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Original article

Strict sequential catheter ablation strategy targeting the pulmonary veins and superior vena cava for persistent atrial fibrillation

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ABSTRACT

Background: An effective catheter ablation strategy, beyond pulmonary vein isolation (PVI), for persistent atrial fibrillation (AF) is necessary. Pulmonary vein (PV)-reconduction also causes recurrent atrial tachyarrhythmias. The effect of the PVI and additional effect of a superior vena cava (SVC) isolation (SVCI) was strictly evaluated.

Methods: Seventy consecutive patients with persistent AF who underwent a strict sequential ablation strategy targeting the PVs and SVC were included in this study. The initial ablation strategy was a circumferential PVI. A segmental SVCI was only applied as a repeat procedure when patients demonstrated no PV-reconduction.

Results: After the initial procedure, persistent AF was suppressed in 39 of 70 (55.7%) patients during a median follow-up of 32 months. After multiple procedures, persistent AF was suppressed in 46 (65.7%) and 52 (74.3%) patients after receiving the PVI alone and PVI plus SVCI strategies, respectively. In 6 of 15 (40.0%) patients with persistent AF resistant to PVI, persistent AF was suppressed. The persistent AF duration independently predicted persistent AF recurrences after multiple PVI alone procedures [HR: 1.012 (95% confidence interval: 1.006–1.018); $p < 0.001$] and PVI plus SVCI strategies [HR: 1.018 (95% confidence interval: 1.011–1.025); $p < 0.001$]. A receiver-operating-characteristic analysis for recurrent persistent AF indicated an optimal cut-off value of 20 and 32 months for the persistent AF duration using the PVI alone and PVI plus SVCI strategies, respectively.

Conclusions: The outcomes of the PVI plus SVCI strategy were favorable for patients with shorter persistent AF durations. The initial SVCI had the additional effect of maintaining sinus rhythm in some patients with persistent AF resistant to PVI.

Introduction

Pulmonary vein isolation (PVI) is a well-established treatment option in patients with paroxysmal atrial fibrillation (AF) [1–3]. The limited clinical success when the same approach is applied in patients with persistent/long-standing persistent AF has led to the search for an ideal ablation strategy. To improve the outcomes, ablation targeting the substrate that maintains AF is often added to the PVI [4,5]. Guidelines suggest that "if patients with long-standing persistent AF are approached, operators should consider more extensive ablation based on linear lesions or complex fractionated electrograms" [6]. However, a recent study reported no reduction in the rate of recurrent AF when either linear ablation or ablation of complex fractionated electrograms was performed in addition to the PVI after the initial and second procedures [7]. In contrast, in most previous studies [7–11], a second procedure was not performed in 42–65% of patients with recurrent atrial tachyarrhythmia after the initial PVI procedure. Left atrium (LA)-PV reconduction also causes recurrent atrial tachyarrhythmias after a PVI of persistent AF

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[12]. Therefore, it is unclear whether recurrent atrial tachyarrhythmias are due to an inadequate strategy or a failure to reach the strategic endpoint. Moreover, although the superior vena cava (SVC) is the most frequent non-PV trigger [13,14], an empiric SVC isolation (SVCI) in addition to the PVI has not improved the outcomes in patients with persistent AF [15]. We hypothesized that the reconduction of the LA-PV is the most dominant factor of recurrent atrial tachyarrhythmias after the initial persistent AF ablation and it masks the efficacy of adding an SVCI strategy. The primary goal of this study was to investigate the efficacy and limitations of a strict PVI alone ablation strategy for persistent AF with multiple procedures. The secondary goal was to identify the efficacy of the initial SVCI for persistent AF resistant to PVI.

Methods

Patient population

This study enrolled 70 consecutive symptomatic patients (54 males; 61.2 ± 11.7 years; range 23–82 years) who underwent an initial PVI of persistent AF. None of these patients had previously undergone an AF ablation. All patients were treated with a circumferential ipsilateral PVI using an open-irrigated catheter (Navistar Thermocool™; Biosense Webster, Diamond Bar, CA, USA). No patients were lost to follow-up. Written informed consent for the AF ablation was obtained from all patients. The study protocol was approved by the institution's ethics committee. The baseline characteristics of the patient population are presented in Table 1.

Electrophysiological study

All patients were provided an anticoagulant for at least four weeks before the procedure and underwent a transesophageal echocardiogram to rule out any left atrial thrombi. Warfarin was controlled to maintain a prothrombin time/international normalized ratio of 2.0–2.5 before the procedure, and was not interrupted before or after the procedure. Dabigatran, rivaroxaban, and apixaban were skipped only on the morning of the procedure. All antiarrhythmic drugs were discontinued for at least five half-lives before the electrophysiological study and ablation procedure. Electrocardiogram (ECG) -gated and contrast-enhanced computed tomographic (CT) imaging was performed before the procedure. Three-dimensional (3D) CT images were reconstructed and recorded as DICOM data. All patients underwent the electrophysiological evaluation under sedation. Sedation was performed by a continuous infusion of propofol. Intravenous heparin was administered just after the femoral and subclavian vein punctures to maintain an activated clotting time (ACT) between 300 and 400 s.

Table 1
Clinical characteristics of the patient population ($n = 70$).

Age, years	61.2 ± 11.7
Male, *n* (%)	54 (77.1)
Persistent AF duration, months	12.0 (5.0–36.0)
Persistent AF, *n* (%)	34 (48.6)
Long-lasting persistent AF, *n* (%)	36 (51.4)
Hypertension, *n* (%)	36 (51.4)
Structural heart disease, *n* (%)	12 (17.1)
CAD, *n* (%)	3 (4.3)
HCM, *n* (%)	5 (7.1)
DCM, *n* (%)	2 (2.9)
Valvular disease, *n* (%)	1 (1.4)
Endomyocardial fibrosis, *n* (%)	1 (1.4)
Left ventricular ejection fraction, %	60.8 ± 10.3
Left atrial diameter, mm	44.6 ± 6.7

AF, atrial fibrillation; CAD, coronary artery disease; HCM, hypertrophic cardiomyopathy; DCM, dilated cardiomyopathy.

One multipolar 6 Fr catheter was positioned in the coronary sinus via the right subclavian vein. A 10 Fr SoundStar ultrasound catheter (Biosense Webster) was inserted into the right atrium via the left femoral vein, and anatomic mapping of the LA by a CartoSound module equipped with a CARTO3 system (Biosense Webster) was performed. Two 8.5 Fr long transseptal sheaths (SL1; St Jude Medical, Minneapolis, MN, USA) were inserted into the LA using a modified Brockenbrough technique. Intracardiac echography (ICE) images were displayed through the CartoSound module using an Acuson X300PE echocardiography system (Siemens Medical Solutions, Erlangen, Germany). The CT and ICE images were integrated manually. Each PV ostium was identified by selective venography and tagged on the electroanatomical map using a 3.5-mm-tip open-irrigated catheter. A 20-polar Lasso-catheter (Biosense Webster) was placed within the superior PVs or within the superior branches of a common PV during radiofrequency delivery.

Ablation protocol during the initial procedure

All patients underwent a circumferential PVI using an irrigated radiofrequency current and an integrated 3D image. Sinus rhythm was restored by external or internal cardioversion before the PVI. If AF did not convert to sinus rhythm, the PVI was performed during AF. After the right or left PVI, external or internal cardioversion was administered aiming at the restoration of sinus rhythm repeatedly. For 30 s at each point, irrigated radiofrequency energy was delivered using a target temperature of 43 °C, maximum power of 20–30 W, and infusion rate of 17 mL/min at the posterior, inferior, and roof aspects of both continuous circular lesions (CCLs). Radiofrequency energy with a maximum power of 30–35 W and flow rate of 17–30 mL/min was delivered to the anterior aspects of both CCLs. The procedural endpoint was defined as the absence or dissociation of all PV potentials, documented by the Lasso catheter, at least 60 min after the PVI during sinus rhythm. No patients underwent ablation of linear lesions, complex atrial electrograms, or ablation of non-PV triggers. A cavotricuspid isthmus ablation was only performed in patients with a history of atrial flutter.

Ablation protocol during repeat procedures

Repeated electrophysiolological procedures were undertaken for recurrent persistent AF. The initial strategy was an assessment of the PV reconduction during sinus rhythm after cardioversion, followed by the closure of all PV conduction gaps and an electrical reisolation. An SVCI was only performed if patients demonstrated no PV reconduction. After confirmation of no PV reconduction, the mapping and ablation catheters were withdrawn back into the right atrium (RA). The geometry of the RA was reconstructed, and the SVC-RA junction was tagged on the geometry based on the SVC angiography. The circular catheter was placed just above the RA-SVC junction. Segmental ablation targeting the earliest RA-SVC junction was applied for the SVCI. High output pacing (10 mA) was performed before radiofrequency current delivery at the posterolateral aspect of the SVC. In such sites, ablation was avoided to prevent phrenic nerve injury. Irrigated radiofrequency energy was delivered using a target temperature of 43 °C, maximum power of 20–25 W, and an infusion rate of 17 mL/min. An SVCI was characterized as the disappearance of the SVC potentials or the dissociation of the SVC potentials with RA activity.

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