Original Article

Relationship between Left Atrial Volume Index and Atrial Fibrillation after Mitral Valve Replacement in Patients with Mitral Valve Disease

Md. Akram Hossain[1], Md. Anwar Hossain[2], Md. Mobarak Hossain[3], Kazi Al- Hosne Jamil[4], Sayeedur Rahman Khan[5], Rampada Sarker[6]

Abstract:

Background: Mitral valve replacement (MVR) is a surgical procedure that is often performed in patients with severe mitral valve disease, to replace the damaged valve with a new artificial valve. Left Atrial Volume Index (LAVI) is a measurement of the size of the left atrium of the heart, normalized to the body surface area which is often used as an indicator of left atrial enlargement, which is a common finding in patients with mitral valve disease. There is a significant relationship between LAVI and Atrial Fibrillation (AF) after MVR in patients with mitral valve disease.

Aim of the study: The aim of this study was to evaluate the relationship between LAVI and the occurrence of atrial fibrillation after mitral valve replacement in patients with mitral valve diseases.

Methods: This prospective observational study was conducted in the department of Cardiac Surgery, National Institute of Cardiovascular Diseases (NICVD), Dhaka from March, 2018 to February, 2019. Total 60 patients were divided into two groups, out of them 30 patients had LAVI e"39 ml/m² (Group-A) and 30 patients had LAVI d" 39ml/m² (Group-B).

Result: In patients with post-operative AF after MVR, was evaluated by ECG in the presence or absence of p-wave and irregular R-R interval and measurement of LAVI more or less than cutoff value 39 ml/m². On postoperative day 3, 7 (23.33%) patients in Group A and 02(6.66%) patients in Group B developed post-operative AF. In Group A there

was reduction in the LAVI but not below the cutoff value whereas in Group B, the LAVI was reduced below the cutoff value (< 39 ml/m2). On overall evaluation, after mitral valve replacement increased LAVI is significantly associated with post-operative AF occurrence and is a better predictor than LA diameters. From univariate analysis in our cohort, high inotropes support, MVT, ACT, CPB time and postoperative LAVI were significantly associated with occurrence of AF. But multiple logistic regression analysis revealed postoperative LAVI to be only significant predictor of occurrence of AF after Mitral valve replacement.

Conclusion: Our study shows that postoperative LAVI measured by 2-D echocardiography is positively and independently associated with the occurrence of post-operative AF following MVR. Moreover, clinical risk factors are fairly good predictors of the occurrence of AF after MVR, but postoperative LAVI was the most significant independent predictor of postoperative AF in our study.

Key words: *Relationship, Left Atrial Volume Index, Atrial Fibrillation, Mitral Valve Replacement and Mitral Valve Disease.*

(Bangladesh Heart Journal 2023; 38(1): 38-45)

1. Specialist Cardiac Surgeon, Department of Cardiac Surgery, United Hospital Limited, Dhaka, Bangladesh
2. Assistant professor, Department of Cardiac Surgery, National Institute of Cardiovascular Diseases (NICVD), Dhaka, Bangladesh
3. Assistant professor, Department of Thoracic Surgery, National Institute of Diseases of the Chest and Hospital (NIDCH)
4. Indoor Medical officer, Department of Cardiac Surgery, Dhaka Medical College and Hospital, Dhaka, Bangladesh
5. Medical officer, Department of Cardiology, National Institute of Cardiovascular Diseases (NICVD), Dhaka, Bangladesh.
6. Professor & Head (Rtd), Department of Cardiac Surgery, National Institute of Cardiovascular Diseases (NICVD), Dhaka, Bangladesh.

Address of Correspondence: Dr. Md. Anwar Hossain, Assistant professor, Department of Cardiac Surgery, Room no 366, Middle block, National Institute of Cardiovascular Diseases, Dhaka, Bangladesh. Contact no. 01716584988.Email-dranwar291@gmail.com

DOI: https://doi.org/10.3329/bhj.v38i1.67217

Introduction

Incidence of rheumatic heart disease had been reported as 26% of total cardiac disease in Bangladesh.[1] Mitral valve is most commonly affected in rheumatic heart diseases followed by aortic valve in a percentage of 56.7% and 6% respectively in Bangladesh.[2] Isolated mitral stenosis accounts for about 25% of all case and an additional 40% have mixed mitral stenosis and regurgitation.[3] Acquired mitral stenosis usually results from rheumatic heart disease, as does mixed stenosis and regurgitation. It occurs as an isolated valvular condition in 40% of the patient with rheumatic heart disease.[4] Atrial fibrillation (AF) develops sooner or later in most cases of the mitral stenosis. At its onset, the ventricular rate is often more than 140 beats/min and the patient may be rapidly precipitated into acute pulmonary edema. It is an important complication, both because it contributes to the development of cardiac failure and because it is responsible for atrial stasis and the consequent risk of thrombosis and embolism.[5] Atrial fibrillation (AF) is a supraventricular tachyarrhythmia characterized by uncoordinated atrial activation with consequent deterioration of atrial mechanical function. AF is thought to be caused by atrial fibrosis and loss of atrial muscle mass. Fibrosis is not limited to the muscle mass of the atria and may occur in the sinoatrial node (SA) node and atrioventricular node (AV node), often leading to sick sinus syndrome (SSS). Prolonged episodes of atrial fibrillation have been shown to correlate with prolongation of the sinus node recovery time, suggesting that dysfunction of the SA node is progressive with prolonged episodes of atrial fibrillation.[6] It can be classified as- (i) Paroxysmal- Continuous AF that stop on its own and lasts <48 hours. (ii) Persistent- Continuous AF that last more than 7 days and requires cardioversion. (iii) Longstanding persistent- Episodic Persistent AF known for >1 year. (iv) Permanent AF episode more than 1-year duration (accepted or therapy failure).[7] The development of paroxysmal and persistent AF is associated with the presence of several factors including age, hypertension, heart failure, mitral valve disease and increased left atrial (LA) dimension as well as LAVI (Left atrial volume index.). Increased LAVI is a major predictor of the both early and late AF. Therefore, in addition to the important prognostic information provided by LAVI and AF occurrence under conservative management in patient with MR, LA size should be integrated into the decision-making process of patients with MR and that surgery may be considered earlier in the course of the disease.[8] After valve replacement surgery, cardiac function gradually improves and the enlarged heart reduces in size, with the cardiothoracic ratio becoming closer to normal. Atrial pressure and left atrial diameter gradually reduce and it may then become possible to convert AF into sinus rhythm.[9] The supero-inferior dimension is measured from the apical 4-chamber view. LAVI e" 39 ml/m² is considered abnormally increased and has a relation for the occurrence of postoperative AF after mitral valve replacement in patient with Mitral valve diseases. The incidence of development of AF is about 18% of patient after successful MVR surgery.[10] The current study was conducted to evaluate the relation of LAVI with occurrence of atrial fibrillation after mitral valve replacement in patient with mitral valve diseases.

Objective

To evaluate the relationship between LAVI and the occurrence of atrial fibrillation after mitral valve replacement in patients with mitral valve diseases.

Methods

This prospective observational study was conducted at the Department of Cardiac Surgery, National institute of cardiovascular diseases (NICVD), Sher-e-Bangla Nagar, Dhaka, Bangladesh. The study duration was 1 year, from Mar, 2018 to Feb, 2019. During this period, a total of 60 patients who underwent Mitral Valve Replacement (MVR) for mitral valve diseases at the study hospital were included in the study following the inclusion and exclusion criteria through a purposive sampling method. The 60 patients were divided in two equal groups, Group A, consisting of 30 Patients who had Left Atrial Volume Index of e" 39 ml/m^2 after operation, while group B had been comprised of 30 patients who had Left Atrial Volume Index of < 39 ml/m^2 after operation. Any patients who had undergone MVR for their mitral valve disease without Atrial Fibrillation (AF) had been included in the study. However, patients with pre-existing AF, patients undergoing concomitant cardiovascular procedures comprising valve surgery (AVR, TVR, PVR) and procedure for congenital heart diseases, patients with electrolyte imbalance and patients with comorbid conditions were excluded. All relevant data were collected from each respondent by use of interview schedule, measured parameters and investigations in a predesigned format. LA volume was measured by planimetry in the four chamber view and two chamber view with the area length method. Informed consent was obtained from the participants prior to their enrollment in the study, and ethical approval for the study was obtained from the ethical review committee of the study hospital. All data were recorded systematically in preformed data collection form (questionnaire). Statistical analyses were performed

by using windows-based computer software devised with Statistical Packages for Social Sciences (SPSS-25). Quantitative data was expressed as mean and standard deviation and qualitative data as frequency distribution and percentage. Continuous variables were compared by using the two independent samples t-test.

Results:

Table I demonstrates demographic characteristics of the study people. Approximately 23.33% of participants in both groups were aged 21-30, while 40% of Group A and 36.66% of Group B were aged 31-40. The majority of participants in both groups were male, with 60% in Group A and 56.66% in Group B, while 40% and 43.33% were female, respectively. In terms of BMI, 53.33% of Group A and 46.66% of Group B had a normal BMI, while 40% and 43.33% were overweight, and 6.66% and 10% were obese, respectively. The mean BMI was slightly higher in Group B than in Group A. Figure 1 shows the NYHA classification of heart failure severity. In our study, 50% of Group A and 36.66% of Group B were in NYHA Class III, while 40% of Group A and 43.33% of Group B were in Class II. Only one participant in Group A was in Class IV, while two participants in Group B were in this class. Table II shows comparison of patients by ECG finding in presence of p-wave and R-R interval (regular). Regarding presence of p-wave and R-R interval (regular) in preoperative period, it was present in both groups. In post-operative period it was present in 25(83.34%) of patients and absent in 5(16.66%) of patient in group B. In Group A presence of p-wave and R-R interval (regular) in post-operative period it was present in 28(93.34%) and absent in 2(6.66%) of patient. The figure 2 shows that the incidence of post-operative AF was significantly higher in Group A than in Group B. Specifically, 23.33% of participants in Group A developed post-operative AF, while only 6.66% of participants in Group B developed it. The p-value for this comparison was 0.015, indicating that this difference was statistically significant. Table III demonstrates that various measurements of left atrial (LA) diameter, LA volume, LA volume index (LAVI), left ventricular internal dimension in diastole (LVIDD), left ventricular internal dimension in systole (LVIDS), and left ventricular ejection fraction (EF) measured pre-operatively and at the third day and first month post-operation. The results demonstrate that Group B had significantly smaller LA diameter, LA volume, LAVI, LVIDS, and LV ejection fraction compared to Group A at all three measurements post-operation ($p<0.05$). However, there was no significant difference between the groups in LVIDD and LV ejection fraction pre-operation ($p>0.05$). Table IV shows that there was no significant difference between Group A and Group B in terms of the need for prolonged ICU stay (>48 hrs.) and prolonged hospital

Table-I

Demographic characteristics of the study people (N=60)

Variables		Group A (n=30) No. (%)	Group B (n=30) No. (%)	p-value
Age (Years)	10-20	1 (3.33%)	2 (6.66%)	0.699^{ns}
	21-30	7 (23.33%)	8 (26.66%)	
	31-40	12(40%)	11(36.66%)	
	41-50	8(26.66%)	6 (20%)	
	51-60	2 (6.66%)	3 (10%)	
	Mean ± SD	39.88 ± 13.51	39.32 ± 11.16	
Gender	Male	18 (60%)	17 (56.66%)	0.382^{ns}
	Female	12 (40%)	13(43.33%)	
BMI (kg/m^2)	Normal (18.5-24.9)	16(53.33%)	14(46.66%)	0.329^{ns}
	Overweight (25.0-29.9)	12(40.0%)	13(43.33%)	
	Obese (>30.0)	2(6.66%)	3(10.0%)	
	Mean ±SD	24.85±2.61	25.73±4.18	

Statistical analysis was done by Chi-square-test
P value ≤0.05 was accepted as significant,
ns = Not significant.
n= Number of subjects in each group.
N= Total number of patients.

stay (>14 days.) as indicated by the p-value of 0.061 and 0.090 respectively. However, there was a significant difference between the two groups in terms of the need for prolonged mechanical ventilation time (>24 hours) and prolonged inotrope support (>48 hrs.) as indicated by the p-values of 0.016 and 0.0006 respectively. Group B had a higher percentage of participants who needed prolonged mechanical ventilation time and inotrope support compared to Group A. Table V shows Multivariable stepwise logistic regression analysis was done to demonstrate that LAVI is independently associated with the occurrence of postoperative AF.

Table-II

Comparison of patients between two groups by ECG finding: presence of p-wave and R-R interval (N=60)

Variables	Group A (n=30) No. (%)		Group B (n=30) No. (%)		p-value
	Presence of p wave	R-R interval (Regular)	Presence of p wave	R-R interval (Regular)	
Pre-operative	30 (100%)	30 (100%)	30 (100%)	30 (100%)	0.023s
Post-operative	23(76.66%)	23(76.66%)	28(93.33%)	28(93.33%)	
% change from preoperative to post-operative	76.66%	76.66%	93.33%	93.33%	

Statistical analysis was done by Chi-square-test
P value d" 0.05 was accepted as significant,
s = Significant.
n= Number of subjects in each group.
N= Total number of patients.

Table-III

Comparison of patients between two groups by Echocardiographic findings (N=60)

Variables		Group A (n=30)	Group B (n =30)	p-value
LA diameter (mm)	Pre-operative	56.56 ± 4.891	47.04 ± 6.093	<0.001^{s}
	Post-operative (3rd day)	51.84 ± 5.121	43.60 ± 5.439	<0.001^{s}
	Post-operative (1month)	49.00 ± 4.690	39.16 ± 4.913	<0.001^{s}
LA Volume(ml)	Pre-operative	60.88 ±8.090	54.20 ±8.684	0.034^{s}
	Post-operative (3rd day)	58.20 ±8.073	51.76±8.136	0.039^{s}
	Post-operative (1month)	54.20±7.963	46.56 ±7.932	0.034^{s}
LAVI (ml/m²)	Pre-operative	48.88 ±7.190	35.21 ±6.884	0.044^{s}
	Post-operative (3rd day)	46.20 ±6.273	33.76±5.146	0.035^{s}
	Post-operative (1month)	42.40±8.664	29.56 ±8.732	0.041^{s}
LVIDD (mm)	Pre-operative	42.86 ±7.090	40.20 ±5.484	0.054^{ns}
	Post-operative (3rd day)	38.20 ±6.073	36.76±8.166	0.059^{ns}
	Post-operative (1month)	35.20±8.963	32.56 ±7.532	0.044^{s}
LVIDS (mm)	Pre-operative	34.96 ± 6.617	30.12±7.155	0.017^{s}
	Post-operative (3rd day)	33.04±6.541	28.32±6.556	0.014^{s}
	Post-operative (1month)	31.40±6.545	26.92±6.164	0.016^{s}
LV Ejection fraction (EF) (%)	Pre-operative	56.00 ± 8.231	60.32 ± 7.674	0.061^{ns}
	Post-operative ((3rd day)	57.48 ±7.241	61.36 ± 6.849	0.057^{ns}
	Post-operative (1month)	58.76 ± 6.815	62.36 ± 6.396	0.060^{ns}

Statistical analysis was done by unpaired Student t-test.
The test of significance was calculated and p values d" 0.05 was accepted as level of significance.
s = Significant
ns = Not significant
n = Number of subjects in each group
N = Total number of patients

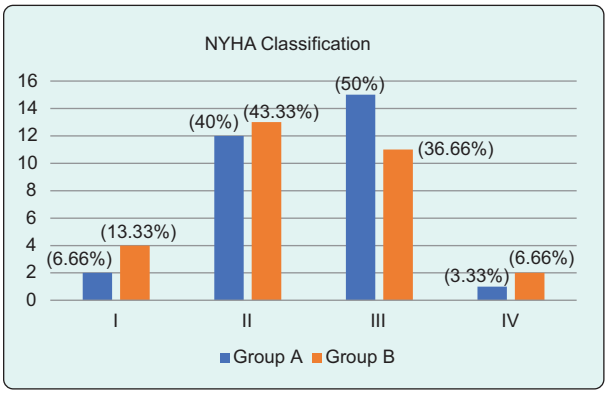

Fig.-1: *Distribution of the patients by NYHA classification between two study groups (N=60)*

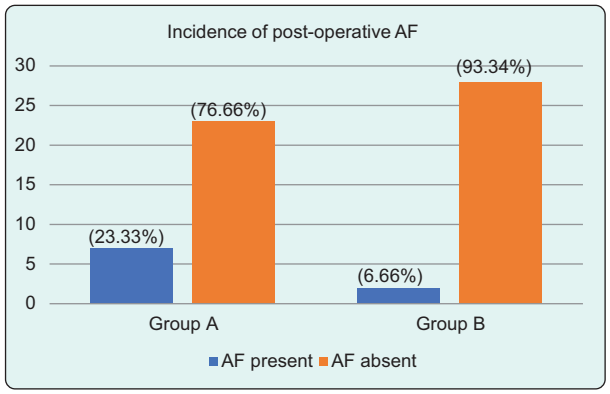

Fig.-2: *Comparison of post-operative AF between two groups (N=60)*

Table-IV

Comparison of Prolonged postoperative care among study groups (N=60)

Post-Operative Variables		Group A (n=30) No. (%)	Group B (n=30) No. (%)	p-value
Prolong ICU stay (>48 hrs.)	Needed	2(6.66.0%)	5(16.66%)	0.061[s]
	Not needed	28(93.34.0%)	25(83.34%)	
Prolong Hospital stay (>14 days)	Needed	6(20.0%)	3(10.0%)	0.090[s]
	Not needed	24(80.0%)	27(90.0%)	
Prolong mechanical ventilation time (>24 hours)	Needed	1(3.33%)	4(13.3%)	0.016[s]
	Not needed	29(96.66%)	26(86.7%)	
Prolong inotrope support (>48 hrs.)	Needed	5(16.66%)	15(50.0%)	0. 0006[s]
	Not needed	25(83.34%)	15(50.0%)	

Fisher Exact was done to analyze the data.
p values d" 0.05 was accepted as level of significance.
s = Significant
ns = Not significant
n = Number of subjects in each group
N = Total number of patients

Table-V

Predictors of post-operative AF according to multiple logistic regression analysis:

Variable(s)	Odds ratio (OR)	95% CI	p value
MVT	1.042	0.967-1.123	0.276[ns]
Inotropes support	1.059	0.920-1.218	0.224[ns]
LAVI	1.098	1.020-1.813	0.001[s]
ACT	0.002	0.0001-12.2	0.166[ns]
CPB	1.92	0.304-11.9	0.148[ns]

Data were expressed as Odds ratio (OR)
S = Significant ($p < 0.05$)
NS = Not significant ($p > 0.05$)

Discussion:

The current study was conducted to evaluate the relation of LAVI with occurrence of atrial fibrillation after mitral valve replacement in patient with mitral valve diseases. In present study, the mean age (years) of the patients in Group A and Group B were 39.88 ±13.51 and 39.32 ± 11.16 years respectively. In Group A, 60% were male and 40 % were female whereas in Group-B, 56.66% were male and 43.33% were female. The mean BMI of group A and group B were 24.85± 2.61 kg/m² and 25.73± 4.18 kg/m² respectively. In our study, the differences in demographic variables (age, sex, BMI) between two groups were not statistically significant (p=0.699, p = 0.382, p = 0.329). These findings are consistent with other similar studies.[11-13] Regarding the NYHA functional class 40% were in NYHA class-II followed by 50% in NYHA class-III in Group-A. In Group-B, 43.33% were in NYHA class-II followed by 36.66% in NYHA class-III. We found no significant association between NYHA and postoperative AF in our study which corresponds to the previous studies.[12] In this study, development of Atrial fibrillation (AF) after MVR was evaluated by the absent of p-wave and irregular R-R interval in ECG. On 3rd POD, postoperative AF was seen in 07 (23.33%) patients in group A and 02 (6.66%) patients in Group B, the difference being significant statistically. Various other prospective studies revealed similar finding claiming postoperative LAVI to be a significant predictor of occurrence of AF.[10] In present study the echocardiographic finding of mean LA diameter was 56.56 ± 4.891 mm in Group A and 47.04 ± 6.093 mm in Group B in preoperative period. After MVR on 3rd post-operative day mean LA diameter was decreased to 51.84 ± 5.121mm in Group A and 43.60 ± 5.439 mm in Group B. After 01 month, mean LA diameter was 49.00 ± 4.690 mm in Group A and 39.16 ± 4.913 mm in Group B. There was significant decrease in LA diameter within 01 month of post-operative period. Petrikovits E et al.[14] performed a prospective study that showed decrease in LA diameter from 56.2 ± 3.42 mm to 50.9 ± 4.40 mm. Another study done by Raine D et al.[13] also showed decrease in LA diameter from 49.2 ± 9.3 mm to 43.2 ± 6.9 mm. In the current study, LA volume was 60.88 ± 8.090 mm in Group A and 54.20 ±8.684 mm in Group B in preoperative period. In 3rd postoperative period it was 58.20 ±8.073 mm in Group A and 51.76 ± 8.136 mm in Group B and during 1st month of post-operative period it was 54.20 ±7.963 mm in Group A and 46.56 ± 7.932 mm in Group B. Raine D et al.[13] also found similar sort of results that revealed reduction from 59.0 ± 6.0 mm to 50.1 ± 8.4 mm. Regarding LAVI, in preoperative period it was 48.88 ± 7.190 ml/m² in Group A and 35.21 ± 6.884 ml/m² in Group B. In 3rd Post-operative period it was 46.20 ± 6.273 ml/m² in Group A and 33.76 ± 5.146 ml/m² in Group B. During 1st month of post-operative period it was 42.40 ±8.664 ml/m² in Group A and 29.56 ±8.732 ml/m² in Group B. The finding was similar to that of Nardi F et al.[15]. In this study, Ejection fraction (EF) in preoperative period was 56.00 ± 8.231%, in 3'rd post-operative day it was 57.48±7.241% and after 01 month 58.76 ±6.815% in Group A. Mean EF in Group B in preoperative period was 60.32 ±7.674%, after 3'rd postoperative day it was 61.36 ± 6.849% and after 01 month it was 62.36 ± 6.396 %. In a study by Osranek M et al.[16], the mean EF was 57.9 ± 12.4% and 59.9 ± 13.4 in two groups, which was close to the findings of our study. Regarding MVT, occurrence of AF was more in patients who required prolonged mechanical ventilation than those who did not. The difference between two groups is statistically significant (p = 0.016). On the other hand, prolonged ICU care needed for more patients in group B than group A, whereas the length of hospital stay was higher in group A than in group B, none of the differences being significant statistically (p =0.061and 0.09 respectively). This finding differs from that of the study carried out by Osranek M et al.[16], they found median length of ICU hospital stay was significantly higher in patients with post-operative AF compared with those without AF (p=<0.0001). The reason may be such that, in our cohort, there were some confounding variables dictating discharge from both ICU and hospital. May be due to these unavoidable factors, length of ICU and hospital stay turned out to be insignificant variable in our study. In this study prolong inotrope support (>48 hours) was needed in 5(16.7%) and 15(50.0%) patients in group A and group B respectively and not needed in 25(83.3%) and 15(50.0%) patients in group A and group B respectively. The difference between the two groups is statistically significant (p = 0.006). The finding was similar to that of Nardi F et al.[15]. Serum electrolytes and serum calcium were done in all patients pre-operatively and postoperatively. Any imbalance or impairment were accordingly managed. But these variables showed no significant effect on postoperative AF. Finally, we performed multivariate logistic regression analysis to find out relation of post-operative AF with others risk factors which revealed that LAVI is an independent risk factor of post-operative AF (OR 1.098; 95% CI; p=<0.001). So, our study showed that left atrial enlargement is associated with post-operative AF and all left atrial echocardiographic parameters were positively associated with postoperative atrial fibrillation. Among the left atrial echocardiographic parameters, left atrial volume index (LAVI) was found to

be more strongly associated with post-operative AF (p=<0.001). Kang MK et al.[10] also found similar result in their study.

Limitations of the study

In our study, there was a small sample size and an absence of a control for comparison. The study population was selected from one center in Dhaka city, so it may not represent the wider population. The study was conducted over a short period of time. There was a lack of reliable methods for recording postoperative arrhythmias. Multiple surgical teams performed the surgery.

Conclusion:

Our study shows that postoperative LAVI measured by 2-D echocardiography is positively and independently associated with the occurrence of post-operative AF following MVR. Moreover, clinical risk factors are fairly good predictors of the occurrence of AF after MVR, but postoperative LAVI was the most significant independent predictor of postoperative AF in our study.

Recommendation:

To maintain sinus rhythm following mitral valve replacement in patients with mitral valve disease, it is wise to add the other surgical procedure to prevent atrial fibrillation along with mitral valve replacement. Measurement of LAVI is a simple and important tool for risk stratification and as a guide for surveillance and therapy in patients with mitral valve disease. A longer period of follow-up would be beneficial to see the exact picture of the association between postoperative LAVI and the occurrence of AF following mitral valve replacement. A multi-center, large-scale study should be carried out.

References:

1. Mohibullah MD, Islam MN, Ali M. Juvenile mitral stenosis in Bangladesh. Bangladesh Heart J. 1992;7:6-14.
2. Hussain M, Zaher A, Yoshitake K, Tokeshi S, Malik A, Rahman M. Active rheumatic fever and rheumatic heart disease in Dhaka Shishu Hospital. Bangladesh Heart J. 1991;6:33-7.
3. BR W. Colledge NR, Ralston SH, Penman ID. Oncology in: Davidson's Principles and Practice of Medicine. 22" edition, Churchil Livingstone.
4. Kouchoukos NT, Blackstone EH, Hanley FL, Kirklin JK. Kirklin/barratt-boyes cardiac surgery. Elsevier Health Sciences; 2012 Oct 26.
5. Julian DG, Cowan JC, Mclenachan JM. Disorders of the cardiac valves in Cardiology. 8th ed, Elsevier Saunders, Edinburgh. 2006
6. University of Toronto, Department of Medicine, Atrial Fibrillation teaching File. 2008. 12:pp.65.
7. Fuster V, Rydén LE, Asinger RW, Cannom DS, Crijns HJ, Frye RL, Halperin JL, Kay GN, Klein WW, Lévy S, McNamara RL. ACC/AHA/ESC guidelines for the management of patients with atrial fibrillation: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines and the European Society of Cardiology Committee for Practice Guidelines and Policy Conferences (Committee to Develop Guidelines for the Management of Patients with Atrial Fibrillation) developed in collaboration with the North American Society of Pacing and Electrophysiology. Journal of the American College of Cardiology. 2001 Oct;38(4):1266-.
8. Kernis SJ, Nkomo VT, Messika-Zeitoun D, Gersh BJ, Sundt III TM, Ballman KV, Scott CG, Schaff HV, Enriquez-Sarano M. Atrial fibrillation after surgical correction of mitral regurgitation in sinus rhythm: incidence, outcome, and determinants. Circulation. 2004 Oct 19;110(16):2320-5.
9. Chen WS, Gao BR, Chen WQ, Li ZZ, Xu ZY, Zhang YH, Yang K, Guan XQ. Comparison of pharmacological and electrical cardioversion in permanent atrial fibrillation after prosthetic cardiac valve replacement: a prospective randomized trial. Journal of international medical research. 2013 Aug;41(4):1067-73.
10. Kang MK, Joung B, Shim CY, Cho IJ, Yang WI, Moon J, Jang Y, Chung N, Chang BC, Ha JW. Post-operative left atrial volume index is a predictor of the occurrence of permanent atrial fibrillation after mitral valve surgery in patients who undergo mitral valve surgery. Cardiovascular Ultrasound. 2018 Dec;16:1-7.
11. Jovin A, Oprea DA, Jovin IS, Hashim SW, Clancy JF. Atrial fibrillation and mitral valve repair. Pacing and clinical electrophysiology. 2008 Aug;31(8):1057-63.
12. Knaut M, Norkus S, Tugtekin SM, Brose S, Jung F, Matschke K. Heart rhythm monitoring over 1 year following cardiac surgery in patients with permanent atrial fibrillation: A mono centric prospective case study. Applied Cardiopulmonary Pathophysiology. 2009;13:277-83.

13. Raine D, Dark J, Bourke JP. Effect of mitral valve repair/replacement surgery on atrial arrhythmia behavior. Journal of Heart Valve Disease. 2004 Jul 1;13(4):615-21.

14. Petrikovits E, Necas J, Bedanova H, Stetka F, Cerny J. Changes in Left Atrial Size and Cardiac Rhythm in Patients After Mitral Valve Surgery. Scripta Medica. 2003;76:363-368.

15. Nardi F, Diena M, Caimmi PP, Iraghi G, Lazzero M, Cerin G, Rossi L, Bongo AS, Cernigliaro C, Lupi A. Relationship between left atrial volume and atrial fibrillation following coronary artery bypass grafting. Journal of cardiac surgery. 2012 Jan;27(1):128-35.

16. Osranek M, Fatema K, Qaddoura F, Al-Saileek A, Barnes ME, Bailey KR, Gersh BJ, Tsang TS, Zehr KJ, Seward JB. Left atrial volume predicts the risk of atrial fibrillation after cardiac surgery: a prospective study. Journal of the American College of Cardiology. 2006 Aug 15;48(4):779-86.