Weight gain potential—a neglected entity during valve replacement

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Abstract

Introduction During valve replacement, appropriate valve size will be chosen based on many factors, neglecting the potential of the patient for gaining weight. We aimed at evaluating the weight gain potential and its effect on hemodynamics in post mitral valve replacement (MVR) patients.

Material and methods In 118 post-MVR patients, demographic and echocardiographic data at the time of discharge and follow-up were obtained and analyzed. Primary aim of study is to analyze the hemodynamics of patients based on weight gain/loss. Secondary aim is to evaluate the same in patient-prosthesis mismatch (PPM) subgroup and to evaluate the study population for the potential to gain/loss weight.

Results Among 118 patients, 87 patients (73.7%) gained weight. In 87 weight gained patients, left atrial (LA) size ($p=0.011$) and pulmonary artery systolic (PA) pressure ($p=0.028$) at follow-up were significantly elevated than the discharge values. Among 53 PPM patients (incidence, 44.9%), 34 patients gained weight and their PA pressure was found to be elevated at follow-up ($p=0.021$) whereas weight lost group does not show any significant difference ($p=0.972$). Frequency of weight gain was more among patients who weighed < 50 kg preoperatively (28 out of 30) ($p=0.013$) and 20 to 30 years age group patients ($p=0.043$). No sex predilection was noted ($p=0.149$).

Conclusion In post-MVR patients, weight gain has definitive influence over hemodynamics. In PPM subgroup, weight gained patients had significantly increased PA systolic pressure at follow-up. Young, < 50 kg weighed, and PPM patients should be advised to maintain their weight post MVR for better hemodynamics.

Keywords Weight gain · PPM · Mitral valve replacement

Introduction

Most valvular heart disease patients are cachectic and have breathlessness, which forbids them from having an adequate diet, and in addition, gut edema also contributes to malabsorption. As a result, patients at the time of surgery are under weight and cachectic. Valve is sized based on many factors, but we never consider the weight gain

potential of the patient at the time of surgery, thereby neglecting an important factor which may influence the postoperative recovery. We aimed at evaluating the weight gain potential and its effect on hemodynamics in post MVR patients at follow-up.

Aim and objectives

Our primary aim was to evaluate the influence of weight gain/loss over hemodynamics during the follow-up.

Secondarily to evaluate:

- The influence of PPM over post-operative hemodynamics
- The influence of weight gain/loss over hemodynamics in PPM subgroups
- Study population for potential to gain weight

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Materials and methodology

Patient population

One hundred eighteen patients who underwent isolated MVR in our Institute of Cardio Vascular Diseases, Madras Medical Mission, Chennai, during the period of January 2015 to December 2016 constituted the study population, based on inclusion and exclusion criteria (Table 1).

Methodology

All demographic and trans-thoracic echocardiography data of the patients at the time of discharge (7th post-operative day) and during follow-up were retrieved retrospectively and analyzed. All patients were followed up for a minimum of 6 months.

Echocardiographic measurements

Echocardiographic analysis was performed by experienced cardiologists in the left lateral position. Standard M-mode measurements were made according to recommendations of the American Society of Echocardiography. Prosthetic mitral valve was evaluated by color Doppler in the apical four-chamber view. The tricuspid regurgitation peak flow rate was obtained using the continuous wave Doppler technique, while the right ventricular-right atrial peak

pressure gradient was estimated by the modified Bernoulli equation. The systolic PA pressure was calculated by adding the systolic right ventricular pressure derived from the tricuspid regurgitation to the estimated right atrial pressure. (PA pressure = $4 \times [\text{tricuspid regurgitation jet velocity}]^2 + \text{right atrial pressure}$) [1–3]. Even though Swan Ganz catheter measures more accurate PA pressure, we used transthoracic echocardiography for maintaining uniformity even during the follow-up period. LA diameter was measured using parasternal long-axis view. The mean trans-prosthetic pressure gradients were determined by the simplified Bernoulli equation.

Patient-prosthesis mismatch definition

Patient-prosthesis mismatch in mitral position is defined clinically significant if the effective orifice area indexed (EOAi) for body surface area was less than $1.2 \text{ cm}^2/\text{m}^2$, moderate is between 0.9 and $1.2 \text{ cm}^2/\text{m}^2$, and considered severe if less than $0.9 \text{ cm}^2/\text{m}^2$ [4, 5]. The prosthetic mitral effective orifice area (EOA) was estimated by dividing the prosthetic mitral valve diastolic flow of the left ventricular outflow path by the integral of the mitral valve (MV) trans-prosthetic velocity using the continuity equation [6]. Effective orifice area was indexed by dividing it by body surface area (BSA) calculated using Mosteller's formula [7]:

Body surface area (m^2)

$$= \sqrt{(\text{height in cm} \times \text{weight in kg} / 3600)}.$$

Table 1 Inclusion and exclusion criteria

Inclusion criteria

- Patients with age > 18 years
- Patients who underwent isolated mitral valve replacement using mechanical and bio-prosthetic valves

Exclusion criteria

- Associated
 - Congenital heart diseases
 - Coronary artery disease
 - Prosthetic endocarditis
 - More than mild other valvular lesions
 - Cardiomyopathy
 - Chronic obstructive pulmonary disease
 - Other comorbid conditions like chronic kidney disease
 - Severe left ventricular function
- Unavailability of echocardiographic data
- Follow-up echo showed valvular leak, paravalvular leak, and restricted leaflet motion
- Patient needed redo cardiac surgery/procedure at follow-up
- Patients who have not completed follow-up of minimum 6 months
- Patient with weight changes within $\pm 1 \text{ kg}$
- Patients on steroid, antidepressants, and other appetite stimulants
- Diabetic patients on insulin

Statistical analysis

All statistical analyses were performed using Statistical Package for Social Science (SPSS, version 17) for Microsoft windows. The data were not normally distributed, and therefore, parametric/non-parametric tests were performed. Descriptive statistics were presented as numbers and percentages. The data were expressed as mean and standard deviation (SD). Independent sample Student *t* test/Mann-Whitney test were used to compare continuous variables between two groups. Paired sample test/Wilcoxon's signed-rank test were used for within groups. A chi-squared test was used for comparison between two attributes. A two-sided *p* value < 0.05 was considered statistically significant.

Results

Overall study group analysis (Table 2(a))

During the study period, 118 patients (48 males/70 females), with mean age of 44.49 ± 11.4 years underwent MVR using either mechanical (n , 70) or bio-prosthetic (n , 48) valves, and completed the follow-up of 20 ± 7.48 months (ranging from 8 to 36 months).

Among 118 patients, 87 patients (73.7%) gained weight at an average of 5.65 ± 3.36 kg and 31 patients (26.3%) had lost weight, averaging 4.04 ± 2.08 kg. In 87 weight gained patients, LA size ($p = 0.011$) and PA pressure ($p = 0.028$) at follow-up (41.53 ± 7.92 mm and 38.62 ± 8.27 mm of Hg respectively) were significantly higher than the discharge values (39.62 ± 7.39 mm and 36.79 ± 8.88 mm of Hg respectively). Patients who got weight reduction had no statistical significant variation in LA size ($p = 0.786$), PA pressure ($p = 0.334$), and mean gradient ($p = 0.50$) at follow-up.

PPM subgroup analysis (Table 2(b, c))

When weight at surgery is used for estimating indexed EOA, incidence of PPM was noted as 44.9%. At the same time, when weight at follow-up was used for indexing EOA, incidence increases to 58.47%. On comparing the discharge vs follow-up values of LA size, PA pressure, and mean gradient in PPM group, we found that PA pressure ($p = 0.048$) was elevated at follow-up even after valve replacement. In no PPM (non-PPM) group, no statistical differences were noted in any of those.

Among 53 PPM patients, 34 patients (73.7%) gained weight and their PA pressure was found to be elevated at follow-up ($p = 0.021$), whereas weight lost PPM subgroup did not show any significant difference ($p = 0.972$).

Weight gain potential analysis (Table 3)

- When study population was stratified based on age group and analyzed, 20 to 30 years age group was found to be more prone for weight gain ($p = 0.043$).
- There is no sex predilection for tendency to gain weight ($p = 0.149$).
- Patients were categorized into < 50 kg, 50 to 70 kg, and > 70 kg based on preoperative weight. Out of 30 patients, 28 patients in < 50 kg weight group gained weight ($p = 0.013$).
- There is no difference in weight gaining pattern when the study population was analyzed based on their primary mitral valve pathology ($p = 0.78$).

Discussion

Cardiac cachexia is defined as the loss of weight and loss of appetite that occurs during the state of chronic low cardiac output and congestive cardiac failure. Wasting process is an independent risk factor for mortality in heart failure patients [8]. Even though mechanism for wasting process is not well established, the probable mechanism for cardiac cachexia may be altered metabolism (increased catabolism with decreased anabolism) [9, 10]. Malabsorption (dietary deficiency) may be due to splanchnic venous congestion, hepatic congestion, and gut edema, secondary to right ventricular impairment. In addition, catabolic effects of neuro-hormones and inflammatory cytokines also contribute to cachexia. Hence, most of the patients are underweight at the time of surgical correction.

Table 2 Results: (a) analysis based on weight gain/loss in overall population; (b) subanalysis of PPM and non-PPM groups; and (c) analysis based on weight gain/loss in PPM subgroup. LA size measured in mm, and PA pressure and mean gradient measured in mm of Hg

Patient population subgroups		Parameter	At discharge	At follow-up	<i>p</i> value
(a) Overall population (118 patients)	Weight gain (87 patients)	LA size	39.62 ± 7.39	41.53 ± 7.92	0.011
		PA pressure	36.79 ± 8.88	38.62 ± 8.27	0.028
		Mean gradient	4.70 ± 2.69	4.25 ± 2.32	0.163
	Weight loss (31 patients)	LA size	39.97 ± 7.43	39.65 ± 8.98	0.786
		PA pressure	39.03 ± 10.09	38.03 ± 9.88	0.334
		Mean gradient	3.74 ± 1.63	3.97 ± 1.99	0.500
(b) Overall population (118 patients)	PPM (53 patients)	LA size	40.45 ± 6.44	42.34 ± 7.71	0.055
		PA pressure	38.13 ± 10.67	40.11 ± 10.34	0.048
		Mean gradient	4.40 ± 2.15	4.38 ± 2.13	0.871
	Non-PPM (65 patients)	LA size	39.11 ± 8.04	39.97 ± 8.52	0.305
		PA pressure	36.77 ± 7.88	37.12 ± 6.85	0.698
		Mean gradient	4.00 ± 2.31	4.51 ± 2.75	0.164
(c) PPM patients (53 patients)	Weight gain (34 patients)	LA size	39.79 ± 6.46	42.32 ± 7.08	0.066
		PA pressure	36.21 ± 9.67	39.26 ± 10.15	0.021
		Mean gradient	4.41 ± 2.18	4.53 ± 2.31	0.839
	Weight loss (19 patients)	LA size	41.63 ± 6.42	42.37 ± 8.93	0.558
		PA pressure	41.58 ± 11.75	41.63 ± 10.78	0.972
		Mean gradient	4.37 ± 2.17	4.11 ± 1.79	0.588

Table 3 Analysis of weight gain potential

Based on parameter		Weight gain/loss patients (in number)		Total of patients	p value
		Gain	Loss		
Age group	20–30 years	13	1	14	0.043
	31–40 years	21	11	32	
	41–50 years	27	8	35	
	51–60 years	23	6	29	
	> 60 years	3	5	8	
Sex	Male	32	16	48	0.149
	Female	55	15	70	
Weight at surgery	≤ 50 kg	28	2	30	0.013
	51–70 kg	49	22	71	
	> 70 kg	10	7	17	
Pathology	Mitral stenosis	14	34	48	0.78
	Mitral regurgitation	6	16	22	
	Mixed lesion	11	37	48	

Palmieri et al. had shown the association of hypertensive patients with valvular (aortic/mitral) regurgitation to higher LV mass, total myocardial biomechanical workload, lower body fat mass, and body mass index [11]. In the Strong Heart Study, Collis analyzed the relationship of stroke volume (SV) and cardiac output (CO) to body composition and concluded that SV and CO were more strongly related to fat-free mass than adipose mass [12]. Study by Buchanan et al. [13] has proven that severe mitral valve disease patients had increased appetite after their corrective procedure (valve replacement/repair).

Lipolytic effects of B-type natriuretic peptide (BNP) 1–32 over adipose tissue in patients with heart failure are well established [14]. Post surgical correction left ventricular dimensions start to normalize. This causes a gradual decline trend in pro-BNP levels, i.e., lipolysis. This explains the reason for the nutritional recovery in patients at follow-up.

On analyzing study population of 406 subjects, Rajila et al. [15] found that mitral valve annular diameter increased steadily with rise in BSA. Mitral valve diameter was 15.5 mm for BSA of 0.61 to 0.7 m² and it suddenly rise from 15 to 18 mm for BSA of 0.71 to 0.80 m². Thereafter, annular diameter increases consistently by 0.2 to 0.6 mm per 0.1 m² increase in BSA. The study also concludes that overall annular diameter in Indian population was less in comparison with standard values. This accommodative change will be hindered with valve replacement. When patient gains weight, the implanted valve may be inadequate for his hemodynamics, i.e., a condition similar to PPM. Hence, we like to entitle it as “acquired PPM.”

For example, when a valve with EOA of 2 cm² (EOAi, 1.21 cm²/m²) is implanted in a patient with 165 cm height and 60 kg weight (at time of surgery) and if patient gained weight postoperatively during the follow-up period, then the effect of weight gain over EOAi is depicted in (Fig. 1).

In adults, height is hardly going to vary; hence, weight is the prime factor to influence the indexed EOA, i.e., hemodynamics.

$$\text{EOAi} = \text{EOA} / \sqrt{(\text{WEIGHT} * \text{HEIGHT} / 3600)}$$

(Keeping height and EOA constant after valve implantation)

$$\text{EOAi} \propto 1 / \sqrt{\text{weight}}$$

We limited our follow-up period to 3 years, mainly to avoid confounding effect caused by the degeneration of bio-prosthetic valves. We also aimed at analyzing the effect of weight gain over the hemodynamics specifically during post-operative period. Hence, it is appropriate to compare the (7th post-operative day) discharge values with follow-up values, rather than comparing preoperative with follow-up values. By considering LA size during discharge instead of preoperative value, we nullified the effect of LA appendage exclusion.

Kumar et al. [16] found that body mass index (BMI) was significantly higher in patients with left atrial enlargement (LAE). They also found that BMI is an independent predictor of LAE. They postulated that increase in weight causes an increase in total blood volume and cardiac output, which results in elevated cardiac filling pressures, eventually ending up with increase in left ventricular and left atrial dimensions. They also attributed the LAE to obesity, due to increased incidence of atrial fibrillation in obese patients. In our study also, LA progressively increased in size with increase in body weight, even after correction of primary mitral pathology. In addition, we found that in weight gained patients, PA pressures had progressively increased in the follow-up period, irrespective of patients having PPM or not. At the same time, patients who got weight reduction did not show any difference in LA size, PA pressures, and mean gradient at follow-up.

PPM is defined as “mismatch between the expected hemodynamic parameter of the prosthesis and requirement of cardiac output for the patient.” The clinical impact of PPM and

Fig. 1 Alteration of EOAI with respect to weight gain of patient. (Valve of EOA 2 cm² implanted in a patient with 165 cm height and 60 kg weight at time of surgery.) EOAI indexed effective orifice area

its influence on hemodynamics after MVR has been relatively unexplored [4, 5, 17], until Rahimtoola and Murphy [17] described the case of a patient with PPM in the mitral position for the first time. In subsequent studies, Dumesnil et al. [4] and Dumesnil and Yoganathan [5] showed that the EOAI of mitral prostheses should ideally be not less than 1.2 to 1.3 cm²/m², to avoid abnormally high residual trans-valvular pressure gradients.

As far as our best knowledge, this is the first study that compares patients' own parameters at discharge with follow-up, instead of comparing PPM with non-PPM patients. According to the literature, incidence varies from 29.7 to 78% [18–22], but we found the incidence of PPM to be 44.9%.

On analysis of LA size, PA pressure, and mean gradient at discharge with follow-up values, we found that post-operative PA pressure was elevated even after replacing the pathologic valve. To the contrary, non-PPM patients did not show any significant difference in PA pressure. However, Magne et al. [18] and Li et al. [19] compared PA pressures of PPM and non-PPM patients and found that there is a significant difference ($p = 0.001$).

Fig. 2 PA pressure elevation was more pronounced when PPM patients gained weight. PA pulmonary artery, PPM prosthesis-patient mismatch

Tuğcu et al. [20] tried to elicit the relation between PPM and its effect on regression of LA size, but they failed to show statistically significant difference between PPM and non-PPM group with regard to LA size regression ($p < 0.061$). Irrespective of patient having PPM or not and gaining or losing weight, in our study also, LA size and mean gradient did not show any significant variation at follow-up.

When we stratified the PPM group into weight gained and weight lost subgroups and evaluated, we came across an interesting finding that PA pressure increases more significantly when PPM group patients gain weight ($p = 0.048$ became $p = 0.021$ on weight gaining—Fig. 2). In the other arm, PA pressure remained static in PPM patients, when they reduced the weight post-operatively.

Hence, it is obvious that when PPM patients gain weight post-operatively, their PA pressures will worsen at follow-up. As there is anatomical limitation in enlargement of mitral annulus, in unavoidable circumstances, we may end up with implanting a valve with smaller EOAI, i.e., PPM. With proper weight maintenance, patient can overcome adverse effect of PPM and may have better hemodynamics, despite PPM.

In 2018, Kim et al. [23] from Korea evaluated 48 patients who underwent MV surgery using simplified nutritional assessment questionnaire for appetite laboratory tests, echocardiography, and dual-energy X-ray absorptiometry before and 1 year after MV surgery. They found that post MV surgery, all patients had increased appetite and improved laboratory data. In addition, they found that there was a significant increase in bone mineral density and body fat percentage in patient with mitral regurgitation (MR) and not in patients with mitral stenosis (MS). They also concluded that right ventricular pressure overload showed a close association with the changes in appetite and body fat percentage in patients with MR. Weight gain was more with MR patients than MS patients postoperatively ($p < 0.05$). Contrarily in our study, no difference was observed in pattern of weight gain, based on their primary mitral valve pathology.

No sex predilection was noted for weight gaining tendency. Young and patients with preoperative weight of < 50 kg were found to gain weight more frequently.

As a cardiac surgeon, we should try to implant a valve with better effective orifice area without under sizing, keeping in mind the postoperative weight gain potential. It is necessary to advice vulnerable patients for adequate physical exercise and educate them about the importance of weight management.

Conclusion

Instead of LA size and PA pressure coming back to normalcy, both parameters worsened with weight gain. While analyzing PPM subgroup, PA pressures elevated more significantly at follow-up in patients who gain weight. Hence, it is evident that weight gain post-operatively influences the recovery after surgery. We should educate the vulnerable groups, such as young, < 50 kg weight, and PPM patients, about the importance of physical exercise and necessity to maintain their weight, for better hemodynamics.

Limitations

It is a non-randomized, retrospective study, with limited sample size. PPM is more pronounced and well established in aortic position, so further studies should be conducted in post aortic valve replacement patients for analyzing the influence of weight gain/loss over hemodynamics despite of PPM prospectively.

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• All authors of this research paper have directly participated in the planning, execution, or analysis of this study.

Compliance with ethical standards

Institutional review board approval has been obtained for the publishing of patient profile and this article.

Informed consent Informed consent was obtained from all individual participants included in the study.

Statement of human rights For this type of study formal consent is not required.

Conflict of interest The authors declare that they have no competing interests.

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