Ultra-low-temperature cryoablation for ventricular tachycardia in nonischemic cardiomyopathy—A case report

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Introduction

Catheter ablation of ventricular tachycardias (VT) has become one of the cornerstones of reducing VT recurrence rates and hence implantable cardioverter-defibrillator (ICD) therapies in patients with structural heart disease. Despite technological advantages in the last decade, recurrence rates range from 28% to 60%, depending on the underlying arrhythmogenic substrate.[1,2]

The use of cryoablation using nitrous oxide cryogen for endocardial ablation of ventricular arrhythmias originating, in particular, from the papillary muscle has been described in a small patient series, with better catheter stability, higher success, and lower recurrence rates as compared to radiofrequency (RF) ablation.[3,4] The noted limitations were problematic catheter maneuverability and smaller lesion size, likely owing to insufficient freezing power for higher myocardial thickness and high thermal load within the ventricle.[5] Ultra-low-temperature cryoablation (ULTC) system (vCLAS™; Adagio Medical, Inc, Laguna Hills, CA) overcomes such limitation by combining high-pressure near-critical nitrogen cryogen at temperature near -196°C, as described elsewhere, with 9F bidirectionally deflectable catheter (≥180 degrees), compatible with 10F steerable and fixed-curve sheath for retrograde or antegrade access. The cryoablation element of the catheter contains 8 electrodes, which are used for mapping, ablation, and pacing. The ULTC technology has been shown to provide deeper, transmural, and homogeneous lesions in animal studies[6] and has been used in treatment of atrial fibrillation (AF), demonstrating 85% freedom from AF at 12 months after a single procedure in persistent AF patients. Furthermore, its acute efficacy and safety has been reported in 13 patients with predominantly ischemic cardiomyopathy and extensive scar area.[7,8] Contrary to ischemic cardiomyopathy, where the arrhythmogenic substrate is primarily distributed subendocardially, the substrate for VT in patients with nonischemic cardiomyopathy is thought to be much more diffuse, rarely compact, and primarily localized deep within the myocardium.[9] In this report, we present a case of the utilization of the ULTC technology in a patient with nonischemic cardiomyopathy.

KEY TEACHING POINTS

- Cryoablation is a safe and effective treatment option for nonischemic cardiomyopathy patients suffering from ventricular tachycardia.
- Preprocedural cardiac magnetic resonance imaging allows the estimation of the desired lesion depth and titration of the ablation duration, which is correlated with the postprocedural depth of the lesion based on cardiac magnetic resonance imaging and late gadolinium enhancement (LGE).
- Cryothermal ablation with an ultra-low-temperature cryoablation catheter resulted in microvascular obstruction at the ablation site, with subendocardial LGE.

Case report

We present the case of a 56-year-old female patient, presenting with electrical storm, multiple ICD shocks, and incessant nonsustained VT at our institute for further treatment. She had history of cardiac sarcoidosis in a chronic fibrotic stage and received a cardiac resynchronization therapy defibrillator for high-degree atrioventricular block and severely reduced left ventricular ejection fraction. In the further course the patient developed acute dizziness accompanied by a transient loss of consciousness, and multiple ICD shocks. The electrocardiogram revealed a VT with a cycle length of 280 ms. Intravenous and later orally administered amiodarone could not

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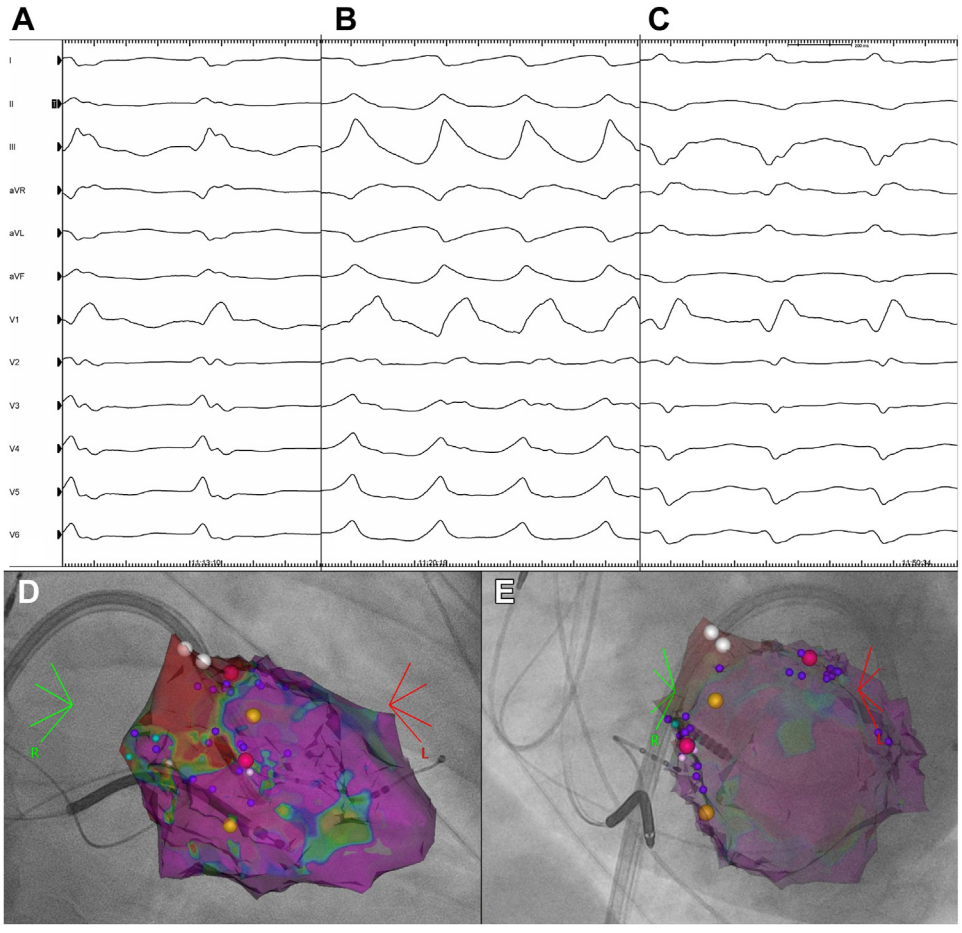

Figure 1 Twelve-lead electrocardiogram morphologies and intracardiac voltage map/CARTOUNIVU. **A:** Ventricular tachycardia (VT) with a basal superior exit. **B:** Comparable to (A), with presumably epicardial exit. **C:** Clinically documented VT with a suggestive septal exit. **D:** Right anterior oblique view during cryoablation. The catheter is placed at the septal aspect at the border zone of a low-voltage area, adjacent to a previous ablation at sides of the best-matching pace map for (C), surrogated by the pink location point. **E:** Left anterior oblique view. The basal superior pink location mark surrogates the best pace map for (B), which was later assessed during the procedure. CARTOUNIVU integrates fluroscopy imaging within the CARTO 3 System maps.

suppress the VT sufficiently; thus the patient was transferred for catheter ablation. The patient met all the requirements for enrollment in the Cryocure-VT trial (NCT04893317), which is intended to evaluate the feasibility and safety of UTLC ablation in patients with monomorphic VT. Preprocedural cardiac magnetic resonance (CMR) imaging revealed intramural late gadolinium enhancement (LGE) lesions in the septum and the 12-lead electrocardiogram of the VT suggested septal origin. Owing to anticipated lower efficacy of conventional RF ablation to achieve deeper and transmural lesions in the septum, UTLC was considered to be the most appropriate treatment option available.

Electrophysiologic study

The procedure was performed in deep analgosedation. Programmed ventricular stimulation from the right ventricular apex and right ventricular outflow tract was performed without initiation of sustained or nonsustained VT. Thus, left ventricular access was obtained with a single transseptal puncture and mapping of the left ventricle was performed using a multipolar catheter and the CARTO 3 system (Biosense Webster, Diamond Bar, CA), revealing an extensive low-voltage area alongside the midventricular to the basal aspects of the interventricular septum, also encompassing the superior aspects of the mitral annulus (Figure 1D and 1E). During intracardiac mapping, 3 different VTs were initiated mechanically, including the clinically documented with an inferior, but also 2 with a basal, superior exit (Figure 1A–1C). Activation mapping was not possible owing to hemodynamic instability of the VTs; thus, a substrate-guided approach for catheter ablation was chosen. The ULTC catheter was introduced via a 10F steerable sheath (Destino Reach; Oscor, Palm Harbor, FL).

Three cryothermal ablations were applied at the anteroseptal portions of the interventricular septum (Figure 2), as well as at the superior basal left ventricle adjacent to the mitral annulus, according to the most appropriate correlations with pace mapping, each lasting 120 seconds, with a mean temperature of -140°C at the tip of the catheter (SD: ±2.98Kelvin). VT could not be induced after programmed ventricular stimulation and continuous infusion of isoproterenol. A remap of the left ventricle revealed no significant

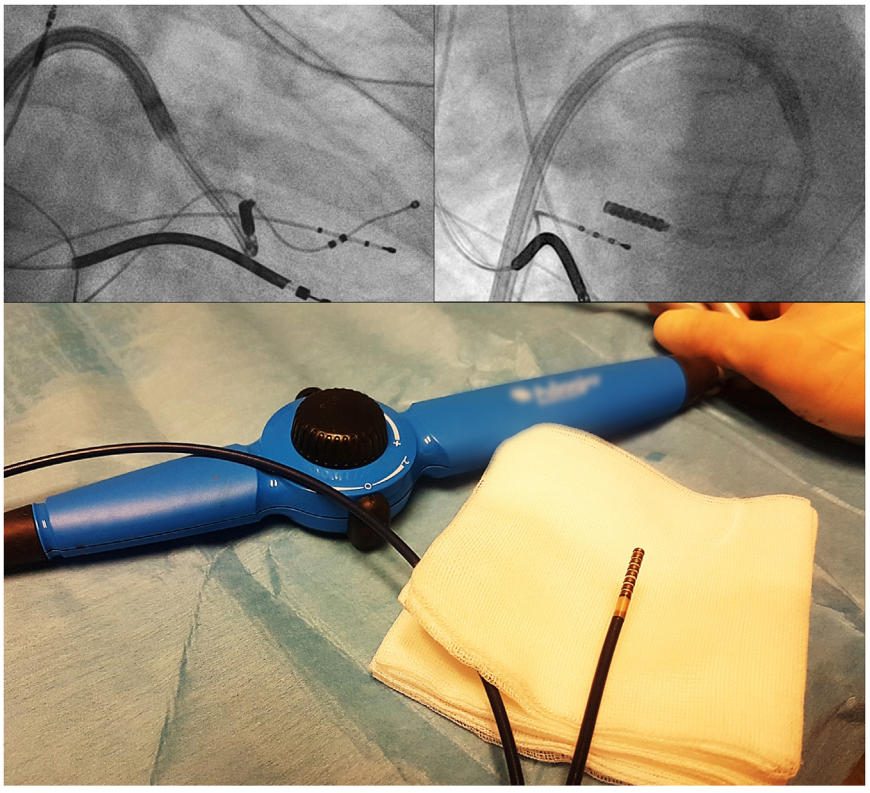

Figure 2 Right anterior oblique (top left) and left anterior oblique (top right) view at sides of the ventricular tachycardia exit; the catheter ex vivo (bottom).

differences compared to the initial voltage map; however, a postinterventional CMR scan visualized the acute ablation effect at sides of the endocardial aspects of the interventricular septum by microvascular obstruction and LGE, additional to the preexisting sarcoid-related fibrosis (Figure 3). The patient remained free from sustained VT (and thus

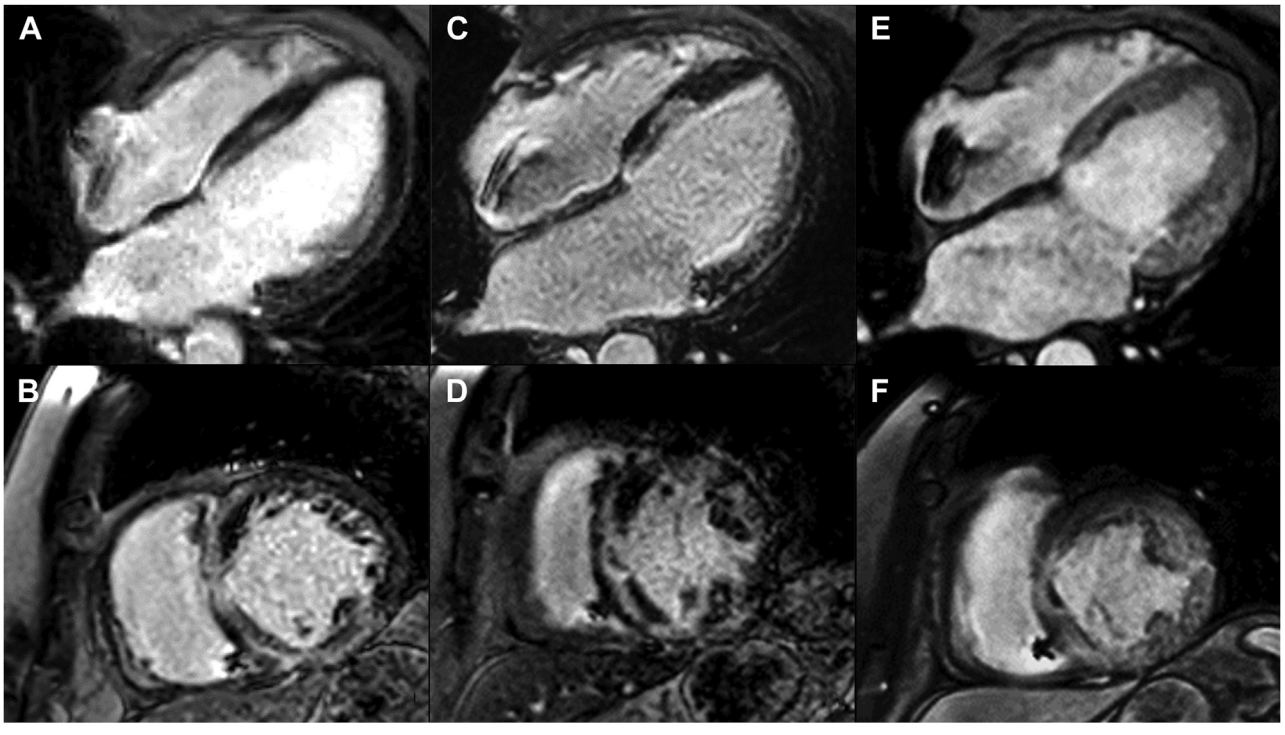

Figure 3 Preprocedural and postprocedural cardiac magnetic resonance (CMR) imaging. **A, B:** Preprocedural CMR scan, 4-Chamber-View (4CHV) and Short-Axis-View (SAV): late gadolinium enhancement (LGE) demonstrating intramyocardial septal fibrosis. **C, D:** Postprocedural CMR scan, 4CHV and SAV: LGE can now be additionally demonstrated at the endocardial surface of the left ventricle at sides of catheter ablation. **E, F:** Postprocedural CMR scan, 4CHV and SAV: This sequence shows microvascular obstruction at the septal aspect of the interventricular septum, surrogating the direct cryothermal ablation effect.

ICD therapies) 1 month after the procedure. Solely a nonsustained VT could be recorded by the ICD, lasting 4.7 seconds (cycle length 260 ms).

Discussion

This case demonstrated the effectiveness and safety of cryothermal ablation of multiple VTs in a patient with a nonischemic cardiomyopathy and electrical storm, which was refractory to antiarrhythmic drug therapy. Cryoablation is routinely used and implemented in the clinical routine for the treatment of multiple supraventricular arrhythmias. Nevertheless, limited data are available on its use for ventricular arrhythmias, particularly in nonidiopathic and nonischemic etiology.[7,10] According to the distribution of the arrhythmogenic substrate in patients with nonischemic cardiomyopathy, RF ablation is associated with higher recurrence rates than in those with ischemic etiology.[2] In our current report, we examined the cryothermal ablation depth following the procedure using a CMR scan to compare it to the preablation status. It was demonstrated that cryothermal ablation with a ULTC catheter resulted in microvascular obstruction at the sides of the ablation. Additionally, a positive subendocardial LGE phenomenon complemented the preexisting sarcoid-related intramyocardial fibrosis.

ULTC ablation has been demonstrated to generate effective lesion depth of up to 1.96 ± 0.8 mm in the atrium and 5.61 ± 2.2 mm in the ventricle in an animal model, with substantially deeper lesions achievable with longer cryoablation cycles and with transmurality dependent on the thickness of the myocardial tissue.[6,8] Thus, preprocedural CMR imaging allows to estimate the required lesion depth and hence titration of ablation duration. In our case, the distance between the endocardial surface and the intramural fibrosis was approximately 4.5 mm at the sides of the targeted ablation side, based on the preprocedurally performed CMR imaging. This allowed an approximation of the ablation duration according to the stipulations of the manufacturer and correlated sufficiently with the postprocedural lesion depth based on CMR imaging and LGE. In summary, our case illustrates the efficiency of ULTC for multiple monomorphic VTs in a patient with nonischemic cardiomyopathy and its compatibility to preprocedural CMR imaging and advanced mapping systems.

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