CASE REPORT
Bali Medical Journal (*Bali MedJ)* 2023, Volume 12, Number 2: 2278-2283
P-ISSN.2089-1180, E-ISSN: 2302-2914

Successful treatment of severe subaortic stenosis with left ventricular dysfunction in children

Enny Karyani[1*], Mahrus Ahmad Rahman[1], I Ketut Alit Utamayasa[1], Taufiq Hidayat[1], Teddy Ontoseno[1]

ABSTRACT

Background: Subaortic stenosis (SAS) is the second most common form of left ventricular outflow obstruction, accounting for 14% of LVOT obstruction in the general population. This obstruction is in the area of the heart under the aortic valve. While only a few cases have been reported in pediatrics, SAS is a gradually progressive disorder rarely seen at birth and infancy. This case study aims to evaluate the successful treatment of severe SAS with left ventricular dysfunction in children.

Case Presentation: We present the case of an 8-year-old boy who presented with shortness of breath on exertion and diaphoresis 3 months ago. Transthoracic echocardiography revealed severe aortic stenosis (PG 69.86 mmHg) with discrete tissue in the anterior LVOT and left ventricular systolic function decreased (EF Teich 29.44%), with global hypokinetic. Transesophageal echocardiography (TEE) results in severe subvalvular AS with a fixed subaortic membrane (PG 51.16 mmHg; Stenotic area 0.1 cm2), anterior to the aortic valve 1 cm long. There was mild mitral regurgitation and moderate tricuspid regurgitation. The patient then undergoes successful medical treatment and surgical subaortic membrane resection with tricuspid repair. After one year's operation, the patient remained stable, in good condition and free of symptoms.

Conclusion: Subaortic stenosis is a gradually progressive disorder and could develop into heart failure with significant left ventricular dysfunction. Monitoring is an important aspect, given the nature of disease progression. Successful management of a patient with subaortic stenosis involves a multidisciplinary approach, including an early diagnosis, a comprehensive understanding of cardiac pathophysiology, risk factors of recurrence, optimal medical management and surgical strategy.

Keywords: Subaortic Stenosis, Left Ventricular Outflow Obstruction, Children.
Cite This Article: Karyani, E., Rahman, M.A., Utamayasa, I.K.A., Hidayat, T., Ontoseno, T. 2023. Successful treatment of severe subaortic stenosis with left ventricular dysfunction in children. *Bali Medical Journal* 12(2): 2278-2283. DOI: 10.15562/bmj.v12i2.4234

[1]Division of Pediatric Cardiology, Department of Child Health, Faculty of Medicine, Universitas Airlangga, Surabaya, East Java, Indonesia.

*Corresponding author:
Enny Karyani;
Division of Pediatric Cardiology, Department of Child Health, Faculty of Medicine, Universitas Airlangga, Surabaya, East Java, Indonesia;
ennykaryani@gmail.com

Received: 2023-03-04
Accepted: 2023-06-01
Published: 2023-07-27

INTRODUCTION

Subaortic stenosis is uncommon in neonates and young children. It is accountable for 15% to 20% of all fixed left ventricular outflow tract obstructive lesions and about 1% of all congenital heart abnormalities (8 in 10,000 births).[1,2] Children with congenital aortic stenosis often have 10% to 14% subaortic stenosis. A male-to-female ratio of 2:1 affects more men than women and accounts for 65% to 75% of cases. In clinical practice, SAS evolves and advances with time, leading the majority to regard it as an acquired lesion instead of a congenital one.[3]

The second most frequent type of left ventricular outflow restriction is subaortic stenosis (SAS). This condition causes 14% of LVOT blockages in the general population. This blockage is located just below the aortic valve in the heart. Subaortic stenosis (SAS) is a gradually progressing condition infrequently detected at birth and infancy, even though only a few cases have been documented in pediatrics. When a patient with the management SAS develops heart failure or clinically significant left ventricular dysfunction, medicinal treatment is initiated until surgery can be done. Although surgical correction is typically advised, SAS surgery time is still debatable.[2-4]

Here, we reported a case of severe subaortic stenosis with left ventricular dysfunction in children that was treated successfully.

CASE PRESENTATION

An 8-year-old boy with a weight of 16 kg and a height of 130 cm came to the emergency room hospital and complained of shortness of breath and coughing 3 months before admission. The patient is often breathless and easily tired when doing light activities, such as walking about 100 meters and lying on his back since 3 months ago and has been heavy 7 days before admission. Complaints of chest pain are also sometimes felt. Complaints of fainting were denied. The patient was known to suffer from SAS 4 years ago when the child was 4 years old because he got tired easily when playing. At that time, the patient had been recommended for surgery by a heart surgeon, but the family did not bring the patient in for further control.

The patient's vital signs from the physical examination were: BP 77/38 mmHg, weak and delayed regular pulse 124 times/minute, respiratory rate 25 times/minute, axillary temperature 36.8°C, and 98% O_2 saturation in free air. From the cardiac examination, palpable left ventricular (LV) apical impulse and suprasternal thrill, regular one and two heart sounds, harsh grade III/VI systolic ejection murmur at

Table 1. Patient's laboratory results

Laboratory parameter	Result	Normal value
Hemoglobin	8.8 g/dL	12–14g/dL (Female) 13–16g/dL (Male)
Hematocrit	29.5%	40 – 50 % (f) 45 – 55 % (m)
Red Blood Cell	4.1 x 10^6/uL	4–5 x $10^{6/}$uL
Platelet	314 x 10^3/uL	150–400x 10^3/uL
Whole Blood Cell	8.52 x 10^3/uL	5–10 x 10^3/uL
BUN	15 mg/dL	8 – 25 mg/dL
Creatinine serum	0.62 mg/dL	0,6–6mg/dL
Sodium	138 mmol/L	135-145mmol/L
Potassium	3.6 mmol/ L	3,5–5,1 mmol/L
Chloride	97 mmol/L	96–106 mmol/L
Calcium	8.5 mg/dL	8,5 – 10,8 mg/dL
Prothrombin time	13 second	12– 14,8 seconds
APTT	27 second	27– 41 seconds
Serum glucose	81 mg/dL	70 – 110 mg/dL
Albumin	3.6 g/dL	3.5 – 5.5 g/dL
SGOT	148 U/L	10 – 40 U/L
SGPT	189 U/L	10 – 35 U/L

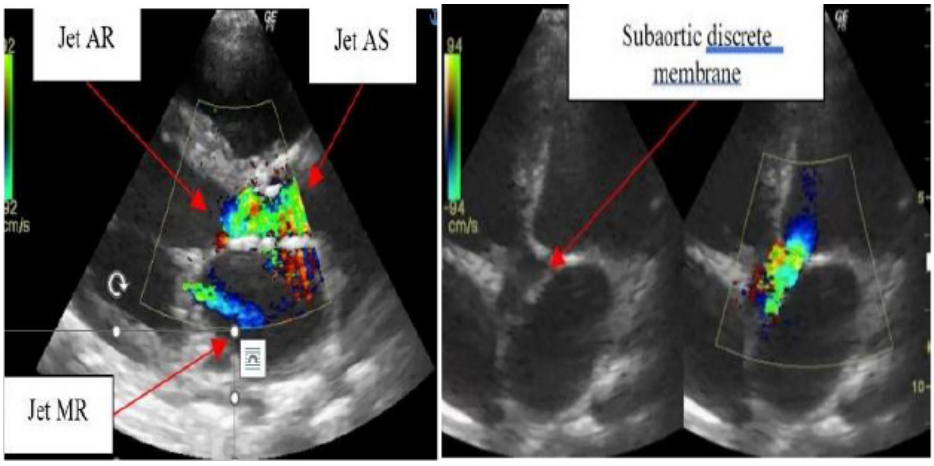

Figure 1. TTE. Left: PLAX view with severe subvalvular AS jets, light MR jets, and intact IVS. Right: view 5C showing a severe subvalvular AS jet with a subaortic discrete membrane.

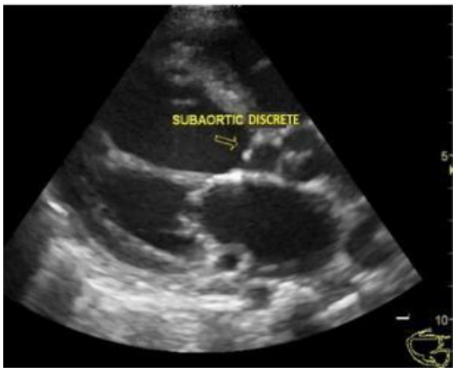

Figure 2. PLAX view showing subaortic discrete membrane anterior to the aortic valve.

Intercostal Space (ICS) 2-3 Left Upper Sternal Border (LUSB) radiating to the carotid artery, high-pitched pansystolic murmur III/VI at the Left Lower Sternal Border (LLSB) radiates to the Right Left Sternal Border (RLSB), and the S3 gallop. Bilateral lung vesicular breath sounds were heard from lung auscultation without rales and wheezing. From the classification of the severity of heart failure according to NYHA class IV, clinical symptoms appear at rest; the Ross criterion score is 10 with the interpretation of severe congestive heart failure. From the chest X-ray results, cardiomegaly was obtained with a CTR of 70%, the rounded apex of the heart, no visible pulmonary infiltrates and good pulmonary vascularization. Laboratory results were obtained as stated in Table 1 above.

Transthoracic echocardiography (TTE) with the results: dilatation of all cardiac chambers with LVIDd 4.97 cm, aortic valve appeared severe subvalvular aortic stenosis/AS (Pressure gradient/ PG 69.86 mmHg) with discrete subaortic membrane anterior to the aortic valve, jet aortic regurgitation/AR, moderate mitral regurgitation/MR (PG 52.74 mmHg), moderate tricuspid regurgitation/TR (PG 47.08 mmHg), left ventricular systolic function decreased (EF Teich 29.44%), with global hypokinetic (Figure 1-Figure 4). Transesophageal echocardiography (TEE) results in severe subvalvular AS with a fixed subaortic membrane (PG 51.16 mmHg; Stenotic area 0.1 cm2), anterior to the aortic valve 1 cm long.

The patient was given therapy: infusion, pump dobutamine 7 mcg/kgBB/minute intravenously, injection of furosemide 10 mg/12 hours i.v, oral L-carnitine 500 mg/12 hours, oral spironolactone 10 mg/24 hours, and oral sildenafil 7.5 mg/8 hours. The patient underwent surgery with resection of the subaortic membrane and repair of the tricuspid valve with de Vega annuloplasty. Durante's operation found a large heart with sufficient contractility; the main pulmonary artery (MPA) size is smaller than the aorta. Normal aortic valve 3 cusps with subaortic stenosis, good mitral valve, aortotomy, subaortic membrane resection and tricuspid valve repair with de Vega annuloplasty procedure (Figure 5).

The patient was discharged from the hospital 14 days post-operative, in good condition and able to carry out daily activities. The patient received therapy: furosemide 15 mg/12 hours, cefixime 80 mg/12 hours, lisinopril 1.6 mg/24 hours, spironolactone 12.5 mg/12 hours, digoxin 0.05 mg/24 hours and betadine gargle 3 times daily. Patients regular control routine checked clinical condition, vital signs, complications, ECG examination and echocardiography at 1, 3, 6, 9, and 12 months and every year after surgery. During control, the condition improved, and there were no complications or recurrence rates.

DISCUSSION

Subaortic Stenosis is seldom encountered in newborns and is rare in infants. It is responsible for approximately 1% of

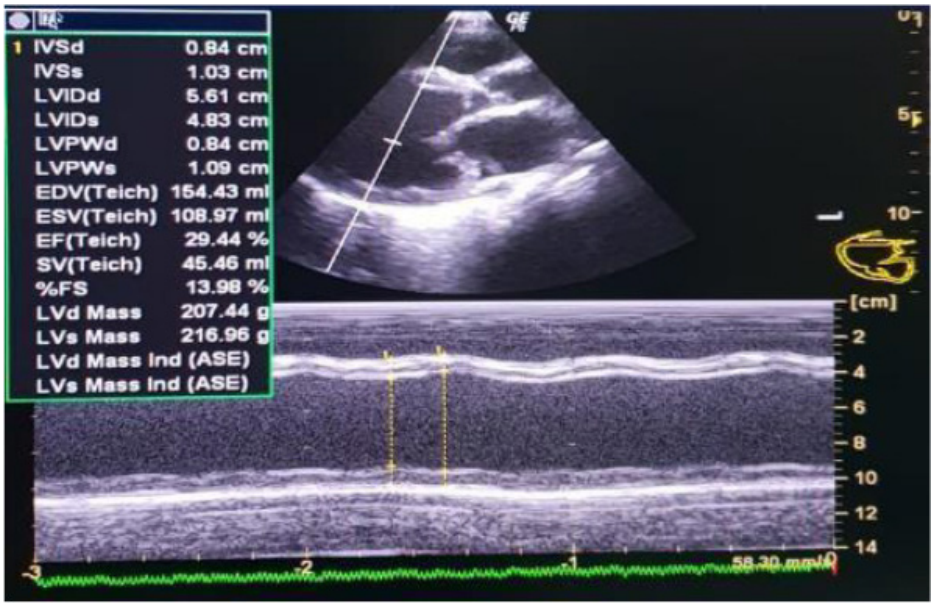

Figure 3. Left: M-mode LV looks EF Teich 29.44%.

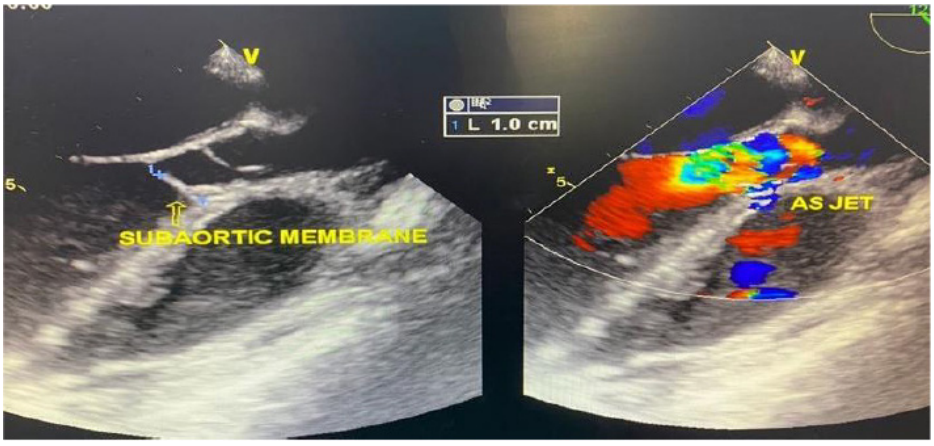

Figure 4. TEE. Left: Severe subvalvular AS jet with subaortic membrane anterior to the aortic valve 1 cm long. Right: looks jet AR.

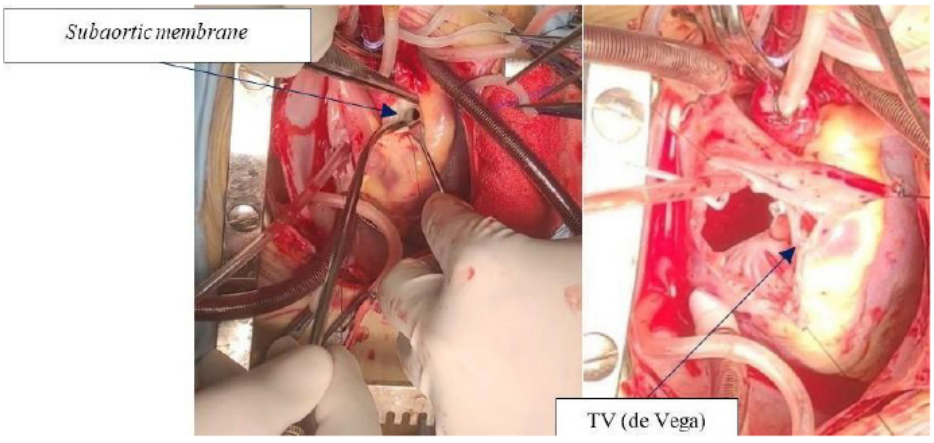

Figure 5. Left: SAS view during resection. Right: tricuspid valve during de Vega procedure.

all congenital heart defects (8 in 10,000 births) and 15% to 20% of all fixed left ventricular outflow tract obstructive lesions. Ten percent to 14% of subaortic stenosis is observed amongst children with congenital aortic stenosis. It is more common in males and is responsible for 65% to 75% of the cases, with a male-to-female ratio of 2:1.[1-4] In clinical practice, SAS develops and progresses over time, so most consider it an acquired rather than a congenital lesion.[5] The spectrum of variants of subaortic stenosis that occurs alone or in combination with the others. These are as follows: 1) A thin discrete membrane: The most common lesion; 2) A fibromuscular ridge; 3) A diffuse fibromuscular tunnel-like narrowing of the left ventricular outflow tract (LVOT); 4) Accessory or anomalous mitral valve tissue; and 5) Fixed SAS in discrete obstructions and ridges occurs in 70%-80% of patients, whereas diffuse tunnel-like obstructions occur in 10%-15%.[5] Located 0.5-1.5 cm beneath the aortic valve, types 1 and 2 involve a variable extent of the LVOT. Previous surgical ventricular septal defect patch closure, a steep (>130°) atrioventricular septal angle, increased mitral-aortic separation, and an exaggerated aortic override are present in children who later develop SAS.[1,5,6] In patients who obtained discrete membrane type, no VSD was found.

The pathophysiological theory explaining the development of SAS lesions was first described by Rosenquist GC et al. that an increase in mitral aortic separation could contribute to the mechanism of SAS development, which may result in a change of the blood flow direction near the distal interventricular septum and thus form a basis for the differentiation of germinal cells into fibroblasts.[7] Other explanations included preexistent morphological abnormality or possible genetic components that have yet to be understood.[8] Clinically significant obstruction to ejection due to SAS results in concentric left ventricular (LV) hypertrophy, often with an excessive septal bulge. This effect leads to a cycle of further obstruction and localized fibromuscular growth. SAS has variable and unpredictable rates of progression in children.[1,5]

Aortic regurgitation, which is usually progressive, develops in nearly 65% of patients during SAS and usually persists even after the SAS is removed.[1] In one study of 220 patients with subaortic stenosis, a peak Doppler gradient ≥50 mmHg at

diagnosis was a significant predictor of at least moderate AR, while patients with no or trivial AR tended to have thin, mobile valve leaflets.[9] Physiologically, localized discrete subaortic stenosis behaves the same as valvar AS. This discrete membrane interferes with LV ejection, causing increased afterload and intraventricular pressure.[10] In these patients, severe SAS that progresses over a long period leads to LVH with LV systolic dysfunction with symptoms of heart failure.

SAS can be diagnosed late because of its progressive natural course and because the patient is not yet symptomatic, requiring evaluation. When symptomatic, symptoms include dyspnea on exertion (DOE), syncope and presyncope on exertion, angina, orthopnea, heart failure, and sudden cardiac death.[1,5] This patient had symptoms of heart failure, shortness of breath during activities, chest pain, and cold sweats. There was a grade 3 systolic murmur, Ross 4 heart failure, abnormal CXR (cardiomegaly), and abnormal BP. Most of these symptoms occur in children, adolescents, and young adults aged 10-21, with moderate or severe LVOT obstruction and a peak-to-peak PG >50 mmHg.[11-13] In this patient, symptoms present with severe SAS obstruction (PG 69,86 mmHg).

This patient also has a weight that is difficult to increase to severe malnutrition. Difficult weight gain or failure to thrive mainly due to increased calorie demand due to increased work of breathing and overworked myocardium with increased energy consumption to maintain adequate cardiac output (CO) combined with poor intake.[5,6]

In SAS patients with heart failure, physical examination findings vary depending on CO, degree of volume overload and pulmonary congestion, and/or systemic venous congestion.[12] This patient has tachycardia, a response to decreased CO in patients with reduced myocardial contractility. Poor perfusion results from decreased CO and is characterized by cold, pale extremities, decreased capillary refill, decreased peripheral pulses, and low blood pressure and gallop rhythm (S3). Pulmonary findings include tachypnea, retraction, no rales and wheezing.

Chest X-ray in subaortic stenosis is similar to valvar AS; there is no cardiomegaly but usually a prominent LV contour is seen. Post stenotic dilatation of the aortic root is rarely seen, only in 25% of patients with valvular AS.[5,12] The ascending aorta is normal in fixed SAS, but in some cases, ascending aortic dilatation or a prominent aortic knob can occur in valvular AS.[6] Significant LV enlargement was found on CXR of infants with severe AS and congestive heart failure and in older children with chronic congestive heart failure. An increase in the size of the LA on the lateral projection is a sign of severity.[5,12]

Echocardiography characterizes the anatomy of the subaortic lesion. It is useful for assessing the dimensions and function of the left ventricle (LV) and the integrity of the aortic and mitral valves. For the discrete type of membrane, the clinician should note: 1) The length of the membrane; 2) The pressure gradient over the obstruction; 3) The distance of the membrane from the hinge point of the aortic valve; 4) Extension of the membrane to the aortic or mitral valve; 5) Presence or absence of AR; and 6) Other accompanying congenital lesions. Some of these things are associated with the risk of recurrence requiring surgery.[6,7] In patients, the type of discrete membrane is obtained, with a membrane length of 1 cm with the largest PG of 69.86 mmHg, the distance of the membrane to the hinge point of the aortic valve is around 0.9 cm, there is expansion membrane to the mitral AML, visible AR jet.

Identified several morphometric predictors for fixed SAS: wide mitral-aortic separation (fibrous intervalvular elongation), exaggerated aortic override, and sharp aortoseptal angle. Lai W et al. performed a multivariate analysis of patients with simple discrete SAS who had TTE follow-up for >= 1 year after symptoms. They found that the best predictor of significant SAS progression was the distance from the fibromuscular ridge to the aortic valve indexed to the square root of the BSA, AML involvement, and initial Doppler gradient. Kleinert S et al. identified several independent predictors of reoperation after discrete SAS surgical resection, namely: distance between the fibromuscular ridge to the aortic valve <6 mm, maximum Doppler gradient >=60 mmHg, and involvement of the aortic or mitral valve requiring surgical peeling.[14,15] In patients with aortoseptal angle > 90^0, the distance between the membrane to the aortic valve hinge point is about 9 mm; there is an expansion of the membrane into the mitral AML

If the management patient develops heart failure or clinically significant left ventricular dysfunction, the patient is started on medical treatment until the surgery can be performed. Medical treatment comprises diuretics, vasoactive drugs and inotropic support, with or without mechanical ventilation. Loop diuretics (furosemide, bumetanide) remain first-line therapy for these patients, while inotropic agents are indicated to restore perfusion pressure, reverse end-organ failure and enable diuresis. Milrinone, dopamine, dobutamine and epinephrine are the most common vasoactive drugs and inotropic used in clinical practice.[16,17]

The recent management, including surgical resection of subaortic stenosis, has generally resulted in satisfactory relief of LVOTO and a reduced incidence of infective endocarditis. Unfortunately, the progression of AI may not be arrested by surgical resection of subaortic stenosis.[18] Results differ regarding the best surgical method to prevent reintervention in discrete membranes. Some propose a more aggressive initial approach with a beneficial effect of septal myectomy over simple enucleation, while others have reported contradictory results.[19,20] Adding a septal myectomy to simple membrane resection in discrete membrane patients did not let us decrease the later reoperation rate in our hands. Surgery for subaortic stenosis carries a low risk of mortality, although recognized morbidities include complete heart block, damage to the aortic or mitral valves, as well as the creation of a ventricular septal defect. In addition, a recurrence rate of 7–27% has been reported in various series.[18,20] Our approach to the timing of surgery in patients with subaortic stenosis is as follows:

- We defer surgery in the first decade of life if the obstruction is moderate or less (i.e., maximum instantaneous

Doppler gradient ≤50 mmHg) and regurgitation are no more than trivial. This peak Doppler gradient is the same as the threshold mean Doppler gradient for surgical intervention >30 mmHg recommended by other major referral centers.52 Other centers recommend surgical intervention in all patients with an LVOT gradient >=50 mmHg and infants or young children (up to school age)with a gradient >=30 mmHg.

- Children with an LVOT gradient <30 mmHg and no significant left ventricular hypertrophy are followed closely for progression, especially in the first several years of life.

In the 2007 American Heart Association guidelines, antibiotic prophylaxis to prevent bacterial endocarditis is no longer recommended in patients with subvalvular AS, except in those with a prior history of endocarditis or a repair requiring prosthetic material or device. In the latter, antibiotic prophylaxis is recommended for the first six months after repair unless a residual defect is present, in which case prophylactic antibiotics are continued beyond the six-month period.[5,18,21] The patient also has problems with tooth and gum infection, action and treatment are carried out. Endocarditis decreases significantly after surgery when the LVOT gradient is < 80 mm Hg.[8,21] Invasive dental procedures and other procedures can contribute to the risk of IE, although most cases of IE do not occur after these procedures.

Mortality following surgery for subaortic stenosis is very low. In a study of 155 patients who underwent subvalvular AS resection at a single institution between 1984 and 2009 and were followed for a median of 10.9 years, survival at 10 and 20 years was 98.6 and 86.3 percent, respectively.[5] Postoperative survival rates are at least 85-95% at 15 years. Hence, operating before the LVOT gradient reaches 80 mmHg is recommended. Furthermore, given the possible recurrence and the presence of mild AR, lifelong regular follow-up with echocardiography is required.[22-25] The severity of subaortic stenosis has generally been felt to be progressive, although some cases remain stable for many years.[1,5] Overall surgical mortality for SAS is now less than 1% in most centers.[23,26,27] In patients after 1 year postoperatively, the patient is still alive and in good condition. Control patients and follow up regularly. No complications were found, such as residual LVOT obstruction, damage to the aortic or mitral valve or both, variable degree of heart block, iatrogenic ventricular septal defect, and infective endocarditis.

CONCLUSION

Subaortic stenosis is a gradually progressive disorder and develops heart failure with significant left ventricular dysfunction. Monitoring is an important aspect, given the nature of disease progression. The diagnosis in this patient was severe subaortic stenosis with left ventricular systolic dysfunction; they underwent subaortic membrane resection and repair of the tricuspid valve with a de Vega annuloplasty procedure. Successful management of a patient with subaortic stenosis involves a multidisciplinary approach, including an early diagnosis, a comprehensive understanding of cardiac pathophysiology, risk factors of recurrence, optimal medical management and surgical strategy.

CONFLICT OF INTEREST

The authors declare that there is no competing interest regarding the manuscript.

ETHICAL CONSIDERATION

Informed consent was taken from participants/parents included in the study. They understand that their names and initials will not be made public and that every reasonable effort will be taken to conceal their identity.

FUNDING

This research received no specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

AUTHOR CONTRIBUTION

All authors read and approved the final manuscript.

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