

Left Ventricular Noncompaction Cardiomyopathy

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Abstract

Left ventricular noncompaction cardiomyopathy (LVNC) is a disease associated with ventricular hyper-trabeculation. LVNC occurs due to the arrested development of endomyocardial morphogenesis. On imaging using echocardiography and cardiac MRI, the pathology results in a 2-layered myocardium consisting of a thin epicardial compacted layer and a thicker noncompacted endocardial layer. The primary goal of imaging is to ascertain the presence of other structural cardiac abnormalities and calculate the ratio of the noncompacted to compacted layer to confirm LVNC. This disease in patients can be asymptomatic or lead to, most commonly, heart failure, arrhythmias, and thromboembolism. While surgical measures, including transplantation, can be curative in advanced disease, LVNC is primarily managed with risk stratification and further medical management.

Keywords: cardiac, myopathy, heart failure

Case Summary

A preadolescent girl with a history of attention-deficit hyperactivity disorder presented for cardiovascular clearance for medication. On physical exam, there were normal vital signs and a harsh III/VI holosystolic murmur at the left mid-sternal border radiating throughout the precordium.

Imaging Findings

A transthoracic echocardiogram showed a small perimembranous ventricular septal defect with left to right shunting and prominent trabeculations in the left ventricle (LV) (Figure 1). Cardiovascular magnetic resonance (CMR) showed prominent trabeculations of the

mid to apical left and right ventricular walls (Figure 2). The noncompacted to compacted ratio was 4:1, consistent with noncompaction cardiomyopathy, congenital heart disease type. The patient's older brother was screened with a CMR that showed prominent trabeculations in the mid to apical left and right ventricle consistent with noncompaction cardiomyopathy (Figure 3).

Diagnosis

Left ventricular noncompaction cardiomyopathy (LVNC).

The differential diagnosis for LVNC is broad but includes dilated, restrictive, and hypertrophic cardiomyopathies, as well as aberrant chordae tendineae and intramyocardial hematoma.

Discussion

LVNC, also known as noncompaction cardiomyopathy or hyper-trabeculation syndrome, is a form of cardiomyopathy characterized by increased left ventricular trabeculations and prominent deep intertrabecular recesses.¹ Though the exact cause of this development is unknown, it is theorized that LVNC occurs due to the arrested development of normal endomyocardial morphogenesis leading to a 2-layered myocardium consisting of a thin compacted epicardial layer and a thicker noncompacted endocardial layer.² The clinical manifestations of LVNC are highly diverse as the primary clinical presentations include arrhythmias, sudden death, heart failure, and/or thromboembolic events. The most common presentation of LVNC is heart failure, occurring in 46% of cases, which can be due to systolic dysfunction, diastolic dysfunction, or combination systolic and diastolic dysfunction. LVNC can also be diagnosed in asymptomatic patients, which occurs in approximately 35% of cases.³ In some cases, LVNC is associated

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Disclosures: The authors have no conflicts of interest to disclose. None of the authors received outside funding for the production of this original manuscript and no part of this article has been previously published elsewhere.

Figure 1. Parasternal long-axis transthoracic echocardiogram with color Doppler in systole showing a small perimembranous ventricular septal defect with left to right shunting (yellow arrow). LV, left ventricle.

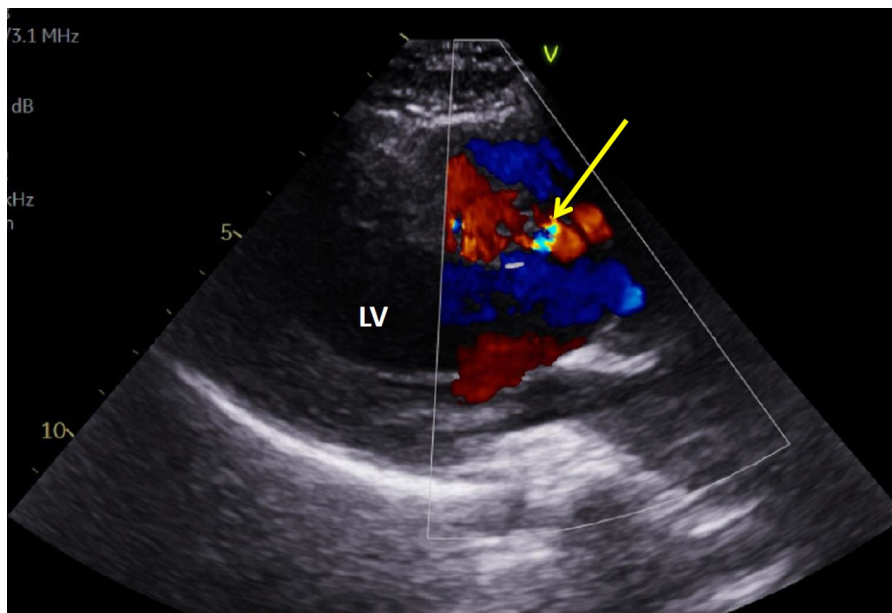
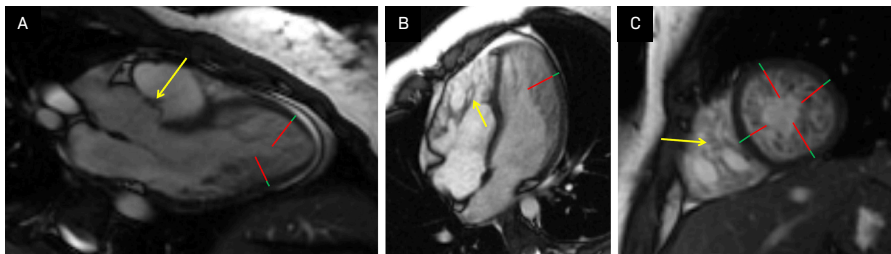


Figure 2. (A) Three-chamber cardiovascular magnetic resonance (CMR) cine steady-state-free precession (SSFP) at end diastole showing prominent trabeculations (red line) of the mid to apical left ventricular anteroseptal and inferolateral walls with a thin compacted layer of myocardium (green line). There is left to right shunting through the small perimembranous ventricular septal defect (yellow arrow). (B) Four-chamber CMR cine SSFP at end diastole showing prominent trabeculations (red line) of the mid to apical left ventricular inferoseptal and anterolateral walls with a thin compacted layer of myocardium (green line). There are prominent trabeculations of the mid to apical right ventricular free wall (yellow arrow) as well. (C) Apical short-axis CMR cine SSFP at end diastole showing prominent trabeculations (red lines) of the left ventricular apical walls with a thin compacted layer of myocardium (green line). There are prominent trabeculations of the apical right ventricular free wall (yellow arrow).



with congenital heart disease, complicating outcomes in these patients. Abnormal ECGs are common in pediatric patients with LVNC; however, these abnormalities are nonspecific to the disease. These nonspecific abnormalities include increased QRS voltages, ST-T changes, T-wave inversion, ventricular tachycardias, supraventricular tachycardias, and atrioventricular reentry tachycardias. Also, there are several reports noting the presence of left ventricular thrombi

related to the trabeculations, especially those in pediatric patients with left ventricular ejection fractions <40%.³

Although this cardiomyopathy has remained unclassified by the World Health Organization, the American Heart Association labeled it as a primary cardiomyopathy of genetic origin in 2006.¹ Genetic variability is exceptionally high in LVNC, as with other cardiomyopathies. Familial cases of LVNC are typically autosomal dominant. Sporadic forms of

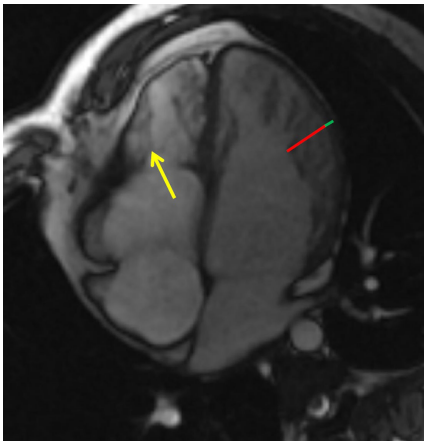
LVNC are attributed to idiopathic or acquired causes such as neuromuscular disorders like myotonic dystrophy due to increased hemodynamic load on the LV, which causes a remodeling process of the myocardium. LVNC can be diagnosed at any age, and its prevalence, according to large-scale studies using echocardiography, is between 0.02% and 0.14%.³ LVNC has been shown to have a higher prevalence in the pediatric population.⁴ LVNC occurs in men more often than in women.⁵ In the pediatric population, the reported number of LVNC cases is increasing, likely due to improved imaging accuracy rather than an actual increase in cases. However, since a gold standard of diagnosis of LVNC does not exist, this disease's true incidence and prevalence still need to be clarified.

Transthoracic echocardiography is the initial noninvasive diagnostic modality used to evaluate for LVNC. Echocardiographic features of LVNC include a bilayered mural appearance of the LV, with a hypoechoic inner layer of the left ventricular wall representing the noncompacted layer.

The most often used diagnostic criteria to confirm LVNC are those proposed by Jenni et al, which necessitate the absence of other coexisting cardiac abnormalities, 2-layer myocardial structure with thin compacted and thicker noncompacted myocardium, excessive prominent trabeculations and deep intertrabecular recesses, as well as a calculated ratio of noncompacted myocardium to compacted myocardium at the end of systole in the short-axis view to be >2:1 using echocardiography.^{6,7} The most apparent trabeculations are usually observed in the apex, as well as in the mid-lateral and mid-inferior segments of the LV. Noncompaction can also affect the right ventricle alone or associated with left ventricular noncompaction as well. An echocardiogram with contrast or 3D echocardiography can be helpful if the LV chamber is challenging to visualize.³

CMR is a secondary diagnostic method with better contrast resolution

Figure 3. Four-chamber cardiovascular magnetic resonance (CMR) cine steady-state-free precession (SSFP) at end diastole of the presenting patient's older brother showing prominent trabeculations (red line) of the mid to apical left ventricular inferoseptal and anterolateral walls with a thin compacted layer of myocardium (green line). There are prominent trabeculations of the mid to apical right ventricular free wall (yellow arrow).



than echocardiography, allowing for enhanced visualization of anatomic details, especially in patients with difficult acoustic chest windows.³ CMRI should be performed to confirm the diagnosis of LVNC after initial echocardiography. CMRI better shows myocardial trabeculae at the end of diastole. Diagnostic criteria for LVNC using CMR are detailed in adults but have yet to be outlined for a pediatric diagnosis. The preferred diagnostic criteria to confirm LVNC using cardiac magnetic resonance are those proposed by Petersen et al, which necessitate a calculated ratio during end diastole of noncompacted to compacted myocardium to be $>2.3:1$.⁸

There is no specific therapy for patients with LVNC. However, most treatment strategies are directed toward improving heart failure and managing significant arrhythmias. For patients with LVNC and associated ventricular systolic dysfunction, medications like angiotensin-converting enzyme inhibitors, angiotensin receptor II inhibitors, and beta-adrenoreceptor blockers, like the treatment of dilated cardiomyopathy, are often used. These medications prevent further cardiac

remodeling and are cardioprotective. For adults with LVNC, warfarin anticoagulation has been shown to be more effective than direct oral anticoagulants in reducing the known risk of thromboembolism. Children with LVNC who have concomitant arrhythmias such as Wolff-Parkinson-White syndrome may benefit from catheter ablation therapy, which may result in improvement of systolic function. Other more invasive treatments, such as cardiac surgery to correct concomitant congenital cardiac abnormalities such as bicuspid aortic valve or mitral regurgitation and cardiac transplantation for advanced heart failure, have been reported in patients with LVNC.⁹

The prognosis of patients with LVNC without complications is fair. Patients with LVNC who are complicated by heart failure, arrhythmias, and thromboembolism are likely to have reduced life expectancy. The prognosis is poor in patients with LVNC, in addition to concomitant congenital cardiac abnormalities, leading to possible sudden cardiac death. A meta-analysis assessing the predictive value of late gadolinium enhancement (LGE) for future major adverse cardiovascular events in LVNC by Grigoratos et al suggests that patients without LGE have better prognosis than those with LGE.⁹ Prognosis depends on whether a patient has isolated LVNC, LVNC with concomitant cardiovascular diseases, electropathology, and, more recently, LGE. Long-term follow-up and cardiac monitoring of patients with LVNC are essential strategies to optimize patient outcomes and improve quality of life.

Conclusion

LVNC is a disease associated with ventricular hyper-trabeculation. LVNC occurs due to the arrested development of endomyocardial morphogenesis. On imaging using echocardiography and cardiac MRI, the pathology results in a 2-layered myocardium consisting of a thin epicardial compacted layer and a

thicker noncompacted endocardial layer. The primary goal of imaging is to ascertain the presence of other structural cardiac abnormalities and calculate the ratio of the noncompacted to compacted layer to confirm LVNC. This disease in patients can be asymptomatic or lead to, most commonly, heart failure, arrhythmias, and thromboembolism. While surgical measures, including transplantation, can be curative in advanced disease, LVNC is primarily managed with risk stratification and further medical management.

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