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ОРИГИНАЛЬНОЕ ИССЛЕДОВАНИЕ

### Meta-analysis of mid-term survival and clinical results of left ventricular surgical reconstruction

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**Abstract. Relevance.** Post-infarction aneurysm of the left ventricle significantly reduces the length and quality of life of patients. The results of comparisons of different methods for surgical restoration of the left ventricle are ambiguous and often contradictory, complicating the choice of an effective treatment strategy and the ability to objectively assess the survival prospects of such patients. *The aim* of the meta-analysis is to assess the one-year survival of patients after surgical reconstruction of the left ventricle, to determine the functional class of heart failure, and to study the morphological and functional characteristics of the heart. A comparative analysis of the results of the meta-analytic assessment of patient survival after left ventricle reconstruction using the DOR (SAVER) method will be performed in comparison with other treatment methods. *Materials and Methods.* As a result of a systematic search in two specialized databases (PubMed, Google Scholar), 1,875 articles were selected. A total of 15 studies were included in the final analysis. The total number of patients in these studies was 1,089. To objectify the assessment of the effectiveness of different surgical approaches, two patient groups were formed. The first group underwent only surgical reconstruction of the left ventricle using the Dor procedure or surgical anterior ventricular endocardial restoration (SAVER); the second group received other methods of surgical ventricular reconstruction, depending on the surgical feasibility. *Results.* The mean age of the examined patients was 62.1 (95% CI: 60.2–64.1) years. The study included 56% (95% CI: 42–69) men. Anterior aneurysm occurred in 87% (95% CI: 74–99) of patients. The mean EuroSCORE value corresponded to 9.7% (95% CI: 7.3–12.1). Before the operation, the patients had a high functional class of heart failure according to NYHA [3 functional class (95% CI: 2.82–3.1)], low left ventricular ejection fraction [31.3% (95% CI: 29.2–33.3)], dilation of the heart chambers [EDVI — 131.7 mL/m<sup>2</sup> (95% CI: 113.1–150.2)]. Meta-analysis of the difference in mean values of ejection fraction in patients before and 1 year after surgery showed an increase of 10.1% (95% CI: 8.01–12.1,  $p < 0.001$ ). Meta-analysis of the difference in mean values of EDVI and NYHA functional class of heart failure in patients before and 1 year after surgery showed a decrease

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of 38.8 ml/m<sup>2</sup> (95% CI: 28.1–49.6,  $p < 0.001$ ) and 1.52 (95% CI: 1.3–1.8,  $p < 0.001$ ), respectively. *Conclusion.* The meta-analysis showed that one year after surgery, survival rates are 94%, with statistically significant increases in ejection fraction and decreases in functional class of heart failure according to the NYHA scale. The studies did not reveal significant differences in patient survival and clinical outcomes one year after operations performed using different surgical methods. The results indicate the effectiveness of left ventricular surgical reconstruction, providing prolonged improvement in patients' functional status. However, it should be noted that there was significant heterogeneity among the studies.

**Keywords:** postinfarction left ventricular aneurysm, surgical ventricular reconstruction; ventricular restoration; dor procedure; ventricular, endoventricular plasty, mid-term survival

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## Introduction

Left ventricular dysfunction caused by ischemic heart disease and myocardial infarction is the main cause of chronic heart failure worldwide [1–5]. One of the most severe complications of acute myocardial infarction is post-infarction left ventricular aneurysms [6, 7]. This condition significantly reduces the duration and quality of life for patients. The incidence of left ventricular aneurysm in patients after myocardial infarction ranges from 10 to 35% [8]. More than 95% of true left ventricular aneurysm cases are the result of transmural myocardial infarction caused by acute occlusion of the left anterior descending artery or the dominant right coronary artery.

Postinfarction disorders lead to scar transformation, thinning of the wall of the left ventricle and its

ischemic remodeling [9]. Subsequently, compensatory hypertrophy of the remaining cardiomyocytes occurs with a change in their spatial location, which is accompanied by a change in the normal geometry, volume and mass of the left ventricle. Echocardiography at an early stage of remodeling reveals a local violation of contractility (akinesis, dyskinesis) with thinning of the wall, dilation and spherification of the left ventricle [10]. These spatial and geometric changes lead to an increase in tension of the wall of the left ventricle, deterioration of microcirculation and further tonic dilation of its cavity. Deterioration of the systolic function of the left ventricle and its dilation cause the progression of heart failure.

Due to the insufficient effectiveness of conservative treatment methods, there is a need to search for and

develop new surgical approaches, as well as to evaluate long-term treatment outcomes and analyze their effectiveness [11–14]. Current guidelines recommend considering left ventricular aneurysmectomy during coronary artery bypass grafting for patients with NYHA functional class III–IV heart failure, large left ventricular aneurysms, high risk of thromboembolism, or ventricular arrhythmias. Surgical reconstruction of the left ventricle can be considered as an operation aimed at reducing the adverse effects of remodeling by excluding dyskinetic and scarred areas of the left ventricle, preventing further dilatation and restoring geometry [15–18].

The basic principles of surgical treatment of left ventricular aneurysms and their modifications were proposed by Cooley, Jatene and Dor more than half a century ago. In general, these methods can be divided into two categories: linear and geometric reconstruction. Currently, the Dor procedure and its modifications are widely used. The analysis of the results of studying the anatomical and physiological features of the heart in the case of post-infarction aneurysm, as well as the concepts of surgical treatment and methods of performing operations in leading medical institutions around the world, has allowed us to formulate the principles of optimal correction of all affected heart structures in patients with post-infarction left ventricular aneurysms.

In the process of reconstructing post-infarction left ventricular aneurysms, it is crucial to achieve an optimal balance between the benefits of reducing left ventricular wall stress due to volume reduction and the necessary cavity size that ensures adequate stroke volume [9]. At present, there are no reliable methods of predicting postoperative morphofunctional changes in the heart, which makes it difficult to calculate an adequate end-diastolic volume and ejection fraction. This causes certain difficulties in clinical practice, since prognostic assessment of these indicators before surgery is extremely important for determining the effectiveness of its performance, choosing further treatment strategies and evaluation of patients' condition in the long term. In addition, the results of studies aimed at comparing different methods of

surgical left ventricular repair are often ambiguous and even contradictory, which does not allow making unambiguous conclusions and complicates the choice of an effective treatment strategy. Unfortunately, the available data on the mid-term and long-term results of surgical treatment of such patients remain very limited. This creates certain difficulties in understanding how different treatment methods affect the survival and quality of life of patients.

The aim of the meta-analysis is to assess the one-year survival of patients after surgical reconstruction of the left ventricle, to determine the functional class of heart failure, and to study the morphological and functional characteristics of the heart. A comparative analysis of the results of the meta-analytic assessment of patient survival after left ventricle reconstruction using the DOR (SAVER) method will be performed in comparison with other treatment methods.

## Materials and methods

### Search for Publications and Selection of Studies

Information was searched for the period from January 1, 2000 to December 31, 2024 in electronic databases using the PubMed and Google Scholar platforms. The search algorithm was developed in strict accordance with the requirements set out in the PRISMA guidelines governing the preparation of reports for systematic reviews and meta-analyses [19]. It included research searches using search queries, keywords (including MeSH), and logical operators. The search queries and data selection were conducted only in English. In order to maximize the sensitivity of the search and obtain the most complete results, various terms and keywords related to the topic under study were combined. Keywords in the research in the PubMed database: (Surgical ventricular reconstruction) OR (Surgical ventricular restoration) OR (Dor procedure) OR (ventricular aneurysmectomy) OR (Ventriculoplasty) OR (Ventricular aneurysm repair) OR (endoventricular plasty) OR (ventricular endocardial restoration) OR (endocardial patch) OR (ventricular infarct

exclusion) AND ((medium-term results) OR (long-term results))).

The following word combinations were searched in the Google Scholar database: Surgical ventricular reconstruction, surgical ventricular restoration, Dor procedure, ventricular aneurysmectomy, ventriculoplasty, ventricular aneurysm repair, endoventricular plasty, ventricular endocardial restoration, endocardial patch, ventricular infarct exclusion.

### **Inclusion/exclusion criteria**

This meta-analysis analyzed only full-text studies of adult patients who underwent left ventricular reconstruction for ischemic cardiomyopathy. It should be emphasized that all included studies had to have a follow-up duration of at least one year after surgery. This condition made it possible to obtain more accurate and reliable data on the results of surgery and on the patients' condition in the mid-term period. All methods of surgical reconstruction of the left ventricle were included in the meta-analysis, which makes it more comprehensive, covering a wide range of approaches used in cardiac surgery.

In addition, a detailed subanalysis of patients after surgical reconstruction of the left ventricular using the Dor procedure or surgical anterior ventricular endocardial restoration (SAVER) was performed. These types of surgical operations have common principles with minimal differences and are often considered equivalent in the literature [9]. Studies in which left ventricular reconstruction was not performed, as well as patients with non-ischemic cardiomyopathy, were excluded. In addition, the analysis did not include publications in which the duration of follow-up of patients after left ventricular reconstruction was less than one year. This decision is due to the fact that the limited follow-up period will not allow for a full assessment of the results of the operation and the potential risks of complications in the medium term.

The meta-analysis included publications describing the preoperative period (stage I), the short-term postoperative period (stage II), and one year after surgery (stage III). In order to objectively evaluate the effectiveness of different surgical

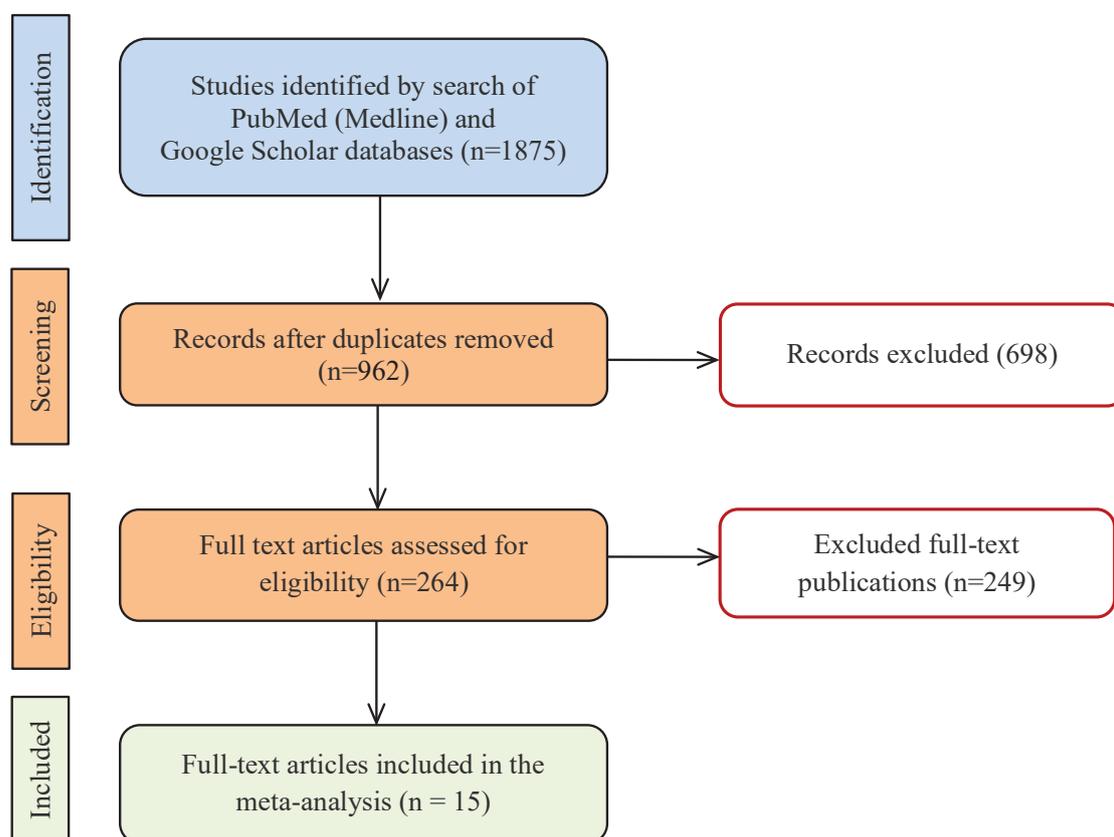
approaches, two groups were distinguished: group 1 patients underwent only surgical reconstruction of the left ventricular using the Dor procedure or surgical anterior ventricular endocardial restoration (SAVER); Group 2 patients underwent various surgical ventricular reconstruction methods, depending on surgical expediency (Table 1). In the second group, surgeons chose the method of surgical reconstruction based on their own preferences and the clinical situation. Publications of clinical cases, abstracts, conference presentations, editorials, reviews, and expert opinions were also excluded, as these materials do not contain sufficient systematic data necessary for conducting a meta-analysis.

### **Extraction and synthesis of study data**

As a result of a systematic search in two specialized databases, a total of 1875 articles dedicated to surgical reconstruction of the left ventricle in patients with ischemic cardiomyopathy were identified. This list included both prospective and retrospective studies on the subject. After careful analysis and exclusion of duplicate materials that could affect data objectivity, a final total of 962 publications remained. A detailed selection process was then conducted, during which the titles and abstracts of each article were assessed. This allowed for the exclusion of 698 articles that did not meet the pre-established criteria.

Thus, a total of 264 articles were included in the final list, which underwent full-text analysis. Out of these, only 15 studies met all the necessary inclusion criteria. The total number of patients involved in these studies amounted to 1089. The PRISMA diagram (Figure 1) clearly illustrates the search, filtering, and selection strategy of the articles, which is crucial for understanding the methodology of this meta-analysis.

The validity and methodological quality of the selected non-randomized studies were assessed using the Newcastle-Ottawa Scale (NOS), which is recommended by the Cochrane Collaboration. The average score on the NOS for the included studies was 6.5. Table 1 provides detailed information regarding the design of individual studies as well as the baseline characteristics of the patients.



**Fig. 1.** PRISMA schematic diagram of the search strategy.

Note: PRISMA – Preferred Reporting Items for Systematic Reviews and MetaAnalysis.

**Table 1**

**Overview of the studies included in the systematic review**

Author, year of publication	Number of patients	Study type	Average age, years (M ± SD)	Study period	Surgical techniques
Donato et al., 2001a [20]	207	Retro-spectively	58 ± 6	January 1991 – December 1996	Surgical reconstruction of the left ventricle by the Dor procedure
Donato et al. (1), 2001b [21]	44	Retro-spectively	58 ± 6	June 1997 – August 1998	Surgical reconstruction of the left ventricle by the Dor procedure
Fujii et al., 2004 [22]	14	Pro-spectively	67 ± 10	-	Endoventricular circular patch plasty (Dor procedure)
Kokaji et al., 2004 [23]	30	Pro-spectively	61 ± 11	1996–2003	Endoventricular circular patch plasty (Dor procedure)
Lee et al., 2007 [24]	49	Pro-spectively	59.7 ± 9.88	2001–2006	Surgical ventricular reconstruction by means of the Dor procedure or surgical anterior ventricular endomyocardial restoration (SAVER)
Bove et al., 2009 [25]	23	Pro-spectively, retro-spectively	68 ± 8	2005–2008	Endoventricular circular patch plasty (Dor procedure)

Table 1 Continued

Author, year of publication	Number of patients	Study type	Average age, years (M ± SD)	Study period	Surgical techniques
Tekumit et al., 2010 [8]	67	Retro-spectively	64.8 ± 8.9	February 2001 – June 2009	Surgical reconstruction of the left ventricle by the Dor procedure
Pocar et al., 2010 [15]	31	Retro-spectively	65.2 ± 7.6	January 2000 – December 2007	Endoventriculoplasty; modified Dor procedure; linear repair techniques
Skelley et al., 2011 [16]	87	Retro-spectively	61 ± 10	January 2002 – April 2008	Endoventriculo-plasty
Marchenko et al., 2011 [17]	116	Retro-spectively	-	2005–2008	Autoventriculoplasty (septalplasty of LV and IVS, modified Stoney technique); endoventriculoplasty with a synthetic patch (Dor–Cooley–Matas technique)
Cho et al., 2012 [14]	60	Retro-spectively	65 ± 8	September 2002 – September 2010	Dor procedure; linear closure; septal anterior ventricular exclusion (SAVE)
Hwang et al., 2014 [12]	63	Retro-spectively	62.7 ± 9	1999–2005	Surgical anterior ventricular endocardial restoration (SAVER)
Kato et al., 2015 [13]	15	Retro-spectively	63.2 ± 9.5	2004–2012	Septal anterior ventricular exclusion (SAVE); overlapping procedure; linear closure
Chen et al., 2022 [18]	78	Retro-spectively	55.3 ± 11.4	From January 1999 – March 2021	Linear ventriculoplasty, endocardial patch reconstruction (Dor procedure); modified left ventricular reconstruction
Solowjowa et al., 2022 [27]	205	Retro-spectively	63.4 ± 11.2	November 2005 – January 2016	Modified Dor procedure

### Methods of left ventricular surgical reconstruction presented in the meta-analysis

In the publications of Donato, M. et al. (2001a, b) analyzes surgical reconstruction of the left ventricle by the Dor procedure in patients with anterior transmural myocardial infarction [20, 21]. Coronary artery bypass grafting was performed simultaneously with the reconstruction of the left ventricle. Both publications are included in the meta-analysis, because the retrospective analysis collected information about patients who underwent surgery at different time periods, and the patient groups did not overlap. This ensures the independence of the results and allows for a more accurate interpretation of the data obtained.

In the Fujii H. study and co-authors (2004), the author discusses the use of endoventricular circular patch plasty, performed according to the Dor procedure [22]. The technique described in the publication Kokaji K. et

al. (2004), is largely similar to the approaches proposed earlier by Dor V. [23].

In a clinical study conducted by Lee S. et al. (2007), patients underwent surgery for left ventricular surgical reconstruction using the Dor procedure or surgical anterior ventricular endomyocardial restoration (SAVER) [24]. At the same time, 45 patients underwent concomitant coronary artery bypass grafting. Ventricular and mitral valve function was assessed using transesophageal echocardiography.

In the publication by Bove T. and co-authors. (2009) the authors reported that the reconstruction was performed using endoventricular patch plasty as described by Dor et al. An intraventricular balloon was used to give the left ventricle an elliptical shape and control the volume of the left ventricle [25].

In 2010, Tekumit H. et al. performed surgery to remove a left ventricular aneurysm using the

Dor procedure [8]. In cases where coronary artery bypass surgery was performed, grafts taken from the left internal thoracic artery and/or saphenous vein were used to restore blood flow. In addition, mitral annuloplasty was performed in patients diagnosed with grade III or IV mitral regurgitation. None of the patients required the implantation of a permanent pacemaker.

In a study conducted by Pocar M. and co-authors. (2010), the author discusses various approaches to surgical reconstruction of the left ventricle of the heart [15]. Several methods were used, among which were: implantation of an oval bovine pericardial or Dacron patch; modified Dor procedure with no internal patch; linear closure when the residual area was small. One of the features of this study was the use of longitudinal septal plication with interrupted sutures. This method was used in 10 cases, of which 8 additionally used an intracavitary patch, and in 2 cases not. The Guilmet overcoat technique was used to close the ventricular septal defect in two patients. Bypass surgery of the left anterior descending artery was performed in 26 patients (84%).

According to a publication by Skelley N.W. et al. (2011), before the reconstruction of the left ventricle, coronary artery bypass grafting was performed [16]. Depending on the condition of the heart valve apparatus, annuloplasty or mitral valve replacement was performed during the operation. Surgical reconstruction of the left ventricle was performed through ventriculotomy, which was performed in the distal part of the anterior wall. After the thrombus was removed, the left ventricle was carefully examined for scar tissue. In most patients, an intraventricular balloon was inserted into the left ventricle, which allowed the chamber size to be controlled and provided optimal conditions for further reconstruction. At the next stage, a purse-string suture was placed around the edge of the intraventricular balloon. In cases where ventricular defects exceeded 2–3 cm, Dacron polyester patch was used to close them. Otherwise, for smaller defects, linear closure was used.

In the study of Marchenko A. and co-authors. (2011), the author performed surgical reconstruction of the left ventricle using autoventriculoplasty in 49% of cases [17]. It was septaloplasty of the left

ventricle and the interventricular septum using the modified Stoney technique. In 51% of cases, endoventriculoplasty with a synthetic patch was performed using the Dor–Cooley–Matas method. Surgical correction of the mitral valve was performed in 34 patients with grade 3–4 mitral regurgitation. At the same time, annuloplasty with rigid ring was preferred in 60% of cases. Suture annuloplasty or annuloplasty with xenopericardium band was performed in 28% of patients, and mitral valve replacement was performed in 12% of patients.

Cho Y. and co-authors. (2012) compared different surgical methods of left ventricular reconstruction. In most cases, surgical reconstruction of the left ventricle using the Dor procedure was performed (40 patients) [14]. Septal anterior ventricular exclusion (SAVE) was applied to 8 patients with ischemic cardiomyopathy and severe scarring who underwent repeated anterior-septal infarction using a large xenogenic patch measuring 8 × 4 cm. Linear left ventricular plasty was performed in 12 patients. During the operations, an intraventricular balloon inflated to the estimated diastolic volume of the left ventricle was used to avoid excessive volume reduction.

Hwang H.Y. et al. (2014) analyzed the results of surgical anterior ventricular endocardial restoration (SAVER) [12]. The left ventricle opened parallel to the left anterior descending coronary artery. An endoventricular circular pursestring suture was placed circumferentially in the transitional zone between the normal and diseased myocardium. An intraventricular balloon was used during the operation. Coronary revascularization was performed after the SAVER operation. Most revascularizations were performed under an on-pump beating heart. Mitral annuloplasty was performed in patients in whom preoperative echocardiography revealed moderate or greater mitral regurgitation. One patient underwent mitral valve replacement.

According to some authors Kato Y. et al. (2015), the choice of the most optimal cardiac surgical methods of ventriculoplasty surgery is significantly determined by the localization of the postinfarction scar [13]. In patients with anterior septal infarction, the septal anterior ventricular exclusion (SAVE) or overlapping procedure

was used, and in patients with posterior infarction, linear closure was used.

In later studies, Chen L. and co-authors. (2022) raised questions about the main approaches to surgical reconstruction of the left ventricle, which are applied depending on the characteristics of the aneurysm and the preferences of surgeons [18]. These methods include Cooley linear ventriculoplasty, endocardial patch reconstruction (Dor procedure), and modified left ventricular reconstruction. Modified reconstruction of the left ventricle described by Zheng Z. et al. [26], includes several key stages. First of all, the surgeon applies an endoventricular pursestring suture using a linear suture in the area of scar tissue. The suture is then tightened to form an opening of about 2 cm in diameter, thus reducing the volume of the ventricle and maintaining its satisfactory geometry. The operation is completed by analogy with standard linear ventriculoplasty, which implies further closure of the ventricle and restoration of its normal structure.

Solowjowa et al. (2022), analyzed the results of left ventricular reconstruction surgery using a modified Dor procedure with multiple Fontan sutures around the perimeter of the aneurysm without the use of a patch in combination with coronary artery bypass grafting [27]. In 12.2% of patients with specific local findings, for example, a defect in the interventricular septum after extensive anterolateral myocardial infarction, a patch was required to close the defect. Mitral valve surgery was performed in patients with echocardiographically confirmed mitral regurgitation  $\geq$  grade 2.

### Statistical analysis

Statistical data processing was carried out using the OpenMeta software (Beta 1.0 version, 2015). The baseline characteristics of patients and clinical outcomes are presented as mean values with 95% confidence intervals (CI). Continuous data were combined using meta-analysis with a random effects model. The heterogeneity of the data was assessed using Cochran's Q test and the  $I^2$  test. Survival data 1 year after surgery, collected from each study, were pooled to obtain a weighted average and a 95% confidence interval.

## Results

### General characteristics of patients

The mean age of the examined patients was 62.1 years (95% CI: 60.2–64.1). The heterogeneity indicators are presented in Table S1. The study included 56% (95% CI: 42–69) men. Angina pectoris occurred in 79% (95% CI: 68–90) of the patients. The time from the onset of myocardial infarction to the surgical reconstruction of the left ventricle was 6.3 years (95% CI: 2.9–9.7). An anterior localization aneurysm was found in 87% (95% CI: 74–99) of patients. At the same time, a thrombus in the ventricle was detected preoperatively in 27% (95% CI: 19–35) of cases. The mean EuroSCORE was 9.7% (95% CI: 7.3–12.1).

The most commonly associated diseases in patients in the meta-analysis are diabetes mellitus [36.7% (95% CI: 31.1–42.3)], atrial fibrillation [10.7% (95% CI: 4.5–16.9)], ventricular extrasystole [23.1% (95% CI: 14–32.2)], stroke or transient ischemic attack [10.4% (95% CI: 8.7–12.2)], and impaired kidney function [13.7% (95% CI: 9.8–17.5)].

### Preoperative characteristics

In most cases, before surgery, patients had a high functional class of heart failure according to NYHA [3 functional class (95% CI: 2.82–3.1)], which is caused by morpho-functional disorders of the heart. Such patients have low left ventricular ejection fraction [31.3% (95% CI: 29.2–33.3)], dilated heart cavities [EDVI — 131.7 mL/m<sup>2</sup> (95% CI: 113.1–150.2); ESVI — 91.8 mL/m<sup>2</sup> (95% CI: 79.6–104.1)], increased pulmonary capillary wedge pressure [15.4 mmHg (95% CI: 13.4–17.5)]. Despite severe impairments, relatively satisfactory cardiac index values were maintained in patients [2.7 L/min/m<sup>2</sup> (95% CI: 2.4–2.9)] and the stroke volume index [45.5 mL/m<sup>2</sup> (95% CI: 30.9–60.1)]. The average degree of mitral regurgitation was at the level of 1.72 (95% CI: 1.4–2.04).

### Operative characteristics

The duration of cardiopulmonary bypass was 144.8 minutes (95% CI: 118–171.6), and the aortic cross-clamping time was 82.7 minutes (95% CI: 72.2–93.3). In 88.7% (95%

CI: 81.5–95.9) of cases, coronary artery bypass grafting was performed simultaneously with left ventricle reconstruction. The average number of grafts during coronary artery bypass grafting was 2.5 (95% CI: 2.2–2.8). Additionally, mitral valve surgery was required in 20.1% (95% CI: 14.3–25.8) of cases. An intra-aortic balloon pump was used in 25.5% (95% CI: 17–34) of cases.

### Postoperative results

After surgical reconstruction of the left ventricle, the patient demonstrated a significant reduction in volumetric parameters [EDVI — 81.71 ml/m<sup>2</sup> (95% CI: 70.5–92.9); ESVI — 50.7 ml/m<sup>2</sup> (95% CI: 44.5–56.9)], which was maintained during the first year after the operation [EDVI — 85.96 ml/m<sup>2</sup> (95% CI: 72.9–99.07); ESVI — 52.1 ml/m<sup>2</sup> (95% CI: 45.7–58.5)]. After the surgical intervention, the cardiac index was 2.8 L/min/m<sup>2</sup> (95% CI: 2.48–3.18), and the stroke index was 38.9 mL/m<sup>2</sup> (95% CI: 24.4–53.6). The left ventricular ejection fraction after geometric reconstruction in the early postoperative period reached 40%, and one year after the operation — 41%. The pulmonary capillary wedge pressure and mitral regurgitation after the operation were 11.5 mmHg (95% CI: 8.9–13.9) and 0.7 grade (95% CI: 0.22–1.16), respectively, and one year after the operation, these indicators reached 12.97 mmHg (95% CI: 8.64–17.3) and 1.14 grade (95%

CI: 0.85–1.44). The NYHA functional class after surgery was 1.58 (95% CI: 1.4–1.7), and one year after the operation it was 1.57 (95% CI: 1.3–1.83).

### Dynamics of the left ventricle end-diastolic volume index

The study included 11 publications with a total of 759 patients. A meta-analysis was performed on the difference in mean values of EDVI in patients before and after surgery. As shown in forest plot (Figure 2), after surgery, the final value of this indicator statistically significantly ( $p < 0.001$ ) decreased by 46.8 ml/m<sup>2</sup> (95% CI: 35–58.5). We adopted the random-effects model because heterogeneity was significant ( $\text{Tau}^2 = 293.9$ ;  $Q(\text{df} - 10) = 97.7$ ;  $p < 0.001$ ;  $I^2 = 90.8$ ). According to the data presented in forest plot (Figure 3), before surgery and one year after it, the value of EDVI decreased by 38.8 ml/m<sup>2</sup> (95% CI: 28.1–49.6,  $p < 0.001$ ) with significant heterogeneity ( $\text{Tau}^2 = 198.8$ ;  $Q(\text{df} - 10) = 53.01$ ;  $p < 0.001$ ;  $I^2 = 84.9$ ). In the course of the meta-analytic assessment conducted to determine changes in EDVI, no statistically significant changes were identified a year after surgery compared to the early postoperative period ( $\text{MD} = -5$ ; 95% CI = -12.9–2.9;  $p = 0.21$ ). Heterogeneity was significant ( $\text{Tau}^2 = 85.4$ ;  $Q(\text{df} - 9) = 31.9$ ;  $p < 0.001$ ;  $I^2 = 78.0$ ).

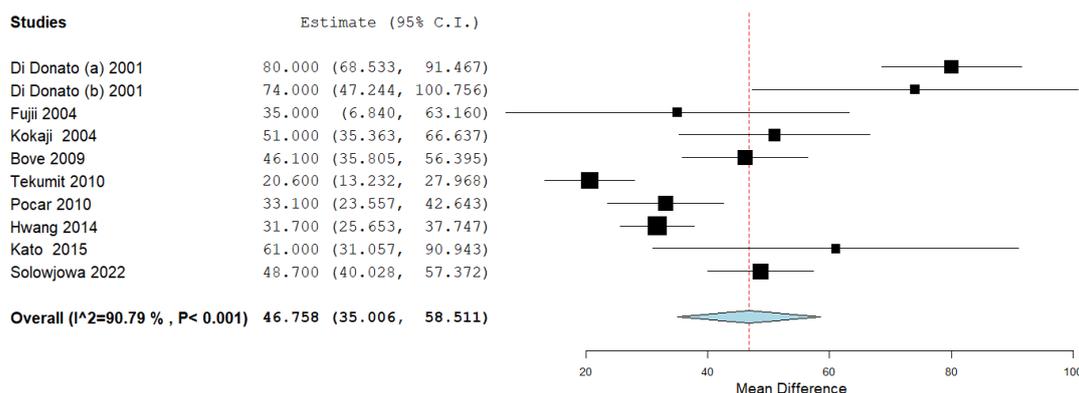


Fig. 2. Forest plot for the meta-analysis of EDVI before and after surgery

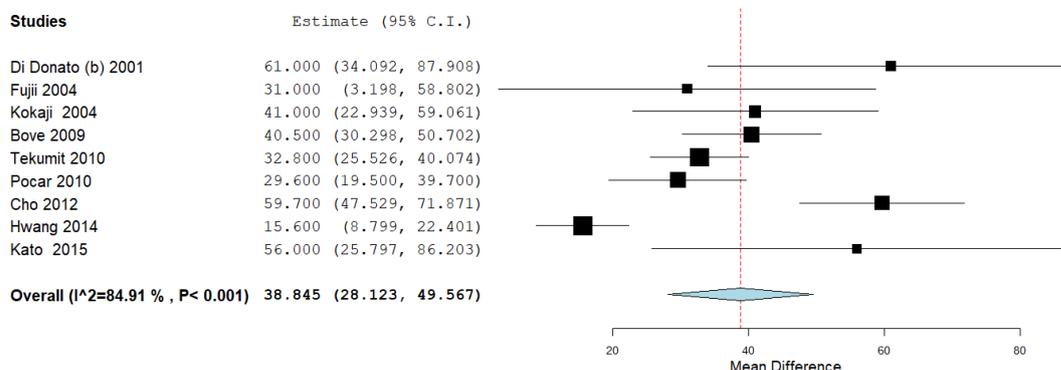


Fig. 3. Forest plot for the meta-analysis of EDVI before and one year after surgery

### Dynamics of the left ventricle end-systolic volume index

In the study, a meta-analysis of 10 publications was conducted, which included 434 patients. A meta-analysis of the difference in mean values of ESVI in patients was performed before and after surgery. According to the data presented in forest plot (Figure 4), after surgery, the final value of this indicator decreased by 39.4 ml/m<sup>2</sup> (95% CI: 29.6–49.2, p < 0.001) with significant heterogeneity (Tau<sup>2</sup> = 223.4; Q(df – 9) = 87.6; p < 0.001; I<sup>2</sup> = 88.6). The data displayed in forest plot (Figure 5) indicate a reduction in ESVI before

surgery and one year after the surgical intervention by 35.15 ml/m<sup>2</sup> (95% CI: 27.4–42.6, p < 0.001), though substantial heterogeneity was observed among the studies (Tau<sup>2</sup> = 105.2; Q(df – 9) = 38.8; p < 0.001; I<sup>2</sup> = 76.8). The results of the meta-analysis did not reveal significant differences in the end-systolic volume index between the measurements recorded one year after the surgical intervention and those in the early postoperative period (MD = –0.95; 95% CI: –4.6–2.74, p = 0.62). The studies showed moderate heterogeneity (Tau<sup>2</sup> = 12.75; Q(df – 9) = 15.7; p = 0.05; I<sup>2</sup> = 49.2).

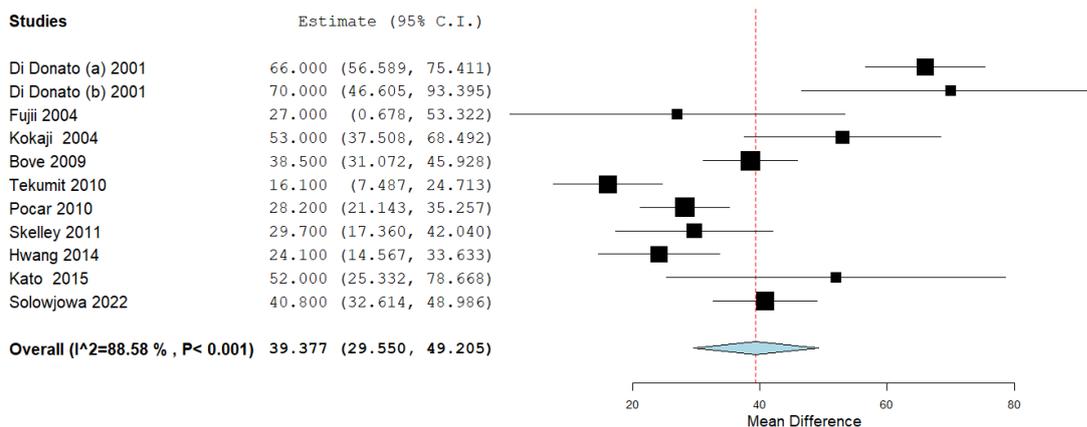


Fig. 4. Forest plot for the meta-analysis of ESVI before and after surgery

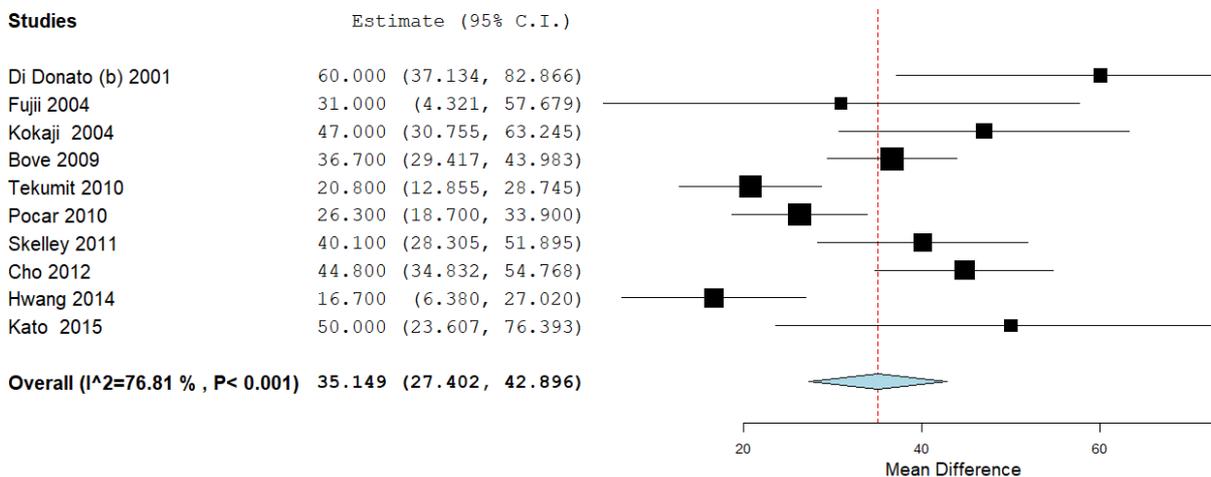


Fig. 5. Forest plot for the meta-analysis of ESVI before and 1 year after surgery

### Dynamics of left ventricular ejection fraction

In the study, 11 publications were analyzed, involving 657 patients. As shown in forest plot (Figure 6), after the surgery, the final value of EF significantly increased ( $p < 0.001$ ) by 9% (95% CI: 6.6–11.4). Adopting the random-effects model, the heterogeneity between the studies was significant ( $Tau^2=13.8$ ;  $Q(df - 10) = 67.3$ ;  $p < 0.001$ ;  $I^2 = 83.7$ ). Forest plot (Figure 7) presents data indicating that one year after the operation, EF increases by 10.1% (95%

CI: 8.01–12.1,  $p < 0.001$ ) compared to preoperative levels. Heterogeneity was significant ( $Tau^2 = 6.7$ ;  $Q(df-10) = 29.5$ ;  $p < 0.001$ ;  $I^2 = 69.5$ ). Through the meta-analysis of EF, we studied the treatment outcomes after surgery and one year post-operation. No statistically significant differences in EF were obtained ( $MD = -2.41$ ; 95% CI:  $-4.9-0.072$ ,  $p = 0.057$ ). Significant heterogeneity was observed between the studied stages ( $Tau^2 = 7.39$ ;  $Q(df - 11) = 19.6$ ;  $p = 0.007$ ;  $I^2 = 64.2$ ).

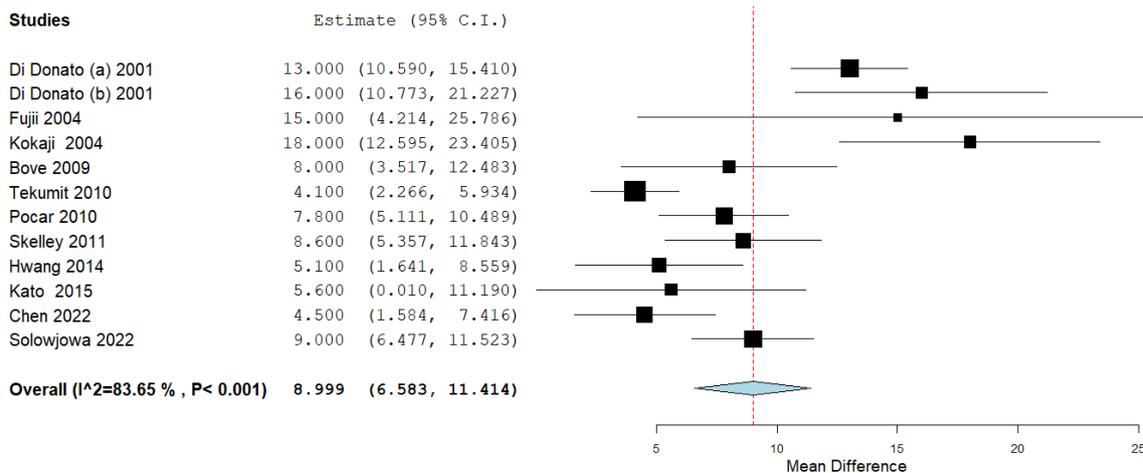


Fig. 6. Forest plot for the meta-analysis of EF before and after surgery

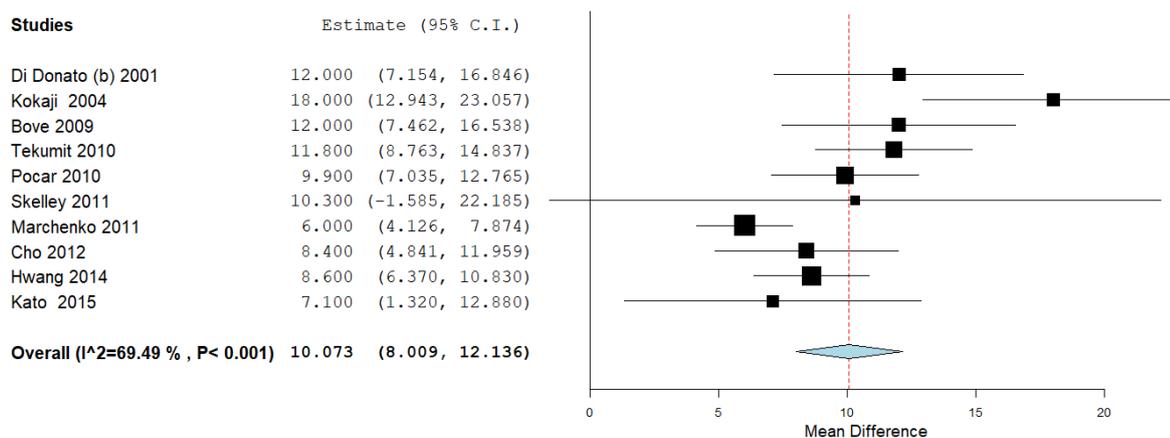


Fig. 7. Forest plot for the meta-analysis of EF before and one year after surgery

### Dynamics of pulmonary capillary wedge pressure (PCWP)

In this study, 4 publications were analyzed, which described the results of examinations of a total of 348 patients. The main focus was on the change in the PCWP indicator before and after surgical intervention. For a deeper analysis, a meta-analytic assessment of the differences in mean PCWP values in patients before and after the operation was conducted. The results presented in forest plot (Figure 8) demonstrate a statistically

significant ( $p = 0.001$ ) overall reduction of this indicator in the early period after surgery by 4 mmHg (95% CI: 1.6–6.3), with significant heterogeneity observed ( $Tau^2=3.6$ ;  $Q(df - 3) = 8.13$ ;  $p=0.043$ ;  $I^2 = 63.1$ ). The meta-analytic assessment did not reveal significant changes in PCWP one year after the operation compared to preoperative levels (MD = 3.4 mmHg; 95% CI: -0.74–7.5,  $p = 0.107$ ). Significant heterogeneity was noted among the studied parameters ( $Tau^2 = 9.32$ ;  $Q(df-2) = 6.6$ ;  $p = 0.037$ ;  $I^2 = 69.7$ ).

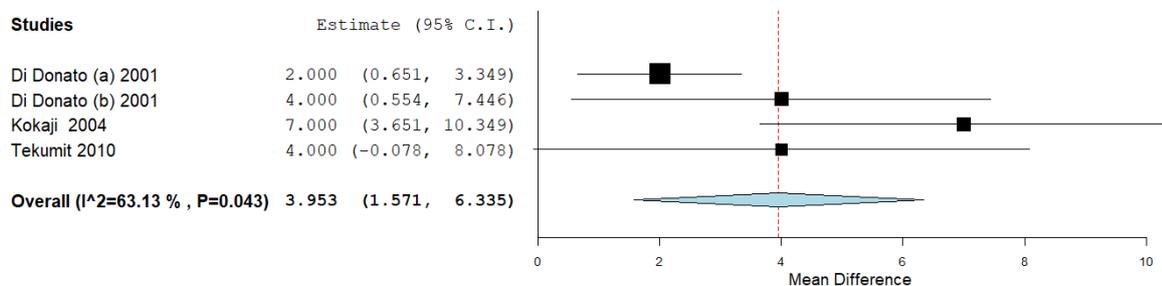


Fig. 8. Forest plot for the meta-analysis of PCWP before and after surgery

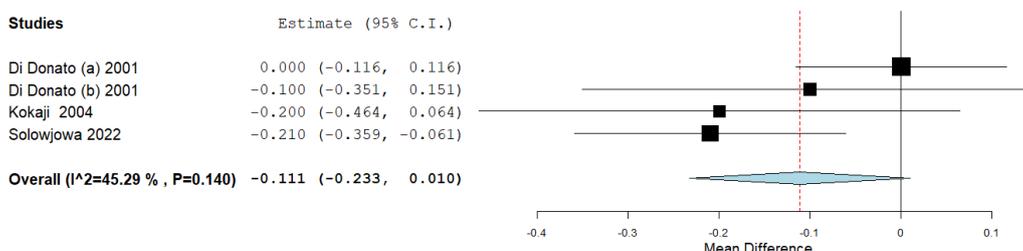
### Dynamics of changes in cardiac index and stroke volume index

In this study, a meta-analysis of four scientific publications was conducted, which described the results of examinations of a total of 486 patients. A meta-analysis of the difference in mean cardiac index (CI) values in patients before and after the

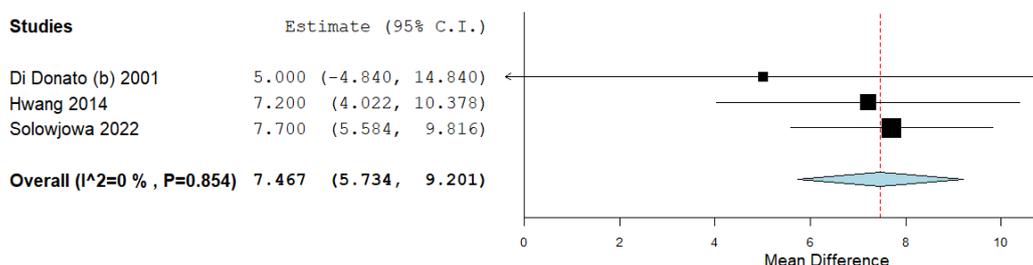
operation was performed (Figure 9). During the meta-analytic assessment aimed at identifying changes in cardiac index, no significant changes were found postoperatively compared to the preoperative period (MD = -0.11; 95% CI: -0.23–0.01,  $p = 0.07$ ). The heterogeneity observed was moderate ( $Tau^2 = 0.007$ ;  $Q(df - 3) = 5.5$ ;  $p = 0.14$ ;  $I^2 = 45.3$ ).

A meta-analysis of stroke volume index (SVI) based on three scientific publications, including 312 patients (Figure 10), revealed a reduction in this indicator in

the early postoperative period by 7.47 mL/m<sup>2</sup> (95% CI: 5.7–9.2,  $p < 0.001$ ) with insignificant heterogeneity ( $\text{Tau}^2 = 0$ ;  $Q(\text{df} - 2) = 0.315$ ;  $p = 0.854$ ;  $I^2 = 7.47$ ).



**Fig. 9.** Forest plot for the meta-analysis of cardiac index before and after surgery

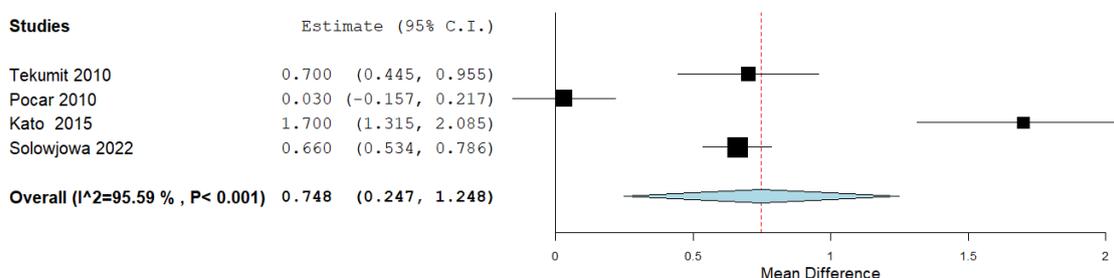


**Fig. 10.** Forest plot for the meta-analysis of stroke volume index before and after surgery

### Dynamics of Mitral Regurgitation

The study included 4 publications, with a total of 318 patients. A meta-analysis was performed to assess the difference in mean MR values in patients before and after surgery. As indicated by the forest plot (Figure 11), after the surgery, the overall value of this parameter decreases by 0.75 grade (95% CI: 0.25–1.25,  $p = 0.003$ ). There was great heterogeneity between studies ( $\text{Tau}^2 = 0.244$ ;  $Q(\text{df} - 3) = 68$ ;  $p < 0.001$ ;  $I^2 = 95.6$ ), so we pooled the data under the random-effects model. According

to the data presented in the forest plot (Figure 12), one year after surgery, there was a reduction in MR by 0.62 grade (95% CI: 0.2–1.04,  $p = 0.004$ ) with significant heterogeneity ( $\text{Tau}^2 = 0.25$ ;  $Q(\text{df} - 5) = 81.5$ ;  $p < 0.001$ ;  $I^2 = 93.8$ ). Additionally, one year after surgery, an increase in MR by 0.2 grade (95% CI: 0.05–0.33,  $p = 0.009$ ) was observed compared to the early postoperative period, with no heterogeneity observed among the studies ( $\text{Tau}^2 = 0$ ;  $Q(\text{df} - 2) = 0.043$ ;  $p = 0.98$ ;  $I^2 = 0$ ).



**Fig. 11.** Forest plot for the meta-analysis of mitral regurgitation before and after surgery

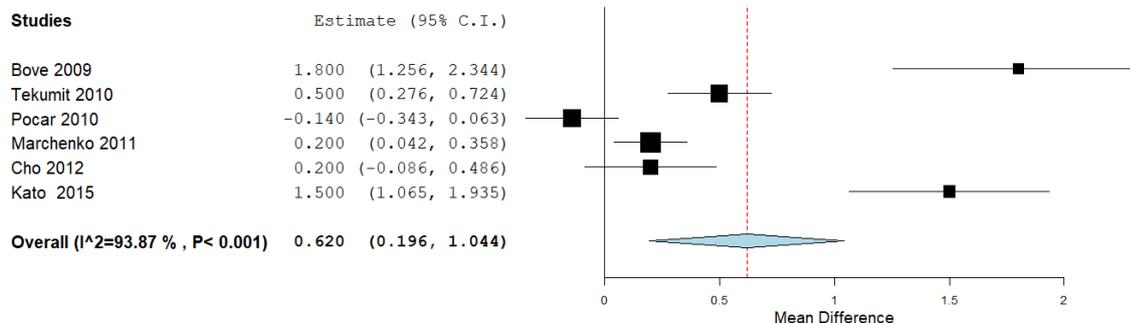


Fig. 12. Forest plot for the meta-analysis of mitral regurgitation before and one year after surgery

### Dynamics of NYHA Functional Class in Heart Failure

This study analyzed data from 325 patients presented in four publications. Meta-analysis allowed for the assessment of the difference in mean NYHA functional class values before and after surgery. According to the results shown in forest plot (Figure 13), after the operation, the overall value of this parameter significantly decreases by 1.5 (95% CI: 1.28–1.72,  $p < 0.001$ ). Heterogeneity was significant ( $\text{Tau}^2 = 0.03$ ;

$Q(\text{df} - 3) = 9.73$ ;  $p = 0.021$ ;  $I^2 = 69.1$ ). The obtained results confirm the effectiveness of surgical intervention, which contributes to the improvement of patients' functional state. According to the data presented in the forest plot (Figure 14), there was a reduction in NYHA by 1.52 (95% CI: 1.3–1.8,  $p < 0.001$ ) before surgery and one year after it, with significant heterogeneity ( $\text{Tau}^2 = 0.08$ ;  $Q(\text{df} - 5) = 35.35$ ;  $p < 0.001$ ;  $I^2 = 85.8$ ). This indicates an improvement in patients' condition that persists for a long time after surgery.

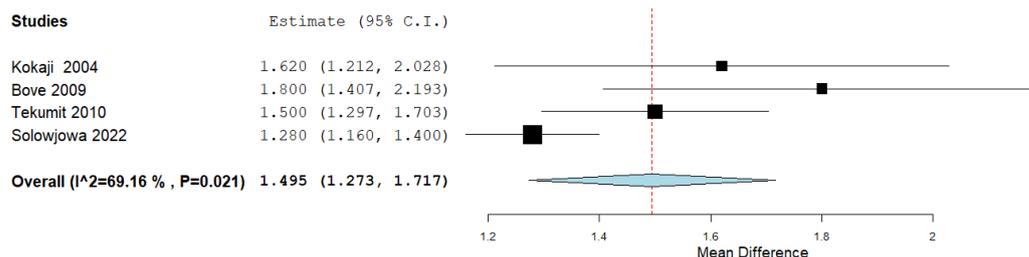


Fig. 13. Forest plot for the meta-analysis of NYHA functional class before and after surgery

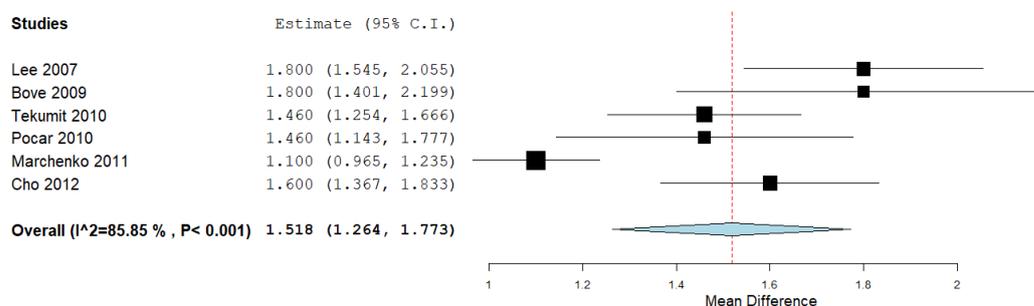


Fig. 14. Forest plot for the meta-analysis of NYHA functional class before and one year after surgery

### Postoperative mortality and one-year survival after surgical left ventricular reconstruction

The meta-analytic assessment conducted to study postoperative mortality includes 11 different publications, analyzing a total of 951 patients. According to the data presented in the forest plot (Figure 15),

the level of postoperative mortality was 5.4% (95% CI: 3.8–7.1). There was great heterogeneity between studies ( $Tau^2 = 8.6$ ;  $Q(df - 10) = 1998.6$ ;  $p < 0.001$ ;  $I^2 = 99.5$ ), so we pooled the data under the random-effects model.

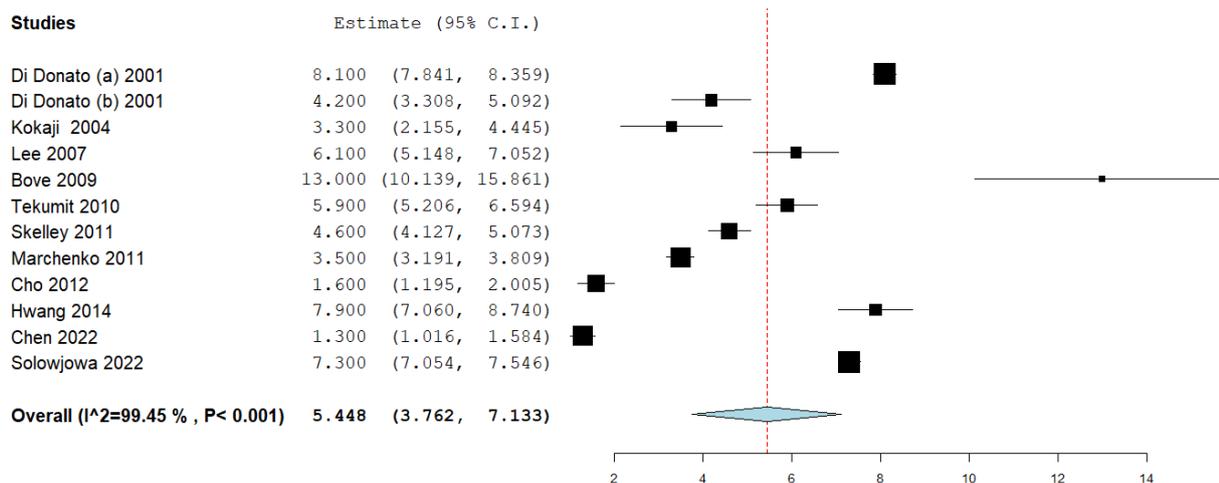


Fig. 15. Forest plot for the meta-analysis of postoperative mortality

The study of patient survival after surgical left ventricular reconstruction has provided fundamentally important information about the mid-term outcomes of this procedure (Figure 16). This research analyzed eight scientific articles involving 788 patients who

underwent the surgery. The results indicated that one year after the surgical intervention, the survival rate was 94% (95% CI: 90–98), with significant heterogeneity ( $Tau^2 = 0.003$ ;  $Q(df-7) = 6023.9$ ;  $p < 0.001$ ;  $I^2 = 99.8$ ).

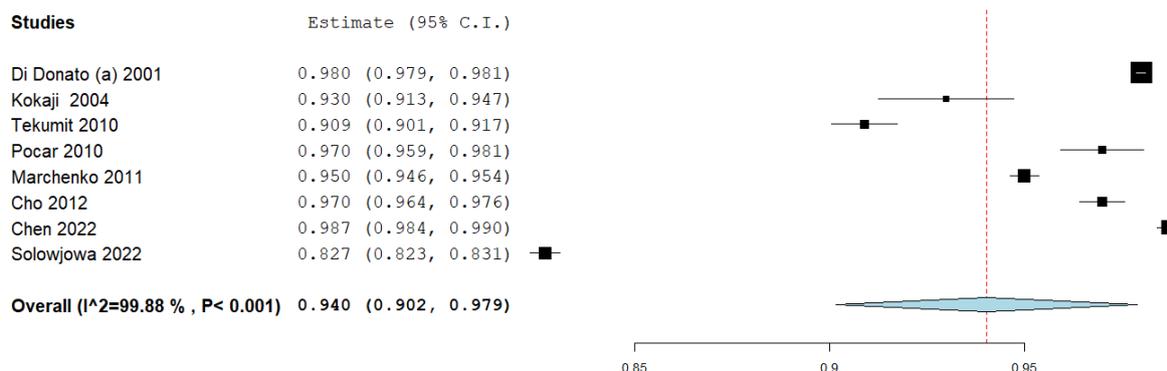


Fig. 16. Forest plot for the meta-analysis of patient survival one year after left ventricular reconstruction surgery

Subanalysis of patients after surgical reconstruction of the left ventricle using the Dor (or surgical anterior ventricular endocardial restoration) technique

Surgical reconstruction of the left ventricle using the Dor technique is one of the most frequently performed operations in patients with complicated forms of coronary heart disease. It should be noted that the surgical anterior ventricular endocardial restoration (SAVER) surgery technique described in the literature has minimal differences from the Dor operation, and in the English literature it is often considered as an analog of the Dor procedure [9]. Therefore, in the meta-analysis, these types of surgical ventricular reconstruction were considered in one group. The subanalysis of patients who underwent surgical reconstruction of the left ventricle is an important stage

in assessing the medium-term results of this surgical procedure. A meta-analytical study conducted a detailed assessment of a sample of patients who underwent surgical ventricular reconstruction. During the study, two groups were identified: group 1 patients underwent only surgical reconstruction of the left ventricular using the Dor procedure or surgical anterior ventricular endocardial restoration (SAVER); Group 2 patients underwent various surgical ventricular reconstruction methods, depending on surgical expediency (Table 1).

The main purpose of the subanalysis was to assess the survival rate of patients who underwent surgical reconstruction of the left ventricular using the Dor procedure or SAVER, compared with patients who underwent various surgical ventricular reconstruction methods, depending on surgical expediency.

Studies	Estimate (95% C.I.)
Di Donato (a)	0.980 (0.979, 0.981)
Kokaji	0.930 (0.913, 0.947)
Tekumit	0.909 (0.901, 0.917)
<b>Subgroup 1 (I<sup>2</sup>=99.34 % , P=0.000)</b>	<b>0.940 (0.886, 0.994)</b>
Pocar	0.970 (0.959, 0.981)
Marchenko	0.950 (0.946, 0.954)
Cho	0.970 (0.964, 0.976)
Chen	0.987 (0.984, 0.990)
Solowjowa	0.827 (0.823, 0.831)
<b>Subgroup 2 (I<sup>2</sup>=99.91 % , P=0.000)</b>	<b>0.941 (0.876, 1.005)</b>
<b>Overall (I<sup>2</sup>=99.88 % , P=0.000)</b>	<b>0.940 (0.902, 0.979)</b>

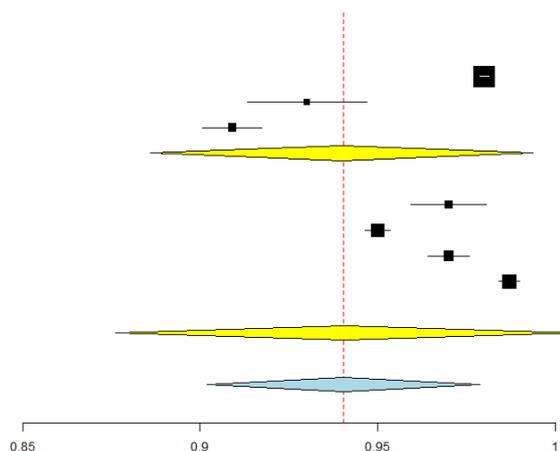


Fig. 17. Meta-regression analysis of patient survival in groups 1 and 2 one year after surgical reconstruction

The subanalysis was performed on the basis of 8 publications with a total of 497 patients. The results of the studies did not reveal a statistically significant difference between the groups by age, preoperative EDVI, ESVI, EF, and NYHA class of heart failure. In group 1, the degree of mitral regurgitation was 0.8 grade higher (95% CI: 0.28–1.25) compared to group 2 (p=0.002). There was no difference in the number of shunts and coronary artery bypass grafting operations in combination with surgical ventricular reconstruction. The meta-regression analysis of survival (Figure 17) did not reveal

statistically significant differences between the two groups (p = 0.98).

The restoration of blood flow in hibernating areas of the myocardium after surgical reconstruction of the left ventricle and aortocoronary bypass leads to an improvement in systolic function [9, 10]. Additionally, reverse remodeling results in a reduction of hypertrophy, volume of the left ventricle, and restoration of its structural and geometric parameters. Since this process takes several weeks to months, assessing the patient's condition in the mid-term period is particularly important for predicting the clinical status of the patient.

The results of the meta-analysis showed that the increase in the ejection fraction after surgery was 9% (95% CI: 6.6–11.4). Moreover, these changes are maintained throughout the first year. Thus, one year after the surgery, no statistically significant differences in EF were found (MD = 2.1; 95% CI = -0.21–4.4;  $p=0.075$ ) compared to the early postoperative period. In the meta-analysis presented in the study by Ferrell (2022), it was found that before the surgery, the ejection fraction increased by 30% [28.8–31.2], and in the early postoperative period, it increased by 40.9% [39.4–42.4] [11]. Similar results were obtained in the study by Dor et al. (2011), according to which, one year after left ventricular surgical reconstruction, the left ventricular ejection fraction (LVEF) increased from 26% to 44% [28].

Unlike these data, the STICH (Surgical Treatment for Ischemic Heart Failure) study provides important information about the impact of coronary artery bypass grafting on patients with ischemic cardiomyopathy [29, 30]. According to these results, in the studied patients, the ejection fraction after surgery increased only from 21 to 27%. Apparently, the peculiarities of the surgical strategy for patients with ischemic cardiomyopathy indicated that coronary artery bypass grafting combined with drug therapy in such patients was associated with a higher risk of mortality within the first month compared to the group receiving only optimal medical treatment. The results of most studies have shown that, after surgical reconstruction of the left ventricle, there is a significant increase in ejection fraction. This is due to a decrease in wall stress and an increase in the contractile ability of the heart muscle following the removal of scar changes and the restoration of the elliptical shape of the left ventricle [31]. However, when considering the long-term perspective, especially in the 10-year interval, the results of the STICH study indicate that the group of patients receiving coronary artery bypass grafting combined with drug therapy demonstrated higher survival rates compared to those who underwent only medical treatment without surgical intervention.

The study by Cleland J.G. et al. (2003) found a positive effect of carvedilol on left ventricular ejection

fraction. This is likely related to the improvement in the function of both hibernating and ischemic myocardium [32]. The use of carvedilol may serve as an important alternative or adjunct to revascularization in patients with hibernating myocardium. Similar results have been observed with other beta-blockers. Their use contributes to an increase in myocardial perfusion duration during diastole and a reduction in heart rate, which creates the conditions for reverse ventricular remodeling.

According to the results of the meta-analysis, in 88.7% (95% CI: 81.5–95.9,  $p < 0.001$ ) of cases, coronary artery bypass grafting (CABG) was performed simultaneously with left ventricle reconstruction. During the CABG procedure, the number of bypasses averaged 2.5 (95% CI: 2.2–2.8,  $p < 0.001$ ). Several studies have highlighted the significant role of revascularization in improving clinical symptoms and patient survival [14, 15, 17]. For instance, in the meta-analysis conducted by Allman (2002), a strong correlation was found between myocardial viability, assessed through non-invasive testing methods, and improved survival of patients post-revascularization [33]. The study involved 3088 patients, with a mean ejection fraction of  $32 \pm 8\%$ . The follow-up for these patients lasted an average of  $25 \pm 10$  months. The results indicated that among patients with viable myocardial regions, revascularization was associated with a 79.6% reduction in annual mortality (16% vs. 3.2%, chi-square = 147,  $p < 0.0001$ ). Furthermore, a direct correlation was observed between the degree of left ventricular dysfunction and the effectiveness of revascularization ( $p < 0.001$ ). All of this underscores the necessity of assessing myocardial viability before making decisions regarding revascularization. Meanwhile, among patients without viable myocardial regions, the mortality rate was intermediate.

According to the results of the study, there was a reduction in mitral regurgitation of 0.75 grade (95% CI: 0.25–1.25,  $p = 0.003$ ) after the operation. The decrease in MR before the surgery and one year postoperatively was 0.6 grade (95% CI: 0.2–1,  $p=0.004$ ). In the meta-analytic assessment conducted one year after the operation, an increase in MR of 0.2 grade (95% CI: 0.05–0.33,  $p = 0.009$ ) was observed compared to the early postoperative period. Surgical

intervention on the mitral valve was required in 20.1% (95% CI: 14.3–25.8,  $p < 0.001$ ) of cases.

Mitral insufficiency is a common complication of heart failure, occurring in 50% of patients. The degree of mitral insufficiency directly correlates with patient survival [9]. Mitral insufficiency can develop as a result of dilation of the fibrous ring, prolapse of the mitral valve due to left ventricular geometry alteration, and ischemic dysfunction of the papillary muscles. In most cases, patients with post-infarction left ventricular aneurysm develop secondary mitral insufficiency, often referred to as “functional.” In this case, the leaflets, fibrous ring, and papillary muscles remain unchanged, but there is inadequate coaptation or restriction of mobility. The dysfunction of the papillary muscles, which leads to their lateral displacement along with the posterior lateral wall of the left ventricle, is often mentioned in the pathogenesis of mitral insufficiency. Risk factors contributing to the development of mitral insufficiency include age, sex, previous myocardial infarction, extent of myocardial infarction, recurrent myocardial ischemia, and multivessel disease [9]. Currently, the question of the appropriateness of performing mitral valve repair in patients with moderate insufficiency remains a topic of discussion.

According to the results of the meta-analysis, after the surgery, the NYHA functional class decreased by 1.5 (95% CI: 1.28–1.72,  $p < 0.001$ ). One year after surgical reconstruction of the left ventricle, the NYHA functional class remained reduced by 1.5 (95% CI: 1.26–1.8,  $p < 0.001$ ) compared to the preoperative level. This decrease indicates the effectiveness of the surgical intervention aimed at improving the functional status of patients and confirms that the achieved effect is maintained for 1 year post-surgery.

Recent scientific studies have confirmed that surgical reconstruction of the left ventricle can be an effective treatment method for patients with ischemic cardiomyopathy, which is characterized by severe left ventricular dysfunction and the formation of aneurysms. The application of this strategy leads to a statistically significant improvement in left ventricular ejection fraction (LVEF), a reduction in functional class according to the New York Heart

Association (NYHA) scale, and an increase in patient survival [34].

A retrospective analysis by Williams et al. demonstrated improvement in NYHA functional class in patients with severe heart failure who underwent left ventricular reconstruction. The results confirm the safety and efficacy of left ventricular reconstruction, both as a standalone procedure and in combination with coronary artery bypass grafting (CABG). The choice of the optimal surgical strategy depends on the individual characteristics of the patient, the severity of heart failure, the presence of comorbidities, and the anatomical features of the left ventricle. It should be emphasized that the need for left ventricular reconstruction is determined using modern imaging techniques, such as multi-slice computed tomography and cardiac magnetic resonance imaging, which allow for detailed visualization of the left ventricle’s anatomy and help determine the optimal volume of surgical intervention. The postoperative period requires careful monitoring and rehabilitation, including medication therapy, physiotherapy, and assessment of left ventricular function.

The meta-analysis of the survival of patients who underwent surgical reconstruction of the left ventricle of the heart provided clinically significant information on the mid-term outcomes of this operation. The results of the studies showed that one year after the surgical intervention, the survival rate was 94% (95% CI: 90–98). The meta-regression analysis did not reveal statistically significant differences in the survival of patients undergoing surgical reconstruction of the left ventricle using the Dor procedure or SAVER, compared to patients who underwent surgical ventricular reconstruction using other surgical approaches ( $p = 0.98$ ).

It should be emphasized that the prognosis for patients with post-infarction left ventricular aneurysms is largely determined by the baseline ejection fraction value. In the Artery Surgery Study (CASS), it was found that the 12-year survival rate for patients with an ejection fraction of less than 35% receiving medical treatment does not exceed 12%. In contrast, for patients with an ejection fraction between 35 and 50%, this rate is 54% [9].

## Limitations

A comparative analysis of data between patients who underwent left ventricular reconstruction in conjunction with coronary artery bypass grafting and those who only had coronary artery bypass grafting could not be conducted. The reason was the lack of comprehensive information on this topic in scientific research.

In this systematic review, publications were analyzed regardless of the sample size of patients. The number of participants ranged from 14 to 207. It is possible that if we had limited the minimum number of participants, the results could have been different. Furthermore, one of the limitations can be considered the selection of studies in which patient observations were conducted for at least one year.

In the future, it seems reasonable to conduct a more detailed study of mitral valve surgeries, as well as to evaluate the effectiveness of different surgical methods for left ventricular reconstruction.

## Conclusion

The meta-analysis showed that one year after surgery, survival rates are 94%, with statistically significant increases in ejection fraction and decreases in functional class of heart failure according to the NYHA scale. The studies did not reveal significant differences in patient survival and clinical outcomes one year after operations performed using different surgical methods. The results indicate the effectiveness of left ventricular surgical reconstruction, providing prolonged improvement in patients' functional status. However, it should be noted that there was significant heterogeneity among the studies.

## References / Список литературы

1. Golukhova EZ, Slivneva IV, Kozlova OS, Berdibekov BS, Skopin II, Merzlyakov VY, Baichurin RK, Sigaev IY, Keren MA, Alshibaya MD, Marapov DI, Arzumanyan MA. Treatment Strategies for Chronic Coronary Heart Disease with Left Ventricular Systolic Dysfunction or Preserved Ejection Fraction — A Systematic Review and Meta-Analysis. *Pathophysiology* 2023;30(4):640–658. doi:10.3390/pathophysiology30040046
2. Golukhova EZ, Keren MA, Zavalikhina TV, Bulaeva NI, Marapov DI, Sigaev IY, Merzlyakov VY, Alshibaya MD, Volkovskaya IV, Yahyaeva KB,

Sheikina NA. Prognosis of Early Outcomes after Isolated Coronary Bypass Surgery: Results of a Single-Center Cohort Study. *Annals of the Russian Academy of Medical Sciences*. 2023;78(3):176–184. doi: 10.15690/vramn8086 (in Russ). [Голухова Е.З., Керен М.А., Завалихина Т.В., Булаева Н.И., Маратов Д.И., Сигаев И.Ю., Мерзляков В.Ю., Алшибая М.Д., Волковская И.В., Яхяева К.Б., Шейкина Н.А. Прогнозирование неблагоприятных госпитальных исходов после изолированного коронарного шунтирования: результаты одноцентрового когортного исследования // Вестник РАМН. 2023;78(3):176–184. doi: 10.15690/vramn8086].

3. Golukhova EZ. Report on the scientific and clinical activity of Bakoulev National Medical Research Center for Cardiovascular Surgery for 2023 and development prospects. *The Bulletin of Bakoulev Center. Cardiovascular Diseases*. 2024;25:5–141 (Special Issue) doi: 10.24022/1810-0694-2024-25S (in Russ). [Голухова Е.З. Отчет о научной и лечебной работе Национального медицинского исследовательского центра сердечно-сосудистой хирургии им. А.Н. Бакулева Минздрава России за 2023 год и перспективы развития. Сердечно-сосудистые заболевания // Бюллетень НЦССХ им. А.Н. Бакулева. 2024. Т. 25. С. 5–141 (Спецвыпуск). doi: 10.24022/1810-0694-2024-25S].

4. Bockeria L.A., Abzhuriev M.N. Surgery tactic in post-infarction aneurism of the left ventricle with functional mitral insufficiency. *The Bulletin of Bakoulev Center. Cardiovascular Diseases*. 2022;23 (1):6–15 doi: 10.24022/1810-0694-2022-23-1-6-15 (in Russ). Бокерия Л.А., Абжуриев М.Н. Тактика хирургического лечения при постинфарктной аневризме левого желудочка с ишемической митральной недостаточностью // Бюллетень НЦССХ им. А.Н. Бакулева РАМН. 2022. Т. 23. № 1. С. 6–15. doi: 10.24022/1810-0694-2022-23-1-6-15].

5. Buziashvili YuI, Asymbekova EU, Ioshina VI, Koksheneva IV. The results of the medical and scientific work of the Clinical-Diagnostic Department of Bakoulev National Medical Research Center for Cardiovascular Surgery for 2020. *The Bulletin of Bakoulev Center. Cardiovascular Diseases*. 2022;23(1):120–129. doi: 10.24022/1810-0694-2022-23-1-130-133 (in Russ). [Бузиашвили Ю.И., Асымбекова Э.У., Иошина В.И., Кокшенева И.В. Результаты лечебной и научной работы клинко-диагностического отделения ФГБУ «НМИЦ ССХ им. А.Н. Бакулева» Минздрава России за 2020 год. Сердечно-сосудистые заболевания // Бюллетень НЦССХ им. А.Н. Бакулева РАМН. 2022. Т. 23. № 1. С. 120–129. doi: 10.24022/1810-0694-2022-23-1-130-133].

6. Alshibaya MD, Popov AS, Belyaev AM. Postmyocardial infarction ventricular septal defect and ventricular aneurysm repair with a “double-patch frame” technique. *J Card Surg*. 2022;37(3):515–523. doi: 10.1111/jocs.16156.

7. Alshibaya MD, Skopin II, Lobacheva GV, Belyaev AM. Complete anatomic surgical myocardial revascularisation during postinfarction ventricular septal defect and ventricular aneurysm repair is associated with improved short- and long-term outcomes. *J Card Surg*. 2022;37(9):2693–2702. doi: 10.1111/jocs.16675.

8. Tekümit H, Polat A, Uyar I, Uzun K, Tataroğlu C, Cenal AR, Akinci E. Left ventricular aneurysm using the Dor technique: mid-term results. *J Card Surg*. 2010;25(2):147–152. doi: 10.1111/j.1540-8191.2009.00971.x.

9. Gordeev ML. Complicated forms of CHD. Remodeled left ventricular surgery. Saint Petersburg, Moscow: NMIC im. V.A. Almazova, ID Akademii im. N.E. Zhukovskogo; 2019. (In Russ.). Гордеев М.Л. Осложненные формы ИБС. Хирургия ремоделированного левого желудочка. СПб, М.: НМИЦ им. В.А. Алмазова, ИД Академии им. Н.Е. Жуковского, 2019.

10. Zhbanov IV, Molochkov AV, Shabalkin BV. Reconstructive surgery for complicated forms of coronary heart disease. Moscow: Praktika; 2013. (In Russ).

Жбанов И.В., Молочков А.В., Шабалкин Б.В. Реконструктивная хирургия осложненных форм ишемической болезни сердца. М.: Практика, 2013.

11. Ferrell BE, Jimenez DC, Ahmad D, Malkani K, Rosen JL, Gaw G, Plestis KA, Guy TS, Massey HT, Tchanchaleishvili V. Surgical ventricular reconstruction for ischemic cardiomyopathy—a systematic review and meta-analysis of 7,685 patients. *Ann Cardiothorac Surg.* 2022;11(3):226–238. doi: 10.21037/acs-2021-ami-17.

12. Hwang HY, Kim JS, Cho KR, Kim KB. Surgical anterior ventricular endocardial restoration performed with total arterial revascularization: serial 5-year follow-up. *J Thorac Cardiovasc Surg.* 2014;148(2):529–235. doi: 10.1016/j.jtcvs.2013.10.022.

13. Kato Y, Bando K, Fukui T, Mahara K, Takanashi S. Surgical treatment of functional mitral regurgitation involving the subvalvular apparatus. *J Card Surg.* 2015;30(1):27–34. doi: 10.1111/jocs.12459.

14. Cho Y, Ueda T, Inoue Y, Shimura S, Aki A, Furuya H, Okada K, Tanaka C. Long-term results and mid-term features of left ventricular reconstruction procedures on left ventricular volume, geometry, function and mitral regurgitation. *Eur J Cardiothorac Surg.* 2012;42(3):462–469. doi: 10.1093/ejcts/ezs363.

15. Pocar M, Di Mauro A, Passolunghi D, Moneta A, Alsheraei AM, Bregasi A, Mattioli R, Donatelli F. Predictors of adverse events after surgical ventricular restoration for advanced ischaemic cardiomyopathy. *Eur J Cardiothorac Surg.* 2010;37(5):1093–1100. doi: 10.1016/j.ejcts.2009.12.006.

16. Skelley NW, Allen JG, Arnaoutakis GJ, Weiss ES, Patel ND, Conte JV. The impact of volume reduction on early and long-term outcomes in surgical ventricular restoration for severe heart failure. *Ann Thorac Surg.* 2011;91(1):104–111. doi: 10.1016/j.athoracsur.2010.09.059.

17. Marchenko A, Chernyavsky A, Efendiev V, Volokitina T, Karaskov A. Results of coronary artery bypass grafting alone and combined with surgical ventricular reconstruction for ischemic heart failure. *Interact Cardiovasc Thorac Surg.* 2011;13(1):46–51. doi: 10.1510/icvts.2010.253716.

18. Chen L, Song Y, Tiemuerniyazi X, Zhang S, Ma H, Zhao D, Feng W. Long-Term Outcomes of Left Ventricular Restoration in Patients Ineligible for Concomitant Coronary Artery Bypass Grafting. *Heart Surg Forum.* 2022;25(3):395–402. doi: 10.1532/hf.4683.

19. Moher D, Liberati A, Tetzlaff J, Altman D G. Preferred Reporting Items for Systematic Reviews and Meta-Analyses: the PRISMA statement. *PLoS Med.* 2009;6(7): e1000097. doi:10.1371/ journal.pmed.1000097.

20. Di Donato M, Toso A, Maioli M, Sabatier M, Stanley AW Jr, Dor V, RESTORE Group. Intermediate survival and predictors of death after surgical ventricular restoration. *Semin Thorac Cardiovasc Surg.* 2001;13(4):468–475. doi: 10.1053/stcs.2001.29972.

21. Di Donato M, Sabatier M, Dor V, Gensini GF, Toso A, Maioli M, Stanley AW, Athanasuleas C, Buckberg G. Effects of the Dor procedure on left ventricular dimension and shape and geometric correlates of mitral regurgitation one year after surgery. *J Thorac Cardiovasc Surg.* 2001;121(1):91–96. doi: 10.1067/mtc.2001.111379.

22. Fujii H, Ohashi H, Tsutsumi Y, Kawai T, Iino K, Onaka M. Radionuclide study of mid-term left ventricular function after endoventricular circular patch plasty. *Eur J Cardiothorac Surg.* 2004;26(1):125–128. doi: 10.1016/j.ejcts.2004.03.008.

23. Kokaji K, Shin H, Hotoda K, Mori M, Kumamaru H, Yozu R. Changes in left ventricular volume and predictors of cardiac events after endoventricular circular patch plasty. *Jpn J Thorac Cardiovasc Surg.* 2004;52(12):551–559. doi: 10.1007/s11748-004-0022-2.

24. Lee S, Chang BC, Youn YN, Kwak YL, Yoo KJ. Changes in left ventricular function and dimension after surgical ventricular restoration with or without concomitant mitral valve procedure. *Circ J.* 2007;71(10):1516–20. doi: 10.1253/circj.71.1516.

25. Bové T, Van Belleghem Y, Vandenplas G, Caes F, François K, De Backer J, De Pauw M, Van Nooten G. Short-term systolic and diastolic ventricular performance after surgical ventricular restoration for dilated ischemic cardiomyopathy. *Eur J Cardiothorac Surg.* 2009;35(6):995–1003; discussion 1003. doi: 10.1016/j.ejcts.2008.11.007.

26. Zheng Z, Fan H, Feng W, Zhang S, Yuan X, Wang L, Song Y, Hu S.. Surgery of left ventricular aneurysm: a propensity score-matched study of outcomes following different repair techniques. *Interact Cardiovasc Thorac Surg.* 2009;9(3):431–436. doi:10.1510/icvts.2009.207134

27. Solowjowa N, Nemchyna O, Hrytsyna Y, Meyer A, Hennig F, Falk V, Knosalla C. Surgical Restoration of Antero-Apical Left Ventricular Aneurysms: Cardiac Computed Tomography for Therapy Planning. *Front Cardiovasc Med.* 2022;9:763073. doi: 10.3389/fcvm.2022.763073.

28. Dor V, Civaia F, Alexandrescu C, Sabatier M, Montiglio F. Favorable effects of left ventricular reconstruction in patients excluded from the Surgical Treatments for Ischemic Heart Failure (STICH) trial. *J Thorac Cardiovasc Surg.* 2011;141(4):905–916. doi: 10.1016/j.jtcvs.2010.10.026.

29. Jones RH, Velazquez EJ, Michler RE, Sopko G, Oh JK, O'Connor CM, Hill JA, Menicanti L, Sadowski Z, Desvigne-Nickens P, Rouleau JL, Lee KL; STICH Hypothesis 2 Investigators. Coronary bypass surgery with or without surgical ventricular reconstruction. *N Engl J Med.* 2009;360(17):1705–1717. doi: 10.1056/NEJMoa0900559.

30. Velazquez EJ, Lee KL, Deja MA, Jain A, Sopko G, Marchenko A, Ali IS, Pohost G, Gradinac S, Abraham WT, Yii M, Prabhakaran D, Szwed H, Ferrazzi P, Petrie MC, O'Connor CM, Panchavinnin P, She L, Bonow RO, Rankin GR, Jones RH, Rouleau JL; STICH Investigators. Coronary-artery bypass surgery in patients with left ventricular dysfunction. *N Engl J Med.* 2011;364(17):1607–1616. doi: 10.1056/NEJMoa1100356.

31. Castelvechchio S, Frigelli M, Sturla F, Milani V, Pappalardo OA, Citarella M, Menicanti L, Votta E. Elucidating the mechanisms underlying left ventricular function recovery in patients with ischemic heart failure undergoing surgical remodeling: A 3-dimensional ultrasound analysis. *J Thorac Cardiovasc Surg.* 2023;165(4):1418–1429. doi: 10.1016/j.jtcvs.2021.02.067.

32. Cleland JG, Pennell DJ, Ray SG, Coats AJ, Macfarlane PW, Murray GD, Mule JD, Vered Z, Lahiri A; Carvedilol hibernating reversible ischaemia trial: marker of success investigators. Myocardial viability as a determinant of the ejection fraction response to carvedilol in patients with heart failure (CHRISTMAS trial): randomised controlled trial. *Lancet.* 2003;362(9377):14–21. doi: 10.1016/s0140-6736 (03) 13801-9.

33. Allman KC, Shaw LJ, Hachamovitch R, Udelson JE. Myocardial viability testing and impact of revascularization on prognosis in patients with coronary artery disease and left ventricular dysfunction: a meta-analysis. *J Am Coll Cardiol.* 2002;39(7):1151–1158. doi: 10.1016/s0735-1097 (02) 01726-6.

34. Hassanabad AF, Ali IS. Surgical ventricular restoration for patients with heart failure. *Rev Cardiovasc Med.* 2021;22(4):1341–1355. doi: 10.31083/j.rcm2204140.

35. Williams JA, Weiss ES, Patel ND, Nwakanma LU, Conte JV. Outcomes following surgical ventricular restoration for patients with clinically advanced congestive heart failure (New York Heart Association Class IV). *Journal of cardiac failure.* 2007;13(6):431–436. doi: 10.1016/j.cardfail.2007.03.006

# Мета-анализ среднесрочной выживаемости и клинических результатов хирургической реконструкции левого желудочка

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**Аннотация.** *Актуальность.* Постинфарктная аневризма левого желудочка значительно снижает продолжительность и качество жизни пациентов. Результаты сравнения разных способов хирургического восстановления левого желудочка неоднозначны и нередко противоречивы, что усложняет выбор эффективной стратегии лечения и возможность объективно оценить перспективу выживаемости таких пациентов. Цель мета-анализа — оценить выживаемость пациентов через 1 год после хирургической реконструкции левого желудочка, определить функциональный класс сердечной недостаточности и изучить морфо-функциональные характеристики сердца. Выполнить сравнительный анализ результатов мета-аналитической оценки выживаемости пациентов после хирургической реконструкции левого желудочка по методике DOR (SAVER), в сопоставлении с другими методами лечения. *Материалы и методы.* В результате систематического поиска по двум специализированным базам данных (PubMed, Google Scholar) отобрано 1875 статей. В окончательный анализ было включено 15 исследований. Общее количество пациентов в этих исследованиях составило 1089. В целях объективизации оценки эффективности разных хирургических подходов было сформировано две группы пациентов. В первой — проводилась только хирургическая реконструкция левого желудочка по методике Дора или операция SAVER (surgical anterior ventricular endocardial restoration); во второй — применялись и другие методы хирургической реконструкции левого желудочка, в зависимости от хирургической целесообразности. *Результаты и обсуждение.* Средний возраст обследованных пациентов составил 62.1 (95% CI: 60.2–64.1) года. В исследовании принимали участие 56% (95% CI: 42–69) мужчин. Аневризма передней локализации встречалась у 87% (95% CI: 74–99) пациентов. Среднее значение EuroSCORE соответствовало 9.7% (95% CI: 7.3–12.1). До операции у пациентов отмечался высокий функциональный класс сердечной недостаточности по NYHA [3 functional class (95% CI: 2.82–3.1)], низкая фракция выброса левого желудочка [31.3% (95% CI: 29.2–33.3)], расширение полостей сердца [EDVI — 131.7 mL/m<sup>2</sup> (95% CI: 113.1–150.2)]. Мета-анализ разности средних значений фракции выброса у пациентов до и через 1 год после операции свидетельствует о ее повышении на 10.1% (95% CI: 8.01–12.1,  $p < 0.001$ ). Мета-анализ разности средних значений EDVI и функционального класса сердечной недостаточности по NYHA у пациентов до и через 1 год после операции показал снижение на 38.8 мл/м<sup>2</sup> (95% CI: 28.1–49.6,  $p < 0.001$ ) и 1.52 (95% CI: 1.3–1.8,  $p < 0.001$ ) соответственно. *Выводы.* Мета-анализ показал, что через год после операции выживаемость составляет 94%, при этом статистически значимо увеличивается фракция выброса и снижается функциональный класс сердечной недостаточности по шкале NYHA. Исследования не выявили значимых различий выживаемости пациентов и их клинических результатов через год после операций, выполненных разными хирургическими методами. Полученные результаты свидетельствуют об эффективности хирургической реконструкции левого желудочка, обеспечивающей пролонгированное улучшение функционального состояния пациентов. Однако необходимо отметить, что между исследованиями наблюдалась значительная гетерогенность.

**Ключевые слова:** Постинфарктная аневризма левого желудочка, хирургическая реконструкция желудочка, операция Дора, эндовентрикулопластика, среднесрочная выживаемость

**Информация о финансировании.** Исследование не имело финансовой поддержки.

**Информация о конфликте интересов.** Автор заявляет об отсутствии конфликтов интересов.

**Этическое утверждение** — неприменимо.

**Благодарности** — неприменимо.

**Информационное согласие на публикацию** — неприменимо.

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