Pulmonary vein isolation using a circular, open irrigated mapping and ablation catheter (nMARQ): a report on feasibility and efficacy

Stephan Zellerhoff1*, Matthew Daly1, Han S. Lim1, Arnaud Denis1,2, Yuki Komatsu1, Laurence Jesel1,2, Nicolas Derval1,2, Frédéric Sacher1,2, Hubert Cochet1,2, Sébastien Knecht1,2, Sunthareth Yiem1, Méleze Hocini1,2, Michel Haïssaguerre1,2 and Pierre Jaïs1,2

1Hôpital Cardiologique du Haut-Levêque, CHU Bordeaux, Université Victor Segalen Bordeaux II, Avenue de Magellan, 33604 Bordeaux-Pessac, France; and 2INSERM U1045—L’Institut de Rythmologie et Modeling Cardiaque, Bordeaux, France

Received 30 December 2013; accepted after revision 25 April 2014; online publish-ahead-of-print 18 June 2014

Aims
Pulmonary vein isolation (PVI) is the mainstay of interventional treatment of paroxysmal atrial fibrillation (PAF). We report on the feasibility and efficacy of a novel, open-irrigated mapping and radiofrequency (RF) ablation catheter.

Methods and results
Thirty-nine consecutive patients (pts; age 60 ± 10 years, 8 females) suffering from drug-refractory PAF referred for PVI were included in this prospective study. Pulmonary vein isolation was performed with the use of a novel 10-pole circular, open-irrigated mapping and ablation catheter (nMARQ, Biosense Webster). Outcome parameters were the acute success rate in establishing complete PVI and the rate of sustained sinus rhythm (SR) during follow-up (FU). Ten patients underwent a repeat procedure for recurrent AF. Ninety-eight percent of the PVs could be acutely isolated using solely the nMARQ catheter by applying a mean total of 10.0 ± 4.6 min of RF energy. The mean total procedure duration was 86 ± 29 min, and the mean fluoroscopy time was 22.2 ± 6.5 min, respectively. Transient reconnection provoked by adenosine was observed in 10 of 24 patients, most frequently in the right superior PV. Cardiac tamponade related to transseptal puncture occurred in one patient. Reconnected PVs could be identified as a source of recurrent AF in 9 of 10 patients undergoing a repeat procedure. Single and multiple procedure success rates during a mean FU of 140 ± 75 days were 66 and 77%, respectively.

Conclusion
Irrigated multi-electrode RF ablation is fast and effective, providing a high rate of isolated PVs without the need of touch-up lesions. Success rates were comparable with other techniques with a low complication rate. Recurrences of AF were mainly due to recovered pulmonary vein/left atrium conduction.

Keywords
Atrial fibrillation • Catheter ablation • Technology

Introduction
The high prevalence of atrial fibrillation (AF) and the limitations of available antiarrhythmic drugs have promoted the role of catheter ablation as an important therapy in patients with symptomatic AF. Since the original description of ectopic foci in the pulmonary veins (PVs) triggering AF, catheter ablation has evolved from an ablation targeting these foci at their origin in the PVs to a therapy which eliminates potential PV triggers by electrically isolating them from the left atrium (LA). After various modifications, pulmonary vein isolation (PVI) is still the cornerstone of most catheter-based interventional procedures for the treatment of drug-refractory paroxysmal AF. Despite the routine use of three-dimensional (3D) mapping systems, manual point-by-point ablation can be complex and time consuming. Moreover, deployment of a durable, contiguous transmural ablation line around the PVs is challenging with single-tip catheters, hampering especially long-term efficacy. Therefore, various specialized devices, utilizing different energy forms and catheter...
What’s new?
- This work provides insight into the performance of a novel circular ablation device (nMARQ, Biosense Webster) in the treatment of paroxysmal atrial fibrillation.
- Irrigated multi-electrode radiofrequency ablation was fast and effective without the need of touch-up lesions.
- Success rates were comparable with other technologies with a low complication rate.

Methods

Study population
Eligible for participation in this study, which was approved by the institutional Clinical Research and Ethics Committee, were patients ≥ 18 years referred for ablation of symptomatic, drug refractory, paroxysmal AF, who provided written informed consent. Exclusion criteria were severe mitral valve stenosis or regurgitation, congestive heart failure, left atrial thrombus, contraindication to oral anticoagulation, and pregnancy. Importantly, inclusion was not based on any imaging modality assessing the individual LA/PV anatomy prior to ablation.

Electrophysiological study
Antiarrhythmic drugs were discontinued ≥ 5 half-lives prior to ablation, except for amiodarone. All patients received oral anticoagulants for at least 1 month prior to the procedure with a target INR of 2–3. Transeophageal echocardiography was performed within 5 days to exclude atrial thrombus. Oral anticoagulation with vitamin K antagonists was not stopped prior to ablation, whereas new oral anticoagulants were interrupted 48 h before the procedure and resumed on the day following ablation.

Femoral venous access was gained under local anaesthesia using bupivacaine and conscious sedation. The latter consisted of intravenous midazolam, morphine sulphate (0.1 mg/kg to 0.2 mg/kg), and, if necessary, sufentanil while monitoring non-invasively blood pressure and oxygen saturation. After gaining vascular access, a steerable quadripolar or decapolar catheter (5 mm electrode spacing, Xtrem, ELA Medical, Montrouge, France) was placed within the coronary sinus (CS). Surface and bipolar endocardial electrocardiograms (ECGs) were continuously monitored at a sweep speed of 100 mm/s and recorded (Labsystem Pro, Bard, Tewksbury, MA, USA). Electrocardiogram and intracardiac electrograms were filtered from 0.05 to 100 Hz and 30 to 250 Hz, respectively.

Left atrial access was gained by transseptal puncture (BRK needle, St. Jude Medical) using fluoroscopic and pressure guidance and confirmed by left atrial contrast injection. A single puncture was used to pass a long sheath (Daig SL0 or Agilis, St. Jude Medical). The long sheath was continuously perfused with heparinized saline at 200 mL/h. After transseptal access, an intravenous bolus of heparin (0.1–0.5 mg/kg of body weight according to INR) was administered and repeated if needed to maintain an activated clotting time > 320 s.

Radiofrequency catheter ablation
Prior to ablation, the individual LA anatomy was reconstructed with an EAMS (Carto 3, Biosense Webster, Diamond Bar) using a novel, decapolar circular catheter, which combines mapping capabilities with the possibility of delivering RF energy using the same electrodes (nMARQ, Biosense Webster). In brief, the catheter consists of 10 separate, openly irrigated electrodes (electrode length 3.5 mm, spacing 4 mm, maximum diameter 8.4 French) arranged on a variable circle (diameter 20–35 mm). An irrigation line is connected to the catheter’s central hub and perfused using a commercially available pump (during energy application 60 mL/min 0.9% saline via CoolFlow, Biosense Webster). The corresponding generator (nMARQ Generator, Biosense Webster) is capable of delivering RF energy over 10 separate channels independently. Maximum power was set to 25 W, temperature was limited to 45°C in unipolar mode. Radiofrequency delivery is in general possible either in a uni- or in a bipolar fashion for the active ablation electrodes, but currently only unipolar RF was used for 60 s per application. The catheter position was displayed in the high-density electroanatomical map of the LA throughout the procedure and confirmed by intermittent fluoroscopy, ensuring optimal catheter placement and tissue contact prior to each energy application. Further information on wall contact was gained from an impedance based technology built into the EAMS (Tissue Connect, Biosense Webster). Electrodes not in contact were deactivated before the start of ablation. The diameter of the circular ablation catheter was carefully adjusted aiming at delivering RF at the antrum and reduce thereby the risk of PV stenosis (Figure 1). Bipolar electrogram recordings of the decapolar catheter were obtained slightly more distal to this.
position prior to and following ablation in order to avoid the recording of misleading ‘pseudo PVPs’ on the ablation line and to clearly demonstrate entrance block. During RF delivery, ablation-related parameters (temperature, impedance, and power delivered) were monitored continuously for each active channel. Intermittent fluoroscopy was also used to assess movement of the diaphragm to avoid injury to the right phrenic nerve. Pacing for phrenic nerve capture and esophageal temperature monitoring were not routinely performed. However, a power limited to 20 W was used for electrodes in contact with the posterior wall.

In patients with documented common atrial flutter, ablation of the cavotricuspid isthmus (CTI) was performed with the nMARQ catheter unless failure to achieve bidirectional block made conversion to conventional ablation necessary. Endpoint was acute achievement of complete PVI using the nMARQ catheter. The necessity of touch-up lesions using a conventional-irrigated-tip catheter (Navistar Thermocool, Biosense Webster) was recorded in each patient. Conventional ablation was performed with 25–30 W depending on the site of ablation.

Follow-up
After ablation, the patients received subcutaneous low-molecular weight heparin in-hospital until the target international normalized ratio was achieved on oral anticoagulation. Antiarrhythmic drugs were continued for 1–3 months (amiodarone in patients with heart disease, flecainide/beta-blocker in others). Post-discharge from the hospital, the patients were admitted for clinical interrogation and 24 h (continuous), in-hospital telemetry at 3, 6, 9, and 12 months serially. The outcome was categorized as persistent or paroxysmal arrhythmia (AF or atrial tachycardia), or stable sinus rhythm (SR). Four weeks post ablation, the patients underwent contrast-enhanced magnetic resonance imaging (MRI) to screen for PV stenosis.

Repeat procedures
A repeat procedure was considered for symptomatic or documented AF or atrial tachycardia (AT). In these cases, LA anatomy was reconstructed with an EAMS (Carto 3, Biosense Webster) using a conventional, irrigated-tip catheter (Navistar Thermocool, Biosense Webster). By these means, a high density left atrial voltage map was obtained (Figure 2). Careful attention was paid to the antral region of each pulmonary vein (PV). Sites of reconnection were thereafter tagged in the individual 3D anatomy and classified according to their location. Reconnected veins were subsequently re-isolated using conventional, irrigated-tip RF ablation.

Statistical analysis
Continuous variables were reported as mean ± standard deviation (SD). Categorical data were expressed as numbers and percentages. Statistical significance was established at $P \leq 0.05$. All statistical analyses were performed using SPSS version 21.0 (SPSS, Inc.) and Prism version 5.00 (GraphPad Software).

Results
Study population
We studied consecutive 39 patients referred for ablation of symptomatic, drug refractory, paroxysmal AF, who provided written informed consent for participation in the study. Details on the patients’ demographics and baseline characteristics are provided in Table 1.

Figure 2 Left atrial voltage map during a repeat procedure (A: RAO; B: AP; C: LAO; D: PA view, respectively).
Immediate procedural results

A total of 154 pulmonary veins were targeted using the nMARQ catheter. Of these, 151 (98%) could be acutely isolated using solely the circular ablation catheter. 3 veins (right superior PV & right inferior PV in one patient; right superior PV in another patient) could only be completely isolated by touch-up lesions using a conventional, irrigated-tip ablation catheter. Thus, 37/39 (95%) patients were be completely isolated using exclusively the nMARQ mapping/ablation catheter by applying a mean of 10.0 ± 2.0 s of RF energy to achieve complete PVI. Mean total procedure duration in this cohort was 86 ± 29 min, and mean fluoroscopy time was 22.2 ± 6.5 min, respectively (Table 2). During the course of the ablation procedure, dissociated PV potentials could be observed in 49% of the patients. Adenosine triphosphate injection to unmask dormant conduction was used in the 24 patients with no contraindications. Of these, 10 exhibited a transient reconnection of at least one PV (1 reconnected vein in 7 patients, 2 veins in 2 patients, 3 veins in 1 patient). Transient reconnection was significantly more frequently observed in the right superior PV compared with the remaining PVs (Table 2, Figure 3).

Repeat procedures

Ten patients underwent a repeat procedure for symptomatic or documented AF 85 ± 42 days after the initial ablation. Recovered conduction of at least one PV could be detected in 9 of 10 (90%) patients. Reconnection of 3/4 and 4/4 veins was present only in one patient each, whereas seven patients exhibited the recovery of conduction of one or two PVs. The rate of reconnection was evenly distributed across the different PVs, showing no statistical

Table 1 Baseline patient characteristics

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>N = 39</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender, n (%)</td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>8 (21)</td>
</tr>
<tr>
<td>Male</td>
<td>31 (79)</td>
</tr>
<tr>
<td>Age, mean ± SD, years</td>
<td></td>
</tr>
<tr>
<td>60 ± 10</td>
<td></td>
</tr>
<tr>
<td>BMI, mean ± SD, kg/m²</td>
<td></td>
</tr>
<tr>
<td>25.9 ± 3.7</td>
<td></td>
</tr>
<tr>
<td>Hypertension, n (%)</td>
<td></td>
</tr>
<tr>
<td>9 (23.1)</td>
<td></td>
</tr>
<tr>
<td>Embolic events, n (%)</td>
<td></td>
</tr>
<tr>
<td>2 (5.1)</td>
<td></td>
</tr>
<tr>
<td>Structural heart disease, n (%)</td>
<td></td>
</tr>
<tr>
<td>5 (12.8)</td>
<td></td>
</tr>
<tr>
<td>Ischaemic heart disease, n (%)</td>
<td></td>
</tr>
<tr>
<td>2 (5.1)</td>
<td></td>
</tr>
<tr>
<td>Left ventricular hypertrophy, n (%)</td>
<td>1 (2.6)</td>
</tr>
<tr>
<td>Hypertrophic cardiomyopathy, n (%)</td>
<td>1 (2.6)</td>
</tr>
<tr>
<td>Valvular heart disease, n (%)</td>
<td></td>
</tr>
<tr>
<td>1 (2.6)</td>
<td></td>
</tr>
<tr>
<td>Echocardiographic parameters</td>
<td></td>
</tr>
<tr>
<td>Left ventricular ejection fraction, mean ± SD, %</td>
<td>65 ± 7</td>
</tr>
<tr>
<td>Left ventricular end diastolic diameter, mean ± SD, mm</td>
<td>50 ± 9</td>
</tr>
<tr>
<td>Left atrial surface area, mean ± SD, cm²</td>
<td>19 ± 5</td>
</tr>
<tr>
<td>AF-related parameters</td>
<td></td>
</tr>
<tr>
<td>AF history, mean ± SD, months</td>
<td>60 ± 48</td>
</tr>
<tr>
<td>Maximum duration of AF episodes, mean ± SD, h</td>
<td>20 ± 29</td>
</tr>
<tr>
<td>Patients presenting in SR, n (%)</td>
<td>37 (94.9)</td>
</tr>
<tr>
<td>Patients with ≥ 1 DC shock, n (%)</td>
<td>2 (5.1)</td>
</tr>
<tr>
<td>Number of AADs used before AF ablation, mean ± SD</td>
<td>2.0 ± 0.7</td>
</tr>
<tr>
<td>History of amiodarone use before AF ablation, n (%)</td>
<td>17 (43.6)</td>
</tr>
</tbody>
</table>

AF, atrial fibrillation; AAD, antiarrhythmic drug; BMI, body mass index.

Table 2 Procedural data

<table>
<thead>
<tr>
<th>Procedure parameters</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Procedure duration, mean ± SD, min</td>
<td>86 ± 29</td>
</tr>
<tr>
<td>Fluoroscopy duration, mean ± SD, min</td>
<td>22.2 ± 6.5</td>
</tr>
<tr>
<td>Total RF delivery duration (PVI), mean ± SD, min</td>
<td>10.0 ± 4.6</td>
</tr>
<tr>
<td>RF delivery duration per vein, mean ± SD, s</td>
<td></td>
</tr>
<tr>
<td>RSPV</td>
<td></td>
</tr>
<tr>
<td>RIPV</td>
<td></td>
</tr>
<tr>
<td>LSPV</td>
<td></td>
</tr>
<tr>
<td>LIPV</td>
<td></td>
</tr>
</tbody>
</table>
| RF, radiofrequency; RSPV, right superior pulmonary vein; RIPV, right inferior pulmonary vein; LSPV, left superior pulmonary vein; LIPV, left inferior pulmonary vein.

Figure 3 Mean RF duration per vein.

A total of 13 patients with documented cavotricuspid isthmus-dependent flutter also underwent CTI ablation: In nine patients (69%) solely the nMARQ catheter was used to achieve bidirectional block using 4.6 ± 2.4 min of RF; in four patients (31%) additional RF lesions using a conventional, irrigated-tip catheter were necessary. One case of cardiac tamponade occurred: Beginning pericardial effusion was noted shortly after transseptal puncture. After finishing PVI and CTI ablation, repeat transthoracic echocardiography showed an increasing effusion while blood pressure was dropping slowly, necessitating percutaneous drainage. The patient fully recovered.

Repeat procedures

Ten patients underwent a repeat procedure for symptomatic or documented AF 85 ± 42 days after the initial ablation. Recovered conduction of at least one PV could be detected in 9 of 10 (90%) patients. Reconnection of 3/4 and 4/4 veins was present only in one patient each, whereas seven patients exhibited the recovery of conduction of one or two PVs. The rate of reconnection was evenly distributed across the different PVs, showing no statistical
difference. On further analysis of the individual LA maps, preferential sites of re-conduction recovery were located at the antero-superior aspect of the left superior PV, close to the carina and anterior of the left inferior PV, antero-superior of the right superior PV and inferior of the right inferior PV (Figure 4). Mapping revealed very defined gaps, which were afterwards closed by focal RF application re-isolating the respective PV.

In 4 of 10 patients, a CTI ablation had been performed using the nMARQ catheter during the initial procedure. Persistent, bidirectional block could be assessed in two of four patients, in the remainder repeat conventional ablation was necessary to obtain conduction block again.

No major intraprocedural complications occurred during the second left atrial procedure. Post interventional one case of a false aneurysm at the femoral puncture site occurred, which was managed conservatively.

Follow-up
The mean follow-up (FU) was 140 ± 75 days. The single procedure success rate was 66%, increasing to 77% after a mean of 1.2 procedures per patient. Hence, approximately three-fourths of the patients were in SR and free of symptomatic or documented asymptomatic AF or AT episodes. Of them, 28% were still on antiarrhythmic medication, including two patients on amiodarone. The mechanism of recurrent atrial arrhythmia in the remaining patients was AF, whereas AT was not documented. No late complications were recorded, no PV stenosis was detected by MRI.

Discussion
Various technical developments like 3D mapping systems and image integration into these systems have been undertaken to simplify catheter ablation of AF. Yet, despite these technologies, this procedure remains relatively time consuming and complex while using point-by-point RF ablation. Therefore, the advent of new technologies is needed.

Packer et al.11 reported on the results of cryoballoon ablation for paroxysmal AF; including the patients who crossed over from the drug therapy group, 228 patients underwent cryoballoon ablation. Eighty-three percent of the targeted PVs could be isolated using solely this device, although in 20.8% of the PVs both the small 23 mm and the bigger 28 mm cryoballoon and a mean application solely this device, although in 20.8% of the PVs both the small 23 mm and the bigger 28 mm cryoballoon and a mean application time of ~44 min were applied. Thus, to achieve isolation of all four PVs, frequently touch-up lesions with a single-tip cryo catheter were necessary, increasing the average total cryoballoon time to 66 min. Recently, using the second-generation 28 mm cryoballoon, Furrkranz et al.9 were able to significantly reduce cryoballoon applications per vein, fluoroscopy duration as well as procedure duration in comparison with the first-generation 28 mm device [1.8 ± 1.2 vs. 1.3 ± 0.8 applications per vein (excluding bonus), 19.5 ± 7.4 vs. 13.4 ± 5.3 min, and 128 ± 27 vs. 98 ± 30 min, respectively]. Notably, also the rate of single-shot PVI increased from 51 to 84% using the second-generation balloon. High success rates in achieving acute PVI with a circular mapping and ablation catheter were reported by several groups using multi-electrode-phased RF ablation (PVAC, Medtronic, Inc).9,11 In the present study, 98% of the PVs were isolated with the nMARQ device, applying RF energy for <10 min on average. Likewise, total procedure time and fluoroscopy time were shorter when compared with cryoballoon ablation reported by Packer et al.11 (86 and 22.2 min vs. 371 and 63 min, respectively) and similar to the durations reported by Boersma et al.8 and by Furrkranz et al.12 The mean total RF duration was lower in the present study compared with the phased RF studies, but a direct comparison of total delivered energy is difficult due to the different methods of current modulation and catheter design.

The nMARQ catheter allows mapping of the PV–LA junction in a similar fashion as a conventional circular mapping catheter. Moreover, discrimination of electrogograms and assessment of PVI are also possible during RF delivery preventing prolonged ineffective RF applications (Figure 5). This feature overcomes one of the limitations of the PVAC catheter, which does not permit the registration of intracardiac electrogogram during delivery of duty-cycled phased RF, blinding the operator to the immediate results of ablation. The cryoballoon itself possesses no mapping capabilities, but a specialized inner lumen mapping catheter can be used to visualize electrogograms online.14 Nevertheless, the rate of isolation observed in real-time in the study by Chierchia et al.13 was only 47%, presumably because the inner lumen catheter is placed more distally in the respective PV to achieve sufficient stability of the catheter assembly and thereby failing to register PV potentials. On the other hand, Furrkranz et al.12 observed PVI in real-time in significantly higher proportion using the second-generation 28 mm cryoballoon.

Recently, Rosso et al.13 reported on discordant recordings using the nMARQ and a conventional circular mapping catheter following RF delivery, leading to under- as well as to over-estimation of PVI by the nMARQ device. We tried to overcome this phenomenon by ablating as antral as possible and by comparing baseline electroggrams recorded slightly more distally with the post ablation recordings. At the beginning of our experience, we used a conventional circular mapping catheter to confirm PVI. This is probably useful to learn how to read the nMARQ signals for PVI. Furthermore, due to the

Figure 4 Distribution of preferential reconnection sites during repeat procedures (percentage per vein for the two most preferential sites).
electrode size, recording far-field PV potentials in an antral position is more frequently observed with the nMARQ catheter compared with a conventional circular mapping catheter.

Establishing good wall contact is facilitated by the out-of-plane design of the catheter shaft, so that pushing the nMARQ catheter will advance the shaft in the respective vein and ensure good contact with the myocardium (Figure 6). Nevertheless, the right superior pulmonary vein (RSPV) required on average significantly more RF applications than the inferior PVs. This is probably due to a larger diameter of this vein compared with inferior PVs. Therefore, catheter orientation had to be changed frequently while targeting the RSPV to improve tissue contact.

Phrenic nerve palsies were registered following cryoballoon ablation in the recently published STOP-AF trial in 29 procedures (11.2%). Of these, the majority resolved during a FU of 12 months. In the current series, we did not observe phrenic nerve paralysis. This may be due to a more antral ablation compared with the cryoballoon (23 or 28 mm vs. 20–35 mm diameter), but potential injury to the phrenic nerve needs to be kept in mind—especially while using a small circular diameter. This hypothesis is also supported by the observation of fewer phrenic nerve palsies while using the 28 mm cryoballoon only.

The cardiac tamponade occurring in 1/39 initial ablation procedures was related to transseptal puncture; evidence of left atrial perforation by the nMARQ device could not be established.

Recently, Shin et al. and Deneke et al. reported on the acute success rates in PVI using the nMARQ catheter. While giving no data on efficacy during FU or repeat procedures, their acute success rates and procedural data are broadly comparable with

![Figure 5](https://academic.oup.com/europace/article-abstract/16/9/1296/2426547)

**Figure 5** Real-time observation of isolation of a left superior PV [(A) (25 mm/s): loss of PV potential 3.5 s after start of ablation (arrow); (B) (100 mm/s): dissociated PV potential following this RF application; (C): catheter position (AP)].

![Figure 6](https://academic.oup.com/europace/article-abstract/16/9/1296/2426547)

**Figure 6** Ten-pole circular, open irrigated mapping and ablation catheter (nMARQTM, Biosense Webster).
our results: Acute PVI using the novel device could be achieved in 100% and 98% of the PVs, respectively. Other procedural characteristics such as RF duration (15 ± 6 and 19 ± 7 min, respectively), overall procedure duration (110 ± 31 and 133 ± 41 min, respectively) and fluoroscopy time (23 ± 9 and 20 ± 6 min, respectively) are also in line with the results presented here, corroborating their portability. No clinical complications were reported by either group.

In the majority of the patients who underwent repeat procedures, recurrent PV/LA conduction was found as potential source of AF recurrence. These findings are in line with results of repeat procedures after initial point-by-point RF ablation: Ouyang et al.15 found recovered PV conduction in 94% of patients during a repeat procedure. Although no PV reconnected predominantly, the sites of preferential conduction recovery per vein display may reflect areas of poor catheter contact. Success rates after one and repeat procedures (66 and 77%, respectively) were similar to the success rates reported in conventional RF and multi-electrode ablation and higher than in cryoballoon ablation.15,16 Interpretation of this positive outcome, however, should be qualified by the fact that we report a rather short FU of patients and consequently 28% of them were still on antiarrhythmic drug (AADs).

**Limitations**

Serious safety concerns regarding silent cerebral lesions (SCLs) caused by multi-electrode ablation in the LA have arisen recently.18,19 We did not routinely acquire cerebral imaging post ablation. Given the irrigated unipolar RF ablation used with the nMARQ device, a similar electrical interference between ablation electrodes as in multi-electrode-phased RF ablation and consecutive development of embolic material is unlikely.20 Therefore, the mechanism of SCL generation recently reported by Deneke et al.21 remains unclear.

Although we did not observe an atrio-esophageal fistula during FU, the findings on esophageal temperature rises and the report of an esophago-pericardial fistula following nMARQ ablation by Deneke et al.21 necessitate further safety studies.

While we did not detect any PV stenosis 4 weeks post ablation, a delayed development of a PV stenosis as described by Saad et al.22 cannot be fully excluded.

The possibility of creating a bidirectional CTI block using solely the nMARQ catheter may increase the versatility of this device, obviating the need of an additional single-tip ablation catheter and associated cost in 69% of the patients who underwent CTI ablation. Nevertheless, recovered CTI conduction was observed in 50% of the patients undergoing repeat ablation, necessitating further studies on efficacy in a larger group of patients.

In general, this study represents a single-centre, non-randomized experience with a rather short FU of 140 ± 75 days. Moreover, repetitive 24 h telemetry during FU might underestimate the occurrence of AF post ablation, especially in comparison with 7-day Holter monitoring. A conclusion on long-term success rates of AAD is therefore not yet possible. However, our observation of a safe treatment of AF with the novel technology of the nMARQ suggests a feasible and promising alternative to conventional point-by-point lesions.

**Conclusion**

Irrigated multi-electrode RF ablation of AF using the nMARQ device is fast and effective. We observed a very high rate of isolated PVs without the need of touch-up lesions in an unselected, consecutive cohort of patients, simplifying and accelerating this otherwise complex ablation procedure. Success rates were comparable with other techniques applied in the interventional treatment of symptomatic AF with a low complication rate. Longer FU and larger, multicenter randomized studies are needed to confirm these results.

**Conflict of interest:** Dr. Zellerhoff was supported by an unrestricted EHRA fellowship grant provided by Biosense Webster. Dr Jais, Haissaguerre, Hocini, and Sacher have received lecture fees from Biosense Webster for <10 000 annual USD.

**Funding**

The research leading to these results has been partially funded by the European Union Seventh Framework Programme (FP7/2007-2013) under Grant Agreement HEALTH-F2-2010-261057.

**References**

Speech-triggered atrial tachycardia originating from the superior vena cava

Akira Ueno*, Norishige Morita, and Yoshinori Kobayashi

Division of Cardiology, Department of Medicine, Tokai University Hachioji Hospital, 1838 Ishikawa-machi, Hachioji-shi, Tokyo 1920032, Japan

* Corresponding author. Tel: +81 42 639 1111; fax: +81 42 639 1144. E-mail address: s4013@nms.ac.jp

A 63-year-old male was referred due to frequent episodes of palpitations during conversation. An incessant form of atrial tachycardia (AT) triggered by premature atrial complexes could be reproducibly induced by starting to speak, and terminated over time after cessation of the conversation. In an electrophysiological study, a short duration AT was reproducibly induced by a single word verbal reply and three-dimensional electroanatomical mapping (Biosense Webster) revealed that the earliest focal activation site of the AT was on the septal side of the superior vena cava (SVC) (Figure). When the ablation catheter was placed at that site, the AT became no longer inducible even by speech manoeuvres, and then radiofrequency energy was applied. After 1 year of follow-up, he has been free of any palpitations during conversations.

It may be inferred that central modulation acting on the pharyngeal muscles via the vagus nerve for a voice production also stimulates the cardiac vagus nerve elements, and the discharges of the sympathetic nervous system simultaneously occur by the initiation of speech. Both autonomic nerve elements collaboratively promote the formation of abnormal triggered activity, and subsequently lead to an occurrence of speech-triggered AT.

The full-length version of this report can be viewed at: http://www.escardio.org/communities/EHRA/publications/ep-case-reports/Documents/Speech-triggered-atrial-tachycardia.pdf.