Ablation of Left Ventricular Epicardial Outflow Tract Tachycardia From the Distal Great Cardiac Vein

Owen A. Obel, MD,* Andre d’Avila, MD,† Petr Neuzil, MD,‡ Eduardo B. Saad, MD,† Jeremy N. Ruskin, MD,* Vivek Y. Reddy, MD*
Boston, Massachusetts; Rio de Janeiro, Brazil; and Prague, Czech Republic

OBJECTIVES
The purpose of this study was to examine the feasibility and safety of ablation of idiopathic outflow tract ventricular tachycardia (OTVT) from the distal ramifications of the coronary sinus (CS).

BACKGROUND
A significant minority of patients presenting with idiopathic OTVT have an epicardial focus, the standard approach to which involves ablation from within one of the aortic valve cusps (AVCs). We describe the successful ablation of idiopathic epicardial OTVT from within the CS in the distal great cardiac vein (GCV).

METHODS
Ablation from the distal GCV was performed in 5 patients with idiopathic OTVT who had unfavorable mapping, in some cases unsuccessful ablation from various endocardial and epicardial sites including the AVCs, and in 1 patient via the direct epicardial approach. An electroanatomic mapping system (Carto) was used in 3 patients, and conventional mapping was performed in 2 patients, and in 3 patients cryothermal ablation was performed.

RESULTS
In all patients, the first ablation lesion in the GCV successfully eliminated the arrhythmia. All patients have remained free of VT after a mean follow-up of 24 (7 to 44) months. There were no immediate or long-term complications.

CONCLUSIONS
Idiopathic epicardial OTVT can be successfully ablated from the distal GCV, and should be seen as an alternative to ablation from the aortic valve cusps.

Idiopathic outflow tract ventricular tachycardia (OTVT) usually arises from the right ventricular outflow tract (RVOT), and in approximately 12% in the left ventricular outflow tract (LVOT) (1). In approximately 18% of patients, the origin of OTVT cannot be localized to either of these sites and is found to have an epicardial origin (2). Ablation of such foci is most often performed from the aortic valve cusps (AVCs), most often the left (3–6).

We report on a group of patients with idiopathic epicardial OTVT in whom mapping, and in some cases ablation from a variety of sites including the AVCs, had failed. Earliest activation and successful ablation took place within the coronary venous system in the distal great cardiac vein (GCV), close to its continuation as the anterior interventricular vein (AIV), overlying the epicardial anterobasal left ventricle.

METHODS

Study population. The subjects were 5 patients (4 male and 1 female), ages 36 to 74 years with symptomatic idiopathic OTVT, in whom the successful ablation site was within the GCV. The clinical and electrophysiological characteristics of the patients are shown in Table 1. A trial of at least 1 antiarrhythmic drug had failed in all patients. In 3 patients, the current session represented the initial ablation attempt. In the other 2, this was the second and fifth attempt, respectively. Two patients had frequent paroxysms of sustained ventricular tachycardia (VT), and 3 had frequent premature ventricular contractions and runs of exercise-induced nonsustained VT. All patients gave written, informed consent before the procedure.

Electrophysiologic study and ablation. Antiarrhythmic drugs were discontinued at least 5 half-lives before the procedure; no patient was taking amiodarone. Standard multielectrode catheters were inserted using fluoroscopic guidance under sterile conditions via the left and right femoral veins. The VT induction was performed from the right ventricular apex, and sometimes the LVOT using a combination of programmed stimulation, rapid ventricular pacing, and when necessary, isoproterenol infusion. Bipolar and unipolar electrograms were recorded using a standard electrophysiology recording system and were used in conjunction with the surface electrocardiogram (ECG) for a combination of activation and pace mapping.

In 3 patients, nonfluoroscopic, electroanatomical mapping was performed with a deflectable 4-mm tip mapping/ablation catheter (Navistar, Carto, Biosense-Webster, Diamond Bar, California). In 2 patients, conventional fluoroscopic mapping was performed using a deflectable 4-mm-tip standard mapping/ablation catheter (Blazer, Boston Scientific, Boston, Massachusetts). Cryoablation (Freezor, Cryocath, Montreal, Ontario, Canada) at a temperature of −70°C for 3 min was used in 2 patients. Radiofrequency...
(RF) ablation at a maximum power of 20 W and temperature of 55°C in 1-min applications was used for the other 3 patients (cooled ablation was not used).

If activation and pace mapping indicated that the right ventricle was not the likely source of VT, mapping of the AVCs and LVOT was performed via the retrograde aortic route after a bolus of 5,000 U intravenous heparin had been administered. In 2 patients, mapping of the left atrial appendage (LAA) was performed after trans-septal puncture. In 2 patients, the epicardium was mapped after percutaneous subxyphoid pericardial puncture as previously described (7). Successful ablation in all cases was performed in the distal GCV after the coronary venous system was accessed from the right atrium.

**RESULTS**

**ECG characteristics.** The ECG in all patients showed an inferior axis and early precordial R-wave transition VT. A right bundle branch morphology was present in 4 patients, and a transition in V3 in 1. Three of the patients had an S wave in lead I. In 4 patients, an S wave was absent in V6 (Fig. 1).

**Mapping and ablation.** Mapping was performed in the RVOT, LVOT, and AVCs in all patients. In 2 patients, ablation had been performed from the left AVC, and had recurred. In 1 patient in whom the LAA was mapped, diffuse early activation was found; however, ablation resulted in late termination and prompt reinitiation of VT. In 2 cases epicardial mapping and in 1 case epicardial mapping and ablation were performed without success. In the patient with mapping and ablation, it was noted that a diagnostic catheter located in the distal coronary sinus (CS) was in close proximity to the epicardial mapping catheter from which ablation had been attempted. Mapping in the GCV confirmed very early activation associated with fractioned electrograms, and cryoablation from this site successfully eliminated VT (Figs. 2A to 2C). It is likely that the VT focus originated from just beneath the GCV, and ablation energy delivery from the pericardial space was attenuated by flow within this vein. In all 5 cases, the first

**Table 1. Clinical, Electrocardiographic, and Electrophysiological Details of the Study Group**

<table>
<thead>
<tr>
<th></th>
<th>Patient 1</th>
<th>Patient 2</th>
<th>Patient 3</th>
<th>Patient 4</th>
<th>Patient 5</th>
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<td>Mild diffuse LV hypokinesis</td>
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<td>Electrocardiogram</td>
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<tr>
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<tr>
<td>S wave in V6</td>
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<td>Distal GCV</td>
<td>LAA Distal GCV</td>
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Epicardium refers to direct epicardial mapping/ablation by subxyphoid pericardial puncture. In all patients, only 1 ablation application was necessary.

AVC = aortic valve cusp; GCV = great cardiac vein; LAA = left atrial appendage; LV = left ventricle; LVOT = left ventricular outflow tract; RVOT = right ventricular outflow tract.
Ablation lesion from within the distal GCV successfully abolished the arrhythmia.

DISCUSSION

Idiopathic OTVT sometimes has an epicardial origin (2). Such epicardial OTVT is amenable to RF ablation from within the AVCs, most often the left (2–5). One case report has described successful ablation of idiopathic epicardial VT from the LAA (8). We report the successful ablation of epicardial idiopathic VT from the distal GCV, close to its continuation as the AIV. In these patients, mapping and in some cases ablation had been unsuccessful from endocardial sites as well from the AVCs in 2, the epicardium using the subxiphoid approach in 2, and the LAA in 2 cases. Cryoablation was performed in 2 cases, and RF ablation in the other 3.

Anatomical considerations. After traversing the posterior interventricular sulcus, the CS, in close relationship to the left circumflex artery, continues as the GCV, which turns anteriorly along the epicardial surface of the anterobasal LVOT, under the base of the LAA and the left AVC. The GCV continues as the AIV, passing adjacent to the left anterior descending (LAD) artery on the epicardial surface of the basal left ventricle. These anatomical relationships are shown in Figure 2D.

Electrocardiographic characteristics. An OTVT in general displays an inferior axis, and when it arises from the LVOT it is distinguished by an early R-wave transition in the precordial leads and an S in lead I. Similarly, epicardial OTVT consistently displays an early precordial R-wave transition (2,4–6). In addition, the ECG characteristics of epicardial OTVT successfully ablated from the left AVC have been reported as: tall inferior R waves (4); absence of an S wave in V6 (4,6); slurring of the R wave in the precordial leads (6); and an rS complex in lead I (2). The 12-lead ECGs from the 5 cases of OTVT are shown in Figure 1. All cases showed an early R wave transition. Four cases had an absent S wave in V6. All had a degree of slurring of the precordial R waves. All cases had either an rS or Rs complex in lead I. The similarities in the ECG characteristics between these cases and those ablated from the left AVC reflect the close anatomical relationships between the GCV and the left AVC.

Mapping of VT from within the coronary venous system. Although this is the first series systematically describing ablation of OTVT from the distal coronary venous system, previous investigators have mapped VT from within the CS. In one report, 6 of 7 patients with idiopathic OTVT had mapping performed in both the GCV and the AVCs (4). The closest pace maps and earliest ventricular activation were obtained from the GCV and AIV; however, ablation was not attempted from these sites because of safety concerns and technical challenges. Similarly, the CS and its tributaries have been used as mapping conduits in a group of patients with predominantly Chagasic cardiac disease and were used as landmarks for simultaneous endocardial ablation in this setting (9). Likewise, simultaneous direct epicardial outflow tract mapping (by subxiphoid puncture), and mapping of the AVCs has been performed in patients with idiopathic VT. Although sites displaying early activation were found using the direct epicardial approach, a large atrial electrogram was noted at favorable sites, and pacing resulted in atrial capture. Ablation was not performed by this approach because of LAA interposition at favorable sites (2).

The close anatomical relationship of the distal GCV and the left AVC, and the similarities between the ECG characteristics noted in our patients and those described as being typical for arising from the left AVC, suggest that these arrhythmias represent the same entity with slight variations in origin. The proportion of cases that can be successfully ablated from either site is unknown.

Ablation of VT from within the coronary venous system. Concern exists regarding catheter ablation via the CS or its branches because complications such as venostenosis, vein rupture, venous thrombosis, and damage to adjacent coronary arteries with resultant stenosis can occur. Radiofrequency ablation of left lateral epicardial accessory pathways from within the coronary venous system has been performed in 8 patients in whom multiple endocardial ablation attempts were unsuccessful. There were no
cases of rupture of the CS; however, in 1 case the ablation catheter remained adherent to the CS wall, necessitating repeat ablation to free it. No coronary stenosis was noted; however, probable mural thrombus in the CS was noted in the levophase CS angiograms in 2 patients (10).

The transition point of the GCV into the AIV is in close proximity to the coronary arteries, most often the circumflex. The LAD runs in close proximity to the AIV. Thus it is possible that RF ablation from within the distal branches of the CS may induce coronary artery stenosis in the long term. The presence of perivascular fat would tend to mitigate against damage to the coronary arteries by radiofrequency current and cryoablation. It nevertheless seems prudent to minimize the amount of RF energy delivered from within the CS. In all cases in which RF was used, a maximum power setting of 20 W was chosen for this reason. Cryoablation is likely to be safer than RF ablation in the branches of the CS, as has been documented in animal models (11,12). Cryoablation within the middle cardiac vein has been performed even within 2 mm of a coronary artery in patients with epicardial accessory pathways, without the occurrence of coronary artery stenosis (13,14). In the present study, coronary angiography was performed in 4 of 5 patients after ablation from the GCV and revealed no evidence of coronary arterial damage; in addition, none of the patients experienced angina after a mean follow-up of 25 months.

It is important to note that ablation from within the AVCs is similarly not without risk. Both acute and chronic occlusion of the left main coronary artery have been described in cases of ablation...
from or close to the left AVC (15,16). In addition, one group has used intracardiac echocardiography to guide ablation in the LVOT, and noted sliding of the catheter within the left AVC during 3 of the RF applications (3).

Stellbrink et al. (17) have reported a case of successful ablation of idiopathic VT from the coronary venous system. Similarly, Tanner et al. (18) have recently described 6 different anatomical approaches to the ablation of idiopathic VT with an early R/S transition (V3). These included the RVOT (the majority of patients), the pulmonary artery, the LVOT, the AVCs, the epicardium, and in 1 patient the GCV. Our report describes the first series of patients in whom successful ablation of idiopathic VT was performed from the coronary venous system. Our data support the suggestion that the CS should be accessed and mapped early in the course of investigation of idiopathic OTVT that does not arise from the RVOT, particularly when there is an early R/S transition.

Conclusions. We describe 5 cases of idiopathic epicardial LVOT in which ablation within the coronary venous system in all cases was successful in treating VT. The relative safety and efficacy of the CS approach compared with the approach via the AVCs is unknown. It is therefore not clear which should be attempted first; however, these results suggest that the CS approach should be considered as a potential approach for the ablation of idiopathic epicardial OTVT. If this approach is used, cryoablation may be a safer and effective alternative to radiofrequency energy.

Reprint requests and correspondence: Dr. Vivek Y. Reddy, Cardiac Arrhythmia Service, Massachusetts General Hospital, 55 Fruit Street, Gray-Bigelow 109, Boston, Massachusetts 02114. E-mail: vreddy@partners.org.

REFERENCES