**"Surgical treatment of atrial fibrillation using cryoablation in patients with rheumatic mitral valve disease and atrial fibrillation, for the first time in Kazakhstan"**

**Abstract** This study presents the results of a clinical analysis of the effectiveness of surgical treatment methods for atrial fibrillation (AF) in patients with rheumatic mitral valve disease. Special attention is given to comparing cryoablation and radiofrequency ablation (RFA), two techniques used in conjunction with mitral valve surgery. The study evaluated operative parameters such as ablation time, aortic cross-clamp time, and total perfusion duration, as well as clinical outcomes including the restoration of sinus rhythm, left atrial volume, end-diastolic volume, stroke volume, and ejection fraction. The results showed that cryoablation, a method first introduced in Kazakhstan, has long-term benefits in restoring sinus rhythm and remodeling the heart, which contributes to improved quality of life for patients. Special attention was given to complications and recovery after surgery. Cryoablation improved the morphometric parameters of the heart and reduced the risk of AF recurrence. However, both strategies demonstrated safety and efficacy in treating arrhythmias associated with rheumatic mitral valve disease. The study highlights the importance of integrating modern technologies into everyday clinical practice and points to the need for further research aimed at optimizing surgical approaches using these technologies.

**Keywords:** atrial fibrillation, cryoablation, radiofrequency ablation, rheumatic mitral valve disease, sinus rhythm, surgical treatment of arrhythmias.

**Aim:** Comparison of the results of cryoablation and radiofrequency ablation in patients with valve pathology correction and heart rhythm disturbances.

**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. Despite advancements in this field, patients with AF continue to be at high risk for stroke and heart failure [1].

According to the World Health Organization, there are more than 37 million cases of atrial fibrillation worldwide [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]. 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%.

The frequency of strokes among patients with AF will rise fivefold if the disease is not diagnosed and treated promptly, leading to increased mortality, disability, and a higher burden on healthcare systems [4].

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 [5]. 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 [6].

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 [7]. Stroke prevention with oral anticoagulants, which are sometimes not used by doctors due to concerns about bleeding, is an important part of AF detection. To avoid replacing anticoagulants with antiplatelet drugs, there is a need to train therapists, cardiologists, and general practitioners to recognize and correct bleeding risk factors [8].

The most common arrhythmia is atrial fibrillation, which increases the risk of heart failure and stroke in patients with rheumatic mitral valve disease [9]. Despite existing treatments, safer and more effective surgical approaches are needed. New surgical methods for treating AF can significantly improve patient outcomes, reduce the risk of complications, and enhance both life expectancy and quality of life. Cryoablation, an innovative procedure first used in Kazakhstan, employs extremely low temperatures to treat diseases and promises significant improvements in this field [10].

Both methods are equally effective in restoring sinus rhythm in the early postoperative period, although radiofrequency ablation (RFA) was found to be easier to perform [11]. Schmidt (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 RFA. However, diaphragm nerve paralysis was observed more frequently with cryoablation [12]. In Tomayko E.'s (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 [13].

Funatsu (2009) analyzed the long-term results of cryomaze procedures for treating atrial fibrillation after mitral valve surgery. The studies showed that cryoablation is an effective method for restoring sinus rhythm with long-term success [14]. Deneke (2002) evaluated the effectiveness of the modified MAZE procedure with radiofrequency ablation in patients with chronic atrial fibrillation who underwent mitral valve replacement. The results showed that this method is effective and safe for restoring sinus rhythm [15]. Tatly (2021) 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].

The randomized FIRE AND ICE study found that cryoablation outperforms radiofrequency ablation in treating paroxysmal atrial fibrillation [17]. Compared to RFA, cryoballoon ablation requires fewer repeat ablations and has a shorter procedure time, as shown in Andrade's study (2019) [18]. According to Schmidt (2016), the recurrence rate of AF one year after RFA and cryoablation is similar, but the complications associated with these methods differ [19]. Malmborg (2013) showed that both multipolar RFA and cryoablation work equally well, but cryoablation requires less fluoroscopy time [20].

**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 CT before and after surgery to assess the left atrial appendage.

**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.

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).

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.

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).

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 (LAA) occlusion was performed using the "AtriCure" clip system in various sizes (see Figure 2).

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.

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

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.

**Conclusion**

The results of the conducted study show that both cryoablation and radiofrequency ablation (RFA) 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.

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.

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.

**Conflict of Interest:**

The authors declare no conflict of interest. All authors equally participated in the preparation of the material.

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