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Role of Transthoracic Echocardiography to Predict Post-Operative Atrial Fibrillation after Mitral Valve Replacement

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ORIGINAL ARTICLE

Role of Transthoracic Echocardiography to Predict Post-Operative Atrial Fibrillation after Mitral Valve Replacement

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Abstract

Background: ***One common complication of cardiac surgeries is post-operative atrial fibrillation (POAF), which can have a detrimental effect on the patient's prognosis. The evidence that was examined here, however, points to the notion that illnesses and frailty are predisposing variables that cause atria remodeling and, in turn, promote POAF. These events are caused by oxidative damage, inflammation, fibrosis, and apoptosis, together with electrical remodeling in the atrium.***

Aim and objectives: ***Among patients undergoing mitral valve replacement for mitral valve disease, the goal is to determine which echocardiographic variables are predictive of post-operative atrial fibrillation.***

Subjects and methods: ***This research was performed on 80 cases of mitral valve disease referred to the Luxor International Hospital outpatient clinic for mitral valve replacement from December 2021 to February 2023 for evaluation.***

Results: ***There were significant differences as regard echocardiographic data, POAF LAAPD(p-value = 0.02), LALD(p-value = 0.001), LATD(p-value = 0.001), LA EF(p-value = 0.028), LA Min volume(p-value = 0.001), LA Max volume(p-value = 0.001), LAVI(p-value = 0.003), E(p-value = 0.003), E/E\(p-value = 0.003), PASP(p-value = 0.005), Mean LS(p-value = 0.001) and Mean GLS(p-value = 0.001) and Laboratory data as regard POAF CRP(p-value = 0.001), K(p-value = 0.001), Ca(p-value = 0.001), Create(p-value = 0.001), Urea(p-value = 0.001), AST (p-value = 0.001) and ALT(p-value = 0.001).***

Conclusion: ***Strain measurement is a straightforward, reliable, and repeatable technique for assessing LV and LA function. Comparing LV and LA strain parameters to traditional ventricular atrial function parameters, the former are more sensitive.***

Keywords: transthoracic echocardiography, atrial fibrillation, mitral valve replacement

1. Introduction

POAF, which refers to the occurrence of new-onset or acute atrial fibrillation in the immediate post-surgical period, is widely recognized as the primary form of secondary atrial fibrillation.[1] POAF is related to a number of negative outcomes, such as hemodynamic instability, increased hospital length of stay, infection, renal problems, bleeding, and in-hospital mortality. [2]

In comparison to non-postoperative AF individuals, it has been demonstrated to be a risk factor for myocardial infarction, stroke, and mortality.[3] The incidence is highest on days two and four after surgery.[4] The incidence of POAF depends on the definition of arrhythmia, type of surgery, diagnosis criteria, methods used to identify arrhythmia, study population, and amount of time spent observing for arrhythmia. [5]

Adults who experience a prolonged heart arrhythmia most often have atrial fibrillation (AF). 6 However, atrial fibrillation has been associated with longer ICU and hospital stays, higher therapeutic costs, and increased early and late mortality following mitral valve replacement—all of which are typically discounted as unrelated to the procedure. [7]

The aim of this study was to identify echocardiographic risk factors for post-operative mitral valve aneurism (POAF) in individuals with mitral valve dysfunction.

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2. Patients and methods

This was a prospective cohort study performed on 80 patients with mitral valve disease who were referred to the Luxor International Hospital outpatient clinic for mitral valve replacement from December 2021 to February 2023 for evaluation.

All patients gave written informed consent, and the ethics committee's approval was sought before the research began.

Inclusion criteria: Prior to MVR, all participants had undergone mitral valve replacement surgery, were in sinus rhythm upon admission, and had normal left ventricular function according to echocardiography and normal coronary angiography.

Exclusion criteria: non-sinus rhythm at admission (a history of atrial fibrillation or atrial flutter, or their detection during the preoperative evaluation or documented in the medical file), Individuals who have undergone prior heart surgery, Individuals who have cardiomyopathy, ischemic heart disease or aortic valve disease that requires concurrent aortic valve replacement or coronary bypass grafting (CABG), or who decline research participation

2.1.Method

All the study populations were subjected to the following: full history taking, clinical examination (general examination, cardiac examination, auscultation of the back, anthropometric measures, and measurement of systemic blood pressure), Laboratory investigation (kidney function tests, electrolytes, C-reactive protein (CRP), liver function tests, and erythrocyte sedimentation rate (ESR)), 12 lead electrocardiography analyses, CHEST X-ray, echocardiography, and coronary angiography.

Echocardiography

As advised by the American Society of Echocardiography, all patients underwent examinations while in the left lateral decubitus posture and were linked to a single-lead ECG. [8]

Assessment of LV dimensions:

Ideally, the measurements were obtained at the end-diastole, when the QRS complex was just beginning, but they were also taken at the end of systole, when the LV cavity diameter was at its narrowest. In M-mode, we measured the following parameters: ventricular septal thickness at end diastole (IVSd), left ventricular posterior wall thickness at end diastole (PWd), left ventricular end diastolic diameter (LVEDd), and left ventricular end systolic diameter (LVEDs). [8]

Standard echocardiography evaluation of LV function: Evaluating systolic function The following is the automated calculation of the left ventricular ejection fraction (EF %): The diastolic function assessment includes mitral flow velocity, left atrial volume, tricuspid regurgitation velocity, and ejection fraction, which is calculated as (EDV−ESV)/EDV×100 9. [10]

Assessment of LA function by 2D Speckle Tracking Echocardiography:

Two LV apical views, apical four-chamber views, and two chambers' views were acquired at a frame rate ranging from 59–82 frame/s, with a mean of 72+6 frame/s. Five consecutive cardiac cycles were acquired at end-expiration breath-holding and digitally stored on a hard disk for offline analysis.

Assessment of LVGLS function by 2D Speckle Tracking Echocardiography:

Left ventricular global longitudinal strain (LVGLS)

The measurement of global longitudinal strain (GLS) using 2D strain necessitates the collecting of numerous 2DE pictures, including three apical views, which prolongs the time it takes to acquire data. The 2DE strain component analysis relies on high-quality apical pictures. On the other hand, there is typically a high level of feasibility and better temporal and geographical resolution. Several validation experiments have been conducted, and multiple large-scale studies have reported normal 2D global strain levels. 11 During a cardiac cycle, the left ventricle may twist or move out of plane, which can cause some speckles or features to be lost in the 2DE imaging plane. This is because 2D strain analysis is done on a fixed 2DE cutting plane. [12]

2.2.Statistical analysis:

SPSS version 24 was employed for the statistical analysis of the data. The numerical information was summarized as a mean ± SD. The frequency and percentage of qualitative data, the mean (average) of a set of numbers, is their center value, calculated by dividing the total by the total number of numbers in the set. By calculating the standard deviation (SD) of a data collection, statistics can quantify dispersion. When the SD is small, the values cluster around the set's mean, but when it's large, the values are more dispersed. A one-way ANOVA, chi-square test, Kruskal-Walli's test, Pearson's correlation coefficient, post-hoc test, and ROC curve (receiver operating characteristic curve) were performed.

3. Results

Table 1 showed that there were no significant differences among individuals with POAF and individuals without POAF concerning demographic data (sex, age, weight, height, BMI, and BSA).

Table 1. comparison of demographic data as regard POAF in examined individuals.

		NPOAF (N = 47)		POAF (N = 33)		Stat. test	P-value
Sex	Male	25	53.2%	15	45.5%	$X^2 = 0.46$	0.496 NS
	Female	22	46.8%	18	54.5%		
Age(years)	Mean ±SD	40.1	± 5.8	39.3	± 6.0	MW = 710	0.519 NS
Weight(kg)	Mean ±SD	80.8	± 6.6	82.2	± 5.0	MW = 699	0.453 NS
Height(cm)	Mean ±SD	171.0	± 4.0	170.7	± 4.4	MW = 755	0.996 NS
BMI(kg/m²)	Mean ±SD	27.7	± 2.7	28.3	± 2.4	T = 0.97	0.332 NS
BSA	Mean ±SD	2.0	± 0.1	2.0	± 0.1	MW = 708	0.509 NS

MW: Mann Whitney U test.
T: independent sample T test.
X2: Chi-square test. NS: p-value > 0.05 is considered non-significant.

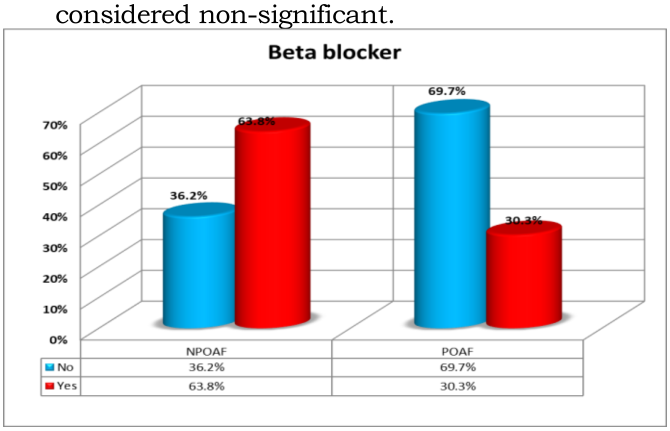

Figure 1. comparison of beta blocker intake as regard POAF in studied patients.

Table 2 shows that there was a statistically significant reduction in the incidence of POAF among patients on beta blockers in comparison to patients' groups who did not take beta blockers (p-value = 0.003) in patients with POAF (10 patients, 30.3%) when compared with patients without POAF (30 patients, 63.8%). Also, there was no statistically significant difference (p-value > 0.05) between patients with POAF and patients without POAF with regard to clinical data (DM (0.536), HTN (0.797), MV (0.654), and NYHA class (0.968).

Table 2. comparison of clinical data as regard POAF in studied patients.

		NPOAF (N = 47)		POAF (N = 33)		X^2	P-value
DM	No	33	70.2%	21	63.6%	0.38	0.536 NS
	Yes	14	29.8%	12	36.4%		
HTN	No	34	72.3%	23	69.7%	0.06	0.797 NS
	Yes	13	27.7%	10	30%		
Beta blocker intake	No	17	36.2%	23	69.7%	8.7	0.003 S
	Yes	30	63.8%	10	30.3%		
MV lesion	MS	28	59.6%	18	54.5%	0.2	0.654 NS
	MR	19	40.4%	15	45.5%		
NYHA class	Class III	24	51.1%	17	51.5%	0.002	0.968 NS
	Class IV	23	48.9%	16	48.5%		

S: p-value < 0.05 is considered significant.
X2: Chi-square test.
NS: p-value > 0.05 is considered non-significant.

Table 3 showed no significant differences among cases with POAF and cases without POAF as regard vital signs SBP (0.921), DBP (0.736), and HR (0.969).

Table 3. comparison of vital signs as regard POAF in studied patients.

		NPOAF (N = 47)		POAF (N = 33)		MW	P-value
SBP (mmHg)	Mean ±SD	128.7	± 11.3	129.1	± 10.4	765.5	0.921 NS
DBP (mmHg)	Mean ±SD	80.4	± 7.8	81.2	± 7.6	742	0.736 NS
HR (beat/min)	Mean ±SD	69.3	± 7.6	69.6	± 8.1	771.5	0.969 NS

Table 4 indicated that there were significant differences amongst the groups as regards CRP (<0.001), K (<0.001), Ca (<0.001), Create (<0.001), Urea (<0.001), AST (<0.001), and ALT (<0.001). Also, there were no significant differences (p-value > 0.05) between cases with POAF and cases without POAF concerning ESR (0.144) and NA (0.345).

Table 4. comparison of laboratory data as regard POAF in studied patients.

		NPOAF (N = 47)		POAF (N = 33)		Stat. test	P-value
CRP	Mean ±SD	2.6	± 1.5	4.8	± 2.1	356	<0.001 HS
ESR	Mean ±SD	31.9	± 8.0	30.2	± 8.1	626	0.144 NS
K	Mean ±SD	4.7	± 0.2	4.2	± 0.4	279.5	<0.001 HS
NA	Mean ±SD	135.3	± 4.4	134.2	± 3.2	679.5	0.345 NS
Ca	Mean ±SD	9.4	± 0.6	8.3	± 0.1	87.5	<0.001 HS
Create	Mean ±SD	1.0	± 0.2	1.3	± 0.1	240.5	<0.001 HS
Urea	Mean ±SD	33.8	± 7.9	45.4	± 2.9	125.5	<0.001 HS
AST	Mean ±SD	29.4	± 5.2	35.1	± 7.0	334	<0.001 HS
ALT	Mean ±SD	36.8	± 10.4	48.9	± 12.0	393.5	<0.001 HS

Using multivariate logistic regression analysis, the following factors could be used as predictive factors for POAF: (LALD, EF, E, E/E, PASP (0.005), mean GLS (<0.001), CRP (<0.001), K (<0.001), Ca (0.002), creatinine (< 0.001), urea (< 0.001), AST (< 0.001), and ALT (< 0.001).

Table 5. Multivariate logistic regression analysis for factors predictive of POAF.

	B	*SE*	*p-value*	*Odds*	*95% CI*	
RV	-0.08	0.61	0.901	0.93	0.28	3.07
PASP	0.13	0.05	0.005	1.13	1.04	1.24
Mean LS	-16.84	2059.67	0.993	0.00	0.00	.
Mean GLS	0.43	0.094	<0.001	1.53	1.27	1.85
CRP	0.61	0.15	< 0.001	1.84	1.38	2.45
ESR	-0.03	0.03	0.333	0.97	0.92	1.03
K	-4.2	0.99	<0.001	0.15	0.002	0.1
NA	-0.07	0.06	0.258	0.93	0.83	1.05
Ca	-8.89	2.93	0.002	0.00	0.00	0.04
CREATE	6.16	1.50	< 0.001	474.61	25.13	8963.2
UREA	0.39	0.09	< 0.001	1.48	1.24	1.76
AST	0.22	0.07	0.001	1.25	1.10	1.42
ALT	0.09	0.02	< 0.001	1.09	1.05	1.14

B: Regression coefficient, SE: Standard error, CI: Confidence interval.

Table 6 demonstrated that there were significant differences among cases with POAF and cases without POAF regarding LAAPD (0.02), LALD (< 0.001), LATD (< 0.001), LA Max volume (< 0.001), LAEF (< 0.001), LA Min volume (< 0.001), LAVI (0.028), E (< 0.001), E/E\ (< 0.001), PASP (0.013), Mean LS (< 0.001), and Mean GLS (< 0.001). Also, no significant differences were found (p-value > 0.05) concerning AO0.084, IVS (0.984), EDD (0.866), ESD (0.847), PW (0.348), EF-MM (0.392), EF-2D (0.546), FS (0.546), S (0.401), A (0.914), and RV (0.615).

Table 6. comparison of ECHO data as regard POAF in studied patients

		NPOAF (N = 47)		POAF (N = 33)		MW	P-value
AO	Mean ±SD	2.9	± 0.3	3.0	± 0.3	599.5	0.084 NS
LAAPD	Mean ±SD	4.4	± 0.4	4.6	± 0.3	539.5	0.02 S
LALD	Mean ±SD	5.3	± 0.2	6.1	± 0.1	27	< 0.001 HS
LATD	Mean ±SD	4.2	± 0.1	4.7	± 0.05	0.0	< 0.001 HS
LA Max volume	Mean ±SD	92.3	± 2.5	103.6	± 2.7	0.0	< 0.001 HS
LA Min volume	Mean ±SD	52.3	± 2.1	64.0	± 4.1	0.0	< 0.001 HS
LA EF	Mean ±SD	43.1	± 1.8	37.9	± 3.3	136	< 0.001 HS
LAVI	Mean ±SD	42.4	± 2.7	44.1	± 3.1	552.5	0.028 S
IVS	Mean ±SD	0.8	± 0.1	0.8	± 0.1	773.5	0.984 NS
EDD	Mean ±SD	4.8	± 0.2	4.8	± 0.2	758.5	0.866 NS

ESD	Mean ±SD	3.1	± 0.3	3.1	± 0.2	756	0.847 NS
PW	Mean ±SD	0.8	± 0.1	0.8	± 0.1	692	0.348 NS
EF-MM	Mean ±SD	65.2	± 4.9	65.7	± 4.8	688	0.392 NS
EF-2D	Mean ±SD	64.4	± 4.9	64.8	± 4.9	714	0.546 NS
FS	Mean ±SD	35.5	± 4.5	35.8	± 4.5	714	0.546 NS
S	Mean ±SD	8.5	± 0.5	8.6	± 0.5	701.5	0.401 NS
E	Mean ±SD	13.2	± 1.3	10.0	± 1.6	141	< 0.001 HS
A	Mean ±SD	10.5	± 1.9	10.2	± 1.6	764.5	0.914 NS
E/E	Mean ±SD	6.7	± 0.8	8.5	± 1.1	106	< 0.001 HS
RV	Mean ±SD	2.5	± 0.4	2.5	± 0.4	725	0.615 NS
PASP	Mean ±SD	50.6	± 4.4	56.3	± 10.8	521	0.013 S
Mean LS	Mean ±SD	24.3	± 1.6	19.4	± 0.8	0.0	< 0.001 HS
Mean GLS	Mean ±SD	-18.9	± 2.33	-15.4	± 2.9	327	< 0.001 HS

4. Discussion

In our study, there was no significant distinction between individuals with POAF and individuals without POAF concerning clinical data (DM, HTN, MV lesion, and NYHA class) in reverse to Rochette et al. Earlier research has investigated the link between diabetes and POAF and determined that HbA1c, the major measure of poor glycemic control, was not an independent preoperative predictor of POAF. Nevertheless, others have observed that HbA1c may constitute a highly significant predictor of POAF, not only in patients with known diabetes but also in diabetes-free people and subjects with undiagnosed diabetes, which is consistent with our findings. Every individual undergoing heart surgery, regardless of prior diabetes history, should have their blood glucose levels monitored during the perioperative period, as illustrated by these findings. [10]

Our results corroborate those of Basaran et al., who indicated that the POAF group wasn't taking beta-blockers (P< 0.003); more individuals in our research with POAF did not take beta-blockers" as there were no differences between the 2 groups as regards diabetes, hypertension, and dyslipidemia. [13]

The size of the LA is a source of disease as well as a marker of cardiovascular risk factors, an indicator of the presence of cardiac disease, and a predictor of cardiovascular outcomes, as demonstrated in previous research by Tsang et al. Hypertension, valvular heart disease, and AF all share a common final pathway involving left atrial (LA) dilation and geometric distortion. Ageing is connected to a greater likelihood of AF, in accordance with data from population-based studies that were carried out in Framingham and Strong Heart. [14]

In our study, both the maximum and minimum LA volumes were substantially higher in individuals who had POAF. Haffajee et al. revealed that the POAF group had greater indexed maximal and minimal LA volumes; therefore, this finding is in accordance with their findings. [15]

In the past, the biplane technique for measuring echocardiographic LA volume was used to find older outpatients who were at risk of AF, people with lone atrial fibrillation who were at risk of long-term bad outcomes, and people who were at risk for cardiovascular events. In addition to these studies, Osranek et al. provide simple techniques for preoperative risk categorization of a large, typical population having cardiac surgery, therefore expanding upon the previous research. While researchers did take body size into account when calculating LA volume, they did not use any gender-based cutoff. [16]

In our study, there was no significant distinction in left atrial emptying fraction (LAEF%) among the two groups. The inclusion of patients with valvular disease and those with coronary artery disease in the current study may help to explain this conclusion. In contrast, Haffajee et al. revealed that the LAEF% was significantly reduced in the POAF group. [15]

Individuals with POAF demonstrated a significant reduction in systolic LA strain. This is consistent with Candan et al.'s findings, which found that the LA strain in the POAF group was reduced. [17]

According to our research, the left ventricular global longitudinal strain (LV GLS%) percentage was significantly lower in the POAF group when assessed using speckle-tracking echocardiography. Basaran et al., on the other hand, looked at how left atrial and ventricular mechanical function predicted the return of atrial fibrillation after surgery. They found that there was no significant difference between the two groups in the global longitudinal strain of the left ventricle (P > 0.005). This may be due to the fact that they analyzed individuals who had CAD and were scheduled for CABG. [13]

According to our research, various biochemical parameters, some of which are modifiable, and clinical factors impact early POAF, whether it is persistent or not. Many different people and different biochemical parameters were studied to add to what was already known about POAF because it may be a syndrome with many different clinical, biochemical, and hematologic factors that can be changed or not changed.

As many prior studies have revealed, several different processes and events have been hypothesized to lead to POAF. In addition, the risk of POAF varies greatly across different types of operations because of the unique nature of open cardiac surgeries. [18]

This latter point must be considered in studies aimed at discovering markers for the risk of POAF. To enhance the validity of the research results, a thorough panel of biochemical and hematologic parameters may be evaluated singly or in combination with a wide range of people participating in a variety of surgical procedures.

In our data, CRP was the most researched metric for POAF risk across all surgical procedures. Our results are consistent with the nearly universal conclusions drawn from other research and meta-analyses that an increased CRP is strongly related to the likelihood of POAF. Preoperatively elevated CRP values may be indicative of a systemic inflammatory profile that is already rather severe. [19]

5. *Conclusion*

Evaluation of LV and LA strains is an accurate, simple, and reproducible method for assessing LV and LA function. The LV and LA strain parameters are more sensitive than conventional ventricular and atrial parameters. Significant predictors of POAF were found for the LV global longitudinal strain and the LA systolic strain. People who are more likely to get POAF and could benefit from preventative measures and choosing the right prosthesis can be found using echocardiographic features.

Disclosure

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Authorship

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Conflicts of interest

There are no conflicts of interest.

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