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Catheter ablation of idiopathic ventricular arrhythmias originating from left ventricular epicardium adjacent to the transitional area from the great cardiac vein to the anterior interventricular vein

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ABSTRACT

Objectives: This study aimed to investigate electrocardiographic characteristics and effects of radiofrequency catheter ablation (RFCA) for patients with symptomatic premature ventricular complexes (PVCs) and idiopathic ventricular tachycardias (IVTs), originating from the different portions of the left coronary veins.
Background: Inadequate distinction was made in the past for the PVC/IVTs located in the different portions of the left coronary veins, especially the distal great cardiac vein (DGCV) and the proximal portion of the anterior interventricular vein (PAIV) and the extended tributary of DGCV located distal to the origin of AIV (EDGCV).
Methods: Characteristics of body surface electrocardiogram (ECG) and electrophysiologic recordings were analyzed in 12 patients with symptomatic PVCs/IVTs originating from the vicinity of the left coronary veins.
Results: Among 490 patients with PVCs/IVTs, the incidence of ventricular arrhythmias originating from the left ventricular epicardium adjacent to the transitional area from the GCV to the AIV was 2.45%. Four had PVCs/IVTs from DGCV, 5 from PAIV, and 3 from EDGCV. There were different characteristics of ECG of PVCs/VT originating from the DGCV and PAIV and EDGCV. Successful RFCA in all 12 patients could be achieved (100% acute procedural success). No complications were observed. During a median follow up of 17 months (range 6–45 months), 2 had recurrent ventricular arrhythmia (recurrence rate: 16.67%).
Conclusions: ECG characteristics of PVCs/VTs originating from the different portions of the left coronary veins (DGCV and PAIV and EDGCV) are different, and can help regionalize the origin of these arrhythmias. RFCA within the coronary venous system was relatively effective and safe for the PVCs/IVTs and should be seen as an alternative approach, when the left-sided PVCs/IVTs could not be eliminated by RFCA from the endocardium or aortic sinus of Valsalva.

1. Introduction

Idiopathic ventricular arrhythmias (VAs), including premature ventricular complexes (PVCs) and idiopathic ventricular tachycardias (IVTs), are the most common arrhythmias observed in patients without structural heart disease [1]. In recent years, catheter ablation has increasingly been used for ablation of repetitive monomorphic IVTs and symptomatic monomorphic PVCs [2–5]. Endocardial radiofrequency (RF) ablation is the common approach for ablation of idiopathic ventricular tachycardias (IVTs). However, some that arise from the epicardial or subendocardial portion are remote from the left ventricular (LV) endocardium and cannot be ablated from the ventricular endocardium [6]. The incidence of an epicardial origin in IVT may be as high as 9% [6]. Therefore, the use of an epicardial approach may improve the success rate of epicardial VT ablation.

Several recent reports have proven that the left coronary veins are potential routes for mapping and ablating VT arising from an epicardial site [7–9]. However, the electrocardiographic characteristics and mapping and catheter ablation of the arrhythmias originating from the vicinity of the left coronary veins may not be fully understood. In addition, inadequate distinction was made in the past for the PVC/IVTs located in the different portions of the left coronary veins, especially the distal great cardiac vein (DGCV) and the proximal portion of the anterior interventricular vein (PAIV) and the extended tributary of DGCV located distal to the origin of AIV (Fig. 1). The purpose of this study was to analyze the electrocardiographic characteristics and the outcome of catheter ablation for such PVCs/IVTs originating from the three regions adjacent to the transitional area from the GCV to the AIV.

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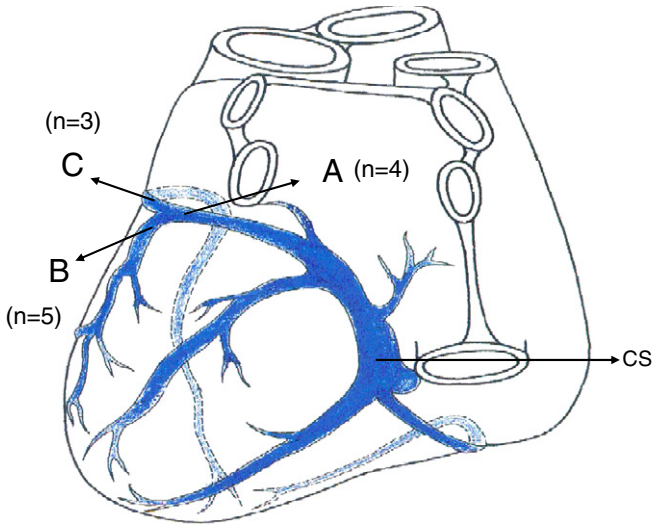

Fig. 1. Schematic left lateral view of the transitional area from the great cardiac vein to the anterior interventricular vein divided into three regions to determine PVC/IVT distribution within the RV and identify region-specific ECG features. A: the distal great cardiac vein (DGCV); B: the proximal portion of the anterior interventricular vein (PAIV); C: the extended tributary of DGCV located distal to the origin of AIV (EDGCV). The numbers indicate the distribution of the target sites of the left ventricular epicardium adjacent to the transitional area from the DGCV to the AIV in 12 patients. CS: coronary sinus.

2. Methods

2.1. Study population

From July 2006 to September 2011, a total of 490 patients (202 men and 288 women; age 45.76 ± 18.59 years [mean ± SD]) without structural heart disease were presented for catheter ablation for PVCs/IVTs in our hospital. Only patients with idiopathic PVCs/IVTs from the vicinity of the left coronary veins were enrolled in the present study. All patients were verified as having no structural heart disease, including coronary artery disease, valvular heart disease, congenital heart disease, left ventricle hypertrophy, and right ventricle abnormalities by routine biochemistry tests, X-ray, color echocardiography examination, exercise electrocardiogram testing, and/or cardiac catheterization with coronary angiography or right ventricular contrast angiography. Before RFCA, a 12-lead ECG was obtained, and 24 h of ambulatory ECG monitoring (Holter) was carried out at least once. The ECG was monitored for 24 h just before catheter ablation. The patients with idiopathic PVCs/IVTs from the vicinity of the left coronary veins were compared with a randomly chosen series of 72 patients with idiopathic PVCs/IVTs in whom the site of origin was in the right ventricular endocardial outflow tract (n = 36, 23 women and 13 men; age 48.17 ± 16.87 years), aortic sinus of Valsalva (n = 24, 16 women and 8 men; age 55.73 ± 17.20 years), or the left ventricular endocardium (n = 12, 6 women and 6 men; age 54.37 ± 17.71 years) including the left ventricular endocardial outflow tract (n = 6) and mitral annulus (n = 6).

A pace mapping study was also performed in fifteen control subjects (8 women and 7 men; age 31.9 ± 13.5 years) without structural heart disease after successful ablation of their original atrioventricular nodal reentrant tachycardia to determine the ECG characteristics of idiopathic PVCs/IVTs originating from the left ventricular epicardium adjacent to the transitional area from the GCV to the AIV.

2.2. Inclusion criteria

The selection criteria of patients were the following reasons: (1) frequent or consecutive PVC occurrence, the average PVC count ≥ 10,000 times/24 h; (2) inability of the patient to tolerate PVCs/IVTs or unsuccessful treatment with at least one antiarrhythmic drugs; (3) no structural heart disease; and (4) consent for the catheter ablation procedure.

2.3. Electrophysiologic study and RFCA

An electrophysiologic study was performed after withdrawal of all anti-arrhythmic drugs for at least five half-lives. Standard multielectrode catheters were inserted through femoral veins under fluoroscopic guidance. A 12-lead surface electrocardiogram was monitored and recorded on a multichannel oscilloscopic recorder. A programmed electrical stimulation was performed from the right ventricular apex at basic drive cycle lengths of 600, 500, and 430 ms, delivering a maximum of three extrastimuli. Pace mapping and endocardial activation mapping were performed. If the clinical arrhythmia did not occur spontaneously and was not induced in the baseline, intravenous isoproterenol (2–4 μg/min) was administered to induce arrhythmia. If pace mapping and activation mapping indicated that the right ventricle was not the likely source of PVC/IVTs, mapping of the aortic sinus of Valsalva (ASOV) and left ventricular outflow tract (LVOT) was performed via the retrograde aortic route. If the pace mapping and activation mapping did not indicate a focus inside the ASOV or LVOT, and the left-sided PVC/IVTs cannot be abolished by RF application from the ASOV or LVOT, mapping and ablation were performed in the vicinity of the GCV via the coronary venous system. Coronary venous anatomy was defined by coronary venous angiography prior to mapping.

The target site of RFCA was determined by the complete or near complete pace mapping (≧ 11/12-lead concordance of major and minor deflections) with the earliest local activation time. Coronary angiography was performed prior to and after RF application. RFCA was applied in all patients by using a conventional catheter under temperature control (target temperature 60 °C, maximum power 20 W) or irrigated-tip catheter (43 °C, 25 W, 30 ml/min) with the three-dimensional mapping (Ensite NavX system). If there is too high impedance within the coronary venous system to deliver RF energy using conventional catheter, we will choose to use an irrigated-tip catheter. If the PVCs/IVTs were terminated within 10 s or more PVCs and/or nonsustained ventricular tachycardia occurred during ablation at the target site, additional current was applied for another 60 to 180 s. Acute procedural successful ablation was defined as complete elimination of spontaneous or inducible VAs. Programmed electrical stimulation was repeated at 30 min after the last application of RF energy to confirm the absence of inducible VAs before removing all catheters and sheaths. If PVCs/IVTs did not terminate within 10 s, the RF energy application was terminated and another target site was sought.

2.4. Definition of regions adjacent to the transitional area from the GCV to the AIV

To determine the distribution within the left coronary veins and identify region-specific ECG features, sites of origin of PVCs/IVTs were grouped into distinct anatomic segments, based on the venogram images (Fig. 1).

2.5. ECG measurements

Twelve-lead electrocardiograms recorded at a paper speed of 25 mm/s were available for all patients with PVCs/IVTs originating from the left ventricular epicardium adjacent to the transitional area from the GCV to the AIV during the clinical arrhythmia. The analysis of the ECG pattern was focusing on the following characteristics: (1) the QRS morphology of the PVCs/IVTs in all 12 leads, (2) the duration of the QRS complex, (3) the site of R-wave transition in the precordial leads.

For comparison, ECGs were also analyzed from patients with PVCs/IVTs arising from other sites. Simultaneous 12-lead ECGs during PVCs/IVTs were recorded digitally at a velocity of 100 mm/s in all patients for offline analysis. The pseudo delta wave (PdW, the interval from the beginning of the QRS complex to the earliest fast deflection in any precordial lead) time, the intrinsicoid deflection time (IDT, the interval from the beginning of the QRS complex to the peak of the R wave in V2), the QRS complex duration, and the maximum deflection index (MDI, IDT divided by the QRS duration) were assessed as previously described [10]. ECGs were reviewed by 2 investigators blinded to the site of origin; discrepancies were adjudicated by a third investigator.

2.6. Pace mapping study

The pace mapping study was performed in the fifteen control subjects. Coronary venous anatomy was defined by coronary venous angiography prior to pace mapping. Pace mapping in the vicinity of the GCV was performed at 5 sites: DGCV, PAIV, proximal-mid AIV (PMAIV), mid AIV (MAIV) and the extended tributary of DGCV (EDGCV) (Fig. 1). A 7-F quadripolar catheter was used. A single electrical stimulus was delivered during the end diastole in a bipolar fashion at an output just greater than the diastolic threshold from the distal electrode pair (with the distal electrode as the cathode). The catheter sites were confirmed by multi-plane fluoroscopy, and pacing was performed from the three sites in each patient. The pacing protocol was performed after a written informed consent was obtained.

2.7. Follow-up

After RFCA, all patients underwent a 72-hour ECG monitoring. Holter was carried out 1 week after RFCA. Patients were not given any antiarrhythmic drugs after RFCA, and underwent color echocardiography and Holter examination 3 and 6 months after RFCA. ECG, echocardiography and 24-hour ECG monitoring were performed whenever the patient had symptoms suggestive of recurrence of VAs.

2.8. Statistical analysis

All values were expressed as mean value ± standard deviation. Student's *t*-test was used to compare the two groups. Analysis of variance (ANOVA) was used when comparisons involved >2 groups, followed by a Fisher protected least significant difference test. A value of $P<0.05$ was considered significant.

3. Results

3.1. Study population

In a total of 490 patients treated by RFCA, 454 PVCs/IVTs (92.65%) were successfully ablated, but the remaining 36 PVCs/IVTs (7.35%)