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LEFT ATRIAL VOLUME INDEX IN ASSESSING THE RISK OF ATRIAL FIBRILLATION AFTER SURGICAL REVASCULARIZATION

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Background: Left atrial dilatation, according to recent studies is important in the onset of atrial fibrillation, stroke and death. The most reliable echocardiographic parameter of left atrial dilatation is the left atrial volume index (LAVI).

Aim: The objective of this study is to evaluate the impact of LAVI on the occurrence of atrial fibrillation after surgical myocardial revascularization (CABG).

Methods: A prospective study included 116 patients undergoing surgical myocardial revascularization followed from admission to discharge. The examination was conducted at the Special Hospital "BH Centre for Heart" Tuzla. Preoperative ultrasound examination determined the parameters of left ventricular diastolic function and LAVI in all patients and postoperatively determined the onset of AF, the day of onset, duration in hours, number of episodes. Logistic regression was used to evaluate whether an event occurred or not, and the effect of time on the event of interest was analysed by Cox's parallel hazard regression.

Results: 75.9% of patients had diastolic left ventricular dysfunction (LVDD). Preoperative values of LAVI are significantly higher when the LVDD grade is higher. In patients with LVDD and higher LAVI values, the risk of AF occurrence is greater, the longer the duration of AF, and the significantly greater number of AF episodes. As a result of the analysis, the most significant predictors of AF are: LVDD and LAVI.

Conclusion: LAVI has the best hazard function in explaining the occurrence of atrial fibrillation after surgical myocardial revascularization.

Keywords: left atrial volume index, atrial fibrillation, surgical myocardial revascularization.

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INTRODUCTION

Atrial remodeling and its dilation may represent an anatomical substrate through which triggers in the postoperative period after surgical myocardial revascularization (CABG) can cause electrical inhomogeneity and arrhythmia. Left atrial dilatation is important in the onset of atrial fibrillation, stroke, and death (Vaziri et al. 1994; Benjamin et al. 1995; Tsang et al. 2001). Also, the authors of some studies report that they found no relationship between left atrial size and atrial fibrillation (Zaman et al. 2000). Left atrial dilatation presented as low left atrial volume (LAVI) by 2D echocardiography is associated with the duration of left ventricular diastolic dysfunction (LVDD) and is a strong marker of cardiovascular risk generally in the population (Ommen et al. 2002, Pritchet et al. 2003). In recent studies, increased LAVI >26 ml/m^2 has also been recognized as a relative independent marker of left ventricular filling pressure and LVDD in patients with suspected heart failure with preserved left ventricular ejection fraction (LVEF) (Lim et al., 2006). Therefore, LAVI has been proposed as a biomarker for both diastolic left ventricular dysfunction and cardiovascular risk (Douglas et al. 2003, Alsaileek et al. 2006).

The most reliable echocardiographic parameter f LA volume is LAVI. It represents the ratio of left atrial volume to body surface area (LAV/BSA). LAVI > 34ml/m^2 is an independent predictor of death, heart failure, atrial fibrillation and ischemic stroke (Abhayaratna et al., 2006). Therefore, the aim of this study is to evaluate the effect of LAVI on the occurrence of atrial fibrillation after surgical myocardial revascularization.

PATIENTS AND METHODS

The prospective study included patients undergoing surgical myocardial revascularization (CABG) conducted at the Special Hospital "BH Heart Centre" Tuzla for a period of one year and included 116 patients followed from admission to the Center until discharge. The criteria for inclusion of respondents in the study are:

1. Presence of significant coronary disease with indication for surgical myocardial revascularization

2. Presence of echocardiographic parameters of left ventricular diastolic function

3. Absence of severe valvular disease and no need for joint cardiac surgery

4. Normal sinus rhythm preoperatively

The criteria for excluding respondents from the study are:

1. Significant valvular disease requiring surgical intervention

2. Previous surgical revascularization or PTCA

3. atrial fibrillation attack preoperatively

The study based on anamnestic data determined basal characteristics of patients included in the study: age, gender, present risk factors that could lead to cardiovascular diseases such as: smoking, obesity, arterial hypertension, hyperlipidemia, heredity. Preoperatively, all patients underwent Doppler echocardiography on the Acuson CV70 2.5-3.5 MHz probe in M mode, 2D, using pulse Doppler, which determined the essential parameters of left ventricular diastolic function, on the basis of which LV diastolic function was registered as normal or as a I, II, or III degree of LV diastolic function. The volume of the left atrium was calculated using the Biplane method using the formula: LAV = 0.85 x LA area from apical 4CH view x LA area from apical 2CH view/ Perpendicular axis of LA.

All measurements were made in end systole, and LAVI was presented as LAV relative to body surface area / BSA/. Areas were made in the apical position with exclusion of LA auricula, the tenting area of the mitral valve and the inflow of the pulmonary veins. The perpendicular length of LA was obtained by measuring from the level of the mitral valve ring (MV) to the roof (upper portions) of LA - taken the shorter from the apical 4CH and apical 2CH views. LAVI was categorized as ≤ 28 ml/m^2 (normal 20 ± 6 ml/m^2), 28.1 - 32 ml/m^2 (slight increase in LAV), 32.1 - 36 ml/m^2 (moderate) and > 36ml /m^2 (severe).

Postoperatively, in the first 24h after CABG, patients were monitored in the Intensive Care Unit and subsequently in the cardiology department, followed by anesthesiologists, then cardiac surgeons and cardiologists, and professional medical staff, where, among other complications in the postoperative period, possible occurence of AF was immediately recorded by ECG and so documented.

STATISTICAL ANALYSIS

To test the hypothesis and evaluate the impact of one or more individual independent variables on a dependent variable that, in addition to whether or not an event occurred, also provided information about the time when that event occurred, Cox parallel hazard regression using time-dependent covariates was used, the dependent variable being 'atrial fibrillation', a predictor of special interest to LAVI.

Dependent variable (FA) prediction based on the values of the independent predictors, their ranking by importance, and the evaluation of the interaction effect was performed by logistic regression. We analyzed a regression model containing the following predictors: gender, age, LVDD, LVDD -I-II-III degrees, and LAVI. The whole model with all predictors was statistically significant (Chi-square 37.15, df-6, p <00001), which shows us that the selected model clearly distinguishes the criterion variable - atrial fibrillation. The model as a whole explains 27.6- 38.8% of the variance in atrial fibrillation status and accurately classifies 68.7% of cases. After the predictor was introduced into the model, the prediction accuracy was increased to 80%.

RESULTS

Of the total number of subjects undergoing surgical myocardial revascularization, the first group preoperatively, without echocardiographically detected LVDD, comprised 24.1% of patients and the second group, with echocardiographic parameters of LVDD, comprised 75.9% of patients. 91.4% of patients had developed hypertensive heart disease, 12.9% with early ICV and 42.2% with diabetes mellitus, and 14% with chronic obstructive pulmonary disease (COPD). In both groups, 32.8% are women and 67.2% are men. The mean age of the subjects included in the study was 61.41 ± 4.69 years. The youngest patient was 48 g. and the oldest 80 years.

Table 1. Basal characteristics and risk factors of the test sample (n = 116)

Parameters:
Age (years) X ± SD
Gender: M / F, n (%)
Age Classes: <45 / 45-64 /> 64, n
BMI kg/m^2, X ± SD
Smoking status: non-smoking / active nicotinism, n (%)
Hyperlipidemia: absent / present, n (%)
Arterial hypertension: absent / present, n (%)
Positive family history of coronary heart disease, n (%)
Left ventricular diastolic dysfunction
Length of hospitalization (days after surgery), median
ICU length (days), median

Legend: X-arithmetic mean, SD-standard deviation; M-male gender; F-Female gender; ICU- intensive care unit. n- number of patients. BMI - body mass index. The parameters are expressed as the central value with the associated dispersion measure.

The sample was not uniform across age categories, significantly more were middle-aged subjects, followed by those older than 65 years, while none were younger than 45 years. The higher incidence of men in this study correlates with already known results showing that men are four times more likely to have coronary disease than women if all age groups are observed.

Given that LV diastolic dysfunction is associated with an increase in LAVI, which is a powerful marker of cardiovascular risk, ultrasound characteristics and LVDD parameters are given in Tables 2 and 3.

According to the degree of diastolic dysfunction, preoperatively the most prevalent diastolic dysfunction was first degree 72/116 (Table 3).

Table 2. Preoperative ultrasound parameters

	Without LVDD	LVDD
E- wave	0.72 (0.51-0.89)	0.55 (0.33-1.17)
A- wave	0.59 (0.44-0.86)	0.81 (0.37-1.15)
E/A ratio	1.18 (0.75-1.57)	0.67 (0.38-2.31)
IVRT	94.50 (72-124)	136 (32-200)
DT	180 (136-276)	216 (104-320)
LVEF	60 (40-65)	52 (28-65)
LVM	236 (115-425)	253 (143-413)
LVMI	116 (60-183)	137 (77-356)
LAV*	57.5 (24-115)	66 (23-128)
LAVI*	29 (12-55)	31.5 (12.5-65)

*Legend: E wave: maximal rate of early diastolic LV filling, A wave: atrial contraction, IVRT: Isovolumic relaxation time - time from closure of the aortic valve to opening of the mitral valve. DT: Deceleration time - time from the tip of the E wave to the point where it intersects the zero line, LVEF: left ventricular ejection fraction, LVM: left ventricular mass, LVMI: left ventricular mass index, LAV: left atrium volume, LAVI: left atrium volume index. The parameters are expressed as an absolute number and as a percentage. n- number: a - Hi square (Pearson Hi square 66.04, df-1, p <0.0001). * Median test.*

Table 3. Degree of left ventricular diastolic dysfunction by age category

Dob	Without LVDD	I-degree	II-degree	III-degree
≤ 45	-	-	-	-
46-64	27	**39**	4	6
≥ 65	1	**33**	5	1

Legend: The parameters are expressed as an absolute number and as a percentage. n- number: [a] - Hi square (Pearson Hi square 18.98, df-3, p <0.0001).

Table 4 shows that although the sample was uneven across the LAVI categories, a markedly elevated index and atrial fibrillation had 52.8% (Goodness-of-fit Chi-Square χ^2 = 19.96, df-3, p <0.0001). Hi square test of independence indicates a significant relationship between LAVI and postoperative atrial fibrillation (Pearson Chi-Square χ^2 = 10.75, df-3, Cramer's V 0.307. P = 0.013).

Table 4. Preoperative left atrial volume index categories and atrial fibrillation

			Atrial Fibrillation	
			No	Yes
LAVI (categories)	Normal range < 26	n	35	7
		%	44.9%	19.4%
	Mildly dilated 27-32	n	14	7
		%	17.9%	19.4%
	Moderaltely dilated 32-36	n	10	3
		%	12.8%	8.3%
	Grossly dilated > 36	n	19	**19**
		%	24.4%	**52.8%**
	Total	n	79	36
		%	100%	100%

*Legend: LAVI - left atrial volume index (preoperatively). The parameters are expressed as No.- absolute numbers and as a percentage. a - Chi square test: Pearson Chi-Square χ^2 = 10.75, df-3, **Cramer's V 0.307**. **p = 0.013.***

Charts 1 and 2 show mitral regurgitation before and after surgery. Chart 2 indicates a statistically significant reduction in postoperative mitral regurgitation (MR) versus preoperative, Chi Square test: Pearson Chi-Square-8.23; df-1; p <0.004.

Only diastolic dysfunction preoperatively (categorically) and LAVI made a statistically significant contribution to the model, whereas gender and age did not. The strongest predictor of post operative atrial fibrillation is grade II and III LVDD. The odds ratio of atrial fibril-

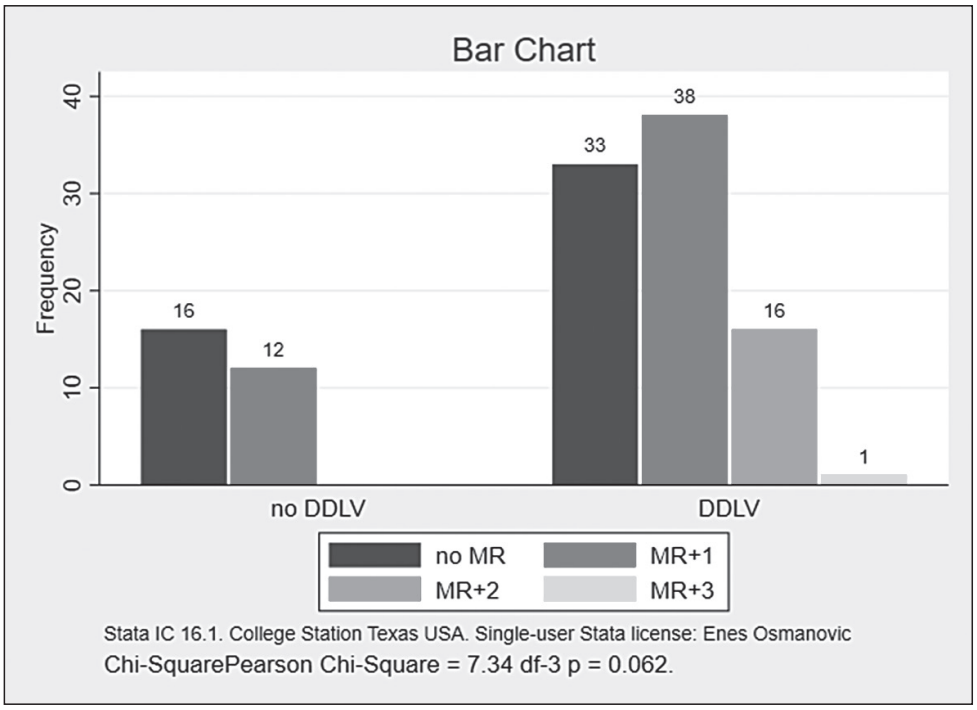

Chart 1. Preoperative MR

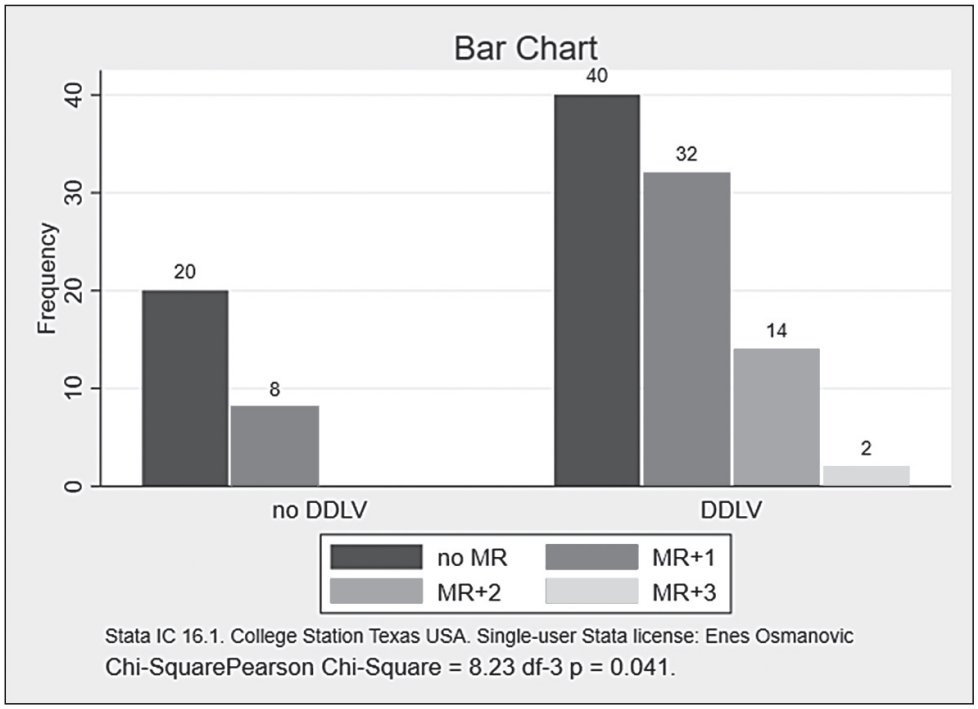

Chart 2. Postoperative MR

lation (odds ratio) is 26.4 times higher with LVDD III compared to those who do not have this disorder of diastolic function. The beta coefficient for LAVI is positive and stands at 0.055, p <0.013, OR (odds ratio): 1.05, which shows us that increasing the left atrium volume by a unit of measure (1 ml/m^2) increases the chance of atrial fibrillation 1-fold.

Table 5. Significant predictors of atrial fibrillation

	B	S.E.	Wald	df	p-value	Exp(B)	95% C.I.for EXP (B)
							Lower
Gender	0.304	0.52	0.34	1	0.56	1.35	0.48
Age	0.05	0.03	2.91	1	0.08	1.05	0.99
LVDD-I	1.226	0.89	1.89	1	0.169	3.40	0.59
LVDD-II	3.01	1.18	6.50	1	**0.011**	**20.38**	2.010
LVDD-III	3.27	1.37	5.70	1	**0.017**	**26.4**	1.79
LAVI	0.055	0.022	6.18	1	**0.013**	**1.05**	1.012

Legend: B-beta coefficient, SE-standard error, Wald statistics; df-degree of freedom, Exp (B) -exponent of coefficient B (OR); 95% C.I. - OR range (odds ratios)

Table 6. Echocardiographic parameters in the prediction of atrial fibrillation

B	S.E.	Wald	df	p-value	Exp(B)	95% C.I.for EXP (B)	
							Lower
LVDD	1.36	0.35	14.38	1	**0.0001**	3.90	1.93
LVMI	0.06	0.01	13.41	1	**0.0001**	1.07	1.03
LAVI	0.06	0.019	13.41	1	**0.0001**	1.07	1.03
LAVI*Age	0.001	0.000	17.86	1	**0.0001**	1.001	1.001
LAVI*Age LVDD	-0.001	0.000	4.26	1	**0.03**	0.99	0.99
LVEF	-0.03	0.02	2.43	1	0.11	0.97	0.93
LVEF*LVDD	-0.04	0.01	7.59	1	**0.006**	0.95	0.92

The previous tables show that the left ventricular mass index (LVMI) and gender are not significant predictors of atrial fibrillation, while age and LAVI are markedly increased, which carries a 3-fold increased risk of atrial fibrillation.

Cox regression showed statistically significant effect of LAVI on the time of onset and the duration of atrial fibrillation. Cox regression examined the influence of covariates that significantly influence the onset time and duration of atrial fibrillation and found that DDLV and LAVI had the largest contribution to the explained variance. The beta regression coefficient indicates that increasing the LAVI value by one unit of measurement shortens the time for atrial fibrillation to occur 4 times, which means that atrial fibrillation occurs earlier and lasts longer.

Table 7. Cox regression results for atrial fibrillation hazard assessment

Explanators:		b	S.E.	p-value	Exp(B) Hazard	C.I.for Exp (B)
						Lower
Age		**0.05**	0.01	**0.008**	**1.04**	1.02
Gender		0.06	0.36	0.87	1.06	0.52
LAVI		0.04	0.01	**0.0001**	1.05	1.02
LAVI	Normale range < 26			0.05		
	Mildly dilated 27-32	0.54	0.53	0.30	1.7	0.6
	Moderately dilated 32-36	0.19	0.69	0.77	1.2	0.3
	Grossly dilated > 36	1.12	0.4	**0.01**	**3.0**	1.2

Legend: LAVI – left atrium volume index.

The early onset of fibrillation and its longer duration is functional with increasing LAVI. Subjects with markedly increased LAVI values were at highest risk for early atrial fibrillation (Charts 3 and 4).

The risk of atrial fibrillation is initially significantly higher in patients with DDLV and in the third postoperative day of hazard function clearly indicates a greater risk of atrial fibrillation in patients with LVDD.

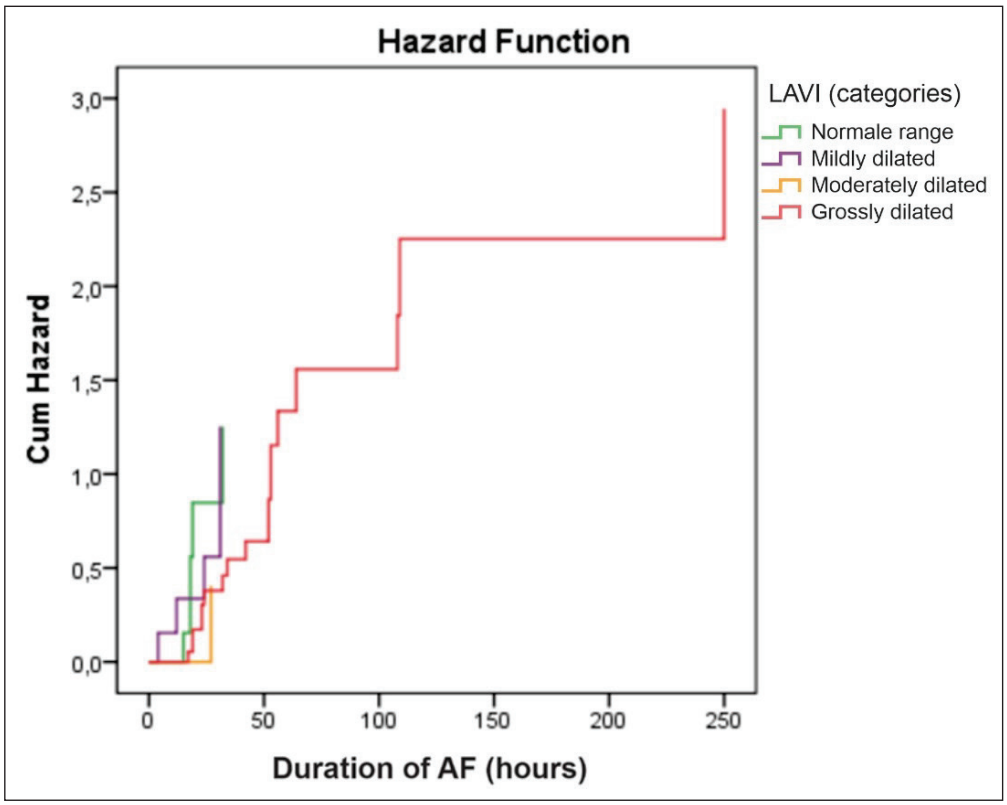

Chart 3. Cumulative Hazard and LAVI

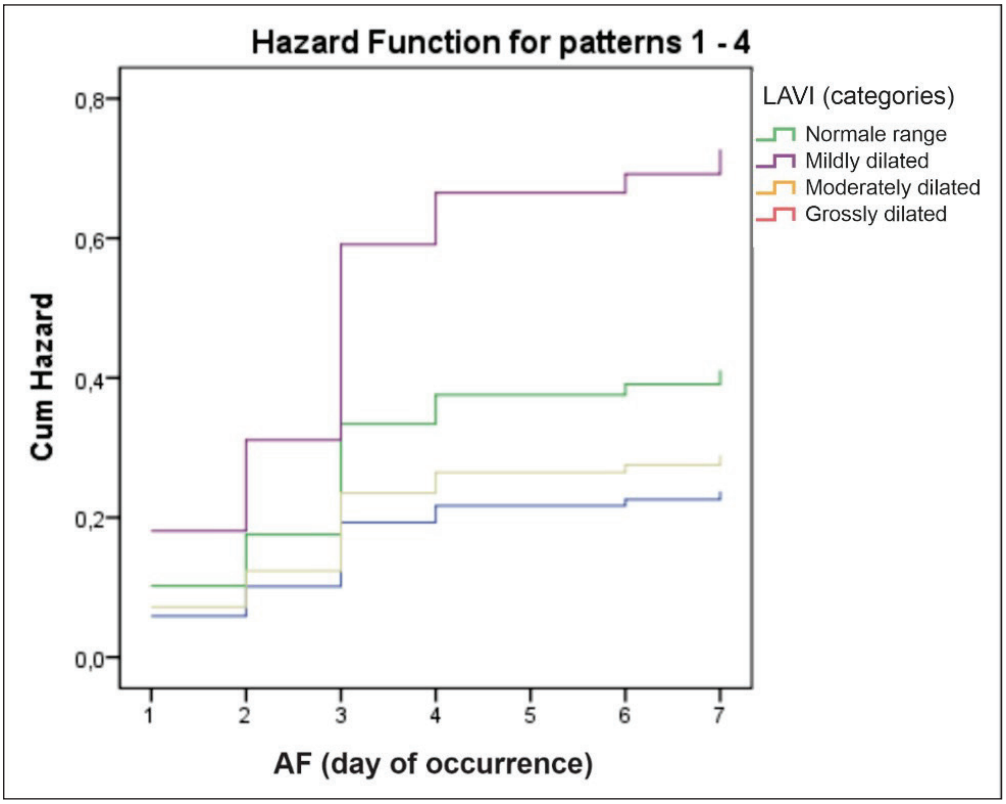

Chart 4. The risk of atrial fibrillation is significantly increased on the third postoperative day in patients with grossly dilated LAVI

Patients without LVDD have an increased risk of atrial fibrillation only on the third postoperative day, while on the third postoperative day the cumulative risk of FA increases sharply in patients with LVDD. Atrial fibrillation occurs earlier in the severely damaged LVEF and lasts longer (Charts 5 and 6).

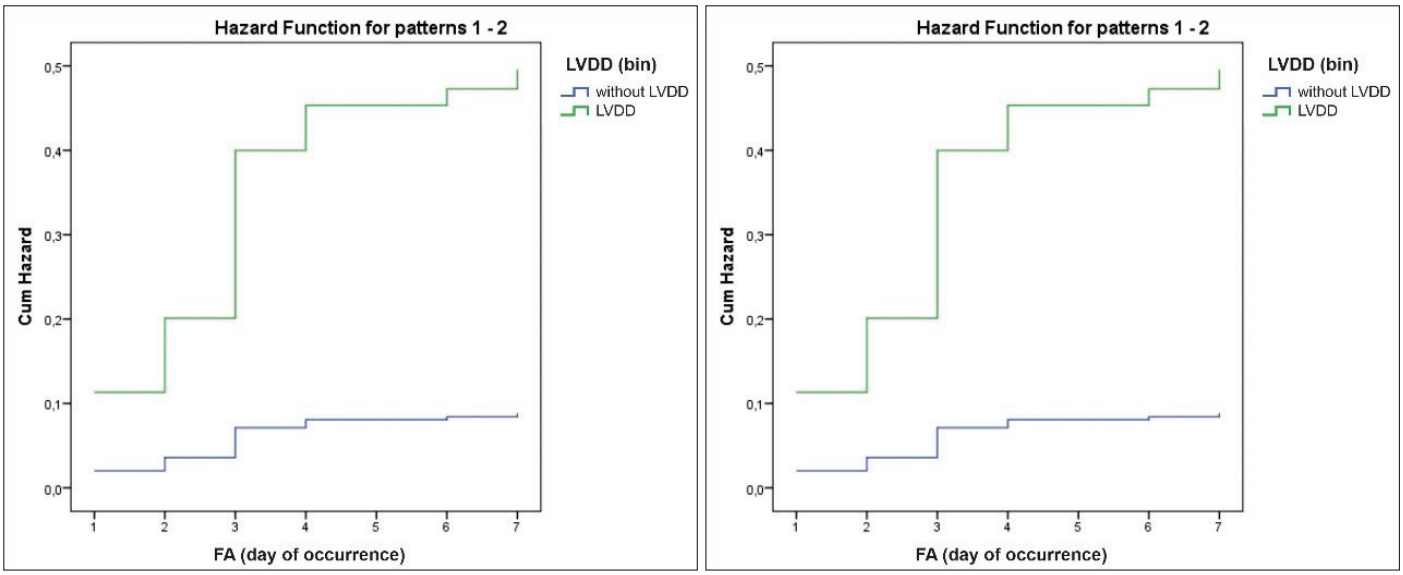

Chart 5 and 6. The risk of postoperative fibrillation versus LVDD and LVEF

DISCUSSION

Despite many studies examining the incidence of postoperative FA, its incidence and prevention, it is still a common complication of CABG. Postoperatively, in this study, out of the total number of patients, FA occurred in 31% (36) of whom 94% in patients with DDLV. According to other studies, atrial fibrillation occurs in 20-30% and according to some data up to 50% of patients, usually on the second or third postoperative day and less than 10% occurs on the first postoperative day, which is the case in our study as in study by Mathew et al. where out of 1503 patients, 32.3% developed FA after CABG. Zaman and colleagues in 2000 find that most FAs occur within the first 5 days after CABG.

The LAVI parameter of LA size according to the results of previous studies has been proposed as a biomarker for both diastolic left ventricular dysfunction and cardiovascular risk, as stated in their study by Douglas et al., 2003, Alsaileek et al., 2006.

The LAVI in this study was significantly higher, the higher the LVDD rate, and was marked by logistic regression and as a predictor of postoperative FA, which agrees with the results in other studies. An increase in LA dimensions is associated with the occurrence of atrial fibrillation and that LA dilation expressed as LAD/BSA is present in men in 18% and 12% in women as a result of research by Pritchet et al., 2003. Increased LA wall tension leads to LV and stretching of the atrial myocardium. Thus, LA volume increases with severity of diastolic dysfunction. In our study, the beta regression coefficient indicates that an increase in LAVI by one unit of measurement shortens the time for atrial fibrillation by 4-fold, which means that atrial fibrillation occurs earlier and lasts longer. Other studies have shown similar results (Abhayaratna et al., 2006). The exacerbation of preoperative LVDD after CABG may cause a higher incidence of FA and other complications, as has been shown in previous studies on the association of diastolic dysfunction with the risk of atrial fibrillation (Tsang et al. 2002, Tsang et al. 2003) and our studies.

The strongest predictor of postoperative atrial fibrillation is grade II and III LVDD. The results indicate that mild diastolic dysfunction such as relaxation disorder also presents a greater risk of FA after surgical myocardial revascularization and the link between LVDD and postoperative FA in patients undergoing CABG is also found by Meineri et al.2005. Our results indicate that the odds of atrial fibrillation (odds ratio) are 26.4 times higher in LVDD III compared to those who do not have this disorder of diastolic function. Tsang et al. 2002, in a study similarly designed for patients not undergoing CABG find that the severity of LVDD, especially grade III LVDD, is an independent predictor of the onset of newly acquired FA. Some studies have not shown an association between LVDD and the onset of postoperative FA (David et all, 2015), except that patients who had CABG surgery included patients who had surgery for the valvular apparatus, with systolic pressure in the lung arteries and LA volume were significant predictors of postoperative FA. Also, the variability and subjectivity of researchers in estimating LVDDI degrees of the same may make it difficult to include diastolic function in the global predictive model of FA occurrence. After the predictor was introduced into the model, the prediction accuracy was increased to 80%. Only diastolic dysfunction was preoperatively categorized and LAVI made a statistically significant contribution to the model, whereas gender and age did not, and in their study, given age, gender, hypertension, Tsang et al. In 2001, they found that a 30% greater volume of LA was associated with a 43% higher risk of FA. The beta coefficient for LAVI is positive and is 0.55, p <0.013, OR (odds ratio): 1.05, indicating that an increase in left atrium volume per unit (1 ml / m2) increases the chance of atrial fibrillation 1-fold. Therefore, an increase in the dimensions of LA and LAVI correlates with cardiovascular disease and it is a risk factor for the development of atrial fibrillation, ICV and death, which was also concluded by Tsang et al in 2002.

CONCLUSION

1. Postoperative atrial fibrillation occurs earlier and lasts longer in patients with elevated left atrial volume index values, especially LAVI > 36ml/m^2.

2. The most significant independent predictors that contribute most to the earlier onset of postoperative atrial fibrillation and its longer duration after surgical myocardial revascularization are left ventricular diastolic dysfunction and LAVI.

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