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CATHETER ABLATION OF ATYPICAL ATRIAL FLUTTER IN PATIENTS AFTER CARDIAC SURGERY

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Abstract

Background: Atypical atrial flutter (AAFL) is often associated with cardiac surgery or catheter ablation of atrial fibrillation. Clinically, patients with AAFL are already complex and serious patients. Mapping and ablation of these complex arrhythmias is a challenge for every arrhythmologist and electrophysiologist. In addition, this category of patients is often ignored: in particular, due to the lack of approved algorithms and clinical protocols for the diagnosis and treatment of such patients in Kazakhstan.

Purpose of the study: to evaluate the improvement in the management of patients with atypical atrial flutter after heart surgery and catheter ablation using innovative technologies.

Materials and methods: The single-center study included 208 patients (AI group - 107 patients, non-AI group - 101 patients) with atrial flutter after heart surgery and catheter ablation. Inclusion criteria: adult patients (18 years and older, regardless of gender) with atrial flutter after undergoing cardiac surgery and catheter ablation, signed informed consent of patients for EPS, RFA. Criteria for exclusion of patients from the study group: age under 18 years, decompensation of concomitant diseases, thrombosis of the left atrial appendage, thrombosis of the left atrium, mechanical mitral valve with atypical flutter from the left atrium, refusal of the patient from EPS and RFA.

Results: Cardiac surgery for valvular heart disease was frequent reason for atypical atrial flutter in both groups, 63 (58,9%) and 46 (45,5%), respectively. The mean left atrial size on transthoracic echocardiography was 42,9 mm (39;47) and 42,5 mm (39;46), respectively. NT-proBNP was high in AI-group, which indicates to heart failure. RFA with index ablation has a high effect in the acute phase ($p=0.001$). A positive correlation was found between left atrium pressure and NT-proBNP ($p<0.001$).

Conclusion: Combined therapy in combination with catheter ablation, antiarrhythmic therapy and heart failure therapy can reduce the risk of recurrent atrial events.

Key words: *atrial flutter, cardiac surgery, heart failure, ablation index, catheter ablation.*

Резюме

КАТЕТЕРНАЯ АБЛАЦИЯ АТИПИЧНОГО ТРЕПЕТАНИЯ ПРЕДСЕРДИЙ У ПАЦИЕНТОВ ПОСЛЕ КАРДИОХИРУРГИЧЕСКИХ ОПЕРАЦИЙ

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Актуальность: Атипичная трепетание предсердий (АТП) часто связано с кардиохирургическим вмешательством или катетерной аблацией мерцательной аритмии. Клинически пациенты с АТП, уже, являются сложными и серьезными пациентами. Картирование и аблация этих сложных нарушений сердечного ритма является непростой задачей для каждого аритмолога и электрофизиолога. Кроме того, данная категория больных часто остается без внимания: в частности, из-за отсутствия в Казахстане утвержденных алгоритмов и клинических протоколов диагностики и лечения таких больных.

Цель: оценить улучшение ведения пациентов с атипичным трепетанием предсердий после операции на сердце и катетерной аблации с использованием инновационных технологий.

Материалы и методы. В одноцентровое исследование включены 208 пациентов (группа АИ - 107 человек, группа без АИ - 101 пациент) с трепетанием предсердий после операции на сердце и катетерной аблации. Критерии включения: взрослые пациенты (18 лет и старше, независимо от пола) с трепетанием предсердий после перенесённых кардиохирургических операций и катетерных аблаций, подписанное информированное согласие пациентов на ЭФИ, РЧА. Критерии исключения больных из группы исследования: возраст до 18 лет, декомпенсация сопутствующих заболеваний, тромбоз ушка левого предсердия, тромбоз левого предсердия, механический митральный клапан при атипичном трепетании из левого предсердия, отказ больного от ЭФИ и РЧА.

Результаты. Кардиохирургия по поводу порока сердца была наиболее частой причиной трепетания предсердий в обеих группах, 63 (58,9%) и 46 (45,5%) случаев соответственно. При трансторакальной эхокардиографии средний размер левого предсердия составил 42,9 мм (39;47) и 42,5 мм (39;46) соответственно. В группе АИ был более высокий NT-proBNP, что указывало на сердечную недостаточность. Аблация с индексом аблации имеет более высокий эффект в острой фазе (p=0,001). Выявлена положительная корреляция между давлением в левом предсердии и NT-proBNP (p<0,001).

Заключение: Комбинированная терапия в сочетании с катетерной аблацией, антиаритмической терапией и лечением сердечной недостаточности может снизить риск повторных предсердных событий.

Ключевые слова: *трепетание предсердий, кардиохирургия, сердечная недостаточность, индекс аблации, катетерная аблация.*

Түйіндеме

ЖҮРЕК ОТАСЫНАН КЕЙІНГІ ПАЦИЕНТТЕРДІҢ АТИПИЯЛЫҚ ЖҮРЕКШЕЛЕР ДІРІЛІНІҢ КАТЕТЕРЛІК АБЛАЦИЯСЫ

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Өзектілігі: Атипиялық жүрекшелер дірілі (АЖД) жиі жүрек хирургиясы немесе жүрекше жыбырын катетерлі аблация арқылы емдеу әдісімен байланысты. Клиникалық түрде АЖД бар науқастар қазірдің өзінде сапалы, күрделі және ауыр науқастар болып табылады. Осы күрделі жүрек ырғағының бұзылыстарын картаға түсіру және абляция жасау әрбір аритмолог, электрофизиолог үшін күрделі мәселе болып табылады. Сонымен қатар, пациенттердің бұл санаты жиі тиісті назардан тыс қалады: атап айтқанда, Қазақстанда мұндай науқастарды диагностикалау мен емдеудің бекітілген алгоритмдері мен клиникалық хаттамаларының болмауына байланысты.

Мақсаты: Инновациялық технологияларды қолдана отырып, кардиохирургиялық және катетер абляциясынан кейін жүрекше дірії бар науқастарды басқарудың жетілдіруін бағалау.

Материалдар мен тәсілдер: Бір орталық зерттеуде кардиохирургиялық отадан және катетер аблациясынан кейін жүрекшелердің дірілі бар екі жүз сегіз науқас (AI тобы - 107 пациент, non-AI топ - 101 пациент) қамтылды. Бұрынғы кардиохирургиялық операциядан және катетер абляциясынан кейін әртүрлі типтегі ЖД-мен ауыратын ересек пациенттер (18 жас және одан жоғары, жынысына қарамастан). Пациенттерді зерттеу топтарына қосу критерийлері: 18 жастан асқан науқастар, атипиялық және типикалық ЖД анықталған диагнозы, ЭФЗ, РЖА үшін пациенттердің қол қойылған ақпараттандырылған келісімі. Пациенттерді зерттеу тобынан шығару критерийлері: 18 жасқа толмаған науқастар, қатар жүретін аурулардың декомпенсациясы, сол жақ жүрекше қосалқысының тромбозы, сол жақ жүрекшенің тромбозы, сол жақ жүрекшенің дірілиндегі механикалық митральды қақпақша, ЭФЗ, РЖА-дан пациенттің бас тартуы.

Нәтижелер: Жүректің қақпақша ауруларына арналған кардиохирургиялық ота екі топта да жүрекше дірілінің жиі себебі болды, сәйкесінше 63 (58,9%) және 46 (45,5%) жағдай. Трансторакальды эхокардиографияда сол жақ жүрекшенің орташа өлшемі сәйкесінше 42,9 мм (39;47) және 42,5 мм (39;46) құрады. AI тобында NT-proBNP жоғары болды, бұл жүрек жеткіліксіздігін көрсетеді. Индекс аблациясымен аблация жасау жіті кезеңде жоғары әсер етеді (p=0.001). Сол жақ жүрекше қысымы мен NT-proBNP арасында оң корреляция анықталды (p<0.001).

Қорытынды: Катетерді аблациямен, антиаритмиялық еммен және жүрек жеткіліксіздігін емдеумен біріктірілген ем жүрекшелердің ритм бұзылысының қайталану қаупін азайтуы мүмкін.

Түйінді сөздер: *жүрекшелердің дірілі, кардиохирургия, жүрек жеткіліксіздігі, аблация индексі, катетер аблациясы.*

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Introduction

With the development of the cardiac surgical service and the increase in the volume of cardiac surgery, such as heart valve surgery, the number of substrates for atypical atrial flutter (AFL) has also increased. And clinically, patients with atypical AFL are already qualitatively different patients [1-3]. Many of these AFL appear in patients who have previously undergone medical interventions, such as valve surgery and congenital heart defects, which in turn involve atriotomy, a surgical 'Maze' procedure, or radiofrequency isolation of the pulmonary vein orifices. Atypical AFL after cardiac surgery is called incisional AFL because the substrate of the arrhythmia is a scar in the atria. Patients after cardiac surgery are considered to be more prone to develop complex rhythm disturbances, and there is a risk of recurrent AFL after radiofrequency ablations (RFA) and the risk of atrial fibrillation (AF) in the postoperative period [4-7]. In this category of patients, there are usually several circles of reentry, i.e. apart from the most frequent typical AFL, atypical AFL also occurs. There are two strategies for rhythm control in these tachyarrhythmias: 1) drug antiarrhythmic therapy combined with electrical cardioversion, which does not irreversibly affect the substrate for re-entry, and 2) radiofrequency ablation, which aims at irreversibly removing the substrate for re-entry. Often, if atypical AFL persists for a long time, sinus rhythm cannot be maintained by medication alone and, unfortunately, a strategy of heart rate control is chosen: medication or pacemaker implantation with creation of an artificial atrioventricular block [8-12]. The latter is a "desperate" therapy when no other method of correcting the heart rate is available. With the development of new technologies in medicine it is possible to avoid this outcome. Modern diagnostic techniques, such as electrophysiological study (EPs) and electro-anatomical mapping, allow to identify the precise localization of the re-entry cycle and perform effective catheter ablation to interrupt the re-entry cycle and prevent further arrhythmia recurrence [13-15].

While the target of ablation in typical AFL is, by definition, the cavotricuspid isthmus (CTI), atypical AFL is a more complex type of tachycardia, in which finding the critical isthmus of re-entry and effective ablation can be challenging [16-19]. Mapping and ablation of these complex arrhythmias is not an easy task for every interventional arrhythmologist and the efficacy is far from ideal. At present, the combination of activation mapping, bipolar mapping and endocardial stimulation (entrainment) maneuvers allows to understand the localization of re-entry and to ablate the critical isthmus of re-entry tachycardia [20-22]. The combination of RFA for atypical AFL and drug therapy (combination therapy) can achieve long-lasting sinus rhythm in most patients [23-25]. Increasing the opportunities for radical therapy of arrhythmias with catheter-based techniques will preserve sinus rhythm in a sufficiently large proportion of patients and avoid complications associated with cardiac arrhythmias [26-28].

In this paper we will try to optimize the management of patients with a complex heart rhythm disorder as atypical AFL in patients after previous cardiac surgery and catheter ablation.

Methods.

The population of patients in the study.

This study compares the efficacy of RFA of atypical AFL with ablation index (AI) in patients with previous cardiac surgery and catheter ablation for heart rhythm disorders. In addition, the efficacy and safety of intracardiac ultrasound for RFA of atypical AFL is evaluated. Inclusion criteria for the study were patients over 18 years of age, established diagnosis of AFL, previous cardiac surgery and catheter ablation (RFA, cryoablation). Exclusion criteria were: age under 18 years, left atrial and left atrial appendage thrombosis, mechanical mitral valve, decompensation of concomitant diseases, refusal to participate in the study. Patients were included in the study according to the inclusion criteria between January 2015 and December 2020. Procedures performed between 2015 and 2017 were analyzed retrospectively, and from January 2018 data were collected prospectively and each patient signed a written consent to participate in the study before the current RFA. The interventional arrhythmologists who have performed RFA are the most experienced in our clinic and perform more than 300 RFA of pulmonary vein occlusion and more than 400 RFA of supraventricular arrhythmias using the Carto3 navigation system (CARTO 3; Biosense Webster, Diamond Bar, CA) per year. Thus, the prospective group of patients who have undergone RFA with ablation index is called the AI group and the retrospective group is called the non-AI group.

The technique of performing RFA for atrial flutter.

Patients with mechanical heart valves took warfarin with achievement of target INR 2.0-3.0, patients without mechanical valves were partly on OAC and partly on warfarin with a target INR 2.0-3.0. The intake of factor Xa inhibitors or direct thrombin inhibitors was not suspended.

Before the procedure, all patients were premedicated with Relanium 2ml/10mg solution and Promedol 1%/2ml solution and injected intramuscularly. Femoral vein puncture was performed under local anaesthesia using 1% lidocaine solution. Intraoperatively, an additional infusion of

0.05mg fentanyl solution was administered for analgesia. In all cases, a 3D navigation system (CARTO 3; Biosense Webster, Diamond Bar, CA) was used to perform electroanatomical mapping of the left and right atria. The right atrium, inferior vena cava, superior vena cava, and tricuspid valve annulus were mapped. Using stimulation maneuvers-entrainment and a diagnostic 10-pole catheter in the coronary sinus-the reentry cycle was localized. When reentry was located in the left atrium, transseptal puncture (TSP) was performed. In the AI group, a TSP was additionally used to visualize cardiac structures more accurately. After TSP, an intravenous heparin solution was administered with an acute clotting time ≥ 300 sec. In both groups, linear point-by-point RFA was performed with fusion of the anatomical structures.

AFL RFA in the Non-AI group was performed using a Thermocool SmartTouch (CARTO 3; Biosense Webster, Diamond Bar, CA) irrigation catheter with contact force sensitivity (CARTO 3; Biosense Webster, Diamond Bar, CA). Contact force ranged from 5g to 40g and application time was 20-40 seconds per point. A power of 30-35V was used in all sections of the left and right atria, depending on the wall. Continuous RFA points were achieved using the automatic marking function (VisiTag, Biosense Webster). The settings for the VisiTag function were as follows: stability of catheter position - minimum time 10 sec, maximal fluctuation 3mm; contact force minimum 5g, from 30% of time; point size 3mm. Criteria for effectiveness of RFA were: termination of AFL and restoration of sinus rhythm or change of tachycardia cycle length when switching to another reentry mechanism, achievement of isthmus block at the critical point, absence of AFL induction during frequent stimulation. If there was no induction of AFL and the efficacy criteria were maintained, the procedure was terminated.

In the AI group, patients underwent RFA using a Thermocool SmartTouch (CARTO 3; Biosense Webster, Diamond Bar, CA) irrigation catheter with ablation index function (Biosense Webster). When using the automatic marking function (VisiTag), the AI group applied similar parameters to the Non-AI group, in order to obtain more accurate results: catheter position stability - minimum time 10 sec, fluctuation no more than 2mm; contact force minimum 5g, from 30% of time; point size 3mm. The distance between two consecutive RFA points was maximum 6 mm. In left atrial RFA, AI changed between 400 and 550, the same as with right atrial RFA. Ablation duration at each point ranged from 20-40 sec. If the catheter was moved from the ablation site before reaching the required AI, the catheter was placed in the same place and the application was continued until the required AI was reached. If there was a history of catheter isolation of pulmonary vein orifices (PVI) (RFA, cryoablation), in addition to linear RFA of atypical AFL, PVI isolation was checked, and if there was a gap, PVA reisolation was performed. In the AI group, left atrial pressure was additionally measured at the rhythm of AFL and after rhythm recovery.

Medication therapy after an RFA procedure.

Patients who had received preoperative antiarrhythmic therapy (AAT) continued for 12 weeks postoperatively. If the patient did not receive any AAT prior to the procedure, an AAT was selected and therapy was continued in the postoperative period. The group of patients with a reduced ejection fraction also received heart failure (HF) therapy.

Outpatient follow-up of patients.

As the Non-AI group underwent dynamic outpatient follow-up every 3 months, the same outpatient follow-up interval was observed in the AI group. Thus, patients came for follow-up outpatient follow-up every 3 months for 12 months after discharge with 24-hour Holter ECG, echocardiography and ECG of cardiac rhythm disturbance. The presence of sustained atrial tachyarrhythmias (atrial tachycardia, atrial flutter, atrial fibrillation) was assessed from the Holter ECG and ECG as an indicator of the effectiveness of the performed RFA. In patients with sustained episodes of atrial tachyarrhythmia (>30 sec), AAT was administered for a minimum of 3 months. Subsequently, if AAT was not effective, RFA was repeated after 3 months. If a patient was treated with AAT and sustained episodes of atrial arrhythmia occurred, RFA was repeated after 3 months. Echocardiography in the postoperative period allowed to assess atrial size, left ventricular (LV) function. In the AI group, patients were additionally tested for NT-proBNP as an indicator of chronic heart failure and dilated heart chambers.

Statistical analysis.

Continuous variables are represented as mean and standard deviation if they were normally distributed. For non-normal distributions, variables are described by median and quartile (25-75%). Student's t-test, Mann-Whitney U-test and Kruskal-Wallis test were used to compare independent samples. Categorical variables were presented as frequency or percentage values and were compared with the *x2* -Pearson test. Spearman's correlation rank was used to identify the relationship between the variables. All statistical analyses were performed on SPSS (version 22, IBM Corp., Armonk, NY, USA).

Results.

Basic patient characteristics.

The study group included 112 patients who were monitored for one year after RFA with ablation index. During the COVID-19 pandemic, 2 patients were excluded from the AI group due to death due to coronavirus infection and 3 patients refused to continue the study. Retrospective data of 101 patients were used as a control group. According to table 1, the main baseline characteristics of the patients in the two groups did not differ (p>0.05).

Mean age of patients in AI group was 57.8±11.1 years and in Non-AI group was 56.6±10.9 years. Male patients predominated in both groups, 60 (56%) and 61 (60.4%) respectively (p=0.528). Patients in both groups were overweight, 27.8±5 and 28.2±4.7kg/m^2, p=0.564.

Arterial hypertension (p=0.791) was equally more common as background disease in both groups, while diabetes (p=0.713) and stroke (p=0.506) were much less common. In the groups, atrial flutter developed mainly after valve cardiac surgery (p=0.054). There was a difference in the groups associated with the cryoballoon PVI (p=0.049).

Thus, 21 (19.6%) patients in the AI group had previously undergone cryoablation compared to the control group with only 10 (9.9%) patients. Both groups had estimated pulmonary artery systolic pressure (ePASP) greater than 25 mmHg (p=0.743) on transthoracic echocardiography. Atypical AFL also occurs more frequently (AI group - 77.6%, non-AI group - 68.3%, p=0.133) than typical AFL in both groups (AI group - 20.6%, non-AI group - 31.7%, p=0.067).

Table 1.

Patients' characteristics according to physical parameters, anamnesis, antiarrhythmic therapy, anticoagulation and transthoracic echocardiography.

Baseline characteristics	AI-group (n=107)	NonAI-group (n=101)	P-value
Age, years	57,8±11,1	56,6±10,9	P=0,441
BMI, kg/m^2	27,8±5	28,2±4,7	P=0,564
Male, n (%)	60 (56)	61 (60,4)	P=0,528
Hypertension, n (%)	72 (67,2)	70 (69,3)	P=0,791
Diabetes mellitus, n (%)	14 (13,0)	15 (14,8)	P=0,713
Stroke/TIA, n (%)	6 (5,6)	8 (7,9)	P=0,506
IHD/operated, n (%)	21 (19,6)	27 (26,7)	P=0,224
CHD/operated, n (%)	10 (9,3)	15 (14,9)	P=0,222
VHD/operated, n (%)	63 (58,9)	46 (45,5)	P=0,054
Afib PVI CRYO, n (%)	21 (19,6)	10 (9,9)	P=0,049
Afib PVI RFA, n (%)	17 (15,9)	19 (18,8)	P=0,577
Afib PVI+lines, n (%)	15 (14,0)	7 (6,9)	P=0,097
AFL RFA, n (%)	21 (19,6)	16 (15,8)	P=0,476
AAFL RFA, n (%)	5 (4,7)	1 (0,9)	P=0,113
AT RFA, n (%)	1 (0,9)	3 (2,9)	P=0,285
HAS-BLED, Me (Q1;Q3)	2,2 (2;3)	2 (1;3)	P=0,770
CHA_2DS_2VASc, Me (Q1;Q3)	1,0 (0;1)	1,0 (1;2)	P=0,791
Pulmonary hypertension, n (%)	53 (49,5)	49 (48,5)	P=0,883
Hyperthyroidism, n (%)	17 (16)	15 (15)	P=0,836
Atrial flutter typical, n (%)	22 (20,6)	32 (31,7)	P=0,067
Atrial flutter atypical, n (%)	83 (77,6)	69 (68,3)	P=0,133
Concomitant atrial fibrillation, n (%)	8 (7,5)	2 (2)	P=0,064
Onset of atrial events after incision/ablation, month, Me (Q1;Q3)	12 (4;25)	8 (3;23)	P=0,072
Duration of tachycardia, month, Me (Q1;Q3)	3 (2;4)	2 (1;4)	P=0,401
I class, n (%)	7 (6,5)	2 (2)	P=0,106
III class, n (%)	47 (43,9)	49 (48,5)	P=0,507
b-blockers, n (%)	82 (76,6)	85 (84,2)	P=0,173
ACE-i/ARB, n (%)	73 (68,2)	61 (60,4)	P=0,239
Diuretics, n (%)	16 (15)	13 (12,9)	P=0,665
Aldosterone antagonists, n (%)	34 (31,8)	33 (32,7)	P=0,890
NOAC, n (%)	41 (38,3)	26 (25,7)	P=0,052
Warfarin, n (%)	66 (61,7)	75 (74,3)	P=0,052
LA diameter, mm	42,9 (39;47)	42,5 (39;46)	P=0,599
EF, Me (Q1;Q3):	55 (50;59)	54 (44;58)	P=0,53
≥40, n (%)	98 (91,6)	86 (81,1)	P=0,146
<40, n (%)	9 (8,4)	15 (18,9)	P=0,146
ePASP, mmHg Me (Q1;Q3)	28 (23;34)	27 (24;32)	P=0,743
EDV, ml, Me (Q1;Q3)	95 (76;117)	114,4 (86;131)	P=0,004
ESV, ml, Me (Q1;Q3)	42 (34;52)	49 (37;69)	P=0,005

BMI – body mass index, TIA – transient ischemic attack. IHD- ischemic heart disease. CHD – congestive heart disease. VHD – valvular heart disease. AAFL – atypical atrial flutter. AT – atrial tachycardia. NOAC – new oral anticoagulants. LA – left atrium. EF – ejection fraction. ePASP – estimated pulmonary artery systolic pressure. EDV – end diastolic volume. ESV – end systolic volume. HAS-BLED – scale for bleeding risk assessment. CHA_2DS_2VASc – scale for thromboembolic risk assessments.

Prior to the current RFA, an increase in LV size was noted in both groups (p=0.599). There was, however, a significant difference between the groups in terms of end-diastolic volume (p=0.004) and end-systolic volume (p=0.005).

Results of the procedure.

According to the results (table 2), the duration of operations was longer in the AI group (110.8±10.4min) than in the Non-AI group (95.52±10.7min), but the difference was not statistically significant (p=0.057). There was a statistically significant difference (p<0.001) in the duration of transseptal puncture. Thus, less time was spent in the AI group than in the control group (5 and 7 min respectively). Similar significant differences between groups were found in fluoroscopy time (2.2min and 5.5min, p=0.003) and radiation dose itself (0.04mSv vs 0.15mSv, p=0.026). Contrast agent was not used at all in AI group in comparison with other group (p<0.001).

The number of reentries, localization of critical isthmus in the atria, localization of scar zones and arrhythmia mechanisms were comparable in both study groups (Table 2).

Table 2.

Procedure based characteristics of patients.

	AI-group (n=107)	Non-AI-group (n=101)	P-value
Mean procedure time, min Me (Q1;Q3)	94 (75;125)	89 (72;117)	P=0,057
TSP mean time, min	5 (5;6)	7 (6;8)	P<0,001
Fluoroscopy time, min	2,2 (0;5,3)	5,5 (0;12,2)	P=0,003
Mean dose area product, mSv	0,04 (0;0,28)	0,15 (0;0,56)	P=0,026
Contrast agent, ml	0	0 (0;50)	P<0,001
Number of re-entry:			
1, n (%)	74 (69,2)	78 (77,2)	P=0,146
2 n (%)	24 (22,4)	17 (16,8)	P=0,310
≥3 n (%)	9 (8,4)	6 (5,9)	P=0,491
LA critical isthmus localization:			
Roof, n (%)	13 (12,1)	6 (5,9)	P=0,120
Anterior, n (%)	18 (16,8)	28 (27,7)	P=0,058
Posterior, n (%)	1 (0,9)	4 (3,9)	P=0,151
Left PVs area, n (%)	8 (7,5)	5 (4,9)	P=0,452
Right PVs area, n (%)	6 (5,6)	3 (2,9)	P=0,350
RA critical isthmus localization:			
CTI, n (%)	55 (51,4)	53 (52,5)	P=0,877
Lateral, n (%)	31 (29)	32 (31,7)	P=0,671
Posterior, n (%)	8 (7,5)	2 (1,9)	P=0,064
Anterior, n (%)	5 (4,7)	3 (2,9)	P=0,523
SVC, n (%)	1 (0,9)	2 (1,9)	P=0,527
Scar zones localization in RA:			
Lateral, n (%)	66 (61,7)	50 (49,5)	P=0,077
Posterior, n (%)	8 (7,5)	2 (1,9)	P=0,064
Anterior, n (%)	1 (0,9)	0	P=0,330
Septal, n (%)	15 (14)	28 (27,7)	P=0,015
1 zone, n (%)	44 (41,1)	31 (30,7)	P=0,117
=>2 zones, n (%)	32 (29,9)	27 (26,7)	P=0,612
Scar zones localization in LA:			
Posterior, n (%)	10 (9,3)	15 (14,9)	P=0,222
Roof, n (%)	19 (17,8)	7 (6,9)	P=0,018
Anterior, n (%)	17 (15,9)	9 (8,9)	P=0,077
PVs area, n (%)	32 (29,9)	38 (37,6)	P=0,303
Septal area, n (%)	4 (3,7)	3 (2,9)	P=0,759
1 zone, n (%)	20 (18,7)	27 (26,7)	P=0,166
=>2 zones, n (%)	25 (23,4)	22 (21,8)	P=0,785
RA Re-entry mechanisms:			
CW, n (%)	13 (12,1)	14 (13,9)	P=0,714
CCW, n (%)	40 (37,4)	34 (33,7)	P=0,575
RL, n (%)	40 (37,4)	33 (32,7)	P=0,477
Septal, n (%)	2 (1,9)	0	P=0,167
Other, n (%)	4 (3,7)	3 (2,9)	P=0,759
1 zone, n (%)	63 (58,9)	56 (55,4)	P=0,617
=>2 zones, n (%)	17 (15,9)	14 (13,9)	P=0,682
Ablation index:			
Minimum AI, Me (Q1;Q3)	404 (401;408)	-	
Maximum AI, Me (Q1;Q3)	506 (503;509)	-	
Mean AI, Me (Q1;Q3)	457 (452;465)	-	
IPG, n (%)	11 (10,3)	6 (5,9)	P=0,390
Complications (tamponade), n (%)	0	9 (8,9)	P=0,002
NT-proBNP, Me (Q1;Q3)	1564 (1025;1906)	-	-

Throughout the follow-up period after surgery, patients in the AI group showed a decrease in atrial recurrence episodes (Figure 1) and an increase in the risk of recurrence in patients in the control group. There was a statistically significant (p=0.002) difference with regard to complications (cardiac tamponade), 0 versus 9 cases, respectively.

Correlation analysis in AI group showed a strong significant positive association (p<0.001) between the LV pressure index and the cardiac marker NT-proBNP (Figure 2).

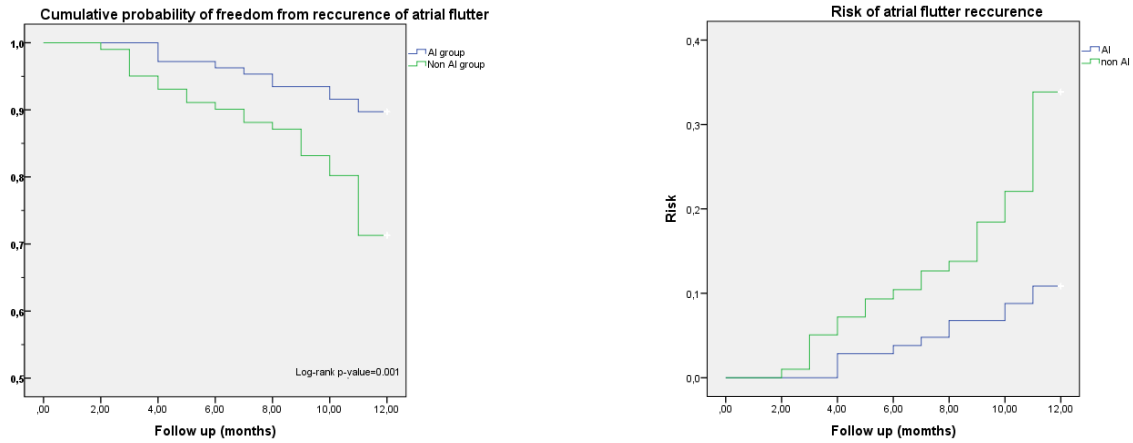

Figure 1. Kaplan-Meier criterion for identifying atrial episodes.

With AI group of patients who received RFA using the ablation index.
Non-AI group of patients who underwent RFA without using the ablation index. p=0,001.

In the AI group, paroxysms of AF were observed in the remote period. According to the odds criteria (Table 3), there was an association between left atrial pressure and episodes of AF (p<0.001). Patients in the AI group were allocated according to the development of recurrent atrial fibrillation in the long term. Left atrial pressure was taken into account during EPs in AFL.

Patients with high LV pressure were included in the risk group, and those without the presence of high LV pressure were included in the comparison group. The significance of the difference in frequencies was calculated by *x2* -test. The odds ratio is within the CI, indicating a high chance of 15.8/1 of developing AF in the long-term period in patients with high LV pressure.

Discussion. Currently, with the increasing number of catheter ablations in the treatment of atrial fibrillation and the increasing number of cardiac surgeries, the proportion of postoperative incisional atrial arrhythmias, especially atypical AFL, is increasing.

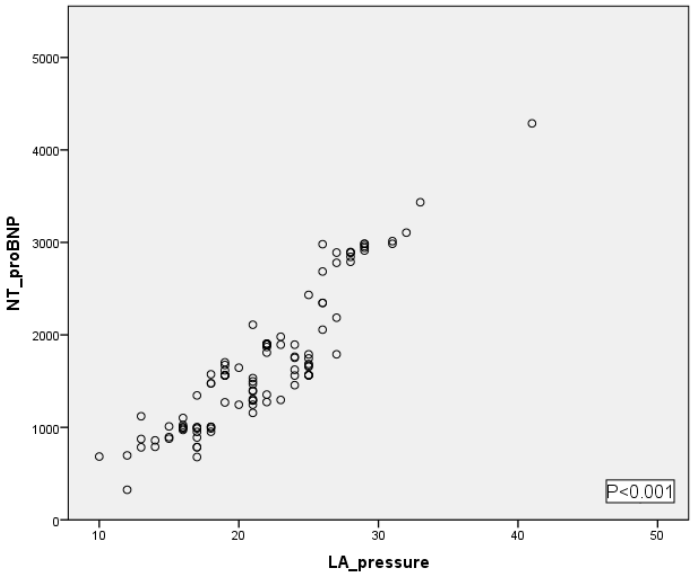

Figure 2. Presence of association with increased NT-proBNP and left atrial pressure. Significance p<0.001.

Table 3.

Risk of atrial fibrillation as a function of increased invasive left atrial pressure.

	AF	No AF	Total	Frequency of AF	CI, 95%
High LA pressure	46	18	64	71,87±5,62%	60,85-82,88%
No pressure in the LP	6	37	43	13,95±5,28%	3,6-24,29%

The difference in frequencies is statistically significant, p<0.001

Such patients clinically endure episodes of AT worse and decompensation of the patient's condition occurs faster. In particular, patients after valve surgery or after correction of congenital heart disease are more likely to develop atypical AFL than those after pulmonary vein cryoisolation for AF (Table 1). The presence of a significant difference (p=0.049) between the groups regarding the development of TP after cryoballoon PVI can be attributed to the lower number of cryoablation procedures in the control group, rather than to the lack of association between cryoablation and AFL development. Atrial fibrillation RFA is a relatively effective treatment for organized incisional atrial fibrillation. However, despite refractory to antiarrhythmic therapy and the relatively rapid development of arrhythmogenic cardiomyopathy, it takes a long time for the patient to reach catheter ablation. This can be seen in table 1, where a patient with AFL has not undergone RFA for an average of 3 (AI group) and 2 (non-AI group) months (p=0,401). Effective RFA for AFL against a background of atriotomy scarring and pre-existing structural heart disease does not reduce the risk of recurrent atrial arrhythmias. However, there is a reduced risk of recurrence when using ablation index with RFA for atypical and typical AFL (Figure 1).

In most cases, 2 or more reentry mechanisms were observed in the patient, increasing the complexity and duration of the procedure itself. Nevertheless, our results showed significant differences in contrast agent exclusion, TSP duration, fluoroscopy time and X-ray dose. Patients in the AI group were divided into 4 groups to identify the association between high LV pressure and the development of recurrent atrial fibrillation in the long-term follow-up (Table 1). The odds ratio with p<0.001 was used to identify

the association. In the risk group, the incidence of AF was 71.87±5.62% (95% CI) (Table 3). The odds ratio showed a high chance of long term recurrence of AF in the risk group (high LV pressure) with a rate of 15.8 (CI 95%).

Conclusion. The RFA with ablation index has a high effect in the acute phase. In the long-term period, patients with high LV pressure have a high risk of developing AF or other atrial events. A direct positive correlation has been found between LV pressure and the cardiac marker NT-proBNP, which in turn is a marker of heart failure, and combined therapy with catheter ablation, antiarrhythmic therapy and HF therapy may reduce the risk of recurrent atrial events. However, this requires more detailed and additional research.

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