ROLE OF STRESS ECHOCARDIOGRAPHY IN THE FUNCTIONAL ASSESSEMENT OF PROSTHETIC MITRAL VALVE

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CERTIFICATE

This is to certify that the dissertation entitled **ROLE OF STRESS ECHOCARDIOGRAPHY IN THE FUNCTIONAL ASSESSEMENT OF PROSTHETIC MITRAL VALVE** is the bonafide original work of Dr.P.S.CHAKKARAVARTHI in partial fulfillment of the requirements for D.M. Branch-II (CARDIOLOGY) examination of THE TAMILNADU DR.M.G.R. MEDICAL UNIVERSITY to be held in August 2013.The period of postgraduate study and training was from August 2010 to July 2013.

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DECLARATION

I, **DR.P.S.CHAKKARAVARTHI** solemnly declare that this dissertation entitled, **ROLE OF STRESS ECHOCARDIOGRAPHY IN THE FUNCTIONAL ASSESSEMENT OF PROSTHETIC MITRAL VALVE** is a bonafide work done by me at the department of Cardiology, Madras Medical College and Government General Hospital during the period 2010 – 2013 under the guidance and supervision of the Professor and Head of the department of Cardiology of Madras Medical College and Government General Hospital, Professor V.E.Dhandapani M.D.D.M. This dissertation is submitted to The Tamil Nadu Dr.M.G.R Medical University, towards partial fulfillment of requirement for the award of **D.M. Degree (Branch-II) in Cardiology**.

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INTRODUCTION

INTRODUCTION

Usually, the assessment of prosthetic valves by echocardiography is done at rest. For the patients with prosthetic valves, the echocardiogram taken at rest will not represent the true functional status of the valve. Patient`s day to day activities may induce symptoms. So in order to assess the functional status of the prosthetic valves, it is necessary that stress echocardiogram is done to mimic the daily activities of the patient. So it is assumed that the abnormalities observed under high flow conditions will not be seen at rest as the pressure gradients are related to flow.

Resting studies of valve hemodynamics are found to be insufficient to diagnose valve dysfunction sometimes. Earlier, studies were done using cardiac catheterization with special emphasis on changes in prosthetic function observed with various types of physical stress like exercise or drug-induced stress. But these studies suffered from an inability to adequately stress catheterized patients .Moreover the procedures were cumbersome to the patient and also to the physician. With the advent of Doppler echocardiography, it was possible that studies could be done after significant exercise with increased ease and low risk. Using Doppler echocardiography, studies of exercise-induced changes in aortic and mitral prosthetic valve hemodynamics had started coming.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Exercise protocols

Physical exercise can be induced by conventional treadmill or bicycle ergometry either in the supine or upright position. Of these various modalities, bicycle ergometry exercise was used in many previous studies. The treadmill protocol must be considerate with the patient`s physical capacity as well as the purpose of the test. In persons with good health, the standard Bruce protocol is used which has 3 minute periods to achieve a steady state before workload is increased so that the patients go for the next stage. (9)

The first stage in Bruce protocol assesses the patient' ability to achieve 4.7 METS. The second and third stage of Bruce protocol achieves a workload of 7.1 and 10.1 METS. In older individuals and those patients who are incapacitated because of cardiac disease, the standard protocol is modified by including two 3 minute warm up stages at 0% grade and1.7 mph and 5% grade and 1.7mph walking speed. The main drawback of standard Bruce protocol is the relatively large increase in VO2 between stages and the necessity for additional energy cost of running as compared with walking in stages of more than Bruce `s stage III. It is necessary that patients be advised not to hold the railings of the treadmill during exercise especially the front handrails or else functional capacity is overestimated to the extent of 20% and the estimated VO2 is reduced. (9,10)

The stress induced by physical exercise is physiological but it needs considerable patient cooperation. It provides much useful information like exercise capacity, BP response, and occurrence of arrhythmias. But it needs considerable patient cooperation. Moreover, it would be difficult to obtain optimal images during exercise. As the pressure gradients come down within one or two minutes after exercise, it should be assured that the images are obtained sooner after the exercise. Once the patient stops exercise, he is asked to assume left lateral position, so that the imaging could be done immediately(14).

Even though any echocardiographic view can be used for imaging and assessing the prosthetic valve, the usual procedure includes acquiring parasternal long, apical four chambers and apical five chamber views to obtain the necessary information in the limited time period available. Reduction in the pressure gradients before post exercise imaging is a cause of false negative results. If the patient achieved adequate workload and the image is obtained within 2 minutes of exercise, then the likelihood of false negative test is reduced. The rapid recovery after exercise is not predicted by exercise duration, workload achieved or type of prosthetic valve.

Static bicycle ergometry was the forerunner for various forms of stress echocardiography. Upright bicycle ergometers were used initially and the images were obtained during and after exercise. Later came the supine bicycle exercise systems which allow a variety of patient positions. It provides a 30 degree head up tilt of the patient thus achieving the balance between the patient comfort and image acquisition. The patients can perform the exercise by pedalling at a constant cadence at incremental levels of resistance. The most commonly used supine bicycle protocol baseline imaging is performed at an initial workload of 25 W. The workload is then increased at the rate of 25 W every 2 – 3 minutes. Imaging is obtained at peak stress and in recovery (8)

The main advantage of bicycle ergometry is its ability to image throughout the period of exercise including at peak exercise. By avoiding the potential problem of rapid recovery, this technique permits the instantaneous pressure gradients be recorded. The image acquisition is less rushed than post exercise imaging thus allowing better image quality. Also, the usage of contrast can be done in bicycle ergometry than treadmill exercise. The drawbacks of the bicycle ergometry are the problem of workload. Some patients find it difficult to do bicycling in the supine position preventing adequate level of stress to be achieved.(8)

Pharmacological Stress

The stress induced by pharmacological agents is a non physiological one but the images are obtained in an easier manner during the infusion of the drug. Also, the stress induced by pharmacological agents mimics the stress induced by isometric exercise and there is no need for patient cooperation. The images are obtained simultaneously because of the absence of patient motion and non interference by respiratory movements. Various drugs are used for pharmacological stress like dobutamine, adenosine, dipyridamole etc...(10)

Of these various agents dobutamine is an artificial catecholamine which stimulates both alpha and beta adrenergic receptors of the adrenergic system with predominant action on the beta 1 receptors. It produces enhanced inotropy and chronotropy thereby increasing the flow across the prosthetic valves. Due to differences in affinity, the effects of dobutamine on heart are dose dependent. Dobutamine produces more effects on inotropy at lower doses and as the dose increases, it has much more effects on chronotropy..the peripheral vascular actions may be vasoconstriction or vasodilatation and these effects are unpredictable.

The overall effect of these interactions is an increase in both transvalvular flow rate associated with an increase in transvalvular gradient and a decrease in diastolic filling period. It should be kept in mind that the mode of action of dobutamine is not identical to exercise. The increase in venous return with physical exercise is not found in dobutamine stress echocardiography. Also, the autonomic nervous system mediated changes in pulmonary and systemic resistance are different with dobutamine when compared with physical exercise.(8,9)

The main indication of dobutamine stress echocardiography is in patients who cannot do exercise sufficiently or those who are unwilling to do exercise. The ability of dobutamine to simulate the cardiac effects of exercise in association with safety and versatility of the test has made the dobutamine echocardiography popular. Likewise with exercise ,the aim is to produce a graded increment in cardiac workload which could be monitored for the increase in flow and pressure gradient. This can be done by infusing dobutamine at increasing rates for 3 to5 minute stages. Even though the duration at each stage is not sufficient to produce a steady state effect, it usually produces a gradual and well tolerated increase in heart rate mimicking physical exercise.

Dobutamine stress echocardiography is done in the following protocol. After preparing the patient and obtaining intravenous access digital images are obtained at baseline. Then dobutamine is infused at a rate of 5 micrograms per kg per minute. The infusion rate is then increased every 3 minutes to a dose of 10 micrograms per kg per minute, then 20 micrograms per kg per minute, and then 30 micrograms per kg per minute. Low dose images are acquired at doses of 5 micrograms per kg per minute at the first sign of increased contractility. Mid dose images are obtained at 20 micrograms per kg per minute and peak images are obtained before the termination of infusion. The patient is monitored till he returns to baseline.(8)

Several series have examined the safety of dobutamine stress echocardiography. Owing to the short half life of dobutamine, inducible ischemia can be rapidly reversed with the termination of infusion or the effects can also be reversed with the usage of beta blockers like metoprolol or esmolol.

In a study of 1118 patients by Mertes et al in 1993, there were no incidence of sudden death, myocardial infarction or sustained ventricular tachycardia or fibrillation during dobutamine stress echocardiography. The commoner side effects of dobutamine stress echocardiography were minor only in the form of premature ventricular depolarisations or atrial arrhythmias and minor symptoms like palpitations or anxiety.3% of patients reported nonsustained ventricular tachycardia during dobutamine stress echocardiography(21). The commoner side effects of dobutamine stress echocardiography were minor only in the form of premature ventricular depolarisations or atrial arrhythmias and minor symptoms like palpitations or anxiety.3% of patients reported nonsustained ventricular tachycardia during dobutamine stress echocardiography.(8)

There are no absolute contraindications to dobutamine stress echocardiography. Dobutamine stress echocardiography has been done safely in patients with recent myocardial infarction, syncope, hypertrophic cardiomyopathy, extensive left ventricular dysfunction or history of ventricular tachycardia. In Each case, the value of the expected diagnostic information must be weighed with the individualized risk to the patient. Dobutamine can be safely used in patients with bronchospastic lung disease.

Stress testing can also be done with the use of vasodilators like adenosine or dipyridamole with atropine being added to enhance test sensitivity. The sensitivity of the test can be enhanced by the addition of hand grip at peak infusion. This mode of stress echocardiogram produces only a mild to moderate increase in heart rate and a mild decrease in blood pressure. Significant side effects are minor but limiting side effects does occur in 1% of patients like myocardial infarction, cardiac asystole and sustained ventricular tachycardia. Hypotension and bradycardia may occur albeit reversed with aminophylline. In patients with chronic obstructive pulmonary disease or conduction disorders, both adenosine and dipyridamole are contraindicated (8)

Pacing stress

Stress echocardiography can also be done in patients with permanent pacemaker by increasing the pacing rate until their target heart rate is achieved. This test can be done with or without the use of dobutamine. Transesophageal atrial pacing stress echocardiography is another effective alternative in patients unable to exercise. The catheter can be placed nasally or orally after local anaesthesia. The cardiac pacing and recording catheter is introduced by asking the patient to swallow in the left lateral position. The pacing protocol is constituted by two minute stages with the paced heart rate being increased to levels of 85% and 100% for information about pre peak and peak stress. Images are acquired at rest and at each stage. The main merit of pacing is the rapid restoration of base line conditions and heart rate once the atrial stimulus is discontinued (8)

Prosthetic valves

The prosthetic valves are broadly classified as biologic or mechanical valves. The most common implanted biologic valve is a stented xenograft which are prepared from an entire porcine or a composite of two or three pigs. The most common implanted mechanical valves are the bileaflet valves. They differ in the composition and purity of the pyrolytic carbon,the design of the pivots, the shape and size of the housing and the design of the sewing ring. Caged ball valves like Starr Edward valves are the valves of olden days and they are encountered owing to their durability. Commonly, the reported size of a prosthesis refers to the outer diameter of the sewing ring in mm.(15)

Echocardiographic Examination

Transthoracic two-dimensional imaging is generally adequate to distinguish among the various types of prosthetic valves. The high reflectance of the prosthetic material creates challenges for the echocardiographer. Because the speed of sound changes as it passes through prosthetic materials, size and appearance can be distorted. Some decrease in gain setting is generally necessary to compensate for these differences. The high reflectance also leads to shadowing behind the prostheses. Reverberations frequently appear behind the prosthetic structures, which may obscure targets of interest. To overcome these problems, multiple echocardiographic windows must be used to fully interrogate the areas around prosthetic valves.(1,15)

Tissue harmonic imaging must be used for stress echocardiographic imaging. This has multiple advantages like reducing near field artifact, enhancing myocardial signals and improving resolution. Moreover, THI imaging is superior to fundamental imaging for visualisation of endocardial borders(8) Echocardiographic appearance of bio-prosthetic leaflets more closely approximates that of native valves. For stented valves, imaging is ideally performed with the ultrasound beam aligned parallel to flow to avoid the shadowing effects of the stents and sewing ring. The leaflets themselves are quite similar to native valve tissue, both in texture and excursion.

In the two dimensional imaging, prosthetic valves must be imaged with special emphasis on the opening and closing motion of leaflets in biological valves and occluders in mechanical valves. The presence of any abnormal echo density found attached to the sewing ring, leaflets

,stents,occluder or cage should also be noted in addition to any abnormal rocking motion during the cardiac cycle. (15)

Occluder motion may not be visualised by TTE owing to artefact and reverberations.Indeed, in case of tilting disc valves the visualization of occluder motion in mitral position requires incremental rotation of imaging plane from the apical views until the motion of occlude is seen. The retention of either native valve leaflet in the mitral position allows enhanced mobility of a normal prosthesis. Microbubbles are a few microcavitations within the left ventricular cavity and are of doubtful significance.

As with two-dimensional imaging, the Doppler examination also faces unique challenges in the setting of a prosthetic valve. Because of the variability of flow through and around the different prostheses, color flow imaging is often helpful to define the location and direction of the various flow patterns. Once the desired flow patterns are localized with color flow imaging, pulsed and continuous wave Doppler imaging can be oriented to quantify flow velocity.

Velocities will always tend to be higher through prosthetic valves, depending in part on the size of the specific prosthesis. Whenever velocity is higher than expected, consider the possibility of pressure recovery. Assessing valvular regurgitation is primarily limited by the shadowing effect of the prosthetic valve itself. Because the signal to noise ratio for Doppler imaging is lower compared with two-dimensional echocardiographic imaging, the shadowing effect is even more pronounced and the ability to record a Doppler signal “behind” a prosthetic valve is very limited. Multiple views must be used to fully interrogate the regurgitant signal.(9,8)

Fig.1 Showing TTK Chiitra valve

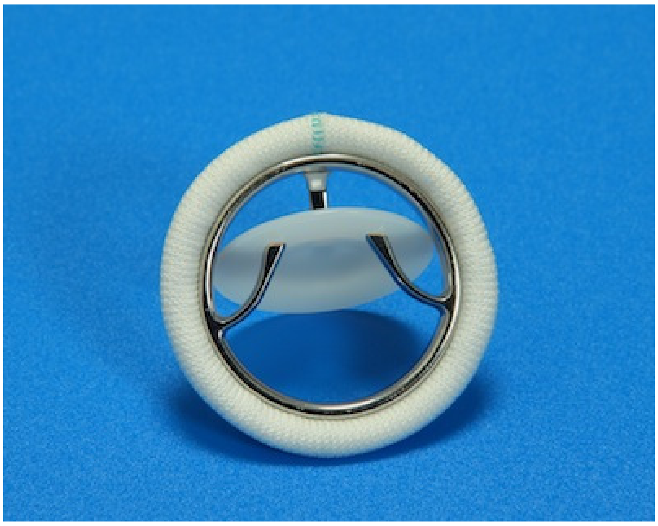


Fig 2,Showing ATS valve

Fig 3 Showing St Jude Medical mitral prostheses

Visualizing mitral prostheses with transthoracic echocardiography is somewhat easier than visualizing aortic prostheses. This is because the prosthetic mitral valve is seated within the mitral annulus and can be easily visualized from both the parasternal and apical windows. Aortic prostheses may be partially obscured by the walls of the aorta and by the prostheses itself from the apical view. Evaluating the stability of the mitral prosthesis, excluding dehiscence, and visualizing the motion of leaflets or the occluding mechanism are generally possible with transthoracic imaging.

Using Doppler imaging, the antegrade flow through the prosthesis can be accurately recorded. Normal values for the various types of mitral prosthetic valves are as follows:

The mean gradient of TTK Chitra valve type in Tilting disk category is 5±2.The mean gradient of St. Jude Medical type in Bileaflet category is 5±2.The maximum and mean gradient of ATS Medtronic type in Bileaflet category are 10±2 and 5±2 respectively.

The mean gradient of in Caged ballvalve like StarrEdward is 7±3and the peak gradient is 23±4 mmHg.(1)

Hemodynamic calculation

Blood velocity across any valve,native or prosthetic depends on various factors like flow and valve type and size. The simplified Bernoulli equation was found to be the key for the noninvasive calculation of pressure gradients across heart valves including prosthetic valves which states that the pressure gradient across any orifice is equal to four times the square of the velocity of the jet in meter per second.

The mean mitral pressure gradient is derived by planimetry of the mitral envelope, taking care to align the Doppler beam as close as possible to direction of inflow. Because of the orientation of the prosthesis and the resulting transprosthesis flow direction, nonstandard views may be necessary for optimal alignment of the Doppler beam. The pressure half-time method can also be performed in the setting of prosthetic valves. With native valves, it was empirically determined that mitral valve area was approximated by the equation:

$$\text{MV area} = 220 \div P_{1/2}t$$

When the same approach is applied to prosthetic valves, the formula tends to overestimate the effective orifice area. Despite this limitation, prolongation of the pressure half-time, especially when a baseline has been established, is a reliable marker of obstruction and is less flow-dependent than gradient alone. For larger valve areas derived from pressure half time method, the pressure half time reflects atrial and left ventricular compliance charecteristics and loading conditions and has no relation to valve area.(15) In most patients, both mean gradient and pressure half-time should be assessed to determine whether prosthetic valve stenosis is present. The continuity equation can be applied (in the absence of mitral regurgitation) according to the formula, in which MV is the mitral valve, LVOT is the left ventricular outflow tract, and TVI is the time velocity integral:

By continuity equation, Stroke volume throughout any valve orifice is constant.

$$\text{i.e. MV area} \times \text{TVI}_{\text{MV}} = \text{Area}_{\text{LVOT}} \times \text{TVI}_{\text{LVOT}}$$

MV area = Area_{LVOT} x (TVI_{LVOT}/T VI_{MV}) where

Area_{LVOT} = 0.785 x LVOT diameter (assuming LVOT as a circular orifice) (15)

Detecting regurgitation through or around a mitral prosthesis using transthoracic echocardiography is limited by the shadowing effect of the prosthetic material. Whether imaging is performed from the parasternal or the apical view, the prosthetic valve will always obscure a portion of the left atrium so that the sensitivity of this method is reduced. In the presence of both aortic and mitral prostheses, most of the left atrium is shadowed and the detection of mitral regurgitation in such patients is very limited. In contrast, the transesophageal approach offers an excellent opportunity to assess the entire left atrium in the presence of prosthetic valves. Differentiating between physiologic and pathologic mitral regurgitation is based on a variety of factors. Characteristics of “normal” prosthetic regurgitation include a jet area less than 2 cm^2 and a jet length less than 2.5 cm. In addition, the patterns of regurgitant flow are typical for each individual prosthesis. St. Jude mitral prosthesis often displays one central and two peripheral small jets, whereas a Medtronic-Hall valve typically has a single central regurgitant jet. In three-dimensional views, the spatial orientation provided by this approach permits the origin of the regurgitant jet to be precisely located outside of the ring, confirming the presence of perivalvular regurgitation.

In article by Tobias Pflederer on echocardiographic followup after placement of prosthetic heart valves in 2010, he has stressed that normally functioning prosthesis create some amount of obstruction to flow and most of these valves have a trivial amount of regurgitation.Hence,baseline echocardiographic assessement should be done in the early postoperative period assuming normal prosthetic valve function .This baseline value should be kept as a reference for later comparison.(14)

Various studies on stress echocardiography

In the study done by Gasior Z et al, the stress echocardiography using upright bicycle ergometry, 46 prosthetic mitral valves were examined with 20 normal persons as control. The peak gradient increased from 9.9 to 17.8mmHg and the mean gradient increased from 4.4 to 7.8mmHg. Statistical analysis revealed a relationship between the percent change in gradient with exercise and percentage change in stroke volume and cardiac output. Significantly, the maximum gradient induced by exercise is related and predicted by the rest gradient. Regarding the change in the peak and mean velocity, the absolute values of the velocities were more increased in the patients with prosthetic valves when compared with normal valves but the percentage change in velocity with stress were comparable in both groups. He concluded that exercise Doppler echocardiography gives a good method to assess prosthetic valve function.(18)

In the study by Leavitt , 11 patients with prosthetic mitral valve were compared with 12 patients with severe mitral stenosis by stress echocardiography using treadmill. The study revealed the increase in heart rate from79±9 at rest to 104±8 with exercise. The mitral valve area increased from 2.5 to 2.9 sq.cm after exercise in the prosthetic group and from 1.4 to 1.6sq.cm. in the mitral stenosis group. The increase in pressure gradient in patients with prosthetic mitral valve with stress was significantly less when compared with mitral stenosis group. Also, the increase in the pulmonary artery pressure was higher in the native mitral stenosis group. They concluded that stress echocardiography was very useful in patients with borderline mitral stenosis and also in assessing the physiologic function of prosthetic valves.(11)

In the study by tatineni et al in 1989, about 42 patients who were in need of mitral valve replacement were studied by rest and stress echocardiography both preoperatively and postoperatively after implanting St. Jude Medical and Medtronic Hall mechanical prosthetic heart valves. They did followup studies six months after valve implantation by doing rest echocardiography and after doing upright treadmill exercise. Various Clinical indices like mortality, morbidity, and functional status ,rest and exercise hemodynamics like valvular area, gradients, and EF were examined. They found that death rates (perioperative, 8.8% and late, 2.4%) was similar between patients in the two valve groups with a single late thromboembolic episode with either valve. They observed an Improvement in New York Heart Association class was seen in more than three fourth of patients at 6 months. In patients with mitral prostheses, no significant differences between St. Jude Medical and Medtronic Hall prostheses was noted with respect to calculated mitral valve areas (3.4 cm2 vs. 3.4 cm2). The rest pressure gradient across both types of prosthetic valves were similar in both rest (2.5 in St.Jude mitral prosthesis vs. 3.0 mm Hg Medtronic Hall mitral prosthesis) and exercise (5.1 vs. 7.0 mm Hg) mean gradients. They concluded that irrespective of primary valvular lesion ,NYHA classification and valvular size, both St.Jude mitral prosthesis and Medtronic Hall mitral prosthesis have given comparable and good results(3) .

In the study by Dressler FA et al in 1992, with the use of Doppler echocardiography, 600 patients have been studied before and after stress echocardiography. They have used four different models of prosthetic valves . All the four models showed no significant differences with the pressure gradients showing 18-26 mmHg in the resting state and 35-63 mmHg with exercise in the aortic position .The heart rate achieved or duration of exercise did not influence the gradient achieved with exercise. Smaller prostheses are found to be associated with larger gradients even though the correlation was not strong. They also found that a ll mitral valve prostheses were also mildly stenotic at rest with the range of mean gradients 2.3-7.1 mmHg becoming 5.1-16.5mm Hg with exercise. The lowest gradients were observed in St.Jude Medical mitral prosthesis and Medtronic Hall mitral prosthesis as observed in previous studies(4).

In the study by E.Schwammenthal et al on stress echocardiography beyond coronary artery disease, they say that evaluation of prosthetic valves by stress echo were focussing on hemodynamic differences between valve types. Jaffe et al has studied matched patient groups after aortic valve replacement and found that allograft prostheses had significantly lower rest and exercise gradient across the prosthetic valves. A major demerit of these in vivo comparisons of Doppler derived gradients was that because of pronounced pressure recovery phenomenon noted in bi-leaflet prosthetic valves leading to overestimation of transprosthetic gradients.As rest and exercise Doppler echocardiographic assessement of heart valve prostheses are amenable to similar limitation, a baseline assessement should be done soon after valve replacement to enable comparision during the followup(5).

Neil A Hobson et al studied 23 patients who had undergone MVR recently by doing stress echocardiography with supine bicycle exercise and dobutamine administration. The heart rate appreciably increases in both kinds of stress and more so with dobutamine administration. At maximum stress, exercise yielded significant increase in peak and mean gradient which is statistically significant when compared to dobutamine stress. On the other hand, dobutamine produces a relatively greater increase in effective orifice area when compared to bicycle ergometry. They concluded that both modes of stress increase the transvalvular flow and thereby the pressure drops, there are certain physiological hemodynamic differences between these kinds of stress.(13)

In their study of comparison of exercise and dobutamine echocardiography aortic valve hemodynamics in 2002, Kadir I et al has studied the behaviour of aortic prosthetic valves of 19 mm size in ten patients with symptom limited treadmill exercise and after dobutamine administration. The mean transvalvular gradient increased by about 16±2.1 mmHg with dobutamine stress and by an equal amount after symptom limited treadmill exercise. This increase in the pressure gradient was statistically significant with a P value of less than 0.001.But there were no significant change in the effective orifice area of the prosthetic valve with either protocol. They concluded that both treadmill exercise and dobutamine stress were equally effective for the hemodynamic evaluation of prosthetic valves.(16)

Wiseth et al in his study of 25 patients with aortic valve replacement of less than 21 mm size found intraventricular flow towards apex during the period of isovolumetric relaxation .This observation suggested left ventricular relaxation asynchrony in a quarter of patients at rest and in about half of patients at exercise. They attributed these postoperative left ventricular diastolic functional abnormalities to insufficient regression of left ventricular mass stressing the fact that a prosthetic valve represents stenosis to outflow which has been termed as patient prosthesis mismatch in extreme cases by Rahimtoola.(6)

In the study by Shimon A Reisner et al in 1989,17 patients with mitral Prostheses 11 with Björk-Shiley (BS) and six with Starr-Edwards (SE) valves did submaximal supine exercise .The patients with with

Björk-Shiley (BS) valves showed an increment in peak and mean gradients from increased from 10 and 5 mm Hg, respectively, at rest to 16 and 10 at peak exercise and the patients with Starr-Edwards (SE) valves showed an increment in gradient from 8 and 5 mm Hg, respectively, at rest to 22 and 13 mm Hg at peak exercise.(7)

Peak exercise pressure gradient and the increase in peak gradient with Exercise were significantly higher in the SE group ($p < 0.05$).They attributed this increase in peak gradient to the occlusive character of the Starr-Edwards valve during maximal flow rate. They concluded from their study that Doppler echocardiographic measurement taken during peak exercise can yield significant information especially in patients with borderline values taken at rest and to identify early prosthetic valve dysfunction(7).

In the article by Picano et al in 2009,he has emphasized the role of patient prosthesis mismatch. As most prosthetic valves are stenotic , the EOA of a prosthetic valve is sometimes too small to body size which is termed as patient prosthesis mismatch.. As moderate when the indexed orifice area is less than 0.85sq.cm/m^2 in the aortic position and severe when it is less than 0.65 sq.cm/m^2 The corresponding values for the mitral position are 1.2 sq.cm/m^2 and 0.9 sq.cm/m^2 respectively. He attributed

PPM as one of the cause for increased transprosthetic gradient(17).When there is discordance between the patients symptomatic status and the valve hemodynamics at rest, stress echocardiography may bring out the diagnosis of either patient prosthesis mismatch or hemodynamically significant prosthetic valve obstruction.˙ A marked increase in the mean transprosthetic gradient (more than 20 mmHg for aortic valve and more than 12 mmHg for mitral valve) was associated with a markedly impaired exercise capacity and raise a suspicion for prosthesis dysfunction. But this fact may be compounded by the factor of patient prosthesis mismatch(16,13)

Jean G Dumesnil et al studied the validity and usefulness of valve gradients and measurement of area in 26 patients with a bioprostheses. They found correlations between continuity equation areas and the peak and mean gradients .They concluded that continuity equation was a valid method for calculation of mitral valve bioprostheses and the method using pressure half time method was not valid in this setting due to its overestimating property(19).

Stress echocardiography can also be used to delineate the cause for dyspnoea in patients with prosthetic valves and concomitant chronic obstructive pulmonary disease. In sedentary patients if the mean transmitral pressure gradient rises to greater than 15 mmHg and pulmonary artery systolic pressure to more than 60 mmHg, the cause of dyspnoea can be identified as hemodynamically significant prosthetic mitral valve. On the other hand, a marked increase in pulmonary artery systolic pressure with only minor changes in transprosthetic pressure gradient narrows down the etiology to underlying lung disease. As noted earlier, dipyridamole and adenosine cannot be used in this context (8)

AIM OF THE STUDY

AIM OF STUDY

1. To study about the resting echo profile of patients with prosthetic mitral valve
2. To assess the function of the prosthetic valves by doing stress echocardiography by treadmill exercise and dobutamine infusion

MATERIALS AND METHODS

MATERIALS AND METHODS

Study Setting

This study was conducted in Madras Medical College and Rajiv Gandhi Government General Hospital. The study was prospective, comparative designed .The patients were taken from outpatient Department of Cardiology and Cardiothoracic Department.

Study population

About 30 patients who came to our cardiothoracic and Cardiology who have been done mitral valve replacement were selected randomly to undergo the stress echocardiography.(14 males and 16 females).Their average age was 35±3.Mitral valve was replaced about 18 to 36 months prior to stress testing.13 patients had St.Jude mitral valve,12 patients had TTK Chitra valve (tilting disk),4 patients had ATS bileaflet valve and a single patient had Starr Edward valve.13 patients received 25mm valves, ten patients received 27mm valve, 3 patients received 29mm valve and two patients received 31mm valve. All the patients were in sinus rhythm. The mean baseline left ventricular ejection fraction was 60± 5%.All these patients had their International Normalized Ratio normal and were included in the study.

EXCLUSION CRITERIA

1. Patients with double valve replacement
2. Patients with atrial fibrillation
3. Patients with left ventricular dysfunction
4. Patients with coexisting other valvular diaease
5. Patients who are unable or unwilling to undergo treadmill exercise

Echocardiographic examination was done with a 2.5 MHz transducer using the Esaote myLab equipment available in our Echo lab. Echocardiographic examination and measurements were recorded according to the American Society of Echocardiography recommendations .Each patient underwent baseline transthoracic echocardiography at rest and the function of the prosthesis was confirmed to be normal before proceeding further..Randomization found out which stress would be undertaken first in order to eliminate any bias.

Exercise studies were performed by asking the patient to walk in the Esoate Treadmill and the exertion was undertaken according to Bruce or modified Bruce protocol depending on the previous functional capacity of the patient on daily activities. The patient was advised to walk to achieve 85% THR but the test was stopped according to the symptom limited exercise. The electocardiography was monitored throughout the procedure and the heart rate and Blood Pressure were noted after each stage of exercise. After the peak stress , patient is asked to assume a left lateral position on the table and the echocardiographic images were taken soon after .Mitral inflow and tricuspid regurgitant signals were acquired with the use of optimal views and various transducer positions which gave the views best at rest and the images were acquired immediately .

Then the patients were subjected to dobutamine stress echocardiography using a modified dobutamine protocol after two hours Dobutamine was started at the dose of 5 mcg/kg/min .The dose was increased at the rate of 5 mcg/kg/min for every 4 minute stages. The heart rate was noted and the echocardiographic images were acquired continuously. The dose was increased to a maximum of 40 mcg/kg/min. The test was stopped if the patient is found to have any arrhythmia on the monitor or any symptom of angina or any hemodynamic instability and Blood Pressure was noted after each phase of increase in dobutamine. Images were obtained at peak stress and the variables were calculated.

The left ventricular outflow tract diameter was estimated from the parasternal long axis view immediately proximal to the aortic annulus with image frozen in midsystole and measurement taken from inner edge to inner edge. Sub aortic pulse wave Doppler recordings were made in the apical five chamber view with the pulse- wave Doppler cursor held in the LVOT immediately proximal to aortic valve. Also from the four chamber view ,pulse wave Doppler and continuous wave Doppler recordings of the mitral jet velocity were acquired. Peak and mean gradients were obtained from the planimetry of the envelope. On an average 5 readings were recorded and the measurements were done at rest and during peak stress.

The following calculations were done.

Stroke volume in ml=CSA $_{\mathbf{LVOT}}$**XVTI**$_{\mathbf{1}}$ **,(12)** where CSA $_{LVOT}$ is left ventricular outflow cross sectional area in cm^2 calculated from the diameter assuming the LVOT having a circular cross sectional area and the VTI_1 represents subaortic velocity time integral in cm.

Cardiac output in ml/sec=HRXSV

where HR is heart rate

Mitral Effective Orifice Area in sq.cm can be calculated using the continuity equation.

i.e $\mathbf{EOA=CSA_{LVOT}XVTI_{LVOT}/VTI_{MV}}$

where VTI_{MV} represents time velocity integral of the mitral diastolic jet. (12)

Pulmonary artery pressure was measured by obtaining the tricuspid regurgitation signal on the colour Doppler. Continuous wave Doppler is then applied over the signal and the obtained envelope is planimetered to find out the right ventricular systolic pressure by simplified Bernoullie`s equation. To this the right atrial pressure (which was obtained by IVC size and its respiratory variation) is added. The sum is taken as Pulmonary artery systolic pressure in the absence of right ventricular outflow obstruction.

Diastolic flow in mitral valve in ml/sec=SV/DT

Where DT is the diastolic filling time in milliseconds .It is measured between the opening of the mitral valve and its closing of the mitral valve artifacts. Mitral flow volume per second was considered equivalent in the absence of mitral or aortic regurgitation to the stroke volume. (9,12)

Ethical considerations

The study was approved prior to its commencement by the Local Medical Ethical Committee and all the participants included in the study had given their written informed consent.

Stastical analysis

The parameters were calculated at each stage of stress for every patient and were presented as mean ± SD. Analyses of change in the variables at rest and comparisons between the stress modes were done using a two way analyses of variance for the measures which are repeated. Using the Bonferroni approach, post-hoc adjustments were done for the p-value to take into account the number of tests performed. Applying the Wilcoxon test, nonparametric data were examined. Transmitral pressure gradients were plotted against cardiac flow in every individual patient.

Statistical analysis of the association of multiple variables was done using Pearson`s correlation coefficient and graphs were devised with the corresponding linear regression equation in the patients who had a square of the correlation coefficient more than 0.50.T he individual variables were compared using Student `s t-test for paired data. All these statistical analysis were performed using the SPSS software package for windows.

RESULTS

RESULTS

Rest and maximum hemodynamics

Resting heart rate ,Mean blood pressure, end-diastolic diameter of left ventricle and peak and mean pressure gradients were comparable prior to commencement of dobutamine stress and exercise. About 8 patients were in New York Heart Association class II and they completed their exercise in the initial stages.

At peak stress ,exercise caused the mean blood pressure to increase by about 19.3 mmHg .On the other hand, dobutamine did not cause a significant change in mean blood pressure. In fact, it decreased the mean BP to fall by 2.1 mmHg.On analysing these values statistically, this increase in mean BP eith dynamic exercise was found to be significant with a P value of <0.0001.

The ratio between the pressure and flow was plotted in about twenty three patients during both stresses. The slope was significantly higher at peak exercise when compared with dobutamine stress (0.046±0.007 mmHg/mi/sec Vs 0.0280.004 mmHg/ml/sec respectively).This comparison was also statistically significant with a P value of 0.006.(FIG A and B)

On comparing the heart rate response , the heart rate increased from rest to exercise by a mean of 24 ±12.5 beats per minute. The heart response to dobutmine was also similar but more than that of exercise i.e 38±10.Head to head comparison between exercise and dobutamine protocol showed a mean difference of 14 bpm ±6.2 higher in the dobutamine group .The paired t test showed a significant correlation with an increase in the dobutamine group with a P value of <0.001) (95% confidence interval of -16.878 to –12.189)(Table1, Fig.6)

Table 1

Showing the comparison of heart rate at rest and exercise and dobutamine stress

Variable	Mean	Standard Deviation	P value
Heart rate rest	81.17	7.922	<0.001
Heart rate exercise	109.533	15.600	
Heart rate rest	81.17	7.922	<0.001
Heart rate dobutamine	126.067	12.542	
Heart rate exercise	109.533	15.600	<0.001
Heart rate dobutamine	126.067	12.543	

The comparison between the peak gradient obtained through the mitral prosthesis showed a similar increase in the pressure gradient in both modes of stress. The peak gradient increased by about 6.53 mmHg±4.09 in the exercise arm and by a marginal increase of about 3.544 ±3.18in the dobutamine arm. Here also, the increase in peak gradient between the two stress protocols were statistically significant with a P value of <0.001(95% confidence interval of 1.035 to 2.948) (Table2, Fig.7&8).

Table 2
Showing the comparison of peak gradients at rest and exercise and dobutamine

Variable	Mean	Standard Deviation	P value
Peak gradient mmHg rest	11.671	4.3157	<0.001
Peak gradient mmHg exercise	18.207	5.4640	
Peak gradient mmHg rest	11.671	4.3157	<0.002
Peak gradient mmHg dobutamine	16.215	4.9776	
Peak gradient mmHg exercise	18.207	5.4640	<0.001
Peak gradient mmHgdobutamine	16.215	4.9776	

The mean gradient obtained at rest and with exercise and dobutamine stress also showed a similar pattern of increase as seen in the peak gradient. Here the mean gradient increased by about 2.78±1.382 mmHg after exercise and by about 1.852±1.376mmHg after dobutamine infusion. The increase in exercise protocol was by a difference of 0.935 mmHg. The T test showed a P value of <0.001 which was statistically significant. (95% confidence interval of 0.469to 1.401) (Table3, Fig.7&8)

Table 3

Showing the comparison of mean gradients at rest and exercise and dobutamine

Variable	Mean	Standard Deviation	P value
Mean gradient mmHg rest	5.187	2.0902	<0.001
Mean gradient mmHgexercise	7.974	2.3083	
Mean gradient mmHg rest	5.187	2.0902	<0.002
Mean gradient mmHg dobutamine	7.039	2.4998	
Mean gradient mmHgexercise	7.974	2.3083	<0.001
Mean gradient mmHg dobutamine	7.039	2.4998	

The effective orifice area of the prosthetic mitral valve was calculated at rest and after exercise and dobutamine stress. The results showed an increase of ERO was more in the dobutamine protocol by a margin of 0.653± 0.25 sq.cm from rest ERO .The corresponding increase in the exercise protocol was only about 0.367±0.25 sq.cm . On comparing the increase in the ERO in both protocol on one to one basis , the increase was about 0.286±0.166 sq.cm in the dobutamine group. The paired T test showed a significant correlation with an increase in the dobutamine group with a P value of <0.001) (95% confidence interval of -3483to –0.2237) (Table4, Fig. 9).

Table 4

Showing the comparison of EOA at rest and stress protocols

Variable	**Mean**	**Standard Deviation**	**P value**
EOA rest in sq.cm	2.1430	0.55516	<0.001
EOA exercise in sq.cm	2.4107	0.65425	
EOA rest in sq.cm	2.1430	0.55516	<0.001
EOA dobutamine in sq.cm	2.8967	0.56067	
EOA exercise in sq.cm	2.4107	0.65425	<0.001
EOA dobutamine in sq.cm	2.8967	0.56067	

As expected ,the pulmonary artery pressure increased from rest on both ways of stress .In about three patients, the pulmonary artery systolic pressure raised to the extent of moderate pulmonary hypertension and in these patients, the exercise was stopped prematurely. Statistical analysis revealed the increase in the PAP was more in the exercise protocol because of involvement of respiratory component in this mode of stress. PAP increased by a mean value of about 15.53±4.43 mmHg during treadmill exercise. The increase in PAP during dobutamine stress was only modest with a mean of 9.97±3.78 mmHg .The net difference in the PAP achieved with both stress protocols were 5.563±4.6mmHg more in the exercise protocol which was statistically significant with a P value of <0.001 (95% confidence interval of 3.837 to 7.290) (Table5, Fig.10).

Table 5

Showing comparison of Pulmonary Artery Pressure (PAP) at rest and exercise and dobutamine

Variable	**Mean**	**Standard Deviation**	**P value**
PAP rest mmHg	23.713	6.4021	<0.001
PAP exercise mmHg	39.247	8.4679	
PAP rest mmHg	23.713	6.4021	<0.001
PAP dobutamine mmHg	33.683	5.5437	
PAP exercise mmHg	39.247	8.4679	<0.001
PAP dobutamine mmHg	33.683	5.5437	

The diastolic flow rates were calculated during both rest and after doing exercise and dobutamine. On comparing the increase in diastolic flow rate in both exercise and dobutamine stress, the increment in the diastolic flow rate was more in the exercise group. It exceeded the increase in the diastolic flow rate of dobutamine protocol by a difference of 30±8.5 ml/sec. This difference was also found to be statistically significant with a P value of <0.001(95% confidence interval of2.458 to 5.649) (Table 6, Fig.11)

Table 6.

Showing the comparison of diastolic flow rates at rest and exercise and dobutamine

Variable	Mean ml/sec	Standard Deviation ml/sec	P value
Diastolic flow rate rest	143.1	15.295	<0.02
Diastolic flow rate exercise	206.15	51.0158	
Diastolic flow rate rest	143.1	15.295	<0.02
Diastolic flow rate dobutamine	231.25	58.046	
Diastolic flow rate exercise	206.15	51.015	<0.001
Diastolic flow rate dobutamine	231.25	58.046	

Fig A. Showing the plot comparing mean pressure gradient during dobutamine stress and cardiac flow

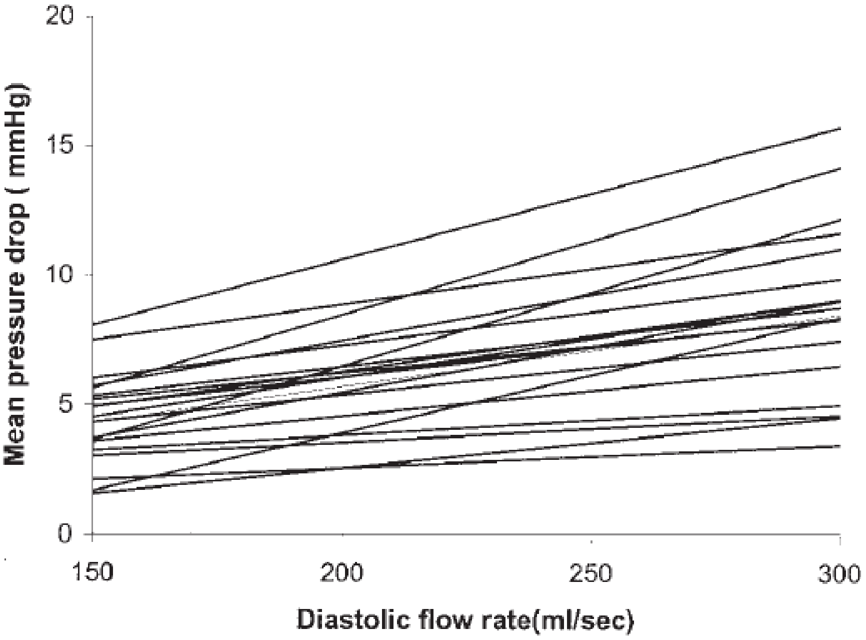


Fig B. Showing the plot comparing mean pressure gradient during exercise stress and cardiac flow

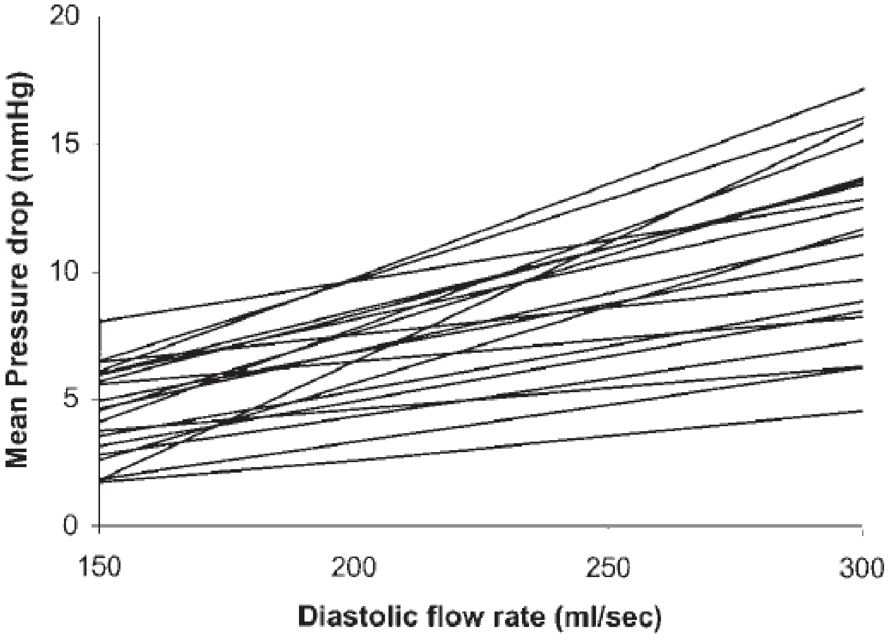


Fig.4

Pie chart showing the sex distribution in the patient population

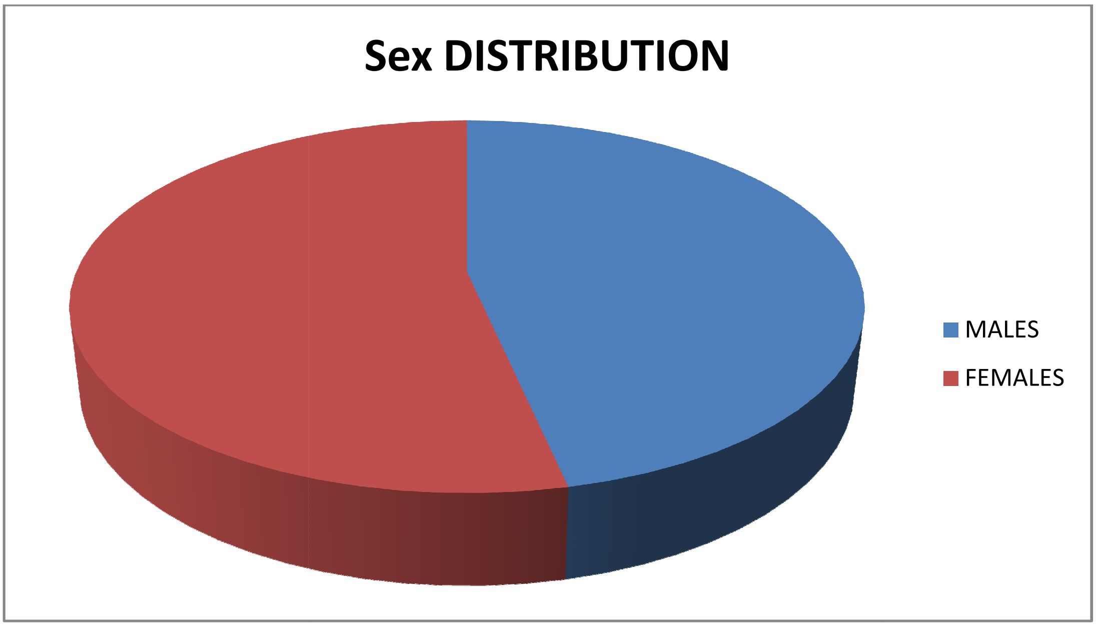


Fig.5.

Pie chart showing the types of valves kept

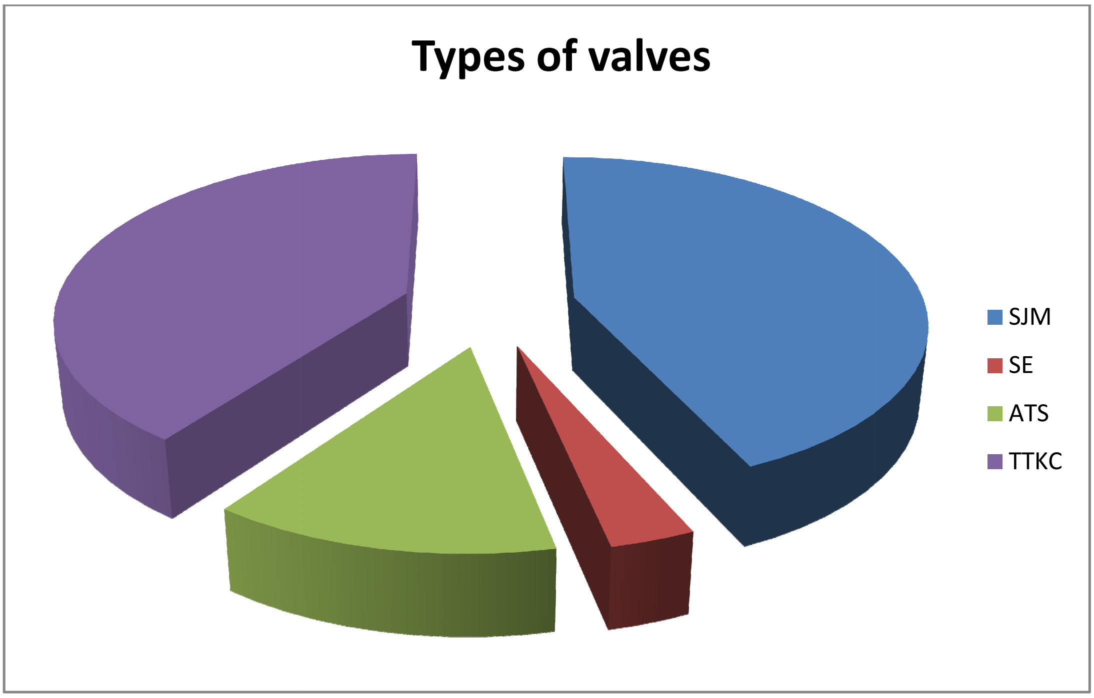


Fig. 6.

Bar diagram Showing the response of the heart rate to exercise and dobutamine stress

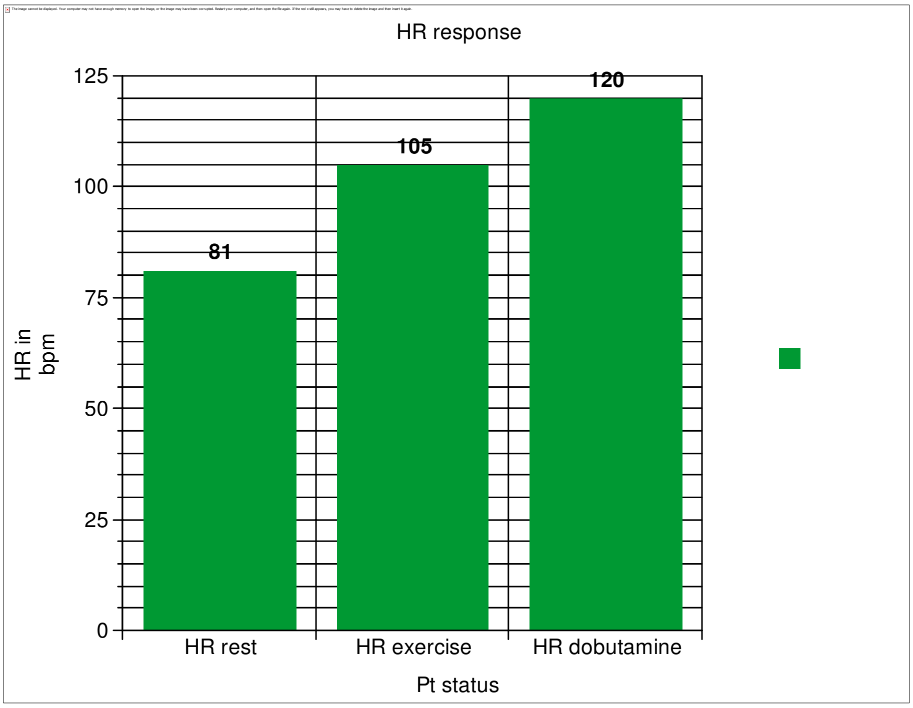


Fig.7

Graph showing the response of pressure gradients to exercise

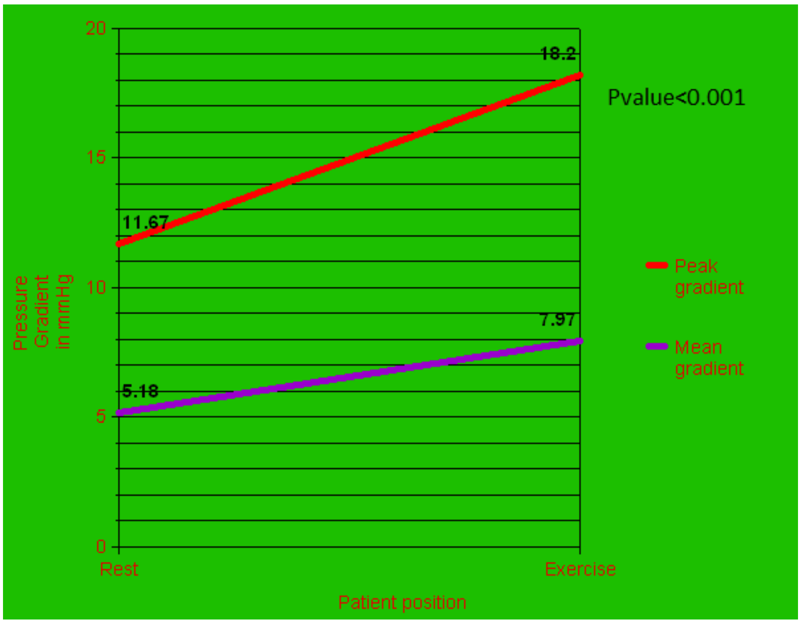


Fig.8

Graph comparing the peak and mean gradient at rest and dobutamine

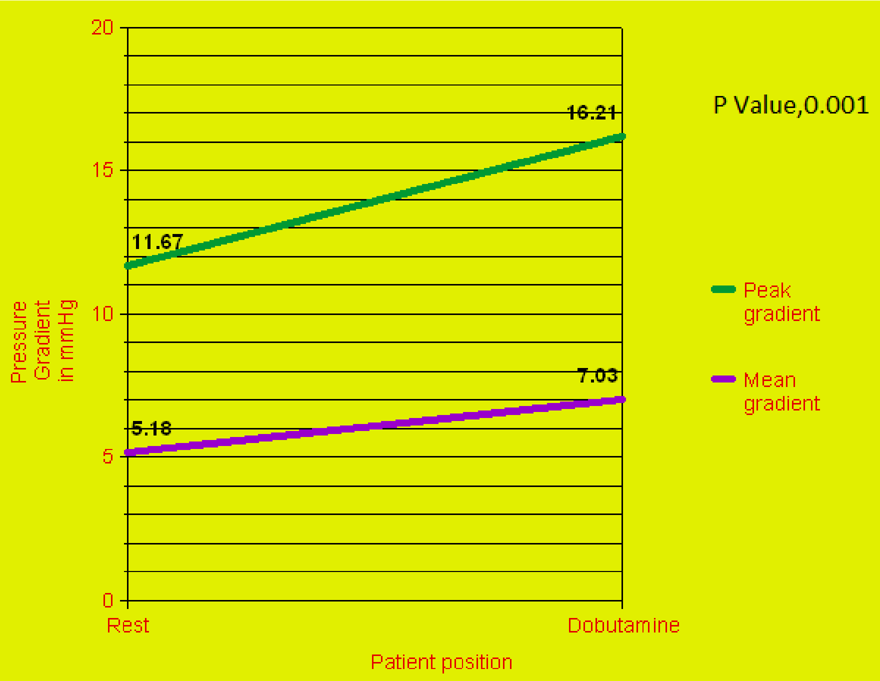


Fig.9

Bar diagram showing the comparison of effective orifice area at rest and after stress

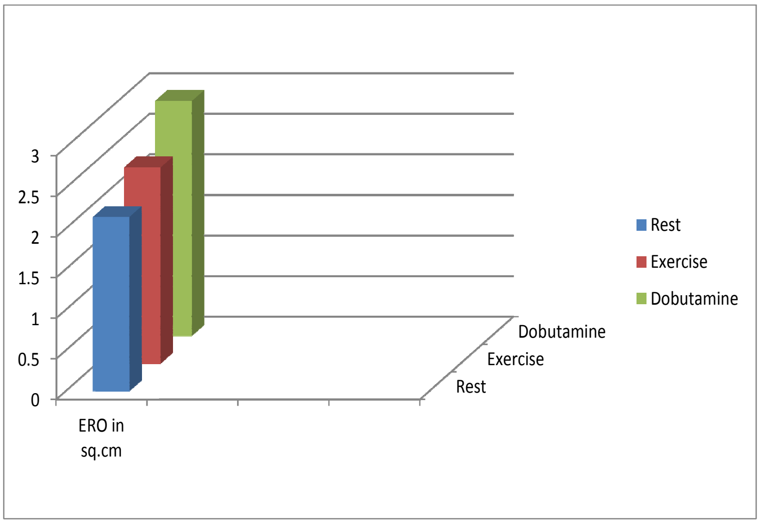


Fig 10.

Bar diagram showing the response of PAP to stress

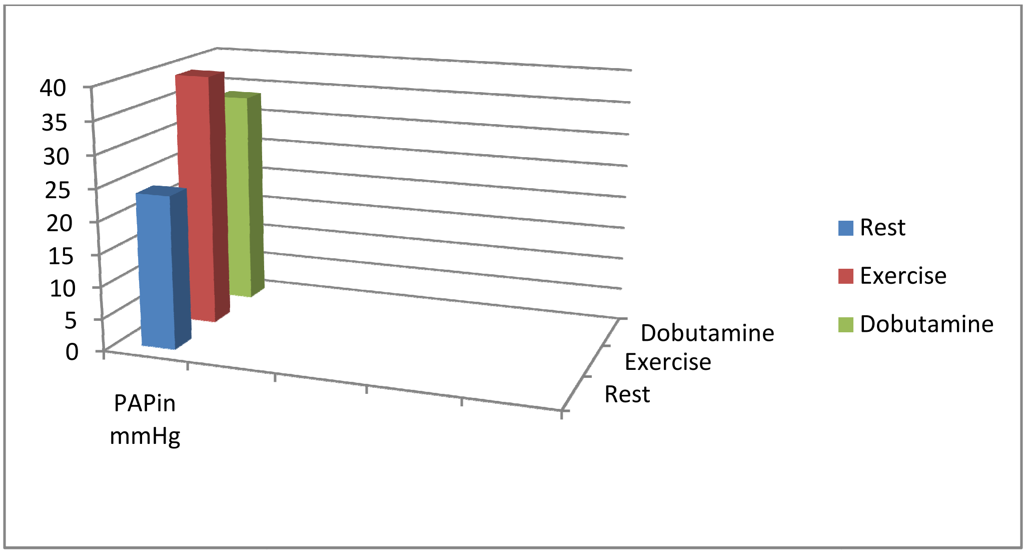
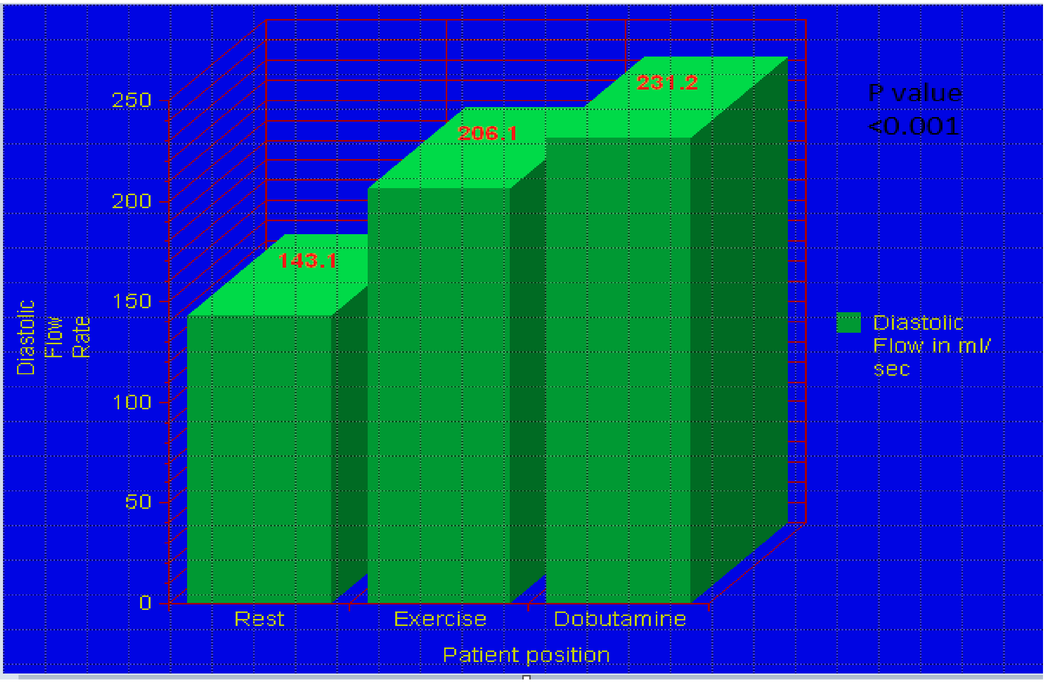


Fig 10

Bar diagram showing the response of diastolic flow rates to stress



DISCUSSION

DISCUSSION

Prosthetic Mitral valves are implanted for patients with severe mitral stenosis who are not suitable for PTMC and in patients with severe mitral regurgitation. These patients were on follwup and were found to have symptoms of breathlessness on exertion which they think that the valve is malfunctioning. It had been shown that under high flow conditions,the mitral prostheses even though normally functioning can produce pressure gradients that might categorize the patients as having moderate to severe mitral stenosis and hence raise doubts that the prosthesis was malfunctioning.

Effect on pressure gradients

In the study by tatineni et al in 1989,about 42 patients who were in need of mitral valve replacement were studied by rest and stress echocardiography both preoperatively and postoperatively after implanting St. Jude Medical and Medtronic Hall mechanical prosthetic heart valves. In these patients, no significant differences between St. Jude Medical and Medtronic Hall prostheses was noted with respect to calculated mitral valve areas (3.4 cm2 vs. 3.4 cm2).

The rest pressure gradient across both types of prosthetic valves were similar in both rest (2.5 in St.Jude mitral prosthesis vs. 3.0 mm Hg Medtronic Hall mitral prosthesis) and exercise (5.1 vs. 7.0 mm Hg) mean gradients.(3)

In the study by Dressler FA et al in 1992, with the use of Doppler echocardiography, 600 patients have been studied before and after stress echocardiography. They have used four different models of prosthetic valves. All the four models showed no significant differences with the pressure gradients showing 18-26 mmHg in the resting state and 35-63 mmHg with exercise in the aortic position .The heart rate achieved or duration of exercise did not influence the gradient achieved with exercise(4).

In the study by Shimon A Reisner et al in 1989,17 patients with mitral prostheses 11 with Björk-Shiley (BS) and six with Starr-Edwards (SE) valves were subjected to submaximal supine exercise .The patients with with Björk-Shiley (BS) valves showed an increment in peak and mean gradients from increased from 10 and 5 mm Hg, respectively, at rest to 16 and 10 at peak exercise and the patients with Starr-Edwards (SE) valves showed an increment in gradient from 8 and 5 mm Hg, respectively, at rest to 22 and 13 mm Hg at peak exercise. . Peak exercise pressure gradient and the increase in peak gradient with exercise were significantly higher in the SE group (*p* $<$ 0.05)(7). Our study has a single patient who has been put on Starr-Edward valve which was kept a dacade ago. His mean pressure gradient at rest was11mmHg and on stress it was found to increase to 14.1 with exercise and with13.1 dobutamine stress echo. This study has thus proved the durability of the ball and cage valve. (7)

In their study of Kadir I et al .,the mean transvalvular gradient increased by about 16±2.1 mmHg with dobutamine stress and by an equal amount after symptom limited treadmill exercise in aortic prostheses..This increase in the pressure gradient was stastically significant with a P value of less than 0.001(16).

In the study by Picano et al in 2009,a marked increase in the mean transprosthetic gradient (more than 20 mmHg for aortic valve and more than 12 mmHg for mitral valve) was associated with a markedly impaired exercise capacity and raise a suspicion for prosthesis dysfunction. But this fact may be compounded by the factor of patient prosthesis mismatch(17). In our study, one patient had a mean pressure gradient of 12.8 mmHg and the patient had reduced functional capacity .He has been kept on serial echocardiographic follow-up.

The rest and stress pressure gradients recorded in our study compared well with all those reported previously. Rest studies using the tilting disc prosthetic valves of 27 to 31 mm size reported peak and and mean gradients 10.2 to 6.2 mmHg comparable to the previous studies.

Similarly, the pressure gradients across the bileaflet valves were comparable to the previous studies.(6.1 mmHg to18.1 mmHg peak gradient and 3.4 to 7.4 mmHg mean gradient).On putting the patient on treadmill, the peak gradient and the mean gradient raised by 6.5 mmHg and 2.78 mmHg respectively which was found to be statistically significant. The stress induced by dobutamine produced similar rate of increase albeit to a lesser extent with as tatistical significance..(4.544 mmHg peak gradient and 1.852mmHg mean gradient)

Effects of dobutamine and exercise on diastolic filling

Both methods produced comparable stroke volumes at maximum stress even though the heart rates were more and diastolic filling times were longer with the protocol using dobutamine. This finding was an unexpected one as the diastolic filling fraction of the cardiac cycle (i.e the ratio of diastolic filling time to cardiac cycle time) tend to reduce at rapid heart rates. This appears completely feasible as the pressure differences are dependent on the flow across the prosthesis and the cross sectional area that is available for flow. (13)

In our study, the diastolic filling time appeared to reduce from 450 milli seconds to 231 milliseconds with dobutamine and about 206 millisecond in the exercise group.Onthe contrary,the diastolic flow rate was more in the exercise arm than dobutamine arm.(273 ml/sec vs241 ml/sec).The relatively more increment in the stroke volume with dynamic exercise might have contributed for this augmentation .

Effects of stress protocol on effective orifice area(EOA)

The effective orifice area is defined during the period of diastole i.e from the period of initial valve leaflet separation at the beginning of diastole to the terminal leaflet closure at the end of diastole. The standard continuity equation uses the velocity time integral across the left ventricular outflow tract and prosthetic valve and thus provides an averaged EOA .

In the study by Leavitt et al, the mitral valve area was compared in 12 patients with prosthetic mitral valve and in 12 patients with moderate mitral stenosis after treadmill exercise. The mitral valve area increased from 2.5 to 2.9 sq.cm after exercise in the prosthetic group and from 1.4 to 1.6sq.cm. in the mitral stenosis group. (11)

In another study by N.A.Hobson et al the effective orifice area was calculated at rest and after supine bicycle ergometry and after dobutamine stress echocardiography .The ERO increased from1.67 sq.cm to 2.1 7sq.cm after dobutamine stress and to 1.87 sq.cm a fter exercisediography(13)

In the study by Picano et al, they studied the relationship between the effective orifice area and the raise mean pressure gradient in mitral prosthesis. They suggested that a large increase in the mean gradient in the presence of small effective orifice area would be indicative of prosthesis or patient - prosthesis mismatch.(17)

In their study of comparison of exercise and dobutamine echocardiography aortic valve hemodynamics in 2002,Kadir I et al had found out that there were no significant change in the effective orifice area of the prosthetic valve with either protocol(16,19,20). But the study was conducted in patients with small size aortic prosthetic valves and the aortic valve orifice area is relatively less affected by diastolic flow rate when compared with mitral prostheses.

In our study, the effective orifice area of the valve at rest was 2.4sq.cm.which increased to 2.8 sq.cm during exercise protocol and 3.1 sq,cm during dobutamine stress protocol. The increase was relatively higher in the dobutamine arm . On comparing the increase in the ERO in both arms ,the results were found to be statistically significant. These results were comparable to previous studies.

It is possible that the apparent increase in effective orifice area is a reflection of a increased rate of change of valve leaflet opening and closing as the cardiac flow increases. It is thus hypothesized that dobutamine results in a maximum ERO being achieved more rapidy and for a greater length of time proportionally when related to the diastolic filling time.(13)

The observed increase in effective orifice area may be affected by various confounding factors and thus may be erroneous.. In the presence of undetected mitral regurgitation, errors may have occurred. In the transthoracic echocardiography, detection of mitral regurgitation is limited. But this difficulty may be nullified by assessing the ratio of velocity time integral over the mitral valve and over the left ventricular outflow tract. This Doppler velocity index has been a predictor of mitral regurgitation with a sensitivity of 89% and specificity of 91% when the index exceeds 2.5.In our study, the Doppler velocity index did not exceed 2.5. (13,1)

Data variability during exercise might also had contributed to the observed differences, but data variability for exercise and dobutamine stress were not found to be statistically significant. The calculation of effective orifice area may also be confounded by the fact that the 3three minute stepwise protocol used during stress studies was not enough time to allow the stabilization of chronotropic and hemodynamic conditions.

LIMITATIONS OF THE STUDY:

1. The study consisted only of a small population of patients .
2. The time available for recording the images soon after peak exercise was very short and it was not possible to obtain the variables in multiple views before the exercise hemodynamics were returned to baseline.
3. Both dobutamine and exercise will produce changes in the contractility of the heart which may induce changes in diastolic function which may have its reverberations on the pulmonary artery pressure.
4. Dobutamine produces reduced afterload and thus produces improved relaxation leading to differences in diastolic filling than exercise. In the ideal setting ,some calculation about the wall stress and thus the estimation of changes in afterload may have identified the reasons for the differences in diastolic filling time.
5. The theory relating the quicker opening or closing rate of valve leaflets to dobutamine must have been quantified by doing M mode echo across the valve leaflets during stress.
6. Another limitation of the study is the lack of invasive correlation of these variables.

CONCLUSION

CONCLUSION

1. This Study helps in comparing the hemodynamic changes noted with stress induced by dobutamine and treadmill exercise..

2. Normally functioning prosthetic valves in the mitral position can produce significant increases in valvular pressure gradients under conditions of high flow, and thus an estimation of diastolic cardiac flow must be measured before concluding that the valve dysfunction has occurred.

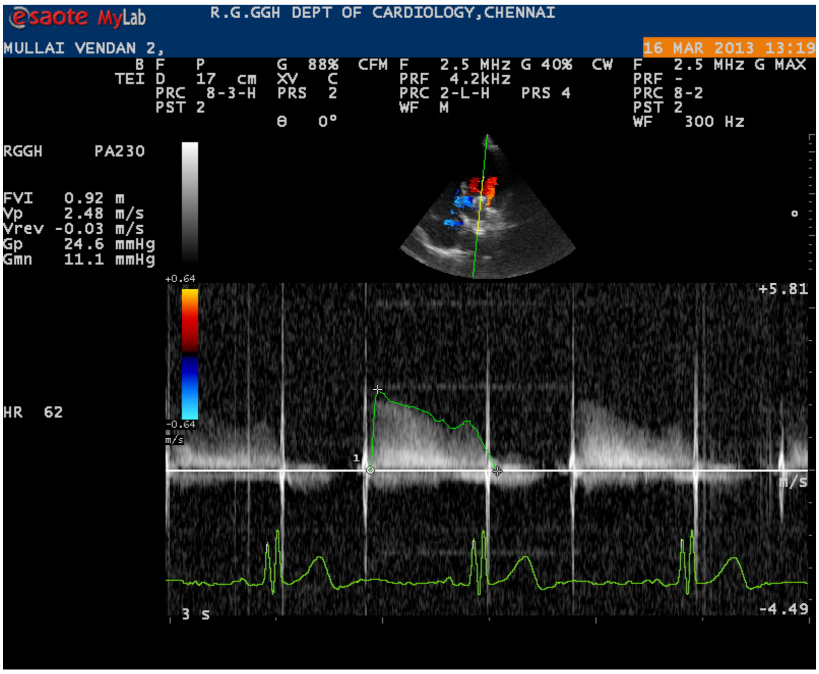
3. Dobutamine produces a greater augmentation in the effective mitral orifice area when compared to exercise.

4. Exercise protocol produces much higher increase in the pressure gradients when compared with dobutamine.

5. An abnormal increase in the pressure gradient without an increase in EOA signifies significant valve dysfunction and these patients should be monitored periodically for further deterioration and further action. Thus this study helps in finding dysfunction of prosthetic valves in the earlier stages itself.

Fig.12

Showing continuous wave Doppler rest(SEV)



R.G.GGH DEPT OF CARDIOLOGY,CHENNAI

MULLAI VENDAN 2,

16 MAR 2013 13:19

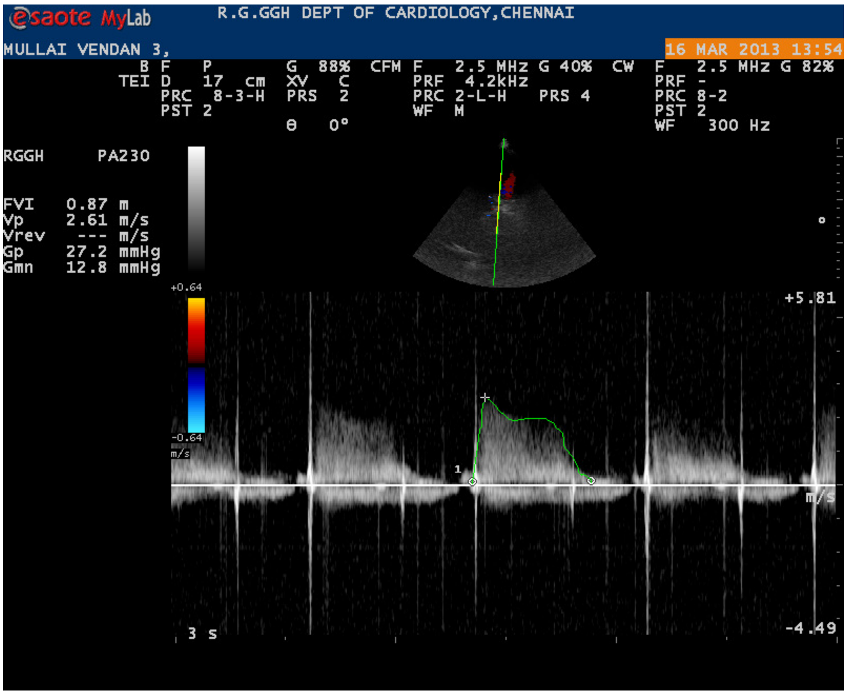
RGGH PA230

FVI 0.92 m
Vp 2.48 m/s
Vrev -0.03 m/s
Gp 24.6 mmHg
Gmn 11.1 mmHg

HR 62

Fig13

Showing continuous wave Doppler at peak exercise –same patient



R.G.GGH DEPT OF CARDIOLOGY,CHENNAI

MULLAI VENDAN 3,

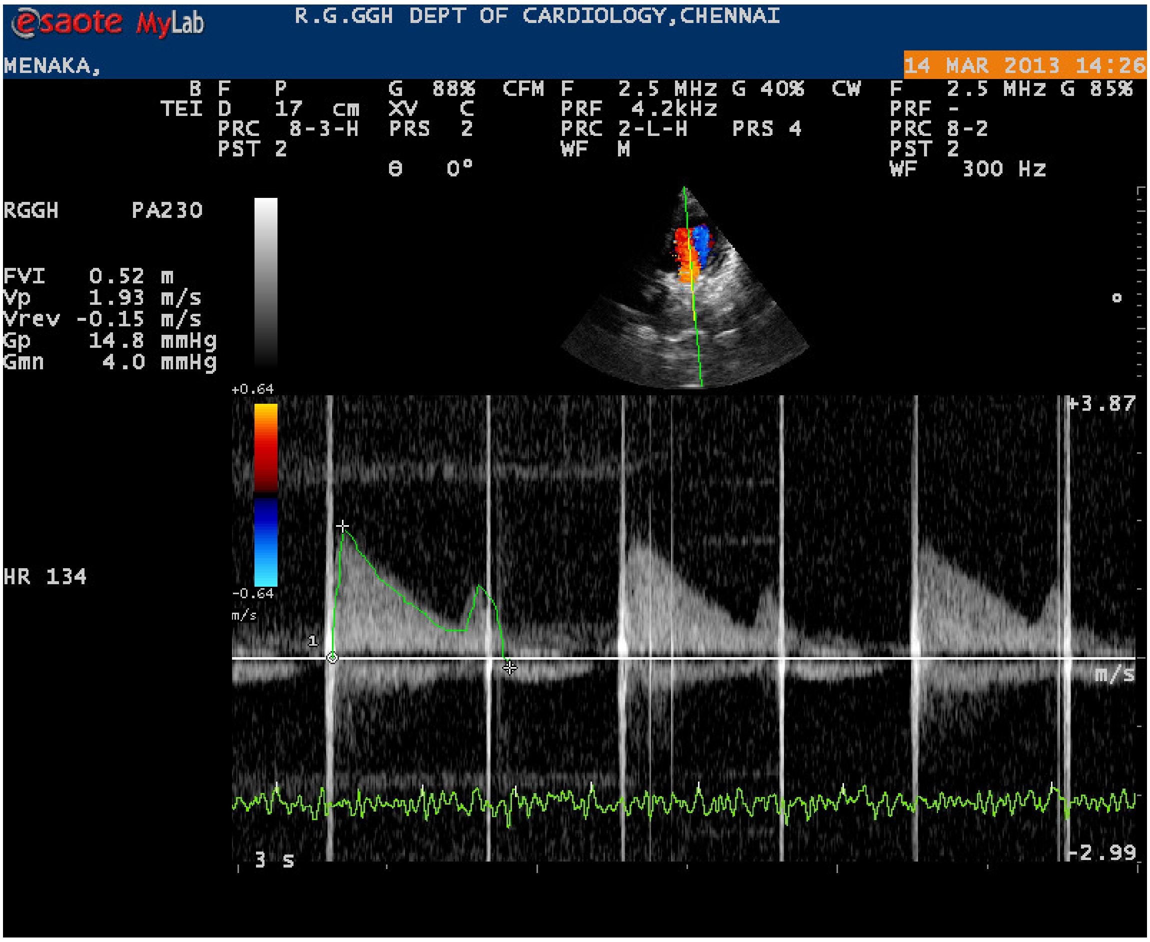
16 MAR 2013 13:54

RGGH PA230

FVI 0.87 m
Vp 2.61 m/s
Vrev --- m/s
Gp 27.2 mmHg
Gmn 12.8 mmHg

Fig12

Showing continuous wave Doppler at peak dose of dobutamine (SJM)



ABBREVATIONS USED

DFP - Diastolic Filling Period

DVI - Doppler velocity index

ERO - Effective orifice area

LVOT - Left Ventricular Outflow Tract

PPM - Patient –prosthesis mismatch

PAP - Pulmonary Artery Pressure

SJM - St Jude Medical

THI - Tissue Harmonic Imaging

TTE - Trans Thoracic Echocardiography

VTI - Velocity Time Integral

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BIBLIOGRAPHY

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PATIENT CONSENT FORM

STUDY TITLE :

ROLE OF STRESS ECHOCARDIOGRAPHY IN THE FUNCTIONAL ASSESSEMENT OF PROSTHETIC MITRAL VALVE

Patient may check (✓) these boxes.

PARTICIPANT NAME : DATE:

AGE: SEX:
C.D.NO. :

1. The details of the study have been provided to me in writing and explained to me in my own language. ☐
2. I confirm that I have understood the purpose of the above study. I have the opportunity to ask the question and all my questions and doubts have been answered to my complete satisfaction. ☐
3. I understand that my participation in the study is voluntary and that I am free to withdraw at any time without giving any reason, without my legal rights being affected. ☐
4. I understand that investigator, the institution, regulatory authorities and the ethical committee will not need my permission to look at my health records both in respect to the current study and any further research that may be conducted in relation to it, even if I withdraw from the study. I understand that my identity will not be revealed in any information released to third parties or published, unless as required under the law. I agree not to restrict the use of any data or results that arise from this study. ☐
5. I hereby consent to, undergo complete physical examination ,and diagnostic tests including hematological, biochemical, radiological and urine examinations ☐
6. I have been given an information sheet giving details of the study. ☐
7. I hereby consent to participate in the above study. ☐

Signature of the Participant

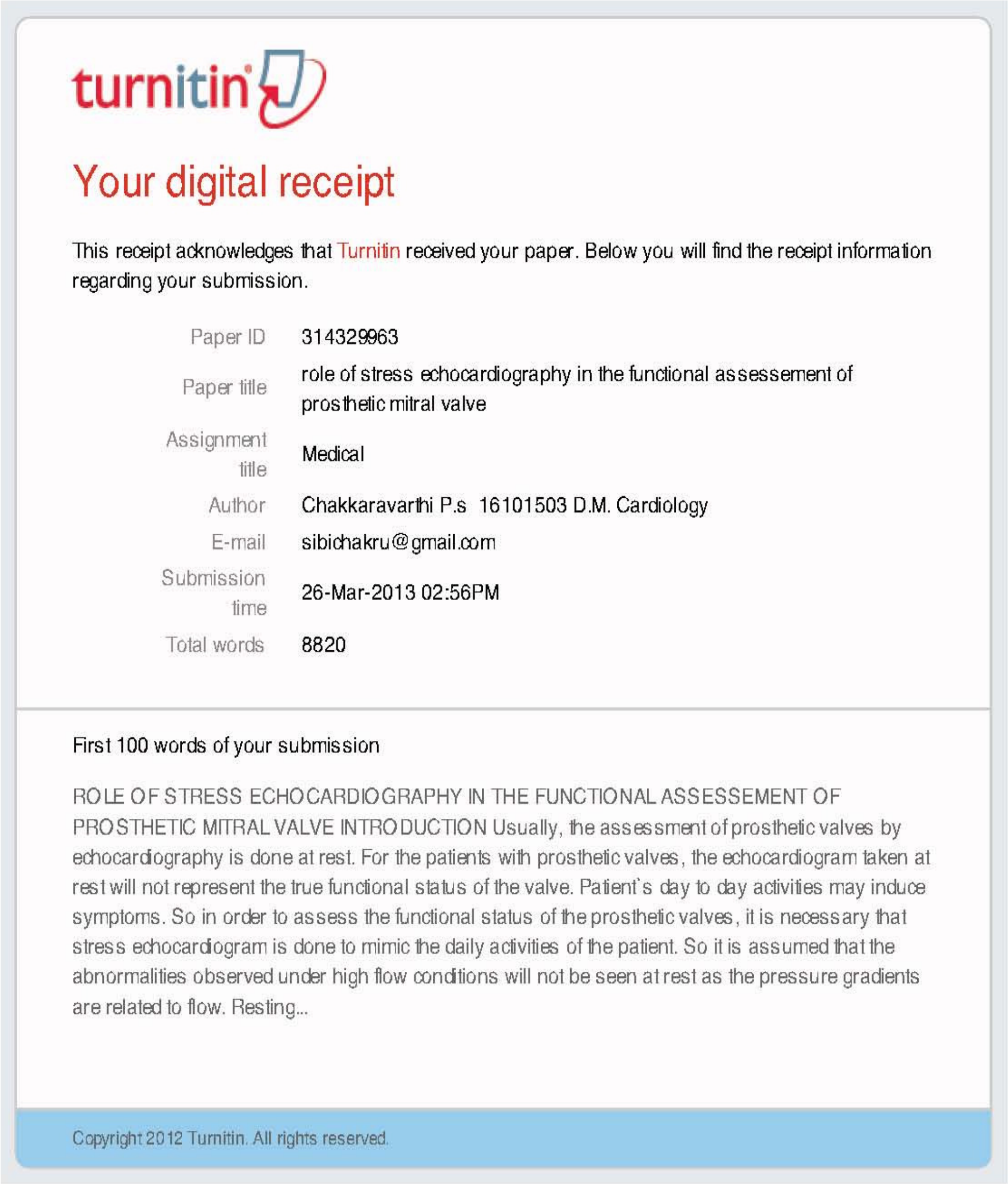
PROFORMA

TITLE **Role of stress Echocardiography in functional assessement of prosthetic mitral valve**

S.NO		CD NO
1	Patient Name	
2	Age (in years)	
3	Sex	1. Male 2. Female
4	Education	
5	Name of Hospital	
6	Contact number	
7	Address:	
8	Name of respondent (patient or attendant)	
9	Date of valve replacement	
10	Type and size of valve	
11	Latest INR	
12.	**SOB and NYHA class**	
13.	Palpitation	
14.	Height	
15.	Weight	
16.	Heart rate	
17.	Blood Pressure	
	ECHOCARDIOGRAPHIC PROFILE	
18.	IMAGING OF VALVE	
	Motion of leaflets	
	Presence of calcification	
	Presence of abnormal echo densities	

19.	LV DIMENSION	
	Diastole	
	Systole	
	Ejection Fraction	
20.	RV size	
21.	TAPSE	

Variable	Rest	Exercise	Dobutamine
Peak velocity			
Peak Gradient			
Mean Gradient			
Heart Rate			
VTI_{MV}			
DVI			
Pressure half time			
Diastolic filling time			
EOA			
PAP			



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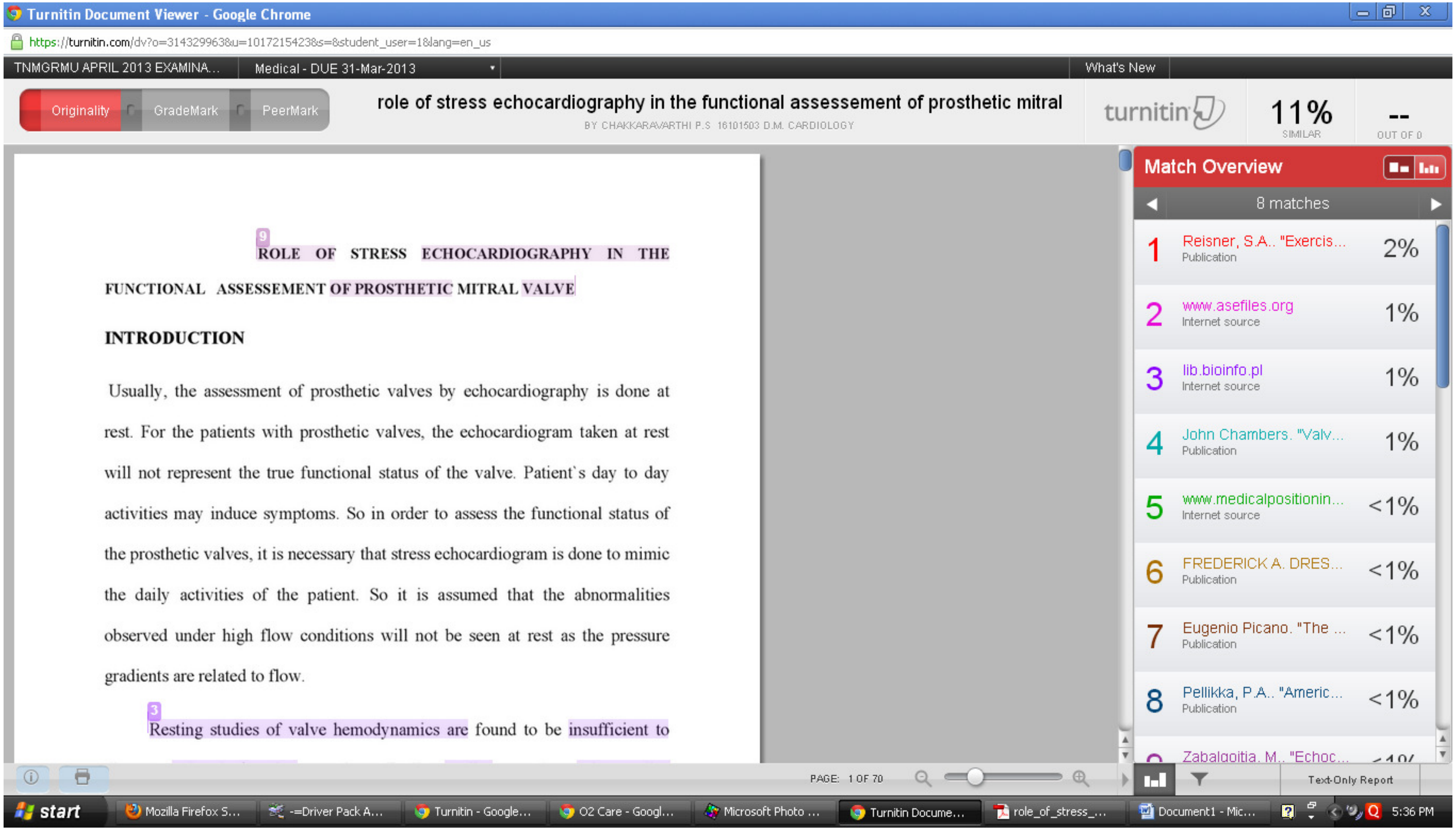

role of stress echocardiography in the functional assessement of prosthetic mitral

BY CHAKKARAVARTHI P.S 16101503 D.M. CARDIOLOGY

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[9] ROLE OF STRESS ECHOCARDIOGRAPHY IN THE FUNCTIONAL ASSESSEMENT OF PROSTHETIC MITRAL VALVE

INTRODUCTION

Usually, the assessment of prosthetic valves by echocardiography is done at rest. For the patients with prosthetic valves, the echocardiogram taken at rest will not represent the true functional status of the valve. Patient`s day to day activities may induce symptoms. So in order to assess the functional status of the prosthetic valves, it is necessary that stress echocardiogram is done to mimic the daily activities of the patient. So it is assumed that the abnormalities observed under high flow conditions will not be seen at rest as the pressure gradients are related to flow.

[3] Resting studies of valve hemodynamics are found to be insufficient to

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