# Radiofrequency ablation of paroxysmal atrial fibrillation with the new irrigated multipolar nMARQ ablation catheter: Verification of intracardiac signals with a second circular mapping catheter

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**BACKGROUND** During radiofrequency (RF) ablation of paroxysmal atrial fibrillation, a circular multielectrode recording "lasso" catheter is generally positioned within each pulmonary vein (PV) to determine when pulmonary vein potentials (PVPs) are present and when they have been ablated. The new irrigated multipolar nMARQ circular ablation catheter is positioned within the left atrium to create contiguous circular ablation lines around each PV ostium.

**OBJECTIVE** To determine whether the recordings obtained from the nMARQ catheter position *around* the PV ostium accurately reproduce the recordings obtained from a lasso catheter positioned *within* that vein.

**METHODS** In 10 patients undergoing RF ablation of paroxysmal atrial fibrillation, we placed an nMARQ and a lasso catheter around and within each PV, respectively. Recordings obtained from both catheters at baseline and after RF ablation were compared.

**RESULTS** At baseline, recordings of PVPs in both catheters were concordant in 92% of all PVs. However, after RF delivery, the concordance between the nMARQ and lasso recordings was poor. The *discordant* result most commonly observed was disappearance of "PVPs" from the nMARQ catheter with persistence of PVPs in the lasso catheter (12 of 39 [30%]). Conversely, the delivery of RF frequently resulted in fragmented electrograms (pseudo-PVPs) on the nMARQ catheter despite evidence of PV isolation by lasso catheter recordings.

**CONCLUSIONS** The use of an nMARQ catheter alone, as currently recommended, may lead to underestimation and overestimation of the number of RF applications required to achieve PV isolation.

**KEYWORDS** Atrial fibrillation; Radiofrequency ablation; Pulmonary veins

**ABBREVIATIONS** **CS** = coronary sinus; **CT** = computed tomographic; **LIPV** = left inferior pulmonary vein; **LSPV** = left superior pulmonary vein; **PAF** = paroxysmal atrial fibrillation; **PV** = pulmonary vein; **PVAC** = pulmonary vein ablation catheter; **RIPV** = right inferior pulmonary vein; **RF** = radiofrequency; **RSPV** = right superior pulmonary vein

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## Introduction

Techniques for radiofrequency (RF) ablation of paroxysmal atrial fibrillation (PAF) are based on the seminal observation that this arrhythmia is triggered by ectopic activity primarily originating from the pulmonary veins (PVs).[1] To achieve circumferential PV isolation, a circular multielectrode *recording* catheter is inserted into the lumen of the PV to record PV potentials whereas a *unipolar* ablation catheter is used for point-by-point ablation around the ostium of that vein.[2,3] The end points of the RF ablation procedure include (1) full circumferential ablation around the PV ostium (evidenced by ablation marks on a mapping system[1]) and (2) abolition of all spontaneous PV potentials within the vein lumen as recorded by the circular recording catheter.[4] However, performance of multiple point ablations around the PV ostium is technically difficult and time-consuming. Moreover, incomplete circumference PV isolation and/or incomplete ablation of all PV potentials, with eventual PV reconnection to the left atrium, are the main reasons for the recurrence of PAF after a seemingly successful ablation.[3–6] In order to overcome these inherent limitations of conventional ablation, *multipolar circular ablation catheters*, such as the nonirrigated multipolar pulmonary vein ablation catheter, "PVAC" (Medtronic, Minneapolis, MN) and, more recently, the irrigated multipolar nMARQ circular ablation catheter (Biosense Webster, Diamond Bar, CA; http://www.biosensewebster.com/nMARQ.php), were introduced into

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clinical practice. The use of multipolar circular ablation catheters is based on the premise that (1) simultaneous ablation from all 10 electrodes of the circular ablation catheter creates a continuous circumferential lesion that will isolate the PV; (2) far-field PV potential activity, as well as abolition of the latter, can be recorded from the circumferential ablation catheter itself. Importantly, and in contrast to conventional techniques, the circumferential ablation catheter is positioned within the left atrium, *around* the PV ostium, but not within the vein. Furthermore, a rigorous comparison of the ability to record PV potentials from the PV lumen (by the circumferential recording lasso recording catheter) and from the surrounding left atrium (by the circumferential ablation catheter) has never been performed. Therefore, in the present study, we performed *simultaneous* recording of PV potentials from within the PV and from the surrounding left atrium with the aid of 2 circumferential catheters: a standard lasso recording catheter and the new nMARQ ablation catheter. We compared the recordings obtained from these 2 catheters before, during, and after each RF application.

## Methods

Ten consecutive patients undergoing RF ablation for PAF by using the double-lasso technique were included (see below). Anticoagulation therapy with warfarin or any of the new oral anticoagulants was replaced by low-molecular-weight heparin 5 or 2 days before the procedure, respectively. A computed tomographic (CT) scan of the left atrium was imported into the CARTO 3 mapping system (Biosense Webster). The ablation procedure was conducted under general anesthesia or conscious sedation. A decapolar catheter was positioned at the coronary sinus (CS), and a quadripolar catheter was positioned at the His bundle level through the right femoral vein. Two 8-F sheaths (SL1, St Jude Medical, St Paul, MN) were introduced into the left atrium with double transseptal puncture performed under fluoroscopic and either transesophageal or intracardiac echocardiography guidance. Upon completion of the first transseptal puncture, intravenous heparin was administered to maintain an activated clotting time of 350 seconds throughout the procedure. A variable-diameter lasso circular mapping catheter (Biosense Webster) was introduced through the SL1 sheath into the PV for electrical mapping. After the second transseptal puncture, the second SL-1 sheath was replaced by a steerable 8.5-F agilis sheath (St Jude Medical). Each of the 4 PVs was imaged by selective angiograms. The nMARQ circular catheter was then introduced into the left atrium through the steerable agilis sheath. The left atrium geometry was created with the nMARQ catheter and then merged with the preacquired CT scan of the left atrium and PVs. The PV antrum was defined according to the angiogram and electrogram analyses of the respective vein. Isolation of each PV was performed at the respective PV antrum by delivery of RF from multiple irrigated electrodes on the nMARQ catheter simultaneously and by using the following settings: catheter irrigation flow rate of 60 mL/min, target temperature of 45ºC, and maximal energy of 25 W for the catheter poles facing the anterior segment of the antrum and of 15 W for the catheter poles near the posterior atrial wall. RF energy was applied at each ablation site for a maximum of 45 seconds. Repeated RF applications were delivered through the nMARQ poles facing the precise lasso electrodes, showing persistent PV potentials until all the local PV electrograms recorded by the lasso catheter disappeared. Isolation of the left-sided PVs was performed during atrial pacing from the distal CS catheter, whereas isolation of the right-sided PVs was performed during sinus rhythm or CS pacing. Importantly, the entire ablation was conducted when the circular recording lasso mapping catheter was positioned distal to the nMARQ catheter within the corresponding PV (Figure 1). The end point of the procedure was the isolation of all PVs, *attested by the disappearance of all PV potentials from the lasso catheter within the vein* and confirmed by pacing maneuvers. Importantly, a comparison of the PV potentials, recorded from the lasso recording catheter *within* the PV and from the nMARQ ablation catheter *around* the PV, was systematically performed for each vein *before*, *during*, and *after* each RF application. However, only the lasso catheter recordings were used to define when PV isolation was achieved by using standard definitions.[7–9]

### Definitions

The signals recorded with the lasso catheter at baseline and during ablation were used as "gold standard" for assessing PV isolation. *Concordance at baseline*: far-field atrial electrograms and PV potentials are simultaneously present or simultaneously absent on both catheters, that is, on the nMARQ catheter positioned at the PV antrum and on the lasso catheter positioned just distal to the nMARQ catheter within the lumen of the same vein. *Lack of concordance at baseline*: the nMARQ positioned at the antrum fails to show PV potentials seen on the lasso catheter or vice versa. *Concordance during RFs* existed whenever a significant change in one catheter was accompanied by similar changes in the other catheter. By *significant changes*, we refer to evidence of PV disconnection (in the form of either disappearance or dissociated activity of PV potentials) or evidence of PV reconnection (reappearance of previously abolished or previously dissociated PV potentials). *Overestimation of PV isolation* by the nMARQ catheter was thought to have occurred when all PV potentials recorded with the nMARQ catheter had disappeared at a time when PV potentials were still seen on the lasso catheter. Conversely, *underestimation of PV isolation* by the nMARQ catheter was thought to have occurred when electrograms resembling PV potentials were still seen on the nMARQ catheter after the disappearance of all PV potentials from the lasso catheter.

## Results

The first patient undergoing RF ablation of PAF with the new nMARQ catheter in our center (on August 15, 2013)