by averaging the R-R interval of 10 consecutive beats during AF. The shortest R-R interval during this period was used to define the shortest AF cycle length.

Electrogram fractionation

Electrogram fractionation was defined as any atrial electrogram with more than two deflections and/or continuous activity during AF.[1,4] Comparisons between AF and control patients were performed on recordings during both sinus rhythm (complex activity ≥50-ms duration)[8] and AF. For each patient, a random 10-second window during AF was selected for analysis of electrogram fractionation.

Dominant frequency

Within the same 10-second window selected for analysis of electrogram fractionation, spectral analysis for determination of dominant frequency was also performed offline using customized software. Exported signals were rectified, filtered, and edge-tapered with a Hanning window. Dominant frequency was determined by fast Fourier transformation using zero padding with a spectral resolution of 0.1 Hz. The dominant frequency was defined as the frequency demonstrating the highest power within the frequency domain 3–15 Hz.

Statistical analysis

All statistical analysis was performed using SPSS software version 17.0 (SPSS, Inc., Chicago, IL, USA). All continuous variables are expressed as mean ± SD. Continuous variables were assessed for normality using the Kolmogorov-Smirnov test and compared using analysis of variance. $P < .05$ was considered significant.

Results

The AF and control patient groups were well matched for age (Table 1).

Atrial conduction

No statistically significant difference in P-wave duration or cycle length during sinus rhythm was seen among the three

Figure 1 Surface ECG leads I, II, V_1, and V_6 and intracardiac recordings of pacing-induced atrial fibrillation in a control patient. Note fractionation on the coronary sinus (CS) bipoles. His = His bundle/right ventricular electrogram.