Sub–mitral valve aneurysm ventricular tachycardia masquerading as arrhythmogenic right ventricular cardiomyopathy

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Introduction

The underlying etiology of ventricular tachycardia (VT) is essential for developing proper risk stratification and treatment strategies. Assessment of an underlying diagnosis such as ischemic or nonischemic disease, genetic cardiomyopathies such as arrhythmogenic right ventricular cardiomyopathy (ARVC), and structural VTs such as mitral valve prolapse or disjunction is critical for each patient presenting with initial and recurrent VT. Sometimes more than 1 etiology coexists and the onus is on the electrophysiologist to determine where and what the cause of the clinical VT is. This requires scrutinization of all available clinical information including prior and presenting electrocardiogram, cardiac imaging (echo, magnetic resonance imaging [MRI], computed tomography [CT]), stress testing, and the presence or absence of coronary artery disease. In addition to the preprocedural data, interprocedural data such as structural defects noted with intracardiac echocardiogram further sharpen the clinician's ability to diagnosis and effectively treat VT. We present a unique case of a VT arising from a submitral aneurysm in a patient who was initially misdiagnosed as VT secondary to ARVC.

KEY TEACHING POINTS

- A left ventricular (LV) submitral aneurysm is a rare but distinct clinical entity that is likely underdiagnosed. The differential includes infarct-related basal LV aneurysm, LV involvement of arrhythmogenic right ventricular cardiomyopathy (ARVC), and arrhythmogenic mitral annular disjunction.
- Awareness of LV submitral aneurysm is important, as these patients have the substrate for ventricular arrhythmias.
- Ventricular tachycardia arising from a submitral aneurysm can be effectively treated with radiofrequency catheter ablation via substrate homogenization and lesion connection to the mitral annulus.
- Clinical re-review of all suspected ARVC cases should always be performed, especially when more minor criteria are met, in light of the more recent scientific statements for diagnostic criteria and enhanced imaging techniques.

Case report

A 65-year-old man with a past medical history notable for ARVC was transferred to our hospital for management of recurrent intracardiac defibrillator (ICD) shocks in VT storm.

Notably, 15 years prior to presentation he suffered an out-of-hospital arrest. A baseline right bundle branch block was noted on electrocardiogram, but no obstructive coronary disease or cardiomyopathy was found. He underwent dual-chamber intracardiac defibrillator implant. One month later he received an appropriate shock for premature ventricular contraction (PVC) triggered polymorphic VT. Holter monitoring showed >10,000 PVCs in 24 hours, with left bundle branch block with inferior axis morphology (Supplemental Figure 1) suggestive of right ventricular outflow tract (RVOT) origin. Cardiac CT showed mild-to-moderate right ventricle (RV) dilation with possible fat infiltration in the RV free wall. Given the PVC morphology and findings on cardiac CT, he was diagnosed with ARVC.

KEYWORDS Arrhythmogenic right ventricular cardiomyopathy; Catheter ablation; Electroanatomic mapping; Submitral aneurysm; Ventricular tachycardia

(Heart Rhythm Case Reports 2021;7:588–592)

Conflict of Interest: The authors have no financial conflict of interest to report. Funding: Dr DeSimone is supported by a benefactor-funded career development award honoring Earl H. Wood. **Address reprint requests and correspondence:** Dr Christopher V. DeSimone, Associate Professor of Medicine, Division of Cardiovascular Diseases, Mayo Clinic, 200 First St SW, Rochester, MN 55905. E-mail address: desimone.christopher@mayo.edu.

https://doi.org/10.1016/j.hrcr.2021.05.014

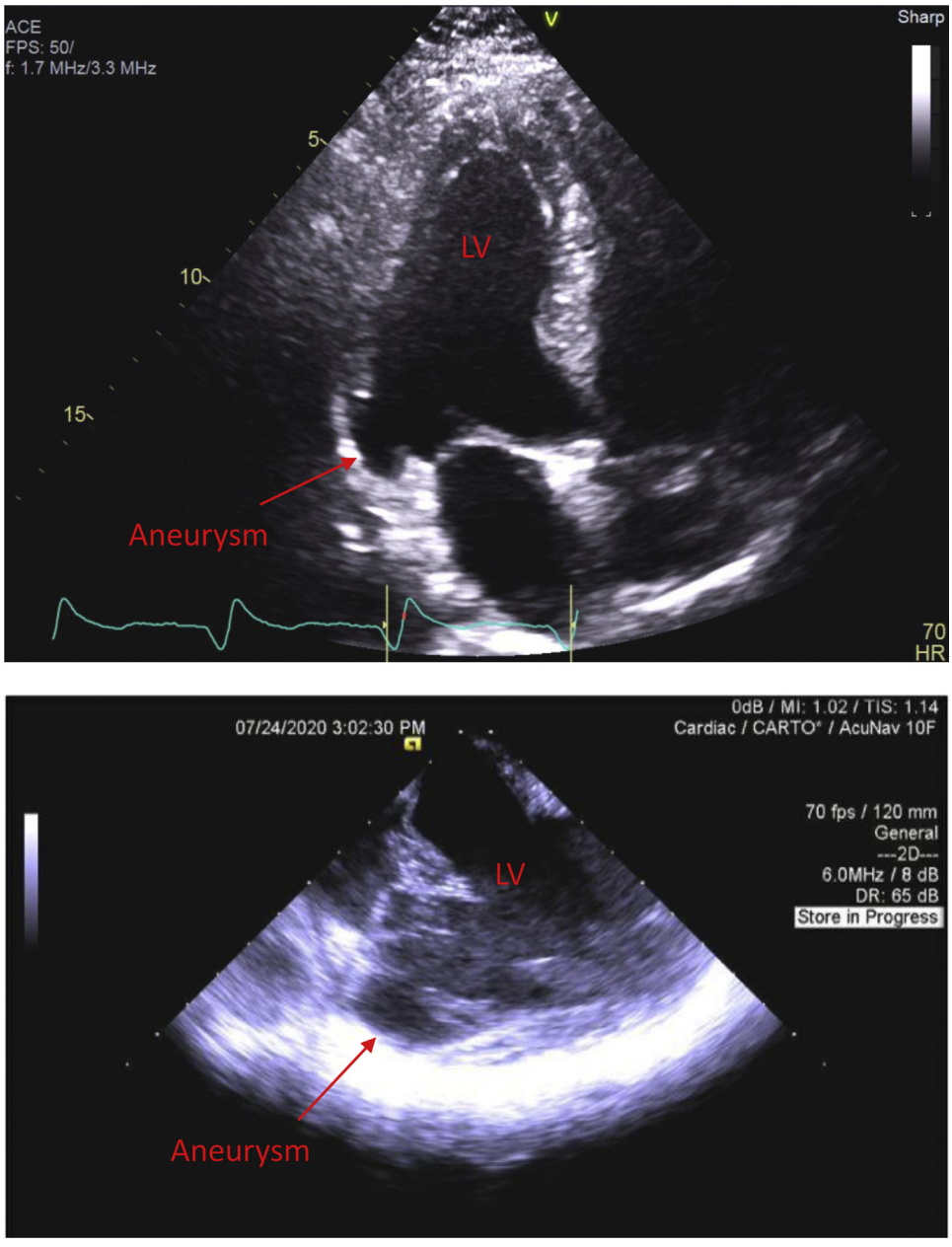

Figure 1 **A:** Transthoracic echocardiogram, apical 4-chamber view (Mayo orientation): mitral apparatus and submitral aneurysm. **B:** Intracardiac echocardiogram: left ventricle (LV), mitral apparatus, and submitral aneurysm.

Because of PVC-induced polymorphic VT, he underwent an electrophysiology study. The patient was found to have pause-dependent PVCs similar in morphology to the clinical PVCs. These were suspected to be related to ectopy from the tip of the ICD lead (Supplemental Figure 2), which had originally been placed in the RVOT. Therefore, the ICD lead was repositioned to the RV apical septum and a right atrial lead was placed to prevent pauses. The RVOT-PVCs subsequently resolved, while mild RV enlargement and dysfunction persisted. He was maintained on atenolol and did well for several years.

In the month preceding admission to our hospital, he developed episodes of monomorphic VT with a total of 7 appropriate ICD shocks. Despite oral amiodarone, he had accelerating episodes with multiple appropriate shocks. He was started on intravenous amiodarone and lidocaine and transferred for invasive management.

Repeat echocardiogram revealed a moderately enlarged left ventricle, left ventricular (LV) ejection fraction of 58% with apical dyskinesis, and a mildly enlarged RV with mildly reduced systolic function. Interestingly, a sub–mitral valve aneurysm was apparent along the inferolateral wall of the left ventricle (Figure 1), in addition to mild mitral valve prolapse. A cardiac MRI showed mild patchy midmyocardial late gadolinium enhancement in the mid inferoseptum at the RV insertion and dyssynchronous contraction of the

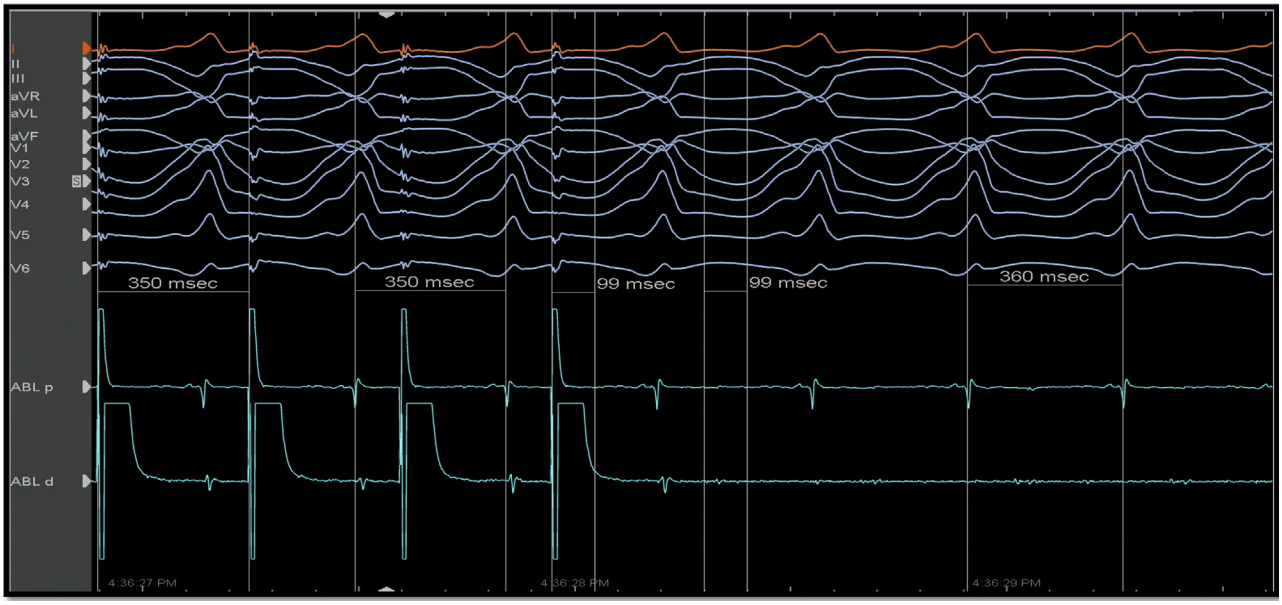

Figure 2 Entrainment mapping within the roof of the aneurysmal pouch. Ventricular tachycardia cycle length previously recorded around 386 ms, postpacing interval found to be shorter. Stim-to-QRS shown here at 99 ms, around 30% tachycardia cycle length, suggesting proximal portion of the isthmus.

RV free wall with a small focal aneurysm, but normal RV size.

Given refractory VT despite medical therapy, he was taken to the laboratory for ablation. A submitral aneurysm was clearly seen on intracardiac echocardiography (Figure 1). Targeted point-by-point mapping in and around the inferolateral LV aneurysmal pouch revealed abnormal substrate with fractionated and late signals. Pace mapping showed long stimulation to QRS with alternating morphology, indicating different exits from a common isthmus. Monomorphic VT with a cycle length of 358 milliseconds was induced with a right bundle morphology and superior axis, like the clinical VT (Figure 2). Entrainment mapping on the roof of the pouch demonstrated concealed entrainment with stim-to-QRS <30% of the total cycle length, suggesting the location of the ablation catheter tip within the distal portion of the isthmus (Figure 2). Substrate homogenization was performed throughout the submitral

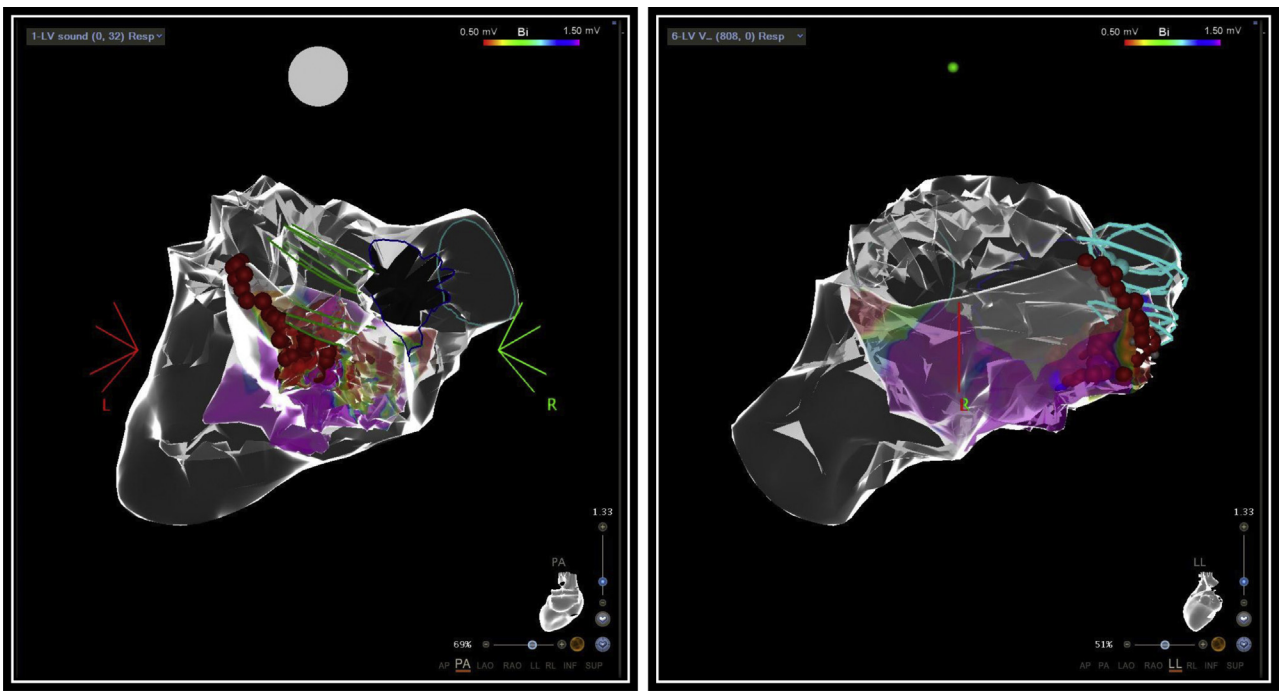

Figure 3 CartoSound (Biosense Webster, Irvine, CA) electroanatomic map of the aneurysm with ablation lesions shown as red dots.

aneurysm (Figure 3). With postablation programmed stimulation and burst pacing on isoproterenol, we were no longer able to induce VT.

The diagnosis of ARVC was reviewed. For mild-to-moderate RV dysfunction, the patient fulfilled only 1 minor criterion of the 1994 Task Force Criteria[1] for the diagnosis of ARVC. Although fibrofatty replacement of myocardium was a major criterion, it had to be demonstrated on endomyocardial biopsy. Additionally, a blinded review of his original CT scan was conducted because of reported fibrofatty changes, and the findings were felt to be inconsistent with ARVC. When the 2010 Revised Task Force Criteria[2] for the diagnosis of ARVC was applied, the patient only fulfilled 1 minor criterion (PVCs >500/24 hours on Holter or left bundle branch block morphology with inferior axis). During the current presentation, the patient did not meet the 2010 criteria either. Therefore, the diagnosis of ARVC was removed and previously recommended restrictions were lifted.

The patient was maintained on amiodarone for another 3 months, after which it was stopped. He has been maintained on low-dose metoprolol and off all antiarrhythmic agents. He has not had any recurrent ICD shocks for 9 months and has noted a complete change in quality of life.

Discussion

Sub–mitral valve LV aneurysms have most commonly been described in the indigenous African population, but have also been reported in many different ethnicities.[3,4] They are typically considered congenital defects composed of a fibrous outpouching from the posterior mitral annulus; however, they can occur in the setting of chest trauma and cardiac surgery.[5] Submitral aneurysms should be differentiated from mitral annular disjunction, which can also be arrhythmogenic. Mitral annular disjunction, often associated with mitral valve prolapse, is recognized by the attachment of the mitral valve to the left atrium away from the fibrous annulus.[6] Although only described in case series and scattered case reports, submitral aneurysms are likely underdiagnosed and more common than currently perceived. While some patients are asymptomatic, the aneurysms can present with a variety of clinically relevant sequelae. Previous reports have described mitral regurgitation,[7] cardiogenic shock,[8] coronary artery compression,[9] and ventricular arrhythmias.[10]

Submitral aneurysms can be a set up for reentrant ventricular arrhythmias. The fibrotic nature of the tissue is suitable as an area of wavefront slowing through or around the aneurysm, which could predispose VT. Previously, LV aneurysms causing hemodynamic or electrical effects have been resected surgically.[3] With the advent of electroanatomic mapping systems and modern catheter ablation, arrhythmias arising from a submitral aneurysm can likely be treated with catheter ablation, as in our patient.

ARVC was first described in 1982 and originally thought of as a congenital defect.[11] It is now better understood as a process driven by genetically abnormal desmosomes in cardiac myocytes, which leads to cell death and replacement with fibrofatty tissue.[12] At the time of our patient's original ARVC diagnosis, the diagnostic criteria were made of 6 major and minor categories, including RV structure and function, tissue characterization, repolarization abnormalities, depolarization abnormalities, arrhythmias, and family history.[1] He met only 1 of the minor criteria: moderate RV enlargement with reduced function. Today the diagnostic criteria have been updated to include specific quantitative measurements, MRI findings, and genetic criteria.[2] However, diagnosis remains a challenge for clinicians because of inherent difficulty in imaging the RV and low specificity of many electrocardiographic findings. Paradoxically, ARVC may also involve the left ventricle, with some series showing this finding in over 60% of patients. [13] The LV involvement is characterized most by late gadolinium enhancement in the subepicardium or midmyocardium representing fibrosis.[13] This can be seen in the setting of LV systolic dysfunction or without dysfunction.

The submitral LV aneurysm described in our case is an entity distinct from the LV phenotype of ARVC. First, the patient did not fulfill 2010 Task Force Criteria for ARVC. Second, the cardiac MRI did not show late gadolinium enhancement in the left ventricle. The outpouching seen in our patient's RV was likely secondary to the readjustment of his ICD. Upon review of our patient's studies from his original presentation, the submitral aneurysm was present and possibly overlooked. It is likely that this aneurysm was the driver of his arrhythmias all along, as opposed to a diagnosis of ARVC.

Conclusion

This case illustrates the importance of careful clinical review of and re-evaluation of all diagnoses via multimodality imaging and interpretation, in the setting of the clinical presentation. Rare clinical entities such as submitral aneurysm can often be missed, leading to delayed diagnosis and inappropriate treatment. In addition, incorrect diagnoses, such as ARVC, can have ramifications on patients' lifestyles, as well as their family members. Furthermore, the rare case of submitral LV aneurysmal VT can present in such a manner and catheter ablation is a viable strategy for treatment.

Appendix

Supplementary data

Supplementary data associated with this article can be found in the online version at https://doi.org/10.1016/j.hrcr.2021.05.014.

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