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Conventional and Two-dimensional Strain Echocardiography in Predicting Postoperative Atrial Fibrillation after Coronary Artery Bypass Grafting Surgery in Shahid Madani Hospital of Tabriz, Iran

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Author's contribution

The sole author designed, analyzed, interpreted and prepared the manuscript.

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ABSTRACT

Objectives: Atrial fibrillation (AF) is a common complication of heart surgery with favorable short- and long-term outcomes. Preoperative left atrial (LA) dysfunction may be a significant component in identifying patients at risk for postoperative atrial fibrillation (POAF) after coronary artery bypass grafting **(**CABG (surgery. Advances in imaging technologies and an understanding of AF pathophysiology can lead to more definitive potential therapeutic approaches. The paper has the aim to present the role of conventional echocardiography and LA two-dimensional (2D) strain. 2D Strain echocardio graphies in assessing LA function in predict POAF after CABG surgery.

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Materials and Methods: In this study, all patients with sinus rhythm who underwent CABG surgery were selected. All the patients had undergone conventional echocardiography and LA 2D-strain echocardiography 24 hours before surgery. In addition to demographic, clinical, and intraoperative features, other assessments, including electrocardiogram (ECG) and Holter monitoring, were recorded. The obtained information was recorded, and the study results were reported using descriptive statistics (mean, standard deviation, and percentage frequency). A Chi-square test was used to evaluate the qualitative variables, and a t-test was used to compare the quantitative variables. Given the multi-factorial nature of AF, univariate and multivariate methods were used to analyze the data and the effect of STRAIN. In this study, $P < 0.05$ was considered significant.

Results: According to the findings, 85 patients (81%) were male with a mean age of 60.26 ± 10.61 years. 50% of the patients underwent off-pump CABG surgery, and 50% underwent on-pump surgery with a mean time of 98.52 ± 22.44 minutes. POAF was seen in 22.9% of patients during hospitalization, and AF's duration was 13.85 ± 14.41 hours. AF patients had higher LA volume index (LAVI) than non-AF patients (p = 0.018). There was no significant difference between the two groups in terms of left ventricular end-diastolic diameter (LVEDD), left ventricular end-systolic diameter (LVESD), left ventricular end-diastolic volume (LVEDV), left ventricular end-systolic volume (LVESV), left ventricular ejection fraction (LVEF), E/e, E/A,and deceleration time(DT) . Non-AF patients had higher rates of LA reservoir (26.97 ± 6.87 VS. 20.46 ± 4.27, p <0.001), LA contractile (14.98 ± 3.68 VS. 12.76 ± 3.72, p =0.012) and LA global (24.28 ± 6.57 VS. 17.71 ± 4.11, p <0.001) than AF patients. The results of the multivariate logistic regression showed that LAVI (p= 0.014) and LA global (p = 0.027) were significant predictors of AF detection. Thus with increasing LAVI, the probability of developing AF increases, and with decreasing LA global, this probability decreases.

Conclusions: Compared to conventional echocardiography, 2D-strain echocardiography is a more effective diagnostic tool in predicting the possibility of post-CABG AF.

Keywords: Conventional echocardiography; LA 2D-strain echocardiography; atrial fibrillation; coronary artery bypass grafting.

1. INTRODUCTION

Atrial fibrillation (AF) is a relatively common disorder that, according to 2010 data alone, affects between 2.7 and 6.1 million people, and according to the logarithmic growth trend, the prevalence will be 12 million by 2030 [1]. AF due to reversible cause is known as secondary AF [2,3]. These secondary causes include cardiac and non-cardiac surgery in the past 30 days, acute myocardial infarction in the last 30 days, acute infection, acute alcohol poisoning, thyrotoxicosis, acute pericarditis or tamponade, and acute pulmonary phenomena (including pulmonary embolism, pneumothorax, and bronchoscope intervention) [3,4]. Focusing on the POAF subpopulation, there are two main categories: cardiac and non-cardiac. The incidence of AF in adults over 45 is only 3% for non-cardiac surgeries, but it varies from 20% to 40% among those undergoing chest or heart surgery [5,6]. Patients undergoing CABG surgery and valvular surgery have the highest risk of developing POAF, ranged from 60% to 80% [5,7]. POAF usually converts to sinus rhythm without intervention [8,9]. The most important complication of untreated AF is stroke, including stroke severity and stroke mortality [1], particularly common in patients after cardiac surgery [5]. Recent data suggest that, compared to non-valvular AF, new-onset POAF has a dangerous long-term thromboembolic profile with increased mortality [9-12].

The clinical prognosis of POAF is essential in identifying patients at risk for POAF. LA dysfunction may be a significant component determining patients at risk for postoperative atrial fibrillation (POAF) after CABG surgery(5).In the current study, we have evaluated the role of conventional echocardiography and LA 2D Strain echocardiography in assessing LA function to predict POAF after CABG surgery [13-15].

Advances in imaging technologies and an understanding of AF pathophysiology can lead to more definitive potential therapeutic approaches. According to recent reports, two-dimensinal (2D), speckle-tracking strain imaging is a practical and reproducible method for evaluating LA function by evaluating LA deformation dynamics, which is a new, angle-independent method for quantitative evaluation of LA contraction and myocardial passive deformation [16-20].

2. MATERIALS AND METHODS

In this study, 105 patients with sinus rhythm underwent elective CABG surgery in Shahid Madani Hospital of Tabriz- Iran, from August 2020 to February 2021were included. All the patients had undergone conventional echocardiography and LA 2D-strain echocardiography 24 hours before surgery. ECG was taken, p wave interval was measured, and echocardiographic information was stored in the system. Before surgery, All ECGs were taken with a single device. Their demographic information was also recorded in the checklist, including age, sex, risk factors [hypertension (systolic blood pressure > 140 mm Hg or taking antihypertensive drugs], self-reported diabetes or taking antidiabetic drugs), obesity (Body Mass Index > 30), history of chemotherapy and history of AF in first-degree relatives, and angiographic information including the number and name of vessels involved.

Then, the patients' operation information, including the number of received grafts, pump time, cross-clamp time, intraoperative complications (such as arrhythmia, etc.), off- or on-pump surgery, were added to the checklist. Also, the type of drugs received by the patients was completely included entirelyin the checklist.

The patients were under Holter monitoring in the ICU for 72 hours after the surgery for the incidence of AF. A cardiac electrophysiologist analyzed the Holter data.

Exclusion criteria for the present study were:

1. No written consent to participate in the study
2. Patients diagnosed with acute coronary syndromes (ACS) who underwent CABG surgery.
3. Lack of suitable image for 2D-strain echocardiography
4. Patients without sinus rhythm
5. Thyroid dysfunction or being treated for thyroid diseases,
6. Patients with electrolyte disorders
7. Being treated with antiarrhythmic drugs (except beta-blockers)
8. Existence of more than mild valve disorder
9. Flutter and AF rhythm

Then, the preoperative echocardiography findings were evaluated with the information from postoperative Holter monitoring, and the predictors of AF were identified, regardless of the patients' risk factors.

12-lead ECG and Holter monitoring established AF. The detection of AF with irregular rhythm lasted for more than 30 seconds was established by variable R-R interval and absence of p-wave. The diagnoses were performed by two specialists who were blind to the patients and their data.

All the echocardiographic findings were reported according to the American Society of Echocardiography. Echocardiography was performed with Philips Epiq 7 echo machine. LVEDD and LVESD were measured in parasternal long- axis view, and LVEDV, LVESV, and LVEF were measured by the modified Simpson's method.

Diastolic function was assessed by mitral inflow velocity (deceleration time, E/A, A wave, E wave). Tissue Doppler was measured by placing a pulsed wave in the medial and lateral part of the mitral annulus in the apical four-chamber view. LA volume was calculated using the biplane method of disks, and LA volume index was obtained based on body surface area.

All the strain parameters were performed by speckle-tracking imaging in apical four-chamber view and apical two-chamber view with a frame rate of 60-80 frames/sec. After manually tracking the LA endocardial border, the software automatically tracked the myocardium. All software evaluations were reviewed to ensure that LA motion tracking was accurate and adequate, and strain results were obtained in two views.

LA strain diagrams were created automatically by the relevant software. The reference point for image analysis was the appearance of the QRS complex. The two peaks, "reservoir" and "contractile", were assessed in the strain diagram.

The LA wall was divided into six segments (basal, mid, and apical segments) in the apical 4- and 2 -chamber views. Fig. 1 shows the LA strain curve throughout the cardiac cycle As the left atrium fills and stretches in the reservoir phase,

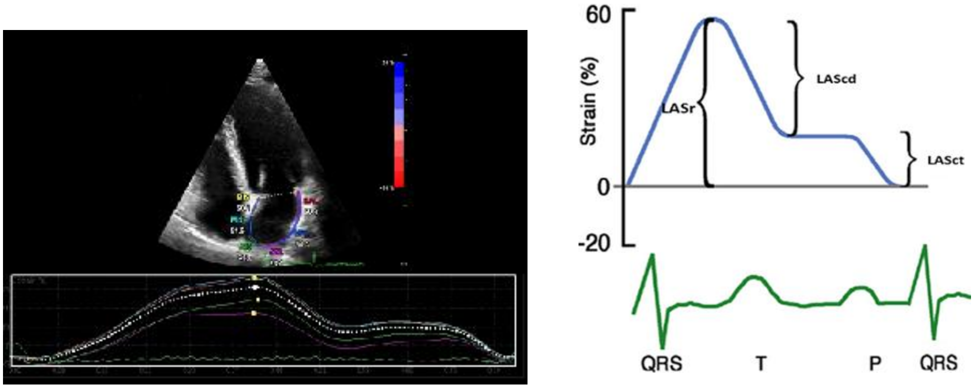

Fig. 1. LA strain curve

Left panel: Two-dimensional speckle tracking strain demonstrating phasic LA strain (LASr, LAScd, and LASct) from the apical 4 chamber view. Segmental strain from 6 segments as well as global LA strain (white dotted line) is shown. Right panel: Phasic LA function relative to the ECG. LA indicates left atrial; LAScd, left atrial conduit strain; LASct, left atrial contractile strain; and LASr, left atrial reservoir strain.

the positive atrial strain reaches its peak in systole at the end of LA filling and before opening the mitral valve, measured as LA reservoir strain (LASr). Following this, passive LA emptying ensues with the mitral valve opening, resulting in decreased atrial strain with negative deflection of the strain curve up to a plateau period, analogous to diastasis and is measured as LA conduit strain (LAScd). A second negative deflection in the strain curve is then observed corresponding to atrial systole, representing LA contractile strain (LASct) [18].

2.1 Statistical Analysis

Data were presented as mean (±standard deviation) and frequency (percentage) for quantitative and qualitative variables. Data analysis was performed in SPSS software version 22.

The normality of data distribution was assessed by using a Kolmogorov–Smirnov test. Since this test had low power in detecting deviation from normality for small sample sizes, descriptive evidence such as skewness and elongation indices and proportionality and reasonableness of standard deviation (com-pared to the mean) were also evaluated. For variables without a normal distribution a suitable conversion was carried out based on the type of skewness to normalize data distribution.

Chi-square test was used to compare the qualitative variables of the participants between the two groups, and independent samples t-test or ANOVA was used to compare their quantitative variables. In order to control for the intervening variables and the basic measurements of the variables, analysis of covariance (ANCOVA) was used. Given the multi-factorial nature of AF, univariate and multivariate methods were used to an analyze the data and the effect of strain. In this study, P > 0.05 was considered significant.

3. RESULTS

The results of the study illustrated that most of the patients (N=85, 81%) were male with a mean age of 60.26 ± 10.61 years. 50% of the patients underwent off-pump CABG surgery, and 50% underwent on-pump surgery with a mean time of 98.52 ± 22.44 minutes. The patients did not receive antiarrhythmic medication before surgery, but all of them received beta-blockers, aspirin, and statins before surgery. All the patients in this study were discharged except 5 (4.8%) patients who had a stroke and passed away. POAF was seen in 22.9% of patients during hospitalization, and AF's duration was 13.85 ± 14.41 hours. Of the 24 AF patients, 6 (25%) patients spontaneously converted to sinus rhythm without medication, while 18 (75%) patients converted to sinus rhythm after receiving amiodarone.

AF patients were older (p = 0.039). The average number of hospitalization days (15.41. 4.88 vs. 17.58 ± 6.11, p = 0.155) and ICU days (5.43 ± 2.64 vs. 8.95 ± 684, p = 0.002) were higher in AF patients. This difference, however, was only significant in the average length of ICU hospitalization between the two groups (p = 0.002). The mean pump time in AF patients was 14.48 minutes longer than in non-AF patients, statistically insignificant. AF occurred in all patients within 72 hours after surgery and lasted 1.2 ± 1.7 days on average. The clinical and underlying variables of echocardiography are presented in Table 1.

Sex and other risk factors (hypertension, diabetes, obesity, history of chemotherapy, and family history of AF) were not significantly different between the two groups. The mean P wave was higher in AF patients, but there was no significant difference between the three types of II, III, and AVF. AF patients had higher LAVI than non-AF patients (P = 0.018). No significant difference was found between the two groups regarding LVEDD, LVESD, LVEDV, LVEF, E/e, E/A, and DT variables.

Non-AF patients had higher rates of LA reservoir (26.97 ± 6.87 VS. 20.46 ± 4.27, p <0.001), LA contractile (14.98 ± 3.68 VS. 12.76 ± 3.72, p =0.012) and LA global (24.28 ± 6.57 VS. 17.71 ± 4.11, p<0.001) than AF patients (Table 2).

The results of the multivariate logistic regression showed that LAVI (P = 0.014) and LA global (P = 0.027) were significant predictors of AF detection (Table 3). Consequently with increasing LAVI, the probability of developing AF increases and with decreasing LA global, this probability decreases.

Table 1. Clinical and echocardiographic characteristics

Variables	Total	No AF(N=81)	AF(N=24)	P-value
Sex Male	85(81)	66(81.5)	19(79.2)	0.503
Female	20(19)	15(18.5)	5(20.8)	
Age	60.26±10.61	59.14±10.79	64.04±9.21	0.039*
HTN	74(70.5)	55(67.9)	19(79.2)	0.212
DM	33(31.4)	23(28.4)	10(41.7)	0.163
BMI>30	1(1)	1(1.2)	0	0.771
Bio-chemo therapy	0	0	0	---
AF history	0	0	0	---
Smoking	42(40)	33(40.7)	9(37.5)	0.485
Angiography				
LML>50%	2(1.9)	1(1.3)	1(4.2)	0.310
1VD	6(5.8)	5(6.3)	1(4.2)	
2VD	26(25)	19(23.8)	7(29.2)	
3VD	64(61.5)	52(65)	12(50)	
LM+1VD	1(1)	1(1.2)	0	
LM+2VD	1(1)	0	1(4.2)	
LM+3VD	4(3.8)	2(2.5)	2(8.3)	
ECG				
P wave duration II)second)	0.06±0.01	0.06±0.01	0.07±0.01	0.002*
P wave duration III)second)	0.04±0.01	0.04±0.01	0.05±0.01	<0.001*
P wave duration AVF	0.04±0.01	0.04±0.01	0.05±0.01	0.003*
Infarcts				
V1-V4	1(1)	1(1.2)	0	0.605
V1-V6	13(12.4)	11(13.6)	2(8.3)	
V1-V6+1,AVL	3(2.9)	2(2.5)	1(4.2)	
inferior	9(8.6)	5(6.2)	4(16.7)	
INF+RV	1(1)	1(1.2)	0	
NO Infarcts	78(74.3)	61(75.3)	17(70.8)	
Treatments				
Aspirin	105(100)	77(95.1)	22(91.7)	0.618
Beta blocker	105(100)	75(92.6)	21(87.5)	0.424
Calcium blocker	27(25.7)	18(22.2)	9(37.5)	0.183

Variables	Total	No AF(N=81)	AF(N=24)	P-value
TNG	5(4.8)	3(3.7)	2(8.3)	0.321
Nitrate	58(55.2)	45(55.6)	13(54.2)	0.999
Diuretic	77(73.3)	60(74.1)	17(70.8)	0.795
Statin	105(100)	76(93.8)	22(91.7)	0.658
Osvix	79(75.2)	60(74.1)	19(79.2)	0.789
Amiodarone	4(3.8)	0	4(16.7)	0.002
Lidocaine	0	0	0	---
Anti-Arrhythmia	0	0	0	---
LAD				
Proximal	70(66.7)	55(67.9)	15(62.5)	0.630
MID	56(53.3)	43(53.1)	13(54.2)	0.999
Distal	12(11.4)	11(13.6)	1(4.2)	0.289
LCX				
Proximal	42(40)	32(39.5)	10(41.7)	0.999
MID	0	0	0	---
Distal	23(21.9)	19(23.5)	4(16.7)	0.583
RCA				
Proximal	29(27.6)	19(23.5)	10(41.7)	0.117
MID	34(32.4)	26(32.1)	8(33.3)	0.999
Distal	27(25.7)	19(23.5)	8(33.3)	0.425
Diag	38(36.2)	29(35.8)	9(37.5)	0.879
OM1	41(39)	31(38.3)	10(41.7)	0.814
PDA	15(14.3)	13(16)	2(8.3)	0.511
Graft				
1	13(12.5)	11(13.8)	2(8.3)	0.293
2	37(35.6)	25(31.3)	12(50)	
3	48(46.2)	40(50)	8(33.3)	
4	6(5.8)	4(5.)	2(8.3)	
Cardio pulmonary				
On pump	51(50)	40(51.3)	11(45.8)	0.641
Off pump	51(50)	38(48.7)	13(54.2)	
Pump time	98.52±22.44	91.42±20.51	105.9±30.02	0.523*
Intraoperative complications				
Arrhythmia	0	0	0	---
Pack Cell				
No	41(39)	35(43.2)	6(25)	0.057
1	45(42.9)	35(43.2)	10(41.7)	
2	14(13.3)	7(8.6)	7(29.2)	
3	3(2.9)	3(3.7)	0	
4	2(1.9)	1(1.2)	1(4.2)	
Hospitalization (day)	15.91±5.23	15.41±4.88	17.58±6.11	0.155*
ICU (day)	6.23±4.23	5.43±2.64	8.95±684	0.002*
Status				
Dead	5(4.8)	3(3.7)	2(8.3)	0.321
Alive	100(95.2)	78(96.3)	22(91.7)	

**: Mann – whiteny U, AF: Atrial Fibrillation, HTN: Hypertension, DM: Diabetes Mellitus, BMI: Body mass index, 1VD: One vessels Disease, 2VD: Two vessels Disease, 3VD: Three vessels Disease,INF+RV: Inferior and Right, Ventricular, TNG: Nitroglycerin, LM: Left main, RCA: Right coronary artery, LCX: Left circumflex artery, PDA: Patent ductus arteriosus*

Table 2. Echocardiography characteristics

Variables	Total	No AF(N=81)	AF(N=24)	P-value
Echocardiography Conventional				
LVEDD mm	46.01±5.45	46.09±5.41	45.75±5.74	0.785**
LVESD mm	33.47±6.41	33.34±6.18	33.91±7.25	0.704**
LVESV cc	50.31±23.99	50.05±21.09	51.16±32.48	0.717*
LVEDV cc	94.63±27.81	96.46±29.10	88.44±22.35	0.395*
LVEF %	48.53±9.52	49.08±10	46.71±7.58	0.345*
LAVI m1/m2	30.13±8.01	29.15±7.46	33.61±9.03	0.018**
E/e	8.94±2.34	8.96±2.33	8.87±2.46	0.844*
E/A	0.87±0.38	0.89±0.41	0.83±0.24	0.997*
DT mse	189.82±42.62	188.06±42.73	196.04±42.57	0.431**
Echocardiography strain				
LA reservior strain %	25.57±6.89	26.97±6.87	20.46±4.27	<0.001**
LA contractile strain %	14.48±3.78	14.98±3.68	12.76±3.72	0.012**
LA global strain %	22.83±6.68	24.28±6.57	17.71±4.11	<0.001**

*LVEDD: Left ventricular end-diastolic diameter, LVESD: Left ventricular end-systolic diameter, LVESV: Left ventricular end systolic volume, LVEDV: Left ventricular end diastolic volume, LVEF: Left ventricular ejection fraction, LAVI: Left atrial volume index, E/e: Early filling/early diastolic, E/A: E wave / the A wave, DT: Deceleration time. LA: Left atrial. *: Mann – whitney U, **: Independent samples T-test*

Table 3. The result of logistic regression analysis

Variables	Univariate		Multivariate	
	OR (95%CI)	P-value	OR (95%CI)	P-value
Conventional				
LVEDD mm	0.98(0.91-1.07)	0.782		
LVESD mm	1.01(0.94-1.08)	0.700		
LVESV cc	1.01(0.98-1.02)	0.842		
LVEDV cc	0.98(0.97-1.01)	0.217		
LVEF %	0.97(0.92-1.02)	0.282		
LAVI m1/m2	1.07(1.01-1.13)	**0.023**	1.08(1.01-1.16)	**0.014**
E/e	0.98(0.81-1.19)	0.881		
E/A	0.63(0.15-2.64)	0.530		
DT mse	1.01(0.99-1.01)	0.427		
Strain				
LA reservoir strain %	0.85(0.78-0.93)	<0.001	0.9(0.75-1.07)	0.249
LA contractile strain %	0.85(0.75-0.97)	0.016	1.23(0.97-1.57)	0.08
LA global strain %	0.83(0.75-0.91)	<0.001	0.8(0.65-0.97)	0.027

LVEDD: Left ventricular end-diastolic diameter, LVESD: Left ventricular end-systolic diameter, LVESV: Left ventricular end systolic volume, LVEDV: Left ventricular end diastolic volume, LVEF: Left ventricular ejection fraction, LAVI: Left atrial volume index, E/e: Early filling/early diastolic, E/A: E wave / the A wave, DT: Deceleration time

4. DISCUSSION

As one of the most common complications of CABG surgery, atrial fibrillation requires special attention in early diagnosis, preventive treatments, and timely interventions. In addition to monitoring patients in the ICU to perform emergency interventions, other predictive diagnostic modalities that can be helpful in the long term and during patient discharge to the ward and reduce the need for 24-hour care are critical in cardiac surgeries, especially CABG. In this study, two modalities, namely 2D-strain and conventional echocardiography, were evaluated in terms of their ability to predict atrial fibrillation.

The present study demonstrated that most of the patients were male with a mean age of 60.26 ± 10.61 years. The mean age in Kawakami's study was 67 years, and the sex distribution of male patients was 296 (56%). In Magne's study, the mean age of patients was 66 ± 10 years, and most of the patients were male (N=149, 88%). In their research, Parsaei's reported a mean age of 60.19 ± 9.0 years and a frequency of 113(75.3%) male patients.

Aging causes structural changes in the heart, such as fibrosis and enlarged cardiac myocytes. Therefore, LV hypertrophy and a decrease in the ratio of premature diastolic filling will occur with age(10). With deceleration of diastolic filling, late atrial contraction increases in compensation and leads to LA enlargement. As a result of aging and LA dysfunction, POAF may become more common in older patients [10,15]. In our study, similar to Parsaei's study, AF patients were older.

In this research, the mean on-pump time was 98.52 ± 22.44 minutes. In Magne's study, the mean on-pump time was 105 ± 42 minutes. This time was 91.32+_30.09 minutes in the research by Parsaei's et al. Contrary to Parsaei's findings, the on-pump time was not significantly longer in AF patients. Contrary to Parsaei's findings, the on-pump time was not significantly longer in AF patients.

The prevalence of AF rhythm in this study was 24 patients (22.9%). This rate was 35 (38%) in Magne's research, 13 (27.1%) in Sadiçet al. and 13 (25%) in Her et al.AF has been reported in 5–40% of patients in the early postoperative period CABG surgery(1-3). POAF after cardiac surgery tends to occur within 2-4 days postoperatively, with a peak incidence on day 2 [1,2,4]. In a study by Aranki et al. on CABG patients, 70% and 90% of the patients developed POAF before the end of days 4 and 6 after surgery, respectively [9]. In our study, the mean length of p-wave with standard 12-lead ECG was significantly longer in patients than that reported by Parsaei. In this study, we did not find an association between POAF and significant risk factors (HTN, DM, obesity, and smoking) and some standard and tissue Doppler echocardiography (E/e', DT, E/A, LVEF). While in other studies such as Wang et al. and Kawakami, the LVEF index had a predictive diagnostic value in AF rhythm, but contrary to Her et al., E/e had no diagnostic value in Kawakami's study.

Recent studies have shown that LA strain becomes impaired in patients with paroxysmal AF before LA enlargement [21-24]. LA remodeling can be confirmed by the amount of elasticity that indicates the amount of local myocardial deformity [22,25-27]. Previous studies have shown the predictive value of LA strain in POAF (23,24,26,28,29,30). Electrical reconstruction-related LA dysfunction may increase recurrent tachyarrhythmias, and this can be confirmed by showing the association between LA dysfunction using strain echocardiography and POAF development [24,28,29]. Her et al. reported LA global as an independent predictor of post-CABG AF. This study evaluated the relationship between the occurrence of POAF and preoperative LA dysfunction by 2D-speckle tracking echocardiography. Lower LA global was significantly associated with increased POAF after CABG surgery. In Kawakami's study, patients with new –onset AF had significantly worse LA reservoir strain (31.4% ± 7.7% vs 38.0% ± 7.3%; p<.01) and contractility strain (16.6 ± 4.3% vs 20.6% ± 4.3%; p< .01) than those without AF.

In our study, the LAVI and LA global indices had a predictive value for detecting AF rhythm.

Therefore with increasing LAVI, the probability of develop=ing of developing AF increases, and with decreasing LA global, this probability decreases.

In Magne's study, the LAVI index was helpful in predicting fibrillation, where the risk of AF had increased by 7.75 times. As a diagnostic cut point for predicting AF, the rate of LAVI was 32 ml/m2. This rate was also helped predict AF in Ozben's study, where the cut point was set at > 36 ml/m2. This index was also of diagnostic value in the study of Her et al. However, in Kawakami's study, LAVI had no diagnostic value. Other indices evaluated in this study had no predictive diagnostic value for AF rhythm. This finding had no diagnostic value for AF rhythm in different tasks such as Karaca.

The present study suffers from several limitations as follows. First, because of the relatively small sample size and the lack of long-term follow-up data, and the impossibility of performing a multivariate analysis commensurate with the risk factors, there is a need for prospective and long-term studies to confirm the results. The use of more advanced echocardiographic systems and the involvement of artificial intelligence software to analyze LA traction can help better predict the AF incidence. Since we had Holter monitoring for 72 hours in the ICU and subsequent ECGs were recorded daily or with symptoms, we cannot exclude missing short periods of asymptomatic POAF and hence may have underestimated the total burden of POAF. We included in this study patients with mild mitral valve regurgitation. We cannot exclude a confounding effect of mild degrees of mitral regurgitation to systolic atrial expansion and hence the LA strain. In the next step, studying and eliminating the effects of confounding, moderating, and controlling variables such as cardiac enzyme levels, BNP, inflammatory markers, social factors affecting cardiovascular diseases before, during, and after surgery that can affect the outcome of surgery, was another limitation of the present study.

As the impact of POAF on hospital resources is significant and is estimated to increase hospital stay by 4.9 days, at an additional amount of $ 10,000 to $ 11,500 for hospitalization costs in the United States(7), and since according to the American Heart Association in 2004 there are at least 640,000 open-heart surgeries annually performed in the United States, and assuming a 30% incidence rate of POAF, the additional cost of this postoperative complication could be estimated at $ 2 billion a year. Further investigation and follow-up measures can play an essential role in saving money and reducing post-CABG mortality.

5. CONCLUSION

To sum up, because the results of this study in which it was tried to control confounding variables as much as possible and to include variables involved in the incidence of postoperative AF rhythm in the analyses, the 2D-Strain method with more indices allows the prediction of AF as well as necessary interventions for the consequences.

CONSENT

It is not applicable.

ETHICAL APPROVAL

Patients' information was entered into the form after approval by the ethics committee and observance of trust and medical ethics.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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