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Left Ventricular Mass Regression in Aortic Valve Replacement for Severe Aortic Stenosis

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Abstract

Aortic stenosis is a common cause of valve replacement, and chronic aortic stenosis increases left ventricular wall tension with subsequent ventricular hypertrophy, dilatation, and failure. The prognosis for such patients is extremely poor if valve replacement is not performed and severe ventricular impairment is not in itself a contraindication to surgery. Early and conflicting reports have examined the peri-operative risk of patients with reduced LV systolic function undergoing aortic valve surgery. Avoiding surgical intervention has been advocated recently in such patients, however, other reports have demonstrated that aortic valve replacement in patients with aortic stenosis and reduced left ventricular function has encouraging long-term survival with improved functional class. Our study has been performed to assess the early left ventricular mass regression in patients undergoing aortic valve replacement for severe aortic stenosis with impaired LV systolic function.

Keywords: LV Mass; Aortic Stenosis; AVR; LV Dysfuction; LV Dimensions.

Introduction

Aortic stenosis is a common cause of valve replacement, and its prevalence increases with age and the aging population. Chronic aortic stenosis increases left ventricular wall tension with subsequent ventricular hypertrophy, dilatation, and failure. The prognosis for such patients is extremely poor if valve replacement is not performed [1].

Severe ventricular impairment is not in itself a contraindication to surgery, despite the increased intra-operative mortality, because the outcome of survivors is greatly improved [2].

Echocardiography is used to measure the trans-valvular pressure drop, but in patients with a failing ventricle, the measured gradient alone may underestimate the severity of the stenosis [3].

Early and conflicting reports have examined the peri-operative risk of patients with reduced LV systolic function undergoing aortic valve surgery [4]. Recently some authors have advocated avoiding surgical intervention in such patients because of prohibitively high risks [5]. However, other reports have demonstrated that aortic valve replacement in patients with aortic stenosis and reduced left ventricular function has encouraging long-term survival with improved functional class [6].

Our study has been performed to assess the early left ventricular mass regression in patients undergoing aortic valve replacement for severe aortic stenosis with impaired LV systolic function.

Aims and Objectives

- To assess the early left ventricular mass regression in patients undergoing aortic valve replacement for severe aortic stenosis with impaired left ventricular systolic function

Materials and Methods

This is a retrospective study, which has been conducted from January 2009 to August 2012 in CTVS unit VI of Sri Jayadeva Institute of Cardiovascular Sciences and Research, Bangalore.

A total of 72 patients with severe aortic stenosis underwent isolated aortic valve replacement in our unit.

Inclusion Criteria

- Isolated aortic valve surgery required for significant valve stenosis, as assessed by Doppler echocardiography
- Poor left ventricular systolic function, with an ejection fraction of < or = 40%
- Availability of complete pre- and post operative echocardiographic studies

Exclusion Criteria

Patients were excluded if they were undergoing a reoperation for aortic valve surgery or any additional procedure (i.e., coronary artery bypass grafting, other valvular interventions)

Sample Size - A total of 20 patients met the inclusion criteria

Procedure - Under general anesthesia, cardiopulmonary bypass was established through a median sternotomy approach. After cross-clamping and arresting the heart, the aorta was opened via a transverse aortotomy and the valve was inspected. The valve was then excised and the annulus decalcified. The annulus was then appropriately sized and a mechanical or bio-prosthetic valve was selected at the choice of the operating surgeon and as per the patient's requirements. The appropriate valve was then implanted by an interrupted suture technique. After testing the valve, the aortotomy was closed, heart de-aired, and slowly weaned off cardio-pulmonary bypass. Routine chest closure was then performed.

Follow-Up

Follow-up was by 2 D echo at 1 month, 3 months and 1 year post-operatively and the left ventricular dimensions and function was analysed

Data Assimilation

The data obtained was assimilated and tabulated, and the appropriate statistical tests were used to determine statistical significance.

Values are expressed as mean±SD p= 0.05 was considered statistically significant.

Observations and Results

Table 1: Patient Demographics

Study period	January 2009 – August 2012
Total no. of patients	20
Male	16 (80%)
Female	4 (20%)
Age	54±7 years
NYHA Class II	4 (20%)
NYHA Class III	10 (50%)
NYHA Class IV	6 (30%)
Sinus rhythm	20 (100%)
Pre-operative aortic valve gradient	47±5 mm Hg

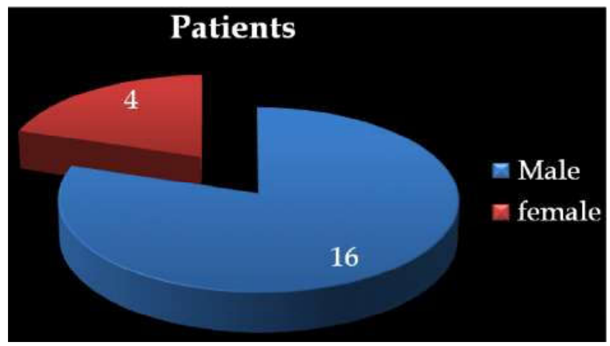

Fig. 1: Patient Demographics

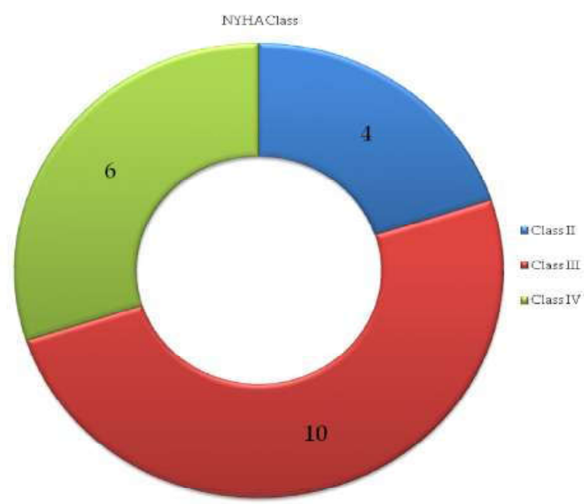

Fig. 2: Patient Demographics

Table 2: Intra-Operative And Post-Operative Details

Study period	January 2009 – August 2012
Aortic cross clamp time	65.2 ±10.9 min
CPB time	87.9±12.7 min
Aortic valve size	21± 2
No. of bio-prosthetic valves implanted	12 (60%)
No. of mechanical valves implanted	8 (40%)
Post-op ventilation	11±2 hours
Drainage	170±32 ml
ICU stay	2 days

Table 3: Echocardiography

Parameter	Pre-op	1 month post-op	p value	3 months post-op	p value	1 year post-op	p value
EDV	93.7±6.0 ml	84.6±5.5 ml	< 0.05	83.2±3.7 ml	< 0.05	83.0±2.6 ml	< 0.05
ESV	53.7±8.7 ml	40.2±7.7 ml	< 0.05	35.8±5.3 ml	< 0.05	33.5±3.2 ml	< 0.05
LVIDd	66.4± 5.3 mm	58.1±5.4 mm	< 0.05	55.6±6.1 mm	< 0.05	53.6±6.2 mm	< 0.05
LVIDs	52.1±6.6 mm	48.2±7.1 mm	< 0.05	46.8±7.3 mm	< 0.05	44.0±5.7 mm	< 0.05
LV Mass	323.4±13.5 g	301.2±14.6 g	< 0.05	290.0±14.5 g	< 0.05	276.8±17.4 g	< 0.05
EF	36.7± 2.1 %	37.3±4.4 %	0.21	40.3±4.6 %	< 0.05	42.7±4.2 %	< 0.05

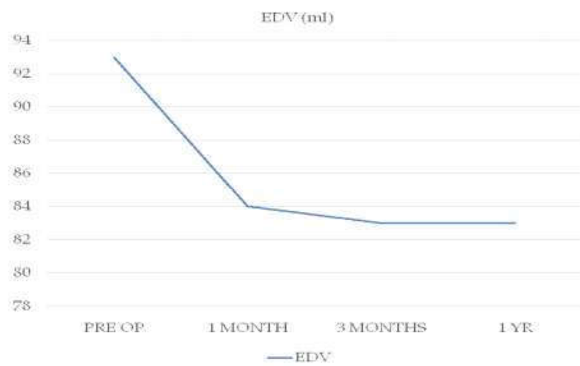

Fig. 3: EDV

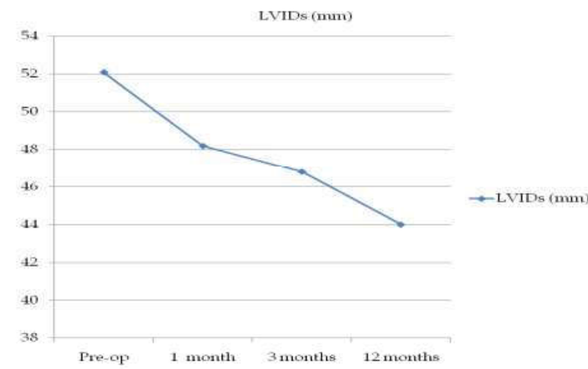

Fig. 6: LVIDs

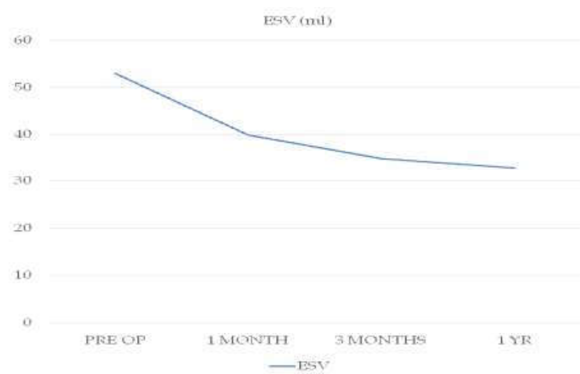

Fig. 4: ESV

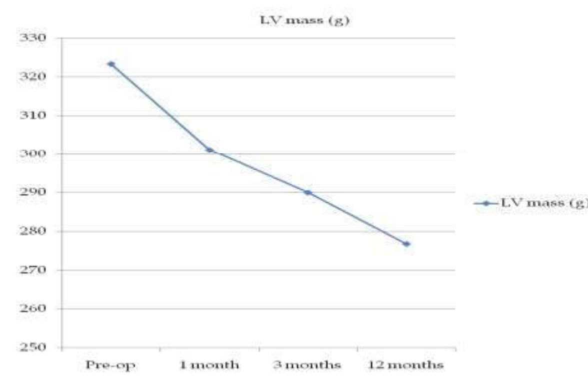

Fig. 7: LV MASS

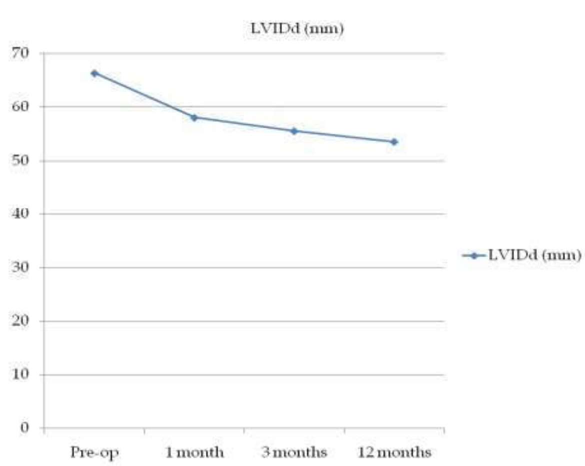

Fig. 5: LVIDd

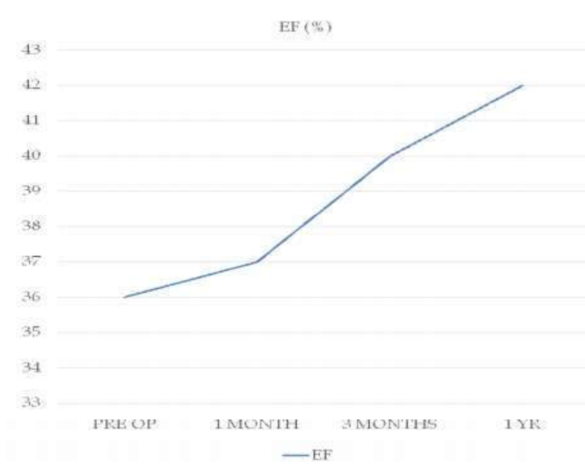

Fig. 8: EF

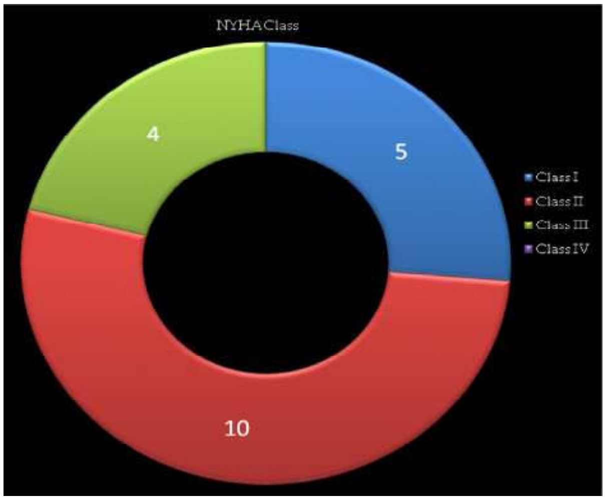

Fig. 9: Post-Operative Nyha Class At 1 Year Post-Operative

Review of Literature

Aortic stenosis is incomplete opening of the aortic valve, which restricts blood flow out of the left ventricle during systole. In developed countries, aortic stenosis is the most prevalent heart disease in adults.

There is no effective medical therapy for aortic stenosis. The effective treatment for severe aortic stenosis is aortic valve replacement, and the onset of symptoms is the primary indication for aortic valve replacement.

The current American Heart Association/ American College of Cardiology guidelines for the management of patients with valvular heart disease define severe aortic stenosis as a patient with an aortic valve area of ≤ 1.0 cm 2(or 0.6 cm 2 / m 2) or a peak trans-aortic jet velocity of ≥ 4.0 m/s or a mean trans-valvular gradient of ≥ 40 mm Hg.

Several studies have examined the rate of progression of aortic stenosis by examining trans-valvular gradient and aortic valve area at two or more points in time [7]. Not surprisingly, aortic stenosis progression is quite variable; however, it is more rapid in more severely calcified valves and in more severely stenotic valves [8].

The potential benefit of early surgery must be carefully weighed against the risk of the operation. The risk of aortic valve replacement is predicated both on the risk factors presented by the patient and on the skill and experience of the cardiovascular team performing the surgery.

Sharony et al., in a study between June 1992 and June 2002, studied 1,402 consecutive patients who underwent isolated aortic valve replacement with or without concomitant coronary artery bypass grafting (CABG) at the New York University Medical Center, Tisch Hospital (New York, NY). Of these, 416 patients (29.6%) had a left ventricular ejection fraction less than 40% and were the principal subjects of their report. They concluded that impaired left ventricular function was demonstrated to be an incremental risk factor for mortality after aortic valve replacement [9].

Lund et al conducted a study on left ventricular systolic and diastolic function in severe aortic stenosis after aortic valve replacement in 1997. They concluded that for patients with impaired left ventricular function, mortality rates range between 8% and 21% in the presence of aortic stenosis [10,11].

However, Bloomstein and co-workers [12] did not find pre-operative impaired left ventricular function to be a predictor for operative mortality. They reported an overall mortality of 16.7%, but they studied only 23 patients with low ejection fraction, most of whom were undergoing elective procedures.

Despite the increased operative risk, it has been recently demonstrated that for patients with aortic stenosis and severe left ventricular dysfunction, a surgical approach is superior to medical treatment with respect to 1-year and 4-year survival. [13].

Increased operative mortality has been reported for aortic valve surgery in certain surgical candidates, including the elderly [14], patients with dialysis dependent renal failure [15], patients undergoing concomitant CABG, 16 and those requiring urgent operation 17 or reoperation. [18]

Powell et al, in their study conducted on 55 patients with severe aortic stenosis (valve area ; or =0.75 cm2) and ejection fractions of 30% or lower who subsequently underwent aortic valve replacement, in the year 2000, concluded that the risk of aortic valve replacement in this sub-group of patients is extremely high, and thus surgery should be avoided [5].

Table 4: Mortality

Parameter	Peri-operative period	Within 1 month post-operative	Within 3 months post-operative	Within 1 year post-operative
Mortality	0 (0 %)	0 (0 %)	0 (0 %)	1 (5 %)

However, studies conducted by Smith et al. [19] and Lund et al. [10,11] have demonstrated that aortic valve replacement in patients with aortic stenosis and reduced left ventricular function has encouraging long- term survival with improved functional class

Discussion

Increased left ventricular wall tension due to aortic stenosis may lead to left ventricular dilatation and heart failure [20]; the prognosis for such patients is extremely poor if valve replacement is not performed [21]. The results of this study represent the early response of the ventricle to replacement of a diseased aortic valve with a well functioning prosthesis. We have described the clinical response of these patients to their surgical procedure to emphasize the excellent results obtained from valve replacement in these highly selected patients with pre-operative left ventricular systolic dysfunction.

The LVIDd was substantially elevated before surgery in our patients (66.4 mm) and decreased significantly (48.7 mm) after surgery. These patients had a significant decrease in EDV following surgery as well. It appears that the decrease in LVIDd parallels the decrease in EDV in these patients. Grossman et al. [22] studied late diastolic wall stiffness in patients with pressure and volume overload by a combined echocardiographic dimensional and left ventricular pressure technique. They found that patients with pressure overload had an increase in diastolic stiffness but that the elevated stiffness values seen in patients with volume overload were not different from controls when corrected for left ventricular dilatation. If their findings are applicable to our patients, it is likely that most of the observed reduction in LVIDd is secondary to a reduction in EDV and not to a change in the diastolic properties of the ventricular myocardium.

The changes in the ejection fraction (EF) following surgery describe the alterations in left ventricular function which occur after aortic valve replacement. The maintenance of normal EF following valve replacement suggests that adequate myocardial protection during cardiopulmonary bypass and a properly functioning prosthetic valve have allowed myocardial hypertrophy to regress and normal ventricular function to be maintained after surgery.

It is not clear if an increase in EF following removal of the aortic valvular obstruction is due to improved left ventricular performance or simply the result of reduced afterload. It is known that an acute increase in afterload such as induced by an angiotensin infusion often results in a reduction in EF [23]. The lowering of peripheral vascular resistance with drugs such as nitroglycerin is also known to increase the EF in some patients with ischemic heart disease [24].

The change in Left ventricular mass (LVM) has also been impressive in these patients. The measurement of LVM depends upon an accurate determination of wall thickness and the assumption that left ventricular myocardial hypertrophy occurs in a uniform manner and is accurately represented by the free wall thickness.

Our patients showed a significant reduction in LVM, with a mean reduction of 47 g 1 year post-operatively. It is possible that further reduction in hypertrophy will occur in some patients if they continue to have good prosthetic valve function over a longer period of time. It is possible that the process of regression in hypertrophy is limited by the myocardial fibrosis which accompanies advanced valvular heart disease. Few serial studies of regression in hypertrophy following valve surgery are available, although estimates of reduction in left ventricular wall thickness with time are possible with current echocardiographic techniques. One such study by Schuler et al. [25] evaluated [13] patients with predominant AR before and seven days, four months, and 18 months after valve replacement. These investigators found an early reduction in chamber dimensions and gradual reduction in left ventricular wall thickness.

Our study does not corroborate with the study performed by Powell et al. at the New York School of Medicine, which was published in the year 2000. The study included 55 patients with severe aortic stenosis and ejection fractions of 30% or lower who subsequently underwent AVR. They concluded that the outcome of AVR for severe AS is worse in patients with impaired LV function [5].

Our study, however, does corroborate with the study performed by Connolly et al, at the Mayo Clinic, published in 1997. They included 154 consecutive patients with EF; or = 35% undergoing aortic valve replacement for aortic stenosis. They concluded that despite LV dysfunction, the risk of aortic valve replacement for AS is acceptable and is related to coronary artery disease [26].

Another study performed by Sharony et al has similar results to the ones obtained in our study. They included 416 patients undergoing isolated aortic valve surgery with or without coronary artery bypass grafting, with an EF & lt; 40%, and the study was performed at the New York School of Medicine. They concluded that aortic valve surgery in patients with impaired ventricular function carries an acceptable operative risk [9].

Conclusions

- LV dimensions and LV mass regress significantly at the end of 1 year with significant improvement in LV function.
- Aortic valve replacement in this subset of patients produces functional improvement in NYHA class and has low mortality.
- Patients with severe aortic stenosis with LV dysfunction should not be denied surgery.

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