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ABSTRACT
of the dissertation for the degree of Doctor of Science

DYSFUNCTIONAL MYOCARDIUM OF ISCHEMIC ORIGIN: PROBLEMS AND THE WAYS OF THEIR SOLUTION

Specialty: 3208.01 Cardiology

Field of science: Medicine

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BACKGROUND

The relevance of research. The main predictor of an unfavorable prognosis for patients with myocardial infarction (MI) who have not undergone primary percutaneous coronary intervention (PCI) is chronic ischemia of the peri-infarcted zone, where surviving myocardium can be present together with fibrotic tissue [1].

This prolonged myocardial ischemia leads to adverse ventricular remodeling, congestive heart failure and persistent tissue hypoperfusion, significantly complicating treatment of such patients [2].

The revascularization of viable myocardium is currently beyond doubt. At the same time, it is noted that the extent of subendocardial ischemia with a zone of cardiac fibrosis, less than 25% of the myocardial wall thickness, is most favorable for the restoration both of regional and general left ventricular contractility [3].

The prognosis of patients with extension of fibrotic tissue between 25 and 50% of the ventricular wall thickness is controversial. Some authors argue that the spread of cardiac fibrosis up to 50% of the myocardial thickness is potentially favorable in terms of restoring its function and others believe that this indicator should not exceed 41–45%[4].

Among all methods of surgical treatment of patients with chronic coronary heart disease (CHD), PCI currently plays the dominant role.

Numerous studies are presented in the literature, which show the

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[1] *Camici, P.G.* Stunning, Hybernating and Assesment of Myocardial Viability / P.G. Camici, S.P. Kumak, O.E. Rimoldi // Circulation. – 2008. - №117. – P.103-114

[2] *Беленков, Ю.Н.* Эпидемиологические исследования сердечной недостаточности: состояние вопроса / Ю.Н. Беленков, В.Ю. Мареев, Ф.Т. Агеев // Сердечная недостаточность. – 2002. – т.3. - №2. – С. 57-58.

[3] *Allman, K.C.* Noninvasive assesment myocardial viability. Current status and future directions / K.C. Allman // J Nucl Cardiol. - 2013. - Vol. 20. - № 4. - P. 618–631.

[4] *Nagel, E.* Shortening without contraction: new insights into hibernating myocardium / E. Nagel, A. Schuster // J. Am. Coll. Cardiol. Img. - 2010. – Vol. 3. - P.731–733.

positive effect of PCI on the restoration of a dysfunctional but viable myocardium in patients with preserved systolic function of the left ventricle, in the form of a reduction in the frequency of adverse cardiovascular events in the long term after endovascular intervention [5].

It is noted that the prognosis of the disease in such patients directly depends on the timing of the revascularizing operation.

On the contrary, in patients with concomitant type 2 diabetes mellitus (DM), as well as with a reduced left ventricular ejection fraction (LVEF), the results of PCI are considered ambiguous [6].

Numerous studies show that in terms of the incidence of cardiovascular complications, the results of coronary artery bypass grafting (CABG) with multivascular coronary artery disease and diabetes are superior to PCI results, even when using drug-eluting stents [7].

Moreover, most authors agree that the prognosis of patients with type 2 diabetes who underwent any type of revascularization have a worse postoperative prognosis compared to patients without carbohydrate metabolism disorders [8].

The recommendations of the European Society of Cardiology on myocardial revascularization in patients with coronary artery disease with multivascular coronary artery disease and concomitant diabetes (2018) indicate that the most preferred method of myocardial revascu-

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[5] *Lau, J.M.* Demonstration of intermittent ischemia and stunning in hibernating myocardium / J.M. Lau, R. Laforest, A. Priatna [et al.] // J Nucl Cardiol. – 2013. – Vol. 20. – № 5. – P.908-912

[6] *Миронков, А.В.* Реваскуляризация миокарда в лечении пациентов с систолической дисфункцией левого желудочка: состояние проблемы / А.В. Миронков // Вестник трасплантологии и искусственных органов. – 2013. – т.XV. - № 2. – С. 156-163.

[7] *Bundhun, P.K.* Coronary artery bypass surgery compared with percutaneous coronary interventions in patients with insulintreated type 2 diabetes mellitus: a systematic review and meta-analysis of 6 randomized controlled trials / P.K. Bundhun, Z.J. Wu, M.H. Chen // Cardiovasc Diabetol. – 2016. - № 15. – P. 2

[8] *Koskinas, K.C.* Impact of Diabetic Status on Outcomes After Revascularization With Drug-Eluting Stents in Relation to Coronary Artery Disease Complexity: Patient-Level Pooled Analysis of 6081 Patients / K.C. Koskinas, G.C. Siontis, R. Piccolo [et al.] // Circ Cardiovasc Interv. – 2016. – Vol. 9. - № 2. – P. e003255.

larization is coronary artery bypass grafting (CABG) - a class of recommendations IA. Moreover, PCI is not recommended for the treatment of such patients if the severity of coronary lesions according to the SYNTAX scale> 22 is class III recommendations, and with SYNTAX from 0 to 22, class IIB recommendations [9].

Nevertheless, it is important to note that the results of the effect of myocardial revascularization on the prognosis of patients with type 2 diabetes were obtained at various stages of improving pharmacotherapy, as well as instruments and technologies for performing PCI or CABG, which does not allow direct comparisons of these methods in this cohort of patients.

Moreover, in patients with reduced LVEF and concomitant type 2 diabetes, multivascular, diffuse lesions of the coronary bed and calcification are often detected, which in real clinical practice does not always allow CABG surgery, and therefore, the only alternative for them is endovascular myocardial revascularization [10].

The existing disagreements regarding the effectiveness of myocardial revascularization methods in patients with reduced LVEF and type 2 diabetes can be explained by the fact that treatment results were evaluated mainly based on clinical and medical history data without the use of modern methods of myocardial imaging. The identification of the potential for a possible improvement in contractility in the area of a dysfunctional myocardium after revascularization is more possible due to the use of imaging methods, such as magnetic resonance imaging (MRI) of the heart, stress echocardiography, and radionuclide methods.

Cardiac MRI is currently being considered as the "gold standard" in assessing the global contractile function of the left ventricle, as well as in identifying local disturbances in contractility of the heart muscle. The methodological feature of modern MRI is the combination of the

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[9] *Neumann, F-J.* 2018 ESC/EACTS Guidelines on myocardial revascularization / F-J. Neumann, M. Sousa-Uva, A. Ahlsson, F. Alfonso [et al.] // European Heart Journal. – 2018. – Vol. 00. – P. 1–96.

[10] *Безденежных, Н.А.* Реваскуляризация миокарда у пациентов с ишемической болезнью сердца при сахарном диабете 2 типа / Н.А. Безденежных, А.Н. Сумин // Сахарный диабет. – 2016. – т. 19. - № 6. – С. 471-478.

complete safety of the method with high spatial resolution of the resulting images, which fundamentally distinguishes MRI from radionuclide methods, especially when it comes to the upcoming myocardial revascularization operation [11].

In turn, the method of stress echocardiography, usually underestimates the volume of viable myocardium, compared with radionuclide methods and cardiac MRI [12]. Small subendocardial zones, as well as basal segments of the left ventricle, may remain inaccessible for visualization [13].

However, in patients with reduced LVEF, according to current recommendations for myocardial revascularization (2018), heart MRI is not recommended for routine use to diagnose myocardial ischemia and its viability [9].

It should be noted that the effectiveness of each of the presented methods in the diagnosis of dysfunctional myocardium is presented mainly on the basis of observational studies and meta-analyzes, which differ in the heterogeneity of the studied groups according to nosologically forms.

In addition, there are practically no studies that evaluate the results of PCI using modern imaging methods, which, in turn, casts doubt on the low effectiveness of PCI in patients with severe systolic dysfunction, as well as concomitant type 2 diabetes. No attention is paid to the personified approach during the selection of patients for PCI, based on the study of factors of poor prognosis of the disease, including those identified using myocardial imaging methods.

All of the above reflects the particular relevance of the studied

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[11] *Осиев, А.Г.* Новый подход к оценке результатов транскоронарной септальной аблации у больных с гипертрофической обструктивной кардиомиопатией / А.Г. Осиев, Е.И. Кретов, Р.А. Найденов [и др.] // Патология кровообращения и кардиохирургия. – 2013. - № 3. – С. 46–49.

[12] *Ling, L.H.* Identification of therapeutic benefit from revascularization in patients with left ventricular systolic dysfunction: inducible ischemia versus hibernating myocardium / L.F. Ling, T.H. Marvick, D.R. Flores [et al.] // Circ. Cardiovasc. Imaging. – 2013. – № 6. – P. 363–372.

[13] *Труфанов, Г.Е.* МРТ в диагностике ишемической болезни сердца : учеб. пособие / Г.Е. Труфанов, С.Д. Рудь, С.Е. Железняк – СПб. : ЭЛБИ-СПб, 2012. – 63 с.

problem and makes it expedient to conduct new studies using the methods of myocardial imaging in a complex cohort of patients with an ambiguous prognosis after PCI.

The aim of the study was to improve the treatment and diagnostic tactics in patients with complicated forms of coronary heart disease by comprehensively analyzing the results of applying modern methods of visualizing a dysfunctional myocardium, predicting postoperative dynamics and identifying unfavorable prognosis factors.

Achieving this goal provided for the solution of the following **tasks**:

1. To determine the effectiveness of imaging methods of dysfunctional myocardium (cardiac MRI and stress echocardiography) at the stage of selection of patients with complicated forms of IHD for PCI.
2. To analyze the effectiveness of the methods of stress MRI of the heart and stress echocardiography with dobutamine in determining the viability of a dysfunctional myocardium.
3. To study the dynamics of the restoration of local contractility in the areas of the hibernated myocardium in the distant period after PCI performed using the method of heart MRI and stress echocardiography.
4. To assess the possibility of restoring myocardial function in patients with complicated forms of ischemic heart disease and concomitant type 2 diabetes mellitus in the long term after PCI, using myocardial imaging methods (heart MRI and stress echocardiography).
5. To identify the relationship between the timing of revascularization in the zone of a viable myocardium and the processes of restoration of myocardial function.
6. 6. To study the dynamics of changes in the global myocardial contractility in patients with complicated forms of coronary heart disease in the long term after PCI.
7. To identify factors of the unfavorable prognosis of endovascular interventions in patients with complicated forms of ischemic heart disease and concomitant type 2 diabetes mellitus.
8. Improve the selection algorithm for patients with complicated

forms of coronary heart disease for PCI and clarify the indications for myocardial revascularization.

Research methods.

In the study, in addition to laboratory research methods, such as hemogram; general urine analysis; study of glucose levels; biochemical blood parameters (creatinine, urea, AST, ALT, total bilirubin, total cholesterol, lipid spectrum); coagulogram; blood plasma electrolytes (potassium, sodium) were also used such methods as ECG, transthoracic echocardiography, stress echocardiography, cardiac MRI, 6-minute walking test, coronary angiography.

Key points to defend:

– The high efficiency of the cardiac MRI method in the diagnosis of dysfunctional myocardium and the determination of its viability has been proved, since it allows to identify a significantly larger number of segments with impaired contractility.

– It was revealed that with an increase in the transmurality index in thickness, the number of segments with hypokinesis decreases and the number of segments with akinesis increases. However, there is no correlation between the volume of cardiac fibrosis and the number of viable segments.

– It was proved that the assessment of myocardial contractile function by cardiac MRI is more objective than stress echocardiography, which is confirmed by the mismatch of the number of identified segments with impaired kinetics, and, accordingly, leads to an incorrect interpretation of the results of endovascular interventions in patients with dysfunctional myocardium.

– It was shown that in patients with complicated forms of ischemic heart disease and concomitant type 2 diabetes, after a PCI, a significant decrease in the number of pathological segments occurs, as in patients without diabetes. Moreover, the lower the transmurality index, the better the processes of restoration of a dysfunctional myocardium occur.

– It was noted that the frequency of adverse cardiovascular complications arising in patients with dysfunctional myocardium and concomitant type 2 diabetes mellitus in the long term after endovascular treatment is comparable to that in patients without diabetes mellitus.

Moreover, the restoration of myocardial function in patients with diabetes mellitus occurs more slowly compared to patients without diabetes.

– It has been proven that in patients with complicated forms of coronary heart disease without concomitant diabetes, PCI performed after 6 months from the moment of myocardial infarction, as well as incomplete myocardial revascularization, are prognostically unfavorable factors for the development of long-term complications of PCI.

– Preoperative indicators of glycosylated hemoglobin (HbA1c) ≥6.5%, fasting plasma glucose ≥6.0 mmol / L, total cholesterol ≥5.2%, triglycerides ≥ 1.7 mmol / L, LDL cholesterol ≥ 2.5 mmol / L - are factors associated with adverse prognosis of PCI in patients with type 2 diabetes. In addition, incomplete myocardial revascularization, SYNTAX score> 25, transmurality index ≥0.45, cardiac fibrosis volume ≥45%, are also prognostically unfavorable factors for the development of cardiovascular complications.

– The feasibility of incorporating the cardiac MRI method into the algorithm for diagnosing myocardial ischemia and its viability at the stage of selecting patients for PCI for patients with reduced LVEF and concomitant type 2 diabetes mellitus has been shown, which can significantly increase the effectiveness of endovascular interventions and improve the prognosis of patients with complicated forms of coronary heart disease.

Scientific novelty.

For the first time in patients with complicated forms of coronary heart disease with multivascular damage to the coronary bed:

– High efficiency of the cardiac MRI method, in comparison with stress echocardiography, in the diagnosis of dysfunctional myocardium at the stage of selection of patients for PCI was proved.

– It was shown that the method of cardiac stress MRI, in comparison with stress echocardiography with dobutamine, is more sensitive in determining the viability of a dysfunctional myocardium.

– The long-term results of PCI were studied using modern methods of myocardial imaging in a homogeneous cohort of patients.

– The possibility of restoration of myocardial function in patients with complicated forms of coronary heart disease and concomitant

type 2 diabetes mellitus in the long term after PCI was performed, demonstrated using myocardial imaging methods (cardiac MRI and stress echocardiography).

– The factors for the unfavorable prognosis of endovascular interventions in patients with complicated forms of coronary heart disease and concomitant type 2 diabetes mellitus have been determined.

– A relationship was found between the timing of revascularization in the zone of a viable myocardium and the processes of restoration of myocardial function.

– The indications for myocardial revascularization have been clarified and the algorithm for selecting patients for surgical treatment based on the identification of risk factors for an unfavorable prognosis of endovascular interventions has been improved.

Practical significance:

– It was shown that the method of heart MRI is more effective and sensitive in the diagnosis of dysfunctional myocardium at the preoperative stage, as it allows to identify a significantly larger number of segments with impaired contractility compared with the method of stress echocardiography.

– A negative correlation was found between the depth of myocardial damage and the type of violation of local contractility, which shows that with an increase in the transmurality index in thickness, the number of segments with hypokinesis decreases and the number of segments with akinesis increases.

– The absence of a correlation between the volume of cardiac fibrosis and the number of viable segments was demonstrated. With an increase in the volume of cardiac fibrosis, the number of viable segments does not significantly decrease, which is yet another practical confirmation of the hypothesis of a hibernating myocardium and determine the advisability of wide coverage of this cohort of patients with surgical care.

– It has been proved that the method of heart MRI is the most effective in determining the viability of a dysfunctional myocardium, compared with stress echocardiography and can be included in stand-

ard examination protocols for patients who have had myocardial infarction, who are planning to perform revascularizing operations.

– It was shown that the assessment of myocardial contractile function by cardiac MRI is more objective than stress echocardiography, which is confirmed by the mismatch of the number of identified segments with impaired kinetics, and, accordingly, leads to an incorrect interpretation of the results of endovascular interventions in patients with dysfunctional myocardium.

– It was revealed that in patients with complicated forms of ischemic heart disease and concomitant type 2 diabetes, there is a significant decrease in the number of pathological segments after an endovascular intervention, as in patients without diabetes. Moreover, the lower the transmurality index, the better the processes of restoration of a dysfunctional myocardium occur.

– It was noted that the frequency of adverse cardiovascular complications arising in patients with dysfunctional myocardium and concomitant type 2 diabetes mellitus in the long term after endovascular treatment is comparable to that in patients without diabetes mellitus. Moreover, the dynamics of recovery of myocardial function in patients with diabetes mellitus is significantly worse compared to patients without diabetes.

– Factors of an unfavorable prognosis of endovascular interventions in patients with complicated forms of coronary heart disease and concomitant type 2 diabetes mellitus have been identified, which will allow a differentiated approach to the choice of treatment method for each specific patient.

– It has been proven that in patients with complicated forms of coronary heart disease without concomitant diabetes, PCI performed after 6 months from the moment of myocardial infarction, as well as incomplete myocardial revascularization, are prognostically unfavorable factors for the development of long-term complications of PCI.

– It was shown that endovascular intervention in patients with a dysfunctional myocardium and concomitant type 2 diabetes is inappropriate when the transmural index is> 0.45 and the volume of cardiac fibrosis is> 45%. It was noted that the performance of PCI after 30 days from the moment of MI in a zone of viable, but dysfunctional,

is also a prognostically unfavorable factor in the development of long-term complications of PCI.

Work approbation. The main provisions of the thesis were reported and discussed at the XXII All-Russian Congress of Cardiovascular Surgeons (Russia, Moscow, 2016); XXI annual session NTSSSH them. Bakuleva (Russia, Moscow, 2017); International Congress Euro CMR 2017 (Czech Republic, Prague, 2017); Russian Congress of Cardiology 2017 (Russia, St. Petersburg, 2017); European Congress of Cardiology 2017 (Italy, Rome, 2017); 8th International Congress of the Emirate Society of Cardiology in conjunction with the American College of Cardiology (ACC) (UAE, Dubai, 2017); International Congress Euro Heart Failure 2017 (France, Paris, 2017); National Congress of the Turkish Society of Cardiology with international participation 2017 (Turkey, Antalya 2017); Russian Congress of Cardiology 2018 (Russia, Moscow, 2018); Asia PCR 2018 International Congress (Singapore, 2018); National Congress of the Turkish Society of Cardiology with international participation 2018 (Turkey, Antalya 2018); National Congress of the Azerbaijan Society of Cardiology with international participation 2018 (Baku, Azerbaijan 2018); International Congress Euro PCR 2019 (France, Paris, 2019); International Congress Euro Heart Failure 2019 (Greece, Athens, 2019); European Congress of Cardiology 2019 (France, Paris, 2019).

Putting work results into practice. The obtained results were introduced into the clinical work of the educational and surgical clinic of the Azerbaijan Medical University, as well as into the educational process at the Department of Internal Diseases-1 of the Azerbaijan Medical University and the departments of cardiology, cardiovascular surgery and x-ray diagnostic methods and treatment of the Central Clinical Hospital No. 2 named after . ON. Semashko JSC "Russian Railways" (Moscow), Department of Hospital Surgery with a course of pediatric surgery, Medical Institute of the Federal State Autonomous Educational Institution of Higher Education "Peoples' Friendship University of Russia" (Moscow).

Publications on the topic of the dissertation. On the topic of the dissertation, 40 publications were published in publications recommended by the Higher Attestation Commission of the Republic of

Azerbaijan for the defense of dissertations. Of 23 scientific articles, 13 were published in journals included in the database of international abstracting and indexing systems, 5 single author articles, one of them was published in a journal included in the database of international abstracting and indexing systems. Of 17 abstracts, 13 are presented abroad.

Volume and structure of the dissertation. The dissertation is presented on 265 pages of typewritten text (342,450 symbols) and consists of an introduction (23,900), 5 chapters, which reflect a review of the literature (99,900), patient characteristics (50,100) and research methods, results and discussion (7,300 + 113,000 + 43,000), conclusions, practical recommendations (5,250) and a list of references, which includes 300 sources local and foreign authors. The work is illustrated by 30 tables, 17 graphics and 35 figures.

THE CONTENT OF THE WORK

MATERIAL AND RESEARCH METHODS

The work was carried out in the framework of the "Agreement on Scientific Cooperation" of the Department of Internal Diseases No. 2 of the Azerbaijan Medical University (Baku) and the Department of Hospital Surgery with a course of pediatric surgery of the Peoples' Friendship University of Russia (Moscow), from 2015 to 2019.

Inclusion Criteria:

– a history of myocardial infarction> 1 month;

– the presence of segments with impaired local contractility of the left ventricular myocardium;

– viable myocardium in the area of dysfunctional myocardium;

– angina pectoris II-III functional class (CCS);

– painless myocardial ischemia;

– the presence of chronic total occlusion in any coronary artery;

– multivascular lesion of the coronary bed (SYNTAXscore I <32);

– circulatory failure functional class I-III (NYHA); ejection fraction of the left ventricle (LVEF) less than 49%.

Exclusion Criteria:

– acute coronary syndrome;

– technically impossible endovascular intervention;

– claustrophobia;

– implanted pacemaker, or cardioverter-defibrillator;

– the presence of contraindications for pharmacological tests or the introduction of a contrast medium.

According to inclusion criteria, the study included 268 patients. At the initial visit, the patient underwent a full physical examination (examination, auscultation, measurement of heart rate, blood pressure, NPV), recording and interpretation of the ECG.

Visual assessment of the myocardium, in order to detect violations of local contractility, for each patient participating in the study, was performed using the echocardiography method at rest and with stress, as well as the method of heart MRI with delayed contrast.

In the case of identifying areas with impaired local kinetics, all patients underwent determination of myocardial viability in the post-infarction zone using stress echocardiography with dobutamine according to the standard method. When performing heart MRI with delayed contrast, viability was assessed indirectly, by the amount of cardiac fibrosis in the pool of one blood supply artery.

A separate subgroup of patients was formed, which included 48 patients who underwent stress echocardiography with dobutamine and stress MRI to determine myocardial viability in order to compare the effectiveness of the methods used.

The next stage, patients underwent coronary angiography, the results of which made a decision on the implementation of PCI.

The assessment of the violation of the local kinetics of the myocardium of the left ventricle was also carried out before discharge of the patient from the hospital, 12, 18 and 24 months after the operation. To assess long-term results, similar to the initial protocol, transthoracic echocardiography and cardiac MRI were performed on each patient.

Prior to PCI, all patients received optimal drug therapy for coronary artery disease, including acetylsalicylic acid 75-100 mg per day, original clopidogrel 75 mg per day or ticagrelor in doses of 90 mg 2 times a day, beta-blockers, ACE inhibitors, statins.

Stenting of the coronary arteries in the zone of viable myocardium in all patients was performed with drug-eluting stents of the second and third generation. Double antiplatelet therapy after PCI was prescribed for a period of 6 to 12 months.

At each follow-up visit, if necessary, a correction of therapy was carried out, together with the patient, methods for modifying his individual cardiovascular risk and lifestyle changes were discussed.

Criteria for the evaluation of research results

The effectiveness of diagnostic methods in relation to visualization of a dysfunctional myocardium before PCI was evaluated by the number of identified segments with impaired kinetics.

When conducting heart MRI with delayed contrasting, the following were assessed: a) the depth of the myocardial lesion, based on the calculation of the transmurality index by thickness - the maximum paramagnet inclusion thickness / myocardial thickness in this segment; b) the prevalence of cardiac fibrosis - the volume of the contrasting myocardium within the segment (%).

In the long-term period, the effectiveness of the endovascular intervention was evaluated by the following parameters: a) the dynamics of segments with impaired kinetics; b) dynamics of indicators of global myocardial contractility (LVEF, final systolic size (CSD), final diastolic size (CSD), final systolic volume (CSR), final diastolic volume (BWW), stroke volume (UO); c) the frequency of adverse cardiovascular complications (death, myocardial infarction, repeated interventions); d) the frequency of restenosis and late stent thrombosis.

When conducting an MRI study, the dynamics of the transmurality index and the prevalence of cardiac fibrosis in the pool of one blood supply artery were additionally evaluated.

The criteria for angiographic success of stenting were: TIMI III blood flow, residual arterial stenosis of less than 10%, no signs of artery dissection.

The clinical result of the intervention was considered satisfactory

with a decrease in angina pectoris by 2 functional classes, or the complete disappearance of the symptoms of angina pectoris and the absence of major cardiovascular complications (death, MI, emergency re-intervention).

A complication in the form of acute myocardial infarction after PCI was set on the basis of an increase in the level of cardiospecific enzymes (troponin T) 5 times or more from the norm, in combination with a protracted angina attack or with the appearance of specific changes in the ST segment on the ECG.

Repeated revascularization procedures of the target vessel were performed in case of progression of the stenosing atherosclerotic process, or restenosis (thrombosis) in a previously implanted stent, in the presence of confirmed ischemia according to stress tests.

Restenosis was defined as stenosis of the stent lumen both inside and around the edges more according to digital angiography.

Stent thrombosis was defined as one of the following events: angiographically proven partial or complete stent occlusion within 30 days from PCI, after 30 days - an acute ischemic event with angiographic evidence, sudden death or post-procedural MI after successful PCI. Thrombosis was classified as subacute (up to 30 days from PCI) and late (after 30 days after PCI).

Characterization of patients included in the study

The study included 268 patients, of which 188 men (70.1%) and 80 women (29.9%). The average age of the patients was 51.2 ± 7.3 years.

In all patients, the presence of myocardial ischemia was proved, the functional class of which was verified by ECG stress tests (Table 1).

Analyzing the clinical and demographic data of patients, it should be noted that according to the New York classification of heart failure, I FC was observed in only 11.9% of patients, while II and III FC were practically equally distributed among themselves and exceeded 40%, which once again confirms the severity of the disease of the included patients.

Table 1

Clinical and demographic characteristics of patients

Indicator	n=68	
	Abc.	%
Male	188	70,1
Female	80	29,9
Average age, year	51,2±7,3	
Stable angina, class 2	98	36,6
Stable angina, class 3	170	63,4
Arterial hypertension	212	79,1
Diabetes mellitus, type 2	88	32,8
Heart failure(NHYA) NHYA I NHYA II NHYA III	 32 116 120	 11,9 43,3 44,8
Smoking	194	72,3
Hypercholesterolemia	221	82,4
Acute cerebrovascular event	27	10,1
Heart rhythm and conduction disturbances	119	44,4

More than half of patients had such risk factors as smoking and hypercholesterolemia, about 80% of patients suffered from concomitant arterial hypertension, 33% from type 2 diabetes mellitus and, in almost 45% of patients, various types of rhythm and conduction disturbances were noted, among which, the most common persistent form of AF, as well as supraventricular extrasystole.

The condition of the coronary bed, determined by the results of digital, quantitative coronarography, is presented in Table 2.

Noteworthy is the late completion of myocardial revascularization, as well as the presence of complex coronary lesions, such as chronic total occlusions (75% of patients) and bifurcation stenoses (46.3% of patients).

In 28 patients (10.4%), stenosis of the main trunk of LCA was revealed by this coronarography. Moreover, the localization of atherosclerotic plaque was predominantly in the terminal section, which made it possible to classify this lesion of the LCA trunk as bifurcation.

In all these patients, lesion of the LCA trunk was combined with damage to one coronary artery.

Table 2

Angiographic characterization of patients

Indicator	n=268 Abc.	n=268 %
Bivascular lesion	91	34
Three vascular lesion	177	66
Bifurcation stenosis	124	46,3
Chronic total occlusion	202	75,3
LMCA trunk stenosis> 50%	28	10,4
Deadline for revascularization after MI (days, Me [LQ; UQ]): Of them, up to 6 months after 6 months	148,5[12;360] 104 164	- 38,8 61,2
SYNTAX score I (points, Me [LQ; UQ])	26,01[22;32]	-

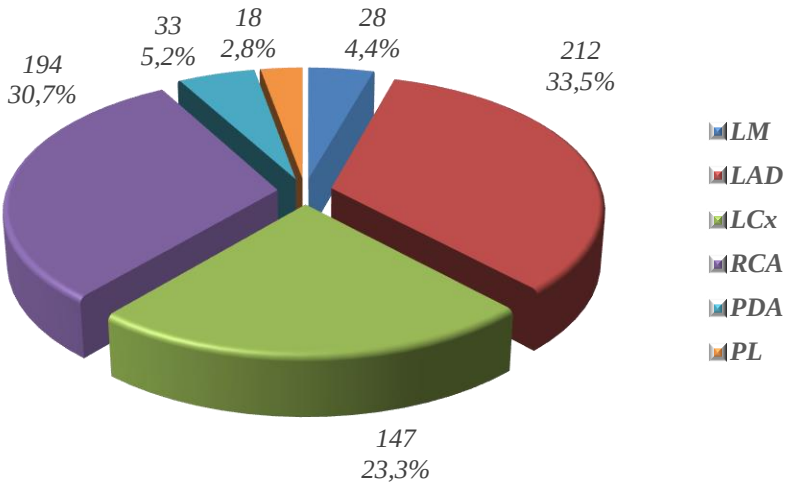
According to the SYNTAX scale, the average severity of coronary lesion was 26.01 [22; 32], which indicates the presence of multivascular coronary lesion in all patients included in the study. Moreover, according to the distribution parameters, the study did not involve patients whose SYNTAX score exceeded 32.

The distribution of patients depending on the affected coronary artery is shown in graph 1.

Complete myocardial revascularization was performed in 210 (78.4%) patients. A total of 665 drug-coated stents were implanted; the average number of stents per patient was 2.48 ± 1.01.

The study primarily used drug-coated coronary stents of the second and third generations coated with everolimus. However, the total number of participants included patients who were implanted with stents coated with biolimus and paclitaxel. This is due to the different stages in which patients are included in the study.

The main biochemical parameters of carbohydrate and lipid metabolism of patients are presented in table.3.



Graph 1. Anatomical characteristics of lesions coronary bed.

Table 3

Biochemical blood counts before surgery

Characteristics	n=268 Me [LQ;UQ]
Glycosylated hemoglobin, HbA1c,% 5.7	5,7 [4,1; 8]
Fasting blood glucose, mmol / L	6,7 [4,1; 11]
Total cholesterol, mmol / l	5,8 [3,7; 7,6]
HDL cholesterol, mmol / L	1,48 [1,4; 1,8]
Triglycerides, mmol / L	1,52 [0,14; 1,9]
LDL cholesterol, mmol / l	3,2 [1,9; 4,5]
Creatinine, mmol / L	98 [61; 139]
Urea, mmol / L	5,4 [2,2; 9,7]

Patients included in the study had fairly good renal function, however, fasting glucose and lipid metabolism, LDL cholesterol, exceeded

the values defined in current guidelines [14].

The increased fasting blood glucose can be explained by the fact that 33% of patients with type 2 diabetes entered the study.

When assessing the global contractility of the myocardium, it should be noted that the size of the left atrium did not exceed normal and amounted to 47.7 ± 1.2 mm in the longitudinal and 38.4 ± 0.8 mm in the cross section. The sizes of the left ventricle were also within normal limits: the final systolic and diastolic sizes were 39.4 ± 0.9 mm and 54.6 ± 1.1 mm, respectively. The thickness of the myocardium of the posterior wall of the left ventricle and interventricular septum corresponded to the upper limit of the norm - 9.3 ± 0.7 mm and 9.7 ± 0.6 mm, respectively. Indicators of systolic myocardial function were slightly reduced: Me [LQ; UQ]) LVEF (%) was 39.2 [35; 43], stroke volume (ml) was 67.8.

When assessing violations of local left ventricular contractility by the method of transthoracic echocardiography, we managed to visualize 1890 segments, among which, in 1070 (56.6%) segments, myocardial kinetics were detected (Graph 2).

Among segments with impaired kinetics, hypokinesis was found in 782 segments (73.1%), and akinesis - in 288 segments (26.9%). When assessing violations of local contractility of the left ventricle by heart MRI, it was possible to diagnose 1122 pathological segments, out of 1950 studied, among which there were 808 segments with initial hypokinesis and 314 segments with initial akinesis (Graph 3).

Prolonged nitrates were needed in 72 (26.8%) patients. Of the statins, 85.8% of patients took atorvastatin, the remaining 14.2% took rosuvastatin. Inhibitors of P2Y12 platelet receptors - clopidogrel and ticagrelor, were represented by the original drugs, while among the

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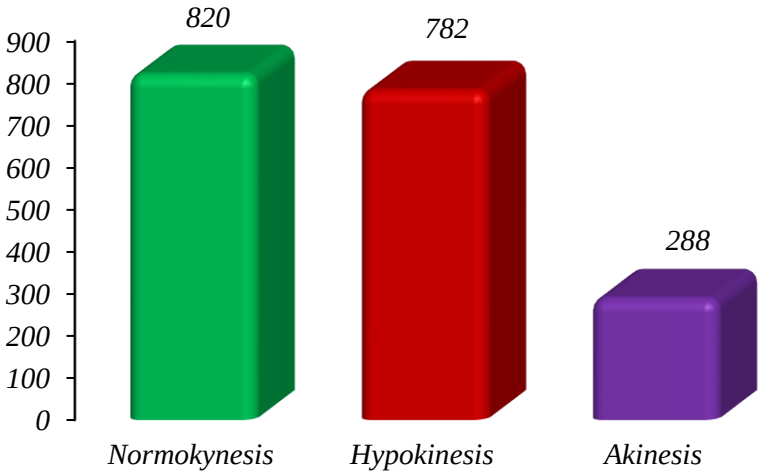
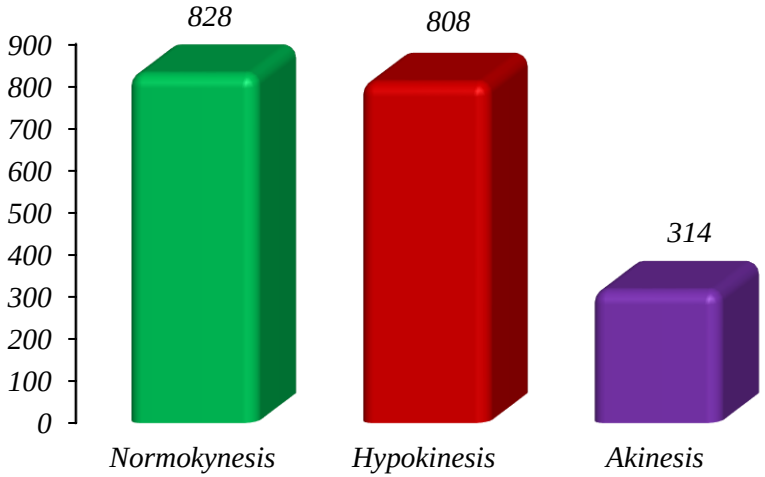
[14] *François Mach, Colin Baigent, Alberico L Catapano, Konstantinos C Koskinas, et al, ESC Scientific Document Group, 2019 ESC/EAS Guidelines for the management of dyslipidaemias:* lipid modification to reduce cardiovascular risk*: The Task Force for the management of dyslipidaemias of the European Society of Cardiology (ESC) and European Atherosclerosis Society (EAS),* European Heart Journal, *Volume 41, Issue 1, 1 January 2020, Pages 111–188, https://doi.org/10.1093/eurheartj/ehz455*

ACE inhibitors and β - adrenergic blocking agents, along with the original drugs, the administration of deneur was also noted.



Graph 2. Types of impaired left ventricular myocardial kinetics detected by echocardiography.



Graph 3. Types of impaired left ventricular myocardial wall motion detected by heart MRI.

In general, there was a high commitment of patients to drug therapy, however, before the initial visit to the clinic, only 89.5% took statins.

Statistical analysis of the results was carried out using the software package Statistica 10.0 for MS Windows.

The results of a clinical study were analyzed using methods of variation statistics with the calculation of the arithmetic mean (M), standard deviation (δ), and the average error of the arithmetic mean (m). The normality of the distribution of quantitative traits was tested using the Shapiro-Wilk test. In the case when the distribution law of the measured quantities could be considered normal, Student's t-test was used. For signs that do not meet the requirements of a normal distribution, the non-parametric Mann-Whitney test (U-test) was used. The values for the groups in the tables are presented as the median and inter-quarter interval. The groups were compared according to the studied parameters using the criteria: Mann – Whitney U-test, Fisher exact, Wald – Wolfowitz criterion. For conjugacy analysis, the Pearson $\chi 2$ criterion was used, the t-test was used to assess the significance of differences between the two groups, and the F-test and the Newman-Cales test were used for multiple comparisons. A comparative analysis of survival rates was performed using the Gehan-Wilcoxon test.

The correlation analysis of quantitative values was carried out by calculating the Pearson correlation coefficient, which was reduced to a special table — the correlation matrix. If it was not possible to establish the normality of the distribution of at least one of the compared indicators, then the Spearman correlation coefficient was used. The critical level of significance (p) when testing statistical hypotheses was assumed to be 0.05. The significance of the estimated risk factors was assessed using multivariate, log-linear analysis, as well as methods of logistic regression, correlation analysis. Differences were considered statistically significant at $p < 0.05$.

RESEARCH RESULTS

The number of segments with impaired contractility, identified at the stage of examination of patients, depending on the diagnostic method used, is presented in Table 4.

Table 4

The number of segments with impaired local contractility (n = 268)

Type of violation of local kinetics	Number of segments		Number of mismatches	p
	Heart MRI	Echocardiography		
Hypokinesis	808	782	26	0.012
Akinesis	314	288	26	0.024
TOTAL	1122	1070	52	0.007

When assessing violations of local left ventricular contractility by echocardiography, we managed to visualize 1070 pathological segments, while 1122 segments were detected during cardiac MRI. The average difference in the number of segments was –52 segments, 95% CI for the difference –62 ..– 36, p <0.01. At the same time, according to the number of identified segments with hypokinesis and akinesis, significant differences were also obtained, compared with the method of echocardiography.

On average, there were 3.99 ± 1.06 segments with impaired kinetics detected by echocardiography and 4.18 ± 1.26 detected by cardiac MRI per patient.

When performing an MRI of the heart, the transmurality index was determined by thickness and the volume of cardiac fibrosis (myocardial contrast within the segment).

Depending on the transmurality index by thickness, patients were conditionally divided into subgroups: 0.3-0.4 - subendocardial type of paramagnet accumulation (n = 77); 0.4-0.5 - intramural type of accumulation (postinfarction fibrosis) (n = 170); more than 0.5 - transmural

type (n = 21).

By the volume of cardiac fibrosis (myocardial contrasting within the segment): 20-30% - 88 patients; 30-40% - 92 patients; 40-50% - 71 patients; more than 50% - 17 patients.

The study revealed a negative correlation between the depth of myocardial damage and the type of violation of local contractility (Table 5).

Table 5

Correlation analysis of the depth of myocardial damage and impaired local contractility (n = 268)

Type of breach of contractility	Thickness Transmurality Index			r	p
	0.3-0.4 (n=77)	0.4-0.5 (n=170)	> 0.5 (n=21)		
Hypokinesis	493	218	97	–0,78	0,031
Akinesis	72	97	145	–0,84	0,028

So, with an increase in the transmurality index in thickness, the number of segments with hypokinesis decreases (r = –0.78; p = 0.031) and the number of segments with akinesis increases (r = –0.84; p = 0.028), which is especially important when choosing treatment tactics for such patients. For all patients with a transmural index of 0.4 or higher, it is advisable to determine myocardial viability before the planned surgical intervention.

It should be noted that there was no correlation between the volume of cardiac fibrosis (contrasting myocardium within one segment) and indicators of global myocardial contractility (Table 6).

Table 6

Correlation analysis of cardiac fibrosis volume and indicators of global myocardial contractile function (n= 268)

Indicators of global myocardial contractility	The volume of the contrasted myocardium within the segment (%)				r	p
	20-30 (n=88)	30-40 (n=92)	40-50 (n=71)	> 50 (n=17)		
EDV	149,2±3,7	146,4±3,2	150,8±3,3	154,2±3,8	0,01	0.632
ESV	71,4±0,9	68,2±0,7	68,8±0,8	64,8±0,8	0,01	0.824

The correlation presented in the table shows that even with a large amount of cardiac fibrosis, morphofunctional parameters of the heart can be within the limits of normal values. This suggests that the magnitude (volume) of cardiosclerosis does not affect the global contractility, and therefore cannot be considered as a key criterion in determining the indications for surgical intervention.

Determining the viability of a dysfunctional myocardium in the preoperative period. In case of confirmation of myocardial ischemia and the presence of areas with impaired local kinetics, all patients underwent determination of myocardial viability in the post-infarction zone using stress echocardiography with dobutamine according to the standard method.

In order to compare the effectiveness of the method of stress echocardiography with dobutamine and stress MRI in determining myocardial viability, a separate subgroup of patients was formed, which included 48 patients.

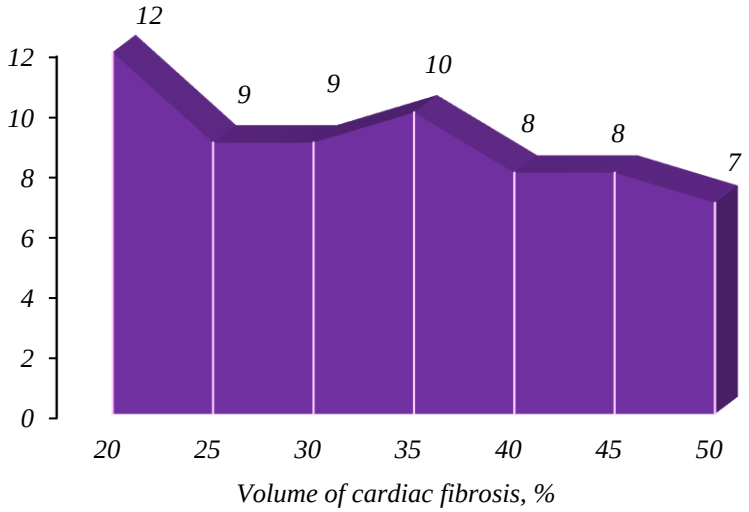
In total, at rest, 346 heart segments were examined, of which, according to stress - MRI of the heart, a violation of local contractile function was detected in 152 segments, while 132 segments were revealed according to stress echocardiography. The difference was 20 segments [-7 ... -38; 95% CI, $p = 0.027$].

When conducting a stress test with dobutamine, among segments with impaired kinetics, 63 segments according to MRI and 52 segments according to stress echocardiography were viable. The difference was 11 segments [-4 ....-18; 95% CI, $p < 0.01$] (Graph 4).

It was revealed that with an increase in the volume of cardiac fibrosis, the number of viable segments does not significantly decrease ($p > 0.05$). When conducting a correlation analysis, we also did not reveal a correlation between the volume of cardiac fibrosis and the number of viable segments.

The presented correlation is especially important for patients in whom the volume of cardiac fibrosis ranges from 40 to 50%. This cohort of patients is the subject of numerous discussions regarding the feasibility of performing surgery. Nevertheless, the results suggest that

in this cohort of patients it is nevertheless advisable to perform revascularization, whereas when the volume of cardiac fibrosis is more than 50%, the myocardium in the postinfarction scar area should be considered unviable, and in this case, revascularization is not advisable.



Graph 4. The ratio of the volume of cardiac fibrosis with the number of viable segments.

PCI results in patients with dysfunctional myocardium 12 months after surgery. 244 patients were invited to a follow-up visit 12 months after PCI, which accounted for 91% of all patients included in the study.

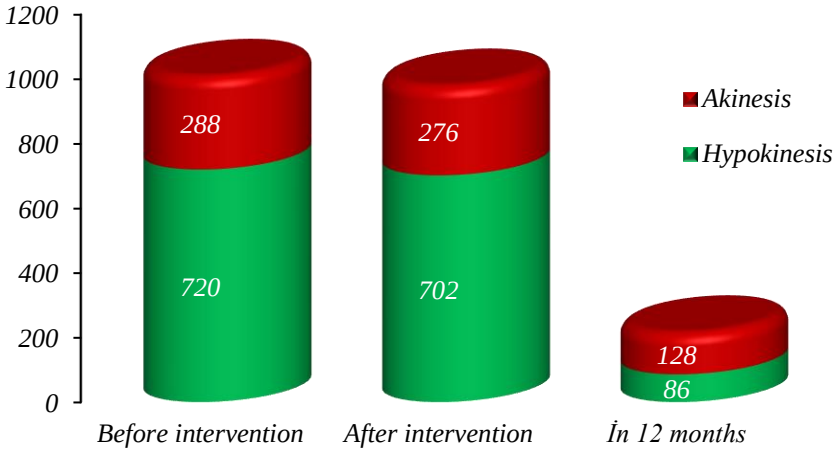
The survival rate of patients by the 12th month was 100%. In all patients, by the end of hospitalization, as well as in the long term, there was a clear positive dynamics in regards to the regression of the clinic of angina pectoris and increased exercise tolerance, compared with the data obtained before performing myocardial revascularization.

However, in 5 (2%) patients, relapse of the angina pectoris was noted. Ischemia was confirmed by ECG stress tests, and therefore, he performed coronary angiography.

According to the results of coronarography, it was revealed that

previously implanted stents are completely passable. There were de novo stenoses, both in the target vessel in 3 (1.2%) patients, and in other arteries in 2 patients (0.8%). Thus, the total frequency of cardiovascular complications that occurred 12 months after PCI was 2%, mainly due to repeated interventions, while MI and death were not recorded in any patient.

A significant decrease in the number of segments with impaired local contractility was noted (Graph 5).



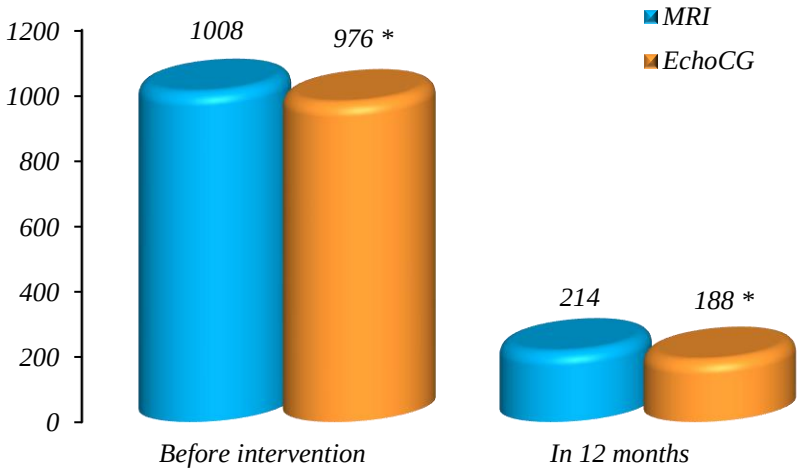
Graph 5. Dynamics of recovery of myocardial contractility after revascularization (heart MRI).

So, if before the operation, in the examined 244 patients, 1,008 pathological segments were revealed, of which 720 were with hypokinesis and 288 with akinesis, then 12 months after the operation, their total number decreased to 214.

The dynamics of segments with initial hypokinesis was significantly better than that of segments with akinesis and amounted, compared with preoperative data, to 702 and 86 segments, respectively ($p < 0.001$), while the number of akinetic segments decreased from 288 to 128 ($p < 0.001$).

Considering the previously described results comparing the effectiveness of the method of stress echocardiography and cardiac MRI in assessing dysfunctional myocardium, which confirmed the high efficiency of the cardiac MRI method, further results reflecting the dynamics of the restoration of the function of the hibernated myocardium are presented according to the MRI of the heart.

The effectiveness of diagnostic methods in assessing the effectiveness of PCI is presented more clearly in graph 6.



Note: *p=0,012; **p<0,001

Graph 6. Effectiveness of heart MRI and echocardiography in assessing the results of myocardial revascularization.

When comparing the number of reconstructed segments after the operation, it should be noted that the echocardiography data were significantly lower than the MRI data of the heart and amounted to 188 and 214 segments, respectively (p <0.001).

The obtained results repeat a similar picture when, using the cardiac MRI method, significantly more pathological segments were also detected at the preoperative stage.

In this regard, the method of echocardiography cannot reflect the

objective dynamics of the restoration of dysfunctional myocardial function after PCI and cannot be recommended as the main diagnostic method in patients with dysfunctional myocardium.

The relationship between the restoration of myocardial contractility and the magnitude of the transmurality index is presented in Table 7.

Table 7

Correlation analysis between the depth of myocardial damage and the restoration of local contractility (n = 244)

Thickness transmurality Index	The number of segments with impaired kinetics		Spearman correlation coefficient, r	p
	Before surgery n=1008	After 12 months n=214		
0.3-0.4 (n=72)	294	34	0.78	0.001
0.4-0.5 (n=160)	525	96	0.82	0.001
more 0.5 (n=12)	189	114	0.34	0.038

A positive correlation was found between the depth of myocardial damage and the restoration of its local contractility, which shows that the lower the transmurality index, the better the restoration of myocardial function in the long term after endovascular intervention.

It should be especially noted that performing myocardial revascularization in patients with a transmural index of more than 0.5, demonstrates a significant reduction in the number of segments with impaired contractility in the zone of the hibernated myocardium, similar to patients with a transmural index of 0.3 to 0.5.

The results show that the performance of PCI in patients with multivascular lesions of the coronary channel and reduced LVEF is feasible and effective.

The study examined the relationship between the volume of cardiac fibrosis and the number of pathological segments in the peri-infarction zone is presented in table 8.

It should be noted that between the indicators of the volume of cardiac fibrosis and the number of pathological segments in the peri-infarction zone, no correlation was obtained.

Features of the restoration of myocardial contractility, depending

on the magnitude of cardiac fibrosis, are presented in table.9.

Table 8

Correlation analysis between the volume of cardiac fibrosis and the number of pathological segments in the peri-infarction zone (n = 244)

The volume of cardiac fibrosis (%)	The number of identified pathological segments n=1008	Spearman correlation coefficient, r
20-30 (n=80)	242	0.36
30-40 (n=86)	358	0.27
40-50 (n=65)	216	0.33
More 50 (n=13)	192	0.05

Table 9

Recovery of myocardial function after PCI performed, depending on the volume of cardiac fibrosis (n = 244)

The volume of cardiac fibrosis (%)	The number of segments with impaired kinetics		p
	Before PCI n=1008	After 12 months n=214	
20-30 (n=80)	242	23	0.001
30-40 (n=86)	358	32	0.001
40-50 (n=65)	216	41	0.001
More 50 (n=13)	192	118	0.035

The distinct dynamics of the restoration of myocardial function in all the subgroups presented, formed depending on the magnitude of the volume of cardiac fibrosis, is shown. However, due to the fact that there is no correlation between the indicators of the volume of cardiac fibrosis and the number of pathological segments in the peri-infarction zone, this indicator cannot be considered as a key one in assessing the results of PCI.

A comparative analysis of the morphological and functional parameters of the left ventricle after PCI performed and 12 months after the intervention is presented in Table 10.

Table 10

Dynamics of global left ventricular myocardial contractility (n = 244)

Index	After PCI	In 12 months after PCI	p
EDV,ml	149,2±3,7	141,5±3,8	0.027
ESV, ml	71,4±0,9	66,2±1,4	0.067
EDD, mm	54,6±1,1	48,7±1,3	0.048
ESD, mm	39,4±0,9	36,8,±1,1	0.234
SV, ml	76,8±1,9	79,4±1,3	0.036
EF, %	43,2±3,4	49,4±4,3	0.022

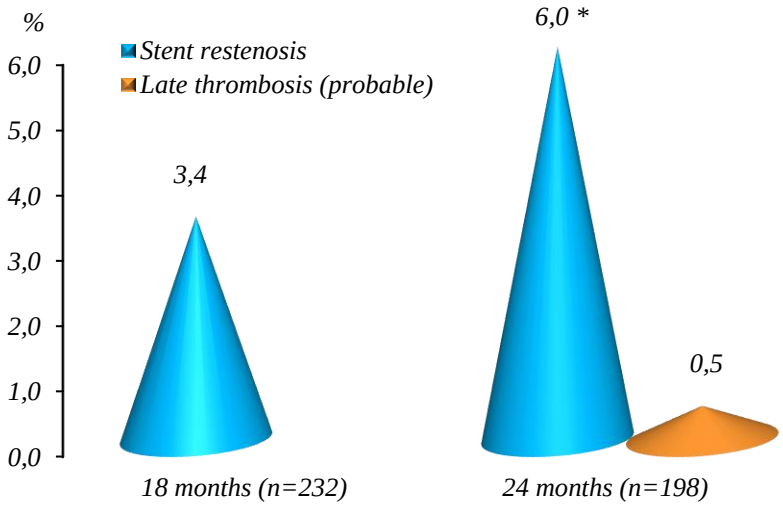
All patients showed a significant increase in LVEF, compared with the data obtained when the patient was discharged from the hospital, as well as a significant decrease in the BWW and CRD of the left ventricle, as well as an increase in UO.

Thus, the results of evaluating the morphofunctional parameters of the heart 12 months after the endovascular intervention performed show a significant role for myocardial revascularization in the prevention of negative heart remodeling.

In addition, there is a significant increase in exercise tolerance according to the 6-minute walk test. Compared with preoperative indicators, the distance covered by patients during the 6-minute walk test after 12 months was 295.04 ± 98.76 and 383.87 ± 109.06 m, respectively ($p < 0.05$), which corresponds to a decrease in cardiac symptoms insufficiency per 1 functional class (according to NYHA classification).

PCI results in patients with dysfunctional myocardium 18 and 24 months after surgery. 232 patients were invited to the follow-up visit 18 months after PCI, which accounted for 86.5% of all patients included in the study, and after 24 months, 198 patients (74%).

Relapse of the angina pectoris clinic was observed in 11 (4.7%) patients - 18 months after the intervention and in 15 (7.5%) patients - 24 months after the intervention ($p > 0.05$). Ischemia was confirmed by ECG stress tests (Graph 7).



Note: * – p < 0,05

Graph 7. Frequency of restenosis and stent thrombosis 18 and 24 months after surgery.

When performing repeated coronary angiography after 18 months, in 8 (3.4%) patients, restenosis was revealed in previously implanted stents, while after 24 months, restenosis was observed in 12 (6%) patients.

The remaining 3 patients examined after 18 and 24 months, respectively, revealed stenosis de novo in non-target arteries.

A case of late stent thrombosis was recorded in 1 (0.5%) patient by 24 months after surgery, which was complicated by death.

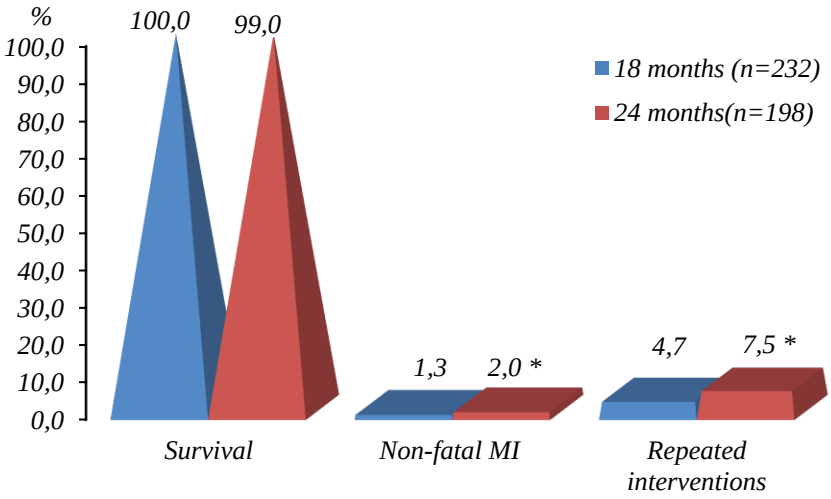
All patients with restenosis in the stent were re-treated with drug-coated balloon catheters with complete restoration of arterial patency.

Patients with identified de novo stenosis in non-target arteries underwent implantation of a drug-coated stent.

The total frequency of major cardiovascular complications is shown in graph 8.

Repeated interventions were required in total by 11 (4.7%) patients 18 months after surgery and 15 (7.5%) patients after 24 months.

Moreover, a significant increase in the studied parameters by the 24th month after the operation was not observed.



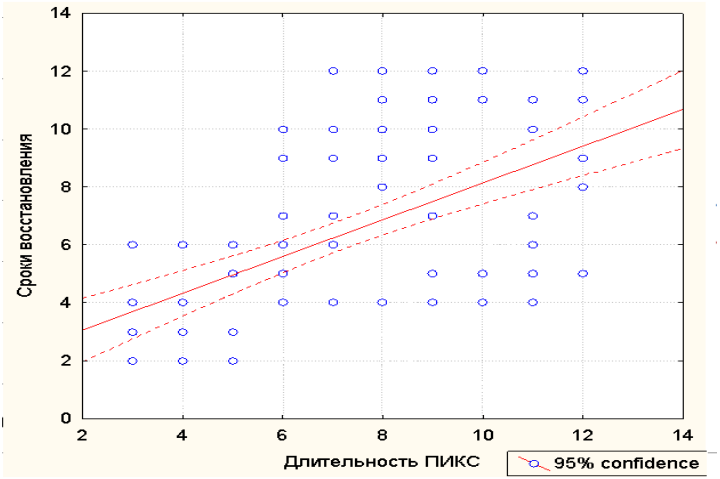
Note: * – p < 0,05

Graph 8. Frequency of major cardiovascular complications 18 and 24 months after surgery.

As a result of the analysis, it was possible to identify a reliable positive correlation (r = 0.58, p <0.05) between the time interval elapsed from the time of the heart attack to the moment of PCI, and the recovery time of the hibernated myocardium (graph 9).

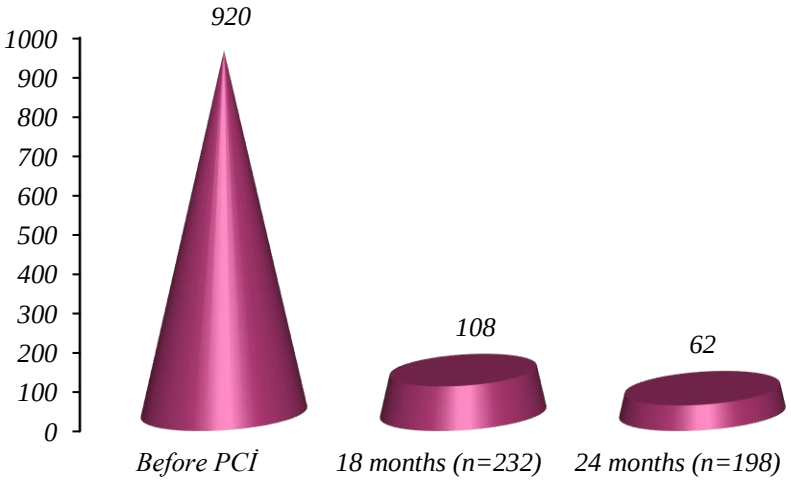
The dependence shown in the figure shows that if from the moment of myocardial infarction to the restoration of coronary blood flow less than 6 months pass, the restoration of local kinetics is much faster compared to patients who underwent revascularization 6 months after the moment of myocardial infarction.

A steady decrease in the number of segments with impaired local contractility was noted both at the 18th and at the 24th month of observation, compared with preoperative results (Fig. 10).



Note: Сроки восстановления – Recovery period
Длительность ПИКС – Post-Mİ period duration

Graph 9. Relationship between the timing of endovascular intervention in patients with postinfarction cardiosclerosis and restoration of hibernate myocardial function.



Graph 10. Dynamics of recovery of myocardial contractility after revascularization (heart MRI).

The dynamics of contraction of segments with impaired kinetics depending on the magnitude of the transmurality index is presented in Tables 11 and 12.

Table 11

Correlation analysis between the depth of myocardial damage and restoration of local contractility after 18 months (n = 232)

Thickness transmurality Index	The number of segments with impaired kinetics		Spearman correlation coefficient, r	p
	Before surgery n=920	After 18 months n=108		
0.3-0.4 (n=72)	296	22	0.88	0.001
0.4-0.5 (n=148)	486	32	0.77	0.001
More 0.5 (n=12)	138	54	0.54	0.038

Table 12

Correlation analysis between the depth of myocardial damage and the restoration of local contractility (n = 198)

Thickness transmurality Index	The number of segments with impaired kinetics		Spearman correlation coefficient, r	p
	Before surgery n=822	After 24 month n=62		
0.3-0.4 (n=76)	274	14	0.91	0.001
0.4-0.5 (n=108)	428	19	0.84	0.001
more 0.5 (n=14)	120	29	0.54	0.024

The data presented in the table reflect a similar steady tendency to decrease in the number of segments with impaired kinetics, which was shown after 12 months.

The lower the transmurality index, the better the restoration of myocardial function.

Nevertheless, the data obtained in patients with a transmural index of 0.5 or higher deserve special attention, which show that the dynamics of the restoration of myocardial function by 18 and 24 months after PCI was more distinct than after 12 months.

The study demonstrates that even with this rather severe type of

myocardial damage, revascularization is advisable, however, the processes of myocardial restoration proceed rather slowly.

A comparative analysis of the morphofunctional parameters of the left ventricle at various stages of the study is presented in Table 13.

Table 13

Dynamics of indicators of global left ventricular myocardial contractility

Index	After PCI (n=268)	After 12 month (n=244)	After 18 month (n=232)	after 24 month (n=198)	p
EDV,ml	149,2±3,7	141,5±3,8	139,4±3,4	132,1±2,1	0.016
ESV, ml	71,4±0,9	66,2±1,4	64,6±1,2	64,3±1,2	0.077
EDD, mm	54,6±1,1	48,7±1,3	46,2±1,8	44,1±2,4	0.028
ESD, mm	39,4±0,9	36,8,±1,1	36,1±0,9	35,8±1,4	0.334
SV, ml	76,8±1,9	79,4±1,3	83,9±1,8	84,8±1,1	0.036
EF, %	43,2±3,4	46,4±4,3	49,1±1,3	51,6±2,4	0.022

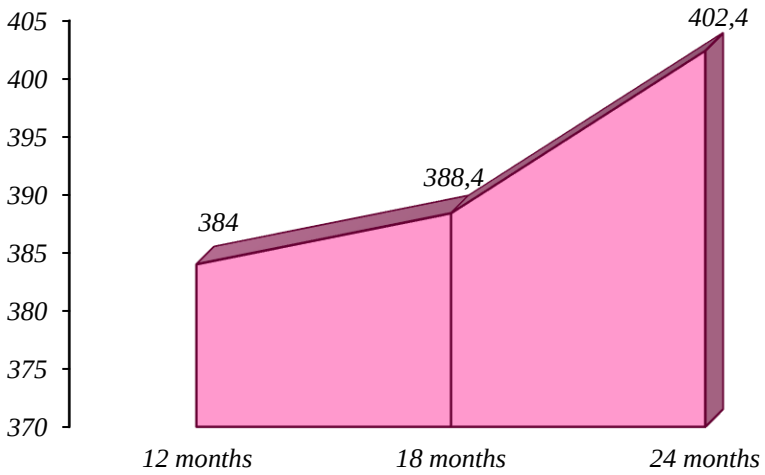
At different periods of observation, against the background of performed myocardial revascularization, all patients showed a steady increase in LVEF and UO indicators, as well as a decrease in the BWW and CRD of the left ventricle. The data obtained reflect the positive effect of myocardial revascularization on the restoration of global myocardial contractility in patients with complicated forms of coronary heart disease.

A comparative analysis of the results of the 6-minute walk test at different observation periods is shown in graph 11.

Despite the fact that, compared with preoperative data, the distance traveled by patients during the 6-minute walk test in the remote period had a significant increase, when comparing these indicators with each other at different observation periods, a slightly different dynamics was revealed.

Thus, a more pronounced dynamics of tolerance is observed by the 24th month after endovascular intervention. At the same time, a significant increase was revealed in the periods of 12-24 months and 18-24 months ($p < 0.05$), while in the interval of 12-18 months the

growth was unreliable (p> 0.05).



Graph 11. Dynamics of exercise tolerance according to the test of 6-minute walk at different periods of observation.

Analysis of PCI results in patients with concomitant type 2 diabetes. The study conducted an additional analysis of the results of treatment of patients with concomitant type 2 diabetes. In order to obtain the correct statistical calculations, by random sampling of the patients participating in the study, we formed a subgroup of patients without diabetes.

Thus, the results of treatment of 88 patients with diabetes mellitus, the main group, and 75 patients without diabetes mellitus, the control group, were subjected to additional analysis.

According to the clinical – demographic and angiographic characteristics, the groups did not differ from each other.

Among patients with diabetes there were 68 men and 20 women aged 41 to 60 years. Moreover, painless myocardial ischemia was diagnosed in 25% of patients, 84% of patients were smokers, and more than 50% had hypercholesterolemia.

All patients underwent complete myocardial revascularization. A total of 244 drug-eluting stents were implanted in both groups. The

average number of stents per person in the main group was 2.48 ± 1.01, and in the control group 2.31 ± 1.04 (p> 0.05).

Clinical and demographic characteristics of patients are presented in table. 14.

Table 14

Clinical and demographic characteristics of patients with concomitant type 2 diabetes

Index	Main (n=88)	Control (n=75)	p
Gender (m/f, n)	68/20	51/24	0,12
Age (year, mean [LQ;UQ])	53[41;60]	52[48;58]	0,72
BMI(kg/m^2,mean [LQ;UQ])	29,3[27,1;32,5]	28,6[26;30,2]	0,21
Angina pectoris III FC, abc.(%)	36(40,9)	30(40)	0,68
Angina pectoris 3 FC abc.(%)	52(59,1)	45(60)	0,52
Silent myocardial ischemia abc. (%)	22(25)	11(14,6)	0,02
Arterial hypertension abc.(%)	80(90,9)	68(90,6)	0,38
Heart failure (NYHA) II FC abc.(%) III FC abc.(%)	 30(34,1) 58(65,9)	 28(37,3) 47(62,6)	 0,27 0,08
Smoking abc.(%)	74(84)	65(86,7)	0,14
Hypercholesterolemia abc.(%)	47(53,4)	22(29,3)	<0,001
ACE history abc.(%)	10(11,4)	8(10,6)	0,63
Heart rhythm and conduction disturb-ances abc.(%)	16(18,2)	13(17,3)	0,37

Note: BMI – body mass index; FC – functional class, ACE – acute cerebrovascular events

There were no statistically significant differences between the groups participating in the analysis in terms of basic clinical and demographic parameters. However, in patients from the main group, painless myocardial ischemia (χ2-5.436, p = 0.02) and hypercholesterolemia (χ2-13.433, p <0.001) were diagnosed significantly more often (χ2-13.223, p <0.001).

The severity of coronary lesions, estimated according to coronarography, as well as indicators of systolic myocardial function, are presented in table 15.

Table 15

Angiographic characteristics of patients with type 2 diabetes

Index	Main (n=88)	Control (n=75)	p
Bivascular lesion abc. %	36(40,9)	31(41,3)	0,16
Three vascular lesion abc. %	52(59,1)	44(58,7)	0,14
Bifurcation stenosis abc. %	34(38,6)	29(38,6)	0,22
Chronic total occlusion abc. %	52(59,1)	49(65,3)	0,18
LM left main stenosis> 50% abc. %	12(13,6)	10(13,3)	0,12
Complete myocardial revascularization abc. %	68(77,3)	62(82)	0,63
The term for performing revascularization after MI (days, mean [LQ;UQ]): Of them, up to 30 days, abc. % after 30 days, abc. %	71,5[14;280] 24(27,3) 64(72,7)	58,5[7;242] 21(28) 54(72)	0,02 0,28 0,24
The number of implanted stents (mean [LQ;UQ])	2,48[2,2;2,7]	2,31[2,1;2,5]	0,24
SYNTAX score I (points, mean [LQ;UQ])	26,01[22;32]	25,6[22;32]	0,33

Note: LCA – left coronary artery

According to angiographic characteristics, as well as features of endovascular intervention, indicators of systolic myocardial function, statistically significant differences between the groups participating in the analysis were not detected. Nevertheless, in the group of patients with diabetes, myocardial revascularization was performed significantly later (χ2-5.231, p <0.02) than in the group of patients without diabetes. Moreover, the groups did not significantly differ in the number of patients who underwent revascularization within 30 days or later.

The average thickness transmurality index, determined using the MRI method of the heart in the main group, was 0.39 [0.2; 0.7]. The average volume of cardiac fibrosis was 33.9 [20; 64]. LVEF did not significantly differ between the groups and amounted to 39.2% [30; 45] and 40.2% [31; 47], p = 0.66.

The direct survival of patients after PCI was 100%, there were no complications. In all patients, by the end of hospitalization, as well as

in the long term, there is a clear positive trend in regards to the regression of the clinic of angina pectoris and increased tolerance to physical activity.

Long-term results after 18 months were monitored in all patients (tab. 16.17).

Table 16

The frequency of complications in the long term after PCI in patients with type 2 diabetes (after 18 months)

Index	After 18 months		p
	Main (n=88)	Control (n=75)	
Death from any cause abs. %	1(1,1)	1(1,3)	0,53
Cardiovascular death abs. %	2(2,3)	1(1,3)	0,67
Nonfatal MI abs. %	2(2,3)	2(2,6)	0,72
Decompensation CHF abs. %	1(1,1)	1(1,3)	0,53
Relapse of angina pectoris, abs. %	4(4,5%)	1(1,3)	0,04
Stent Restenosis> 70%, abs. %	2(2,3)	1(1,3)	0,54
Repeated intervention on target lesion, abs. %	2(2,3)	1(1,3)	0,53
Repeated intervention on the target vessel, abs. %	2(2,3)	-	0,27

Table 17

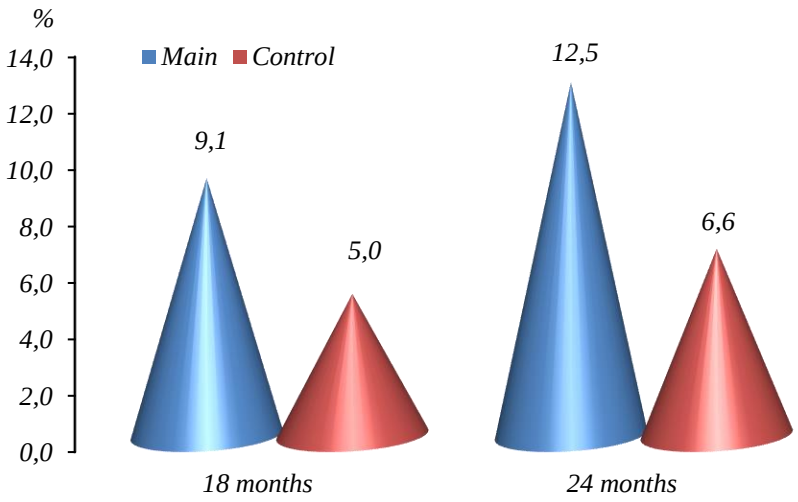
The frequency of adverse cardiac events in the long term after PCI in patients with type 2 diabetes (after 24 months)

Index	After 24 months		p
	Main (n=88)	Control (n=75)	
Death from any cause abs. %	1(1,1)	1(1,3)	0,69
Cardiovascular death abs. %	3(3,4)	2(2,6)	0,24
Nonfatal MI abs. %	2(2,3)	2(2,6)	0,69
CHF decompensation abs. %	2(2,3)	1(1,3)	0,18
Residive angina pectoris, abs. %	8(9,1)	3(4)	0,02
Stent restenosis >70%, abs. %	4(4,5)	1(1,3)	0,03
Repeated intervention on target lesion, abs. %	4(4,5)	1(1,3)	0,03
Repeated intervention on the target vessel, abs. %	2(2,3)	-	0,19

The results of endovascular intervention in patients with diabetes, after 18 months, were comparable in both groups. Significant differences were observed in the frequency of angina recurrence (χ2-5.625, p = 0.04), which was caused in 2 patients by stenosis in the target artery (de novo), and in 2 patients - stent restenosis, about which they underwent repeated intervention . When comparing groups in terms of repeated interventions, no significant differences were found.

The results of observation after 24 months demonstrate an increase in the frequency of relapse of angina pectoris, stent restenosis and repeated interventions on the target lesion in the group of patients with diabetes. In addition, there are significant differences between the groups in the frequency of angina recurrence (χ2-5.625, p = 0.02), stent restenosis (χ2-5.127, p = 0.03) and repeated interventions on the target lesion (χ2-5.434, p = 0.03).

At the same time, a comparison of these indicators with the results after 18 months did not show significant differences in either the main or the control groups (p> 0.05). In addition, no significant differences were found when comparing the indicators of each group with each other at different periods of observation (graph 12).



Graph 12. The total frequency of cardiovascular complications.

The results show a comparable number of cardiac complications in the long term in patients with complicated course of coronary artery disease and concomitant type 2 diabetes and the same cohort of patients without diabetes, which reflects the advisability of performing PCI in such patients.

Analysis of the identified adverse events allowed us to study the effect of preoperative indicators of carbohydrate and lipid metabolism on the frequency of their occurrence. The following points were considered as an endpoint: death, nonfatal MI, the need for repeated intervention after 24 months (Table 18).

Table 18

The effect of lipid and carbohydrate metabolism and their correction on the development of adverse cardiovascular events in patients with type 2 diabetes after PCI

Indicator	OR {95%CI]	p
Before intervention		
HbA_{1c} ≥6.5% (n=42)	1,98 [1.04-3.69]	0.004
HbA_{1c} <6.5% (n=46)	1,58 [1.12-3.19]	0,250
Total cholesterol ≥5.2% (n=37)	3.25[1.57-6.71]	<0,001
Total cholesterol <5.2% (n=51)	2.05[0.87-5.71]	0,318
Triglycerides ≥ 1,7ммоль/л (n=34)	1.92[1.07-3.71]	0,002
Triglycerides < 1,7ммоль/л (n=54)	1.4[0.7-6.88]	0,218
LDL-C ≥ 2,5ммоль/л (n=48)	3.47[1.3-7.9]	<0,001
LDL-C < 2,5 mmol / l (n=40)	1.23[0.67-3.41]	0,288
Fasting plasma glucose ≥6.0 ммоль/л (n=58)	1,84[1.01-3.68]	<0,001
Fasting plasma glucose <6.0 ммоль/л (n=30)	1.26[0.89-3.28]	0,342
After 24 months		
HbA_{1c} ≥6.5% (n=10)	2,68 [1.24-4.68]	<0.001
HbA_{1c} <6.5% (n=78)	1,28 [0.47-3.29]	0,352
Total cholesterol ≥5.2% (n=25)	4.52[1.17-6.91]	<0,001
Total cholesterol <5.2% (n=63)	1.45[1.18-5.21]	0,004
Triglycerides ≥ 1,7 mmol / l (n=14)	1.91[1.07-3.66]	0,003
Triglycerides < 1,7 mmol / l (n=74)	0.48[0.37-0.88]	0,288
LDL-C ≥ 2,5 mmol / l (n=25)	3.77[1.28-8.24]	<0,001
LDL-C < 2,5 mmol / l (n=63)	2.32[1.42-4.21]	0,002
Fasting plasma glucose (with an increase of 1 mmol / L (n=17)	1,36[1.10-1.67]	<0,001

LDL-C - low density lipoprotein cholesterol, HbA1c – glycosylated hemoglobin

Among the biochemical indicators of carbohydrate metabolism, determined before PCI in patients with a dysfunctional myocardium with concomitant type 2 diabetes and CHF, the most significant ones in relation to the risk of developing distant adverse cardiovascular events may include: glycosylated hemoglobin (HbA1c) ≥6.5%, plasma glucose on an empty stomach ≥6.0 mmol / l, which indicates the need for preoperative correction of these indicators.

In relation to the lipid spectrum, the most significant ones in relation to the risk of developing long-term adverse cardiovascular events after PCI can be: total cholesterol ≥5.2%, triglycerides ≥ 1.7 mmol / l, LDL cholesterol ≥ 2.5 mmol / l.

Moreover, factor analysis data obtained in the long term when all patients underwent correction of carbohydrate and lipid metabolism are of particular interest.

So, on the background of statin therapy, 24 months after PCI, 25 patients did not reach the target LDL cholesterol and total cholesterol, and 14 patients did not reach triglycerides, among whom were patients with developed cardiovascular events, which indicates the need for prescribing in the postoperative period more aggressive regimens of lipid-lowering therapy.

With regard to carbohydrate metabolism, there is a tendency comparable to the preoperative period, when the level of glycosylated hemoglobin (HbA1c) ≥6.5%, is a serious adverse factor in the development of cardiovascular complications.

In addition, a multivariate analysis of clinical, demographic and angiographic parameters, as well as data obtained during imaging of the myocardium by cardiac MRI, was performed (Table 19).

Multivariate analysis of clinical demographic and angiographic parameters showed that PCI performed in patients with complicated forms of CIHD with concomitant type 2 diabetes after 30 days from the moment of myocardial infarction, as well as incomplete myocardial revascularization, SYNTAX score> 25, transmurality index ≥0.45, volume cardiac fibrosis ≥45% and, in fact, the presence of diabetes mellitus itself are prognostically unfavorable factors for the development of large cardiovascular events in the separated period.

It should be noted that such indicators as the number of coronary

stents, as well as reduced LVEF (less than 45%), are not predictors of an unfavorable prognosis of PCI in such patients.

Table 19

Predictors of adverse cardiovascular events in the long term after PCI in patients with diabetes

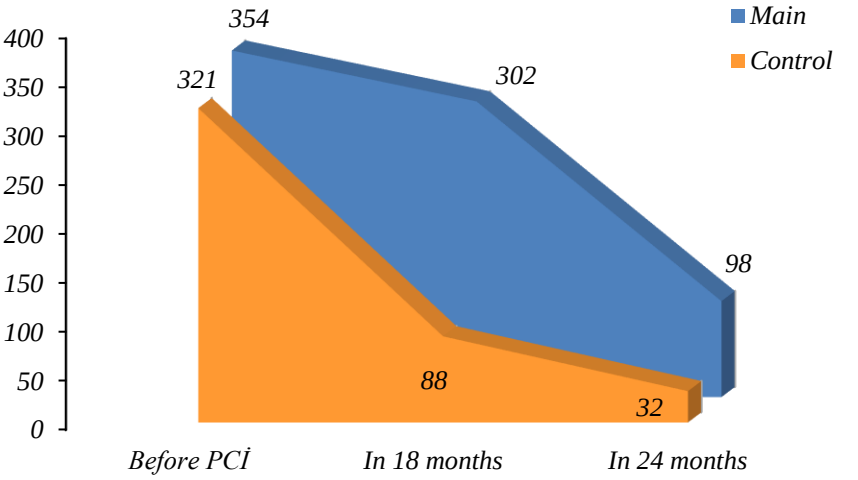
Indicator	OSH / 95% CI	p
ChKV performance later than 30 days from the moment of AMI	1,98 [1.04-3.69]	0.004
Incomplete myocardial revascularization	2,78 [1.08-7.11]	0,037
Transmurality Index ≥0.45	3.05[1.37-6.78]	<0,001
Cardiac fibrosis volume ≥45%	2.75[1.07-7.04]	0,038
LVEF <45%	1.02[1.00-1.08]	0,062
Number of coronary stents ≥3	1.4[0.86-1.88]	0,268
Female	3.17[1.3-7.13]	0,005
SYNTAX score >25	1.46[1.02-1.88]	0,008
DM type 2	3,48[1.59-7.88]	<0,001

The analysis of unfavorable prognosis factors for the treatment of patients with complicated forms of ischemic heart disease and decreased LVEF shows the feasibility of performing myocardial revascularization in such patients at an earlier date from the moment of myocardial infarction.

Initially, before the endovascular intervention was performed, 354 segments with impaired local contractility were diagnosed in the main group, and 321 segments in the control group. On average, 4.0 ± 0.3 segments with impaired kinetics accounted for one patient in the main group, and 4.2 ± 0.2 in the control group.

After PCI, in both groups there was a significant decrease in the number of segments with impaired local contractility in the zone of the hibernated myocardium, compared with the initial data obtained before the intervention ($p < 0.05$) (graph 13).

However, in the group of patients with diabetes, the restoration of the function of the hibernated myocardium by the 18th month after PCI is significantly slower compared with patients without diabetes ($p < 0.001$). At the same time, by the 24th month, a more distinct dynamics of the restoration of the function of the hibernated myocardium is noted.



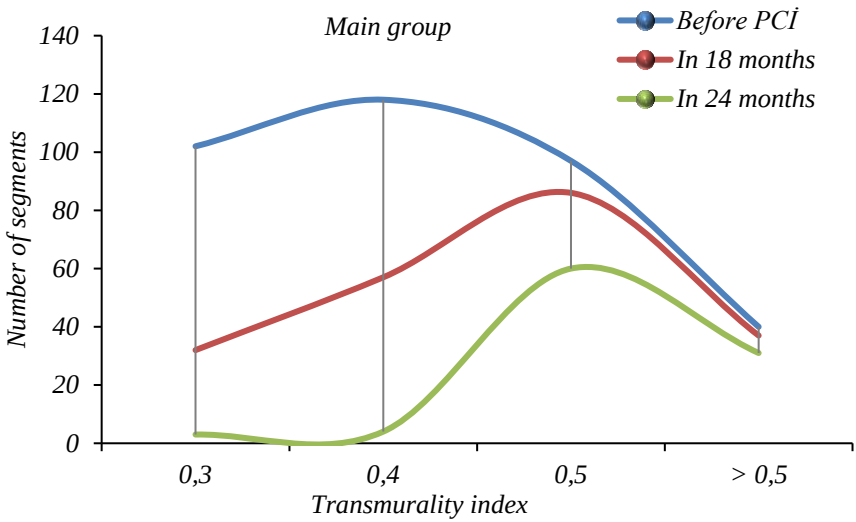
Graph 13. Dynamics of restoration of myocardial contractility after revascularization.

The average transmurality index in the main group decreased, compared with preoperative values, from 0.39 ± 0.07 to 0.22 ± 0.02. The average difference was 0.17 [0.1-0.32; 95% CI, p = 0.01].

Of the greatest interest was the analysis to study the relationship between the transmurality index and the restoration of myocardial contractility in the main group of patients with diabetes (graph 14).

The figure shows that in patients with diabetes, the number of identified pathological segments in the zone of the hibernated myocardium directly correlates with the index of transmurality. The lower the transmurality index, the less the number of pathological segments is detected.

In addition, in this cohort of patients, there is also a significant decrease in the number of pathological segments after endovascular intervention, as in patients without diabetes. At the same time, a negative correlation was revealed, which shows that the smaller the transmurality index value, the better the processes of restoration of a dysfunctional myocardium occur.



Note: Spearman coefficient for IT (0.3) = 0.78 (p <0.001),
for IT (0.4) = 0.82 (p <0.001)

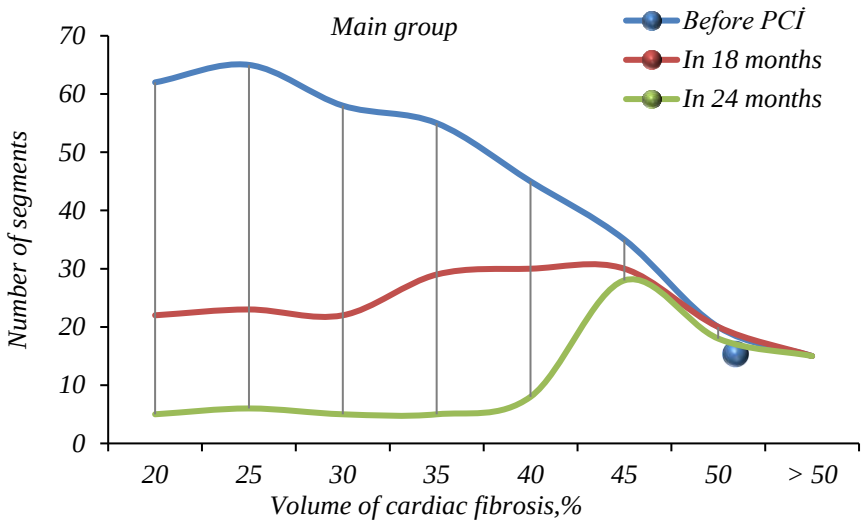
Graph 14. Dynamics of recovery of myocardial contractility, depending on the transmurality index in the main group.

It should be specially noted that in patients with diabetes with a transmural index of 0.5 or more, there is no significant reduction in the number of segments with impaired contractility in the zone of the hibernated myocardium, and, accordingly, no correlation between the studied parameters was revealed.

The relationship between the index of cardiac fibrosis detected by MRI with delayed contrast and restoration of dysfunctional myocardial function is shown in graph 15.

Reliable dynamics of the restoration of myocardial function after PCI was performed with volumes of cardiac fibrosis from 20 to 45%.

In contrast to the transmurality index, the index of cardiac fibrosis volume does not correlate with the number of pathological segments in the hibernation zone. There were no significant differences in the number of pathological segments in the hibernation zone, with different volumes of cardiac fibrosis.



Graph 15. The ratio of the volume of cardiac fibrosis with the number of restored segments in the main group.

Analysis of morphofunctional parameters of the heart is presented in table. 20 and 21.

Table 20

The dynamics of global left ventricular myocardial contractility in the main group

Indicator	After PCI	After 18 months	After 24 months	p
EDV, ml	153,2±3,7	147,5±3,8	139,4±2,1	0.017
ESV, ml	73,2±0,9	70,5±1,1	68,7±1,7	0.072
EDD, mm	58,6±2,1	52,3±1,3	47,7±1,8	0.038
ESD, mm	37,2±0,9	36,8±1,1	36,1±0,7	0.234
SV, ml	70,8±1,4	79,4±1,3	83,9±1,3	0.036
EF, %	39,3±3,4	43,3±2,1	47,6±2,8	0.001

Table 21

Dynamics of indicators of global left ventricular myocardial contractility in the control group

Indicator	After PCI	After 18 months	After 24 months	p
EDV, ml	148,1±1,4	144,5±1,2	139,8±1,4	0.007
ESV, ml	77,6±0,2	76,4±1,1	73,4±0,4	0.272
EDD, mm	55,6±2,2	49,3±1,8	44,3±1,1	0.013
ESD, mm	40,2±0,7	38,8±1,7	37,7±0,9	0.324
SV	71,4±1,2	77,9±1,1	81,8±1,1	0.022
EF, %	40,2±4,4	44,4±2,3	49,6±1,3	0.001

The tables show that in patients with type 2 diabetes, as well as in patients without diabetes, there is a significant increase in LVEF and SV already by the 18th month after the operation, as well as a decrease in BWW and CRD of the left ventricle. A similar steady trend persists by the 24th month of observation.

Based on the results of the study, for patients with complicated forms of coronary heart disease with reduced LVEF and multivascular lesions of the coronary channel, an improved algorithm for diagnosing dysfunctional myocardium and selecting such patients for revascularizing surgery is proposed (Fig. 1).

According to the presented algorithm, it is advisable for all patients who underwent MI who were complicated by the subsequent development of heart failure to perform myocardial imaging using cardiac MRI with delayed contrast.

In patients with a transmural index of 0.3 to 0.4 and a volume of cardiac fibrosis of 20 to 40%, the myocardium is considered viable, and therefore, such patients are recommended to perform revascularizing surgery.

With indicators of the transmurality index from 0.4 to 0.5 and the volume of cardiac fibrosis from 40 to 50%, it is advisable to perform stress MRI in order to more accurately determine myocardial viability, with the subsequent resolution of the issue of revascularization.

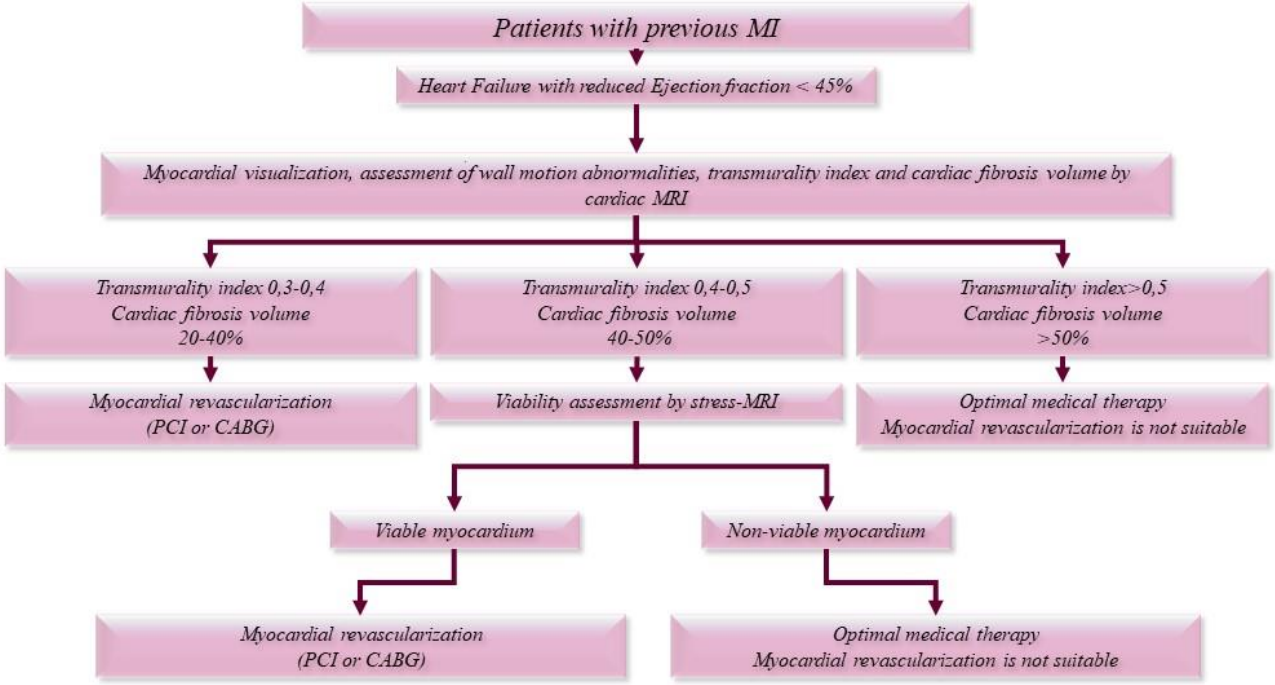


Figure 1. Algorithm for selecting patients with complicated forms of ischemic heart disease and decreased LVEF for performing myocardial revascularization.

While the transmurality index values are more than 0.5 and the volume of cardiac fibrosis is more than 50%, performing myocardial revascularization is impractical, since in such patients myocardium is considered unviable.

In patients with concomitant type 2 diabetes, the myocardium is considered viable with a transmural index of 0.3 to 0.45 and a volume of cardiac fibrosis of up to 45%. If the indicators exceed the indicated values, then the implementation of myocardial revascularization is inappropriate, due to the lack of a viable myocardium.

CONCLUSIONS

1. The method of cardiac MRI in patients with a dysfunctional myocardium with reduced LVEF, allows to identify significantly better segments with impaired contractility and to determine its viability, compared with the method of stress echocardiography [9, 17].

2. Evaluation of the results of PCI in patients with a dysfunctional myocardium with decreased LVEF using the MRI method of the heart is more objective compared to the method of stress echocardiography, which is confirmed by the mismatch of the number of restored segments, and, accordingly, leads to an incorrect interpretation of the results of endovascular interventions in such patients [15].

3. Performing PCI in patients with multivascular lesions of the coronary bed and decreased LVEF is appropriate and effective. Moreover, the lower the transmurality index, the better the restoration of myocardial function in the long term after endovascular intervention. A significant reduction in the number of segments with impaired contractility in the zone of the hibernated myocardium is also observed in patients with a transmurality index of more than 0.5 [16].

4. In patients with complicated forms of ischemic heart disease and concomitant type 2 diabetes, after PCI, there is a significant increase in global myocardial contractility and a decrease in the number of pathological segments, as in patients without diabetes, with the exception of patients with a transmural index of more than 0, 45 and the volume of cardiac fibrosis> 45% [23].

5. The frequency of adverse cardiovascular complications arising

in patients with dysfunctional myocardium and concomitant type 2 diabetes mellitus in the long term after endovascular treatment is comparable to that in patients without diabetes mellitus. Moreover, the restoration of myocardial function in patients with diabetes mellitus occurs more slowly compared to patients without diabetes [33].

6. Performing PCI in patients with complicated forms of coronary heart disease with decreased LVEF is later than 6 months from the moment of myocardial infarction, as well as incomplete myocardial revascularization, are associated with the development of unfavorable cardiac complications of PCI in the long term. Moreover, in patients with concomitant type 2 diabetes, the implementation of revascularization is advisable in up to 30 days from the moment of myocardial infarction [18].

7. Preoperative indicators of glycosylated hemoglobin (HbA1c) ≥6.5%, fasting plasma glucose ≥6.0 mmol / L, total cholesterol ≥5.2%, triglycerides ≥ 1.7 mmol / L, LDL cholesterol ≥ 2.5 mmol / L - are factors associated with unfavorable prognosis of PCI in patients with type 2 diabetes. In addition, incomplete myocardial revascularization, SYNTAX score> 25, transmurality index ≥0.45, cardiac fibrosis volume ≥45%, are also prognostically unfavorable factors for the development of cardiovascular complications [30].

8. The inclusion of heart MRI as an essential component in the diagnosis of myocardial ischemia and its viability in patients with reduced LVEF and type 2 diabetes mellitus can significantly increase the effectiveness of endovascular interventions and improve the prognosis of patients with complicated forms of coronary artery disease [40].

PRACTICAL RECOMMENDATIONS

1. Cardiac MRI is the most effective for the diagnosis of dysfunctional myocardium, and should be included in the standard examination protocols for patients with complicated forms of coronary artery disease and low LVEF, as well as concomitant type 2 diabetes, which are planned to perform revascularizing operations.

2. The determination of the transmurality index by thickness and

volume of cardiac fibrosis in patients with dysfunctional myocardium is a key component in the selection algorithm for surgical treatment.

3. In patients with a transmural index of 0.3 to 0.4 and a volume of cardiac fibrosis of 20 to 40%, the myocardium should be considered viable, and therefore, such patients are recommended to perform revascularizing surgery.

4. With indicators of the transmurality index from 0.4 to 0.5 and the volume of cardiac fibrosis from 40 to 50%, it is advisable to perform stress MRI in order to more accurately determine myocardial viability, with the subsequent resolution of the issue of revascularization.

5. When the transmurality index is more than 0.5 and the volume of cardiac fibrosis is more than 50%, performing myocardial revascularization is impractical, since in such patients myocardium should be considered unviable.

6. Endovascular intervention in patients with complicated forms of ischemic heart disease and reduced LVEF should be performed within no more than 6 months from the moment of myocardial infarction.

7. In patients with complicated forms of ischemic heart disease and concomitant type 2 diabetes, endovascular intervention should be performed within no more than 30 days from the moment of myocardial infarction.

8. If patients with a dysfunctional myocardium and concomitant type 2 diabetes have such risk factors as SYNTAX score> 25, glycosylated hemoglobin (HbA1c) ≥6.5%, fasting plasma glucose ≥6.0 mmol / L, total cholesterol ≥5.2%, triglycerides ≥ 1.7 mmol / l, LDL cholesterol ≥ 2.5 mmol / l - additional preoperative correction of these parameters is required, and the choice of myocardial revascularization method should be made according to the decision of the heart team.

9. PCI in patients with complicated forms of ischemic heart disease and concomitant type 2 diabetes with a revealed transmural index of ≥0.45 and cardiac fibrosis of ≥45%, is inappropriate.

List of scientific works published by the theme of the dissertation

1. Role of Myocardial Revascularization in Treatment of Patients With ST-Elevation Myocardial Infarction / Imanov G, Dzhamilov R, Rustamova Y.// Kardiologiia. 2010;50(8):91-6

2. STEMI hastalarında yapılan kolaylaştırılmış PTCA ile primer PTCAnın sol ventrikül sistolik ve diyastolik fonksiyoları üzerindeki etkilerinin karşılaştırması / Q. İmanov, A. Baxşəliyev, R.Camilov, Ü.Mirzəyev, Rustamova Y. // XXVI. Ulusal Kardiyoloji Kongresi, Türk Kardiyol Dern Arş 2010, Supl 2,-165

3. Dynamics of echocardiographical parameters of left ventricular remodelingin patients with acute myocardial infarction after successful primary angioplasty in dependence on the state of coronary blood flow before interventi on/ Imanov G, Bakhshaliev A, Azizov V, Dzhamilov R, Mirzoev U, Rustamova Y.// Kardiologiia 2011;51(7):13-6.

4. Gated SPECT evaluation of left ventricular function using a CZT camera and a fast low-dose clinical protocol: Comparison to cardiac magnetic resonance imaging // A. Giorgetti, P.G. Masci, Yasmine K. Rustamova, G. Marras et al. // European Journal of Nuclear Medicine and Molecular Imaging, 2013 40(12) 10-17 · July 2013

5. Проблемы диагностики дисфункционирующего миокарда коронарной этиологии: в поисках лучшего метода / Я.К. Рустамова, В.А. Азизов, Д.А. Максимкин, А.Г. Файбушевич // Бюллетень НЦССХ им. А.Н. Бакулева РАМН. Приложение. – 2016.- том 17.- №6. – С.212.

6. Miokard infarktı keçirmiş xəstələrdə müalicə problemləri və mümükün həlləri / Y. Rüstəmova, Q.G.İmanov, D.A. Maksimkin, A.O. Faybuşeviç, V.Ə.Əzizov// Azərbaycan Kardiologiya Jurnalı № 1(9), 2016, 29 – 37

7. Diagnosis of myocardial viability in patients with chronic heart failure: search for the best methods / Ya. Rustamova, V. Azizov, D. Maximkin, A. Faibushevich // European Journal of Heart Failure. – 2017. – Vol.19. (Suppl.1). – P. 405

8. МРТ-сердца в диагностике гибернированного миокарда и определение показаний для реваскуляризации миокарда/ Я.К. Рустамова, В.А. Азизов, Д.А. Максимкин, А.Г. Файбушевич // Бюллетень НЦССХ им. А.Н. Бакулева РАМН. Приложение. – 2017.- том 18.- №3. – С.66.

9. MRI vs. stress-echocardiography with dobutamine: in search of a better method of diagnosis myocardial viability / Ya. Rustamova, V. Azizov, D. Maximkin, A. Faibushevich // Eur Heart J Cardiovasc Imaging.- 2017. - № 18 (suppl_2): P. ii154. doi: /10.1093/ehjci/jex129

10. МРТ-сердца в диагностике гибернированного миокарда в сравнении со стресс-эхокардиографией с добутамином: результаты двухцентрового рандомизированного исследования / Я.К. Рустамова, В.А. Азизов, Д.А. Максимкин, А.Г. Файбушевич // Материалы конгресса Кардиология 2017: профессиональное образование, наука и инновации, С-Пб, 2017. – С.380

11.. CMR imaging for evaluation the myocardial viability in patient underwent percutaneous coronary intervention after previous myocardial infarction / Y.Rustamova //Anatol J Cardiol. – 2017. – Vol.18 (Suppl 1). – P. 1-109

12. The evaluation of the long-term results of percutaneous coronary intervention of patients with previous myocardial infarction using cardiac MRI with delayed enhancement/ Y.Rustamova, Galib Imanov // 8th Emirates Cardiac Society Congress in collaboration with ACC Middle East Conference 2017 Abstract Submission 2017 ID: ECS2017-A-1143

13. МРТ сердца в оценке прогноза больных ИБС с дисфункциональным миокардом после выполненного эндоваскулярного вмешательства / Я.К. Рустамова, Г.Г. Иманов, В.А. Азизов // Диагностическая и интервенционная радиология - 2018 –12-№2, с.30-39

14. Возможности магнитно-резонансной томографии в определении жизнеспособности миокарда / Я.К. Рустамова // Трудный пациент. – 2018. - №3. – С.11-15

15. Определение жизнеспособности дисфункционального миокарда - выбор эффективного метода / Я.К. Рустамова, Г.Г. Иманов, В.А. Азизов // Вестник РГМУ. – 2018. - №4. – С.74 – 79

16. Результаты чрескожных коронарных вмешательств у больных с дисфункциональным миокардом / Я.К. Рустамова, Г.Г. Иманов, В.А. Азизов // Клиническая медицина. – 2018. – т. 96. - №8. – С.762-768

17. Оценка эффективности и прогностической значимости метода МРТ сердца в определении жизнеспособности миокарда / Я.К. Рустамова, В.А. Азизов // Бюллетень Сибирской медицины.- 2018. – т.17. - №4. – С.131-140

18. Koronar etiologiyalı disfunksional miokardı olan xəstələrdə perkutan müdaxilının effektivliyi / Rüstəmova Y.K., Əzizov V.Ə., İmanov Q.G. // Azərbaycan Tibb Jurnalı 2018, № 2; 92-98

19. Biomarkers in heart failure: From the bedside back to biology / Dobreanu D., Rustamova Y. // Revista Romana de Medicina de Laborator – 2018-Vol.26, №3, 267 – 270

20. Сравнительный анализ эффективности методов визуализации дисфункционального миокарда / Я.К. Рустамова, Г.Г. Иманов, В.А. Азизов, И.С. Исмайлов // Sağlamlıq – 2018 - №4, 175 – 181

21. Effectiveness of percutaneous coronary interventions in diabetic patients with dysfunctional myocardium / Y. Rustamova, G.İmanov // Anatol J Cardiol, October 2018 Vol: 20, (Suppl 1),101 2018

22. Cardiovascular magnetic resonance vs. Stress-echocardiography with dobutamine: in search of a better method of diagnosis of myocardial viability / Rustamova Y., Azizov V., Daniil M.// Asia PCR SingLive 2018, 25-27 2018, Sıngapore

23. Эндоваскулярное лечение пациентов с дисфункциональным миокардом и хронической сердечной недостаточностью на фоне сахарного диабета 2 типа: результаты двухлетнего наблюдения / Я.К. Рустамова, Иманов Г.Г., Азизов В.А., Максимкин Д.А. Файбушевич А.Г. // Трудный пациент. – 2018. - №11. – С.6-10

24. МРТ сердца в оценке отдаленных результатов эндоваскулярных вмешательств у пациентов с инфарктом миокарда в анамнезе / Я.К. Рустамова, Азизов В.А., Иманов Г.Г. И.С.Исмайлов // Azərbaycan Tibb Jurnalı , 2018, № 4; 46-51

25. Miokard infarktli xəstələrdə perkutan koronar müdaxilənin uzunmüddətli nəticələrinin qiymətləndirilməsində ürək mrt müayinəsinin rolu / Rüstəmva Y.K., İmanov Q.G. , Əzizov V.A., Ismayılov I.S. // Azərbaycan Kardiologiya Cəmiyyətinin 7-ci Milli beynəlxalq iştrakla Konqress Materialları, 2018

26. Miokard infarktı keçirmiş xəstələrdə miokard canlılığını dəyərləndirmək üçün optimal metodun seçilməsi / Rüstəmova Y.K., İmanov Q.G., Əzizov V.A., Rəhimova A.S. // Azərbaycan Kardiologiya Jurnalı № 2(14) 2018, 67 – 73

27. МРТ сердца в оценке отдаленных результатов эндоваскулярных вмешательств у пациентов с инфарктом миокарда в анамнезе / Рустамова Я.К., Г.Г. Иманов, В.А. Азизов, И.С. Исмайлов// Актуальные вопросы современной медицины: Материалы III международной конференеции прикаспийских государств – 4-5 октябрь 2018, 13-15 Астрахань

28. Магнитно-резонансная томография сердца в оценке отдаленных результатов эндоваскулярного леченмя пациентов с дисфункциональным миокардом и сопутствующим сахарным диабетом II типа / Рустамова Я.К., Иманов Г.Г., Азизов В.А., Исмайлов И.С. // Sağlamlıq – 2018 - №5, 55-65

29. Актуальные вопросы диагностики жизнеспособного миокарда / Я.К. Рустамова // Кардиология. – 2019. – т.59. - №2. – С.68-78.

30. Факторы неблагоприятного прогноза эндоваскулярных вмешательств у больных с дисфункциональным миокардом и сопутствующим сахарным диабетом 2 типа / Рустамова Я.К., Азизов В.А , Иманов Г.Г. ,, Джахангиров Т.Ш. , Максимкин Д.А // Казанский медицинский журнал– 2019. – т.100. - № 3. – С. 392-401

31. Эффективность эндоваскулярных вмешательств у пациентов с инфарктом миокарда в анамнезе и сопутствующим сахарным диабетом 2 типа / Рустамова Я.К., Иманов Г.Г., Азизов В.А., И.С.Исмайлов// BDU 100 illiyinə həsr olumuş konfrans materilları, 2019

32. Значение метода МРТ сердца в диагностике дисфункционирующего миокарда ишемической этиологии / Y. Rüstəmova,

V.Əzizov, A. Rəhimova // «Tibbin görən gözü» adlı beynəlxalq radioloji konqresin materialları, 30-31 mart 2019

33. Отдаленные результаты реваскуляризации дисфункционального миокарда у пациентов с сахарным диабетом 2 типа / Рустамова Я.К., Иманов Г.Г., Азизов В.А., Максимкин Д.А. Файбушевич А.Г. // Вестник национального медико-хирургического центра им. Н.И Пирогова 2019 Том 14, № 1, 15-22

34. Choosing an effective methods for assessing the results of percutaneous coronary interventions in post-myocardial infarction patients/ Rustamova Y., Azizov V., Imanov G., Maximkin D., Faibushevich A // European Journal of Heart Failure. – 2019. – vol. 21 (Suppl. S1). P. 401 doi:10.1002/ejhf.1488

35. CMR in the evaluation of the results of percutaneous coronary interventions in patients with diabetes mellitus type 2 and chronic heart failure/ Rustamova Y., Azizov V., Imanov G., Maximkin D., Faibushevich A. // European Journal of Heart Failure. – 2019. – vol. 21 (Suppl. S1). P. 433 doi:10.1002/ejhf.1488

36. Choosing an effective methods for assessing the results of PCI in post-myocardial infarction patients / Rustamova Y., Azizov V., Imanov G., Maximkin D., Faibushevich A // Eurointerventional (Abstracts EuroPCR 2019). – Euro19A- POS350. – P. 350

37. Disfunksional miokardı olan ÜİX xəstələrinin endovaskulyar üsulla müalicəsinin 2-illik nəticələri/ Y. Rüstəmova // Azərbaycan Kardiologiya Jurnalı № 1(15) 2019, 32 - 40

38. Особенности реваскуляризации миокарда у больных со сниженной фракцией выброса левого желудочка и многососудистым поражением коронарного русла / Рустамова Я.К // Azərbaycan Metabolizm Jurnalı № 3 (16) 2019,31 - 36

39. Динамика глобальной сократительной способности дисфункционального миокарда после выполненной реваскуляризации у пациентов с сопутствующим сахарным диабетом 2 типа / Рустамова Я.К // Sağlamlıq – 2019 - №5, 65 – 74

40. Ischaemic cardiomyopathy. Pathophysiological insights, diagnostic management and the roles of revascularisation and device treatment. Gaps and dilemmas in the era of advanced technology // Cabac-

Pogorevici I, Muk B, Rustamova Y, Kalogeropoulos A, Tzeis S, Vardas P. // Eur J Heart Fail. 2020 May;22(5):789-799. doi: 10.1002/ejhf.1747. Epub 2020 Feb 5. PMID: 32020756.

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