Original Article

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Evaluation of Prosthetic Heart Valves by Postoperative Echocardiography

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Abstract

Objective: To determine the Doppler derived mean gradients of mechanical & Bio-prosthesis in early postoperative period in patients undergoing valve replacement at a tertiary care cardiac centre. *Methods:* One-hundred-ninety-nine (n = 199) consecutive patients who underwent mitral, aortic or dual (mitral and aortic) valve replacement by mechanical prosthesis or Bio-prosthesis were studied. Base line Doppler echo study was done with in 7 days after surgery (pre-discharge) and derived mean gradients were assessed and recorded. *Results:* Doppler derived mean gradient for different mitral prosthesis of ATSAP prosthesis, St Jude mechanical prosthesis, TTK Chitra disc mechanical prosthesis & Bio-prosthetic valves were 5.5 ± 0.77 mm Hg, 5.0 ± 0.01 mm Hg, 9 ± 0.3 mm Hg and 5.0 ±1.3 mm Hg respectively and mean gradient for different aortic prosthesis of ATSAP prosthesis, St Jude mechanical prosthesis, TTK Chitra disc mechanical prosthesis & Bio-prosthetic valves were 9 ± 0.07 mm Hg, 13.35 ± 4.14 mm Hg, 9.5 ± 0.5 mm Hg and 10.3.0 ± 0.5 mm Hg respectively. *Conclusions:* The study assessed baseline gradients across mitral and aortic mechanical prosthesis/Bio-prosthesis in valve replacement patients & pointing out the need to perform routinely an accurate baseline Doppler-echocardiography evaluation early after surgery used as reference gradients to assess prosthetic valve function at follow-up.

Keywords: Doppler-Echocardiography; Prosthetic; Aortic; Mitral.

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Introduction

Doppler echocardiography parameters (i.e. pressure gradients, effective orifice area, Doppler velocity index) can be estimated to study the hemodynamic performance of aortic prosthetic valves, but the interpretation of the data is much more difficult as compare to native valve evaluation. Prosthetic valves have some degree of obstructive to blood flow. Thus this makes it difficult to decide whether a calculated Doppler-echocardiography measure indicate the performance of a normal functioning valve or prosthetic valvedysfunction.[1,2]

The interpretation of Doppler-echocardiography data requires the knowledge of the exact type and size of the implanted valve and will play an important role in determining hemodynamic features. Certainly, tables based on solid data summarizing normal value range would be useful to evaluate the Doppler-echocardiography measurements in each patient.[3,4] Number of studies have tried to summarizing normal value range based on available data, but they have been

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limited by inadequate number of patients, different Doppler-echocardiography evaluation timings, as the large number of valve types available on the market, and different center echo cardiographic assessment.[5]

Emerson et al. studied mean gradient in 180 St. Jude mechanical aortic prosthesis and found mean gradient of 14 ± 5 mm Hg, Bitar and colleagues found Doppler-derived mean gradient average 4 ± 2 mm Hg for mitral St. Jude mechanical prosthesis.[6] These values serve as a reference reading in patient with suspected prosthesis dysfunction in those without an initial postoperative Doppler assessment record. Unfortunately the routine postoperative Doppler derived prosthetic valve gradients has been underutilized in our patients and no data was found regarding the mean Doppler gradients in patients undergoing valve replacement in our population.The aim of our study was to determine the early postoperative mean gradients for mitral and aortic St. Jude mechanical, ATS AP mechanical, TTK Chitra Telting Disc Mechanical Mitral & Aortic Prosthetic Valves, $ St. Jude Bicor Valve, St. Jude Trifeta, Medronic Hencock Ii Ultra Porcine Valve, Bio-prosthetic Carpentier-Edwards Perimount standard (CEPS), Sorin Mosiac Mitral & Aortic Valves which are the most widely used in current clinical practice. These gradients can be utilized as reference gradients for our valve replacement patients

Materials and Methods

One hundred Ninety nine (199) consecutive patients affected by Mitral stenosis (MS)/Mitral insufficiency (MR), aortic stenosis (AS) and/or aortic insufficiency (AI), who had had either St. Jude mechanical, ATS AP mechanical TTK disc valve, St. Jude Bicor Valve, St. Jude Trifeta, Medronic Hencock Ultra Porcine Valve, Edwards Lifescience Perimounts, Bio-prosthetic Carpentier-Edwards Perimount standard (CEPS) Mitral & Aortic Valves or both aortic & mitral valve implanted were included for this study.

Indications for valve replacements were: severe AS, severe AI or moderate AS associated with coronary artery disease requiring surgical revascularization. Severe MS not suitable for valvotomy or severe MR

All patients underwent either aortic or Mitral valve replacement or both (DVR) with or without TV repair/TV Annuloplasty through conventional midline sternotomy, during total normothermic cardiopulmonary bypass. Myocardial protection was achieved by intermittent anterograde cold blood cardioplegia. Prosthesis size was selected according to the size of the aortic annulus, & Mitral annulus which was incisures using specific manufacturer's sizers. All patients underwent complete preoperative Doppler-echocardiography evaluation and a control Doppler-echocardiography examination within 7 days after surgery. The Doppler-echocardiography examinations were performed with a i.e. 33 (Philips, Eindhoven,) in the same echo-laboratory by four Echocardiographers. The investigator was blinded to the prosthetic valve type and size.

Left ventricle ejection fraction (EF) was estimated through Simpson's method. The maximum flow velocity and mean gradients were calculated. The presence of physiological intra prosthetic regurgitation and/or paraprosthetic leak was investigated.

Results

The Mean mitral valve gradient (MVG) was 5.1 ± 1.3 mm Hg. According to valve sizes of 29 mm sized valve, 27 mm sized valve, 30 mm valve and 25 mm sized St. Jude mechanical valve Mean Mitral valve gradient (MVG) were 5.9 ± 1.0 mm Hg, 5.9 ± 1.0 mm Hg, 5.5 ± 0.8 mm Hg and 5.0 ± 0.1 mm Hg respectively without statistical significance difference (p = 1.0) Commonly used Bio-prosthetic mitral valves were St. Jude bicorn valve, Medtronic mosaic porcine valve Medtronic Hancock II porcine valve Edward life science paramount's valve.

The Mean Mitral valve gradient (MVR) of different types of mitral prosthetic ATSAP, St. Jude, TTK Chitra and Bio-prosthetic valves were 5.5 ± 0.77 mm Hg, 5.0 ± 0.01mm Hg, 5.09 ± 0.3 mm Hg, and 5.0 ± 1.3 mm Hg hg respectively. Comparing the St Judas mach valve with ATS AP mach valve and TTK Chitra mach valve, St jades mach valve has low mitral gradients $ good hemodynamic profile with statistical significant difference (p < 0.0019) But Comparing the St. Jude mach valve with Bio-prosthetic valve have same equal mitral gradients and good hemodynamic profile without statistical significant difference.

Among 63 AVR patients, 28% of ATS AP mechanicalvalve (n = 18) were implanted 23.8% were St. Jude mechanical valve (n = 15) and 6.5% were TTK Chitra disc mechanical valve. Other AVR patients (n = 26) were implanted different types of Tissues valves (41.2%).

Among 18 ATSAP AVR patients. 61% were male (n = 11). Mean age was 41.3 ± 13.3 years. Mean BSA was 1.50 ± 0.18 m^2. Mean EF was 53.5 ± 4.5%. Mean post ATSAP AVR LA size was 3.4 ± 0.3 compare to pre AVR 4.15 ± 0.8. More commonly used valve sizes were 18 (n = 5), 20 (n = 3) & 22 (n = 2). The Mean Aortic valve gradient (AVG) was 9 ± 0.07 mm Hg. According to valve sizes of 29 mm sized valve 18mm sized valve, 20 mm sized valve, and 22 mm valve sized valve Mean Aortic valve gradient (AVG) were 11.5 ± 2.07 mm Hg, 11 ± 2.07 mm Hg and 9.04 ± 0.01 mm Hg respectively without statistical significant difference (p = 1.0).

No of patients in different age group were in age group of 30–39 was 6, 40–49 was 4 and 50–59 was 5. FIVE Grade IV, Three Grade III AR were noted.

Among 15 St. Jude AVR patients, 66% were male (n = 10). Mean age was 43.6 ± 14.3 years. Mean BSA was 1.58 ± 0.18 m^2. Mean EF was 55.5 ± 4.5%. Mean post St. Jude AVR LA size was 3.26 ± 0.47 compare to pre AVR 3.95 ± 0.8. More commonly used valve sizes were 19 (n = 3), 21 (n = 7) & 25 (n = 4). The Mean Aortic valve gradient (AVG) was 13.35 ± 4.14 mm Hg.

According to valve sizes of 19 mm sized valve, 21 mm sized valve, 25 mm valve and 17 mm sized valve Mean Aortic valve gradient (AVG) were 17.6 ± 6.8 mm Hg, 13.1 ± 4.4 mm Hg, 11.2 ± 4.89 mm Hg and 18.0 ± 0.01 mm Hg respectively without statistical significant difference (p = 1.02). Four Grade IV, one Grade III AR werenoted. Number of patients in different age group were a) in age group of 30–39 was 4,b) 40–49 was 3 and c) 50–59 was 3.

Among 26, Bio-prosthetic AVR patients. 80% were male (n = 21). Mean age was 57 ± 10 years. Mean BSA was 1.56 ± 0.18 m^2. Mean EF was 54 ± 5.0%. Mean post Bio-prosthetic AVR LA size was 3.02 ± 0.35 compare to pre AVR 4.7 ± 0.6. More commonly used valve sizes were 19 (n = 10), 23(n = 4) 25 (n = 6) & 21 (n = 5).

The Mean Aortic valve gradient (AVG) was 10.3.0 ± 0.5 mm Hg. According to valve sizes of 19 mm sized valve, 21 mm sized valve, 23 mm valve and 25 mm sized valve Mean Aortic valve gradient (AVG) were 9.25 ± 1.0 mm Hg, 8.4 ± 1.0 mm Hg, 7.75 ± 01.2 mm Hg and 8.1 ± 0.7 mm Hg respectively.

Commonly used Bio-prosthetic mitral valves were St. Jude bicorn valve (n = 8), Medtronic mosaic porcine valve (1), Medtronic Hancock II porcine valve (6), Edward life science paramount's valve (3). No of patients in different age group are 1) in age group of 30–39 was 1,2) 40–49 was 7 and 50-59 was 7. Two Grade IV, One Grade III AR were noted

Among 4 TTK Chitra disc mechanical AVR patients. 75% were female (n = 11).Mean age was 52 ± 8 years. Mean BSA was 146 ± 0.18 m^2. Mean EF was 56 ± 5.3%. Mean post TTK Chitra disc

Table 1: Showing peak mean gradients in different types of MVR

	ATSAP MVR		St MVR Judes		TTK Chitra MVR		Bioprosthesis	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Peak MVG	16.7 ± 11.9	9.9 ± 8.6	17.5 ± 10.8	10.5 ± 8.3	21.2 ± 2.3	11 ± 2.5	12.5 ± 14.4	5.5 ± 6.5
Mean MVG	9.6 ± 3.3	5.5 ± 0.7	10.5 ± 2.8	5 ± 0.1	12.3 ± 2.8	5.09 ± 0.3	12.2 ± 3.2	5 ± 2.3

Table 2: Showing ECHO parameters in different types of MVR

	ATSAP MVR		St. Judes MVR		TTK Chitra MVR		Bioprosthesis MVR	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Mean (cm) LVID D	4.6 ± 0.4	4.3 ± 0.3	5.2 ± 0.8	4.4 ± 0.6	5.9 ± 0.7	4.9 ± 0.8	5.99 ± 4.4	4.4±4.9
Mean (cm) LVID S	3.7 ± 0.6	3.02 ± 0.5	3.8 ± 0.7	3.1 ± 0.7	4.9 ± 0.8	4.37 ± 0.6	3.8 ± 0.6	3.3 ± 0.36
Mean (cm) LASI ZE	4.7 ± 0.6	3.9 ± 0.6	5.12 ± 0.8	4.05 ± 0.9	5.1 ± 0.8	3.96 ± 0.9	5.2 ± 0.6	3.6 ± 0.36

Table 3: Showing size by size comparison of mean mitral gradients in different types of MVR

	ATSAP MVG (Hg)		TTK Chitra MVG (Hg)		St. Judes MVG (Hg)		Bioprosthes IS MVG (Hg)	
Valve Size (mm)	Pre	Post	Pre	Post	Pre	Post	Pre	Post
25	11 ± 1.25	7.04 ± 6.44	16.6 ± 2.3	5 ± 0.1	0 ± 0.1	5 ± 0.1	8.4 ± 6.2	5 ± 0.1
27	9 ± 12.7	5 ± 0.1	13 ± 2.9	5 ± 0.1	10.6 ± 2.6	5 ± 0.1	0	5.9 ± 1.0
29	10.5 ± 9.7	5.5 ± 0.7	13 ± 4.2	5 ± 0.1	9.5 ± 3.5	5 ± 0.1	0	5.9 ± 1.0

Table 4: Showing different types of aortic valve surgery and base line charecterstic avr patient

Total 63 Patients	ATSAP AVR (*n* = 18)	St. Jude Mech AVR (*n* = 15)	TTK Chitra AVR (*n* = 4)	Bioprosthetic AVR (*n* = 26)
Mean age (Y)	41.3 ± 13.3	43.6 ± 14.3	52 ± 8 years	57 ± 10 year
Female	39% (*n* = 7)	34% (*n* = 5)	75% (*n* = 3)	20% (*n* = 5)
Male	61% (*n* =11)	66% (*n* = 10).	25% (*n* = 1)	80% (*n* = 21)
Mean BSA m^2	1.50 ± .18	1.58 ± 0.18.	146 ± 0,18	1.56 ± 0.18
Mean EF	53.5 ± 4.5%.	55.5 ± 4.5%.	56 ± 5.3%	54 ± 5.0%

mechanical AVR LA size was 2.8 ± 0.5 compare to pre AVR 3.45 ± 0.8. More commonly used valve sizes were 19 (*n* = 3) & 23(*n* = 1). Post TTK Chitra disc mechanical AVR Mean Aortic valve gradient (AVG) was 9.5 ± 0.5 mm Hg. The Mean Aortic valve gradient (AVG) for 19 mm sized valve and 23 mm sized valve were 9.5±0.57 mm Hg, and 10.0 ± 0.01 mm Hg respectively (Tables 1–4).

Discussion

Assessment of prosthetic valve function is a common in practice of clinical cardiology. The number of valve replacement patients is increasing due to significant number of rheumatic valvular heart disease. Mechanical valve acts as a double edged sword. It provides durable solution for valvular heart disease, but on the other hand has potential risks related to anticoagulation and valve dysfunction i.e. infective endocarditic, valve thrombosis, panes formation and dehiscence.

Doppler echocardiography is an versatile, radiation-free and low cost non-invasive feasible and sensitive modality of choice to early postoperative baseline and serial evaluation of prosthetic valve function. Out of all Doppler derived parameters, baseline mean gradient across prosthesis is invaluable for subsequent assessment of prosthesis dysfunction. The St. Jude Medical valve has excellent hemodynamic performance and reliability and is currently the most frequently implanted prostheticvalve.

TTK Chitra heart valve prosthesis (CHVP) is designed and developed by Sri Chita Tribunal Institute for Medical Sciences and Technology (SCTIMST) and more widely used in enveloped countries.As the occlude disc is radiolucent, Doppler echocardiography assumes the predominant tool in the evaluation of prosthetic valve dysfunction of CHVP and no study regarding its echocardiography characteristics. It can provide information on the gradients across and the mitral valve area (MVA), which are comparable with those obtained at invasive cardiac catheterization.

Mean Doppler gradients for St. Jude mechanical prosthesis at mitral and aortic location have been previously described. Mean gradients were reported in four patient groups who had St. Jude mechanical prosthesis at mitral location.

According to valve sizes of 29 mm, 27 mm, 20 mm, and 25 mm, mean mitral gradients were 5.0 ± 0.77 mm Hg, 5 ± 0.1 mm Hg, 5.5 ± 0.1 mm Hg and 5.0 ± 0.1 mm Hg, respectively The gradients among the four valve sizes were not statistically significant (*p* = 1.0). Langley and colleagues found mean gradient of 4 ± 1 mm Hg across 66 mechanical St. Jude mitral prosthesis.[7,8] In our study mean mitral valve gradient was 5 ± 0.1 mm Hg.

Mean gradients were reported in four patient groups who had St. Jude mechanical prosthesis at aortic location. According to valve sizes of 19 mm, 21 mm, 25 mm and 17 mm, mean aortic gradients were 17.6 ± 6.8 mm Hg, 13.1,± 4.4 mm Hg, 11.2 ± 4.89 mm Hg and 18.0 ± 0.01 mm Hg respectively. The gradients among the four valve sizes were not statistically significant (*p* = 1.05). Miller and colleagues found mean gradient of 14.4 ± 7 mm Hg across 44 St. Jude aortic prosthesis.[9,10] In our study mean aortic valve gradient was 13.35 ± 4.14 mm Hg.

Mean gradients were reported in four patient groups who had ATSAP mechanical prosthesis at mitral location. According to valve sizes of 29 mm, 27 mm, 25 mm, valve and 23 mm, mean mitral gradients were 5.5 ± 0.77 mm Hg, 5 ± 0.01 mm Hg, 7.04 ± 6.44 mm Hg and 5.0 ± 0.01 mm Hg respectively. The gradients among the four valve sizes were not statistically significant (*p* = 1.05). Mean gradients were reported in four patient groups who had ATSAP mechanical prosthesis *at aortic* location. According to valve sizes 18 mm sized valve, 20 mm sized valve, 22 mm valve and 29 mm sized valve, mean aortic gradients were 11.5 ± 2.07 mm Hg, 11 ± 2.07 mm Hg, 9.04 ± 0.01 mm Hg and 12.0 ± 0.01 mm Hg, respectively. The gradients among the four valve sizes were not statistically significant (*p* = 1.05).

Mean gradients were reported in four patient groups who had TTK Chitra mechanical prosthesis

at mitral location. According to valve sizes of 29 mm, 27 mm, 26 mm and 25 mm sized TTK Chitra valve were 5.0 ± 0.77 mm Hg, 5 ± 0 mm Hg, 5.5 ± 08 mm Hg and 5.0 ± 0.01 mm Hg respectively The gradients among the four valve sizes were not statistically significant (p =1.07). Mean gradients were reported in two patient groups who had TAT Chitra mechanical prosthesis at aortic location. According to valve sizes for 19 mm sized valve and 23 mm sized valve were 9.5 ± 0.57 mm Hg, and 10.0 ± 0.01 mm Hg respectively.

Mean gradients were reported in four patient groups who had Bio-prosthesis at mitral location. According to valve sizes of 29 mm, 27 mm, 30 mm and 25 mm sized Bio-prosthesis valve were 5.9 ± 1.0 mm Hg, 5.9 ± 1.0 mm Hg, 5.5 ± 08 mm Hg and 5.0 ± 0.1 mm Hg respectively. The gradients among the four valve sizes were not statistically significant (p =1.05). Mean gradients were reported in four patient groups who had Bio-prosthesis *at aortic* location. According to valve sizes of 19 mm, 21 mm, 23 mm and 25 mm sized Bio-prosthesis valve were 9.25 ± 1.0mm Hg 8.4 ± 1.0 mm Hg, 7.75 ± 01.2 mm Hg and 8.1 ± 0.7 mm Hg respectively The gradients among the four valve sizes were not statistically significant (p = 1.05).

The Mean Mitral valve gradient (MVG) of ATSAP mechanical, St. Jude mechanical TTK Chitra disc mechanical and Bio-prosthetic mitral valves were 5.5 ± 0.77 mm Hg, 5.0 ± 0.01 mm Hg. 5.0 9 ± 0.3 mm Hg and ± 1.3 mm Hg respectively. Comparing the St. Judes mach valve with ATS AP mechanical valve and TTK Chitra mechanical valve, St Judes mechanical valve has low mitral gradients and good hemodynamic profile with statistically significant difference (p < 0.0019). But comparing the St. Judes mechanical valve with Bio-prosthetic valve have same equal mitral gradients and good hemodynamic profile without statistical significant difference.

The Mean Aortic valve gradient (AVG) of ATSAP mechanical St. Jude mechanical TTK Chitra mechanical disc and Bio-prosthetic aortic valves were 9 ± 0.07 mm Hg , 13.35 ± 4.14 mm Hg, 9.5 ± 0.5 mm Hg, and 10.3.0 ± 0.5 mm Hg respectively St. Jude mechanical valve has good hemodynamic profile but compare to ATSAP mach AV & TTK Chitra mach valves the, ATSAP mach AV valves have good hemodynamic profile among them with statistical significant difference (p < 0.01) ,may due to less no of cases in ATSAP group and needs father study in large sample size. Comparing the St. Jude mechanical aortic valves with Bio-prosthetic aortic valves, Bio-prosthetic aortic valves have low aortic gradients & good hemodynamic profile with statistical significant difference (p < 0.01)

This is the first study from SJICR centre at Bangalore in India which has looked at the most commonly used mechanical valve with Doppler derived mean gradients across all possible valve sizes. Early postoperative measurement of Doppler mean gradient is of pivotal importance in future assessment of prosthesis dysfunction and is invaluable in clinical decision making.[11]

Conclusion

We strongly recommend measurement of mean gradients acrossprosthetic valve in early postoperative period which can be used as baseline value for future reference. The study determined baseline gradients across mitral and aortic mechanical prosthesis/Bio-prosthetic in our population and can be used as reference gradients to assess prosthetic valve function.

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