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SURGICAL TREATMENT OF ATRIAL FIBRILLATION USING CRYOABLATION IN PATIENTS WITH RHEUMATIC MITRAL VALVE DISEASE AND ATRIAL FIBRILLATION, FOR THE FIRST TIME IN KAZAKHSTAN

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Atrial fibrillation, cryoablation,
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surgical treatment of arrhythmias.

Abstract

Background. This study presents the results of a clinical trial evaluating the effectiveness of surgical treatments for atrial fibrillation in patients with rheumatic mitral valve disease. Special attention is given to the comparison of cryoablation and radiofrequency ablation, two methods used in conjunction with mitral valve surgeries. The results indicate that cryoablation, a method first used in Kazakhstan, has long-term advantages for restoring sinus rhythm and cardiac remodeling, thereby improving patients' quality of life.

Materials and Methods. The study was conducted at the period from January 2020 to March 2024 through a retrospective analysis of data from patients with atrial fibrillation and rheumatic mitral valve disease who underwent surgical treatment using one of two methods: Cryoablation with left atrial appendage clipping (Group I) – 50 patients; Radiofrequency ablation with left atrial appendage suturing (Group II) – 50 patients.

Results. According to the conducted research, both cryoablation and radiofrequency ablation are highly effective in restoring sinus rhythm in patients with atrial fibrillation and rheumatic mitral valve disease. Cryoablation, a procedure that was used for the first time in Kazakhstan, demonstrated significant advantages in the long-term maintenance of sinus rhythm and improvement in heart remodeling parameters, such as left atrial volume. This has enhanced the quality of life for patients.

Conclusions. There is a need for the widespread implementation of innovative treatments for atrial fibrillation, such as cryoablation, as surgical procedures are more effective and patients with severe cardiovascular diseases have better outcomes.

Introduction

Currently, cardiac arrhythmia surgery, particularly atrial fibrillation (AF), is a multifaceted field of knowledge encompassing electrophysiology, anatomy, pathophysiology, cardiology, and surgical techniques. It is an actively developing area both in scientific and practical medicine. The main complication today remains stroke.

According to the World Health Organization, there are more than 37 million cases of atrial fibrillation worldwide.^{1,2} Age is the main risk factor for AF, and its

prevalence is expected to increase by 2.3 times due to the rising life expectancy of the population.^{3,4} The age structure of the population in Kazakhstan, like in other European countries, is characterized by an increasing proportion of elderly individuals. It is estimated that by 2050, the global burden of AF may increase by more than 60%.^{5,6}

Currently, the following methods are available for diagnosing AF worldwide: electrocardiogram (ECG), Holter ECG monitoring, and portable devices. The first two methods are available in

the Republic of Kazakhstan. Enhancing the diagnostic capabilities for AF can be achieved through the use of various existing diagnostic methods. However, for coordinated work among healthcare professionals, proper structuring and optimal sequence of actions are necessary.^{7,8}

Guidelines from the European Society of Cardiology indicate that there should be between 280,000 and 560,000 cases of AF among 14 million adults in Kazakhstan. This sharply contrasts with the current situation in the country, which is due to the low level of disease detection.⁹ Stroke prevention with oral anticoagulants, which are sometimes not used by doctors due to concerns about bleeding, is an important part of AF detection. There is always a risk of bleeding.^{3,10,11}

Atrial fibrillation is the most common arrhythmia in patients with rheumatic mitral valve disease. Despite existing treatments, safer and more effective surgical approaches are needed. Cryoablation, an innovative procedure first used in Kazakhstan, employs extremely low temperatures to treat diseases and promises significant improvements in this field.^{12,13}

Schmidt et al. (2016) presented one-year follow-up data from the German Ablation Registry, showing that the recurrence rate of atrial fibrillation one year after the procedure was similar for cryoballoon and radiofrequency ablation (RFA).¹⁴ However, diaphragm nerve paralysis was observed more frequently with cryoablation.^{4,14} In *Tomayko E.'s et al.* (2019) study, it was found that cryoablation and RFA have the same efficacy in restoring sinus rhythm in patients undergoing mitral valve surgery. However, patients who underwent RFA had a greater need for inotropic support in the postoperative period.¹⁵

Engin M. et al. (2024) conducted a retrospective study comparing the safety and clinical outcomes of cryoablation and RFA. Both methods demonstrated similar effectiveness in restoring sinus rhythm one year after surgery.¹⁶

Kuck K. et al randomized study found that cryoablation outperforms radiofrequency ablation in the treatment of paroxysmal atrial fibrillation.¹⁷ Compared to

RFA, cryoballoon ablation requires fewer repeat ablations and has a shorter procedure time, as shown in *Andrade's et al.* study (2019).¹⁸ According to *Schmidt et al.* (2016), the recurrence rate of AF one year after RFA and cryoablation is similar, but the complications associated with these methods differ.¹⁴

Materials and Methods

The study was conducted at the JSC "Scientific Research Institute of Cardiology and Internal Diseases" from January 2020 to March 2024 using a retrospective analysis of data from patients with atrial fibrillation (AF) and rheumatic mitral valve disease who underwent surgical treatment. The study involved a retrospective analysis of data from patients with atrial fibrillation and rheumatic mitral valve disease who underwent open-heart surgery with one of two treatment methods: Cryoablation with left atrial appendage (LAA) clipping (Group I). Radiofrequency ablation (RFA) with suturing of the left atrial appendage (Group II).

A total of 100 patients participated in the study. Group I consisted of 50 patients who underwent valve replacement with cryoablation and LAA clipping. The ArtiCure system for cryoablation of the right and left atria is an innovative method that was first used in Kazakhstan. During the procedure, nitrogen freezes the heart tissue to a temperature of -71°C, and additionally, a clip is placed on the left atrial appendage. This method was applied during open surgeries, such as mitral valve replacement or repair. Group II included 50 patients who underwent valve replacement with radiofrequency ablation and suturing of the left atrial appendage. This traditional method uses radiofrequency heating for ablation, followed by suturing of the left atrial appendage.

The goal of the statistical analysis was to determine the significance of the differences between the two groups. The primary research methods were ECG, echocardiography (ECHO), 24-hour Holter ECG monitoring, and heart computed tomography (CT) before and after surgery to assess the left atrial appendage.

Statistical Analysis. A comparative examination of clinical outcomes, including tracking the incidence of atrial fibrillation recurrence and the emer-

gence of post operative complications, was conducted to evaluate the efficacy of each treatment approach. The gathered data were statistically processed in order to ascertain the significance of the differences between the two groups. The groups were compared using descriptive statistics, the x2 test for categorical data, and the t-test for continuous variables. When the differences' significance was at $p < 0.05$, it was deemed significant. Mean and standard deviations (SD) were calculated for each group.

Ethical approval for this study was obtained from the local ethics committee of the Kazakh Medical University "Higher School of Public Health", No. 3, dated February 2, 2024.

Results

Demographic data were analyzed to assess the safety and effectiveness of

cryoablation and radiofrequency ablation in patients with rheumatic mitral valve disease. The number of patients in both groups was the same (50 patients in each group). The average age (in years) was 60.6 ± 9 in Group I and 60.7 ± 9.1 in Group II ($p = 0.960$). The gender distribution (female/male) was 82 (64%) / 18 (36%) in Group I and 83 (66%) / 17 (34%) in Group II ($p = 0.869$).

An analysis of surgical parameters revealed the following key findings (Table 1):

The ablation time in Group I was significantly longer than in Group II ($p < 0.001$), indicating that radiofrequency ablation is quicker than cryoablation.

The aortic cross-clamp time was shorter in Group II compared to Group I ($p = 0.043$), indicating lower invasiveness of radiofrequency ablation.

Table 1.
Operative Parameters

Parameter	Group I (cryoablation) n=50	Group II (RFA) n=50	P value
Ablation time (minutes)	13.7 ± 1	8.6 ± 1	< 0.001
Aortic compression time (minutes)	76.8 ± 7.3	74.1 ± 10.4	0.043
Total perfusion time (minutes)	108.5 ± 12.7	107.3 ± 14.1	0.869

There were no significant differences in total perfusion time between the groups ($p = 0.101$), suggesting comparable operation duration in both groups.

Sinus rhythm restoration in patients

with rheumatic mitral valve disease was evaluated at 6 and 12 months post-surgery to determine the effectiveness of cryoablation and radiofrequency ablation (see Table 2).

Table 2.
Frequency of Sinus Rhythm Restoration

Parameter	Group I (cryoablation)	Group II (RFA)	P value
After 6 months	$66\% \pm 5$	$52\% \pm 5$	< 0.05
After 12 months	$66\% \pm 5$	$50\% \pm 5$	< 0.05

The results showed that, both at 6 months and 12 months post-surgery, the rate of sinus rhythm restoration was significantly higher in the cryoablation group compared to the radiofrequency ablation group. These findings confirm that cryoablation is more effective in restoring sinus rhythm in patients with rheumatic mitral valve disease.

The left atrial volume (LAV) is an important indicator for assessing the degree of reverse remodeling of the heart.

LAV was measured before the operation, immediately after the operation, and 6 months post-operation. The results of LAV analysis (see Table 3) showed that in the cryoablation group, the left atrial appendage volume was significantly lower both immediately after the operation and 6 months later, compared to the radiofrequency ablation group. This suggests more pronounced reverse remodeling of the heart in the cryoablation group.

Observation period	Group I (cryoablation) n=50	Group II (RFA) n=50	P value
Before the operation	119.2 ± 20.1	120.5 ± 21.3	0.761
Immediayely after the operation	82.68 ± 15.3	95.7 ± 18.2	< 0.001
After 6 months	78.64 ± 12.5	94.1 ± 16.4	< 0.001

Table 3.
Left Atrium Volume (ml)

The study also showed that stroke volume in both groups decreased immediately after surgery and remained at the same level after six months. However, no significant differences were found between the groups. Both the end-diastolic volume and end-systolic volume decreased immediately after surgery and

continued to decrease over six months, with no significant differences between the groups.

Ejection fraction (EF), the percentage of blood volume ejected from the left ventricle in one cardiac cycle, was also an important indicator of the heart's pumping function (see Figure 1).

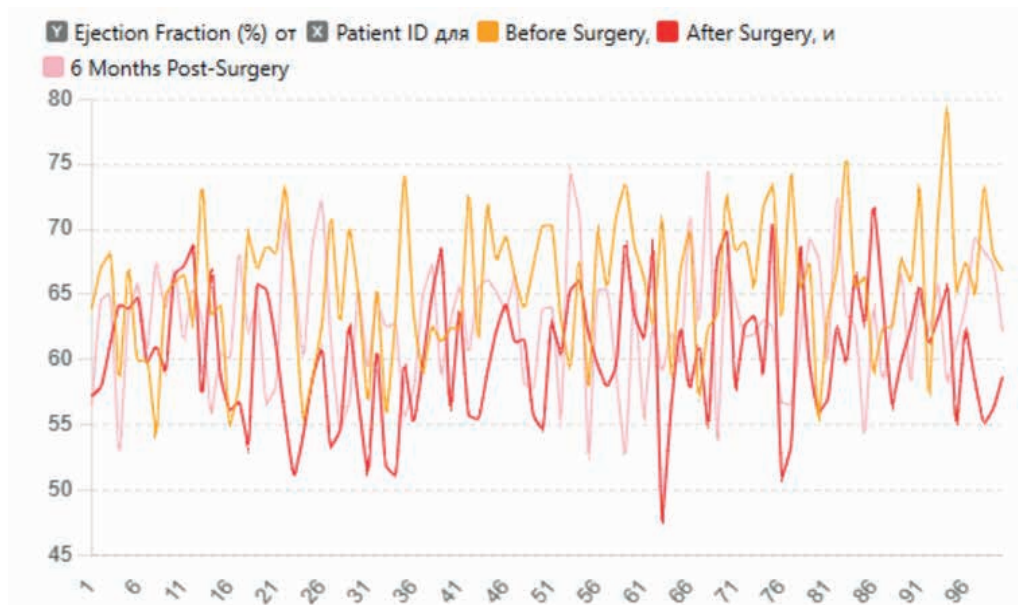


Figure 1.
Changes in Ejection Fraction Over Time

Post-surgery, positive changes were observed in the normalization of heart rhythm and improved regulation of heart activity. This was confirmed by ECG data reflecting changes in heart rate (HR) during the day and night. An increase in the number of premature ventricular contractions (PVCs) after surgery may be the result of short-term impact on heart rhythm due to surgical intervention. Such an increase may indicate a temporary rise in the arrhythmic potential of the heart, which is a common response to stress caused by the surgery.

At 6 months post-surgery, the average number of PVCs decreased to levels below baseline, indicating heart stabilization and improved electrical stability. This suggests that the surgical intervention positively impacts heart function

and reduces the risk of arrhythmias. ST segment changes after surgery should be closely monitored, as they may indicate ischemia or changes in myocardial perfusion. Since these changes may signal the need for treatment adjustments or additional diagnostic procedures, they require careful observation. Overall, positive trends in heart electrical activity are observed when considering ECG changes before and after surgery, as well as in the long-term recovery period. This underscores the importance of regular monitoring to evaluate heart function recovery, treatment effectiveness, and potential complications.

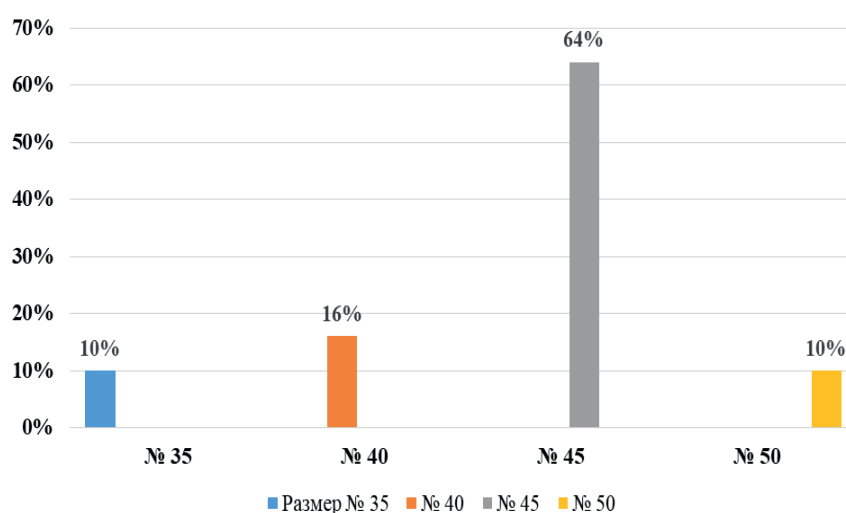
In most cases (80%), left atrial appendage occlusion was performed using the "AtriCure" clip system in various sizes (see Figure 2).

Figure 2.
Left atrial appendage clipping device



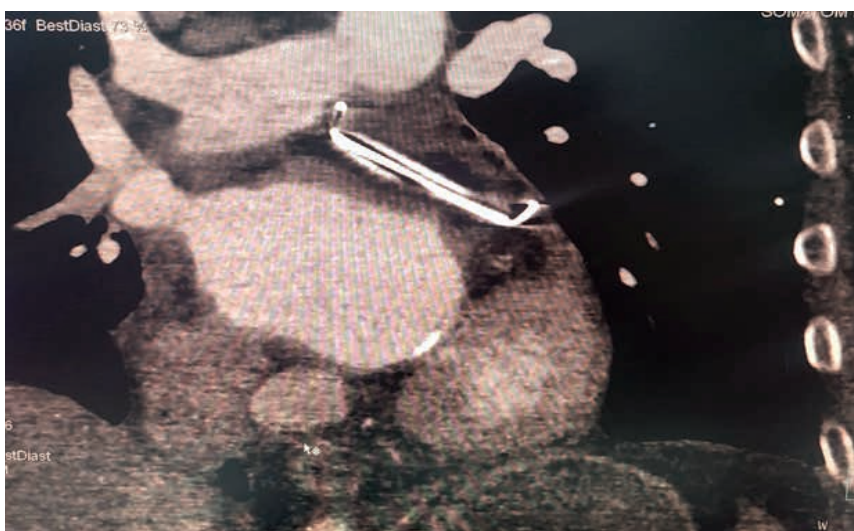
In fewer cases (20%), LAA closure was achieved through suturing due to anatomical features of the LAA and the inability to use a clip (for example, in 2 patients, the LAA was too short and small for the clip, and in 8 patients, the presence of thrombi in the LAA made clip placement contraindicated). The sizes of the clips used are shown in Figure 3.

Figure 3.
Shows the sizes of the clips used for left atrial appendage clipping



In the postoperative period, LAA was also assessed via heart CT to evaluate the integrity and correctness of the clip placement (see Figure 4).

Figure 4.
Hermetically closed left atrial appendage according to cardiac CT scans



After surgery, 99% of patients were successfully discharged for outpatient follow-up, indicating a positive surgical outcome and effective recovery. No deaths were reported in either group. After surgery, three patients in the cryoablation group and one patient in the radiofrequency ablation group had pacemakers implanted. Six months after surgery, six patients in the cryoablation group and three in the radiofrequency ablation group had pacemakers. Twelve months after surgery, six patients in the cryoablation group and four in the radiofrequency ablation group had pacemakers.

The average time spent in the intensive care unit was 1.4 days, indicating rapid recovery and minimal time in intensive care. No serious complications occurred in the postoperative period, reflecting a high level of postoperative care and management of potential risks.

Discussion

The results of the conducted study show that both cryoablation and radiofrequency ablation are highly effective methods for restoring sinus rhythm in patients with atrial fibrillation and rheumatic mitral valve disease. Cryoablation, which was used for the first time in Kazakhstan, demonstrated significant advantages in the long-term maintenance of sinus rhythm and improved heart remodeling parameters, such as left atrial volume. This contributed to an enhancement in the patients' quality of life.^{5,6}

Compared to radiofrequency ablation, cryoablation is more effective and reduces the risk of arrhythmia recurrence, despite the longer surgery time. However, both methods showed similar results in terms of total perfusion time and mortality, confirming their safety and applicability in clinical practice.^{2,13,17}

Our results, which showed that cryoablation is more effective than radiofrequency ablation in restoring sinus rhythm at 6 and 12 months, are consistent with the findings of the *Kuck et al. (2016)* study,¹⁹ where similar effectiveness of both procedures was observed. However, our data differ in terms of more pronounced left atrial remodeling, which was not reflected in the *Kuck et al. (2016)* study.¹⁷

Cryoablation and radiofrequency ablation have shown effectiveness in re-

storing sinus rhythm. Previously, both cryoablation and RFA have been shown to be effective in treating atrial fibrillation, with comparable success rates. Previously, both cryoablation and RFA have been shown to be effective in treating atrial fibrillation, with comparable success rates. Studies such as those by *Schmidt et al. (2016)* and *Engin M et al. (2024)* reported similar outcomes in restoring sinus rhythm, but complications differ across the methods.^{14,16}

This is especially evident in the improvement of long-term sinus rhythm restoration outcomes and more pronounced left atrial remodeling.³

Limitations. Retrospective and single-center study design. The sample size, though sufficient for initial comparisons, may not be large enough to draw definitive conclusions applicable to broader populations. Additionally, the study focused solely on patients with rheumatic mitral valve disease, limiting the generalizability of the findings to other patient groups.

What's known? It has been previously established that AF is a common arrhythmia in patients with mitral valve disease. Cryoablation and radiofrequency ablation have shown similar effectiveness in restoring sinus rhythm.

What's new? Our study, conducted for the first time in Kazakhstan, showed that cryoablation has significant advantages over radiofrequency ablation in treating atrial fibrillation in patients with rheumatic mitral valve disease.

Conclusion

The data suggest the need for further research and widespread implementation of innovative methods for treating atrial fibrillation, such as cryoablation, as surgical interventions are more effective, and patients with severe cardiovascular diseases achieve better outcomes. A comprehensive approach, including the use of modern technologies and personalized therapy, promotes sinus rhythm recovery and reduces the risk of complications and mortality.

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T.R.: Drafting of manuscript; N.Zh, T.R., D.A.: Writing the text of the article; K.R.: Critical revision of the manuscript. All authors approved the final version of the manuscript.

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