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Influence of Left Atrium Volume Index on effectiveness of Thoracoscopic Ablation in the Treatment of Atrial Fibrillation

© **Amiran Sh. Revishvili[1], Madina Kadirova[1], Vadim A. Popov[1], Egor S. Malishenko[1], Grigory G. Karmazanovsky[1], Elizaveta D. Strebkova[2]*, Vadim S. Shirokov[1], Maxim A. Novikov[1], Eugenia V. Yalova[1], Irina A. Taimasova[1]**

[1] A.V. Vishnevsky National Medical Research Center of Surgery of the Ministry of Healthcare of the Russian Federation; 27, Bol'shaya Serpukhovskaia str., Moscow, 117997, Russian Federation

[2] Russian Medical Academy of Continuous Professional Education of the Ministry of Healthcare of the Russian Federation; 2/1 bld. 1, Barrikadnaya str., Moscow 125993, Russian Federation

Research objective: establish the impact of Left Atrium Volume Index (LAVI) on on effectiveness of Thoracoscopic Ablation (TSA) in the Treatment of Atrial Fibrillation (AF) and define the risk factors for manifestation of supraventricular arrhythmias in the long-term follow-up results

Methods. Prospective cohort study of 121 patients with AF (from 2018 to 2021) who performed TSA. The patients were divided into two groups: patients with increased LAVI (group I), patients with normal LAVI less than 34 ml/m^2 (group II).

Results. According to echocardiography, the mean LAVI was 45.48 ± 9.3 ml/m^2 and 28.59 ± 4.13 ml/m^2 in groups I and II, respectively (p = 0.012). The mean value of left ventricular ejection fraction (LVEF) according to Teicholz in group I was 61.62 ± 7.041%, in group II 63.57 ± 6.16% (p = 0.8). Spearman's correlation analysis showed the relationship between LAVI and LVEF before surgery and in the long-term follow-up period, that is agreed with world literature data about contribution left atrial (LA) to left ventricular (LV) function. According to our study, only LAVI < 34 ml/m^2 is a risk factor for arrhythmia after TSA. Effectiveness TSA in I group was 77.8%, that is lower than the II group – 88.9%. 3 months after TSA, 20 (17%) patients were required catheter ablations (CA), mainly in I group.

Conclusions. Research results showed that an increase in LAVI significantly reduces the effectiveness of TSA in the long-term period by 11.1% compared with LAVI < 34 ml/m^2. That are conform with other data of previously submitted works.

Keywords: left atrial volume index (LAVI), atrial fibrillation (AF), thoracoscopic ablation (TSA)

Conflict of interest. The authors declare no conflict of interest. The study had no sponsorship.

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Влияние индексируемого объема левого предсердия на эффективность торакоскопического лечения фибрилляции предсердий

© Ревишвили А.Ш.[1], Кадырова М.[1], Попов В.А.[1], Малышенко Е.С.[1], Кармазановский Г.Г.[1], Стребкова Е.Д.[2]*, Широков В.С.[1], Новиков М.А.[1], Ялова Е.В.[1], Таймасова И.А.[1]

[1] ФГБУ “Национальный медицинский исследовательский центр хирургии им. А.В. Вишневского” Минздрава России; 117997 Москва, ул. Большая Серпуховская, д. 27, Российская Федерация

[2] ФГБОУ ДПО “Российская медицинская академия непрерывного профессионального образования” Минздрава России; 125993, Москва, ул. Баррикадная, д. 2/1, стр. 1, Российская Федерация

Цель исследования: установить влияние индексируемого объема левого предсердия (LAVI) на эффективность торакоскопической аблации фибрилляции предсердий (ФП) (ТА ФП) и определить факторы риска развития наджелудочковых нарушений ритма в отдаленном периоде наблюдения.

Материал и методы. Проведено проспективное когортное исследование 121 больного с ФП (с 2018 по 2021 г.), которым была выполнена ТА ФП. Пациенты были разделены на две группы: в I группу были включены пациенты с увеличенным LAVI, во II группу – пациенты с нормальным LAVI менее 34 мл/м².

Результаты исследования. По данным эхокардиографии средний показатель LAVI составил 45,48 ± 9,3 мл/м² и 28,59 ± 4,13 мл/м² в I и II группах соответственно (p = 0,012). Среднее значение ФВ ЛЖ по Тейхольцу в I группе было 61,62 ± 7,041%, во II группе 63,57 ± 6,16% (p = 0,8). Корреляционный анализ по Спирмену показал взаимосвязь между LAVI и ФВ ЛЖ как до операции, так и в отдаленном периоде наблюдения, что согласуется с данными мировой литературы о вкладе ЛП в работу ЛЖ. Согласно нашему исследованию, только LAVI >34 мл/м² является фактором риска развития аритмии после ТА ФП. В группе I эффективность ТА ФП составила 77,8%, что существенно ниже показателей восстановления синусового ритма по сравнению со II группой – 88,9%. Через 3 мес после операции потребовалось выполнение 20 (17%) дополнительных катетерных аблаций, преимущественно у пациентов I группы.

Заключение. Данные нашего исследования показали, что увеличение LAVI достоверно снижает эффективность ТА ФП в отдаленном периоде на 11,1% по сравнению со II группой при LAVI < 34 мл/м². Полученные результаты согласуются с данными ранее представленных работ.

Ключевые слова: индексируемый объем левого предсердия (LAVI), фибрилляция предсердий (ФП), торакоскопическая аблация фибрилляции предсердий (ТА ФП)

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Atrial fibrillation (AF) is the most common arrhythmia, the prevalence in the population is on average 0,4–2% [1, 2]. Number of patients with AF will double by 2050 [3].

AF is associated with high risks of thromboembolic events (12-31% of all ischemic strokes), heart failure (2.9-26%) and significantly reduces the quality of life of patients [4]. Progression of arrhythmia leads to remodeling of the chambers of the heart, in particular the left atrium (LA).

Patients with symptomatic AF and refractory to drug therapy are recommended to perform catheter ablations (CA) and/or Maze procedures [5, 6]. However, the effectiveness of CA decreases with the progression of AF from 80 to 60%, and during the 10-year follow-up period is 52% [7, 8, 9].

The surgical strategy for the treatment of non-paroxysmal AF, presented by the Cox-Maze IV procedure and its modifications, demonstrates the best results in the early and long-term period with freedom from AF up to 93%, remaining the "gold standard" of treatment [10, 11, 12, 13]. Early number of previously published studies have shown that an increase in the size of the LA can affect the effectiveness of the Maze procedure [14, 15, 16, 17].

In the current recommendations of the American Echocardiography Society (ASE) and the European

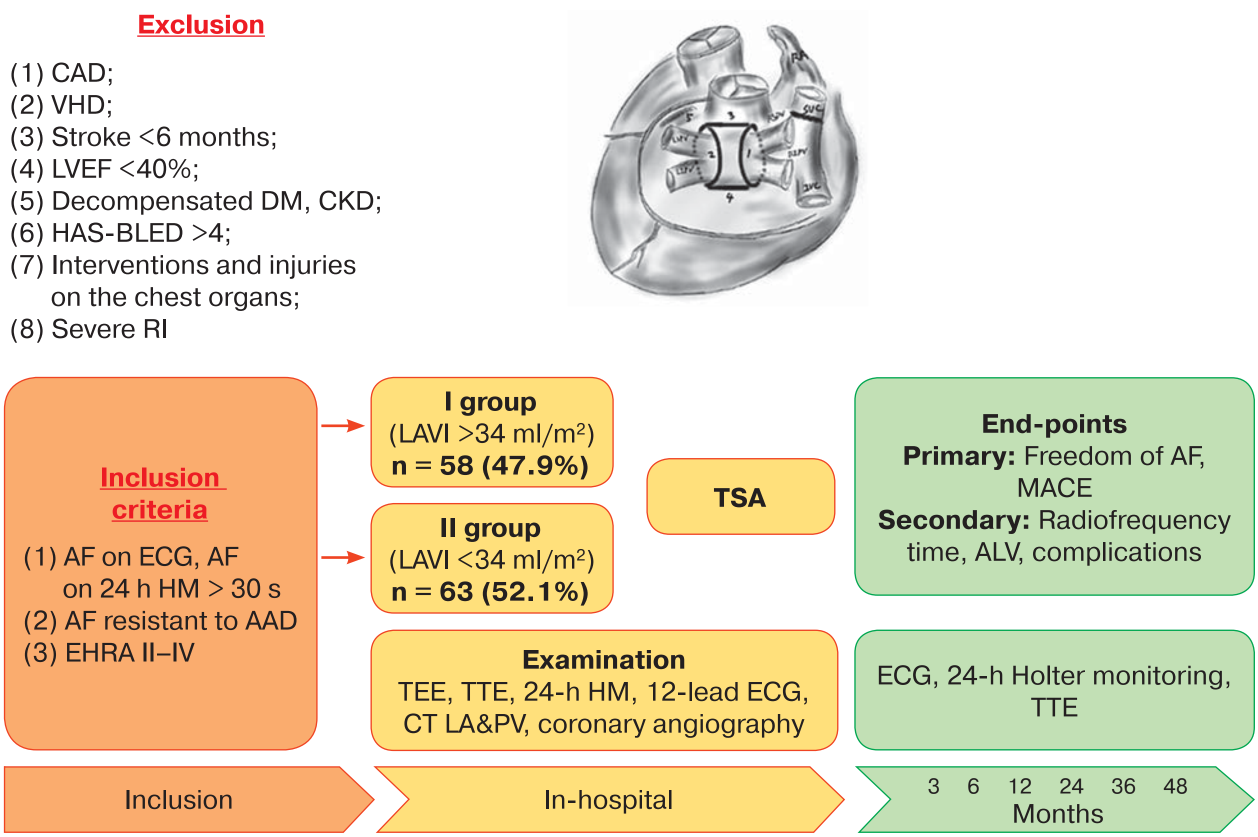

Fig. 1. Study design.
Рис. 1. Дизайн исследования.

Association of Specialists in Cardiovascular Imaging (EACVI), it is proved that LA remodeling is better evaluated using left atrial volume index (LAVI) [15, 18]. LAVI is the most accurate indicator of stratification of the risk of adverse cardiovascular events [6, 19]. Increased LA increases the propensity to AF as a consequence of structural remodeling of the atrium due to fibrosis and deposition of extracellular matrix proteins [20, 21].

Despite the high efficiency of surgical treatment of progressive forms of AF, these procedures are highly traumatic and involve a high risk of perioperative complications, which is undesirable for patients with isolated AF, and therefore epicardial ablation methods using endovideosurgical equipment have been introduced into clinical practice. Thoracoscopic ablation (TSA), as an isolated procedure, demonstrated promising results, with 65-96% free of AF [22, 23, 5, 21]. The influence of LA size on TSA has not yet been studied [24].

The purpose of this study was to establish the influence of LAVI on effectiveness of TSA of AF and determine the risk factors for manifestation of supraventricular arrhythmias in the long-term follow-up results.

Methods

Study population

Prospective cohort study enrolled 121 consecutive patients performed TSA with drug-refractory AF at A.V. Vishnevskiy National Medical Research Center of Surgery (Moscow, Russia) between 2018 to 2021.

All patients were divided into two groups: group I included patients with LAVI > 34 ml/m², group II patients with LAVI ⩽ 34 ml/m² [18].

Before surgery was performed examinations: transesophageal echocardiography (TEE), transthoracic echocardiography (TTE), 24-hours holter monitoring of electrocardiogram (24-h HM ECG), 12-lead electrocardiogram (ECG), multispiral computed tomography using radiocontrast left atrium and ostium pulmonary veins (MCT LA and PV), coronary angiography.

In the postoperative period, the patient was interviewed by phone, TTE, 24-h HM ECG, 12-lead ECG after 6, 12, 24, 36 and 48 months.

Design study is shown in Fig. 1.

Inclusion criteria: (1) symptomatic AF registered on ECG, 24-h HM ECG (even with a single paroxysm of AF lasting longer than 30 seconds); (2)

drug-refractory AF; (3) mEHRA II-IV (modification European Heart Rhythm Association symptom classification for AF).

Exclusion criteria: (1) coronary artery disease (CAD); (2) valvular heart disease (VHD); (3) Stroke/TIA (transient ischemic attack) < 6 months; (4) left ventricular ejection fraction (LVEF) < 40%; (5) decompensated diabetes mellitus (DM); (6) HAS-BLED > 4 (Hypertension [H], Abnormal renal-liver function [A], Stroke [S], Bleeding history or predisposition [B], Labile international normalized ratio [L], Elderly (65 years) [E], Drugs or alcohol concomitantly [D]); (7) decompensated chronic kidney disease (CKD); (8) interventions and injuries on the chest organs; (9) severe respiratory failure (RI).

Follow-up

All patients were followed up at 3 months, 6 months, and every 6 month thereafter. At each visit, 12-lead ECG or 24-h Holter monitoring ECG was performed to evaluate rhythm and atrial activity. Recurrence was defined as symptomatic or asymptomatic episodes of AF lasting longer than 30 seconds and identified on 12-lead ECG or 24-h Holter monitoring ECG after a blanking period of 3 months (HRS/EHRA/ECAS guidelines) [17]. Antiarrhythmics drugs (AADs) were discontinued at 6 months or up to 12 months.

The main adverse cardiovascular events (MACE) in the early and long-term follow-up result were also taken into account.

Surgery ablation technique

Procedures were performed thoracoscopically under general anaesthesia with sequential single lung ventilation using either a double-lumen tube or bronchial blocker. Patients were positioned supine.

The features of the modified TSA technique suggested in our center are the provision of simultaneous bilateral approaches and electrophysiological control of bidirectional block. In case of incomplete isolation, the possibility of applying additional ablution set critical points remains. This makes it possible to complete the creation of a “Box lesion” along the back wall of LA with high reliability.

Right-sided and left-sided stages of the operation were represented by performing isolation of the pulmonary veins (PVs) with a bipolar electrode for 10 ablations with a gradual displacement of the branches to increase the isolation zone and the formation of the upper and lower lines of LA with a monopolar electrode (Fig. 2, 3). When registering a signal from superior vena cava (SVC), additional ablation was performed using a bipolar electrode (Fig. 4).

Exclusion of left atrium appendage (LAA) is performed from the left-sided access using an endospler (Fig. 5–7).

An electrophysiological study was performed intraoperatively, the transmurality and achievement of bidirectional block of conduction through the ablation lines (exit and entrance block) were estimated. With the help of high-frequency stimulation, the start of AF was caused, its spontaneous blocking within 30 seconds was considered the norm. When registering a stable AF at the end of the procedure, electropulse therapy was performed.

Left atrial volume index

Compliance with the clinical guidelines on imaging methods of the cardiovascular system (EACVI), asymmetric LA remodeling is more accurately evaluated when measuring its volume. LA volume varies throughout the cardiac cycle.

Measurement of LA volumes can be performed by many methods, but two are used in clinical practice. The first is the calculation of the LA area along the long axis from the four-chamber and two-chamber positions, after which calculations are made using a special formula.

Considering that AF was registered in many patients included in the study at the time of the TEE study, we performed LAVI measurements using the Simpson’s method [18]. This measurement is carried out similarly to the measurement of left ventricle (LV) volumes, in 2D echocardiography mode from apical access. At the same time, the mouths of PVs and LAA should be excluded from the measurements. ACE/EACVI specialists recommend indexing LA volumes to body surface area (BSA) [18, 19]. For an accurate assessment of LA, it is necessary to obtain 3 main volume indicators. The maximum LA size at the end of the LV isovolumic relaxation phase before the opening of the mitral valve is the measurement point of the maximum LA volume. The minimum LA volume is measured at the end of the LV diastole when mitral valve closes. The presystolic LA volume (mean LA volume) is measured before the atrial systole (before the P wave on the ECG).

Normal LAVI values are considered 22 ± 6 ml/m^2. LA dilatation is defined as LAVI>28 ml/m^2 (one standard deviation from the mean value), however, to determine LV diastolic dysfunction, a value of LAVI > 34 ml/m^2 (two standard deviations from the mean) is proposed as the upper bound [22, 25, 19]. The ASE/EACVI recommendations indicate that the upper limit of the LAVI norm is 34 ml/m^2 [18]. Method of measuring the volume of LA with PVs using MCT was similar in the previously published work of M Sangsriwong et al. [16].

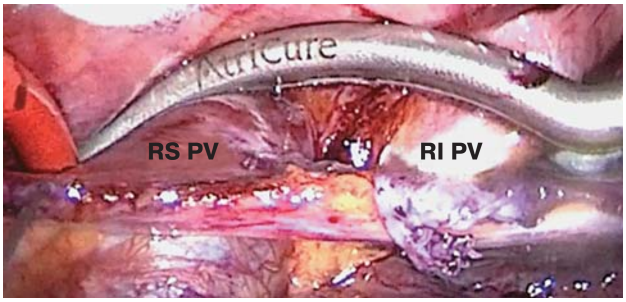

Fig. 2. Radiofrequency ablation of the right pulmonary veins (intraoperative photo).

Рис. 2. Радиочастотная аблация устьев легочных вен справа (интраоперационная фотография).

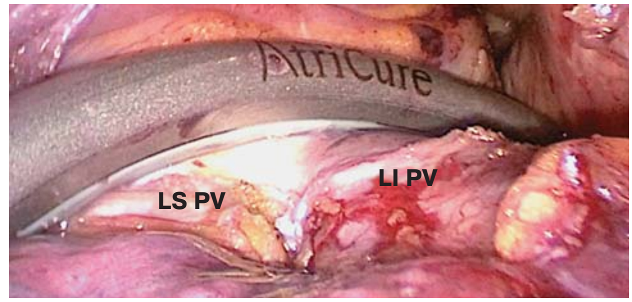

Fig. 3. Radiofrequency ablation of the left pulmonary veins (intraoperative photo).

Рис. 3. Радиочастотная аблации устьев легочных вен слева (интраоперационная фотография).

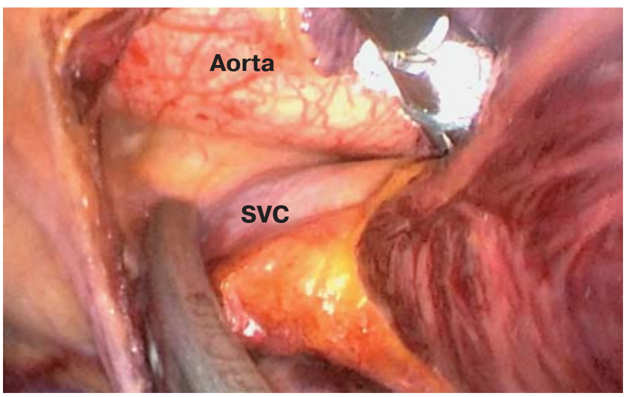

Fig. 4. Line of ablation of the superior vena cava using a bipolar electrode (intraoperative photo).

Рис. 4. Линия аблации верхней полой вены с применением биполярного электрода (интраоперационное фото).

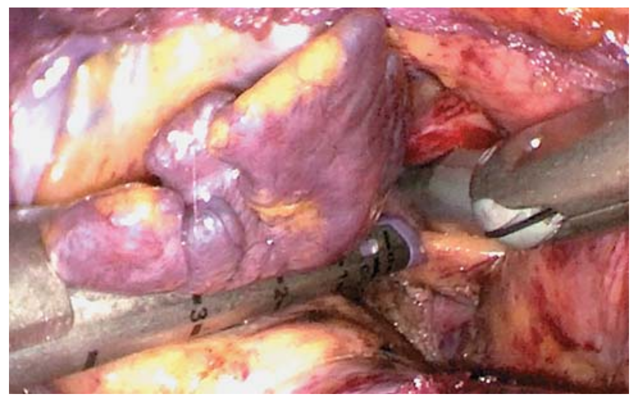

Fig. 5. Exclusion of the left atrial appendage using endostapler (intraoperative photo).

Рис. 5. Ампутации ушка левого предсердия эндостеплером (интраоперационное фото).

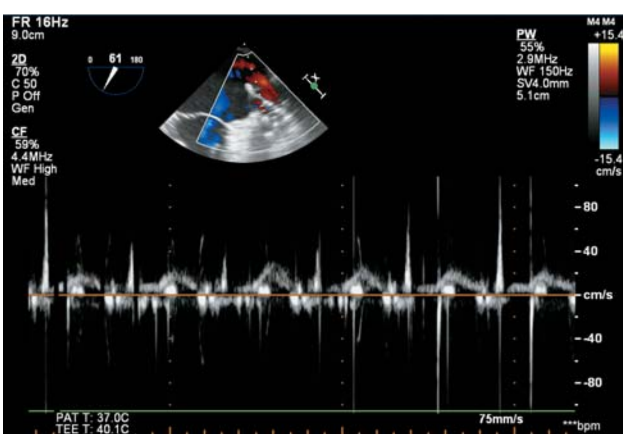

Fig. 6. Intraoperative transoesophageal echocardiographic before exclusion of the left atrial appendage, blood flow velocity in the left atrial appendage.

Рис. 6. Интраоперационная чреспищеводная ЭхоКГ до ампутации ушка левого предсердия, оценка скорости кровотока в ушке левого предсердия.

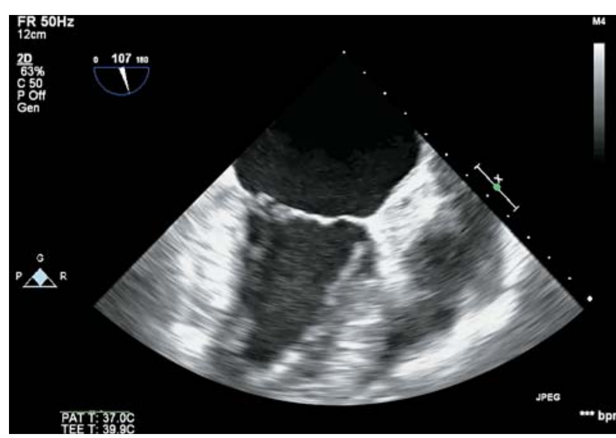

Fig. 7. Intraoperative control transoesophageal echocardiographic after exclusion of the left atrial appendage.

Рис. 7. Интраоперационная контрольная чреспищеводная ЭхоКГ после ампутации ушка левого предсердия.

Statistical analysis

Statistical data processing was carried out using the built-in Excel 2016 spreadsheet processor analysis package and the SPSS 24.0 spreadsheet application package.

Descriptive statistics are represented by arithmetic averages (M) ± standard deviation (SD).

When assessing the statistical reliability of differences (p) in groups for quantitative features (with normal distribution), a comparison of averages (M) was used using parametric criteria – the Student's two-sample t–criterion - homoscedastatic with equal variances, heteroscedastic with inequality (variance difference was evaluated using the Fisher criterion (F-test), in the absence of a normal distribution, U-the Mann-Whitney criterion. The differences were considered significant at a significance level of $p < 0.05$.

Correlation analysis was carried out using Spearman rank correlation coefficient, the values were considered significant at $p < 0.05$.

Results

All patients in the two groups were comparable in terms of the main clinical parameters: age, gender, and concomitant diseases. The AF duration prevailed in the group of patients with LAVI > 34 ml/m² 6.71 ± 3.14 y, compared 5.41 ± 5.19 y in group with normal LAVI (p = 0.062). Baseline characteristics and examinations data are shown in Table 1 and Table 2.

Table 1. Baseline characteristics (n=121)

Таблица 1. Основные клинические характеристики пациентов до торакоскопической аблации

Variables	LAVI > 34 ml/m² n = 58 (47,9%)	LAVI normal n = 63 (52,1%)	p-value
Age, y (mean ± SD)	57.95 ± 8.45	56.83 ± 9.28	0.526
Sex, n (%):			
male	39 (67.2)	41 (65.1)	0.803
female	19 (32.8)	22 (34.9)	0.683
AF duration, y (mean ± SD)	6.71 ± 3.14	5.41 ± 5.19	0.062
Type AF, n (%):			
paroxysmal	20 (34.5)	29 (46)	0.221
persistent	14 (24.1)	13 (20.6)	0.178
long-standing persistent	24 (41.4)	21 (33.3)	0.23
mEHRA, n (%):			
II	10 (17.2)	11 (17.5)	0.954
III–IV	48 (82.7)	46 (73)	0.834
Hypertension, n (%)	45 (77.6)	52 (82.5)	0.497
Stages of congestive heart failure, n (%):			
I	33 (56.9)	45 (71.4)	0.91
IIa	13 (22.4)	10 (15.9)	0.923
Classes of heart failure (NYHA), n (%):			
2	43 (74.1)	50 (79.4)	0.276
3	3 (5.2)	5 (7.9)	0.182
Stroke / TIA, n (%)	4 (6.9)	7 (11.1)	0.411
CHA2DS2-VASc, n (%):			
0–1	22 (37.9)	18 (28.5)	0.511
⩾2	36 (62.1)	45 (71.5)	0.782
HAS-BLED, n (%):			
0–1	50 (86.2)	53 (84.1)	0.17
⩾2	8 (13.8)	10 (15.9)	0.16
Previous catheter ablation, n (%)	12 (20.6)	26 (41.2)	**0.014***
Antiarrhythmics drugs, n (%)	58 (100)	63 (100)	0.268
Anticoagulants, n (%):			
NOAC	38 (65.5)	49 (77.8)	**0.04***
warfarin	13 (22.4)	6 (9.5)	**0.04***

Note. AF – atrial fibrillation; mEHRA – modification European Heart Rhythm Association symptom classification for atrial fibrillation; NYHA – New York Heart Association Functional Classification; TIA, transient ischemic attack; CHA2DS2 –VASc, congestive heart failure [C], hypertension [H], age > 75 years (2 points) [A2], diabetes [D], previous stroke (2 points) [S2], vascular disease [V], age 65–74 years [A], female sex [Sc]; HAS-BLED, Hypertension [H], Abnormal renal-liver function [A], Stroke [S], Bleeding history or predisposition [B], Labile international normalized ratio [L], Elderly (65 years) [E], Drugs or alcohol concomitantly [D]; NOAC – new oral anticoagulant; y – year.

Table 2. Instrumental research characteristics (n = 121)

Таблица 2. Данные инструментальных методов исследования до торакоскопической абляции

Variables	LAVI > 34 ml/m² n = 58	LAVI normal n = 63	p-value
Transthoracic echocardiography			
Volume LA, ml (mean ± SD)	94.41 ± 21.4	58.9 ± 9.8	**0***
LAVI, ml/m² (mean ± SD)	45.48 ± 9.3	28.59 ± 4.13	**0.012***
MR, n (%):			
0	9 (15.5)	5 (8.0)	0.194
mild	49 (84.5)	58 (92.0)	0.119
LVEF, % (mean ± SD)	61.62 ± 7.041	63.57 ± 6.16	0.8
X-ray computed tomography using radiocontrast			
LA&PV VI, ml/m² (mean ± SD)	76.63 ± 20.31	69.48 ± 16.45	**0,01***

Note. LA – left atrium; BSA, body surface area; LAVI – left atrium volume index to BSA; MR – mitral regurgitation; LVEF – left ventricular ejection fraction; LA&PV VI – left atrium and ostium pulmonary veins volume index to BSA.

Table 3. Procedure characteristics (n =121)

Таблица 3. Характеристика интра- и послеоперационного периода

Variables	LAVI > 34 ml/m² n = 58	LAVI normal n = 63	p-value
Sinus rhythm at start of procedure, n (%)	16 (27.5)	24 (38.1)	0.119
Intraoperative sinus conversion, n (%)			
surgical lesion right	4 (6.9)	7 (11.1)	0.617
surgical lesion left	4 (6.9)	3 (4.8)	0.422
Cardioversion	37 (63.8)	1 (1.6)	0.08
SVC circular ablation, n (%)	4 (6.9)	0 (0)	0.617
Radiofrequency time, min (mean ± SD)	127.28 ± 26.65	123.59 ± 23.95	0.425
Sinus rhythm at end of procedure, n (%)	52 (89.7)	57 (90.5)	**0.039***
ALV time, min (mean ± SD)	719.66 ± 464.05	617.41 ± 535.0	0.112
Effusion by pleural drains, ml (mean ± SD)	191.55 ± 105.88	229.37 ± 150	0.528

Note. SVC – superior vena cava; ALV – Artificial Lung Ventilation.

No correlation was established between the history of AF duration and LAVI.

Before surgery the differences in the groups were in previous catheter ablations (CA) and anticoagulants.

The distribution of type AF in the groups is presented in Table 1, patients with non-paroxysmal AF prevailed in two groups ($p > 0.05$).

The average value of LVEF (Teicholz method) in I group was 61.62 ± 7.041%, in II group 63.57 ± 6.16% ($p = 0.8$). The LAVI according to TTE data in group I was 45.48 ± 9.3 ml/m² compared to 28.59 ± 4.13 ml/m² in group II ($p = 0.212$), whereas according to MCT using radiocontrast LA and PVs was 94.41 ± 21.4 ml/m² and 58.9 ± 9.8 ml/m², in I and II groups, respectively ($p = 0.473$).

Spearman rank correlation coefficient showed that there is a relationship between LAVI and LVEF.

All patients underwent bilateral isolation of the PVs, excepted of 1 (1.6%) patient from II group, whom isolation of the left PVs wasn't performed due to a expressed commissural process. Intraoperatively, the sinus rhythm was restored at the right-stage of surgery in 4 (6.9%) and 7 (11.1%), at the left-stage of surgery in 4 (6.9%) and 3 (4.8%) in I and II groups, respectively for patients only with non-paroxysmal AF. Additional VCS circular ablation was performed 4 (6.8%) patients in I group.

At the end of the operation, electrical cardioversion was required in I group – 63.8%, in II group – 1.6% ($p = 0.08$). The sinus rhythm at the end of the procedure in I was 89.7%, in II – 90.5% ($p = 0.039$).

The ventilation time was 719.66 ± 464.05 min and 617.41 ± 535.0 min, blood loss in the early postoperative period was 191.55 ± 105.88 ml and 229.37 ± 150 ml for I and II groups, respectively.

The time of hospitalization was comparable for patients with LAVI > 34 ml/m² was 5.8 ± 4.5 and with a normal LAVI was 5.4 ± 6.2 days ($p = 0.82$) Table 3.

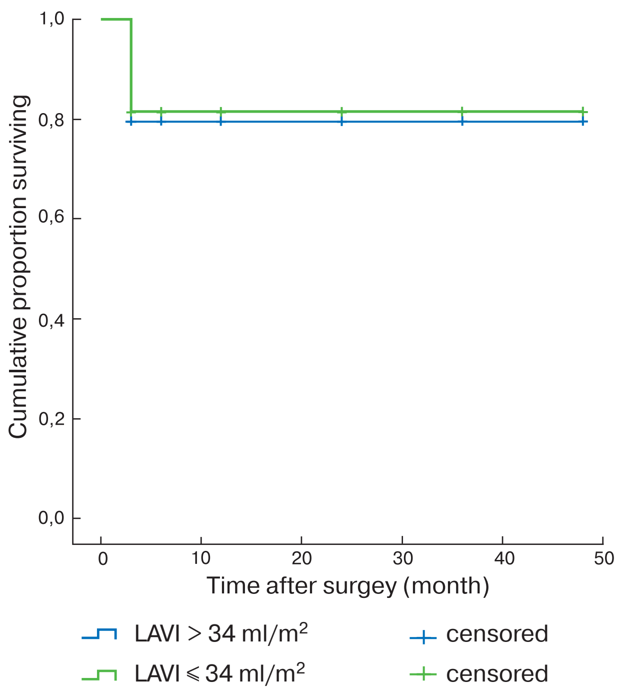

Fig. 8. Kaplan–Meier curve freedom from supraventricular arrhythmias after thoracoscopic ablation.

Рис. 8. Кривая Каплана–Майера свобода от наджелудочковых нарушений ритма после торакоскопической аблации.

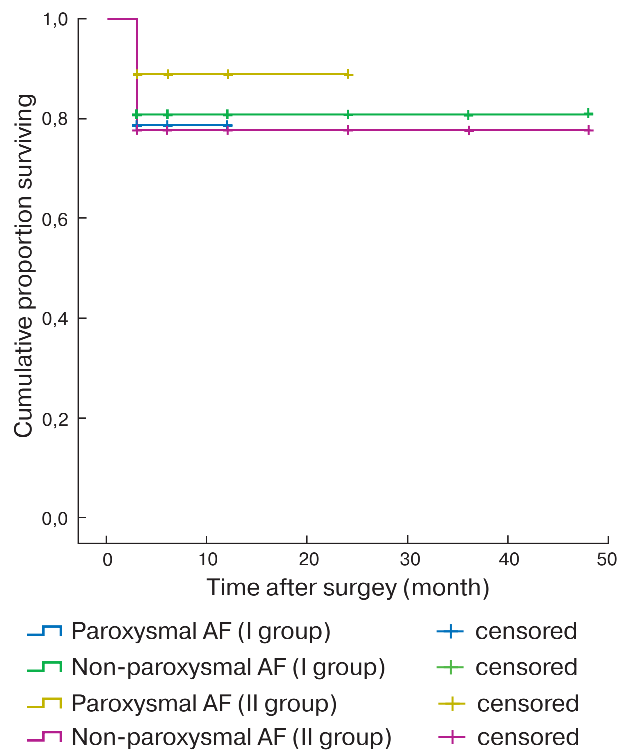

Fig. 9. Kaplan–Meier curve freedom from supraventricular arrhythmias after thoracoscopic ablation for paroxysmal and non-paroxysmal AF.

Рис. 9. Кривая Каплана–Майера свобода от наджелудочковых нарушений ритма после торакоскопической аблации для пароксизмальной и непароксизмальных форм ФП.

Table 4. Predictors for recurrence of atrial tachyarrhythmia
Таблица 4. Факторы, влияющие на эффективность торакоскопической аблации ФП

Variables	Correlation coefficient	p
Sex	–0.03	0.742
Age	–0.134	0.146
LVEF	0.025	0.798
LAVI	0.122	0.184
LAVI > 34 ml/m^2	**–0.189***	**0.038**
AF duration	0.005	0.959

Note. LVEF – left ventricular ejection fraction; LAVI – left atrium volume index to BSA; AF – atrial fibrillation. * Correlation is significant at the level of 0.01 (pair correlation).

Follow-up

At the follow–up of 36 months the freedom from atrial arrhythmia was 80.8% in I group (for non-paroxysmal AF 78.6% and for paroxysmal AF 88.9%). In II group, sinus rhythm was recorded in 81.5%, mainly in patients with paroxysmal AF – 88.9%, versus 77.8% with non-paroxysmal AF (Fig. 8, 9).

Spearman rank correlation coefficient showed the dependence of sinus rhythm recovery and retention on the LAVI indicator (Table 4). LAVI is the only factor that affects the effectiveness of TSA in our study.

Figure 10 shows a positive correlation between the history of atrial fibrillation (years) and LAVI (ml/m^2) in patients with sinus rhythm in the long-term follow-up period. It is worth noting that it is an increase in the LAVI more than 40 ml/m^2 that may be a risk factor in the return of AF after TSA.

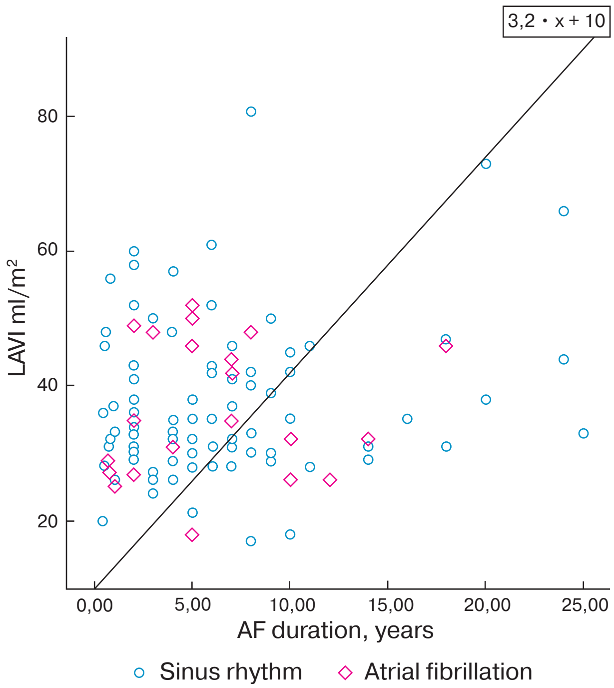

Fig. 10. Linear correlation of LAVI (ml/m²) and history of atrial fibrillation (years) for patients with sinus rhythm and atrial fibrillation in the long-term follow-up period.

Рис. 10. Линейная корреляция LAVI (мл/м²) и анамнеза фибрилляции предсердий (лет) для пациентов с синусовым ритмом и фибрилляцией предсердий в отдаленном периоде наблюдения.

AADs was discontinued after 1 year in 74.4% patients.

The types of recurrent atrial tachyarrhythmia were unevenly distributed (p = 0.07). Recurrence of AF with LAVI > 34 ml/m² was in 7 (12.1%) patients and in 5 (8%) patients with normal LAVI.

Just 3 months after TSA, 20 CA were performed, 6 months later one patient (II group) underwent repeated CA, and another patient (I group) performed CA of arrhythmogenic zones of the right atrium.

Complications

Complications associated with the procedure and MACE were not registering within 30 days after surgery.

Implantation pacemaker device, paralysis diaphragmatic nerve, bleeding in the early postoperative period that required conversion were not registered.

Discussion

The choice of optimal methods for the treatment of various forms of AF remains one of the advanced problems of contemporary arrhythmology. The progression of AF is accompanied not only by clinical manifestations with subsequent deterioration in the quality of life of the patient, but also leads to morphological changes in LA. To date, it has not been studied what is the primary arrhythmia or LA remodeling [12, 35, 26, 27].

According to published data, an increased LAVI worsens the results of CA and surgical treatment of AF. The impact of LAVI on TSA outcomes is presented to date only in the work of J. Neefs et al. [24] in relation to giant LA (LAVI > 50 ml/m²).Therefore interest remains for further study of this problem [28–32].

The ASE/EACVI guidelines indicate that the upper limit of normal for LAVI is 34 ml/m² [24], an increase in this indicator is a predictor of adverse cardiovascular events [7, 22, 3, 29]. All patients included in the study underwent TSA (Figure 1). Before surgery, patients in the two groups were comparable in almost all clinical characteristics (p > 0.05) (Table 1), with the exception of previous CA and anticoagulants (p < 0.05).

According to the TEE the average LAVI was 45.48 ± 9.3 ml/m² and 28.59 ± 4.13 ml/m² in I and II groups, respectively (p = 0.012). The average value of LVEF (Teicholz method) in I group was 61.62 ± 7.041%, in II group 63.57 ± 6.16% (p = 0.8).

Spearman rank correlation coefficient showed that there is a relationship between LAVI and LVEF, that is consistent with the research data on the contribution of LA to LV function [33, 34]. According to our study, only LAVI > 34 ml/m² is a risk factor for arrhythmia after TSA (Table 4). In I group, the effectiveness of TSA was 77.8%, that is significantly lower than the recovery of sinus rhythm compared to II group – 88.9%. 3 months after the TSA, 20 (17%) additional CA were required, mainly in patients of I group [7, 14, 22].

Long-term development of MACE events was not registered in any of the groups, even after discontinuation of anticoagulants and AADs. The findings confirm that LA remodeling and volume expansion reduces the effectiveness of TSA. It is possible that the presence of excess fibrous tissue (more than 20–30%) in the left and right atrium, as well as the presence of epicardial fat in the left atrium, affect the effectiveness of TSA [20, 29, 33, 34]. We will present the results of research in this area in subsequent publications.

Thus, the LAVI score should be taken into account before the CA and the TSA.

Conclusion

Research results showed that an increase in LAVI significantly reduces the effectiveness of TSA in the long-term period by 11.1% compared with LAVI < 34 ml/m². That are conform with other data of previously submitted researches.

Thus, to increase the effectiveness of epicardial ablation, it is necessary to conduct a more detailed study of the parameters of LA.

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Ревишвили А.Ш. – научное редактирование, принятие окончательного решения о готовности рукописи к публикации.

Кадырова М., Попов В.А., Малышенко Е.С., Кармазановский Г.Г. – научное редактирование.

Кадырова М.В., Стребкова Е.Д. – концепция и дизайн, написание текста статьи, сбор и анализ данных, статистическая обработка данных.

Широков В.С., Новиков М.А., Ялова Е.В., Таймасова И.А. – литературный обзор, написание текста статьи, анализ данных.

Все авторы – утверждение окончательной версии для публикации.

Authors' participation

Revishvili A.Sh. – scientific editing, making a final decision on the readiness of the manuscript for publication.

Kadirova M., Popov V.A., Malishenko E.S., Karmazanovsky G.G. – scientific editing.

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All authors – approval of the final version for publication.

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Contact*: Elizaveta D. Strebkova – phone: +7-919-273-67-77. E-mail: elizabeth.strebkova@yandex.ru

Amiran Sh. Revishvili – Academician of the Russian Academy of Science, Doct. of Sci. (Med.), Professor, Director of A.V. Vishnevsky National Medical Research Center of Surgery, Moscow. https://orcid.org/0000-0003-1791-9163

Madina Kadirova – Cand. of Sci. (Med.), Head of the Department of Ultrasound diagnostics of A.V. Vishnevsky National Medical Research Center of Surgery of the Ministry of Healthcare of the Russian Federation, Moscow. https://orcid.org/0000-0001-8231-6866

Vadim A. Popov – Doct. of Sci. (Med.), Professor, Head of the Department of Cardiovascular Surgery of A.V. Vishnevsky National Medical Research Center of Surgery of the Ministry of Healthcare of the Russian Federation, Moscow. https://orcid.org/0000-0003-1395-2951

Egor S. Malishenko – Research Officer, cardiovascular surgery of the Department of Cardiac Surgery of A.V. Vishnevsky National Medical Research Center of Surgery of the Ministry of Healthcare of the Russian Federation, Moscow. https://orcid.org/0000-0002-1572-3178

Grygory G. Karmazanovsky – Academician of the Russian Academy of Sciences, Doct. of Sci. (Med.), Professor, Head of the Radiology Department of Vishnevsky National Medical Research Center of Surgery; Professor of the Chair of Radiology, Pirogov Russian National Research Medical University, Moscow. http://orcid.org/0000-0002-9357-0998. E-mail: karmazanovsky@ixv.ru

Elizaveta D. Strebkova – postgraduate student in cardiovascular surgery of Russian Medical Academy of Continuous Professional Education of the Ministry of Healthcare of the Russian Federation, Moscow. https://orcid.org/0000-0001-5837-7255

Vadim S. Shirokov – radiologist of the Department of Radiology and Magnetic Resonance Research of A.V. Vishnevsky National Medical Research Center of Surgery of the Ministry of Healthcare of the Russian Federation, Moscow. https://orcid.org/0000-0001-7683-3672

Maxim A. Novikov – cardiovascular surgery of the Department of Cardiac Surgery of A.V. Vishnevsky National Medical Research Center of Surgery of the Ministry of Healthcare of the Russian Federation, Moscow. https://orcid.org/0000-0001-9160-6531

Eugenia V. Yalova – resident in ultrasound diagnostics of A.V. Vishnevsky National Medical Research Center of Surgery of the Ministry of Healthcare of the Russian Federation, Moscow. https://orcid.org/0000-0002-9409-5164

Irina A. Taimasova – cardiovascular surgery of Arrhythmological Center of A.V. Vishnevsky National Medical Research Center of Surgery of the Ministry of Healthcare of the Russian Federation, Moscow. https://orcid.org/0000-0002-9280-9063

Для корреспонденции*: Стребкова Елизавета Дмитриевна – тел.: +7-919-273-67-77. E-mail: elizabeth.strebkova@yandex.ru

Ревишвили Амиран Шотаевич – академик РАН, доктор мед. наук, профессор, директор ФГБУ “НМИЦ хирургии им. А.В. Вишневского” Минздрава России, Москва. https://orcid.org/0000-0003-1791-9163

Кадырова Мадина – канд. мед. наук, заведующая отделением ультразвуковой диагностики ФГБУ “НМИЦ хирургии им. А.В. Вишневского” Минздрава России, Москва. https://orcid.org/0000-0001-8231-6866

Попов Вадим Анатольевич – доктор мед. наук, профессор, руководитель отдела сердечно-сосудистой хирургии ФГБУ “НМИЦ хирургии им. А.В. Вишневского” Минздрава России, Москва. https://orcid.org/0000-0003-1395-2951

Малышенко Егор Сергеевич – научный сотрудник отделения кардиохирургии ФГБУ “НМИЦ хирургии им. А.В. Вишневского” Минздрава России, Москва. https://orcid.org/0000-0002-1572-3178

Кармазановский Григорий Григорьевич – академик РАН, доктор мед. наук, профессор, заведующий отделом рентгенологии и магнитно-резонансных исследований ФГБУ “НМИЦ хирургии им. А.В. Вишневского” Минздрава России, Москва. https://orcid.org/0000-0002-9357-0998

Стребкова Елизавета Дмитриевна – аспирант по специальности “сердечно-сосудистая хирургия” ФГБОУ ДПО “Российская медицинская академия непрерывного профессионального образования” Минздрава России, Москва. https://orcid.org/0000-0001-5837-7255

Широков Вадим Сергеевич – врач-рентгенолог отделения рентгенологии и магнитно-резонансных исследований ФГБУ “НМИЦ хирургии им. А.В. Вишневского” Минздрава России, Москва. https://orcid.org/0000-0001-7683-3672

Новиков Максим Андреевич – врач сердечно-сосудистый хирург отделения кардиохиргии ФГБУ “НМИЦ хирургии им. А.В. Вишневского” Минздрава России, Москва. https://orcid.org/0000-0001-9160-6531

Ялова Евгения Владиславовна – ординатор по специальности “ультразвуковая диагностика” ФГБУ “НМИЦ хирургии им. А.В. Вишневского” Минздрава России, Москва. https://orcid.org/0000-0002-9409-5164

Таймасова Ирина Азатовна – врач сердечно-сосудистый хирург аритмологического центра ФГБУ “НМИЦ хирургии им. А.В. Вишневского” Минздрава России, Москва. https://orcid.org/0000-0002-9280-9063