

ORIGINAL ARTICLE

FLUOROSCOPY VERSUS TRANSTHORACIC ECHOCARDIOGRAPHY FOR DETECTION OF MITRAL VALVE CALCIFICATION IN PATIENTS UNDERGOING PERCUTANEOUS MITRAL BALLOON VALVULOPLASTY

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Objectives: Rheumatic heart disease remains a significant problem in developing countries, with mitral stenosis (MS) being a frequent manifestation. The objective of this study was to compare transthoracic echocardiographic (TTE) findings of mitral valve calcification with fluoroscopy.

Methodology: This cross-sectional study was conducted at the department of adult cardiology, National Institute of Cardiovascular Diseases (NICVD) Karachi. All patients were candidates for percutaneous mitral balloon valvuloplasty (PMBV), aged between 15 to 65 years of either gender. Patients who underwent TTE were subjected to fluoroscopy before PMBV. The Kappa coefficient was calculated to assess the agreement between the two modalities. An appropriate t-test or Mann-Whitney U test was applied, and a p-value ≤ 0.05 was taken as the criterion for statistical significance.

Results: A total of 160 patients were included in this study with a mean age of 34.01 ± 12.32 years, 119 (74.4%) were between 18 to 40 years of age, and 108 (67.5%) were female. Calcification was observed in 40.6% (65) on echocardiography and 50.6% (81) of the patients on fluoroscopy. A substantial agreement was observed between the two modalities with a Kappa coefficient of 0.75 for the detection of calcification.

Conclusion: No significant difference was observed in the detection of calcification on echocardiography and fluoroscopy, along with a substantial agreement between the two modalities for the detection of calcification. Echocardiography can be a less invasive alternative to fluoroscopy for the detection of calcification before PMBV.

Keywords: mitral stenosis, percutaneous mitral balloon valvuloplasty, echocardiography, mitral valve area, fluoroscopy

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INTRODUCTION

Rheumatic heart disease (RHD) remains a significant problem in developing countries, with mitral stenosis (MS) being a frequent manifestation.¹ Although rheumatic fever and its complications have declined in developed countries, the disease is still a significant health problem in many developing countries. The mitral valve (MV) is the most commonly and severely affected (65%–70% of patients) by the rheumatic process of stenosis and/or regurgitation.² Definitive treatment of symptomatic MS patients is either percutaneous mitral balloon valvuloplasty (PMBV) or mitral valve replacement (MVR). Calcification assessment is essential before deciding if a patient is

best suited for PMBV or surgical intervention. This assessment is most commonly made by 2D echocardiography. However, calcifications are much more easily seen with fluoroscopy.^{3,4}

The two-dimensional echocardiogram can help determine whether MS patient is a good candidate for balloon mitral valvuloplasty or replacement. Valve calcification on radiography is pathognomonic of significant valve disease. If calcification is present, it is much easier to see with fluoroscopy. Despite the lower resolution of fluoroscopy compared to a standard chest radiograph, real-time visualization aids in calcification definition.⁵

Transthoracic echocardiography remains the most crucial investigation in the pre-procedure assessment of mitral stenosis.⁶ Currently, the assessment relies on a semi-quantitative scoring system, including leaflet mobility, leaflet thickening, valvular calcification, and subvalvular apparatus assessment.^{2,7}

Calcification assessment is essential before deciding if a patient is best suited for PMBV or surgical intervention. This assessment is most commonly made by 2D echocardiography. However, calcifications are much more easily seen with fluoroscopy. PMBV, since its introduction in 1984 by Inoue, remains the first-line treatment for symptomatic patients with favorable anatomy. Valve morphology and valve anatomy remain essential predictors of procedure outcome.⁸ Some have reported a lower success rate with mitral valve calcifications.^{9,10} With the introduction of PMBV by Inoue in 1984, the treatment of Mitral stenosis has been completely revolutionized.¹¹ For the first time, Inoue et al. introduced to the literature PMBV, which has now become a reliable alternative treatment option to commissurotomy or valve replacement in MS patients with symptomatic and suitable mitral valve morphology.¹²

In contrast, others have suggested an acceptable outcome with a percutaneous procedure that could postpone surgery in patients with favorable characteristics. We aim to compare calcifications as seen on 2D transthoracic echocardiographic (TTE) and fluoroscopy since it is an essential predictor of PMBV outcome. Such a study can help identify an effective and more reliable method of quantifying calcification that can help choose the patients wisely for the procedure.

METHODOLOGY

This cross-sectional study was conducted at the Department of Adult Cardiology, National Institute of Cardiovascular Diseases (NICVD) Karachi, between January 2019 and December 2020. The study received approval from the institution's ethical review board. The study enrolled patients who were candidates for percutaneous mitral balloon valvotomy (PMBV) and met the inclusion criteria of being between 15 and 65 years of age, irrespective of gender. Patients were excluded based on the following criteria: indication for mitral valve replacement (e.g., severe mitral regurgitation, left atrial thrombus, high Wilkin's Score). Informed consent was obtained from all patients by the principal investigator. Patients who underwent transthoracic echocardiography (TTE) were also subjected to fluoroscopy prior to PMBV.

The sample size was calculated based on the 80% power of the test, 5% margin of error (d), an expected prevalence of 52% on echocardiography, and an anticipated prevalence of 33% on fluoroscopy. The minimum required sample size was determined to be 160 patients with mitral stenosis (MS).

Calcification grading was defined as 1-3 using multiple views on 2D TTE. A grading of 1 indicated fewer than three spicules of calcium on the mitral valve apparatus (MVA), 2 indicated 3-5 spicules of calcium on MVA, and 3 indicated more than 5 spicules of calcium on MVA. Fluoroscopic calcifications on the mitral valve were predefined as 1: involving the leaflets, 2: involving the annulus, and 3: involving both leaflets and annulus. All patients underwent comprehensive echocardiography, which included 2D measurements performed by experienced sonographers. The mean transmitral gradient was calculated using the modified Bernoulli equation and a continuous wave Doppler signal across the mitral valve.

Data analysis was performed using the statistical package for social sciences (SPSS 21). The suitability of all parameters to the normal distribution was evaluated using the Kolmogorov-Smirnov test. For comparing quantitative data and employing descriptive statistical methods (mean \pm SD), the Student's t-test was used for parameters showing normal distribution, while the Mann-Whitney U test was used for parameters that did not exhibit normal distribution in cross-group comparisons. Categorical variables were presented as frequency and percentages. The agreement between echocardiography and fluoroscopy in detecting mitral valve calcification was assessed using the Kappa coefficient, with a two-sided p-value of less than 0.05 considered statistically significant.

RESULTS

A total of 160 patients were included in the study, with a mean age of 34.01 ± 12.32 years. Among them, 119 (74.4%) were between 18 to 40 years old, and 108 (67.5%) were female. The majority of participants, 65 (40.6%), were housewives, followed by 27 (16.9%) laborers, 30 (18.8%) students, 5 (3.1%) nurses, and 6 (3.8%) engaged in other occupations. Sindhi was the most common mother tongue among the participants, accounting for 77 (48.1%) individuals. Urdu was the second most prevalent language with 40 (25%) participants, followed by Balochi, Punjabi, and Pashto with 30 (19%) participants, and the remaining 8% spoke other languages. Common symptoms reported

by the patients included shortness of breath (149; 93.1%), palpitation (98; 61.3%), dyspnea (92; 57.5%), chest pain (75; 46.9%), easy fatiguability (72; 45%), and acute pulmonary edema (43; 26.9%). Hypertension was present in 22 (13.8%) patients. Details of the patients' demographics and presenting complaints are presented in Table 1. Additionally, the average echocardiographic parameters of the patients can be found in Table 2.

Table 1: Demographics, clinical characteristics, and presenting complaints of the patients

Characteristics	Summary
Total (N)	160
Gender	
Male	32.5% (52)
Female	67.5% (108)
Age (years)	
Mean ± SD	34.01 ± 12.32 years
18 to 40 years	74.4% (119)
41 to 60 years	25.6% (41)
Mother Tongue	
Sindhi	48.1% (77)
Pashto	4.4% (7)
Balochi	6.9% (11)
Urdu	25% (40)
Punjabi	7.5% (12)
Others	8.1% (13)
Occupation	
Laborer	16.9% (27)
Security Guard	3.8% (6)
Housewife	40.6% (65)
Electrician	5.6% (9)
Student	18.8% (30)
Salesman	7.5% (12)
Nurse	3.1% (5)
Others	3.8% (6)
Presenting Complaints	
Shortness of Breath	93.1% (149)
Palpitations	61.3% (98)
Dyspnea:	57.5% (92)
Chest Pain	46.9% (75)
Easy Fatiguability	45% (72)
Acute Pulmonary Edema	26.9% (43)
Fever	24.4% (39)
Dizziness	21.3% (34)
Swelling on legs	16.9% (27)
Co-morbid Conditions	
Hypertension	13.8% (22)
Smoking	9.4% (15)
Family history of VHD	8.1% (13)
Diabetes mellitus	7.5% (12)
Stroke	3.1% (5)
Chronic kidney disease	2.5% (4)
Dyslipidemia	1.9% (3)

SD = Standard Deviation, VHD = valvular heart disease

Table 2: Echocardiographic parameters of the patients

Parameters	Total (n = 160)
Ejection fraction (EF)	54.39 ± 10.05 %
Left Ventricular End-Systolic Dimension (LVESD)	31.23 ± 8.65 mm

Left Ventricular End- Diastolic Dimension (LVEDD)	43.78 ± 9.08 mm
Left Atrial (LA)	48 ± 13.51 mm
Aorta	26.17 ± 4.08 mm
Right Ventricle	25.99 ± 8.62 mm
Septal Thickness	8.33 ± 1.09 mm
Posterior Wall Thickness	8.87 ± 1.82 mm
PA Pressure	53.95 ± 14.52 mmHg
Mitral Valve Area Planimetry	0.75 ± 0.36 cm ²
Mitral Valve Area Pressure half-time (PHT)	0.98 ± 0.37 cm ²
Pressure Gradient Across MV: Peak	20.13 ± 7.02 mmHg
Pressure Gradient Across MV: Mean	13.46 ± 5.74 mmHg

Wilkin's Score was determined to be 6.9±1.37, and calcification was observed in 65 patients (40.6%) on echocardiography and 81 patients (50.6%) on fluoroscopy. Patients with calcification on fluoroscopy had a significantly higher Wilkin's Score compared to those without calcification (7.38±1.10 vs. 6.32±1.19; p-value = 0.032). Similarly, patients with calcification on echocardiography had a significantly higher Wilkin's Score compared to those without calcification (7.98±1.07 vs. 6.23±0.87; p-value < 0.001). Detailed information on calcification on both modalities and ECG findings can be found in Table 3.

Table 3: Calcification on fluoroscopy and echocardiography

Finding	Summary
Total (N)	160
Wilkin's Score	6.9 ± 1.37
Calcification on mitral valve apparatus (TTE)	
None	59.4% (95)
< 3	25.6% (41)
3 to 5	13.1% (21)
> 5	1.9% (3)
Flow abnormality	
None	49.4% (79)
Mitral regurgitation	41.9% (67)
Others	8.8% (14)
Fluoroscopy finding (Calcification)	
No Calcification	49.4% (79)
Leaflets Only	35.6% (57)
Annulus Only	5% (8)
Leaflets and Annulus	10% (16)
ECG Finding	
Sinus Rhythm	59.4% (95)
Atrial Fibrillation	40.6% (65)
Calcification on echocardiographic	
No	59.4% (95)
Yes	40.6% (65)
Calcification on fluoroscopy	
No	49.4% (79)
Yes	50.6% (81)

Table 4 presents the agreement between fluoroscopy and echocardiography in detecting calcification. A good agreement was observed between the two modalities, with a Kappa coefficient of 0.75. The accuracy of echocardiography compared to

fluoroscopy was 87.5% [95% CI: 81.36% to 92.19%], with a sensitivity of 96.92% [95% CI: 89.32% to 99.63%] and specificity of 81.05% [95% CI: 71.72% to 88.37%].

Table 4: Assessment of agreement between Echocardiography and Fluoroscopy for the detection of mitral valve calcification

	Echocardiography		
	Yes	No	Total
Fluoroscopy			
Yes	39.4% (63)	11.3% (18)	50.6% (81)
No	1.3% (2)	48.1% (77)	49.4% (79)
Total	40.6% (65)	59.4% (95)	100% (160)
Kappa coefficient	0.75 (p-value <0.001)		

DISCUSSION

Despite increasing diagnosis and treatment methods, RHD remains a significant health problem. The most common mitral RHD, which presents with MS, is a severe source of morbidity and mortality, especially in developing countries.¹³ Usually, up to adulthood, asymptomatic but untreated complications of MS include atrial arrhythmias, cerebral or peripheral embolism, infective endocarditis, right ventricular failure, and pulmonary hypertension.²⁻⁴

Evaluation of Mitral valve calcification is of great importance as it decides the treatment plan for the patient. Valve calcification assessment can be done via echocardiography (TTE) and/or fluoroscopy. In this study, the diagnostic value of echo is a sensitive method in showing the agreement and overall accuracy of calcification. The echocardiography's accuracy, sensitivity, and specificity compared with fluoroscopic mitral valve calcification are 87.2%, 96.92%, and 81.05%, respectively. A definitive diagnosis for demonstrating valve calcifications and grading system should have high sensitivity and specificity.¹⁴

A study by Nowak et al.¹⁵ selected those patients who underwent valve replacement by digital methods before the procedure. A controlled 2D echo was performed. From the procedure, radiographs of the excised valves were taken to determine the degree of calcification. Echo in valve calcifications was detected with a sensitivity of 89.5%, specificity of 91.7%, and diagnostic accuracy of 90.3%.¹⁶

Wilkins et al.¹⁷ Mitral valve calcification in the method in which they scored the structure 1 to 4. Accordingly: Wilkin's score of < 8 is considered favorable for PMBV. In our study, the mean Wilkins Score was 6.8 ± 1.18 . Although the number of patients was limited, no major complications developed in our research. Similarly, there was a significant decrease in

mean mitral gradient and systolic pulmonary artery pressure after the procedure.

We intended to find the difference between echocardiographic and fluoroscopic quantification of mitral valve calcification. Our results found that eighteen patients accounted for 11.3% of patients who had no calcification on 2D echocardiography but were found to have calcification on fluoroscopy. A study was done by Geoffrey V et al.⁵ based on Fluoroscopy's Diagnostic Value Compared to Echocardiography in the Evaluation of Mitral Valve Calcification. At the same time, the correlation coefficient is found to be perfect ($k=0.99$). Fluoroscopy is 10% higher than echocardiography; there is no significant concordance between the two diagnostic modalities. Another study by Mahnken AH et al. indicated that the presence of mitral valve calcification on MDCT and echocardiographically proven mitral valve sclerosis had an excellent agreement ($k = 0.882$).¹⁸

The most common presentation of patients in our study were shortness of breath 93.1%, palpitation 61.3%, dyspnea 57.5%, chest pain 46.9%, easy fatigability 72 45%, and acute pulmonary edema 26.9%. Some patients were also hypertensive, accounting for 13.8%. Both mitral annular calcification and aortic valve calcification are related to age and vascular risk factors. Age, female sex, hypertension, diabetes, and high cholesterol have been strongly associated with mitral ring and aortic valve calcification. The coefficients range from 2.2 to 2.8 reported by Boon and colleagues.¹⁹ In many populations, RHD is more common in females than men.²⁰

Zühlke L et al. conducted a study based on the Global Rheumatic Heart Disease Registry. They concluded that rheumatic heart disease patients were young and found that 63.9% of participants had multivalvular disease complicated by congestive heart failure (33.4%), pulmonary hypertension (28.8%), atrial fibrillation (21.8%), stroke (7.1%), infective endocarditis (4%), and major bleeding (2.7%).²⁰

Large-scale studies reported that PMBV showed short- and long-term effective symptomatic and hemodynamic improvement.^{21,22} However, like any other procedure, the success of PMBV depends on careful patient selection. Chen et al., in a multicenter study, which included 4832 (70% female) MS patients, the procedure success rate was 99%.²¹ Güntürk EE et al.²³ successfully performed PMBV (mean MCA increased from 1.1 cm² to 1.6 cm²) in 30 patients, 80% of whom were women, with a mean age of 32 years, and did not report any significant cardiovascular complications.²³ In another study,

Tomai F et al.²⁴, studied a total of 482 consecutive patients, and successful PMBV treatment was achieved in 91% of patients. The group of 45 (8.5%) patients had suboptimal valve dilation (post-PMV valve area <1.5 cm²), severe MR, and need for surgery (repair or replacement).

The generalizability of study findings is limited by the single center coverage and limited sample size. It is important to note that further research and larger studies are warranted to validate these findings and assess the long-term outcomes associated with using echocardiography as a substitute for fluoroscopy in the context of PMBV. Nevertheless, the results of this study provide valuable insights into the potential role of echocardiography in improving the diagnostic process and patient care in the management of mitral valve calcification.

CONCLUSION

In conclusion, this study found no significant difference in the detection of calcification between echocardiography and fluoroscopy, indicating that echocardiography can serve as a viable and less invasive alternative to fluoroscopy for the detection of calcification prior to percutaneous mitral balloon valvuloplasty (PMBV). The high level of agreement between the two modalities further supports the reliability of echocardiography in identifying calcification.

AUTHORS' CONTRIBUTION

RA, MNM and ZY: Concept and design, data acquisition, interpretation, drafting, final approval, and agree to be accountable for all aspects of the work. MFK, MKA, MA, and AAK: Data acquisition, interpretation, drafting, final approval and agree to be accountable for all aspects of the work.

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