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[CASE REPORT]

Mitral Ebstein's Anomaly Modified with a Scarred Rhabdomyoma in Tuberous Sclerosis: An Extremely Rare Cause of Mitral Insufficiency

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Abstract:

We present an extremely rare case of mitral Ebstein's anomaly that resulted in severe mitral regurgitation (MR). A 41-year-old woman with a history of tuberous sclerosis underwent surgery. Preoperatively, it was assumed that MR had occurred due to leaflet tethering related to left ventricular posterior wall motion asynergy due to a scarred rhabdomyoma. However, surgical inspection revealed a dysplastic posterior leaflet adhering to the ventricular wall, which was completely covered by the endocardium. Both congenital mitral Ebstein's anomaly and acquired wall motion abnormality due to a scarred rhabdomyoma may have contributed to the development of severe MR in this case.

Key words: Ebstein's anomaly, mitral valve, plastering, mitral regurgitation, tuberous sclerosis, delamination failure

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Introduction

Ebstein's anomaly is a rare congenital heart disorder of the tricuspid valve and right ventricle (RV), which is characterized by adhesion of the posterior and septal tricuspid leaflets to the underlining myocardium, downward displacement of the functional tricuspid annulus, and dilation of the atrialized portion of the RV (1). Thus, this congenital malformation is generally associated with various degrees of tricuspid regurgitation and RV dysfunction (2).

On the other hand, tuberous sclerosis is an inherited neurocutaneous disorder that is characterized by pleomorphic features that involve many organs, including multiple benign hamartomas of the brain, heart, lungs, liver, kidneys, and skin (3). Rhabdomyoma, which is the most common pediatric cardiac tumor, is the characteristic cardiac involvement of tuberous sclerosis (4). Rhabdomyomas are typically multifocal, mostly asymptomatic, usually regress over time, and rarely require surgical intervention (5).

We herein present an extremely rare case of mitral Ebstein's anomaly as a cause of severe mitral regurgitation (MR) in combination with a left ventricular (LV) wall motion abnormality due to a scarred rhabdomyoma that occurred in association with tuberous sclerosis.

Case Report

A 41-year-old woman was admitted to our institution for the evaluation of MR and LV systolic dysfunction. She had a medical history of tuberous sclerosis, which included West syndrome, bilateral renal angiomyolipomas, and pulmonary lymphangioleiomyomatosis. Regarding cardiac involvement, rhabdomyomas had been detected by transthoracic echocardiography at 5 months of age. Most notably, a remarkable tumor was located in the left ventricle, which spontaneously regressed when the patient was 6 years of age. After developing leg edema at 19 years of age, the patient underwent transthoracic echocardiography, which revealed basal- to mid-posterolateral wall asynergy and the presence of moder-

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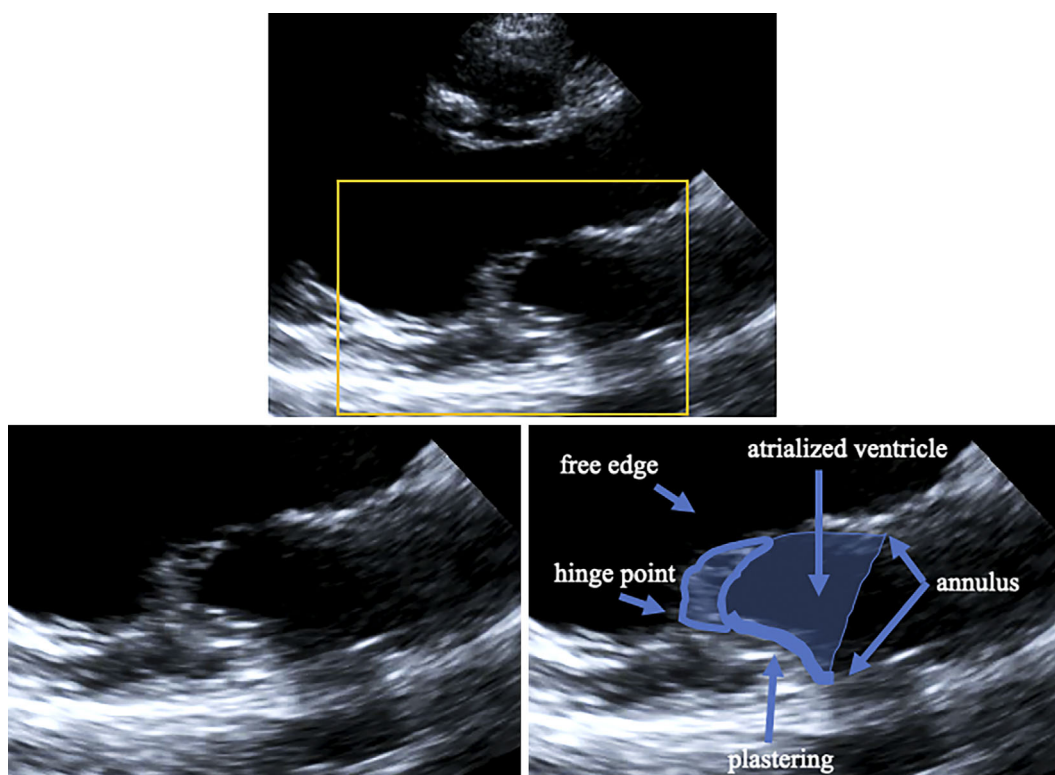


Figure 1. Transthoracic echocardiography of a 41-year-old woman with mitral Ebstein's anomaly. The parasternal long-axis view shows that the hinge point of the posterior mitral leaflet is apically displaced due to adhesion to the ventricular wall. As a result, the coaptation point is displaced downward and towards the left ventricular apex.

ate MR. At that time, however, the global LV contractile function was preserved, with an ejection fraction of 62%. She subsequently underwent regular cardiac check-ups. Although her LV contractile function had been preserved for years, the LV ejection fraction gradually decreased and her MR progressively deteriorated. At 29 years of age, she underwent bilateral nephrectomy for ruptured renal angioliomas. Renal replacement therapy was subsequently initiated.

On admission, the patient's blood pressure was 106/60 mmHg, her heart rate was 72 beats/min, and her oxygen saturation was 98% (room air). Auscultation revealed a harsh holo-systolic murmur at the apex, which radiated to the axilla. On inspection, slight pretibial edema was observed. Transthoracic echocardiography revealed that the LV end-diastolic and end-systolic dimensions were 43 mm and 31 mm, respectively, and the LV contractile function was decreased, with an ejection fraction of 47%. Notably, the basal- to mid-posterolateral wall of the LV was thin and showed a hyperechogenic appearance (Supplementary material 1), presumably indicating myocardial scarring associated with the regression of the cardiac rhabdomyoma (Fig. 1). Moreover, the thickened posterior leaflet of the mitral valve appeared to be tethered to the posterolateral wall, and the hinge point of the leaflet was displaced downward (Supplementary material 2). On the other hand, the anterior mitral leaflet was thickened and elongated; thus, the coaptation point of the mitral leaflets was also displaced downward to

the apex, resulting in significant MR (Supplementary material 3).

Exercise stress echocardiography was performed for the further assessment of the severity of MR and its hemodynamic consequences. Although the patient could not tolerate maximal exercise stress, visually, both the proximal isovelocity surface area and MR jet area showed significant deterioration (Fig. 2, Supplementary material 4), and the pressure gradient between the right atrium and RV was significantly increased, from 15 mmHg to 45 mmHg during peak exercise stress. Preoperative transesophageal echocardiography revealed dilation of the mitral annulus to 38.5×37.3 mm in diameter and thickening of the bilateral mitral leaflets (Fig. 3). Interestingly, the dysplastic posterior mitral leaflet was restricted due to leaflet tethering. The anterior mitral leaflet was elongated, which attempted to cover the entire mitral annulus; however, the coaptation of the mitral leaflets was insufficient, which resulted in severe MR. From these findings, we considered that the main mechanism of MR was tethering of the posterior mitral leaflet, which resulted from posterolateral LV asynergy, presumably due to myocardial scarring after the regression of the rhabdomyoma. Pre-operative right heart catheter examination revealed a cardiac index of as much as 3.1 L/min/m², even in the presence of severe MR, presumably due to artificial arterio-venous shunt.

Contrary to our expectations, however, surgical inspection

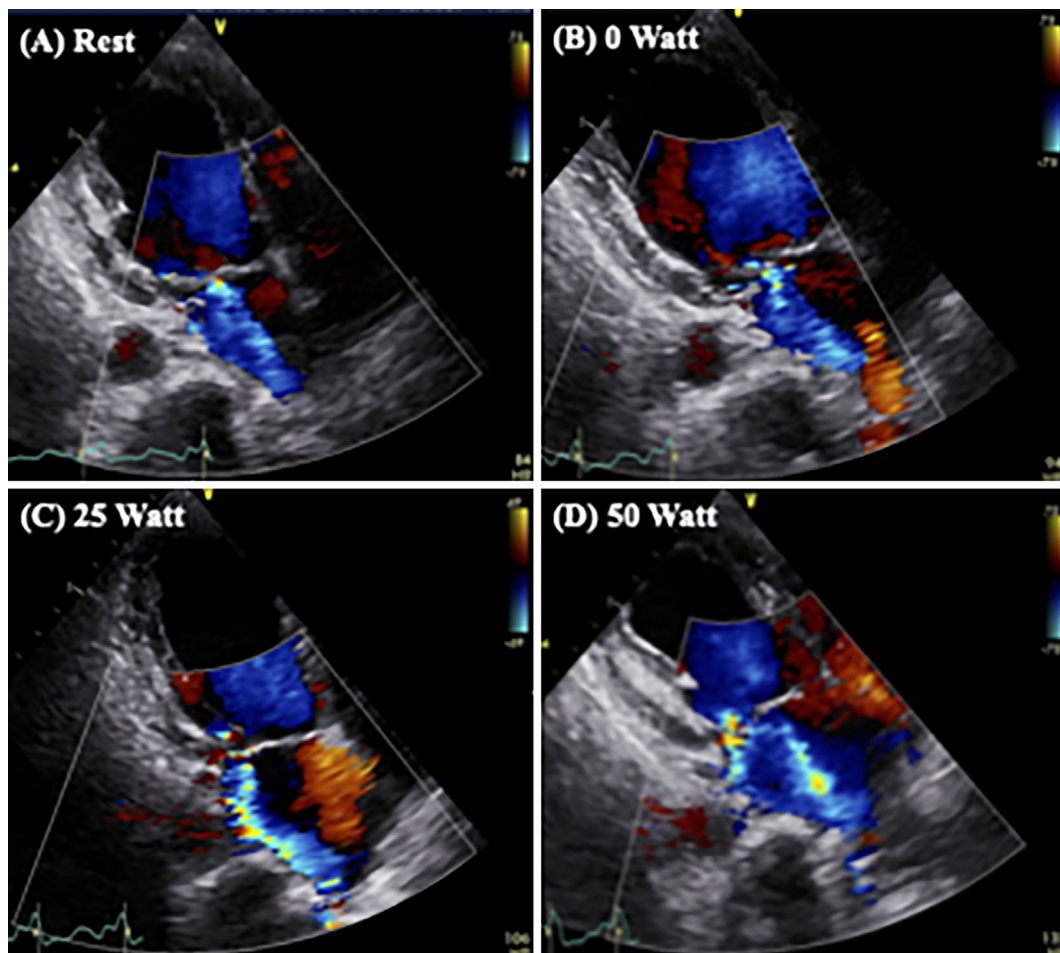


Figure 2. Exercise stress echocardiography of a 41-year-old woman with mitral Ebstein's anomaly. Color Doppler echocardiography shows that the proximal isovelocity surface area and color signal of the mitral regurgitation gradually deteriorated during stepwise exercise stress (A-D), which ultimately resulted in severe mitral regurgitation at peak exercise (D).

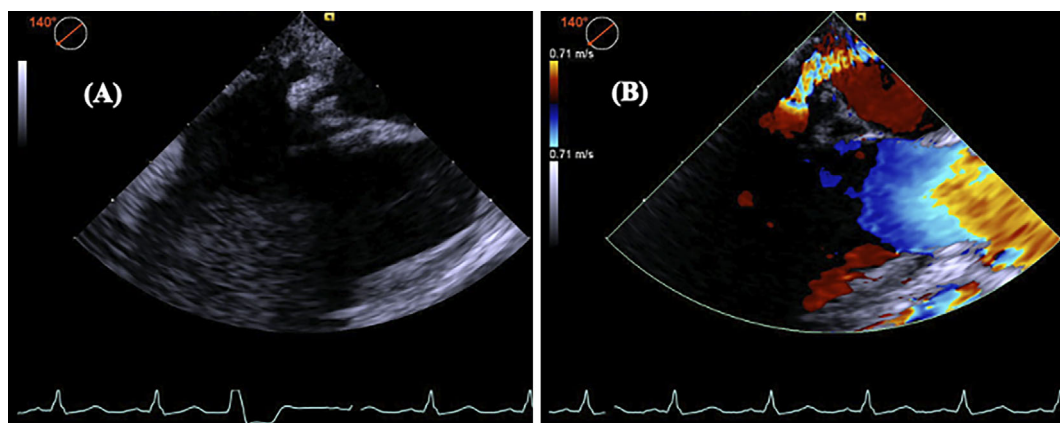


Figure 3. Transesophageal echocardiography of a 41-year-old woman with mitral Ebstein's anomaly. (A) A mid-esophageal horizontal view shows a thickened posterior mitral leaflet. (B) Color Doppler imaging shows severe eccentric regurgitant jet along the left atrial wall.

confirmed a congenitally dysplastic posterior mitral leaflet, with its middle portion adhering to the LV posterior wall and completely covered by the endocardium. Moreover, the subvalvular apparatus of the middle portion of the posterior

mitral leaflet was entirely lacking (Fig. 4). The dysplastic antero-lateral papillary muscle originated from the abnormal mid-LV endocardium and was attached to the lateral position of the posterior mitral leaflet. During surgery, the mitral

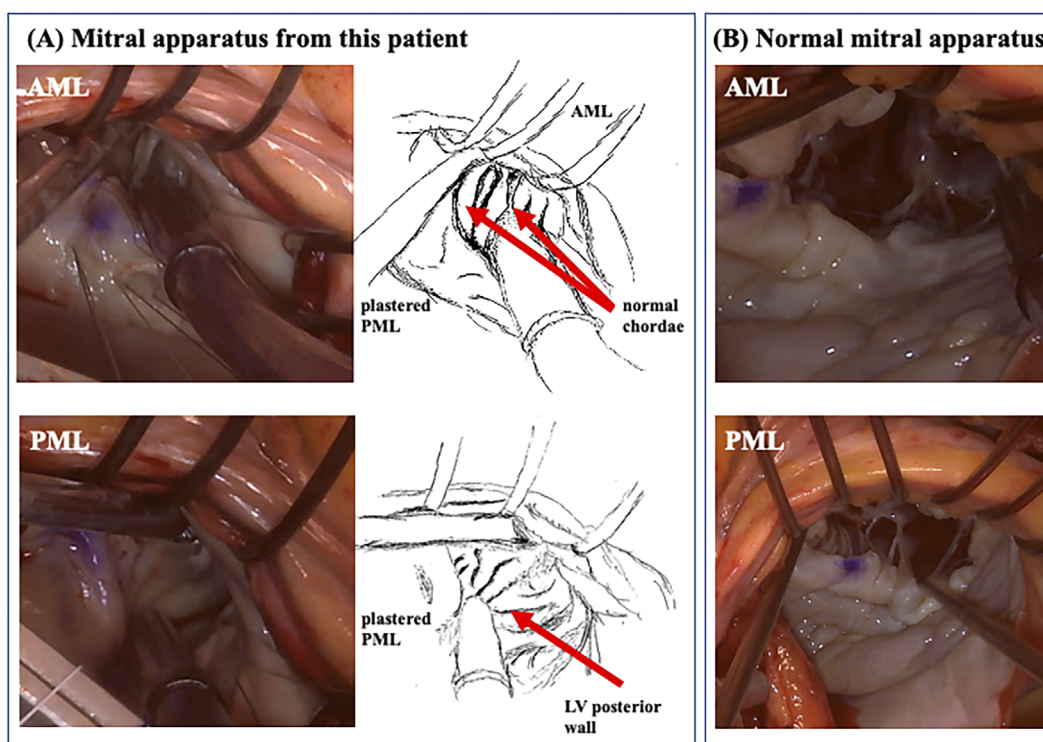


Figure 4. Surgical pictures of a 41-year-old woman with mitral Ebstein's anomaly and pictures from a normal subject. (A) Surgical inspection revealed an elongated anterior mitral leaflet with an intact sub-valvular apparatus. In contrast, the dysplastic posterior mitral leaflet was plastered to the left ventricular posterior wall. Moreover, the subvalvular apparatus of the middle portion of the leaflet was absent. (B) A normal mitral valve has sufficient leaflet volume to cover the entire mitral orifice. Of note, the sub-valvular apparatus is observed to be clearly attached to both mitral leaflets.

annular circumference was reduced using a semi-rigid artificial annular ring, so that the elongated anterior mitral leaflet alone could cover the entire mitral annulus, which resulted in a successful mitral valve repair without any residual MR.

Discussion

Ebstein's anomaly is a rare congenital heart disorder that occurs in approximately 1 per 200,000 live births and which accounts for <1% of all cases of congenital heart disease (2). This disorder occurs due to a malformation of the right-sided atrioventricular valve and the RV, which is characterized by a process known as "undermining". This leads to the incomplete resorption of the primitive myocardial tissue underlying the atrioventricular valve. In this way, "delamination failure" occurs in the atrioventricular valve, resulting in the "plastering" of the atrioventricular valve leaflet to the RV wall (6). The apical displacement of the hinge point of the plastered tricuspid valve eventually leads to tricuspid regurgitation. At the same time, RV myocardial dysplasia, which occurs due to incomplete generation, results in RV dysfunction (7).

Ebstein's anomaly of the mitral valve is an even rarer congenital malformation (8). In 1976, Ruschhaupt et al. (9) reported the first case of Ebstein-like malformation of the mitral valve in a newborn who died within the first few

hours after birth. Thereafter, although similar cases were reported, urgent mitral valve surgery during infancy was considered to be necessary in all reported cases (10, 11). These previous reports suggest that it may be extremely difficult to expect prenatal and infant survival in cases with mitral Ebstein's anomaly. On the other hand, Bär et al. prospectively evaluated 26,484 consecutive asymptomatic adult patients from a single center, and found three cases (1:8,800) with a hypoplastic posterior mitral leaflet; some cases even lacked a functional posterior mitral leaflet (12). Notably, in all of these cases, the anterior mitral leaflet showed compensatory elongation, whereas the posterior leaflet was hypoplastic and apically displaced. It can be hypothesized that the compensatory elongation of the anterior mitral leaflet, which is sufficient to cover the entire mitral annulus, may be necessary for the prolonged survival of patients with mitral Ebstein's anomaly, as was observed in our case. Based on previous reports, the clinical and anatomical characteristics of classical Ebstein's anomaly and mitral Ebstein's anomaly are summarized in Fig. 5.

In the present case, we considered that significant MR was avoided during childhood, because plastering of the hypoplastic posterior mitral leaflet was relatively mild and the compensatory elongation of the anterior mitral leaflet was able to cover most of the mitral orifice. However, it is hypothesized that the mitral annulus may have extended gradu-

	Classical Ebstein's anomaly	"Mitral" Ebstein's anomaly
Affected valve	Tricuspid valve	Mitral valve
Involved ventricle	Right ventricle (usually with atrialized portion)	Left ventricle (occasionally with atrialized portion)
Affected leaflet	Septal and posterior tricuspid leaflet	Posterior leaflet
Subvalvular apparatus	Hypoplastic	Hypoplastic or partially absent
Recommended surgical procedure	Valve repair	Valve replacement
Prognosis	Valuable	Generally poor

Figure 5. Clinical and anatomical characteristics of classical Ebstein's anomaly and mitral Ebstein's anomaly

ally as a result of prolonged exposure to a relatively high cardiac output state owing to the presence of an artificial arterio-venous shunt in the left forearm, which was used for dialysis. Consequently, the anterior mitral leaflet could not cover the entire mitral orifice, leading to insufficient coaptation and severe MR. We hypothesize that wall motion abnormality, degeneration of the papillary muscle, and LV remodeling due to a scarred rhabdomyoma may have also contributed to the development of severe MR in this case. Although sufficient mitral valvular coaptation was regained after mitral annuloplasty using an artificial ring, which successfully controlled the severe MR in our patient, this is not always the case. Rather, in many similar cases, mitral valve repair is not feasible and mitral valve replacement is required for the majority of these cases. We are therefore of the opinion that an accurate preoperative diagnosis of mitral Ebstein's anomaly based on the anatomical characteristics of mitral Ebstein's anomaly (Fig. 5) will significantly contribute to the preoperative planning of the surgical strategy.

Conclusion

We encountered an extremely rare case of "mitral Ebstein's anomaly" that was characterized by plastering of the hypoplastic posterior mitral leaflet and an atrialized LV. The close observation of the atrialized portion of the LV, the characteristic morphology of the plastered posterior leaflet, and the hypoplastic subvalvular apparatus can lead to an accurate preoperative diagnosis and may contribute to the management of similar cases.

The authors state that they have no Conflict of Interest (COI).

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