International Journal of Cardiology 228 (2017) 401–405

Contents lists available at ScienceDirect

International Journal of Cardiology

journal homepage: www.elsevier.com/locate/ijcard

Preliminary experience with high-density electroanatomical mapping for ablation of atrial fibrillation – Comparison of mini-basket and novel open irrigated magnetic ablation catheter in consecutive patients

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ARTICLE INFO

Article history:
Received 10 August 2016
Received in revised form 7 November 2016
Accepted 10 November 2016
Available online 13 November 2016

Keywords:
Cardiac mapping
Catheter ablation
Atrial fibrillation
Rhythmia

ABSTRACT

Background: Recently, a novel electroanatomic mapping system enabling rapid and automatic acquisition of high-resolution maps has been introduced. Previous reports focused on system use in combination with a mini-basket catheter. However, a novel system-specific, magnet-enabled ablation catheter eliminates the need for the mini-basket catheter and can potentially reduce procedure complexity and cost. Here we present our first experience from two consecutive case series using both procedural settings.
Methods: In 14 consecutive patients (67 ± 9 years, 5 male) with paroxysmal (n = 10) or persistent AF (n = 4) undergoing de-novo (n = 8) or repeat (n = 6) AF ablation, left atrial electroanatomical maps were acquired with a mini-basket and in 22 patients (64 ± 9 years, 17 male) with paroxysmal (n = 4) or persistent AF (n = 18) undergoing de-novo (n = 12) or repeat (n = 10) AF ablation with the new ablation catheter.
Results: Both complete (7.9 [IQR 4.5–16.2] vs 18.8 [IQR 12.0–25.5] minutes, p = 0.005) and partial maps (3.0 [IQR 2.0–4.6] vs 4.5 [IQR 2.0–6.0] minutes, p = 0.014) acquired with mini-basket required significantly shorter mapping time and had higher point density: 8832 ± 4809 vs 4460 ± 3914 (p = 0.014) and 2483 ± 1774 vs 1111 ± 1926 data points (p = 0.002) in partial maps.
However, procedural (201 ± 52 vs 159 ± 29 min, p = 0.004) and fluoroscopy time (33 ± 11 vs 25 ± 6 min, p = 0.005) was significantly higher in the mini-basket group. Procedural endpoints and complications rates were similar in both groups.
Conclusion: The high-density mapping system can successfully be used with both mini-basket catheters and ablation catheters employed for electro-anatomic reconstruction of the left atrium. While mapping is faster and point density higher with the mini-basket, procedure and fluoroscopy times are longer. The clinical significance of those findings needs to be investigated in future and larger studies.

1. Introduction

Over the last decades, electroanatomical mapping systems have evolved to indispensable tools for most of electrophysiological procedures in patients with complex arrhythmias such as atrial fibrillation (AF). Nevertheless mapping was still limited by relatively low mapping point density and/or long acquisition times.

Recently, a new rapid high-resolution electroanatomical cardiac mapping system (Rhythmia™ Mapping System, Boston Scientific Inc., Natick, MA, USA) has been introduced. The first preclinical and clinical experiences have shown accurate and quick acquisition of high-density electroanatomical maps with a resolution up to 1.8 mm [1–6] suggesting additional value for treatment of complex arrhythmias such as AF. However, the published series focus on generation of electroanatomical maps by means of a diagnostic mini-basket catheter. Such solution adds further complexity to the procedural setting, increases cost and may potentially increase risk of complications.

With the release of system-specific, magnet-enabled, ablation catheter the data collection can be performed in a standard clinical setting employing only ablation catheters or additional spiral catheters.

Here we present for the first time our experience with this novel technology in the setting of AF ablation comparing both acquisitions with mini-basket and ablation catheters. Furthermore, we provide suggestions for new users on how to optimally make use of its potential for AF ablation.

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http://dx.doi.org/10.1016/j.ijcard.2016.11.243
0167-5273/

2. Methods

2.1. Patients

36 patients suffering from drug-refractory AF were included in the study. Detailed patient characteristics are provided in Table 1 and in Supplementary Tables A1 and A2.

The study was performed in compliance with the principles of the Declaration of Helsinki and all applicable local laws and regulations. All patients provided written informed consent for intervention and data collection and analysis.

2.2. Procedural setting

Left atrial catheter ablation was performed using an approach which has been described in detail previously [7]. In brief, patients were studied under deep propofol sedation with continuous invasive monitoring of arterial blood pressure and oxygen saturation. *trans*-Septal access and catheter placement was performed using a steerable sheath (Agilis, St. Jude Medical, St. Paul, MN, USA). In all patients circumferential left atrial ablation lines were placed around the antrum of the ipsilateral pulmonary veins (PVs) with a open irrigated 4 mm ablations catheter (Blazer OI or IntellaNaV OI, Boston Scientific Inc., Natick, MA, USA) with pre-selected tip temperature of 48 °C and power of 30–45 W.

2.3. Electroanatomical mapping and ablation

In 14 patients electroanatomical mapping with the high density mapping system was conducted as previously described [1–6] by usage of 8 Fr bidirectional, irrigated, deflectable mini-basket catheter (IntellaMap Orion™, Boston Scientific Inc., Natick, MA, USA). In subsequent series of 22 patients mapping was conducted using system-specific, magnet-enabled ablation catheter (IntellaNAV™, Boston Scientific Inc., Natick, MA, USA). Beats were included in the map based on cycle length stability, relative timing of reference electrograms, electrode location stability, and respiratory gating. The criteria were selected by the operator before beginning the map. All maps were created including only those electrograms that were acquired within 5 mm of the surface reconstruction. All electrograms were stored for later review. Selecting individual electrograms with a virtual roving probe inspected regions of interest. For each map we collected a) the number of beats, b) the number of electrograms included into the map and c) total mapping time. Before ablation at least one complete map of the PVs on each side were created. Re-mapping after ablation could either produce a complete map of the ipsilateral PVs or a partial map of the region of interest. In accordance with previous studies [8,9] peak-to-peak electrogram amplitudes of 0.5 mV and above in sinus rhythm were defined to represent healthy myocardium, 0.2 mV and below to represent scar tissue and 0.2 to 0.5 mV to represent diseased myocardium.

2.4. Statistical analysis

Categorical variables are provided as total numbers and frequencies (%) and continuous variables as mean ± standard deviation. Continuous variables were compared using unpaired Student's *t*-test or Mann-Whitney *U* test, according to normality, and paired data using paired Student's *t*-test or Wilcoxon analysis. Categorical variables were compared using Chi-square analysis. p-Values ≤0.05 were considered statistically significant.

All data management and analysis were performed using SPSS 18.0 software (SPSS, Illinois, USA).

Table 1
Characteristics of the study population.

	Mini-basket (n = 14)	Ablation catheter (n = 22)	p-Value
Age, (years ± SD)	67 ± 9	64 ± 9	0.341
Males, n (%)	5 (36)	17 (77)	0.013
Hypertension, n (%)	13 (93)	19 (86)	0.546
Diabetes mellitus, n (%)	4 (29)	3 (14)	0.270
Congestive heart failure, n (%)	0 (0)	5 (22)	0.055
History of stroke/TIA, n (%)	1 (7)	0 (0)	0.204
Peripheral vascular disease, n (%)	0 (0)	1 (5)	0.418
Coronary artery disease, n (%)	1 (7)	6 (27)	0.137
Persistent AF, n (%)	4 (29)	18 (82)	0.001
Median CHA_2DS_2-VASc, [IQR]	3 [2–3]	2 [1–3]	0.175
Left ventricular ejection fraction, (%)	61 ± 8	57 ± 8	0.303
Left atrial diameter, (mm ± SD)	40 ± 4	53 ± 12	0.068
Statins, n (%)	6 (43)	10 (46)	0.878
ACE inhibitors, n (%)	10 (71)	15(68)	0.837
Beta blocker, n (%)	11 (79)	17 (77)	0.927
Amiodarone, n (%)	2 (14)	4 (18)	0.527

3. Results

3.1. Mapping with mini-basket catheter

In 14 patients electroanatomical maps of the PVs and LA were created with a mini basket. In total, partial (n = 121) or complete (n = 9) high resolution maps were successfully acquired in all patients (Fig. 1). Median acquisition time for the partial map was 3.0 [IQR 2.0–4.6] minutes and 7.9 [IQR 4.5–16.2] minutes for complete maps. During complete mapping 8832 ± 4809 data points and during partial mapping 2483 ± 1774 data points were automatically annotated without manual correction.

3.2. Mapping with ablation catheter

The ablation catheter group consisted of 22 patients Complete electroanatomical maps of the PVs and LA containing 4460 ± 3914 data points were created with an ablation catheter within 18.8 [IQR 12.0–25.5] minutes, and partial maps contained 1111 ± 1926 data points and were acquired in 4.5 [IQR 2.0–6.0] minutes.

3.3. Comparison of procedural data and endpoints

In both series the procedural endpoint of bidirectional PVI was achieved in all patients. However, the duration of the procedure was significantly higher in mini-basket group (201 ± 52 vs 159 ± 29 min, p = 0.004). Furthermore the procedures with mini-basket required also more fluoroscopy time (33 ± 11 vs 25 ± 6 min, p = 0.005).

Both complete (p = 0.005) and partial maps (p = 0.014) generated with mini-basket required significantly less time. The density of acquired points was also significantly higher in the mini-basket group in complete maps (p = 0.014) in the partial maps (p = 0.002).

3.4. Periprocedural complications

During the study 4 procedure-related complications occurred: in both groups 1 case of pericardial effusions have been detected by a postprocedural echocardiography and safely treated with pericardiocentesis. It could not be established with certainty at which step of the procedure the complications occurred. Furthermore, in both groups a single case of groin haematoma was observed.

3.5. Novel approaches

During this initial experience several additional approaches employing unique features of automatic annotation have been elaborated and are being presented in details in the following sections:

3.5.1. Automatic identification of the earliest local vein potential

Automatic identification of the earliest local vein potential after incomplete isolation has been performed as follows. First, a high-density activation map of the target region of RF ablation was conducted after the first isolation attempt (Fig. 1A). The initial time window was calibrated automatically based on the reference signal (atrial signal of the distal pole of the coronary sinus catheter). In this setting the algorithm preferentially annotated the earlier and more prominent far field signal, thereby identifying the earliest activation side at the anterior wall in the proximity of the left atrial appendage. The manual adjustment of the time window (set to 10 ms after the far field signal, Fig. 1 Box) leads to a change of activation pattern, revealing the zone of conduction on the posterior wall (Fig. 1B). Video material demonstrating both this mapping strategy and immediate isolation of the PV by targeted ablation can be observed in Video S1 (provided as a supplement).