

Congenital left ventricular wall defects presenting with ventricular arrhythmias: A case series



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Introduction

Congenital left ventricular aneurysms (LVA) and left ventricular diverticula (LVD) are ventricular wall defects without a known genetic cause. LVA are characterized by akinetic or dyskinetic walls composed of fibrous tissue, whereas LVD contain 3 intact myocardial layers with preserved contractility.¹ Estimated prevalence is 0.3% for LVA and 0.4% for LVD,² which may be an underestimation, since many individuals with LVA/LVD are asymptomatic and routine imaging modalities such as transthoracic echocardiography (TTE) are insensitive in detection.² Among individuals with congenital LVA/LVD, the risk of ventricular arrhythmias is 13%–18%, which is significantly greater than in the general population.^{1,3} Owing to the heterogeneous clinical manifestations and because the majority of individuals with LVA/LVD have preserved left ventricular ejection fraction (LVEF),³ traditional recommendations for primary prevention implantable cardioverter-defibrillators (ICD) do not apply and identifying individuals at risk of sudden cardiac death (SCD) is challenging. We highlight 3 patients with congenital LVA/LVD presenting with ventricular arrhythmias. In each case, a congenital etiology was determined after excluding alternative causes. We highlight and discuss key issues regarding diagnosis, risk stratification, and management of arrhythmias in congenital LVA/LVD with insights for further investigation in larger patient cohorts.

KEYWORDS Electrophysiology study; Implantable cardioverter-defibrillator; Late gadolinium enhancement; Left ventricular aneurysm; Left ventricular diverticulum; Sudden cardiac death; Ventricular arrhythmia (Heart Rhythm Case Reports 2020;6:715–719)

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KEY TEACHING POINTS

- Congenital left ventricular aneurysms and diverticula (LVA/LVD) are rare but are a cause of ventricular arrhythmias that may be missed without increased clinical suspicion for an occult structural defect.
- Although there are no pathognomonic electrocardiogram (ECG) findings for LVA/LVD, baseline ECG abnormalities raise suspicion for an underlying cardiac abnormality, particularly in patients presenting with arrhythmias, and warrant further cardiac imaging during the diagnostic workup.
- Cardiac magnetic resonance is more sensitive in the diagnosis of congenital LVA/LVD than transthoracic echocardiography, and the presence of scar as quantified by late gadolinium enhancement may be helpful in risk stratification.
- Inducibility of ventricular tachycardia during electrophysiology study is a potential risk stratification tool for sudden cardiac death prevention in the congenital LVA/LVD population.
- Management strategies for LVA/LVD-associated ventricular arrhythmias include antiarrhythmic medications, ablation, implantable cardiac defibrillator, or, if conservative measures fail, surgical resection.

Case series

Patient 1

A 20-year-old woman was diagnosed with a congenital LVD by TTE as an infant after presenting with frequent premature ventricular contractions (PVCs). Coronary angiography at 7 days of age excluded coronary abnormalities. Annual

follow-up in pediatric cardiology clinic with regular Holter monitor and exercise treadmill testing revealed minimal baseline monomorphic PVCs that were suppressed during exercise. Her exercise capacity remained normal. TTE performed every 2 years showed a large, basal anterolateral LVD with contractile myocardium and preserved LVEF.

At age 16, cardiac magnetic resonance imaging (CMR) without gadolinium demonstrated a $2.8 \times 1.3 \times 0.5$ cm contractile LVD; dimensions were unchanged from prior TTEs. One year later, Holter monitoring revealed increasing PVC burden (9%) without nonsustained ventricular tachycardia (NSVT). Over the next 3 years, she remained asymptomatic with preserved LVEF and PVC burden varying between 6% and 9%. At age 20, Holter demonstrated a 4-beat run of NSVT. An implantable loop recorder was recommended for continuous monitoring but the patient declined, opting to continue with her usual surveillance routine.

Two months later, she suffered a ventricular fibrillation (VF) arrest at work. After resuscitation, an electrocardiogram (ECG) showed frequent PVCs localized to the basal anterolateral area of her LVD (Figure 1). Post-cardiac arrest care was provided and she made a full neurologic recovery. A single-chamber subpectoral ICD was implanted for secondary prevention and she was discharged home on metoprolol succinate. She returned to normal activities and after 2 years remains asymptomatic without ICD therapies.

Patient 2

A 65-year-old woman presented with recurrent transient episodes of slurred speech and right hand tingling suspected to be transient ischemic attacks (TIA). Computed tomography angiography of the head and neck and magnetic resonance imaging of the brain were negative for acute intracranial pathology but revealed chronic left cerebellar infarcts. TTE showed preserved LVEF without apparent structural defect. She was discharged with a 30-day cardiac event monitor and subsequently experienced TIA symptoms while exercising at home. Cardiac monitor demonstrated a single episode of VT at a rate of 200 beats per minute for 59 seconds (Figure 2) at the time of her TIA event.

Further workup including coronary angiography revealed no significant coronary artery disease. CMR with gadolinium revealed 2 LVAs. One was akinetic, $2.5 \times 1.7 \times 2.4$ cm, and located beneath the mitral valve annulus (Figure 2). The other was dyskinetic, $1.6 \times 0.8 \times 1.4$ cm, and located along the mid-inferior left ventricle (LV). Late gadolinium enhancement (LGE) was demonstrated within the smaller aneurysm, suggesting myocardial fibrosis or scar. Thrombus was not detected in either aneurysm. A secondary prevention ICD was implanted and metoprolol succinate was started. Apixaban was also prescribed, given the likelihood that her cerebellar infarcts and TIAs were thromboembolic sequelae of her LVAs. After 3 years, the patient has remained asymptomatic without a recurrent TIA or ICD therapies.

Patient 3

A 40-year-old female long-distance runner presented with fatigue and decreased exercise tolerance. An ECG revealed frequent PVCs and TTE showed preserved LVEF without obvious structural abnormalities. A 24-hour Holter monitor showed a 35% burden of monomorphic PVCs with occasional runs of NSVT up to 16 beats. Metoprolol failed to reduce her PVC burden and she chose to undergo PVC ablation. PVCs were mapped to the inferior LV base and were successfully eliminated with radiofrequency ablation (Figure 3). During the procedure, the catheter engaged easily and more basally than expected. Given suspicion for a structural abnormality missed on TTE, CMR with gadolinium was performed and revealed a dyskinetic, $2.3 \times 3.0 \times 1.5$ cm aneurysm at the inferior LV base without LGE.

The patient's fatigue improved after ablation and PVC burden decreased to 2% on follow-up cardiac monitor. The next year, however, mild fatigue recurred. Holter monitor showed a 3.6% PVC burden and a 6-beat run of NSVT. She underwent an electrophysiology study (EPS) as risk stratification for SCD. As VT was noninducible, an ICD was not implanted, and close surveillance was planned instead. She has remained asymptomatic without significant ventricular arrhythmias.

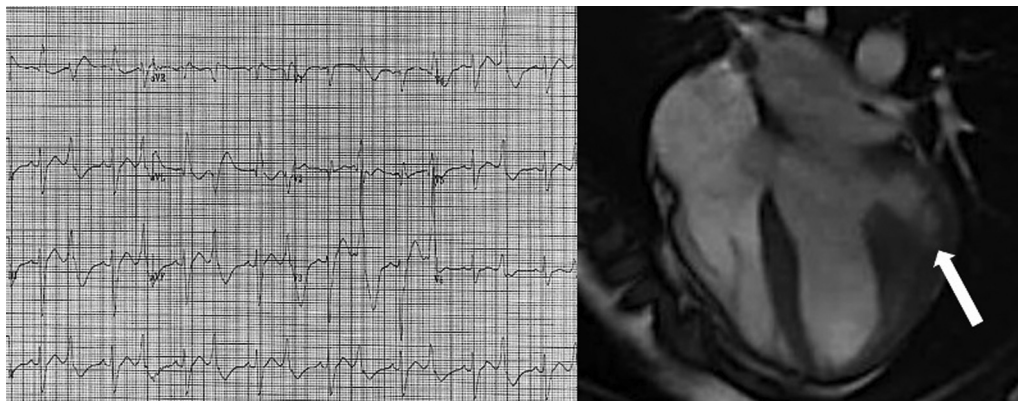


Figure 1 Twelve-lead electrocardiogram (ECG) at presentation (left) and cardiac magnetic resonance imaging (right) for patient 1. ECG shows premature ventricular contractions following ventricular fibrillation arrest localized to her basal anterolateral left ventricular diverticulum (white arrow).



Figure 2 Ventricular tachycardia onset (top left), signal-averaged electrocardiogram (ECG) (bottom left), and cardiac magnetic resonance imaging (CMR) (right) for patient 2. Cardiac monitor rhythm strip shows onset of 59-second episode of ventricular tachycardia. Evidence of late potentials on signal-averaged ECG raised suspicion for scar and this was confirmed with late gadolinium enhancement on CMR. The larger, anterior basilar aneurysm is appreciated in the CMR image (*white arrow*).

Discussion

Clinical presentation and diagnosis of arrhythmogenic LVA/LVD

Congenital LVA/LVD are rare, often asymptomatic structural cardiac defects with a wide spectrum of clinical mani-

festations. Morbidity and mortality in LVA/LVD patients are mainly related to heart failure, lesion rupture, thromboembolism, and ventricular arrhythmias ranging from occasional PVCs to SCD.¹ Because our patients presented with LVA/LVD-associated ventricular arrhythmias, we focus on

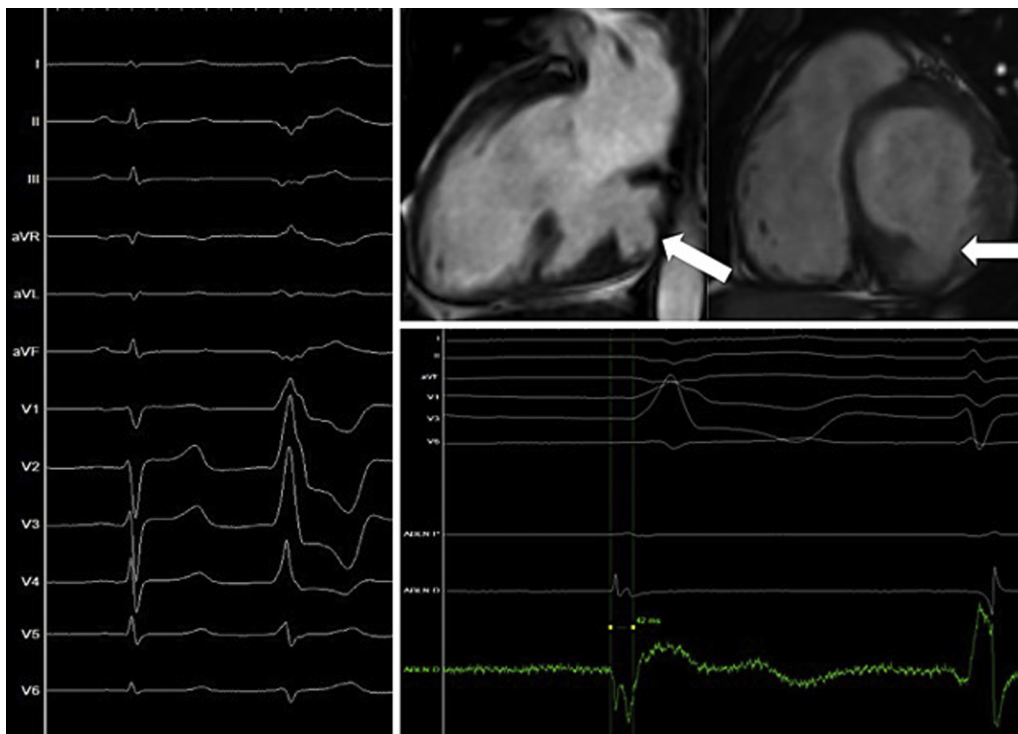


Figure 3 Twelve-lead electrocardiogram of a premature ventricular contraction (PVC) (left) originating from the posterior basilar left ventricular aneurysm (top right, *white arrows*) and intracardiac electrogram (bottom right) for patient 3. Intracardiac electrogram shows the ablation catheter mapping PVCs to the posterior mitral annulus region. During ectopy, local activation preceded the QRS complex onset by 42 ms. Ablation at the site of the QS complex at the unipolar distal ablation electrode successfully eliminated PVCs.

the diagnosis and management of arrhythmic sequelae of LVA/LVD. For patients 2 and 3, LVA-related symptoms did not manifest until adulthood, consistent with an average age of diagnosis being the fourth to fifth decade.¹ Congenital LVA/LVD is a diagnosis of exclusion, particularly in patients over the age of 20 years. After thorough workup (Supplement), it is our opinion that the LVA/LVD in these patients is congenital in origin.

In the majority of patients with congenital LVA/LVD and ventricular ectopy, the arrhythmogenic origin is localized to the LVA/LVD,³ which is corroborated in our small series. Although most patients with LVA/LVD-associated ventricular arrhythmias initially present with palpitations or syncope,³ our patients had variable clinical presentations ranging from fatigue to neurologic symptoms to cardiac arrest. LVA was not visualized on initial TTE for patients 2 and 3, consistent with prior reports that TTE is an insensitive modality for LVA/LVD detection.² Given clinical suspicion for an occult structural or infiltrative etiology of their arrhythmias, diagnosis was ultimately made by CMR. CMR should be considered in patients with ventricular ectopy, particularly of LV non-outflow tract origin (superior axis, right bundle branch block morphology) like patient 3, to screen for structural abnormalities including LVA/LVD.

Although baseline ECG irregularities occur in over half of LVA/LVD patients, the abnormalities are variable and nonspecific and include atrial and ventricular conduction delays, pathologic Q waves, delayed precordial R-wave progression, and repolarization abnormalities.^{1,3,4} All patients in our series had ECG abnormalities during sinus rhythm (Supplementary Figures 1–3): left bundle branch block and delayed precordial R-wave progression (patient 1), nonspecific ST depression and T-wave abnormalities (patient 2), and right axis deviation and abnormal QRS-T angle (patient 3). Despite the lack of pathognomonic ECG findings for LVA/LVD, among patients presenting with ventricular arrhythmias baseline ECG abnormalities raise suspicion for an underlying cardiac abnormality and warrant further cardiac imaging during the diagnostic workup.

Risk stratification of LVA/LVD-associated arrhythmias

Despite a higher incidence of ventricular arrhythmias among those with congenital LVA/LVD than in the general population, proper risk stratification of SCD in LVA/LVD patients is unknown. High-quality and consistent surveillance neither predicted nor prevented cardiac arrest in patient 1. In retrospect, a CMR with gadolinium may have aided decision-making regarding primary prevention ICD or further risk stratification with an EPS. LGE quantified on CMR is an accurate measure of myocardial fibrosis⁵ and may be a risk stratification tool for SCD in LVA/LVD patients; there is precedence for its prognostic utility in the hypertrophic cardiomyopathy population.⁶ LGE on CMR is associated with an increased risk of malignant ventricular arrhythmias in indi-

viduals with congenital LVA/LVD⁷ and in patients with hypertrophic cardiomyopathy-associated LVAs.⁸

As a risk stratification tool, an EPS assessing VT inducibility is better defined in patients with ischemic cardiomyopathy⁹ than in other structural abnormalities. However, considering the presence of scar in some LVA/LVD patients and limited clinical experience in this population, EPS may be considered in patients with NSVT and congenital LVA/LVD. Based on current guidelines, EPS can be a useful risk stratification tool for SCD prevention in patients with ischemic cardiomyopathy, nonischemic cardiomyopathy, or congenital heart disease who have ventricular arrhythmias and do not otherwise meet indications for a primary prevention ICD.¹⁰

Management of arrhythmic sequelae of LVA/LVD

The decision to implant an ICD in patient 2—who presented with cryptogenic TIAs and sustained VT originating from the LVA—was made based on extrapolation from secondary prevention guidelines in patients with nonischemic cardiomyopathy who experience hemodynamically unstable VT.¹⁰ Patient 2 also had LVA-associated LGE on CMR, which may signify increased risk for recurrent arrhythmic events.¹⁰ Thromboembolic complications, as seen in patient 2's case, occur in 3%–5% of patients with akinetic or dyskinetic congenital LVA/LVD.¹ Thus patient 2 was started on a direct oral anticoagulant. The decision to not implant an ICD in patient 3 was made, in part, owing to noninducibility of VT during EPS, extrapolated from data in patients with ischemic-related¹¹ and nonischemic-related VT.¹² She also had no LGE on CMR.

Because the congenital LVA/LVD population is at significantly higher risk of ventricular arrhythmias than the general population and based on our experiences outlined here, we recommend proactive cardiac rhythm monitoring once LVA/LVD is discovered. For individuals with increasing burden of ventricular ectopy or NSVT, like patient 1, it is now our practice to risk-stratify by CMR with gadolinium and/or EPS to assess for VT inducibility. The patients in our series have remained asymptomatic and without recurrent arrhythmias with medical therapy (patient 1 and 2) and PVC ablation and medical therapy (patient 3). We plan to follow cardiac function and LVA/LVD size by CMR for all patients. Surgical resection of the LVA/LVD is an option in the case of heart failure or intractable ventricular arrhythmias unresponsive to drug or ablation therapy; however, perioperative mortality was 7% and 15.3% for LVD and LVA, respectively, in the largest case series.¹

There is a paucity of data regarding proper risk stratification and prevention of SCD in LVA/LVD patients. We extrapolated literature on prognostication and management of ventricular arrhythmias due to nonischemic and ischemic causes to the care of our patients. Further research tailored to congenital LVA/LVD patients is needed, particularly as increasingly sophisticated cardiac imaging may uncover LVA/LVD more frequently. Future

areas of study in this population include determining the prognostic value of LGE on CMR; evaluating the predictive value of VT inducibility on EPS; assessing VT ablation outcomes; and refining the true prevalence of LVA/LVD, risk factors for SCD, and long-term outcomes based on epidemiologic studies and multicenter registries.

Conclusion

Although documented in case reports and series, no standard for risk stratification and management exists for arrhythmic sequelae of congenital LVA/LVD. The heterogeneous presentation of our 3 patients with arrhythmogenic congenital LVA/LVD highlights the spectrum of clinical phenotypes characteristic of this structural defect. Nonetheless, uniform strategies for diagnosis, risk stratification, and management of asymptomatic and symptomatic patients are needed. The use of ambulatory cardiac rhythm monitoring, CMR with gadolinium, and EPS are potential risk stratification tools for SCD in congenital LVA/LVD patients who are not otherwise candidates for ICD. Those with inducible VT could undergo ablation and/or ICD placement. Further research investigating risk factors for adverse outcomes would be instructive and aid in the development of concrete risk-stratification strategies in these patients.

Appendix

Supplementary data

Supplementary data associated with this article can be found in the online version at <https://10.1016/j.hrcr.2020.06.026>.

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