**Case
Report**

Aortic Valve Replacement for Aortic Regurgitation with Rare Left Ventricular Non-Compaction

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Left ventricular noncompaction cardiomyopathy is a rare type of congenital cardiomyopathy characterized by prematurely arrested compaction of the endocardial and myocardial fibers and the progressive deterioration of left ventricular contractility. This entity is a genetically heterogeneous disorder and has a wide spectrum of presentation from no symptoms to critical disabling congestive heart failure, which can appear at any age. The prognosis is therefore varied. An elderly patient with left ventricular noncompaction underwent aortic valve replacement for associated aortic regurgitation. Follow-up at two years after surgery revealed an improved clinical condition and recovered cardiac function. This is the fourth known aortic valve replacement in a patient with left ventricular noncompaction.

Keywords: cardiomyopathy, ventricular noncompaction, aortic valve replacement

Introduction

Left ventricular noncompaction cardiomyopathy (LVNC) is believed to be a morphogenetic abnormality involving arrested compaction of the loose myocardial meshwork during early embryogenesis.¹⁾ The World Health Organization categorizes LVNC as an unclassified cardiomyopathy.²⁾ The pathophysiology of this abnormality is the progressive deterioration of LV systolic function,¹⁾ but the cause remains controversial. A relationship between coronary micro-circulatory dysfunction and subendocardial ischemia is suspected.^{3,4)} The triad of heart failure, systemic embolism and arrhythmias is the major clinical presentation when the LV systolic function deteriorates.^{1,5)} Various non-invasive imaging modalities have been

used to diagnose LVNC including echocardiography, magnetic resonance imaging and computed tomography. Left ventricular noncompaction was initially considered as one cause of critical congestive heart failure in a pediatric population,¹⁾ but this abnormality has been identified in an adult population due to advances in imaging techniques.⁶⁾ Cardiac surgery for adult patients with LVNC has rarely been reported. Here we describe aortic valve replacement to treat aortic regurgitation (AR) in a patient with LVNC.

Case Report

A 74-year-old woman without a family history of cardiovascular disease or sudden death was referred to our hospital with dyspnea that had persisted for three months. The physical findings were unremarkable except for a diastolic murmur at the left sternal edge. A chest x-ray showed cardiomegaly with a cardiothoracic ratio of 70%. Plasma levels of brain natriuretic peptide (BNP) and noradrenalin were elevated to 1540 and 481 pg/ml, respectively. Transthoracic echocardiography revealed extreme regurgitation of the tricuspid aortic valve and diffuse left ventricular (LV) hypokinesis that was particularly severe in the apex, lateral and posterior walls at the mid-ventricular and basal level. The aortic annulus was 23 mm in

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Fig. 1 Two-dimensional echocardiographic appearance of the left ventricle on apical 3-chamber view. (A) noncompacted area along the posterior and lateral wall showing meshwork of trabeculations and intratrabecular recesses (arrowheads), (B) contrast echocardiography showing the direct perfusion of intratrabecular recesses (arrow).

diameter on apical longitudinal axis view. The hypokinetic wall was a bilayered myocardial structure with a thin compacted epicardial layer and a thicker, non-compacted endocardial layer comprising hypertrabeculations and deep intertrabecular recesses. Contrast echocardiography showed a direct passage between the LV cavity and the deep intertrabecular recesses (**Fig. 1**). The ratio of non-compacted to compacted thickness was about 2:3, which met the diagnostic criteria for LVNC. The left ventricular end-diastolic diameter and ejection fraction (LVEF) were 53.6 mm and 42.2%, respectively. No other cardiac anomaly was evident. Cardiac catheterization showed Sellers grade 3 AR and LV dilatation with an end-diastolic volume of 233 mL (volume index of 226 mL/m²). No morphological abnormality of sinus of Valsalva or sinotubular junction was detected (**Fig. 2**). No significant coronary artery disease was found. The diagnosis was severe AR and LVNC, presenting with New York Heart Association (NYHA) functional class 3 chronic heart failure. She was treated conventionally with medication for heart failure, including an angiotensin-converting enzyme inhibitor and a diuretic and aortic valve replacement was scheduled.

The chest was opened through a median sternotomy and a cardiopulmonary bypass was established by aortic cannulation into the ascending aorta and venous cannulation via the right atrium. Cardiac arrest was established with selective antegrade cold crystalloid. Prominent trabeculations in the left ventricular cavity were observed through the left ventricular outflow tract. The aortic valve had slightly thickened cusps and this was replaced with a 23-mm Carpentier-Edwards PERIMOUNT Magna (Edwards Lifesciences LLC, Irvine, CA, USA) in the supra-annular position.

Aortic regurgitation had arisen due to dilatation of the aortic annulus. The patient's postoperative course was uneventful, and she was discharged on postoperative day 27 under medication with an oral anticoagulant, heart failure medication and a beta blocking agent.

Echocardiography one year later showed improved left ventricular function with a LV end-diastolic diameter of 48.1 mm and a LVEF of 54.8%. The patient remained free of cardiac events at two years, when the symptoms of heart failure improved to NYHA functional class 1. Echocardiography at that point showed the persistent recovery of left ventricular function with a LV end-diastolic diameter of 37.7 mm and a LVEF of 64.9%. The characteristic features of non-compaction remained unchanged.

Discussion

Left ventricular non-compaction is a rare congenital cardiomyopathy with a genetic origin that is characterized by numerous, excessively prominent trabeculations and deep intratrabecular recesses.¹⁾ This cardiomyopathy is genetically heterogeneous and can be inherited as an autosomal dominant or X-linked recessive disorder.^{7,8)} Echocardiography is considered the reference standard for a diagnosis of LVNC. Multiple trabeculations and deep recesses communicate with the ventricular cavity and the ratio of non-compacted to compacted myocardial thickness is above 2.^{5,6)} Apical and mid-ventricular segments of both inferior and lateral walls are commonly affected. The prevalence of LVNC ranges from 0.05% to 0.24% per year in echocardiographic databases.⁶⁾ In pediatric patients,

Fig. 2 Aortography revealed Sellers grade 3 AR. The morphology of sinus of Valsalva and sinotubular junction was normal.

LVNC often coexists with other cardiac and extracardiac anomalies such as facial dysmorphism, and the mortality rate is high due to disabling heart failure or sudden death.¹⁾ On the other hand, LVNC is a distinct entity in adults that has a wide spectrum of presentation from asymptomatic to symptomatic.⁹⁾ The prognosis is therefore varied and clearly better for asymptomatic, than for symptomatic patients.⁶⁾ A larger LV end-diastolic diameter at the time of initial presentation, NYHA functional class 3/4 and chronic atrial fibrillation are significantly more frequent clinical characteristics of non-survivors than in long-term survivors of LVNC.⁵⁾ However, asymptomatic and symptomatic non-compaction remain morphologically indistinct. Gene analysis for the pathophysiology of LVNC has been recently performed. Shan et al. speculate that genes encoding ion channels are involved in the pathophysiology of LVNC, demonstrating higher prevalence of human cardiac sodium channel alpha-subunit gene (SCN5A) variants in patients with heart failure than in those without.¹⁰⁾ They suggest the presence of SCN5A variants increases the severity of LVNC.¹⁰⁾

A cure for LVNC has not yet been established. Heart failure, arrhythmia and oral anticoagulation (to prevent systemic emboli) in patients with LV systolic dysfunction are therefore managed by palliative therapies and heart transplantation is recommended for refractory heart failure.⁵⁾ Our patient presented with chronic heart failure and mild LV systolic dysfunction. Hence, similar to treatment for other cardiomyopathies, we replaced

the aortic valve after introducing medication to treat the heart failure. The postoperative course was uneventful. Although intraoperative air trapping from the LV cavity required careful monitoring because of very deep recesses, standard valve replacement was feasible.

To our knowledge, only three case reports have described aortic valve replacement for aortic valve diseases in patients with LVNC.^{11–13)} The associated diseases comprised aortic stenosis in one and aortic regurgitation in two due to a congenital bicuspid valve. This report is the fourth documented replacement of an aortic valve in a patient with LVNC and associated AR due to dilatation of the aortic annulus. Left ventricular noncompaction often coexists with other cardiovascular anomalies. Coexistence with anomalies involving bicuspid aortic valve, ventricular septal defect, sinus of Valsalva aneurysm and aortic coarctation was reported.^{14,15)}

Cardiovascular extracellular matrix (ECM) is implicated in cardiovascular development and adult homeostasis. Therefore, defects in ECM or its modifying enzymes could cause of both congenital and adult-onset cardiovascular disorders. Versican is a large chondroitin sulfate proteoglycan of the ECM, which is cleaved by proteases of the ADAMTS (A Disintegrin-like and Metalloprotease domain with ThromboSpondin type 1 motifs) family.¹⁶⁾ It was suggested that versican cleavage was required for correct cardiovascular development and adult homeostasis in a recent report in which mice with reduced versican cleavage due to ADAMTS9 haploinsufficiency were analyzed.¹⁷⁾ In this report, anomalies in the aortic wall, valvulosis and valve leaflets were specifically found in adult mice with ADAMTS9 haploinsufficiency, and furthermore, left ventricular noncompaction was also found in mice with that.¹⁷⁾ In present case left ventricular noncompaction coexisted with dilatation of the aortic annulus, which may reflect common pathway in origin.

A long-term follow-up of 34 adult patients with LVNC showed that of the 35% of them died, half was due to sudden death, and 12% had received a heart transplant.⁵⁾ The prognosis of patients with LVNC is generally poor when clinically symptomatic or when LV systolic function deteriorates. Our patient presented with heart failure at the time of admission. Regardless, our patient's symptoms had improved within two years and the cardiac function has persistently recovered. Because our patient's clinical presentation appeared after a long asymptomatic course, we presumed that she had LVNC with a favorable prognosis, and that severe

AR rather than LVNC worsened her clinical condition. Therefore, our patient's clinical condition might have been improved by the aortic valve replacement.

Conclusion

The present case indicates that cardiac surgery for associated valve disease can improve the clinical condition and recover cardiac function even among patients with left ventricular non-compaction.

Disclosure Statement

We disclose that we have no conflict of interest.

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