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SHORT-TERM RESULTS OF TWO STRATEGIES IN THORACOSCOPIC ABLATION FOR LONE ATRIAL FIBRILLATION

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Background: *Thoracoscopic ablation is an effective treatment of patients with atrial fibrillation. Nowadays, 2 types of ablative devices are available in clinical practice allowing one to perform the thoracoscopic procedure — Medtronic and AtriCure. However, the contemporary clinical literature does not have enough data that would compare these two approaches.* ***Aims:*** *to perform a comparative analysis of the short-term results of two minimally invasive strategies in thoracoscopic ablation for atrial fibrillation.* ***Methods:*** *232 patients underwent thoracoscopic ablation for atrial fibrillation in two clinical centers for the period from 2016 to August 2021. The patients were divided into 2 groups. The first group was represented by those patients to whom a Medtronic device was applied (n=140), the second group was treated with an AtriCure device (n=92). The patients were comparable in their age, gender, initial severity of the condition. The follow-up consisted of laboratory tests, chest X-ray, electrocardiography, 24-hour Holter monitor, echocardiography. The structure and prevalence of postoperative and intraoperative complications, specifics of the postoperative period were compared between the two groups.* ***Results:*** *According to the structure and prevalence of intraoperative complications the 2 groups are comparable to each other: 4.3% and 1.1% for the 1st group and 2nd group, respectively (p >0.05). The postoperative complications had developed in 6 (4.3%) and 5 (5.4%) patients in groups 1 and 2, respectively (p >0.05). At the time of discharge from hospital, a sinus rhythm was registered in 93.6% of patients (1st group), and 85.9% (2nd group) (p <0.05).* ***Conclusions:*** *Both strategies have demonstrated comparable short-term results in patients with lone atrial fibrillation. A further research is needed to evaluate the effectiveness of this strategy in a long-term period.*

Keywords: *ablation technique; atrial fibrillation; surgery; thoracoscopic ablation.*

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BACKGROUND

Thoracoscopic ablation is an effective method for the treatment of patients with atrial fibrillation. Compared with endocardial catheter ablation, this technique has demonstrated safety and freedom from arrhythmia in the treatment of isolated atrial fibrillation, and it is less invasive than maze III surgery (cut and sew) [1, 2]. Previous electrophysiological studies have demonstrated the important role of the posterior wall of the left atrium in the pathogenesis of atrial fibrillation [3–8]; therefore, complete isolation of the posterior wall of the left atrium is a critical component in the treatment of arrhythmia [9].

Thoracoscopic ablation enables the isolation of the antrum of the pulmonary veins in combination with the isolation of the posterior wall of the left atrium, thus forming a “box lesion” pattern. To date, two types of ablation devices are available in clinical practice, namely, the Medtronic radiofrequency generator and electrode (bipolar, irrigation) and the AtriCure radiofrequency generator with two types of electrodes (bipolar, non-irrigation) (Figs. 1 and 2). However, in the modern clinical literature, only one study has compared the efficacy and safety of these two approaches [10].

Study aim. In this study, we attempted to perform a comparative analysis of the immediate results of treatment using two thoracoscopic ablation strategies (using Medtronic and AtriCure equipment) in patients with atrial fibrillation.

a

b

Fig. 1. Medtronic equipment: *a* — bipolar ablative device (clamping-electrode) Medtronic Cardioblate Gemini-S; *b* — cardioblate Generator 68000 RF generator.

METHODS

Study design

A two-center retrospective study was conducted.

Study conditions

Thoracoscopic ablations using Medtronic equipment were performed at the Federal Research and Clinical Center for Specialized Types of Medical Care and Medical Technologies of the Federal Medical and Biological Agency of Russia, and cases using AtriCure equipment were performed at the Clinical Hospital of the Department of Presidential Affairs of the Russian Federation.

The inclusion criteria were as follows: (1) persistent or chronic atrial fibrillation, (2) age >18 years, (3) failure of conservative therapy using antiarrhythmic drugs of classes I and III (Vaughan Williams classification), and (4) absence of a pronounced structural pathology of the heart that requires surgical treatment.

The exclusion criteria were as follows: (1) secondary atrial fibrillation resulting from a reversible cause (pericarditis, hyperthyroidism, thromboembolism of the pulmonary artery, pneumonia, hypokalemia, etc.), (2) surgical interventions on chest or mediastinal organs, (3) age <18 years, (4) indications for open heart surgery

a

b

c

d

Fig. 2. AtriCure equipment: *a* — bipolar clamping-electrode Isolator EMR2, right; *b* — bipolar clamping-electrode Isolator EML2, left; *c* — electrode for linear ablation MLP1; *d* — radio frequency generator AtriCure.

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under cardiopulmonary bypass, (5) heart failure with an ejection fraction of <30%, (6) history of acute cerebrovascular accident <3 months ago, (7) acute myocardial infarction or coronary stenting <3 months ago, (8) active systemic infection, (9) thrombosis of the left atrial appendage, detected 1 day before the surgery, (10) hemodynamically significant atherosclerotic lesions of the coronary arteries and myocardial ischemia at the time of determination of indications for surgery (confirmed by functional methods of research and coronary angiography), (11) contraindications to intake of direct and indirect anticoagulants, and (12) concomitant diseases of other organs and systems that can lead to death during the first 2 years after surgery.

Medical intervention

Clinical data were collected from the electronic patient information database of both hospitals and analyzed retrospectively. Each of the two centers employed only one thoracoscopic ablation strategy using Medtronic or AtriCure equipment. Both strategies require general anesthesia, separate pulmonary ventilation, and clamp electrode for the isolation of the antrum of the pulmonary veins. However, the isolation of the posterior wall of the left atrium with AtriCure equipment was performed using a linear electrode, whereas with Medtronic equipment, the "box lesion" pattern was formed by alternating ablation on the right and left sides with a clamp-type electrode (i.e., the electrode design enables achieving the "box lesion" pattern by acting alternately on the right and left sides). The scheme of the isolation of the antrum of the pulmonary veins and the posterior wall of the left atrium using Medtronic and AtriCure equipment is presented in Fig. 3.

The procedures of thoracoscopic ablation of atrial fibrillation using different techniques were described in detail in our previously published manual and in international works [11, 12].

The final step in both techniques is the resection of the left atrial appendage to reduce the risk of thromboembolic events and possible subsequent discontinuation of anticoagulants. The resection of the left atrial appendage was performed using a 60-mm endoscopic stapler (Endo GIA Universal Stapler, USA) (Fig. 4).

After the ablation procedures, in both cases, the conduction block was checked, and if necessary, additional ablation treatments were performed. Patients who did not regain sinus rhythm received electrical impulse therapy. Patients with persistent atrial fibrillation after electrical impulse therapy were transferred to the intensive care unit, where saturation with amiodarone was performed, followed by repeated sessions of electrical impulse therapy.

Ethical considerations

The study was approved by the local ethics committee.

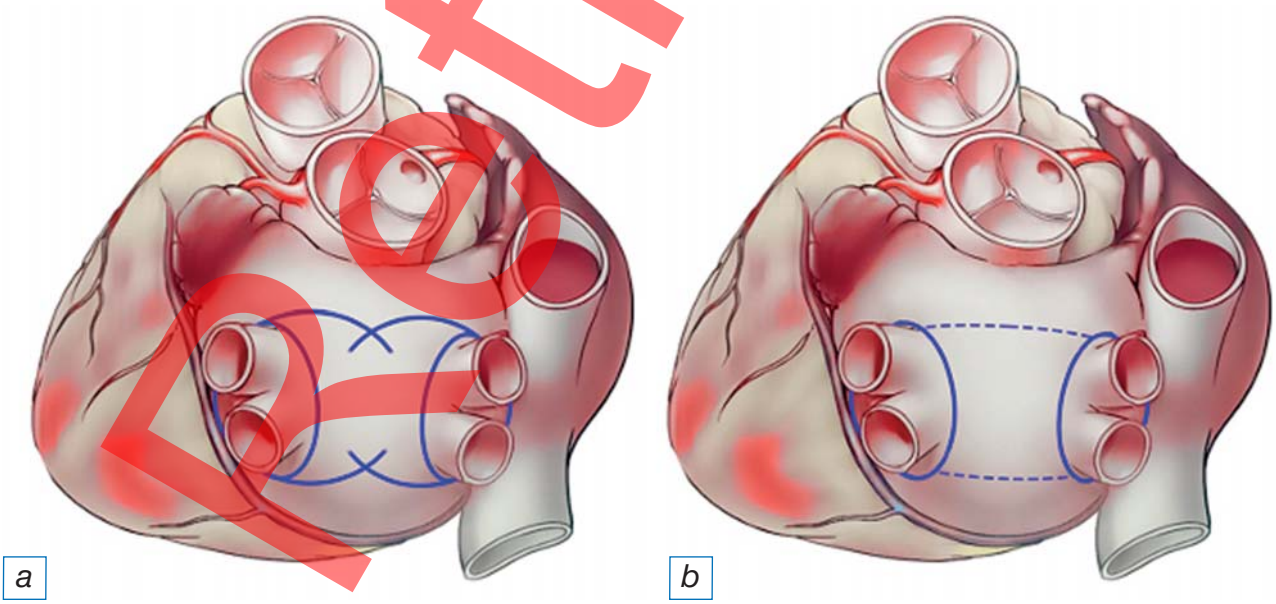

Fig. 3. Pattern of isolation of the antrum of the pulmonary veins and the posterior wall of the left atrium using Medtronic equipment (*a*) and AtriCure (*b*).
Note: The solid line shows the ablation lines formed by the clamping electrode, the dotted line shows the ablation lines formed by the linear electrode.

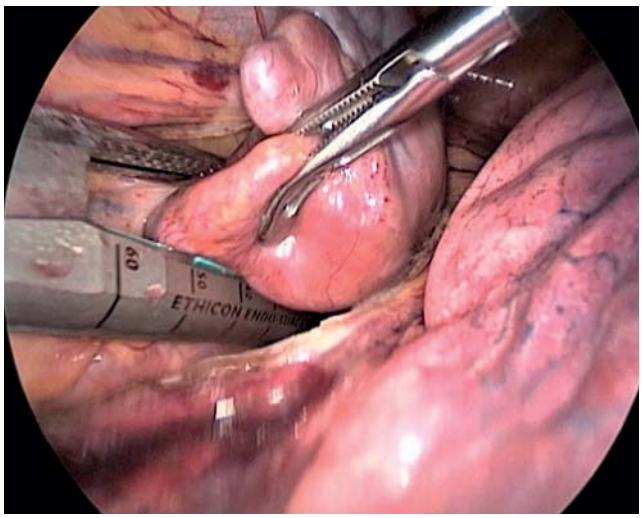

Fig. 4. Positioning of the stapler during resection of the left atrium appendage.

RESULTS

Study participants

From 2016 to August 2021, 232 patients underwent thoracoscopic ablation for atrial fibrillation at two centers in Moscow. These patients were distributed into two groups depending on the surgical method and equipment used, namely, the Medtronic group (*n*=140) and the AtriCure group (*n*=92). The groups were comparable in terms of the main clinical and demographic indicators. A statistically significant difference was noted in the distribution of patients according to the course of atrial fibrillation and heart failure grade according to the New York Heart Association classification (p <0.001) (Table 1). The distribution of patients according to the risk of development of thromboembolic complications (CHA2DS2-VASC score) and

Table 1

Preoperative characteristics of patients

Indicator	Medtronic group (*n*=140)	AtriCure group (*n*=92)	*p*-value
Age, years	59 (53.3; 64)	56.5 (49.61)	>0.05
Number of male/female patients, *n* (%)	110 (78.6)/30 (21.4)	62 (67.4)/30 (32.6)	>0.05
Duration of atrial fibrillation, years	5 (2; 9.7)	4 (2; 7)	>0.05
Body mass index, kg/m^2	29 (26; 33)	29 (27; 32)	>0.05
Arterial hypertension, *n* (%)	106 (75.7)	71 (77.2)	>0.05
Ischemic heart disease, *n* (%)	39 (27.9)	32 (34.8)	>0.05
Thyroid pathology, *n* (%)	30 (21.4)	21 (22.8)	>0.05
COPD, *n* (%)	13 (9.3)	15 (16.3)	>0.05
Kidney pathology, *n* (%)	14 (10)	12 (13)	>0.05
Diabetes mellitus, *n* (%)	14 (10)	11 (12)	>0.05
CVA/TIA, *n* (%)	11 (7.9)	4 (4.3)	>0.05
Form of atrial fibrillation, *n* (%)			
• Paroxysmal • Persistent • Long-term persistent	17 (12.1) 38 (27.1) 85 (60.7)	13 (14.1) 58 (63) 21 (22.8)	**<0.001**
EHRA index, *n* (%)			
• I • II • III • IV	30 (21.4) 87 (62.6) 23 (16.4) -	22 (23.9) 46 (50) 23 (25) 1 (1.1)	>0.05
NYHA grade, *n* (%)			
• 0 • I • II • III	35 (25) 17 (12.1) 79 (56.4) 9 (6.4)	10 (10.9) 41 (44.6) 36 (39.1) 5 (5.4)	**<0.001**

Note: Quantitative data are presented as Me (Q_1; Q_3), where Me is the median, and Q_1 and Q_3 are the lower and upper quartiles, respectively. True results are highlighted in bold. COPD, chronic obstructive pulmonary disease; CVA, cerebrovascular accident; EHRA, European Heart Rhythm Association Scale of Atrial Fibrillation-related Symptom; NYHA, New York Heart Association functional classification of heart failure; TIA, transient ischemic attack.

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bleeding (HAS-BLED score) is presented in Tables 2 and 3, respectively.

All patients who were admitted to the hospital for surgical ablation underwent a comprehensive preoperative examination, which included laboratory and instrumental diagnostic methods (Table 4). Atrial fibrillation was diagnosed based on modern recommendations and criteria adopted by the international medical community [13].

Preoperative and intraoperative echocardiography parameters are presented in Tables 5 and 6, respectively.

Primary results

The analysis of operational data in the study groups revealed a significant difference in the duration of the surgical intervention. Such a difference was attributed to performing a modified ablation technique using Medtronic equipment, i.e., a change in the electrode curvature and an increase in the number of applications [14]; as a result, the ablation time also differed statistically significantly between the groups (Fig. 5). A difference was also found in the duration of stay in the intensive care unit, i.e., 1 and 2 days for groups 1 and 2, respectively (p <0.001).

To analyze perioperative complications, we used the systematic classification of complications proposed previously [15]. All complications were divided into minor and major complications. The nature and frequency of intraoperative and postoperative complications (within 30 days after surgery) are presented in Table 7.

No lethal outcomes occurred in our study. Intraoperative bleeding that required access conversion occurred in 6 (4.3%) patients in group 1 (a thoracotomy

Table 2

Distribution of patients according to CHA2DS2-VASC Score

Risk of thromboembolic complications		CHA2DS2-VASC Score							Total
		0	1	2	3	4	5	6	
Medtronic group (*n*=140)	Quantity	3	25	55	32	17	5	3	140
	Group %	2.1	17.9	39.3	22.9	12.1	3.6	2.1	100
AtriCure group (*n*=92)	Quantity	4	9	19	35	18	7	0	92
	Group %	4.3	9.8	20.7	38.0	19.6	7.6	0.0	100

Table 3

Distribution of patients according to the risk of bleeding according to HAS-BLED Score

Risk of hemorrhagic complications		HAS-BLED Score					Total
		0	1	2	3	4	
Medtronic group (*n*=140)	Quantity	28	59	35	13	5	140
	Group %	20.0	42.1	25	9.3	3.6	100
AtriCure group (*n*=92)	Quantity	9	16	51	13	3	92
	Group %	9.8	17.4	55.4	14.1	3.3	100

Table 4

Algorithm of preoperative evaluation

Research methods	
Laboratory	**Instrumental**
• Clinical blood test • Biochemical blood test (alanine aminotransferase, aspartate aminotransferase, creatinine, amylase, and total bilirubin) • Short coagulogram • Common urine test • Pro-B-natriuretic peptide • Thyroid hormones • HBsAg (hepatitis B surface antigen), anti-HCV (antibodies to hepatitis C virus), RW (Wassermann's test), and human immunodeficiency virus	• Echocardiography • Transesophageal echocardiography • Coronary angiography (according to indications) • Fibrogastroduodenoscopy • Ultrasound duplex scanning of brachiocephalic arteries • Ultrasound duplex scanning of the veins of lower extremities • Ultrasound duplex scanning of the arteries of the lower extremities • Function of external respiration • Computed tomography/chest X-ray

Table 5

Preoperative echocardiographic parameters

Echocardiographic parameters	Medtronic group (*n*=140)	AtriCure group (*n*=92)	*p*-value
Left ventricular ejection fraction, %	57 (53; 60)	63 (58; 68)	>0.05
Indexed volume of the left atrium, mL/m^2	41 (35; 47)	40.5 (33; 49)	>0.05
End-diastolic volume of the left ventricle, ml	108 (95; 130)	113 (96; 134)	>0.05
End-diastolic volume of the left ventricle, ml	47 (38; 59)	41 (35; 55)	>0.05

Note: Quantitative data are presented as Me (Q_1; Q_3), where Me is the median, Q_1 and Q_3 are the lower and upper quartiles, respectively.

Table 6

Intraoperative data

Intraoperative indicators	Medtronic group (*n*=140)	AtriCure group (*n*=92)	*p*-value
Duration of surgery, min	145.5 (120; 172.5)	130 (105; 150)	**0.02**
Ablation duration, min	32 (30.7; 39.8)	22 (20.5; 24)	**0.001**
Resection of the left atrial appendage, number of patients, *n* (%)	138 (98.6)	85 (92.4)	**0.031**
Blood loss, mL	40 (20; 180)	35 (20; 135)	>0.05
Cardioversion on the operating table, number of patients, *n* (%)	71 (50.7)	37 (40.2)	>0.05
Duration of artificial lung ventilation, h	4.75 (3.37; 6.15)	4.5 (3.2; 6)	>0.05
Duration of stay in the intensive care unit, days	1 (1; 1)	2 (2; 2)	<**0.001**

Note: Quantitative data are presented as Me (Q_1; Q_3), where Me is the median, Q_1 and Q_3 are the lower and upper quartiles, respectively. True results are highlighted in bold.

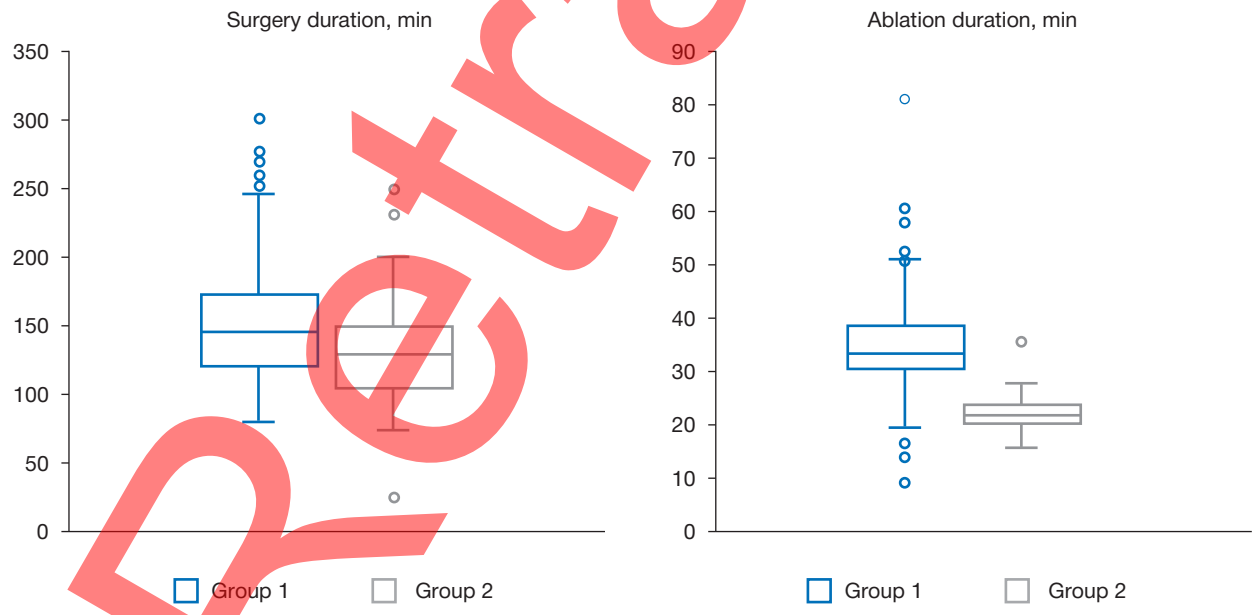

Fig. 5. Operative time and time of ablation time in the studied groups (p <0,05).

was performed in two patients) and 1 (1.1%) patient in group 2 (p >0.05).

In both groups, the majority of the complications (>50%) were minor ones and did not affect the prognosis and date of discharge from the hospital. The incidence of major (life-threatening) complications was at an acceptable level, occurring in 2 (1.4%) and 1 (1.1%) patients in groups 1 and 2, respectively.

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Table 7

The nature and frequency of intraoperative and postoperative complications

Complications	Medtronic group (*n*=140)	AtriCure group (*n*=92)	*p*-value
Intraoperative complications			
Bleeding requiring sterno-/thoracotomy, *n* (%)	6 (4.3)	1 (1.1)	>0.05
Postoperative major complications			
Total number, *n* (%)	2 (1.4)	1 (1.1)	>0.05
• Respiratory failure requiring artificial lung ventilation >1 day, *n* (%)	1 (0.7)	0 (0.0)	>0.05
• CVA/TIA, *n* (%)	1 (0.7)	0 (0.0)	>0.05
• Multisystem organ failure, *n* (%)	0 (0.0)	1 (1.1)	>0.05
Postoperative minor complications			
Total number, *n* (%)	4 (2.8)	4 (4.3)	>0.05
• Implantation of a pacemaker, *n* (%)	2 (1.4)	0 (0.0)	-
• Puncture of the pleural cavity, *n* (%)	2 (1.4)	3 (3.3)	>0.05
• Infectious complications, *n* (%)	0 (0.0)	1 (1.1)	>0.05

Note: CVA, cerebrovascular accident; TIA, transient ischemic attack.

Table 8

Heart rhythm at discharge from the hospital

Rhythm	Medtronic group (*n*=140)	AtriCure group (*n*=92)	*p*-value
Sinus rhythm, *n* (%)	131 (93.6)	79 (85.9)	**<0.05**
Atrial fibrillation, *n* (%)	6 (4.3)	11 (11.9)	**0.028**
Pacemaker rhythm, *n* (%)	3 (2.1)	2 (2.2)	>0.05

Note: True results are highlighted in bold.

The nature of the rhythm at hospital discharge is presented in Table 8. Sinus rhythm was registered in 93.6% of the patients in group 1 and 85.9% in group 2 (p <0.05).

DISCUSSION

The results of this study corresponded to the findings of international studies in the field of thoracoscopic arrhythmology [16, 17]. Moreover, a significant part of the complications occurred during the learning period, i.e., the period of technology introduction in clinics when both surgeons and anesthesiologists-resuscitators were trained on a new procedure in cardiac surgery. In this study, 50% of intraoperative complications occurred during this period. Naturally, as experience increases, the number of complications will decrease even more to reach the level of endovascular arrhythmology.

The interpretation of treatment results, namely, the recurrence of atrial fibrillation upon hospital discharge, is not an entirely correct task because in most cases such arrhythmias during the first 3 months are caused by incisional arrhythmias [18–20]. Nevertheless, the data obtained demonstrate encouraging results.

Our analysis of the safety and efficacy of thoracoscopic ablation methods (Medtronic and AtriCure) showed that both methods provide acceptable immediate treatment results, regardless of the form of atrial fibrillation and duration of arrhythmological history. In our opinion, treatment results will depend on the experience of the surgical and anesthesia team. Certainly, before the so-called learning curve, surgeons will encounter various complications. According to our experience, the learning curve on average corresponds to the first 50–70 surgeries, but as experience is gained, the number of complications will decrease, as will the severity of these complications.

In the Russian literature, very few studies have focused on thoracoscopic ablation in patients with isolated atrial fibrillation. The present study demonstrated that both techniques provide comparable immediate results in the treatment of patients with isolated atrial fibrillation. A somewhat similar result was obtained by our Dutch colleagues [10]. In our opinion, the approach using Medtronic equipment is more convenient for mastering thoracoscopic ablation because only a few instruments are used, and it demonstrates acceptable results. In

addition, the approach using AtriCure technology, due to the use of a linear electrode, enables modifying the "box lesion" pattern to "Dallas lesion" and performing right atrial isolation, i.e.,., achieving a complete biatrial scheme. The implementation of biatrial ablation patterns and the electrophysiological prerequisites for this approach were described in detail by Cox [21].

In the Russian literature, the issues of thoracoscopic ablation in patients with heart failure, with both preserved and reduced ejection fraction, are scarcely covered. Further studies, including multicenter ones, are required to evaluate the safety and efficacy of thoracoscopic ablation strategies in the long-term period.

CONCLUSION

A comparative analysis of two thoracoscopic ablation strategies, i.e., using Medtronic and AtriCure technologies, in the treatment of patients with isolated atrial fibrillation showed comparable immediate results in terms of the number of intraoperative and early postoperative complications, and they do not significantly differ in efficiency in the early postoperative period. Further research is required to evaluate the long-term efficiency of these strategies.

ADDITIONAL INFORMATION

Author contribution. *A.S. Zotov* — treatment of patients, participation in the operation, processing and discussion of the results of the study, writing the text of the article, management of patient treatment; *O.Yu. Pidanov* — treatment of patients, participation in the operation, discussion of the results of the study, management of patient treatment; *I.S. Osmanov* — treatment of patients, participation in the operation, processing and discussion of the results of the study, writing the text of the article, search and analytical work; *A.V. Troitsky* — discussion of the results of the study, management of patient treatment; *A.A. Silaev* — treatment of patients, participation in the operation, management of patient treatment; *E.R. Sakharov* — treatment of patients, participation in the operation, writing the text of the article; *V.N. Sukhotin* — treatment of patients, participation in the operation; *O.O. Shelest* — writing the text of the article, search and analytical work; *R.I. Khabazov* — discussion of the results of the study, management of patient treatment; *D.A. Timashkov* — discussion of the results of the study, management of patient treatment; search and analytical work. The authors made a substantial contribution to the conception of the work, acquisition, analysis, interpretation of data for the work, drafting and revising the work, final approval of the version to be published and agree to be accountable for all aspects of the work.

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Competing interests. The authors declare that they have no competing interests.

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