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PREDICTORS OF ATRIAL FIBRILLATION RECURRENCE AFTER SIMULTANEOUS MAZE-V PROCEDURE AND CORONARY ARTERY BYPASS GRAFTING

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Aim. To identify the predictors of atrial fibrillation (AF) recurrence after simultaneous Maze V procedure in combination with coronary artery bypass grafting.

Methods. Medical records of 102 patients with coronary artery disease and concomitant AF were retrospectively reviewed. All patients underwent coronary artery bypass grafting and the combined Maze V procedure. The patients were divided into 2 groups: 51 patients with paroxysmal AF (group I), and 51 patients with non-paroxysmal AF (group II). In group I, 6 cases of AF recurrence were detected (subgroup IA), while 45 patients (subgroup IB) maintained sinus rhythm for the entire follow-up period. Accordingly, in group II, the return of AF was noted in 9 patients (subgroup IIA), sinus rhythm - in 42 patients (subgroup IIB). The follow-up period was 36 months. Clinical and echocardiographic parameters were studied as predictors of AF recurrence.

Results. A significant predictor in patients with paroxysmal AF was a recurrence of AF at the hospital stage (odd ratio (OR) 10,25; 95% confidence interval (CI) 1,53-68,20; p=0.032). The duration of the AF history was the main predictor in patients with non-paroxysmal AF (OR 8,8; 95% CI 1,01-76,1; p=0.04). ROC analysis revealed a significant effect on the AF recurrence of left atrium (LA) dimension >48.5 mm, LA volume index >44.4 ml/m^2 for patients with paroxysmal AF, and left ventriclular end-diastolic volume > 150 ml for patients with non-paroxysmal AF

Conclusion. A recurrence of AF at the hospital stage, LA dimension, LA volume index were significant predictors of AF recurrence after coronary artery bypass grafting + Maze V procedure in patients with paroxysmal AF. A long AF history and left ventriclular end-diastolic volume played the role of predictors for patients with non-paroxysmal AF.

Key words: atrial fibrillation; recurrent arrhythmia; Maze V; coronary artery bypass grafting; coronary artery disease; radiofrequency ablation; left atrium

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In the current stage of clinical medicine development, the matter of surgical treatment for coronary heart disease through coronary artery bypass grafting (CABG) surgery remains relevant [1]. Concomitant atrial fibrillation (AF) occurs in 5-10% of cases during open myocardial revascularization surgery, and addressing its correction is a pivotal aspect in enhancing the outcomes of CABG [2]. Currently, the gold standard for treating AF during cardiac surgery is the Maze procedure in various modifications. This approach allows the achievement of freedom from AF in 70-98% of cases within a follow-up period of up to 10 years, particularly in nonparoxysmal forms of the disease [2, 3].

Simultaneously, the appropriateness of conducting the standard combined Labyrinth operation during CABG has raised valid concerns among numerous authors. This is attributed to the necessity of opening the heart cavities, potentially increasing the risk of various complications when the primary operation is exclusively performed in the epicardial zones [4].

Previously, favorable results and high efficacy of the Labyrinth V operation (an author's method by A. Sh. Revishvili) for correcting concomitant AF during simultaneous CABG operations were demonstrated [5]. Considering the peculiarities of the technology, it can be called optimal for use in combination with CABG. This technique offers

advantages such as performing the entire radiofrequency ablation stage on the functioning heart without opening the left heart cavities. This reduces the duration of myocardial ischemia and provides complete electrophysiological control overachieving exit block and restoring sinus rhythm. Freedom from arrhythmia without antiarrhythmic therapy after CABG combined with Maze V at 12, 24 and 36 months follow-up was 91%, 88%, and 77%, respectively [6]. However, to determine the future role of the technique in the treatment of concomitant AF, it is important to identify potential risk factors for recurrent AF. According to the literature, significant risk factors for the recurrence of AF during Maze surgery include the patient's age, duration of arrhythmia, left atrial size, and some other factors [7].

The aim of this study was to investigate the predictors of the recurrence of AF after combined Maze V surgery for CABG by analyzing various clinical and echocardiographic parameters.

METHODS

A retrospective study evaluated the long-term surgical outcomes of 102 patients who underwent CABG in conjunction with Labyrinth V surgery. Coronary revascularization was performed by a single surgical team using standardized technology with artificial circulation and thermal blood cardioplegia. The Labyrinth V procedure was performed before the CABG stage according to the described technology [6]. All patients provided informed consent for the surgical intervention encompassing CABG and Labyrinth V surgery before the operation. The study received approval from the institution's local ethics committee (Local Ethics Committee Minutes No. 006-2023 dated May 30, 2023).

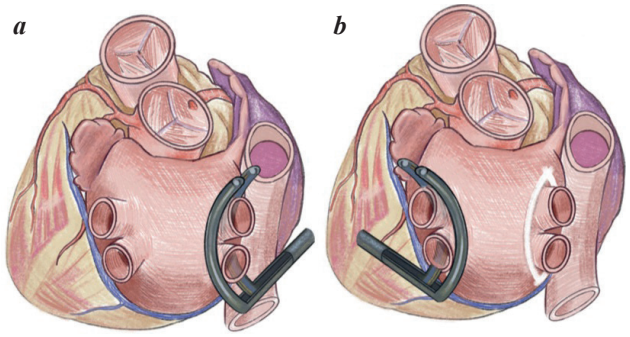

Fig. 1. Paired bipolar radiofrequency isolation of pulmonary vein, where a and b are isolation of right (a) and left pulmonary veins (b) with a bipolar clamp.

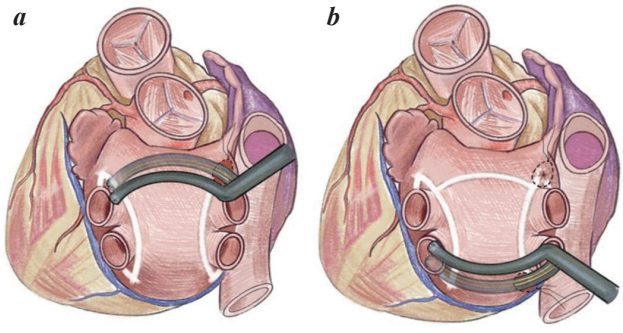

Fig. 2. Left atrial stage Labyrinth V surgery, where a and b are the formation of the upper and lower Box Lesion lines.

Operation technology Labyrinth V

The left atrial (LA) stage of the operation (Fig. 1) began with the pairwise isolation of the pulmonary vein (PV) using a bipolar electrode. On a working heart, right PVs were prominent. Subsequently, the bipolar electrode was positioned in a manner such that one branch was situated behind and the other ahead of the veins. The electrode branches were clamped, and ablation of the right PV was performed. The completeness of PV transmural tissue damage was assessed by the change in the resistance curve on the generator monitor. Up to 10 sets of radiofrequency treatment were performed. Similar manipulations were performed on the left side, after preliminary crossing of the ligament of Marshall with a coagulator.

Creation of the upper ablation line on the LA was executed by passing through the brush suture, guiding the lower branch of the bipolar clamp along the roof of the LA in the direction of the left upper PV. The inferior insulating line was created in a similar fashion by passing the upper branch of the bipolar electrode behind the inferior vena cava through a brush suture on the LA wall opposite and slightly behind the mouth of the inferior vena cava. Thus, after the completion of all ablation lines, the isolation of the posterior wall of the LA was accomplished, resulting in the creation of the isolation zone - «Box Lesion» (Fig. 2). At the end of this stage, an epicardial electrophysiological study was conducted to assess the adequacy of bidirectional conduction block and to confirm the consistency of ablation lines.

The control of conduction block through ablation lines against sinus rhythm was carried out with an multicontact electrode (Pentaray). We conducted sequential stimulation with a current intensity of 15-25 mA in the areas delimited by the ablation lines, with a frequency 30-50% higher than the heart's own rhythm. If there was no increase in heart rate against the background of the conducted stimulation, the situation was evaluated as the achievement of isolation. In a situation where the patient had recorded atrial fibrillation (AF), the electrode was used to record atrial signals. The absence of a signal was considered as achieving isolation.

After left PV isolation, the appendage was ligated twice with a Lavsan ligature, and the resulting isthmus between the two ligatures was ablated to definitively eliminate the contractile activity of the tissue. In some cases, appendage amputation using an endostapler was performed.

The right-sided stage of surgery (Fig. 3) included the opening of the right atrium (RA) with an incision of about 5 cm parallel to the border furrow on the outer wall of the RA. From the lower edge of the atriotomy incision, a bipolar electrode was used to ablate epicardially along the outer wall of the RA toward the mouth of the inferior vena cava. The apex of the RAappendage was resected, and then two ablation lines were performed: one from the upper edge of the atriotomy incision to the base of the RA appendage along its external surface, and the other from the middle of the base of the resected RA appendage toward the anterior commissure and the fibrous ring of the tricuspid valve. At the final stage, cavo-tricuspidal isthmus ablation and electrophysiological study were performed to confirm conduction block.

After the passage of cardioplegia, the coronary stage was performed, which included the formation of distal anastomoses on the arrested heart, and proximal anastomoses during myocardial reperfusion, after the removal of the aortic clamp. Two groups – paroxysmal (n=51) and non-paroxysmal AF (n=51) - were retrospectively identified based on the type of arrhythmia. The grouping of patients with persistent and long-term persistent AF into the «non-paroxysmal AF» group was due to the inability to clearly define the specific date of arrhythmia manifestation, which occurred in most patients in this group.

During a follow-up period of 36 months, data were obtained from all patients (Fig. 4). Based on the clinically significant outcome, which was considered as the endpoint of the study (recurrence of AF with a paroxysm duration of not less than 30 seconds according to the Clinical Recommendations), two subgroups were identified within each of the studied groups. In the paroxysmal AF group, recurrence of AF was diagnosed in 6 patients (subgroup 1A) and absence of AF in 45 patients (subgroup 1B). In the nonparoxysmal AF group, recurrence of AF was diagnosed in 9 patients (subgroup 2A) and absence of AF in 42 patients (subgroup 2B).

The assessment of the fact of AF recurrence development was based on the analysis of 48-hour ECG monitoring data in the clinic after 3, 6, 12, 24, 36 months. The first three months after surgery were defined as a «blind period» and, therefore, early recurrence of AF of this time was not evaluated [8].

The strategy of drug therapy in the postoperative period was to prescribe antiarrhythmics and anticoagulants for at least 3 months. The first-line antiarrhythmic drug was amiodarone. Among other things, most patients were taking beta-adrenoblockers not only for antiarrhythmic effects but also as a component of heart failure therapy. Patients were started on warfarin immediately after surgery. The duration of warfarin administration after reaching the target international normalized ratio of 2-3 units was 3-6 months. Anticoagulant therapy was discontinued based on the absence of AF recurrence, after confirming the occlusion of the LA appendage and the absence of thrombus according to the data of transesophageal echocardiography, as well as considering the risk stratification of thromboembolism. Among other things, all patients after CABG were obligatorily prescribed antiplatelets – acetylsalicylic acid preparations.

Preoperative, intraoperative, and postoperative parameters were analyzed to identify potential predictors associated with an increased risk of developing recurrent AF at long-term follow-up. Potential predictors were selected based on expected risk factors studied in other studies of combined surgical ablation for cardiac surgery.

Statistical analysis

The database for processing of the obtained material was formed in Excel program (Microsoft Office pack-

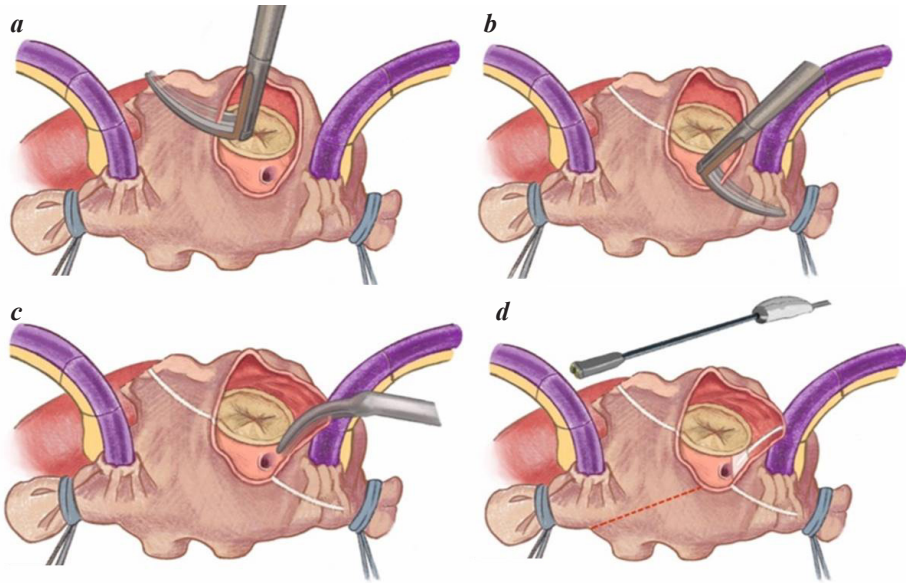

Fig. 3. Right atrial stage of the operation Labyrinth V, where a - ablation line from the upper edge of the atriotomy incision to the base of the right atrial appendage (RA) along the external surface of the RA; b - ablation line on the outer wall of the RA from the lower edge of the atriotomic incision towards the inferior vena cava; c - ablation line from the middle of the RA appendage base to the anterior commissure of the tricuspid valve; d - ablation line of the cavo-tricuspid isthmus with a monopolar electrode.

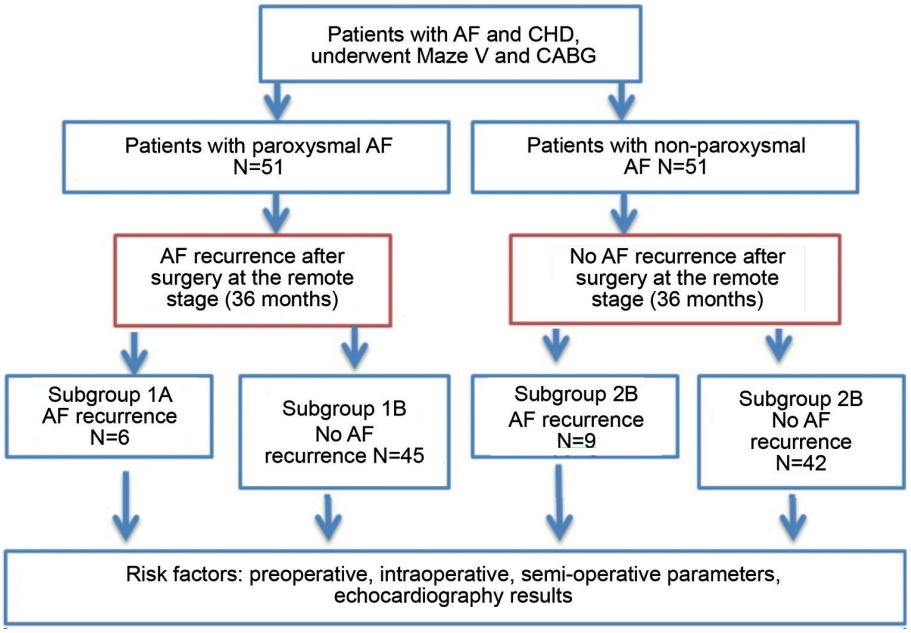

Fig. 4. Study design.

age, USA). Statistical processing of the obtained data was performed using Statistica 6 (USA) and IBM SPSS Statistics 26 (USA) software packages. Given the relatively small number of patients in the recurrence subgroups, the nonparametric Mann-Whitney test was used to compare quantitative parameters. Pearson's chi-square, Fisher's criterion was used to compare categorical data. Logistic regression analysis with the construction of a prognostic model was performed to predict the category of outcome, which was taken as the fact of the recurrence of AF in the remote period. To evaluate the sensitivity and specificity of the obtained model, ROC analysis with curve plotting was performed. The critical level of significance for testing statistical hypotheses was taken as 0.05.

RESULTS

When analyzing the inter-subgroup preoperative parameters, no differences were found by sex, age, nature of comorbidity (Table 1). There were no significant differences in the incidence of grade 3-4 FC angina pectoris and postinfarction cardiosclerosis. The extent of coronary lesions was identical. The median duration of

Table 1.

Preoperative parameters in the compared groups

	Paroxysmal AF group (n=51)		p	Non-paroxysmal AF group (n=51)		p
	Subgroup IA (n=6)	Subgroup IB (n=45)		Subgroup IIA (n=9)	Subgroup IIB (n=42)	
Age, years	64(57;65.7)	63(58;68)	0.826	60(58;66)	63(58;67)	0.638
Men, n(%)	5(183.3%)	38(84.4%)	0.298	8(88.9%)	35(83.3%)	0.187
Women, n(%)	1(16.7%)	7(15.5%)	0.298	1(11.1%)	7(16.7%)	0.432
Obesity, n(%)	3(50%)	23(51.1%)	0.827	5(55.6%)	19(45.2%)	0.845
Diabetes mellitus, n(%)	1(16.7%)	12(26.7%)	0.976	3(33.3%)	15(35.7%)	0.803
Angina pectoris 3-4 FC, n(%)	2(33.3%)	23(51.1%)	0.701	3(33.3%)	23(54.8%)	0.423
History of myocardial infarction, n(%)	2(33.3%)	22(48.9%)	0.778	2(22.2%)	18(42.9%)	0.423
Arterial hypertension, n(%)	5(83.3%)	39(86.7%)	0.682	7(77.8%)	40(95.2%)	0.277
Stroke, n(%)	0	4(8.9%)	0.976	2(22.2%)	3(7.1%)	0.445
Single-vessel lesion, n(%)	0	5(11.1%)	0.897	1(11.1%)	5(11.9%)	0.615
Bivascular lesion, n(%)	2(33.3%)	12(31.1%)	0.886	5(55.6%)	14 (33.3%)	0.383
Three-vessel lesion, n(%)	4(66.7%)	28(62.2%)	0.811	3(33.3%)	23(54.8%)	0.423
Median arrhythmia history, months.	12(7.5;30)	12(6;75)	0.506	96(48;114)	36(12;108)	0.040
Catheter RFA in the history, n(%)	0	2(4.4%)	0.553	2(22.2%)	6(14.3%)	0.928
History of cardioversion, n(%)	0	4(8.9%)	0.962	3(33.3%)	4(9.5%)	0.177

Notes: hereinafter AF - atrial fibrillation; FC - functional class of angina pectoris; RFA - radiofrequency ablation. Results are presented as median and interquartile intraval (Me (Q1-Q3)), absolute value and percentages (n,%). Mann-Whitney test, χ^2 test, Fisher's exact test were used.

Table 2.

Intraoperative parameters and hospital outcomes

	Paroxysmal AF group (n=51)		p	Non-paroxysmal AF group (n=51)		p
	Subgroup IA (n=6)	Subgroup IB (n=45)		Subgroup IIA (n=9)	Subgroup IIB (n=42)	
Time of aortic occlusion, min	43,5(10,5;50,2)	40(30:56)	0,671	30(29;42)	40,5(27;51,7)	0,496
IC duration, min	156(134;173)	125(108;140)	0,085	125(112;131)	126(103;153)	0,852
Duration of ablation stage, min	58(62;70)	47(42;56)	0,090	50(50;61)	49,5(45;51,5)	0,166
Total volume of blood loss, ml	500(500,570)	500(500;600)	0,608	500(500;500)	500(500;500)	0,504
Recurrence of AF on HS after surgery	3(50%)	4(8,9%)	0,034	2(22,2%)	11(26,2%)	0,862
Preservation of FP at discharge	0	0	-	1(11,1%)	3(7,1%)	0,778
Retention of SR at discharge	6(100%)	45(100%)	1,00	8(88,9%)	39(92,9%)	0,687
AAT before surgery	-	-	-	-	-	-
Taking beta-adrenoblockers	6(100)	32(71,1)	0,112	9(100%)	30(71,4%)	0,060
Taking amiodarone	0	4(8,9%)	0,962	2(22,2%)	11(26,2%)	0,862

Notes: IC - artificial circulation; HS - hospital stage; SR - sinus rhythm; AAT - antiarrhythmic therapy.

arrhythmia in the non-paroxysmal AF group was expectedly significantly higher in patients with remote-onset episodes of AF - 96 (48;114) vs. 36 (12;108) months (p=0.04). In the paroxysmal AF group, differences between subgroups in terms of the median duration of AF did not demonstrate reliability. Intergroup analysis showed no differences in the frequency of preoperative catheter-based radiofrequency ablation (RFA) and electrical pulse therapy.

Evaluation of intraoperative parameters showed that there were no significant differences in duration of aortic clamping, time of artificial circulation, and duration of the ablation step (Table 2). Patients of subgroup IA were more likely to have arrhythmia recurrence in the hospital after surgery than patients of subgroup IB - 50% and 8.9%, respectively (p=0.034). There were no significant differences in this index in subgroups IIA and IIB - 22.2 and 26.2% (p=0.504). However, all patients with paroxysmal AF had sinus rhythm by the time of discharge, which is not the case with patients with nonparoxysmal AF. Preservation of sinus rhythm at discharge in subgroups IIA and IIB was 88.9% and 92.9%, respectively (p=0.687). Analysis of the use of major antiarrhythmic drugs showed no significant inter-subgroup differences.

At the remote stage (36 months), a significant trend of lower frequency of amiodarone administration in subgroup IA relative to subgroup IB was revealed - 50% vs. 88.9% of patients (p=0.06). In subgroups IIA and IIB, 77.8% and

Table 3.

Antiarrhythmic therapy at a remote stage

	Paroxysmal AF group (n=51)		p	Non-paroxysmal AF group (n=51)		p
	Subgroup IA (n=6)	Subgroup IB (n=45)		Subgroup IIA (n=9)	Subgroup IIB (n=42)	
Taking beta-adrenoblockers	6(100%)	42(93.3%)	0.785	8(88.9%)	38(90.5%)	0.884
Taking amiodarone	3(50%)	40(88.9%)	0.060	7(77.8%)	26(61.9%)	0.365

Таблица 4.

Эхокардиографические показатели при внутригрупповом сравнении на отдаленном этапе

Parameter	Paroxysmal AF group (n=51)		p	Non-paroxysmal AF group (n=51)		p
	Subgroup IA (n=6)	Subgroup IB (n=45)		Subgroup IIA (n=9)	Subgroup IIB (n=42)	
LA size, mm	50(49.2;50)	45(43;46)	0.033	48(47;50)	42(40;48)	0.070
LA area, cm^2	28.5(25.7;40)	23.7(22.8;24.5)	0.038	31(27.6;34)	28(17.7;28)	0.070
Volume of LA, ml	100.5 (98;107)	74(68.6;85.2%)	0.027	106(93;127)	93(48;99)	0.090
LAVI, ml/m2	47.7(46.7;48)	36 (28.9;40)	0.003	47.6(41.6;55)	37.3(26.6;43.8)	0.070
LV EDD, mm	51.5(51;56.5)	55 (54.5;60)	0.187	58(58;60)	54(53;56)	0.020
LV ESD, mm	35(34.2;38.7)	40 (35;41.5)	0.361	40(40;41)	32(32;39)	0.010
LV EDV, ml	129(123:164)	128 (123;155)	0.864	164 (136;167)	137 (130;143)	0.030
LV ESV, ml	56(50;65.5)	56(50;65.5)	0.864	70(69;75)	46 (39;54)	0.004
LV PW, mm	12(11.2;12)	12(11.5;13)	0.458	12(12;12)	11(10;15)	0.525
LV amplitude, mm	10(10;10)	11(11;11.5)	0.010	11(10;11)	12(11;12)	0.060
MR, degree	1(1;1.3)	1.5(1;1.7)	0.359	1.5(1;1.5)	1.5(1;2)	0.456
RA area, cm2	22.6 (20.9;23.6)	17.2(16.5;19.3)	0.018	27.5(20;28)	19(19;20.6)	0.106
RA volume, ml	58.8(57;59)	45.6(41.3;53.5)	0.122	62(58;94)	53(53;55)	0.070
RV adventitious tract, mm	29(28.2;29.7)	28(25;29.5)	0.243	32(30;35)	23(23;29)	0.004
LV BP, mm.Hg.	33(30.2;37.2)	25(22.5;36.5)	0.173	30(25;35)	27(26;30)	0.531
TR, degree	1.75(1.5;2)	1.5(1.25;1.75)	0.198	1.5(1.5;2)	1.5(1;1.5)	0.211
IVS amplitude, mm	10.5(10;11)	11(8;11)	0.742	8(8;11)	11(8;11)	0.141
IVS thickness, mm	10.5(10;12.5)	12(11.5;13.5)	0.112	13(12;13)	11(10;15)	0.590
Strike volume, ml	76.5(73.7;84.5)	80(70.5;88.5%)	0.919	91(83;94)	89 (86;103)	0.890
Simpson's LVEF, %	55(55;55)	58(54;60)	0.194	52 (52;52.7)	58.5 (57;60)	0.010

Note: LAVI - left atrium indexed volume; LV EDD, LV ESD, LV EDV, LV ESV - left ventricular end-diastolic and end-systolic dimensions and volumes; LV PW - posterior wall of the left ventricle; MR - mitral regurgitation; RA - right atrium; RV - right ventricle; BP - blood pressure; TR - tricuspid regurgitation. IVS - interventricular septum; LVEF, left ventricular ejection fraction.

61.9% of patients were taking amiodarone (p=0.365). No differences were also noted in the frequency of beta-adrenoblocker use (Table 3).

The differences between the groups in echocardiography parameters were analyzed separately to assess the severity of cardiac chamber changes and their influence on the recurrence of AF (Table 4). In the paroxysmal arrhythmia group, patients with recurrent AF had larger LA dimensions (50(49.2;50) vs. 45(43;46) mm, p=0.033), LA area (28.5 (25.7;40) vs. 23.7(22.8;24.5) cm^2, p=0.038), LA volume (100.5 (98;107) vs. 74(68.6;85.2%) ml, p=0.027) compared to patients who maintained sinus rhythm. In inter-subgroup comparison in this group no differences were found in left ventricular (LV) volumetric indices (end-systolic dimension (ESD), end-diastolic dimension (EDD), end-systolic volume (ESV), end-diastolic volume (EDV)).RA area was significantly higher in the AF recurrence group, 22.6(20.9;23.6) vs. 17.2(16.5;19.3), while RA volume was also higher in this subgroup, although without statistical significance. The median degree of tricuspid regurgitation was slightly higher in subgroup 1A: 1.75(1.5;2) vs. 1.5(1.25;1.75), p= 0.198. Patients with recurrent AF had a slightly lower ejection fraction (EF) than patients with sinus rhythm, still without statistical significance, 55% vs 58%, at p=0.194.

In the non-paroxysmal arrhythmia group, we found that patients with recurrent AF also had larger LA size (48 (47;50) mm vs. 42 (40;48) mm, p=0.07), LA area (31 (27.6;34) and 28 (17.7;28) cm^2, p=0.07) and LA volume (106 (93;127) mL and 93 (48;99) mL, p=0.09) than patients whose arrhythmia did not recur at a remote stage, but only a statistical trend was observed for these parameters. A detailed review of LV linear and volumetric indices revealed significant increases in the relapse subgroup in such parameters as EDD (58 (58;60) vs. 54 (53;56) mm, p=0.02); ESD (40 (40;41) vs. 32 (32;39) mm, p=0.01); EDV (164 (136;167) vs. 137 (130;143) ml, p=0.03); ESV (70 (69;75) vs. 46 (39;54), p=0.004). EF was also significantly lower in the AF recurrence subgroup: 52 (52;52.7) vs. 58.5 (57;60)%, at p=0.01.

Among the most important potential categorical predictors, a single-factor analysis was performed to estimate the odds ratio and 95% confidence interval (95% CI). The results are presented in Table 5.

Based on these data, we concluded that the predictor with the greatest influence on the development of AF in the paroxysmal AF group was the fact of arrhythmia recurrence in the hospitalization after surgery - odds ratio (OR) 10.25; 95% confidence interval (CI) 1.53-68.62, p=0.034. In the nonparoxysmal arrhythmia group, only duration of history of AF was a significant predictor of recurrence of AF - OR 8.8; 95% CI 1.01-76.1, p=0.020.

Among several echocardiographic parameters for which reliable differences between subgroups were obtained, logistic regression analysis was performed with the construction of a prognostic model for the onset of recurrent AF. Among the identified quantitative predictors (LA size, LA area, LA volume, indexed LA volume, LV amplitude, and RA area), factors such as LA size (OR 2.2; p=0.04) and indexed LA volume (OR 1.32; p=0.047) showed significant influence in the paroxysmal AF group

ROC analysis allowed to determine the cutoff point, which shows the optimal separating value of the parameter, exceeding which indicates a high risk of AF recurrence at a distant stage after surgery. With a prediction sensitivity of 83.3%, the specificity was 72.7%. the cutoff point for the «LA size» parameter was 48.5 mm. For the indexed LA volume with a sensitivity of 85.7% and specificity of 90%, the cutoff point was 44.4 mL/m^2.

To objectivize the use of the obtained prognostic models of risk factors, ROC curves were constructed (Fig. 5). The AUC for LA size was 0.932; 95% CI 0.809-1.00, p=0.004, and for indexed LA volume was 0.914; 95% CI 0.776-1.00, p=0.005.

In the group of nonparoxysmal AF, after analyzing such factors as EDD, EDV, ESD, ESV, right ventricular inflow tract, and ejection fraction, a prognostic model consisting of only one predictor, LV EDV, was obtained (OR 1.1; p=0.043). To assess the sensitivity and specificity of the obtained model, ROC analysis with curve plotting was also performed. With a prediction sensitivity of 77.8%, the specificity was 100%. The cut off point for the parameter «LV EDV» was 150 ml. The area under the curve (AUC) was 0.858; 95% CI 0.667-1.00, p=0.01, indicating that the quality of outcome prediction considering this parameter is quite high (Fig. 6).

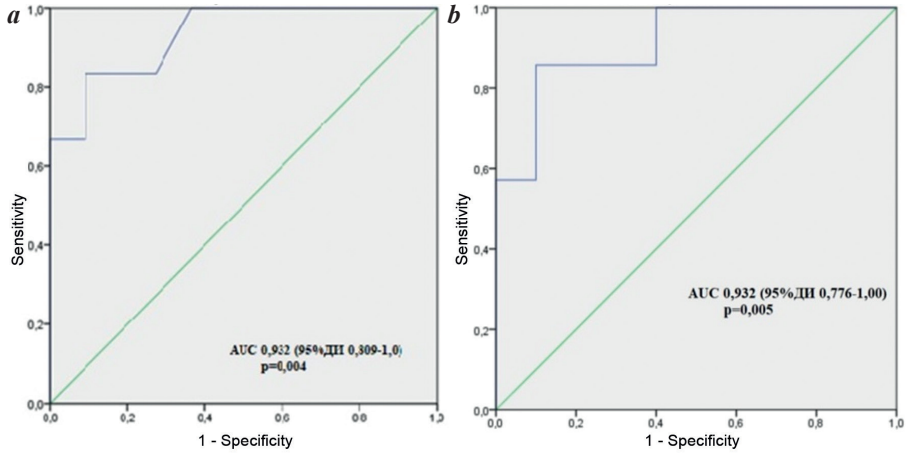

Fig. 5. ROC curves showing the sensitivity and specificity of predicting the outcome of surgery in the paroxysmal AF group based on LA size (a) and indexed LA volume (b).

DISCUSSION

The factors that predict the efficacy of different RFA techniques and assess the risk of recurrent AF remain a matter of debate. Some studies have shown the significance as predictors of a number of clinical and demographic indicators (sex, age, body mass index) [9]. In our work, there was no relationship between the distribution of patients according to sex and age characteristics. There were no significant differences in the nature and degree of coronary lesions, as well as in the volume

of revascularization, which allows us to exclude the influence of the heart failure factor on the results obtained in our work.

Quite often the form of arrhythmia is considered as risk factors. It is generally accepted that patients with persistent and long-term persistent form of AF are more likely to have recurrences after surgery and, in general, the results of treatment of this group of patients are somewhat worse than the results of treatment of patients with paroxysmal AF. Thus, J.Kornej et al. (2020) found that the presence of persistent AF is a predictor of distant recurrences of AF after PV RFA [26]. Significant influence of AF form on recurrence in the remote period after surgical ablation was also shown in the study of W.Gu et al (2017) [10]. American colleagues led by R.Damiano also confirmed that patients with nonparoxysmal AF were more likely to have atrial tachycardia and incisional atrial flutter after Maze IV surgery than patients with paroxysmal AF (308/513 (60.0%) vs. 177/340 (52.1%), p=0.024 [7]. On the other hand, there are papers in the literature that show that the presence of persistent arrhythmia before surgery did not significantly increase the risk of recurrence compared with patients with paroxysmal arrhythmia [11, 12]. In our work, the factor of arrhythmia form was used as the main criterion for dividing patients into groups - paroxysmal and nonparoxysmal AF.

We analyzed the parameters of the course of the hospital period and found that in the paroxysmal AF group, rhythm disruption in the hospital period was associated with arrhythmia recurrence and at the distant stage: OR 10.25; 95% CI 1.53 - 68.62, p= 0.034. Similar findings were reported in a study by McGilvray et al (2021). In this study, paroxysms of AF during hospitalization after isolated IV Maze surgery were associated with late recurrence, OR 2.06; 95% CI 1.06- 4.00, p=0.033 [13].

An association between antiarrhythmic therapy and distant arrhythmia recurrence has been demonstrated in some observational series. In our work, we did not identify such a correlation. In part, this may be due to heterogeneous data regarding the timing and duration of postoperative antiarrhythmic therapy, which in most cases was determined by the cardiology service at the patients' place of residence.

The duration of arrhythmia is often recognized by many authors as a strong predictor of recurrence of AF. The fact that patients with long-standing arrhythmias have certain structural changes in atrial tissue, due to chamber remodeling and fibrosis, which contribute to changes in their electrophysiologic properties, may be a logical assumption. We found significant differences by arrhythmia history for the group of nonparoxysmal AF. Patients with recurrence at a remote stage had a longer history of AF compared to patients who had a correct rhythm at a remote stage: 96 (48;114) and 36 (12;108) months, respectively (p=0.04). Single-factor analysis also established the influence of arrhythmia duration on the risk of developing recurrence at a distant stage (OR 8.8 (95% CI 1.01- 76.1), p=0.04. Similar results were reported by Z.Peng et al (2022) [14].

Q.Hu et al (2014) found in a cohort of patients who underwent bipolar PV RFA that a 31.5-month history of AF was associated with a 3.67-fold higher chance of recurrent AF in the long-term [15]. M.S.Takagaki et al (2019), by performing multivariate logistic regression analysis, showed that 98% of patients after Labyrinth IV surgery with a history of AF of less than 5 years remained without arrhythmia recurrence at a distant stage [16]. In a study by McGilvray et al (2021), a long history of AF was also associated with an increased risk of recurrent AF - OR 1.92; 95% CI 1.16-3.17, p=0.011 [13].

The persistence of AF by the end of the hospitalization period is often noted as a potential risk factor. It is important to note that after Labyrinth V surgery, all patients in the group of paroxysmal AF had a correct rhythm by discharge, which, on the one hand, once again demonstrates the effectiveness and safety of Labyrinth V surgery in this group, but on the other hand, did not allow using this parameter for single-factor analysis. In the nonparoxysmal AF group, we found no significant relationship between the persistence of arrhythmia at the time of discharge and distant recurrences.

Many researchers have highlighted the presence of various changes in the heart chambers associated with the presence of AF, which could subsequently influence the outcomes of surgical treatment for this arrhythmia.

Several studies have shown a significant effect of LA size, LA volume, LV volume indexed to body surface area (LAVI), LA parameters, and LVEF [17]. LA size serves as one simple indicator of structural remodeling of the heart in AF and remains currently a widely accepted prognostic factor for arrhythmia recurrence after Maze IV surgery [7, 18,19].

In our work, we found that in the paroxysmal AF group, patients with arrhythmia recurrence at the remote stage had significantly larger AF size compared to patients without recurrence - 50 (49.2;50) vs. 45 (43;46) mm, (p=0.033). In the nonparoxysmal arrhythmia group, LA size was also higher in patients with recurrent AF, 48

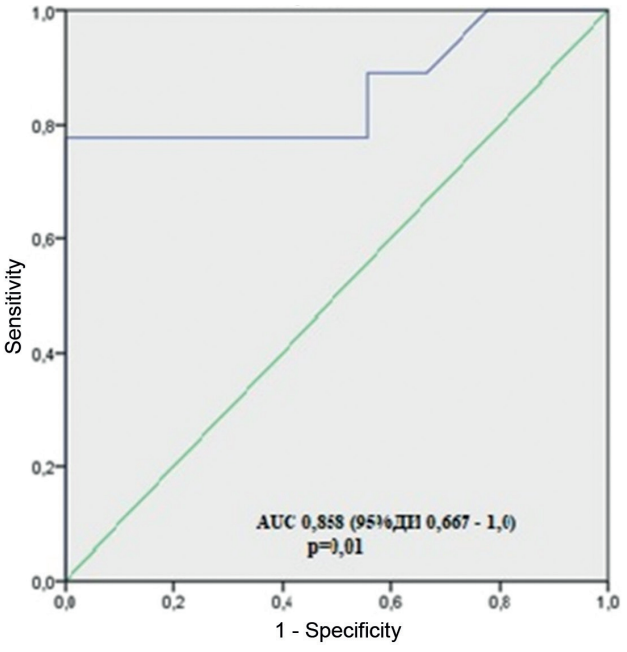

Fig. 6. ROC curve showing sensitivity and specificity of outcome prediction in the nonparoxysmal AF group based on left ventricular end-diastolic volume.

(47; 50) versus 42 (40; 48), however, only a statistical trend was obtained (p=0.07). Regression analysis with the construction of a prediction model found that patients with enlarged LA size had a 2.2-fold greater chance of recurrent AF than patients with normal size. ROC analysis showed that the threshold value above which patients had a high risk of rhythm disruption in AF was 48.5 mm. Indexed LA volume in intergroup comparisons was higher in patients with arrhythmia recurrence and was associated with 1.34-fold increased odds. The threshold value of indexed LA volume at which the risk of AF increased was 44.4 ml/m^2 in our study.

Similar results were obtained in a study by M.Kranert et al (2020). According to the ROC-analysis in the mentioned work, the LA size more than 41 mm and indexed LA volume more than 36 ml/m^2 were defined as limit values, above which the risk of AF recurrence was sharply increased in patients [17]. ROC analysis in a study by Z.Peng et al. (2022) also showed that an increase in LA size above 43.5 mm (OR 1.115, p<0.001; AUC 0.722 (95% CI: 0.664-0.779) was associated with a higher incidence of late recurrent AF [13]. Data from nine studies (1425 patients) from the A.Njoku meta-analysis evaluating LAVI showed that patients with recurrent AF had a higher mean LAVI compared to patients without recurrence (OR 0.596; 95% CI 0.305-0.888) [25].

In our work, in the group of nonparoxysmal AF patients with arrhythmia recurrence were characterized by significantly lower LV ejection fraction, higher EDV, ESD, and larger LV dimensions relative to patients with sinus rhythm. There was also a trend in the increase in size, volume and area of the LA in these patients. ROC analysis found that patients with LV volumes greater than 150 mL were significantly more likely to have late recurrences of AF. In the literature, a number of studies have noted the mutual influence of LA characteristics and function on linear-volume parameters of LV and showed their relationship with the development and existence of AF. P.Jaïs et al. (2000) found a correlation between the increase in LV diastolic pressure and the frequency of recurrence of non-valvular AF, which may indirectly indicate the influence of LV diastolic dysfunction on arrhythmia recurrence [20]. J.A.Dodson et al. (2014) examined 346 patients with AF who underwent PV magnetic resonance mapping before RFA and found a strong correlation between decreased LA passive emptying function and recurrent AF after surgery [21].

In conclusion, our data reaffirm the notion that processes of heart chamber remodeling, occurring for various reasons, including aging of the organism and heart dysfunction in the context of chronic diseases, play a significant role in the recurrence of AF after surgical treatment [22, 23].

Cardiac remodeling against the background of long-standing arrhythmia causes an increase in LV dimensions and end-diastolic volume with diastolic and systolic dysfunction [24]. The obtained results allow us to suggest that LA size and indexed LA volume as possible predictors of the recurrence of AF are of greater importance for the paroxysmal form, while for patients who underwent a transition to the nonparoxysmal form of AF the linear-volume characteristics of LA and LV are of primary importance, and, as it was established in our work, in particular, EDV, which reflect the correlation with the degree of progression of arrhythmogenic cardiomyopathy occurring in this cohort of patients.

Limitations of the study

A limitation of the study conducted is its single-center retrospective character.

CONCLUSION

Predictors of AF recurrence in the paroxysmal AF group according to our study were arrhythmia recurrence in the hospital period after surgery, LA size >48.5 mm, and indexed LA volume >44.4 mL/m^2. Predictors of AF recurrence in the nonparoxysmal AF group were a long history of arrhythmia and LV EDV >150 mL.

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