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THE EFFECTIVENESS OF THORACOSCOPIC TREATMENT OF NON-PAROXYSMAL ATRIAL FIBRILLATION

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Aim. To evaluate the efficacy of thoracoscopic ablation (TSA) of persistent and long-standing atrial fibrillation (AF) in the long-term follow-up period.

Methods. TSA of AF with unilateral left atrial appendage exclusion was performed in 50 patients with persistent (group I) and 50 patients with long-onset AF (group II). Efficacy was defined as the absence of any atrial tachyarrhythmia (atrial fibrillation, atrial flutter, or supraventricular tachycardia) lasting more than 30 seconds recorded on Holter ECG monitoring at study controls.

Results. TSA was 78% effective in group I and 63% effective in group II over the three-year follow-up period (p=0,037). Catheter ablations 3 months after TSA were required in 8 (16%) patients in group I and 9 (18%) in group II (p>0,05), of which two patients had typical atrial flutter on ECG, which required radiofrequency ablation of the cavotricuspid isthmus. The efficacy of staged treatment of AF at 3 months after additional catheter ablation was 100% and 88,2% after 6 months.

Conclusion. Video-assisted thoracoscopic ablation of atrial fibrillation should be considered a promising approach for the management of persistent and long-standing atrial fibrillation.

Key words: atrial fibrillation; toracoscopic ablation; persistent form; long-standing atrial fibrillation

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Atrial fibrillation (AF) is the most common tachyarrhythmia, its incidence in the general population is 1-2% among all cardiac arrhythmias [1-3]. An increase in AF patients is expected over the next few years, due to the rapid demographic aging of the population. AF is associated with a high risk of ischemic strokes, heart failure and is an independent predictor of mortality [1, 4, 5].

An urgent problem of modern arrhythmology is the search for highly effective, minimally invasive methods of treatment of isolated nonparoxysmal forms of AF, which account for up to 70% of all forms of AF [6].

For a long time, surgery was considered the only highly effective method for the treatment of AF. In modern arrhythmology, Cox-Maze IV surgery and its modifications are considered exclusively as an additional procedure in cardiac surgery [1, 7-9].

Thanks to the work of M.Haïssaguerre et al. (1998) [10], it was established that the main target of catheter ablation in AF should be considered pulmonary veins (PV), but the effectiveness of radiofrequency ablation in persistent forms of AF was extremely low [1]. Electroanatomical mapping data in patients with nonparoxysmal forms of AF usually demonstrate areas of marked low-amplitude activity in the left atrium (LA) [11]. In such cases, the long-term success rate of catheter ablations is 20-60%, decreasing with each subsequent procedure [12, 13]. Consequently, alternative surgical treatments have been developed that are closer in efficacy to the Cox-Maze procedure, but with a lower complication rate. Video-assisted thoracoscopic ablation (TA) of AF is an alternative surgical method for the treatment of isolated forms of AF in the working heart [1, 14]. Currently, thoracoscopic ablation of AF includes isolation of PV, fragmentation of the posterior wall of the LA (Box lesion technique) and amputation of the PV appendage [1, 15-18], but its efficacy varies considerably from 38 to 83% due to heterogeneity of patients, surgical technique, and follow-up period [17, 19, 20].

The aim of the present work was to evaluate the efficacy of thoracoscopic ablation of persistent and long-term persistent forms of atrial fibrillation in the long-term follow-up period.

METHODS

Thoracoscopic ablation of AF with one-stage amputation of the LA appendage was performed in 100 patients

with persistent and long-term persistent form of AF included in the study. All patients were divided into two groups: group I included 50 patients with persistent form of AF, group II included 50 patients with long-term persistent form of AF.

All patients underwent complex examination before surgery, including: electrocardiogram (ECG), Holter monitoring (HM), transthoracic echocardiography (Echo), transesophageal Echo 24 hours before surgery and intraoperative control after LA appendage amputation, multispiral computed tomography with PV and LA contrast, coronary angiography.

Patient inclusion criteria: (1) symptomatic persistent (lasting more than 7 days to 1 year) and long-term persistent form of AF (lasting more than 1 year) [1, 2]; (2) EHRA symptom class III-IV.

Exclusion criteria: (1) paroxysmal form of AF; (2) symptomatic ischemic heart disease and hemodynamically significant coronary artery stenoses detected by coronarography; (3) acquired heart defects; (4) acute cerebral circulatory disorder of less than 6 months' duration; (5) left ventricular ejection fraction less than 40%; (6) chronic diseases in decompensation stage; (7) traumas and operations on chest organs.

The efficacy of the procedure (primary endpoints of the study) was determined every 3, 6, 12 months and annually thereafter by HM. The procedure was considered successful in the absence of any atrial tachyarrhythmia (atrial fibrillation, atrial flutter, or supraventricular tachycardia) lasting more than 30 seconds [1, 2, 16]. ECG recording was recommended for any symptomatic rapid non-rhythmic heartbeat. The "blind period" during the first 3 months after surgery was excluded from the study.

Secondary endpoints of the study were considered to be: major adverse cardiovascular events (MACE), operation time, ventilator time, hospitalization period (bed days), intra- and postoperative complications. The study design is shown in Fig. 1.

Before surgery, at least 5 days before surgery, all patients from new oral anticoagulants or warfarin were switched to low molecular weight heparins. Anticoagulant therapy with warfarin (target INR (2-3) or direct anticoagulants was started the day after surgery. No correction of antiarrhythmic therapy (AAT) was performed preoperatively. The preoperative Vaughan-Williams distribution of antiarrhythmic drugs is summarized in Table 1. In the absence of contraindications postoperatively, all patients received amiodarone. All medications were recommended to be continued for up to 3 months.

Prior to surgery, all patients were discussed in a consilium with a cardiologist, arrhythmologist, and cardiac surgeon. Participants gave informed consent to undergo video-assisted thoracoscopic ablation of AF. The study was approved by the local ethical committee.

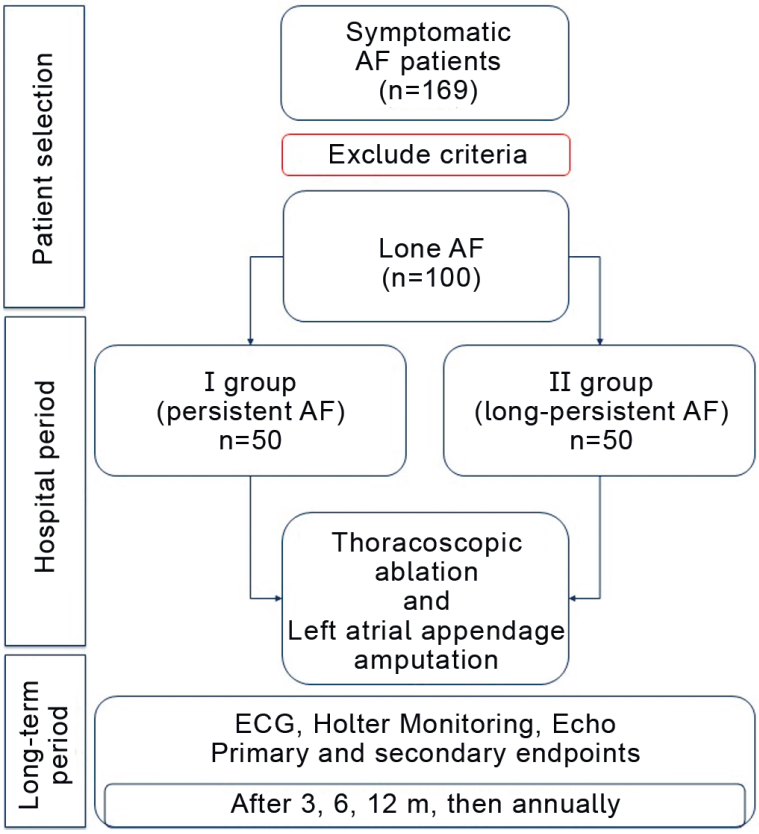

Fig. 1. Study design. Note: AF - atrial fibrillation, ECG - electrocardiogram, m - month.

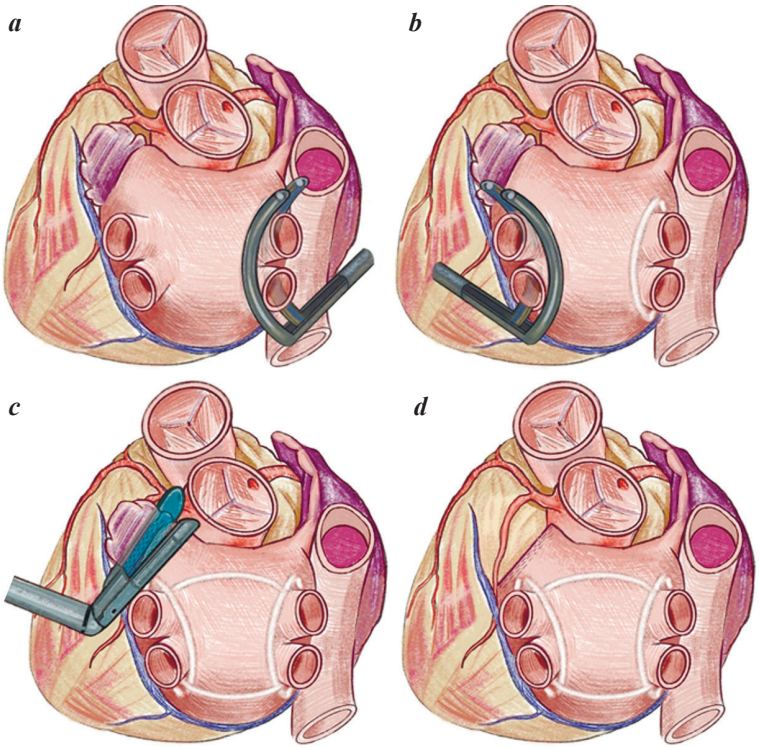

Fig. 2. Stages of surgery. Note: a - radiofrequency ablation of the right pulmonary veins, b - radiofrequency ablation of the left pulmonary veins, c - fragmentation of the posterior wall of the left atrium according to the scheme «Box lesion», amputation of the left atrial appendage with the help of endostepler, d - final scheme of ablation lines.

Surgical technique

All operations were performed in the cardiac surgical operating room by one surgical team, under general anesthesia with selective lung ventilation. The procedure was performed according to the Box lesion scheme (Fig. 2) [19]. PV isolation was performed using an ablation bipolar clamp (AtriCure, Inc., West Chester, Ohio, USA). Ablation was performed under impedance control. When the impedance decreased, the clamp was opened and repositioned to perform a subsequent series of applications to increase the ablation zone. The upper and lower Box lesion lines were formed, using a Cool Rail linear bipolar electrode (AtriCure, Inc., West Chester, Ohio, USA). LA appendage amputation was performed through one of the ports of left-sided access using EndoGIA cutting and cross-linking endostepper (Medtronic, Minneapolis, Minnesota, USA) under the control of transesophageal echocardiography. At all stages of surgery, transmurality and achievement of bidirectional conduction block through the performed ablation lines (exit and entrance block) were evaluated.

With the help of overdrive stimulation we provoked triggering of AF, its spontaneous suppression within 30 seconds was considered normal. In case of registration of sustained AF at the end of the procedure, cardioversion was performed. A detailed description and intraoperative photographs are presented in previously published papers [6, 21].

Таблица 1.

Основные клинические характеристики пациентов и данные инструментальных методов исследования (n=100

Indicator	Group I (n=50)	Group II (n=50)	p
Sex (male), n (%)	33.0 (75)	34.0 (70.83)	0.83
Age, years (Me (IQR))	58 (51:63)	56 (48:62.75)	0.29
BMI, kg/m2 (Me (IQR))	29 (27:31)	30 (28:32.75)	0.188
History of AF, years (Me (IQR))	2.25 (0.77-5)	5 (2-8)	0.001
DA, years (mean ± SD)	0.53±0.27	4.4±3.2	<0.0001
EHRA III, n (%)	38 (76)	34 (68)	0.46
EHRA IV, n (%)	12 (24)	16 (32)	
Hypertension, n (%)	38 (76)	39 (78)	0.99
Diabetes mellitus, n (%)	4 (8)	9 (18)	0.23
CHF II FC NYHA, n (%)	32 (64)	40 (80)	0.15
CHF III FC NYHA, n (%)	8 (16)	6 (12)	
Prior RFA and CBA of PV, n (%)	11 (22)	12 (24)	0.81
Not receiving AAD	2 (4)	0 (0)	0.24
AAD class IC, n (%)	5 (10)	1 (2)	
AAD class II, n (%)	26 (52)	27 (54)	
AAD class III, n (%)	12 (24)	17 (34)	
AAD class IV, n (%)	5 (10)	5 (10)	
Not receiving ATT, n (%)	7 (14)	4 (8)	0.06
Apixaban, n (%)	13 (26)	15 (30)	
Rivaroxaban, n (%)	24 (48)	14 (28)	
Dabigatran, n (%)	3 (6)	7 (14)	
Warfarin, n (%)	3 (6)	10 (20)	
CHA_2DS_2-VASc, scores (Me (IQR))	2 (1-3)	2 (1-2)	0.698
HAS-BLED, scores (Me (IQR))	1 (0-1)	1 (0-1)	0.232
Simpson's LVEF, % (Me (IQR))	61.5 (59-68)	61 (57-65.5)	0.317
LAVI, ml/m2 (Me (IQR))	35 (30.25-45.75)	36 (31-47)	0.836
LA APD, mm (Me (IQR))	40.5 (39-43)	42 (40-46)	0.192
No MR, n (%)	28 (56)	24 (48)	0.50
Minor MR, n (%)	20 (40)	25 (50)	
Moderate MR, n (%)	2 (4)	1 (2)	

Note: BMI - body mass index; AF - atrial fibrillation; DA - duration of continuous arrhythmia; CHF - chronic heart failure; FC - functional class; RFA - radiofrequency ablation; CBA – cryoballoon ablation; PP - pulmonary vein; AAD - antiarrhythmic drugs; ATT - antithrombotic therapy; LVEF - left ventricular ejection fraction; LAVI - left atrial volume indexed to body surface area; LA APD, - left atrial anteroposterior dimension; MR - mitral regurgitation.

Statistical analysis

Statistical analysis and visualization of the obtained data were performed using JASP 2.3.18. statistical computing environment (Jamovi Software). Descriptive statistics are presented as number of observations (relative frequency) for qualitative variables and mean (standard deviation) and median (1st and 3rd quartiles) depending on normality of distribution - for quantitative variables. The Shapiro-Wilk test was used to test whether the sampling distribution conformed to the normal law. Kaplan-Meier method, log-rank test were used to evaluate the effectiveness of the procedure.

RESULTS

The median age of patients was 58 (51-63) years and 56 (48-62.75) years, the two groups were male dominated 33 (75%) and 34 (70.83%) in group I and II, respectively. A statistically significant difference between groups preoperatively was obtained for total history of AF 2.25 (0.77-5) years in group I and 5 (2-8) years in group II (p=0.001). The mean duration of continuous arrhythmia in group I was 0.53±0.27 years and in group II 4.4±3.2 years (at p<0.0001). The complete clinical characteristics of patients and data of instrumental methods of investigation are presented in Table

1. All patients underwent radiofrequency ablation of the right and left PVs, upper and lower Box lesion line formation. The intraoperative features of the procedures are summarized in Table 2.

Postablation epicardial changes of PV aortic tissue were visualized in all 23 patients after prior CA. Moreover, right, and left PVs were isolated before TA in group I only in 8 (16%), in group II in 6 (12%) patients, p>0.05 (Table 2). Restoration of sinus rhythm at the time of ablation was in 3 (6%) and 5 (10%) patients in groups I and II, respectively. Restoration of sinus rhythm after LA appendage amputation was registered in 2 patients in group I and in one patient in group II (Table 2).

Sustained AF at the end of surgery was recorded in 89 (89%), which required cardioversion. Persistent sinus rhythm at the end of the procedure, after cardioversion, was registered in 100% and 96% of patients in groups I and II, respectively. Two patients were transferred to the intensive care unit with typical atrial flutter followed by successful cardioversion on amiodarone therapy. The mean operation time was 220 (188.5-260) min, the mean artificial ventilation (AVL) time was 9.4 (7.5-12) hours, and the mean duration of hospitalization was 6 (5-7) days.

Efficacy of thoracoscopic ablation

The mean follow-up period of the patients was 2.8±0.7 years. The efficacy of epicardial ablation of persistent AF was - 86.0% and 78.0%, and of long-term persistent AF - 77.1% and 68.8% after 6 and 12 months, respectively (p=0.037) (Fig. 3, Table 3) (Fig. 3, Table 3). In the remote follow-up period, the efficiency of TA in Group I was 78.0% and in Group II 63.0% (Fig. 3, Table 3). Catheter ablations for returning atrial tachyarrhythmias 3 months after TA were required in group I - 8 (16%) patients, in group II - 9 (18%), p>0.05. Two patients from group II had typical isthmus-dependent atrial flutter (AFt), 4 (4%) patients had recorded AF on ECG, and 11 (11%) patients were found to have atypical left atrial AFt.

Before the endocardial ablation procedure, all patients underwent high-density LA mapping with study of isolation zones and gaps zones. The PVs were isolated in all patients, confirming that transmurally was achieved with the use of the ablative bipolar clamp.

Residual fragmented commissural activity with absence of conduction in the LA during PV stimulation in 4 (4%) patients: right upper PV in 3 cases and left upper LV in 1 patient. In all cases, pointwise antral isolation of active PV segments was performed until the disappearance of potentials.

In 9 (9%) patients with atypical AFt, the area of failed thoracoscopic ablation was verified in the region of the upper «Box lesion» line of the LA roof. These patients underwent endocardial linear ablations between the upper PVs. The restoration of sinus rhythm or change of the activation front from left atrial to right atrial was noted. AFt with verification of a delayed conduction zone along the anterior wall of the LA was detected in 2 (2%) patients. We performed linear radiofrequency interventions from the roof of the LA to the mitral isthmus with restoration of sinus rhythm (Fig. 4).

In two patients with long-term persistent form of AF, typical AFt was registered at the onset of CA, in connection with which radiofrequency ablation of cavotricuspidal isthmus was performed, with successful restoration of sinus rhythm (Fig. 4). The efficacy of stage treatment of AF was 100% within 3 months after the second stage (CA). In the long-term follow-up period (24 months after additional CA) the efficacy of two-stage treatment of nonparoxysmal forms of AF was 86.9%.

Complications

Major complications were not reported in any patient. The incidence of minor complications in the two groups was 11% (Table 4). Bleeding was reported only in patients in group II (exclusively after prior CA) and accounted for 3% of the total complications. Conversion was not required in any patient, after surgical and medical hemostasis.

Pneumothorax that resolved on its own was reported in 4 (4%) patients in the two groups. Temporary diaphragmatic nerve palsy was reported in 4 (4%) patients that resolved within 12 months. MACE, thromboembolic complications including pulmonary embolism were not reported in any patient.

Table 2.

Intraoperative features of the procedures (n=100)

Indicator	Group I (n=50)	Group II (n=50)	p
PV isolated, after previous CA n, (%)			
Right PVs	8 (16)	6 (12)	0.49
Left PVs	8 (16)	6 (12)	0.99
Rhythm recovery n, (%)			
At the time of right LV ablation	0 (0)	1 (2)	0.99
At the time of left PV ablation	0 (0)	1 (2)	0.99
At the time of upper line ablation	0 (0)	1 (2)	0.99
At the time of the lower line abla-tion.	3 (6)	2 (4)	0.99
At the time of the amputation of the LAA	2 (4)	1 (2)	0.56
ECV at the end of surgery	45 (90)	44 (88)	0.61
Rhythm at the end of the operation n, (%)			
Sinus rhythm	50 (100)	48 (96)	0.11
Typical atrial flutter.	0 (0)	2 (4)	
Operation time, min (Me (IQR))	221 (190-251.25)	247.5 (197.5-305)	0.077
Ablation time, min (Me (IQR))	69.5 (58.75-84)	73 (64-91)	0.114
Ventilation time, hour (Me (IQR))	9.125 (8-11.31)	10 (6.55-15.525)	0.759
TSD, ml (Me (IQR))	200 (150-300)	190 (100-200)	0.050

Note: PV - pulmonary veins; CA - catheter ablations; LAA - left atrial appendage; ECV - electrical cardioversion; AVL - artificial ventilation; TSD - trace secretion by drains.

DISCUSSION

The treatment of patients with persistent and long-standing persistent AF is challenging. The Cox-Maze procedure and its modifications are the gold standard for the treatment of stable forms of AF, but their widespread use in patients with isolated AF is limited due to their high traumatic nature and the need for artificial circulation [1, 7-9]. Radiofrequency ablation for persistent and long-term persistent forms of AF shows extremely low efficacy due to pronounced «electrophysiologic remodeling of atria» [6, 9, 22].

This led to the development of alternative surgical treatments that are closer in efficacy to the Cox-Maze procedure, but with a lower complication rate. For the first time, the method of video-assisted thoracoscopic ablation of PV and LA appendage amputation was proposed by R.Wolf et al. (2005) [14]. The authors presented the efficacy results of thoracoscopic ablation comparable to Maze III surgery [14]. Thus, epicardial ablation has become a new promising direction of treatment of isolated forms of AF. This technique may include PV isolation, fragmentation of the posterior wall of the LA, ablation of the ganglionic plexus, crossing of the ligament of Marshall, and removal of the appendage of the LA.

A multicenter study by E. Beyer et al. (2009) in a mixed patient population showed that the efficacy of TA for persistent AF was 96% and 71% for long-term persistent AF; after withdrawal of AAT, the overall efficacy of the procedure in all patients was 62%. Complications amounted to 13% and were represented by: pacemaker implantation, diaphragmatic nerve injury, postoperative hemothorax and transient ischemic attack [23].

The FAST and FAST II randomized clinical trials demonstrated high efficacy of TA 65.6% compared to catheter ablation 36.5% (p=0.002), but with a higher complication rate [20, 21]. According to the meta-analysis, freedom from AF after TA for patients with paroxysmal form was 72.7% (174/241), persistent 68.9% (111/161) and 54.2% (32/59) for long-standing persistent FP. The overall efficacy of the procedure with AAT was 68.8% (317/461) and without AAT was 63.3% at a mean follow-up period of 20±9 months [24].

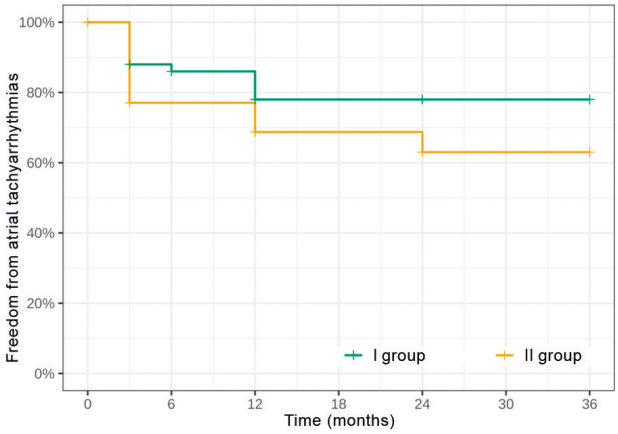

Fig. 3. Kaplan-Meier survival curve of freedom from atrial tachyarrhythmias in the two study groups after thoracoscopic treatment (p=0.037).

In the study by L.M.Vos et al (2020), freedom from AF was 60% (49/82) and 86% (42/49) after AAT withdrawal during a four-year follow-up period. The efficiency of TA for paroxysmal forms of AF was 71%, for non-paroxysmal forms of AF - 49% (p=0.07) [25]. The long-term results of our procedure are comparable with the data of M.S.Choi et al. (2020), which presented a comparison of the effectiveness of isolated TA and hybrid treatment of exclusively persistent forms of AF. The efficacy of TA and hybrid treatment for persistent AF at 1-year follow-up was 69.6% and 68.2% at p=0.920, respectively [26].

Similar results were obtained from isolated left-sided access. The efficacy of TA was 73% in nonparoxysmal forms of AF during 12 months of follow-up, without withdrawal of AAT [27]. Freedom from atrial tachyarrhythmias in the presented study in persistent form of AF was 78.0% and in long-term persistent AF - 63.0% (p<0.05).

In our study, additional CAs 3 months after TA were required in group I - 8 (16%) patients and in group II - 9 (18%) patients, p >0.05. Two patients from group II had typical isthmus-dependent AFt, 4 (4%) patients had AF recorded on ECG, and 11 (11%) patients showed atypical left AFt. Before the endocardial ablation procedure, all patients underwent high-density LA mapping with study of isolation zones and excitation breakthrough zones. The PVs were isolated in all patients, confirming that transmurality was achieved with the use of the ablative bipolar clamp.

Residual fragmented commissural activity with absence of conduction in the LA during PV stimulation in 4 (4%) patients: right upper PV in 3 cases and left upper LV in 1 patient. In all cases, pointwise antral isolation of active PV segments was performed until the disappearance of potentials. In 9 (9%) patients with atypical AFt, the area of failed thoracoscopic ablation was verified in the region of the upper «Box lesion» line of the LA roof. These patients underwent endocardial linear ablations between the upper PVs. Restoration of sinus rhythm or change of the activation front from left atrial to right atrial was noted. Perimitral AFt with verification of a delayed conduction zone along the anterior wall of the LA was detected in 2 (2%) patients. We performed linear radiofrequency interventions from the roof of the LA to the mitral isthmus with restoration of sinus rhythm (Fig. 3).

An important factor in failed epicardial ablations is most often epicardial fat along the posterior wall of the LA and in the region of the PV apertures. K.N.Hong et al

Table 3.

Freedom from atrial tachyarrhythmias in the two study groups after thoracoscopic treatment

	3 months	6 months	12 months	24 months	36 months
Group I, %	88.0 [79.4; 97.5]	86.0 [76.9; 96.2]	78.0 [67.3; 90.4]	78.0 [67.3; 90.4]	78.0 [67.3; 90.4]
Group II, %	77.1 [66.1; 89.9]	77.1 [66.1; 89.9]	68.8 [56.8; 83.2]	63.0 [50.3; 79.0]	63.0 [50.3; 79.0]

Note: [Confidence interval, 95%].

(2007) in their study showed that epicardial transmural ablation lines can be performed only in patients with absence of epicardial fat, epicardial ablations are not effective in epicardial fat thickness more than 3 mm [28]. Another study showed that often, epicardial fat is more prevalent along the roof of the LA compared to the inferior portion, which may explain the efficient and reliable formation of the inferior Box lesion line in contrast to the superior line. The results of our study are in full agreement with the data of previously published works [29].

Two patients had typical atrial flutter at the onset of CA, and radiofrequency ablation of cavotricuspidal isthmus was performed, with successful restoration of sinus rhythm. Technically, from epicardial access, the cavotricuspidal isthmus lines and to the mitral isthmus are incomplete. Therefore, a staged treatment approach should be considered for some patients with persistent and long-standing persistent forms of AF [30].

In our study, AF after prior PV CA were isolated in 9 (9%) patients in two groups. In all 23 patients after previous CAs, intraoperatively there were marked fibrotic changes and adhesions in PV apertures, which technically complicated the operation. In this regard, three patients (3%) developed bleeding at the stage of PV isolation, which required surgical and medical hemostasis. However, a recent systematic review aimed at examining exclusively complications after thoracoscopic ablation showed that neither prior catheter ablation nor the form of AF was associated with the risk of intraoperative complications, with an overall complication rate for TA of 11.8% [31]. In our study, the incidence of all complications was 11%. The absence of major intraoperative complications and 30-day mortality were related to the experience of the surgical team.

An important advantage of TA is the ability to amputate the appendage of the LA. Today, there is no consensus on the optimal prophylaxis of thromboembolic events in patients with AF. However, it is proved that up to 90-95% of all thrombi in patients with non-valvular AF are formed in the appendage of the LA [4, 32, 33]. Therefore, occlusion or amputation of the appendage of the LA is of great clinical importance.

In our center, the endoscopic cutting and stapling device is preferred, which has proven itself in TA. LA appendage amputation was performed in 100%. All anastomoses in the LA appendage stump region were complete. After LA appendage amputation, restoration of sinus rhythm was registered in 2 (4%) patients with persistent AF and in 1 (2%) patient with long-term persistent form of AF, and sinus rhythm was registered in these patients in the long-term follow-up period. In the work of L. Di Biase et al (2016), it was shown that LA appendage isolation improves freedom from atrial tachyarrhythmias in patients with long-term persistent AF [34-36], which warrants further study.

TA combined with LA appendage amputation significantly reduces the risks of thromboembolic complications. This method has a simple and safe approach, and no MACE events were recorded in any of our patients in the long-term follow-up period. Anticoagulant therapy 6 months after TA was discontinued in 70 patients (group I - 40 patients, group II - 30 patients), after registration of stable sinus rhythm on 24-h HM ECG, results of CHA_2DS_2-VASc testing and exclusion of thrombus according to transesophageal Echo-CG and multispiral computed tomography with contrast.

CONCLUSION

Video-assisted TA of AF should be considered an effective method of arrhythmia management for patients with persistent and long-term persistent AF. Freedom from atrial tachyarrhythmias was 78.0% for persistent AF and 63% for long-term persistent AF during the three-year follow-up period.

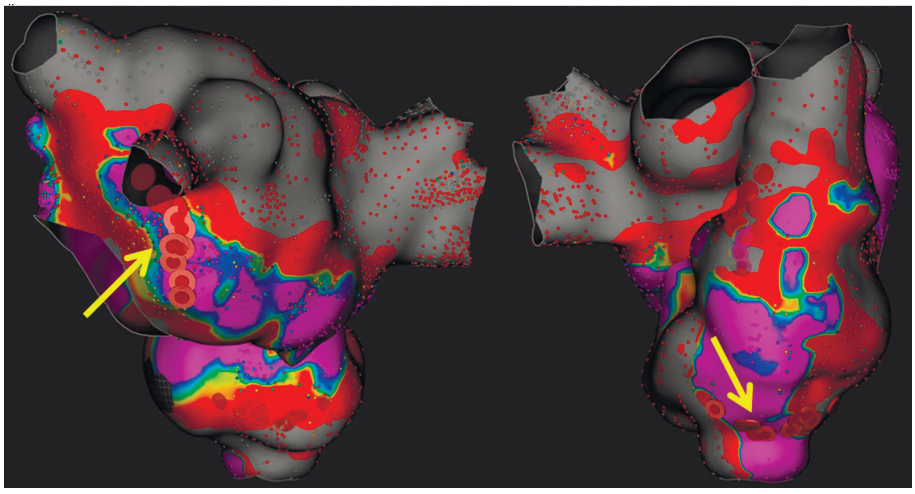

Fig. 4. High-density mapping with additional endocardial ablations (yellow arrows) in the mitral isthmus and cavotricuspid isthmus regions.

Table 4.

Minor complications (n=100)

	All patients (n=100)	Group I (n=50)	Group II (n=50)	p
Bleeding, n (%)	3 (3%)	0 (0%)	3 (6%)	0.24
Pneumonia, n (%)	0 (0%)	0 (0%)	0 (0%)	-
Pneumothorax, n (%)	4 (4%)	3 (6%)	1 (2%)	0.49
Hemothorax, n (%)	1 (1%)	0 (0%)	1 (2%)	0.99
Hydrothorax, n (%)	1 (1%)	0 (0%)	1 (2%)	0.47
TIA, n (%)	0 (0%)	0 (0%)	0 (0%)	-
Temporary PDP, n (%)	4 (4%)	1 (2%)	1 (2%)	0.37
Overall frequency, n (%)	11 (11%)	4 (8%)	7 (14%)	0.24

Note: TIA - transient ischemic attack; PDN – phrenic nerve palsy.

The efficacy of stage treatment of AF was 100% within 3 months after the second stage (radiofrequency catheter ablation). In the remote follow-up period (3 years after additional CA) the efficacy of two-stage treatment of nonparoxysmal forms of AF was 86.9% Stage treatment of nonparoxysmal forms of AF can increase the efficacy up to 86.9% in the remote follow-up period 24 months after the second stage (catheter ablation), which requires further study on a larger sample of patients. Thus, a staged approach should be considered as the method of choice for the treatment of persistent and long-term persistent forms of AF.

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