SURGICAL TREATMENT OF ATRIAL FIBRILLATION: TECHNIQUE OF THORACOSCOPIC RADIOFREQUENCY FRAGMENTATION OF THE LEFT ATRIUM

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Presented in the article is a detailed description of a modified technique of minimally invasive surgical treatment of patients with atrial fibrillation − thoracoscopic radiofrequency fragmentation of the left atrium. This modification differs from the prototype GALAXY procedure by a significant increase of the "quantitative" rather than "qualitative" parameter of surgical aggression in relation to the left atrium. This technique results in creation of multiple transmural continuous closed lines of lesion to the left atrium and, consequently, a reduced risk of inadequate surgical treatment for atrial fibrillation.

Besides the radiofrequency action on the wall of the left atrium, the protocol of the operation included destruction of the ligament of Marshall and resection of the left atrial appendage.

An indication for performing this operation is the presence of various forms of atrial fibrillation.

Key words: atrial fibrillation, surgical treatment, radiofrequency ablation, thoracoscopy.

INTRODUCTION

A "gentle killer" is a term rightly applied to diseases taking an asymptomatic course before the development of either fatal or incurable complications. Atrial fibrillation (AF) fully comes within the scope of this definition, since in at least one third of patients (until the development of typical complications), no obvious clinical manifestations of this most common type of supraventricular arrhythmia are observed. A further third of patients appear to experience no discomfort associated with its symptoms [1].

Despite abundance of drugs possessing various mechanisms of action, all currently available therapeutic methods of restoration and preservation of the sinus rhythm of the heart in patients with AF, including electrical pulse therapy [2], are neither self-sufficient nor radical. At the present time relative radicality regarding freedom of the patient from atrial fibrillation may be achieved only by means of surgical methods of treatment.

In the late 1980s, based on the results of a series of experimental studies James Cox developed and implemented into clinical practice a surgical approach aimed at effectively creating an electrical maze in the atrium and thus termed the maze procedure [3] which due to unrivalled efficacy became and still remains the "gold standard" for surgical treatment of AF. In 1991, James Cox put forward a supposition that the posterior wall of the left atrium and ostia of the pulmonary veins (PVs) are the main anatomical substrates for triggers of AF [4, 5]. In 1998, M. Haïssaguerre practically confirmed the presence of AF triggers in the ostia of the PVs [6].

By the early 2000s, owing to the works of J. Cox, M. Haïssguerre and others, the operation of isolation of the posterior wall of the right atrium and PV ostia acquired the status of an independent operation and in the English-language literature became to be referred to as a box lesion procedure [7].

The evolution of this surgical approach to treatment of AF resulted in the appearance of devices of bipolar radiofrequency ablation (RFA) which made the maze procedure technically easier and faster to perform and led to refusal from sternotomy in favour of thoracotomy and mini-thoracotomy [8, 9]. Subsequently there appeared instruments making it possible to perform the box lesion operation by a totally thoracoscopic method through trocar ports [10].

In this article we provide a detailed description of our modification of the GALAXY procedure [10]. It differs from the prototype by increased surgical aggression in relation to the left atrium, namely, by increasing the number and diversity of the direction of ablation lines.

The purpose of present work was to modify the technique of performing the operation of thoracoscopic radiofrequency ablation of the posterior wall of the left atrium and PL ostia by means of increasing the "quantitative" impact on the left atrium in order to achieve its fragmentation.

TECHNIQUE OF THE PROPOSED OPERATION

The operation is performed under general anaesthesia. A necessary requirement is a possibility of performing separate and one-lung ventilation which is ensured by using a double-lumen endotracheal tube.

The patient is placed on the operating table in the supine position, with the arms along the body. To perform the operation requires provision of a free access to the 3rd and 4th intercostal spaces along the middle axillary line. Therefore, the patient's arms should be positioned and fixed so that the forearms are below the level of the contact of the patient's back with the operating table. In order to achieve this position it is feasible to set the arm holders at the level beneath the surface of the operating table and to fix the arms to them. If there is no possibility to use the arm holders, it is necessary to put an additional wide bolster-cushion under the patient's back (at the level of the inferior third of the shoulder blades).

The operation commences from deflation of the right lung and the initiation of unipulmonary ventilation of the left lung. Three thoracoports are introduced into the right pleural cavity:

• 3rd intercostal space along the anterior axillary line;
• 4th intercostal space along the midaxillary line;
• depending on the patient's body-build, 4th or 5th intercostal space along the anterior axillary line.

A hook electrocoagulator[1] is used to perform longitudinal opening of the pericardial cavity from the superior vena cava to the inferior vena cava. The line of resection of the pericardium should pass at a distance of not less than 1−1.5 cm anteriorly to the phrenic nerve in order to avoid its thermal damage (Fig. 1).

The next stage is blunt dissection of the pericardial duplicature posteriorly to the inferior vena cava and posteriorly to the superior vena cava. This is followed by retrieving the thoracoport inserted in the 5th intercostal space along the anterior axillary line and replacing it by two guides to be introduced into the contraperture. Then during the operation they would be attached to the Medtronic Cardioblate Gemini-s bipolar ablation device. The free ends of the guides are inserted through the fenestrations formed behind
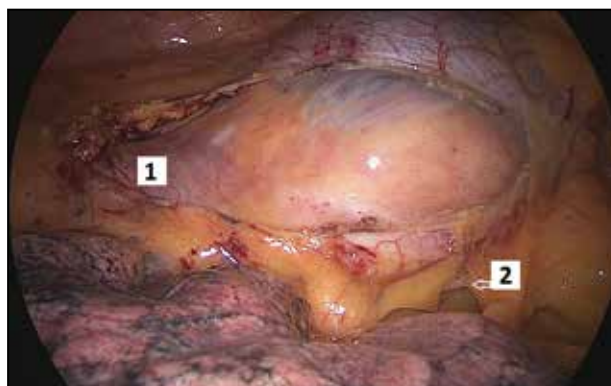

Fig. 1. Right longitudinal pericardiotomy: 1 – superior vena cava; 2 – phrenic nerve
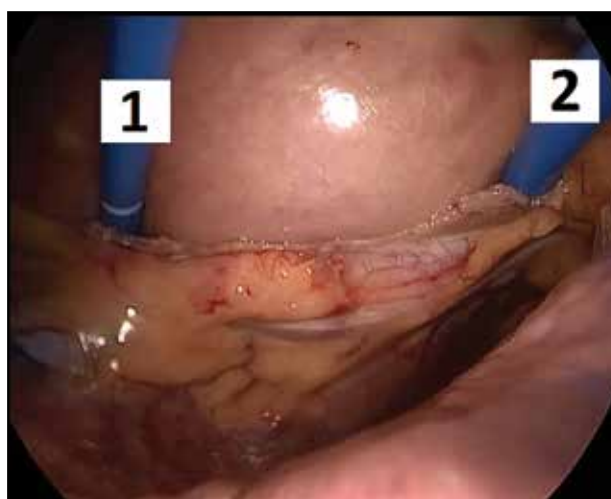

Fig. 2. The guides of the bipolar ablation device inserted through fenestrations of the pericardial duplicature into the transverse (1) and oblique (2) sinuses of the pericardium

the venae cavae into the transverse (under the superior vena cava) and oblique (under the inferior vena cava) sinuses of the pericardium (Fig. 2).

The free ends of the guides, remaining outside the pleural cavity are fixed with clamps or sewn to the covering operation linen in order to prevent their dislocation relative to the preset position during the subsequent manipulations.

Then the instruments (with the exception of the guides) are retrieved out of the right pleural cavity, followed by initiating unipulmonary ventilation of the right lung. Three thoracoports are inserted into the left pleural cavity:

• 3rd intercostal space along the anterior axillary line;
• 4th intercostal space along the midaxillary line;
• 5th intercostal space along the midaxillary line.

An electrocoagulator is used to perform longitudinal opening of the pericardial cavity. The access to the heart should be formed anteriorly to the phrenic nerve, at a distance of 1.5−2 cm therefrom. The landmarks of the length of the incision are the PVs and pulmonary

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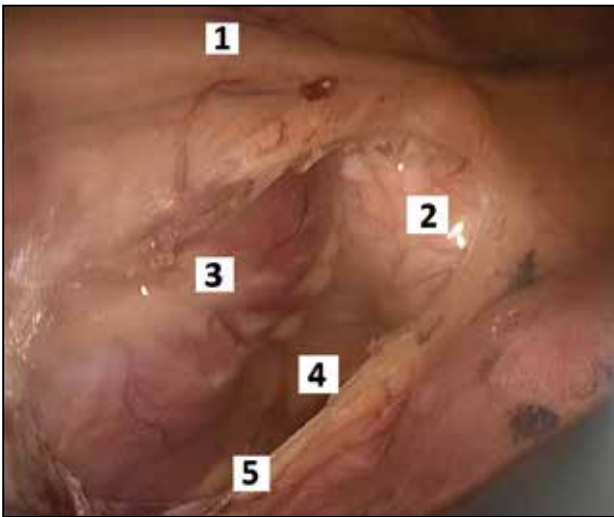[1] If possible, it is safer to use for this purpose the endoscopic dissector ValleyLab™ LigaSure (Medtronic).

Fig. 3. Left longitudinal pericardiotomy: 1 – left phrenic nerve; 2 – pulmonary artery; 3 – left atrial appendage; 4 – ligament of Marshal; 5 – left pulmonary veins
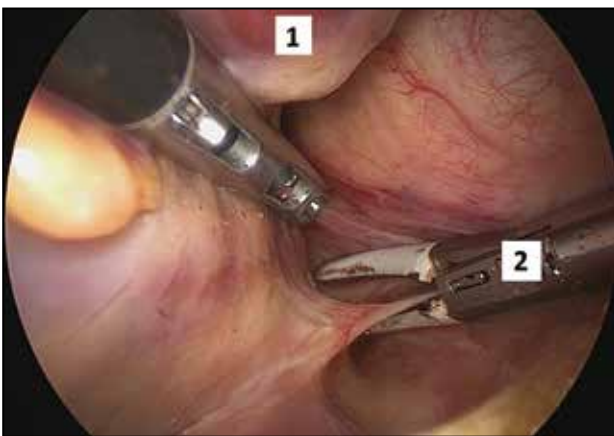

Fig. 4. Destruction of the ligament of Marshall with the help of the endoscopic dissector ValleyLab LigaSure, Covidien (Medtronic). The left atrial appendage (in the centre) is pulled aside by an endoscopic clamp (1); the ligament of Marshall is positioned between the jaws of the dissector (2)

artery. While dissecting the pericardium from the side of the left pleural cavity the primary aim is full visualization of the left atrial appendage (Fig. 3).

The ligament of Marshall[2] should preferably be destroyed prior to the beginning of the procedure of fragmentation of the left atrium immediately after left pericardiotomy. This is related to the fact that after the use of the ablation device the tissues of the area

of location of the ligament of Marshall are difficult to differentiate (Fig. 4).

Next, the ends of the guides situated in the transverse and oblique sinuses of the pericardium are inserted into the left pleural cavity and then are pulled out through the nearest to the diaphragm ("inferior") contraperture, from which the thoracoport has preliminarily been removed.

The ends of the guides drawn out of the left hemithorax are attached to the ablation device and under the control of a thoracosopic camera its jaws are inserted into the pericardial cavity, with the left PVs and the left atrium — its inferior and superior walls being situated between the jaws of the ablation device. The procedure of fragmentation of the left atrium commences.

Initially, the ablation device is inserted into the pericardial cavity with the convexity of the jaws upwards the patient's vertebral column (Fig. 5, a). A total of 10 applications are performed with the achievement of transmurality as the result of each of them. After each application, the jaws of the ablation device are disconnected and the device is slightly displaced relative to its initial position. Upon completion of 10 applications the ablation device is removed from the pleural cavity and reconnected to the guides so that being inserted into the pericardial cavity it would take the position with the convexity of the jaws facing downwards the patient's vertebral column (Fig. 5, b). In this position the ablation device is again inserted into the pericardial cavity and the procedure of creating the ablation lines is repeated.

Once the manipulations from the side of the left pleural cavity are completed, the instruments are retrieved. This is followed by the initiation of the left-sided unipulmonary ventilation and the right-sided stage of fragmentation of the left atrium (Fig. 5, c, d).

Once radiofrequency ablation of the left atrium according to the described scheme is completed, the atrium becomes fragmented (Fig. 6).

The next stage of the operation is resection of the left atrial appendage, for which purpose a suturing device such as, for example, Covidien ENDO GIATM (Medtronic) is inserted into the left pleural cavity. The suturing device is inserted either immediately through the "lower" contraperture or through a 15-mm thoracoport installed in it.
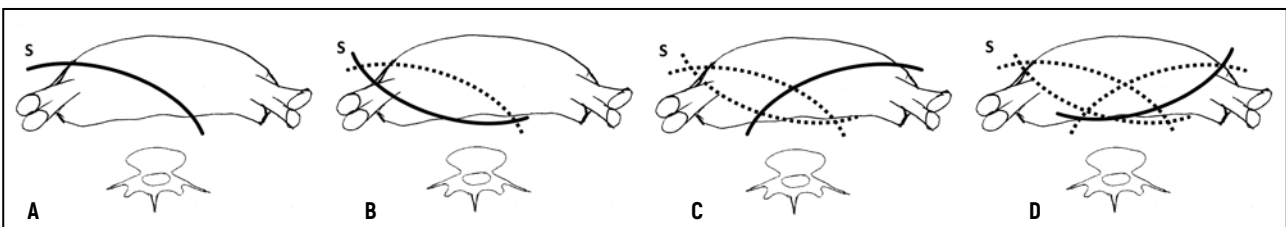

Fig. 5. Schematic illustration of the sequence of creating ablation lines on the left atrium (a → b → c → d)
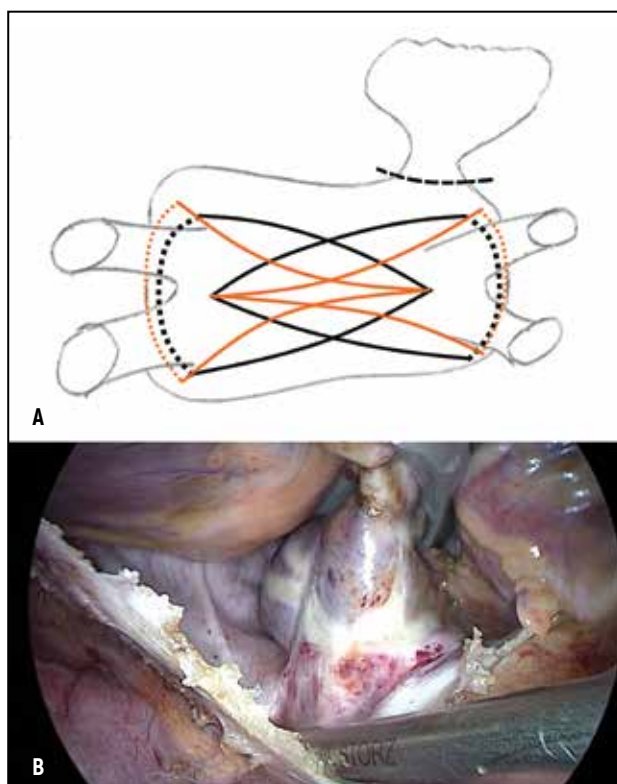
2 The ligament of Marshall is located in the epicardium between the left atrial appendage and the left PLs. It is a conglomeration of ganglionated plexuses. It plays a significant role in the initiation and maintenance of AF [11].

Fig. 6. a – final scheme of the operation of fragmentation of the left atrium. View from the side of the inferior wall (posterior surface) of the left atrium; b – intraoperative photograph showing the ablation lines on the inferior wall of the left atrium

Fig. 7. Resection of the left atrial appendage: a – entrapment of the left atrial appendage by the suturing device's jaws; b – the line of resection of the left atrial appendage

For resection of the left atrial appendage it is recommended to use an endoscopic suturing device with a 60-mm-long cartridge and 4.8-mm high staplers (green) [12, 13]. The left atrial appendage is positioned between the jaws of the suturing device. The jaws are closed. After thorough control for the lack of interposition of any structures, with the exception of the left atrial appendage, its resection is performed (Fig. 7).

Upon completion of resection of the left atrial appendage it is feasible to restore the sinus rhythm and to check the conduction block by any available method [14–17].

The operation is completed by draining of both pleural cavities.

RESULTS

According to this technique over the period from April 2017 to December 2018, a total of 59 patients were consecutively operated on. In order to substantiate the confirmation that it was necessary to increase the scope of surgical aggression during the operation in each of these patients we performed testing of "conduction blocks" from the PV and posterior wall of the left atrium, determining that the classical variant of performing the operation by the equipment Cardioblate Gemini-s (GALAXY procedure) was
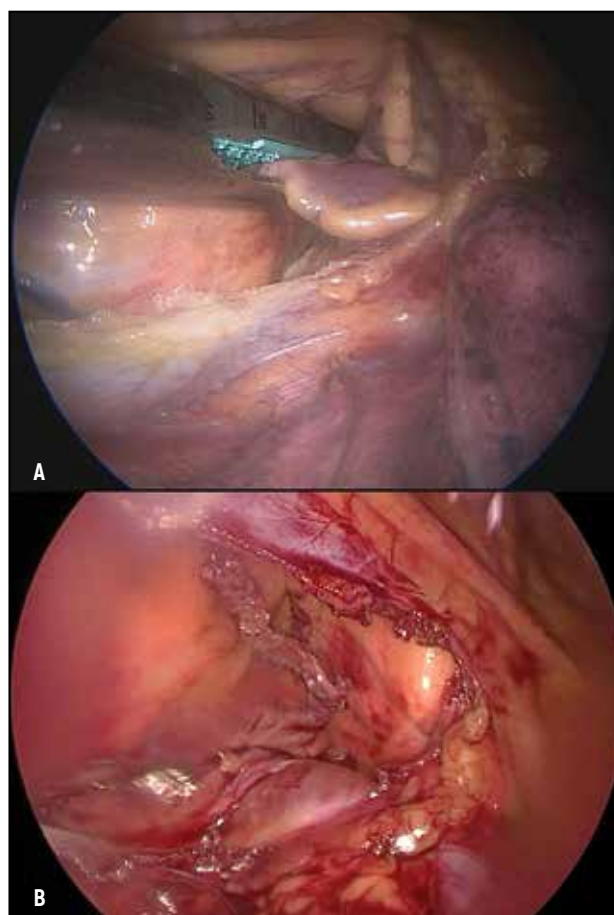
inadequate, since the achievement of the conduction block occurred not in all patients. That was why we took the decision to increase the scope of impact on the left atrium. After that we again checked the "conduction block" and noted the achievement of the necessary result in the form of its development.

The whole cohort of our patients was followed up for 6 months. So far at the current stage of follow up, efficacy of this intervention has been confirmed in all 59 patients by preservation of the sinus rhythm restored resulting from the operation.

DISCUSSION

ASSESSMENT OF SAFETY OF THE OPERATION

A typical intraoperative complication of thoracosopic interventions aimed at restoring the sinus rhythm in patients with AF is generally considered to be haemorrhage developing as a result of trauma of the structures subjected to exposure during the main stage of the operation and the structures located in the zone of the access to the heart: PVs, pulmonary arteries, venae cavae, left atrium [17–20].

Despite increased aggression in relation to the left atrium, none of our 59 patients developed typical complications. The absence of complications associated with an increased scope of the operation may be explained by altering the "quantitative" rather than "qualitative" parameter of surgical aggression in relation to the left atrium, since we did not change intensity of the impact.

SUBSTANTIATION OF INCREASED AGGRESSION

Besides the GALAXY procedure, the currently available literature has described a series of protocols of using the Medtronic Cardioblate Gemini-s ablation device [10, 17, 18, 21].

Compared to the literature-described methods, the RFA protocol we chose for conventional use of acting on the left atrial wall is characterized by the highest level of aggression. We substantiate our choice by the fact that according to the existing studies, there is a risk of obtaining a false-negative result concerning the achievement of transmurality of myocardial damage. Especially it concerns the patients with an increased volume of the left atrium and with left atrial hypertrophy [7]. Taking this fact into consideration the increase of the number of ablation lines and their multiple intersection should lead to reduced risk of obtaining such false-negative results from a radiofrequency generator.

In the course of the work we obtained confirmation of the assumption we put forward. All our patients operated on according to the presented technique and followed up for not less than 6 months demonstrated preservation of the sinus rhythm.

CONCLUSION

Hence, despite increased surgical aggression, there were neither intraoperative nor early postoperative complications in our patients (n = 59). Besides, during 6-month follow up all patients were found to have the preserved sinus rhythm. Therefore, the worked out technique of the operation may be considered safe and recommended for use.

Conflict of interest: none declared.

ЛИТЕРАТУРА/REFERENCES

1. *Savelieva I., Camm A.*J. Clinical relevance of silent atrial fibrillation: prevalence, prognosis, quality of life, and management. J. Interv. Card. Electrophysiol. 2000; 4: 2: 369–382.

2. *Vishnevsky A.A., Tsukerman B.M., Smelovsky S.I.* Elimination of ciliary arrhythmia by means of electrical atrial defibrillation. Clinical Medicine. 1959; 37: 26–29 (in Russian).

3. *Cox J.L., Schuessler R.B., D'Agostino H.J. Jr., et al.* The surgical treatment of atrial fibrillation. III. Development of a definitive surgical procedure. J. Thorac. Cardiovasc. Surg. 1991; 101: 4: 569–583.

4. *Gillinov M.* Surgical Treatment of Atrial Fibrillation. J. Atr. Fibrillation. 2008; 1: 1: 53–59.

5. *Ruaengsri C., Schill M.R., Khiabani A.J., et al.* The Cox-maze IV procedure in its second decade: still the gold standard? Eur. J. Cardio-Thoracic Surg. 2018; 53 (suppl. 1): 19–25.

6. *Haïssaguerre M., Jaïs P., Shah D.C., et al.* Spontaneous Initiation of Atrial Fibrillation by Ectopic Beats Originating in the Pulmonary Veins. N. Engl. J. Med. 1998; 339: 10: 659–666.

7. *Kalil R.A., Lima G.G., Leiria T.L., et al.* Simple surgical isolation of pulmonary veins for treating secondary atrial fibrillation in mitral valve disease. Ann. Thorac. Surg. 2002; 73: 4: 1169–1173.

8. *Robertson J.O., Saint L.L., Leidenfrost J.E., et al.* Illustrated techniques for performing the Cox-Maze IV procedure through a right mini-thoracotomy. Ann. Cardiothorac. Surg. 2014; 3: 1: 105–116.

9. *Wolf R.K., Burgess S.* Minimally invasive surgery for atrial fibrillation-Wolf Mini Maze procedure. Ann. Cardiothorac. Surg. 2014; 3: 1: 122–123.

10. *Doty J.R., Clayson S.E.* Surgical Treatment of Isolated (Lone) Atrial Fibrillation With Gemini-S Ablation and Left Atrial Appendage Excision (GALAXY Procedure). Innovations (Phila). 2012; 7: 1: 33–38.

11. *Hwang C., Chen P.-S.* Ligament of Marshall: Why it is important for atrial fibrillation ablation. Heart Rhythm. 2009; 6: 2: 35–40.

12. *Wolf R.K.* Treatment of lone atrial fibrillation: minimally invasive pulmonary vein isolation, partial cardiac denervation and excision of the left atrial appendage. Ann. Cardiothorac. Surg. 2014; 3: 1: 98–104.

13. *Gillinov A.M., Pettersson G., Cosgrove D.M.* Stapled excision of the left atrial appendage. J. Thorac. Cardiovasc. Surg. 2005; 129: 3: 679–680.

14. *Furniss G., Panagopoulos D., Newcomb D., et al.* The use of an esophageal catheter to check the results of left atrial posterior wall isolation in the treatment of atrial fibrillation. Pacing Clin. Electrophysiol. 2018; 41: 10: 1345–1355.

15. *Krul S.P., Driessen A.H., van Boven W.J., et al.* Thoracoscopic Video-Assisted Pulmonary Vein Antrum Isolation, Ganglionated Plexus Ablation, and Periprocedural Confirmation of Ablation Lesions. Circ. Arrhythm. Electrophysiol. 2011; 4: 3: 262–270.

16. *De Groot J.R., Driessen A.H., Van Boven W.J., et al.* Epicardial confirmation of conduction block during thoracoscopic surgery for atrial fibrillation — a hybrid surgical-electrophysiological approach. Minim. Invasive Ther. Allied Technol. 2012; 21: 4: 293–301.

17. *Guo Q.Z., Zhu D., Bai Z.X., et al.* A novel "box lesion" minimally invasive totally thoracoscopic surgical ablation for atrial fibrillation. Ann. Acad. Med. Singapore. 2015; 44: 1: 6–12.

18. ***Janusauskas V., Puodziukaite L., Maneikiene V.V., et al.*** Long-term results of minimally invasive stand-alone bi-atrial surgical ablation with a bipolar ablation device for persistent and longstanding persistent AF: a single-center case series of 91 patients. J. Cardiothorac. Surg. 2016; 11: 1: 23—31.

19. ***Phan K., Phan S., Thiagalingam A., et al***. Thoracoscopic surgical ablation versus catheter ablation for atrial fibrillation. Eur. J. Cardio-Thoracic Surg. 2016; 49: 4: 1044—1051.

20. ***Vos L.M., Kotecha D., Geuzebroek G.S.C., et al.*** Totally thoracoscopic ablation for atrial fibrillation: a systematic safety analysis. Europace. 2018; 20: 11: 1790—1797.

21. ***Antikeev A.M., Shamuratov I.K., Dyurzhanov A.A. et al.*** Thoracoscopic radiofrequency ablation for atrial fibrillation: operative technique and immediate results of three clinical cases. Annals of Arrhythmology. 2017; 14: 3: 150—154 (in Russian).

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