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COMPARATIVE CHARACTERISTICS OF ENDOVASCULAR OCCLUSION AND THORACOSCOPIC AMPUTATION OF LEFT ATRIAL APPENDAGE IN PATIENTS WITH ATRIAL FIBRILLATION

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Aim. To compare the effectiveness and safety of endovascular occlusion and thoracoscopic amputation of the left atrial appendage (LAA) in patients with atrial fibrillation (AF).

Methods. We present a retrospective single-center study with a prospective component including 25 patients with AF who underwent thoracoscopic amputation of the LAA and 31 patients on prospective part who underwent endovascular occlusion of the LAA. All patients signed voluntary informed consent for medical intervention and participation in the study. The criteria for selecting patients for thoracoscopic amputation of the LAA were the impossibility of performing an endovascular technique, features of its anatomy and increased trabecularity.

Results. In the group of patients with thoracoscopic amputation of the LAA, 2 cases of embologenic stump of the LAA with a depth of 1.6 cm (8%) were identified; these patients were recommended to continue taking anticoagulant therapy. Among patients who underwent thoracoscopic amputation, no complications were identified in the first 30 days after surgery, including mortality, bleeding, phrenic nerve paresis, acute cerebrovascular accident, pleurisy, pneumothorax, hemothorax. In 3 patients who underwent endovascular occlusion of the LAA, hematomas were detected at the site of puncture of the great vessels (9.7%), in 2 patients thrombus were detected on the occlusion device according to the results of transesophageal echocardiography (6.5%), which required the prescription of warfarin in these patients. Also, in 2 patients (6.5%) during implantation of the occluder into the LAA, as a result of the incorrect diameter of the disk of the occluding device, a residual cavity with a depth of 0.7 cm was formed between the ridge and the occluder. No significant differences in the frequency of non-severe complications were found in the groups, p =0.139. During the year of postoperative observation, thromboembolic complications were absent in the operated patients of both groups.

Conclusion. When comparing two methods of LAA isolation, no severe complications were identified, either in the perioperative or in the early or late postoperative period. There were no significant differences in the incidence of non-severe complications in the early postoperative period. Thus, the effectiveness and safety of thoracoscopic amputation and endovascular occlusion of the left atrial appendage are comparable.

Key words: atrial fibrillation; the left atrial appendage; thoracoscopic amputation; endovascular occlusion; complications

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Atrial fibrillation (AF) has become a critical public health problem over the past decades, and its prevalence has been increasing due to greater ability to treat chronic cardiac and non-cardiac diseases, as well as improved ability to diagnose AF [1, 2]. AF remains the most common arrhythmia, occurring in the general population in 2% of cases and associated with an increased risk of thromboembolic complications (TEC) [1, 3-5]. AF has been found to result in a fivefold, and according to some reports, a sixfold increase in the risk of TEC and stroke and a twofold increase in mortality among patients [6, 7]. In patients with AF, thrombi form in the left atrial appendage (LAA) in 90% of cases, which can embolize the main vessels [8, 9]. The LAA has a multitude of functions, including modulating sympathetic and parasympathetic tone, regulating the balance of natriuretic peptides, managing pressure and volume in the left atrium, and contributing to left ventricular diastolic filling [10, 11]. The architecture of the left atrial appendage is complex, characterized by heterogeneous wall thickness and consisting of endocardial and epicardial fibers arranged in various orientations [8]. Anatomical features of the left atrial appendage, such as its long, tubular shape and narrow atrial-appendage junction, predispose it to blood stasis and thrombus formation. This risk is particularly pronounced in the context of AF, where the absence of effective atrial contraction results in decreased blood flow velocity within the LAA [8, 12-14].

It is the alterations in blood flow velocity within the left atrial appendage and the structural remodeling of its endothelium that are associated with an increased risk of thrombus formation in patients with AF [8]. Traditionally, anticoagulants are prescribed to patients with AF for prevention of TEC, but such therapy is associated with the risk of hemorrhagic complications, in particular hemorrhagic strokes. Moreover, in some patients it is impossible to prescribe anticoagulants due to contraindications. Given the critical role of the LAA in thrombus formation and migration in patients with AF, surgical or transcatheter methods of LAA exclusion are emerging as viable alternatives to anticoagulant therapy. These methods can help reduce the risk of thrombosis and prevent cardioembolic ischemic events in patients with AF [12]. To date, there are two main techniques to exclude LAA, thoracoscopic amputation (TA) and endovascular occlusion (EO).

LAA TA has certain advantages compared to EO: firstly, additional risk of thrombosis can be avoided without implantation of foreign materials, and secondly, there is no endothelialization of the implant, which does not require prescription of antithrombotic therapy [15]. Despite this, there remains a risk of a residual cavity (stump) of the LAA following the TA procedure. The presence of such a residual cavity in a patient precludes the discontinuation of anticoagulant therapy [15]. With LAA EO, there is a risk of residual blood flow around the implant and thrombosis on the device itself, which has a significant impact on prognosis. However, with the improvement of this technique and the use of new-generation occluders, the risks of these complications are also decreasing [10, 15]. Virtually all previous studies have focused on comparing the efficacy of traditional methods (such as anticoagulant therapy) and alternative methods (such as LAA EO and TA) for thromboembolism prophylaxis in patients with AF. However, there is a notable paucity of research comparing the efficacy of the two surgical techniques for LAA closure. This is what prompted this study.

The aim of the study was to compare the efficacy and safety of endovascular occlusion and thoracoscopic LAA amputation in patients with atrial fibrillation.

METHODS

The study was approved by the local ethical committee, protocol No.8 dated 10.10.2022. All patients signed an informed consent form for surgical intervention and participation in the study.

We present a retrospective single-center study with a prospective component that included 56 patients with AF who had established contraindications for ongoing anticoagulant therapy: high risk of bleeding on anticoagulants (HASBLED > 1 point) and ischemic events (CHA_2DS_2-VASc in men > 1 point, in women > 2 points), as well as a history of bleeding and stroke, and inability to take anticoagulant therapy. 25 patients underwent LAA TA due to impossibility of endovascular technique due to various factors (anatomical anomalies, increased trabecularity of LAA according to the results of transesophageal echocardiography (TE Echo), inferior vena cava occlusion); 31 patients underwent LAA EO. Before occluder implantation, patients underwent visualization of the LAA by TE Echo and contrast angiography to determine the optimal size of the occluding device (Table 1).

The sample size of patients with atrial fibrillation who underwent left atrial appendage exclusion and transcatheter LAA occlusion was not calculated, as there is a lack of literature providing data on the expected outcome

Table 1.
Assessment of left atrial appendage (LAA) size in patients in the endovascular occlusion group by transesophageal echocardiography (TE Echo) and contrast angiography (CA) methods

#	LAA size according to TE Echo data, mm				LAA size, mm, according to CA	
	0°	45°	90°	135°	ЛКП	ПКП
1.	21	19	22	21	22	18
2.	23	23	24	24	26	26
3.	20	16	18	22	24	23
4.	18	17	20	16	20	18
5.	19	19	20	20	17	16
6.	15	14	16	20	19	17
7.	21	19	21	20	19	20
8.	19	19	16	19	22	19
9.	17	16	17	19	23	18
10.	25	22	22	23	25	22
11.	21	17	18	20	20	19
12.	16	20	20	16	19	17
13.	23	18	20	20	23	19
14.	20	23	23	23	21	23
15.	15	14	17	15	16	14
16.	24	19	17	16	22	18
17.	17	15	18	18	19	18
18.	15	13	13	13	15	14
19.	18	17	18	18	19	20
20.	15	16	16	17	20	15
21.	22	19	22	23	23	19
22.	20	20	19	18	21	18
23.	20	20	19	18	21	18
24.	19	17	17	18	17	17
25.	23	25	26	24	24	25
26.	23	20	17	15	21	18
27.	18	16	18	19	18	18
28.	18	17	16	18	19	17
29.	15	16	16	18	20	15
30.	22	20	22	23	23	19
31.	20	20	19	20	20	18

Note: LCP - left caudal projection; RCP - right cranial projection rates for these patient categories. The group of patients undergoing LAA TA was represented by a continuous retrospective sample of all patients operated on between 2018 and 2022. The LAA EO group was formed by pseudorandomization from 170 patients operated on in 2023, observed prospectively.

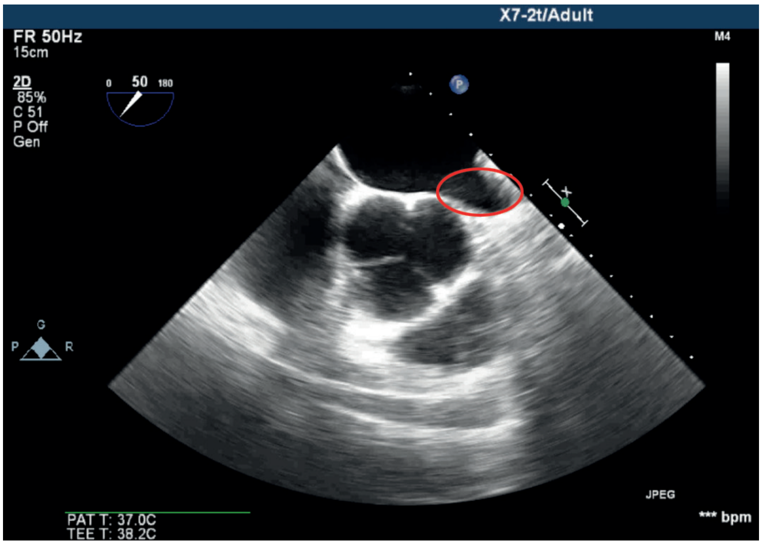

Fig. 1. Transesophageal echocardiography after thoracoscopic left atrial appendage amputation. There is an embologenic left atrial appendage stump with a depth of more than 1 cm, its cavity is highlighted by an oval.

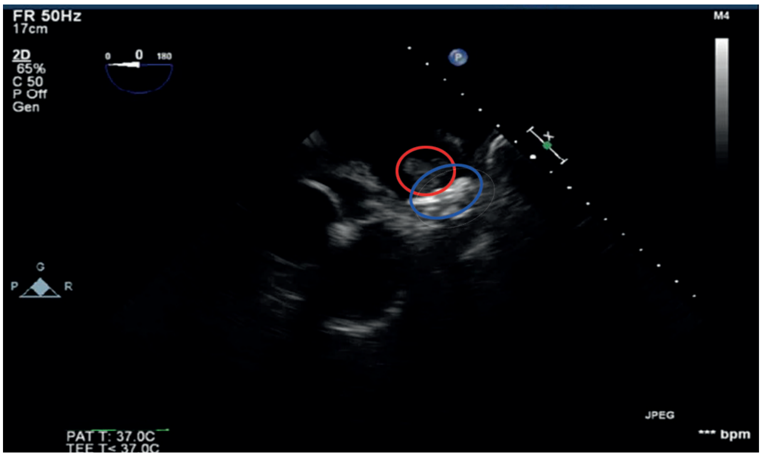

Fig. 2. Transesophageal echocardiography after endovascular occlusion of the left atrial appendage. The thrombus (red oval) on the occluding device (blue oval) is visualized.

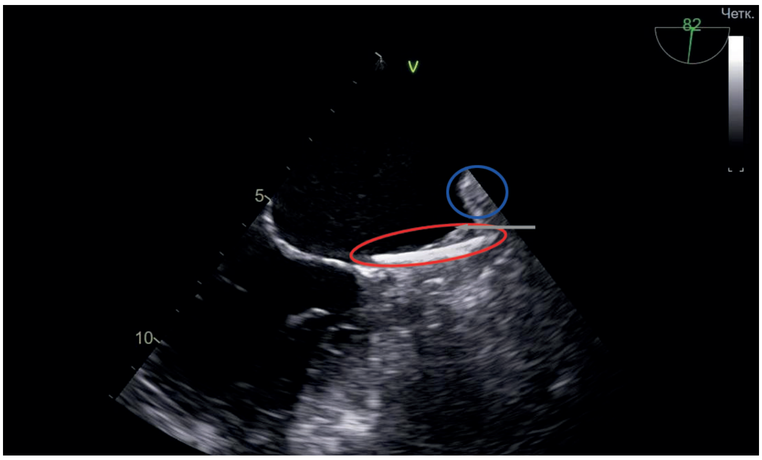

Fig. 3. Transesophageal echocardiography after endovascular occlusion of the left atrial appendage. Residual cavity (gray arrow) between the ridge (blue oval) and the occluder (red oval).

The following outcomes were analyzed in the comparison groups: mortality, hemorrhage, diaphragmatic nerve paresis, acute cerebral circulatory failure, pleurisy, pneumo- and hemothorax, hematomas at the site of main vessels puncture, embolized stumps of the LAA, thromboses on the occluding device according to the results of TE Echo.

Technique of LAA thoracoscopic amputation

LAA TA was performed under general anesthesia. Separate lung intubation facilitated single-lung ventilation, alternating between the left and right lungs. Thoracoscopic ports were placed at the 4th, 5th, and 6th intercostal spaces along the left mid axillary and posterior axillary lines. Thoracoscopy was performed under conditions of positive pressure in the pleural cavity (CO_2 insufflation at a flow rate of 8-10 L/min until intrapleural pressure of 8-13 mmHg was achieved). During thoracoscopy, the pleural cavity was examined for changes. Pericardial dissection was performed with a coagulator. The Endo GIA™ stapler was placed on the left, which was used to amputate the LAA. For LAA amputation in patients, 60 mm long cassettes with 4.2 mm high staples were used. After revision of the LAA amputation line, the left pleural cavity was drained through the contraperitoneum for the stapling device, followed by thoracoport extraction and suturing of the postoperative wounds.

Technique of LAA X-ray endovascular occlusion

Catheterization of the right femoral vein was performed under endotracheal anesthesia. Mid-inferior interatrial septal puncture was performed using the Brockebrough TE Echo technique. A super rigid guidewire was used to guide the delivery introducer and Pig-tail catheter and to perform LAA contrast. Based on angiography and TE Echo data, the choice of the optimal occluder size was performed. The Amulet occluder (Abbott) was delivered to the LAA, and sequential opening of the lobe and disk of the occluder was performed. The occluder lobe deployed behind the envelope artery, and the disc did not impinge upon the mitral valve. A positive tension test was performed. The delivery device was detached from the occluder, with careful monitoring of its stable position and the absence of blood flow through the occluder. Subsequently, the introducer was removed.

Statistical analysis

Statistical processing was performed in Statistica 12.0 program (Statsoft) and included presentation of absolute values and their percentages, medians, 1st and 3rd quartiles (25th and 75th percentiles), and interquartile range [Me (25;75)]). Nonparametric criteria were used to evaluate and analyze the obtained data: two independent groups were compared quantitatively using the Mann-Whitney U-criterion. The significance of differences between nominal traits was analyzed using Pearson's chi square criterion with Yates' correction. Differences were considered statistically significant when the level of first-order error was less than 0.05.

RESULTS

In terms of age, the compared groups were similar: the median age of patients in the LAA TA group was 59 years (interquartile range: 52 to 67 years), while in the LAA EO group it was 62 years (interquartile range: 50 to 67 years), with a p-value of 0.499. The groups also did not differ in gender composition. There were 6 females (24%) in the TA group and the rest were males 19 (76%), while in the EO group there were 9 females (29%) and 22 males (71%), p=0.673. Patients in the TA group had in 14 cases persistent form of AF (56%), in 11 cases paroxysmal form of AF (44%). There were 15 cases of persistent AF (48.4%), 6 cases of paroxysmal AF (19.4%), and 10 cases of persistent AF (32.2%) in the EO group.

During the examination, all patients in both groups were confirmed to be at high risk of TE and bleeding: median risk of TO CHA_2DS_2-VASc was 4 points (3; 5); median risk of bleeding HASBLED was 3 points (3; 5). Thromboembolic events in the anamnesis that occurred against the background of anticoagulant drugs were observed in 10 people (17.8%).

Among patients who underwent LAA TA, no complications were detected within 30 days after surgery, including no cases of death, bleeding, diaphragmatic nerve paresis, acute cerebral circulatory failure, pleurisy, pneumo- and hemothorax. After 1.5 months after LAA TA, residual cavities - embolized LAA stumps 1.6 cm deep were detected according to TE Echo in 2 patients (8%) (Fig. 1). These patients were advised to continue anticoagulant therapy. The remaining patients (n=23) were discontinued anticoagulants in the postoperative period.

In the LAA EO group, 3 patients had hematomas at the site of puncture of the main vessels (9.7%). In 2 patients of the LAA EO group thrombi were found on the occluding device according to the results of TE Echo (6.5 %) (Fig. 2). These 2 patients were prescribed warfarin with a TE Echo 1.5 months later to monitor thrombus status. After 1.5 months of warfarin therapy, no thrombotic masses at the occluding device were detected on control TE Echo and anticoagulant therapy was discontinued. The remaining patients (n=29) were discontinued anticoagulant therapy in the postoperative period. In 2 patients (6.5%) during occluder implantation in the LAA, a residual cavity between the ridge and the occluder with a depth of 0.7 cm was formed because of incorrect selection of the occluder disk diameter (Fig. 3).

There was a total of 2 complications in the LAA TA group and 7 complications in the LAA EO group. There were no significant differences in the frequency of non-serious complications between the groups, p=0.139. During one year of postoperative follow-up, TE and mortality were absent in operated patients of both groups.

DISCUSSION

According to our results, comparing the two methods of LAA isolation showed no severe complications, incidences of thromboembolic and fatal events among patients in both groups. No significant differences were also found in the incidence of non-serious complications in the early postoperative period.

Most of the previously published materials cover comparative evaluation of the efficacy of LAA EO and anticoagulant therapy, as well as studies of the efficacy of LAA TA alone and in comparison, with anticoagulants. According to one literature report, LAA EO results in lower rates of hemorrhagic stroke, cardiovascular and total mortality, and non-procedural bleeding compared to warfarin [16], while other data suggest that LA EO is comparable to anticoagulants in terms of stroke and all-cause mortality with lower rates of bleeding [17, 18]. The efficacy and safety of TA LAA in stroke prevention in patients with AF when anticoagulant therapy is not available has also been established [19, 20]. Moreover, it was found that LAA TA was even superior to warfarin with respect to stroke prevention in patients with non-valvular AF [21].

However, the issue of comparative characterization of the efficacy and safety of LAA TA and EO is poorly studied, and only a few studies have been devoted to this problem. Jian-Long Wang et al. conducted a study of 209 patients with non-valvular AF. The authors monitored patients starting from the first day after surgery and evaluated efficacy endpoints, including stroke, transient ischemic attack, systemic embolism, and death. They also assessed safety endpoints, such as bleeding events, and recorded perioperative complications. It was concluded that LAA TA and EO had similar efficacy in preventing stroke, but there were fewer bleeding events in the LAA TA group [15]. Our data about stroke are consistent with Jian-Long Wang et al, but our results showed no differences in the incidence of bleeding during LAA TA and EO.

According to a large meta-analysis by Shijie Zhang, including 19 studies and more than 1,500 patients, which evaluated primary endpoints (incidence of stroke during a follow-up period of at least 12 months) and secondary endpoints (incidence of successful complete closure of LAA with EO or TA and post-procedural mortality and complications, and all-cause mortality during a follow-up period of at least 12 months), the authors found no significant differences in stroke and all-cause mortality in patients of both groups after 12-month follow-up [22]. When comparing the two techniques of LAA closure, our results also showed no differences in stroke incidence and all-cause mortality according to our results. In our study, there were no cases of stroke and all-cause mortality in both groups.

A.Yoshimoto et al. in their study found no significant differences in the number of intraoperative and postoperative bleeding or the incidence of intraoperative massive bleeding and postoperative thrombosis of the LAA stump with 100% successful LAA closure when comparing LAA TA and EO. In terms of feasibility and efficacy about stroke prevention, the two methods had no significant differences [23]. We found no differences in the incidence of bleeding in the perioperative period and in the incidence of stroke among patients in both groups. In 2 cases of stump formation after LAA TA, no cases of thrombosis were detected. Two cases of thrombosis at the occluding device recorded in the LAA EO group were successfully eliminated after a course of warfarin therapy followed by withdrawal of anticoagulant therapy.

L.Raman et al. performed a study among patients with AF who underwent LAA TA or EO due to inability or refusal to take anticoagulant therapy. The authors demonstrated the feasibility and comparable clinical outcomes of both techniques without significant periprocedural or postprocedural complications. The authors pointed out that 1 patient in the TA group with hypertrophic cardiomyopathy had a wall thrombus at successful closure of LAA at 4 months of follow-up, and 1 patient after EO had a thrombus on the occluding device at 6 months of follow-up. The authors noted that these patients resumed anticoagulants with follow-up TE Echo showing resolution of thrombus in both cases [24]. In our study, we also found no significant differences in the sum of periprocedural complications in both groups (LAA TA group had a total of 2 complications, LAA EO group had 7 complications, p=0.139). In our study, there were also isolated cases of device-related thrombosis in the LAA EO group (n=2), which were undetectable after 1.5 months of anticoagulant therapy.

Thus, our findings are consistent with the few previously published data by other authors and indicate that there are no significant differences in efficacy and safety between LAA TA and EO. The absence of differences in the incidence of mortality, stroke and the number of non-serious periprocedural complications in the compared groups proves that the efficacy and safety of LAA TA and EO are comparable. Thus, both techniques of LAA closure are comparable and can be recommended as an alternative to anticoagulant therapy in patients with various forms of AF for the prevention of cardioembolic complications.

CONCLUSION

Thoracoscopic amputation and endovascular occlusion of the LAA are comparable in efficacy and safety and are worthy alternatives for the prevention of cardioembolic complications in patients with AF and inability or contraindications for anticoagulant therapy.

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