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Case Reports

Atrioventricular Nodal Ablation Is Not an Effective Treatment Strategy in Catecholaminergic Polymorphic Ventricular Tachycardia

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Abstract

Catecholaminergic polymorphic ventricular tachycardia is a rare but lethal heritable arrhythmia syndrome associated with both atrial and ventricular arrhythmias. Treatment includes antiarrhythmics, sympathetic denervation, and implantable cardioverter-defibrillators. The use of atrioventricular nodal ablation as a treatment strategy to prevent ventricular arrhythmias in catecholaminergic polymorphic ventricular tachycardia was not found in the literature. This report describes a teenager with a presenting rhythm of atrial and ventricular fibrillation and cardiac arrest. Her clinical arrhythmia was predominantly atrial dysrhythmias, which delayed her diagnosis of catecholaminergic polymorphic ventricular tachycardia. Before her diagnosis, she underwent atrioventricular nodal ablation in an effort to prevent ventricular arrhythmias, which was ultimately ineffective. This report highlights the importance of recognizing atrial arrhythmias in catecholaminergic polymorphic ventricular tachycardia and provides evidence that atrioventricular nodal ablation is not an effective treatment strategy for this disease.

Keywords: Catecholaminergic polymorphic ventricular tachycardia; atrioventricular node; cardiac arrhythmias; ablation technique; developmental disabilities; death

Introduction

Catecholaminergic polymorphic ventricular tachycardia (CPVT) is a heritable arrhythmia disorder most commonly caused by pathogenic variants in the cardiac ryanodine receptor *RYR2*.[1-9] Abnormal diastolic calcium release, in response to adrenergic stimulation, results in life-threatening ventricular arrhythmias.[10,11] Although ventricular arrhythmias in CPVT have been well characterized, less is known about whether atrial arrhythmias result in rapid conduction to the ventricles triggering the ventricular arrhythmias or whether arrhythmias within the atria and ventricles occur independently. This article presents the first known report of atrioventricular (AV) node ablation as a management strategy in a patient with suspected atrial-driven ventricular arrhythmias in CPVT. The presented evidence suggests that AV nodal ablation is not an optimal treatment modality for this patient population and indicates that atrial and ventricular arrhythmias in CPVT can occur as independent arrhythmias; hence, elimination of AV nodal conduction may not prevent ventricular tachycardia or fibrillation.

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Case Report

Presentation and Medical History

A non-Hispanic White female with a history of developmental delays initially presented at 12 years of age after a resuscitated ventricular fibrillation cardiac arrest. Her electrocardiogram including corrected QT interval was normal for her age, and her echocardiogram demonstrated a structurally normal heart with normal biventricular size and systolic function. Her diagnosis of CPVT was not initially elucidated because her primary clinical rhythm after resuscitation was atrial fibrillation (AF). The ventricular fibrillation (VF) was attributed to degeneration of AF into VF.

Management

The patient underwent placement of a single-chamber implantable cardioverter-defibrillator (ICD) at an adult center. Multiple antiarrhythmic medications were attempted, including sotalol (58 mg/m^2/d), amiodarone (4 mg/kg/d), and metoprolol XL (0.5 mg/kg/d); however, her atrial arrhythmias persisted. She therefore underwent an electrophysiology (EP) study by experienced adult electrophysiologists at the age of 13 years. During this study, AF could not be induced. No abnormalities were identified during mapping or with atrial voltages. Given her clinical atrial arrhythmia, although AF could not be induced, a standard pulmonary vein isolation was performed using radiofrequency ablation. Two months later, she was diagnosed with atrial flutter and underwent a repeat EP study at the same center. During this EP study, atrial flutter could not be induced, and a prophylactic cavotricuspid isthmus block was performed. She had persistent ICD discharges for both atrial arrhythmias and VF. She was then trialed on single-agent, high-dose atenolol (3.7 mg/kg/d), followed by single-agent mexiletine (8.3 mg/kg/d), and then a trial of combination nadolol (2 mg/kg/d) and verapamil sustained release (3.3 mg/kg/d). Because the VF was thought to be caused by rapid AV nodal conduction of AF, she underwent an AV nodal ablation at the age of 14 years. The nadolol and verapamil were discontinued after AV nodal ablation. Despite complete AV block and pacemaker dependence (Fig. 1), she continued to have both atrial and ventricular arrhythmias, including isolated atrial arrhythmias in the absence of ventricular tachycardia or VF (Fig. 2) and simultaneous atrial and ventricular tachycardias (Fig. 2 and 3). For this patient, ICD discharges indicated that defibrillation failed to terminate atrial or ventricular arrhythmias (Fig. 4). An important feature of CPVT is the lack of response of some arrhythmias to defibrillation[3,4]; for this reason, device revision would not be recommended. Therefore, combination high-dose nadolol (4.4 mg/kg/d), verapamil sustained release (3.3 mg/kg/d), and flecainide (65 mg/m^2/d) were initiated. Because of recurrent atrial and ventricular arrhythmias and persistent ICD discharges, at age 15 years, she underwent bilateral sympathetic denervation.

Key Points

- Atrial arrhythmias occur in catecholaminergic polymorphic ventricular tachycardia and can be the predominant rhythm, which is important to consider so as not to miss this diagnosis.
- Atrioventricular nodal ablation is not an effective treatment strategy to prevent ventricular arrhythmias in this disease.
- Collaborations between adult and pediatric centers can be helpful in diagnosing and managing patients with catecholaminergic polymorphic ventricular tachycardia.

Abbreviations and Acronyms

AF	atrial fibrillation
AV	atrioventricular
CPVT	catecholaminergic polymorphic ventricular tachycardia
EP	electrophysiology
ICD	implantable cardioverter-defibrillator
VF	ventricular fibrillation

Outcome

At this point, the patient was referred to the pediatric center for heart transplant evaluation. During her initial consultation, the suspicion for CPVT was raised because of the combination of AF and polymorphic ventricular tachycardia. Genetic testing was conducted and revealed a known de novo pathogenic variation in *RYR2* (c.14311 G>A, p.Val 4771Ile). The recommendation was made to increase flecainide and use combination nadolol and flecainide therapy with close follow-up. Unfortunately, she was lost to follow-up and ultimately was found deceased in her home. The cause of death was not determined but was felt to be the result of noncompliance and possible device malfunction. An autopsy was not performed and the device was unable to be interrogated.

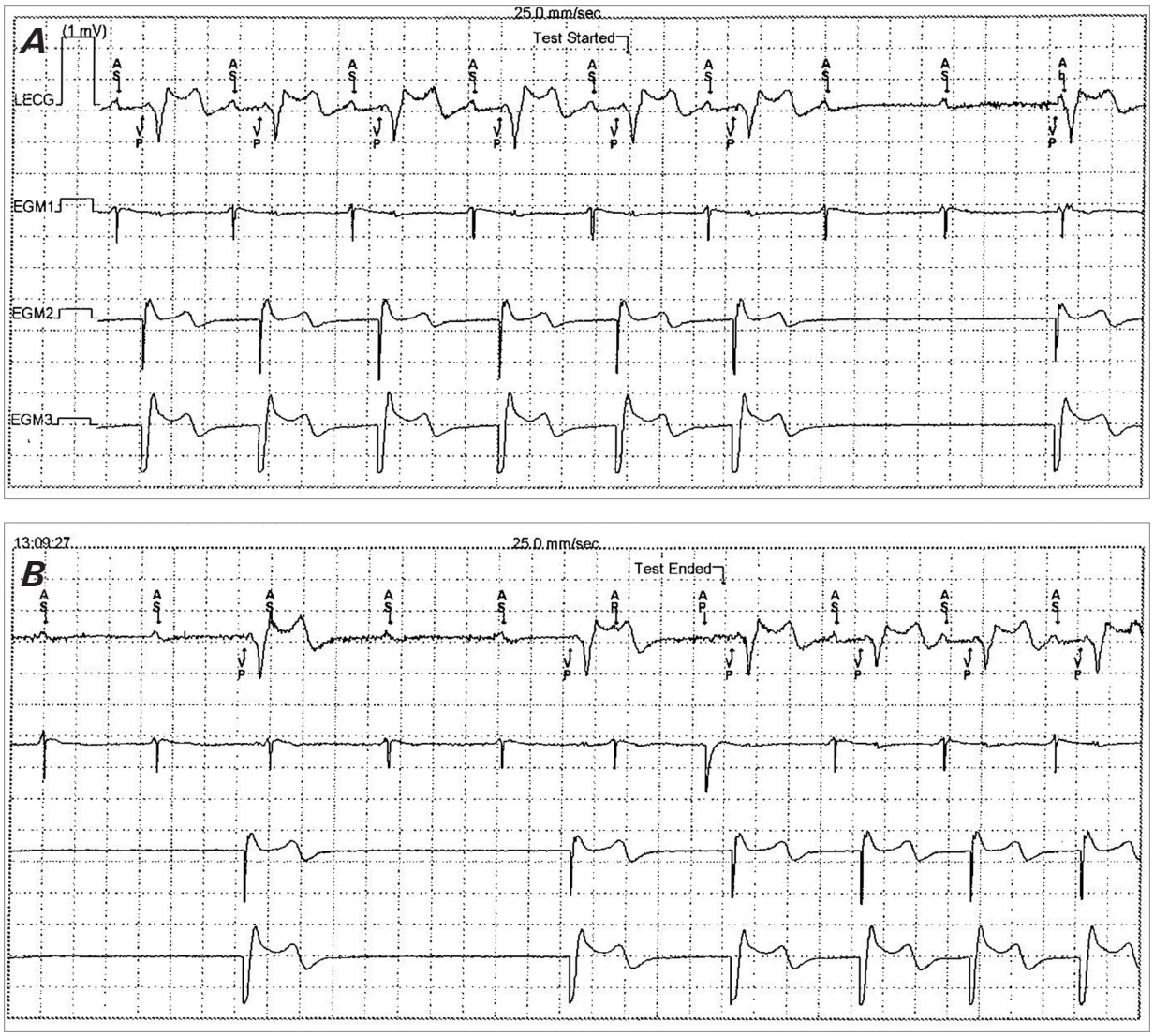

Fig. 1 Continuous electrograms recorded during device interrogation. The first row (labeled LECG) is the combined atrial and ventricular surface electrocardiogram, EGM 1 (second row) is the intracardiac atrial electrogram (atrial lead tip to atrial lead ring), EGM 2 (third row) is the intracardiac right ventricular electrogram (right ventricular lead tip to right ventricular lead ring), and EGM 3 (fourth row) is the right ventricular electrogram (right ventricular lead tip to right ventricular coil). **A**) The electrogram begins with the patient in sinus rhythm with atrial sensing and ventricular pacing, with termination of ventricular pacing shown. **B**) Complete heart block is demonstrated with a ventricular escape rate below 30 bpm, consistent with the patient being pacemaker dependent.

Ab, atrial sensed in postventricular atrial blanking; AP, atrial pace; AS, atrial sense; EGM, electrogram; LECG, leadless electrocardiogram; mV, millivolt; VP, ventricular pace.

Discussion

Catecholaminergic polymorphic ventricular tachycardia is one of the most malignant heritable arrhythmia syndromes.[1-9] In this case, the diagnosis may have initially been missed because her primary arrhythmia was supraventricular tachyarrhythmias rather than ventricular tachycardia. This case report offers several important learning points. Importantly, this report highlights that atrial arrhythmias can be the predominant and presenting rhythm in CPVT and should be considered in this diagnosis, particularly when seen in combination with ventricular arrhythmias. Atrial arrhythmias in CPVT have been observed even in the initial description of CPVT but have been less well characterized than ventricular arrhythmias in this disease.[2-4,6-9] It is important

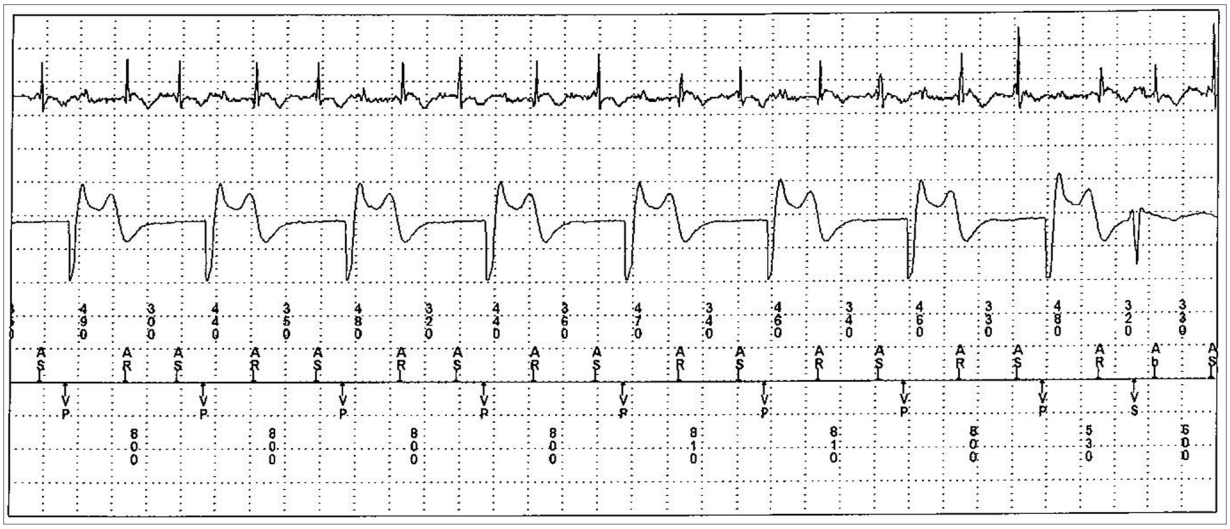

Fig. 2 Electrograms recorded during device interrogation. The top row represents the intracardiac atrial electrogram (atrial lead tip to atrial lead ring). The second row represents the intracardiac right ventricular electrogram (right ventricular lead tip to right ventricular coil). The third row shows device channel markers and cycle lengths. This figure demonstrates an irregular atrial tachyarrhythmia (with atrial electrocardiograms that differ from the sinus atrial electrocardiogram seen in Figure) 1 that occurs independent of a ventricular tachycardia.

Ab, atrial sensed in postventricular atrial blanking; AR, atrial refractory sense; AS, atrial sense; VP, ventricular pace; VS, ventricular sense.

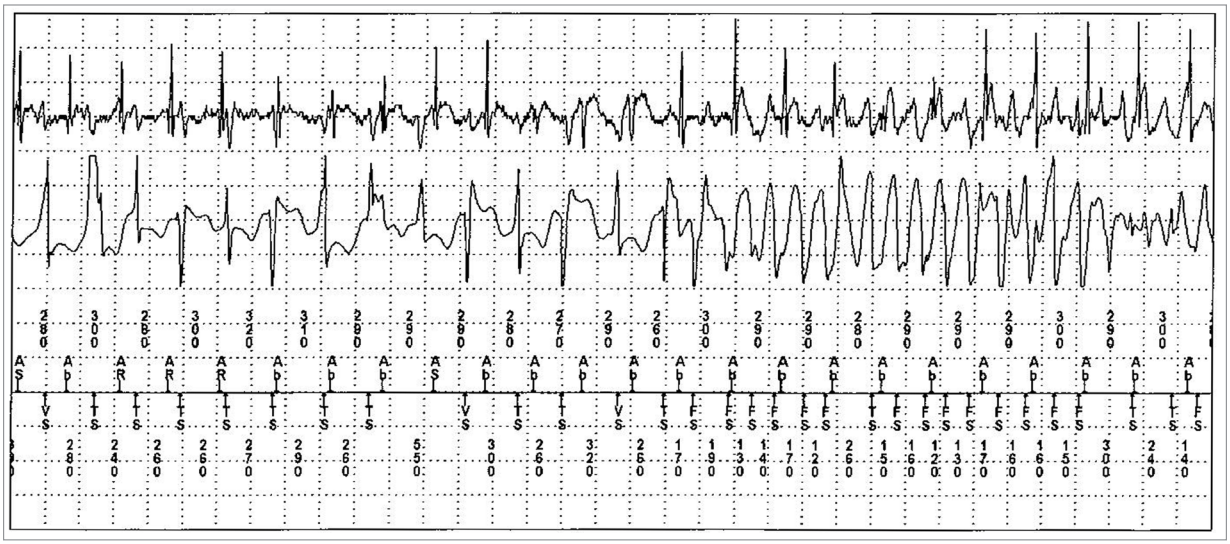

Fig. 3 Electrograms recorded during device interrogation. The top row represents the intracardiac atrial electrogram (atrial lead tip to atrial lead ring). The second row represents the intracardiac right ventricular electrogram (right ventricular lead tip to right ventricular coil). The third row shows device channel markers and cycle lengths. This figure demonstrates both atrial and ventricular tachycardia and ventricular fibrillation occurring independently of each other.

Ab, atrial sensed in postventricular atrial blanking; AR, atrial refractory sense; AS, atrial sense; FS, ventricular fibrillation sense; TS, ventricular tachycardia sense; VS, ventricular sense.

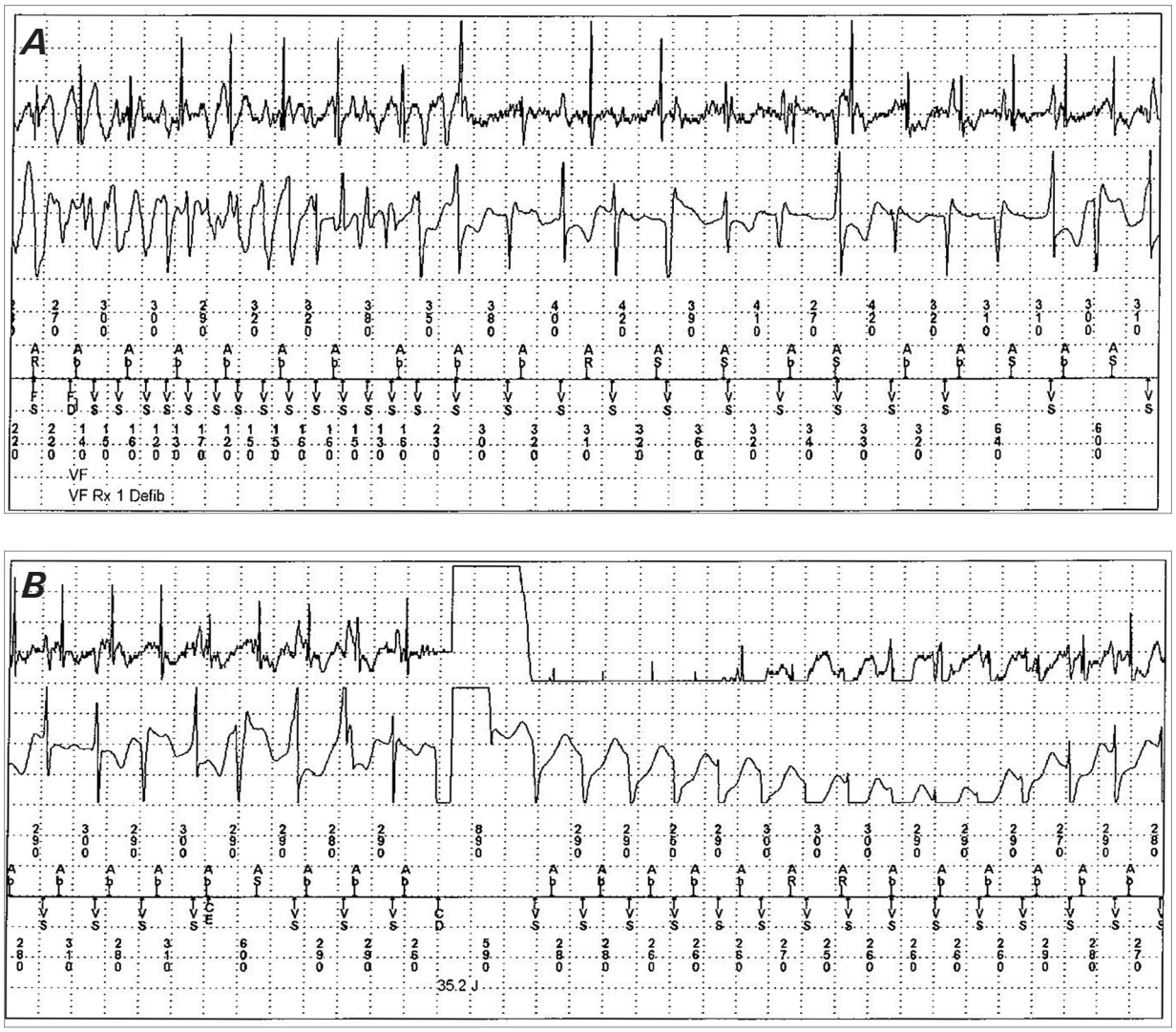

Fig. 4 Continuous electrograms recorded during device interrogation. In each panel, the top row represents the intracardiac atrial electrogram (atrial lead tip to atrial lead ring). The second row represents the intracardiac right ventricular electrogram (right ventricular lead tip to right ventricular coil). The third row shows device channel markers and cycle lengths. This figure demonstrates that simultaneous atrial and ventricular tachycardias do not terminate with defibrillation. **A**) Ventricular fibrillation is detected; atrial tachycardia is present with atrial electrograms often falling in the postventricular blanking period. **B**) A defibrillation pulse is delivered without termination of the atrial or ventricular arrhythmia.

Ab, atrial sensed in postventricular atrial blanking; AR, atrial refractory sense; AS, atrial sense; CD, cardioversion/defibrillation pulse; CE, charge end; Defib, defibrillation; FD, ventricular fibrillation detection; FS, ventricular fibrillation sense; Rx, treatment; VF, ventricular fibrillation; VS, ventricular sense.

to consider CPVT as a diagnosis even when the presenting rhythm is an atrial tachyarrhythmia.

Second, because rapid conduction of atrial arrhythmias can cause ventricular tachyarrhythmias, AV nodal ablation as a treatment strategy has been raised for CPVT. In patients with CPVT, even among those with ICDs, it can be difficult to determine whether atrial arrhythmias are conducting rapidly to the ventricle and resulting in ventricular arrhythmias or whether the atrial and ventricular arrhythmias are occurring independently. This report demonstrates that atrial and ventricular arrhythmias can be independent and simultaneous events and, importantly, that AV nodal ablation may not be an effective treatment modality for prevention of ventricular arrhythmias in the CPVT patient population. The effectiveness of AV nodal ablation for CPVT has not

been established, and this case suggests that AV nodal ablation should not be a treatment strategy in this patient population. These data may be helpful in directing future management and treatment for this disease. Last, this case report highlights how patient care can be improved when adult and pediatric centers work together to make a diagnosis, particular in genetically driven syndromes among young patients. Catecholaminergic polymorphic ventricular tachycardia is a rare but lethal disease, and these learning points will be helpful to all clinicians caring for these patients.

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