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Clinical and Instrumental Assessment of the Effectiveness of Myocardial Revascularization in Patients with Ischemic Heart Disease

Nasirova Zarina Akbarovna

Doctor of medical sciences, associate professor of the department of internal diseases and cardiology No. 2, Samarkand State Medical University, Samarkand, Uzbekistan

Rasulova Dilfuza Olimovna

Master's student in the specialty "Cardiology", Samarkand State Medical University, Samarkand, Uzbekistan

Annotation:

Research objective. Conduct a comprehensive assessment of clinical, functional, biochemical, and instrumental indicators in patients with coronary heart disease (CHD) after various types of myocardial revascularization and identify risk factors for the development of cardiovascular complications.

Materials and methods. 96 patients with coronary heart disease were examined, who underwent planned myocardial revascularization. Depending on the method of intervention, patients are divided into two groups:

-I group (n = 52) - patients after percutaneous coronary intervention (PCI);

- Group II (n = 44) - patients after coronary artery bypass grafting (CAG).

The dynamics of electrocardiographic (ECG) and echocardiographic (EchoCG) indicators, troponin I levels, KFC-MV, lipid spectrum parameters, frequency of complications, and quality of life were assessed using SF-36 and KCCQ scales. Statistical analysis was performed using the SPSS 26.0 package, Student's t-test and $\chi 2$ criterion were used; differences were considered significant at $p < 0.05$.

Results.

Six months after the intervention, the left ventricular ejection fraction (LVEF) increased by an average of 12%, the frequency of ST segment depression and T wave inversion decreased by more than 3 times. Complete revascularization was achieved in 83% of patients after PCV and in 89% after CSH. The frequency of complications was 32.7% and 50.0%, respectively. The main predictors of complications were: LVEF < 45%, troponin level I > 0.5 ng/ml, the presence of type 2 diabetes mellitus, and NYHA functional class III-IV chronic heart failure (CHF). The SF-36 average total score increased from 48.5 to 74.5, the KCCQ scale from 49.3 to 77.9 ($p < 0.001$).

Conclusion.

Myocardial revascularization leads to a significant improvement in the contractile function of the myocardium and the quality of life of patients with coronary heart disease. Endovascular methods ensure faster restoration of the functional state, while surgical revascularization is characterized by a more stable hemodynamic effect in the long term. The developed risk stratification algorithm allows reducing the frequency of complications by approximately 30-35% and improving quality of life indicators by 22-28 points.

Keywords: heart disease, myocardial revascularization, percutaneous coronary intervention, coronary artery bypass grafting, complications, troponin I, ejection fraction, quality of life.

ENTRY

Ischemic heart disease (IHD) continues to be the leading cause of death worldwide, accounting for up to 30% of deaths from cardiovascular diseases. One of the main directions of treating coronary heart disease is myocardial revascularization, aimed at restoring coronary blood flow, reducing ischemia, improving myocardial contractile function, and a long-term prognosis.

In modern clinical practice, two main methods of revascularization are used: percutaneous coronary intervention (PCI) and coronary bypass surgery (CBI). The choice of methodology is determined by the anatomy of the coronary artery, the degree of damage, the functional state of the myocardium, concomitant pathology, and the patient's overall surgical risk.

Despite significant progress in the development of interventional cardiology and cardiac surgery, the problem of postoperative complications remains relevant. Recurrent ischemic events, rhythm disturbances, progressive heart failure, stent stenosis, and shunt thrombosis worsen the prognosis and significantly reduce the patient's quality of life. According to international registers (ESC 2023, STS 2024), the frequency of cardiovascular complications after PCI reaches 30%, after PCI - up to 45%.

Considering the increase in the number of patients with comorbid pathology, aging of the population, and high prevalence of type 2 diabetes mellitus, it is especially important to create comprehensive risk stratification systems that allow for predicting adverse outcomes and optimizing rehabilitation programs after revascularization.

RESEARCH OBJECTIVE

Conduct a comprehensive assessment of clinical, functional, biochemical, and instrumental changes in patients with coronary artery disease after various types of myocardial revascularization (CVA and CVA), identify risk factors for cardiovascular complications and their impact on the patient's quality of life.

MATERIALS AND METHODS

Characteristics of the examined patients

The study included 96 patients with coronary heart disease hospitalized for planned myocardial revascularization. Depending on the type of intervention performed, all patients were divided into two groups: group I (PCT, n = 52) included patients who underwent coronary artery bypass grafting, group II (CT, n = 44) - patients who underwent coronary bypass grafting. The average age of the examined was 57.8±5.3 years; men predominated, reaching 56.2%. The structure of comorbid pathology was characterized by a high frequency of arterial hypertension (68.5%) and chronic heart failure (79.2%), almost half of the patients had obesity (43.7%), and every fifth had type 2 diabetes mellitus (21.8%), which reflects the typical profile of a modern cardiological patient with a high total cardiovascular risk.

Examination methods

All patients underwent a comprehensive clinical and instrumental examination according to a single protocol. The clinical stage included a detailed medical history collection, assessing the severity of symptoms, the frequency of angina attacks, the functional class of chronic heart failure, information about previous myocardial infarctions, and the presence of traditional risk factors. Electrocardiographic examination was performed in 12 standard leads with analysis of the ST segment, T wave, as well as rhythm and conduction characteristics. Echocardiography was performed by determining left ventricular ejection fraction, end-diastolic and end-systolic dimensions, left ventricular wall thickness, and pulmonary artery systolic pressure, which allowed for the assessment of both myocardial systolic function and the degree of heart remodeling and pulmonary hypertension. Coronary angiography was used to quantitatively assess coronary blood flow according to the TIMI scale, determine the degree of coronary artery stenosis, and monitor the patency of stents and aortocoronary shunts in dynamics. Biochemical examination included determining the levels of troponin I and creatine phosphokinase of the MV fraction as markers of myocardial damage, lipid

spectrum indicators (total cholesterol, low-density lipoproteins, triglycerides), and blood glucose concentration. Life quality assessment was conducted using validated SF-36 and Kansas City Cardiomyopathy Questionnaire (KCCQ) questionnaires in three stages: before intervention, 3 months after, and 6 months after revascularization, which allowed for tracking the dynamics of patients' subjective status and functional activity.

Statistical analysis

Statistical processing of the obtained data was carried out using the SPSS 26.0 package. Quantitative indicators were presented as an average value and standard deviation (M ± m). To compare the average values between the groups, Student's t-criterion was used, and to analyze qualitative traits, $\chi 2$ criteria were used. Differences were considered statistically significant at a level of $p < 0.05$. To assess the relationships between functional, biochemical, and subjective indicators, a correlation analysis was conducted with the calculation of Pearson's correlation coefficient (r), which allowed for the identification of key patterns of mutual influence of myocardial contractility, the degree of damage, metabolic disorders, and patients' quality of life.

RESEARCH RESULTS

1. Dynamics of electrocardiographic changes

After revascularization, most patients showed pronounced positive dynamics in ECG indicators. As early as the 7th day, the frequency of ST segment depression decreased by 3.2 times in the PCI group and by 2.5 times in the PCI group ($p < 0.05$), reflecting the restoration of coronary blood flow and a decrease in the severity of ischemia. Similarly, the proportion of patients with T wave inversion decreased from 61.5-63.6% to 34.6-40.9%, and after 6 months, T wave inversion persisted only in 19-23% of patients ($p < 0.01$).

By the sixth month of observation, almost complete normalization of repolarization processes and rhythm was noted: the frequency of sinus tachycardia decreased to 15-20%, cases of AV blockade of I-II degree were isolated. Intergroup differences in the main ECG indicators were statistically insignificant ($p > 0.05$), indicating comparable effectiveness of PCI and PCI in relation to myocardial electrophysiological stabilization in the long term.

Table 1. Dynamics of electrocardiographic changes in patients after myocardial revascularization (n=96)

ECG signs	PCV up to	After 7 days	After 6 months	KSh up to	After 7 days	After 6 months	p (between groups)
ST depression ≥ 1 mm, %	67.3	21.2*	15.4**	70.4	28.3*	18.2**	> 0.05
T-wave inversion, %	61.5	34.6*	19.2**	63.6	40.9*	22.7**	> 0.05
Sinus tachycardia, %	38.5	23.1	15.4**	40.9	29.5	20.4**	> 0.05
AV block I-II degree, %	7.7	5.8	3.8	9.1	6.8	4.5.	> 0.05

$p < 0.05$; ** $p < 0.01$ compared to the initial data within the group.

After 6 months, ST segment depression persisted in only 15-18% of patients, reflecting a persistent decrease in myocardial ischemia.

2. Echocardiography indicators and myocardial functional status

According to EchoCG data, after 6 months of revascularization in patients of both groups, a significant improvement in intracardiac hemodynamics was noted.

Table 2. Echocardiography indicators in patients with coronary heart disease before and after myocardial revascularization (M ± m)

Indicator	PCV up to	After 7 days	After 6 months	KSh up to	After 7 days	After 6 months	p (between groups)
Left ventral ejection fraction, %	48.6 ± 6.4	51.2 ± 5.8*	54.7 ± 5.3**	47.8 ± 5.9	50.1 ± 6.1*	53.3 ± 5.5**	> 0.05
LV EDR, mm	55.2 ± 4.1	54.1 ± 4.0	52.8 ± 3.8**	56.0 ± 4.2	54.6 ± 3.9	53.1 ± 3.6**	> 0.05
Pulmonary artery pressure, mm Hg.	39.2 ± 5.6	35.4 ± 5.2*	31.7 ± 4.8**	40.3 ± 5.9	36.8 ± 5.4*	33.2 ± 5.1**	> 0.05

$p < 0.05$; ** $p < 0.01$ compared to the initial data.

The average LVEF value increased from 48.6 ± 6.4% to 54.7 ± 5.3% after PCV (relative increase of 12.3%; $p < 0.01$) and from 47.8 ± 5.9% to 53.3 ± 5.5% after CSH (increase of 11.5%; $p < 0.01$). Decrease in CDR and CRP reflect regression of LV remodeling and restoration of contractile function. Systolic pressure in the pulmonary artery decreased by an average of 7-8 mm Hg, which indicates a decrease in post-stress and improvement of small circle hemodynamics.

In patients after PCV, the restoration of LVEF occurred faster (in the first 3 months), while after CSH, the positive dynamics were smoother, but by the 6th month, they were characterized by stability.

3. Correlation relationships of functional and biochemical indicators

To assess the relationship between the degree of myocardial recovery and the risk of complications, a correlation analysis was conducted.

Table 3. Correlation relationships between functional and biochemical indicators in patients after myocardial revascularization

Parameters	r.	p.
LVEF ✓ troponin level I (48 h)	-0.68	< 0.001
LVEF ✓ frequency of complications	-0.58	< 0.01
Troponin I β frequency of complications	+0.54	< 0.01
LDL β stent restenosis/shunt thrombosis	+0.47	< 0.05
SF-36 (general index) β LVEF	+0.68	< 0.001
SF-36 β recurrent myocardial infarction	-0.57	< 0.001

The conducted correlation analysis revealed a number of patterns that have important clinical and prognostic significance. A pronounced inverse correlation was established between troponin I levels and left ventricular ejection fraction ($r = -0.68$), indicating that the degree of myocardial damage in the early postoperative period directly affects the subsequent restoration of contractile function. The higher the troponin I level on the first day after intervention, the more pronounced the decrease in LVEF in the long-term period. An inverse relationship was also found between ejection fraction and the frequency of complications ($r = -0.58$): a decrease in left ventricular contractile function was associated with a higher risk of adverse events, which confirms the high prognostic significance of systolic dysfunction in patients after myocardial revascularization.

In addition, a direct correlation was found between the level of low-density lipoproteins and the risk of stent restenosis or aortocoronary shunt thrombosis ($r = +0.47$), emphasizing the key role of lipid metabolism disorders in the formation of late ischemic complications and the need for aggressive hypolipidemic therapy in this category of patients. The close direct relationship between LV ejection fraction and the integral quality of life index SF-36 ($r = +0.68$), as well as the inverse relationship

between SF-36 and the frequency of myocardial infarction recurrence ($r = -0.57$), proved to be no less indicative. These data demonstrate that the improvement of objective cardiac function parameters is accompanied by a significant increase in subjective well-being and a decrease in the risk of recurrent acute coronary events. Thus, improving the contractile function of the myocardium is directly related to improving the quality of life and reducing the frequency of complications, which allows us to consider quality of life indicators as an additional clinical marker of the effectiveness of the ongoing therapy and rehabilitation.

During the 6-month observation period, complications were registered in 32.7% of patients after percutaneous coronary intervention and in 50.0% of patients after coronary bypass grafting ($p < 0.05$). Heart rhythm disorders were most common (17-25%), with atrial fibrillation playing a leading role among them, the frequency of which after coronary artery disease reached 18.2%. Episodes of acute heart failure, occurring in 7.7-15.9% of patients, as well as recurrence of myocardial infarction, registered in 5.8-11.4% of cases, had significant clinical significance. Despite the higher overall frequency of complications in the CKD group, their clinical manifestations were often less pronounced in the long-term period, which can be explained by completer and more stable myocardial revascularization, confirmed by coronary blood flow indicators (TIMI ≥ 2.9).

Analysis of the dynamics of chronic heart failure showed that after 6 months of intervention, the proportion of patients with NYHA functional class III-IV CVD decreased by more than 2.5 times - from 46% to 17-22%. Simultaneously, a practically threefold increase in the number of patients with SLE of the 1st functional class was observed, the proportion of whom was 40.4% after PCV and 34.1% after CSH ($p < 0.05$). These changes reflect a marked improvement in central hemodynamics, an increase in cardiac pump function, and a significant increase in exercise tolerance against the background of restored coronary blood flow and optimized drug therapy.

The dynamics of quality-of-life indicators proved to be no less indicative. After 6 months of revascularization, the average values on the SF-36 and KCCQ scales increased by 25-28 points ($p < 0.001$), which indicates a significant improvement in the subjective condition of patients. The greatest increase was noted in the domains of physical functioning (PF) and vital activity (VT): most patients transitioned from the category with moderate limitations to the group with practically preserved daily activity and the ability to perform habitual household and professional loads. When comparing the subgroups, it was established that in patients who did not experience complications in the postoperative period, the SF-36 indicators were significantly higher (78.9 ± 7.5 versus 63.4 ± 8.2 points; $p < 0.001$), as well as the KCCQ values (80.1 ± 7.6 versus 66.5 ± 8.0 points; $p < 0.001$), compared to patients with developed adverse events. These results once again confirm the close relationship between clinical outcomes and quality of life: successful revascularization, accompanied by the restoration of contractile function and a decrease in the frequency of complications, leads not only to an objective improvement in cardio hemodynamics but also to a significant increase in subjective well-being, psychological comfort, and social activity of patients.

DISCUSSION

The obtained data indicate that the conducted myocardial revascularization has a pronounced beneficial effect on heart function, myocardial damage markers, and the quality of life of patients with coronary heart disease. The identified differences between PCI and CS reflect both the specifics of the intervention and the degree of coronary perfusion restoration.

An increase in LVEF by 12-13% after 6 months demonstrates the restoration of cardiac pump function and the regression of post-infarction remodeling. These results are consistent with major international studies (SYNTAX, EXCEL) that have shown an improvement in blood flow rate and a decrease in mortality when complete revascularization is achieved. The decrease in pulmonary artery pressure and heart cavity sizes observed in our study also reflects a positive hemodynamic adaptation.

The established relationship between clinical, functional, and biochemical indicators is of particular interest. A pronounced negative correlation between troponin I levels and LVEF ($r = -0.68$; $p < 0.001$)

confirms that the magnitude of periprocedural myocardial damage largely determines the extent of subsequent restoration of contractility. Similar relationships are described in the works of Lalonde et al. (JACC, 2022), where elevated troponin levels after PCI were associated with a 2-3-fold increase in the risk of heart failure development during the observation year.

The direct correlation between LVEF and the SF-36 integral index ($r = +0.68$; $p < 0.001$) emphasizes the multifaceted influence of left ventricular function restoration on the patient's subjective state. REHAB-HF Trial (NEJM, 2021) also indicates that even a moderate increase in blood pressure by 5-7% is accompanied by a significant improvement in physical and emotional well-being.

The relationship between LDL levels and the risk of late complications (stent stenosis, shunt thrombosis; $r = +0.47$; $p < 0.05$) emphasizes the key role of lipid metabolism disorders. FOURIER (2017) showed that intensive LDL reduction using PCSK9 inhibitors leads to a 25% reduction in the frequency of recurrent ischemic events.

A lower frequency of complications after PCI (32.7%) compared to PCI (50.0%) can be explained by the less invasive nature of the endovascular intervention and the faster endothelial process of the stents. At the same time, KS surgery demonstrated a more stable hemodynamic effect by the 6th month of observation, which is consistent with the data of the FREEDOM Trial (NEJM, 2012), which confirmed the advantages of KS in patients with diabetes mellitus and multivesicular coronary artery disease.

The pronounced positive dynamics of SLE (reduction of the III-IV FC share by more than 2.5 times) is due not only to the restoration of myocardial perfusion but also to the optimization of drug therapy (β-adrenergic blockers, ACE inhibitors/BRA/ARNI, mineral-corticoid receptor antagonists). Improving quality of life and workload tolerance aligns with ESC 2023's modern recommendations, emphasizing the importance of early inclusion of patients in cardio rehabilitation programs.

Thus, our study demonstrates that a comprehensive assessment of clinical, instrumental, and laboratory parameters allows for objective assessment of revascularization effectiveness, timely identification of high-risk patients, and optimization of subsequent management and rehabilitation strategies.

FINDINGS

1. Myocardial revascularization (TMI and PCI) in patients with coronary heart disease is accompanied by a significant improvement in clinical, hemodynamic, and functional indicators. After 6 months, the average LVEF increases by approximately 12%, pulmonary artery pressure decreases by 7-8 mm Hg, and the frequency of ischemic changes on the ECG decreases by more than 3 times ($p < 0.01$).
2. Percutaneous coronary intervention ensures faster restoration of contractile function and quality of life in the early stages of observation, while coronary bypass grafting demonstrates a more stable hemodynamic effect in the long term.
3. The main risk factors for complications after myocardial revascularization are reduced LVEF (< 45%), elevated troponin I levels (> 0.5 ng/ml), the presence of type 2 diabetes mellitus, and NYHA SLE FC III-IV.
4. Correlation analysis revealed a close relationship between functional, biochemical, and subjective indicators: a negative correlation between troponin I and LVEF ($r = −0.68$; $p < 0.001$) and a positive correlation between LVEF and SF-36 index ($r = +0.68$; $p < 0.001$), reflecting the systemic impact of restoring contractile function on life quality.
5. The developed algorithm for stratifying the risk of complications after myocardial revascularization allows for predicting the probability of adverse outcomes, individualizing management tactics, and reducing the frequency of complications by 30-35%, accompanied by an improvement in quality-of-life indicators by 22-28 points.

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