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# Comparison of outcomes of coronary artery stenting in acute myocardial infarction due to massive coronary thrombosis

A.V. Azarov✉[1,2], M.G. Glezer[1,2], A.S. Zhuravlev[1,2], I.R. Rafaeli[1], S.P. Semitko[1], K.V. Gyulmisaryan[1], S.A. Kurnosov[2]

[1]*I.M. Sechenov First Moscow State Medical University (Sechenov University),*

*8 Bldg. 2 Trubetskaya St., Moscow 119991 Russia;*

[2]*Moscow Regional Research and Clinical Institute n.a. M.F. Vladimirskiy,*

*61/2 Shchepkin St., Moscow 129110 Russia*

✉Corresponding author: Alexey V. Azarov, Cand. Sci. (Med.), Associate Professor of the Interventional Cardioangiology Department of the Institute of Professional Education, I.M. Sechenov First Moscow State Medical University (Sechenov University); Head of the Department of Endovascular Treatment of Cardiovascular Diseases and Rhythm Disorder, Leading Researcher, Moscow Regional Research and Clinical Institute n.a. M.F. Vladimirskiy, azarov_al@mail.ru

## Abstract

***Introduction.*** *Therapy of patients with acute ST-elevation myocardial infarction and massive coronary thrombosis (TTG ≥3) is a far from solved problem of modern medicine, since often in such patients immediate stent implantation is associated with the development of myocardial hypoperfusion, reducing the long-term prognosis of life.*

***Aim.*** *To evaluate short-term and long-term efficacy and safety of delayed and immediate coronary artery stenting techniques in patients with acute ST-elevation myocardial infarction and massive coronary thrombosis.*

***Material and methods.*** *Comparative study in parallel groups, a total of 153 patients with ST-elevation myocardial infarction and massive coronary thrombosis (TTG ≥3), 75 patients in the delayed coronary artery stenting group, 78 patients in the immediate coronary artery stenting group. In the immediate coronary artery stenting group, percutaneous coronary intervention was performed in one stage with stent implantation, in the delayed coronary artery stenting group; percutaneous coronary intervention was performed in two stages: the first was achieving TIMI-3 blood flow using a minimally invasive mechanical strategy, the second was control coronary angiography 5-6 days and the decision on the implantation of the stent. The primary endpoint is: the rate of achieving optimal myocardial perfusion according to angiography, the secondary combined endpoint is the rate of major adverse cardiovascular events.*

***Results.*** *In the hospital period, optimal reperfusion (TIMI-3 and MBG 2-3) after the primary procedure was achieved in 88% in the delayed coronary artery stenting group and 69.2% of immediate coronary artery stenting with an advantage in the delayed coronary artery stenting group (p=0.005). Of the 75 patients in the delayed coronary artery stenting group, 38 patients (51%) did not receive a stent in the delayed period due to the insignificance of stenosis on the control coronary angiography. There was no significant difference in the incidence of major adverse cardiovascular events between the groups. In the long-term period, the median follow-up period was 47 months. The frequency of major adverse cardiovascular events was 13.3% in the delayed coronary artery stenting group and 23.1% in the immediate coronary artery stenting group, with a trend towards the advantage in the delayed coronary artery stenting group (p=0.1). Overall mortality (9.3% vs. 11.7%), recurrent myocardial*

*infarction (2.6% vs. 5.1%), target vessel revascularization rate (1.3% vs. 6.4%) were without significant benefit between groups.*

***Conclusion.*** *In patients with ST-elevation myocardial infarction and massive coronary thrombosis, the use of delayed coronary artery stenting gives an advantage in achieving myocardial perfusion after the procedure, and demonstrates a tendency to reduce adverse cardiovascular events in the long-term period.*

**Keywords:** massive coronary thrombosis, delayed coronary artery stenting, acute ST-segment elevation myocardial infarction

**Conflict of interests** Authors declare no conflict of interest

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CAG, coronary angiography
DAPT, dual antiplatelet therapy
DCAS, delayed coronary artery stenting
ESC, European Society of Cardiology
ICAS, immediate coronary artery stenting
IRA, infarct-related artery
MACE, major adverse cardiovascular event
MBG, myocardial blush grade
MIMS, minimally invasive mechanical strategy
PCI, percutaneous coronary intervention
QCA, quantitative coronary angiography
STEMI, ST-segment elevation myocardial infarction
TIMI, thrombolysis in myocardial infarction
TTG, TIMI thrombus grade score

## Introduction

Acute myocardial infarction still remains one of the leading causes of mortality in the Russian Federation and is associated with unfavorable

clinical outcomes, both in the short and long term [1]. Acute ST-segment elevation myocardial infarction (STEMI) is primarily caused by acute occlusion of the main epicardial coronary artery and is usually accompanied by ascending thrombosis corresponding to at least TTG (TIMI thrombus grade) score 3 caused by the rupture of a lipid-rich atherosclerotic plaque in the overwhelming majority of cases [2, 3]. Today, the most studied invasive treatment for acute STEMI is percutaneous coronary intervention (PCI) with stent implantation in the infarct-related coronary artery (IRA) [4]. However, in some patients (10–40%), despite anoptimal time interval before reperfusion after the stent implantation procedure, a slowdown in blood flow in the epicardial IRA is determined angiographically, as well as a slowdown in myocardial contrast passage or a complete absence of myocardial "blush" (parenchymal phase of contrast) [5]. This complication is known as the "slow-/no- reflow" phenomenon (unrestored coronary blood flow) and indicates damage to the microvascular bed [6]. Since the myocardium remains in a hypoperfusion state, this complication is associated with a fairly high long-term mortality rate: from 7.4% to 30.3% [7–10]. One of the possible options for preventing damage to the microvascular bed is the tactics of delayed coronary artery stenting (DCAS) [11, 12]. In the 2017 Guidelines of the European Society of Cardiology (ESC) for the management of STEMI, this technique has III B class and level of evidence that is low [13]. Therefore, a routine use of the DCAS technique is not recommended in the treatment of patients with STEMI. In our opinion, the use of DCAS in patients with STEMI and a high level of thrombotic load in the IRA (TTG 3–5), the so-called massive thrombosis, is a pathogenetically substantiated and very promising technique. The first stage of endovascular intervention is the restoration of blood flow, which is performed ensuring minimal mechanical impact on thrombotic

masses. The second stage is a stent implantation performed after a few hours or days. By this time, there is a decrease or complete resorption of residual thrombotic masses in the IRA [14, 15].

**Aim.** To evaluate the short- and long-term efficacy and safety of delayed and immediate coronary artery stenting techniques in patients with acute STEMI and massive coronary thrombosis.

## Material and methods

The study design was a parallel group comparative study.

The study was conducted at the base of Mytishchi City Clinical Hospital of the Moscow Region and the Scientific and Practical Center for Interventional Cardioangiology (Sechenov University). Patients were enrolled in the period between January 2013 and February 2018. The follow-up period continued till 2022.

### Study inclusion criteria

Age over 18 years old, acute (primary) STEMI, time from the onset of anginal status no more than 12 hours, angiographic visualization of a large thrombus in the lumen of the main epicardial coronary artery (TTG 3–5) after the restoration of antegrade blood flow, the diameter of the infarct-related coronary artery no less than 2.5 mm, patient's giving consent for PCI.

### Study exclusion criteria

A history of previous MI or myocardial revascularization due to chronic ischemic heart disease, true cardiogenic shock at the time of admission, patients with liver cirrhosis, conditions and diseases in which dual antiplatelet therapy (DAPT) is impossible, pregnancy.

A total of 153 patients who underwent primary PCI for acute STEMI were included; the 1st group included 78 patients in whom the standard technique of immediate coronary artery stenting of (ICAS) was used, the 2nd group included 75 patients in whom the delayed coronary artery stenting technique was used. Primary PCI in the ICAS group was performed according to the standard technique: the restoration of blood flow (mechanical recanalization, balloon angioplasty, and/or manual vacuum thromboaspiration) and implantation of a drug-eluting stent. Primary PCI in the DCAS group was performed in two stages: the first stage was the so-called “index” procedure aimed at achieving antegrade coronary blood flow of Thrombolysis In the Myocardial Infarction (TIMI) 3 grade by using a minimally invasive mechanical strategy (MIMS) and creating an optimal hypocoagulation environment. In case the coronary blood flow TIMI 3 was present at the stage of the diagnostic procedure (in combination with the ST segment resolution on the electrocardiogram (ECG) of at least 70% of the original), MIMS was not performed.

The second stage was to perform a control angiography no less than 5-6 days later; in the absence of angiographically significant stenotic lesion or the presence of a stenotic lesion of less than 50% at quantitative coronary angiography (QCA), a stent implantation in the IRA was not performed. MIMS implied the restoration of a stable epicardial coronary blood flow at TIMI flow grade 3 by the recanalization of the thrombotic occlusion with a coronary guidewire. In case of blood-flow non-recovery, the transluminal angioplasty with a balloon catheter of no more than 2.0 mm in diameter and/or aspiration thrombectomy was performed.

**Pharmacological support**

At the prehospital stage, all patients received DAPT, the first drug was acetylsalicylic acid in a loading dose of 300 mg, and the second drug was clopidogrel or ticagrelor, in a loading dose of 600 and 180 mg, respectively. Starting from the 2nd day, clopidogrel was administered at a dose of 150 mg/day to enhance antiplatelet therapy; in case when ticagrelor was used, the dose did not exceed the recommended one and was 90 mg 2 times/day. All patients in the DCAS group received glycoprotein IIb/Ixia receptor blockers in combination with intravenous infusion of sodium heparin. For the period from the first day of hospital admission until the discharge from the hospital, atorvastatin was administered at a dosage of 80 mg/day to enhance anti-inflammatory therapy, and all patients also received β-blockers, angiotensin-converting enzyme inhibitors, and, if necessary, diuretics and proton pump inhibitors.

**Angiographic examination**

Coronary angiography (CAG) was performed upon admission and again on day 5–6 in the DCAS group. At coronary angiography, coronary blood flow parameters and myocardial contrast passage were assessed: the coronary blood flow was assessed using the TIMI flow grading System, the myocardial contrast enhancement was assessed using the Myocardial Blush Grade (MBG). The thrombotic load was assessed using TIMI Thrombus grade (TTG) score after the blood flow restoration in the IRA.

The primary endpoint was the case rate of achieving an optimal myocardial perfusion according to angiography assessments (TIMI, MBG) after the procedure. Secondary composite endpoint was the incidence of major adverse cardiovascular events (MACE) including

overall mortality, recurrent myocardial infarction, repeated target vessel revascularization in the hospital and mid-term follow-up period.

**Statistical processing of obtained data**

IBM SPSS Statistics 26.0 software (USA) was used for statistical processing of the data obtained. The normality of data distribution was checked using the Kolmogorov–Smirnov method with the Lilliefors correction. If the data were normally distributed, the quantitative parameter was presented as the arithmetic mean (M) with a standard deviation (± SD), and 95% confidence interval [95% CI]. A quantitative parameter was presented as a median (Me) with an interquartile range (Q1; Q3) in case of non-normal data distribution. Intergroup differences were assessed using the Mann–Whitney U test. Comparative analysis of independent categorical variables was made using Pearson's $\chi^2$ or Fisher's exact test. The nominal indicator was presented as the absolute number of cases; the percentage of the characteristic in the groups was given. To assess the statistical significance of the relationship between a factor and the occurrence of an event depending on time, the Kaplan–Meier method and the Mantel –Cox log rank test were used. In all statistical analysis procedures, the critical significance level was set as $p<0.05$.

**Results**

Table 1 presents the initial clinical and previous history data of the patients. The groups were comparable in clinical and medical history data with the exception of hypercholesterolemia predominating in the ICAS group ($p<0.001$).)

**Table 1. Clinical and angiographic characteristics of patients**

| Parameter | DCAS (n=75) | ICAS (n = 78) | p |
|---|---|---|---|
| Age, M±SD [95% CI], years | 56.5±13.9 [53.3;59.7] | 56±11.7 [53.4;58.7] | 0.827 |
| BMI, M±SD [95% CI] kg/m$^2$ | 29.3±5.7 [25.9;32.5] | 29±3.8 [24.3;33.8] | 0.939 |
| Male gender, n% | 60 (80) | 66 (84.6) | 0.527 |
| Diabetes, % | 15 (19.2) | 15 (19.5) | 1.000 |
| Arterial hypertension, % | 58 (77.3) | 51 (65.4) | 0.103 |
| Smoking, % | 37 (49.3) | 48 (61.5) | 0.129 |
| Cholesterol, Me (Q1;Q3), mmol/L | 4.72 (4;6.6) | 5.8 (5.3;6.8) | 0.004* |
| Triglycerides, Me(Q1;Q3), mmol/L | 1.55 (1.3;2.7) | 1.6 (1.15;2.8) | 0.759 |
| Hyperlipidemia, % (increased cholesterol >5 mmol/L and/or LDL <3.5 mmol/L | 28 (47.5) | 60 (83.3) | <0.001* |
| HGB M (Q1;Q3), g/L | 141 (123;152) | 140 (130;154) | 0.679 |
| Red blood cells, M ± SD, [95% CI], $10^{12}$/L | 4.6±0.7 [4.4;4.8] | 4.6 ± 0.6 [4.4;4.7] | 0.941 |
| Lymphocytes, Me (Q1;Q3), $10^9$/L | 1.9 (1.5;2.3) | 2 (1.4;3.3) | 0.488 |
| Platelets, Me (Q1;Q3), $10^9$/L | 243 (204.5;287.5) | 227 (193;262) | 0.261 |
| Leukocytes, Me (Q1;Q3), $10^9$/L | 10.65 (8.7;13.6) | 10.4 (8.1;13.9) | 0.729 |
| CPK, Me (Q1;Q3), Units/L | 678 [337.5;1113] | 780.5 (360;2034) | 0.066 |
| CPK MB, Me (Q1;Q3), Units/L | 71.5 (37;136) | 88 (36;176.2) | 0.285 |
| ICAs | | | |
| LCA main trunk, n % | 4 (5.3) | 1 (1.3) | 0.204 |
| LAD, n % | 32 (42.7) | 43 (55.1) | 0.123 |
| Cx, n % | 5 (6.7) | 8 (10.3) | 0.565 |
| RCA, n % | 34 (45.3) | 26 (33.3) | 0.129 |
| “Symptom to balloon” time, Me (Q1;Q3), h | 4 (2.7; 6) | 3 (2.5;4) | 0.054 |

Notes: BMI, body mass index; LDL, low density lipoproteins; HGB, hemoglobin, concentration; CPK - creatine kinase; ICA, intact coronary artery; LCA, left coronary artery; LAD, Left anterior descending artery (or anterior interventricular branch); Cx, circumflex artery; RCA, right coronary artery; DCAS, delayed coronary artery stenting; ICAS, immediate coronary artery stenting

Table 2 presents the angiographic characteristics of the coronary bed of patients at primary coronary angiography and after the percutaneous coronary intervention (PCI).

**Table 2. Angiographic criteria of epicardial blood flow and tissue myocardial perfusion before and after percutaneous coronary intervention**

| Parameter | DCAS (n=75) | ICAS (n=78) | p |
|---|---|---|---|
| Before the PCI procedure | | | |
| TIMI, Me (Q1;Q3) | 1 (0;3) | 1 (1; 1) | 0.983 |
| TTG, Me (Q1;Q3) | 4 (3;4) | 3 (3;4) | 0.011 |
| After the PCI procedure | | | |
| TIMI, Me (Q1;Q3) | 3 (3;3) | 3 (3;3) | 0.001* |
| MBG, Me (Q1;Q3) | 2 (2;2.5) | 2 (1;2) | 0.031* |
| Control study (for DCAS) | | | |
| TIMI, Me (Q1;Q3) | 3 (3;3) | | |
| MBG, Me (Q1;Q3) | 2 (2;2) | | |

Notes: * statistically significant difference ($p<0.05$). DCAS, delayed coronary artery stenting; NCAS, immediate coronary artery stenting; PCI, percutaneous coronary intervention; TIMI, thrombolysis in myocardial infarction; TTG, TIMI thrombus grade score; MBG, myocardial blush grade

The TIMI assessments of epicardial blood flow were comparable between the DCAS and ICAS groups during primary coronary angiography (p=0.983), while in the DCAS group more severe coronary thrombosis was more often identified according to the TTG assessment (p=0.011).

After PCI, the coronary blood flow by TIMI scale and the microvascular perfusion assessed by MBG were significantly better in the DCAS group than in the ICAS group (p=0.001 and p=0.031, respectively), with the advantage retained at the control study.

Table 3 presents the criteria for achieving the state of optimal myocardial perfusion, which are the combination of TIMI-3 blood flow and MBG 2-3 perfusion, as well as the incidence of ST segment resolution ≥70% within 60 minutes after the primary intervention. According to the data, the state of optimal myocardial perfusion (TIMI-3 and MBG 2-3) at the end of the first procedure was significantly better in

the DCAS group than in the ICAS group (88% vs. 69.2%, p=0.005). In addition, ST segment resolution ≥70% after the intervention was achieved in 64.1% of cases in the ICAS group and in 84% of cases in the DCAS group, with a significant advantage in the latter (p=0.006). During the control study, due to the absence of angiographically significant stenotic lesion in 38 patients (51%), the stent implantation was not performed in them.

**Table 3. The occurrence rate of ST-segment resolution ≥70 and TIMI-3, MBG 2–3 blood flow with regard to the method of treatment**

| Parameter | Treatment method | | | | p | OR; 95CI% |
|---|---|---|---|---|---|---|
| | DCAS | | ICAS | | | |
| | Abs. | % | Abs. | % | | |
| TIMI-3, MBG 2–3, n (%) | 66/75 | 88% | 54/78 | 69.2% | 0.005 | 3.3 [1.4;7.6] |
| ST-segment resolution ≥ 70% n (%) | 63/75 | 84% | 50/78 | 64.1% | 0.006 | 2.94 [1.4;6.4] |

Table 4 shows cardiac complications during the in-hospital period. There was no significant difference in MACE incidence between the groups. During hospital stay, 2 patients in the DCAS group (2.8%) and 2 patients in the ICAS group (2.6%) experienced nonfatal major bleeding. None of the patients in the DCAS group required immediate coronary angiography or revascularization in the period between the "index" procedure and the control procedure.

**Table 4. Cardiac complications and bleeding in the hospital period and in the close follow-up period**

| Parameter | DCAS (n=75) | ICAS (n=78) | p |
|---|---|---|---|
| MACE, n (%) | 5 (6.6) | 4 (5.1) | 0.742 |
| Death, n (%) | 2 (2.7) | 2 (2.6) | 1.000 |
| Recurrent myocardial infarction, n (%) | 2 (2.7) | 1 (1.3) | 0.610 |
| Repeated revascularization in IRA, n (%) | 1 (1.3) | 1 (1.3) | 1.000 |
| Major bleeding, n (%) | 2 (2.7) | 2 (2.6) | 1.000 |

The median follow-up period in the DCAS group was 49 months (Q1;Q3: 40.5;60.5) and 46.5 months (Q1;Q3: 13;65) in the ICAS group (p=0.649). Table 5 shows the characteristics of clinical endpoints in the long-term period.

**Table 5. Cardiac complications and bleeding in the hospital period and in the long-term follow-up period**

| Parameter | DCAS (n=75) | ICAS (n=78) | p |
|---|---|---|---|
| MACE, n (%) | 10 (13.3) | 18 (23.1) | 0.11 |
| Death, n (%) | 7 (9.3) | 9 (11.7) | 0.793 |
| Recurrent myocardial infarction, n (%) | 2 (2.7) | 4 (5.1) | 0.682 |
| Repeated revascularization in IRA, n (%) | 1 (1.3) | 5 (6.4) | 0.210 |
| Major bleeding, n (%) | 4 (5.3) | 4 (5.1) | 1.000 |

The long-term results demonstrated the MACE incidence of 13.3% in the DCAS group and 23.1% in the ICAS group, with an advantage trend in the DCAS group (p=0.11). There were no statistical differences between the DCAS and ICAS groups in the incidence of overall mortality (9.3% vs. 11.7%, respectively, p=0.793), recurrent myocardial infarction (2.7% vs. 5.1%, respectively, p=0.682), the need for repeated revascularization of the target vessel (1.3% vs. 6.4%, respectively, p=0.210).

**Major adverse cardiovascular events (MACE)**

When assessing event-free survival in patients after the PCI, no statistically significant differences were found between the treatment groups (p=0.1), however, there is a tendency to superiority in the DCAS group.

The mean timing of MACE development was 74.5±2.8 months in the DCAS group, and 78.3±4.4 months in the ICAS group (Fig. 1).

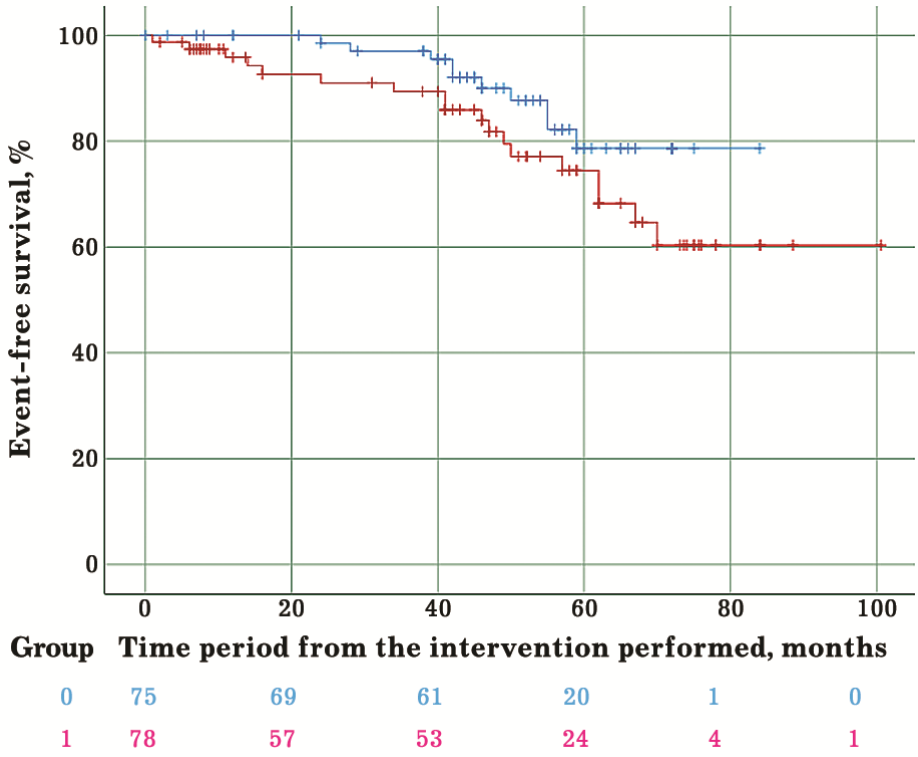


**Fig. 1. Kaplan-Meier curves characterizing event-free survival of patients depending on the treatment group (the group of patients with delayed coronary artery stenting is shown in blue, the group of patients with immediate coronary artery stenting is shown in red)**

**Overall mortality**

When assessing survival in patients after the intervention, no statistically significant differences were found between the treatment groups (p=0.558).

The mean period of mortality occurrence made 77.7±2.2 months in the DCAS group, and 88.2±4.7 months in the ICAS group (Fig. 2).

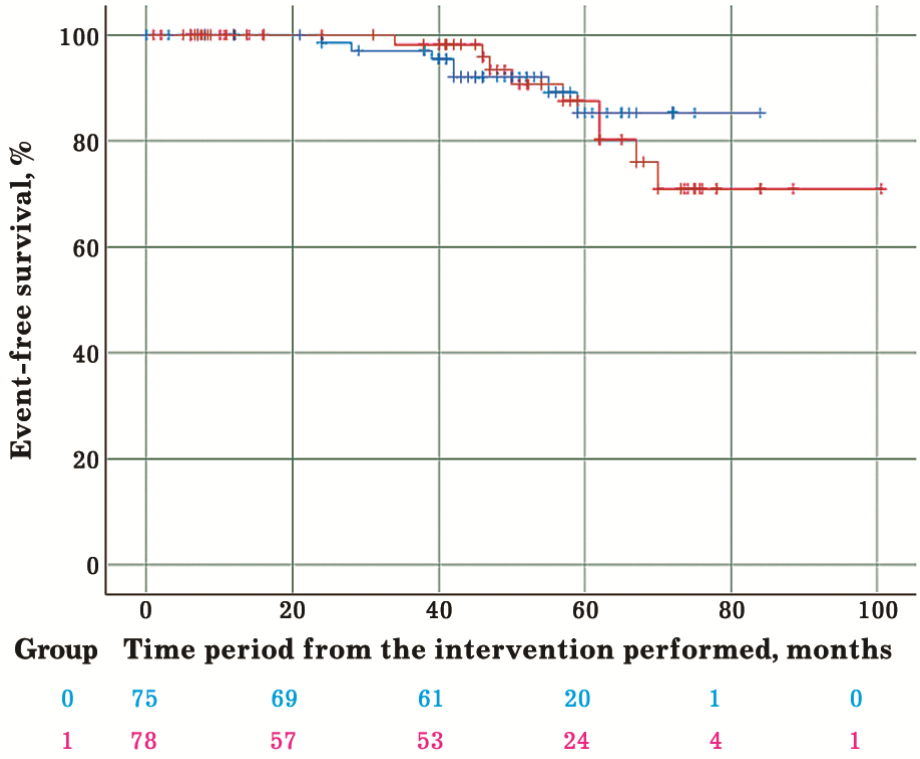


**Fig. 2. Kaplan-Meier curves characterizing the survival of patients depending on the treatment group (the group of patients with delayed coronary artery stenting is shown in blue, the group of patients with immediate coronary artery stenting is shown in red)**

**Recurrent myocardial infarction**

The difference in the risk of recurrent myocardial infarction between the treatment groups, as assessed using the Mantel-Cox log-rank test, was not statistically significant (p=0.431).

The mean period of the myocardial infarction recurrence was 81.8±1.5 months in the DCAS group, and 95.4±2.5 months in the ICAS group (Fig. 3).

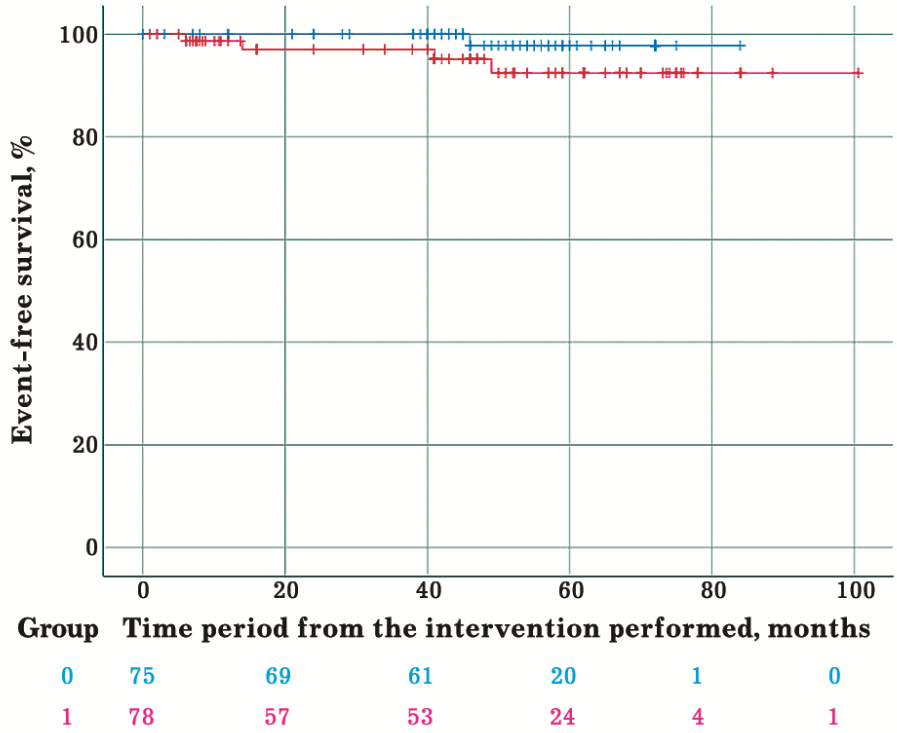


**Fig. 3. Kaplan–Meier curves characterizing event-free (repeated myocardial infarction) survival of patients depending on the treatment group (the group of patients with delayed coronary artery stenting is shown in blue, the group of patients with immediate coronary artery stenting is shown in red)**

**Repeated revascularization of the target vessel**

The need for repeated target vessel revascularization depending on the initial treatment group, as assessed using the Mantel–Cox log-rank test, was statistically insignificant (p=0.12).

The mean period while the need for repeated revascularization of the target vessel occurred was 82.8±1.1 months in the DCAS group, and 94.26±2.7 months in the ICAS group (Fig. 4).

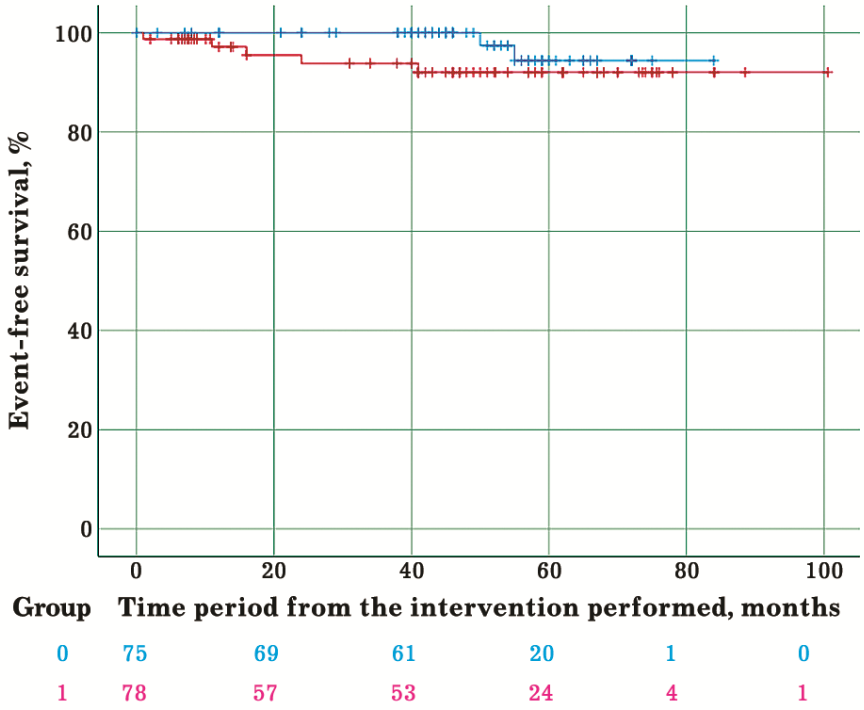


**Fig. 4. Kaplan-Meier curves characterizing the event-free (need for repeated target vessel revascularization) survival of patients depending on the treatment group (the group of patients with delayed coronary artery stenting is shown in blue, the group of patients with immediate coronary artery stenting is shown in red)**

A total of 153 patients were included in the study, 75 patients in the DCAS group, 78 in the ICAS group. After the primary procedure for STEMI, an optimal angiographic result was statistically significantly more often recorded in the DCAS group: when analyzing TIMI ($p=0.001$), MBG ($p=0.031$), the combined angiographic characteristics of optimal perfusion TIMI-3 and MBG 2-3 (88% and 69.2%, $p=0.005$), as well as when analyzing the rate of ST segment resolution $\geq 70\%$ after the procedure (84% and 64.1%, $p=0.006$). In addition, in the DCAS group during control CAG, a stent implantation was not performed in 38 (51%) patients due to the absence of angiographically significant stenotic lesion or the presence of a stenotic lesion of less than 50% according to

quantitative coronary angiography. The median follow-up period was 48 (39;62) months. There was seen a trend towards a clinical advantage in the DCAS group when analyzing the adverse cardiovascular events (13.3% vs. 23.1% in the ICAS group (p=0.1)). There were no significant advantages of one group over the other in mortality rate (9.3% vs. 11.7%), the incidence of recurrent myocardial infarction (2.6% vs. 5.1%), or repeated target vessel revascularization rates (1.3% vs. 6.4%) between the DCAS group and ICAS group, respectively.

## Discussion

Since primary PCI has become the mainstay of treatment for acute STEMI, interventional cardiologists around the world have to face the challenge of achieving adequate myocardial perfusion despite a successful restoration of the epicardial coronary artery lumen, i.e. the development of the unrestored coronary blood flow phenomenon. To achieve optimal myocardial perfusion in patients with a high level of thrombotic load in IRA, we applied the DCAS technique. To date, many studies have been published that evaluate the DCAS efficacy compared to the standard ICAS in preventing microvascular lesions in STEMI. The randomized studies conducted cannot demonstrate the clinical benefit of using the DCAS technique. This can be explained by the fact that when selecting patients for subsequent randomization, the patient initial angiographic and other data, being important initial factors for determining further tactics, are not taken into account. This assumption is also confirmed in the study by K. Isaaz et al. [16].

In our study we were guided by the criteria proposed in 2015 by B. Harbaoui et al. [17]. Factors that, according to the authors, should serve as a reason for choosing the DCAS strategy are the following: the presence of epicardial coronary blood flow on the TIMI scale of at least

3, the chest pain reduction, the ST segment resolution >50% on the ECG after the blood flow restoration, as well as the presence of a high level thrombotic load (TTG 3–4). Therefore, one of the most important criteria for our inclusion of patients in the DCAS group was the achievement of stable coronary blood flow in the IRA of at least TIMI 3 during the "index" procedure using MIMS. The second equally important inclusion criterion was the level of thrombotic load starting from TTG 3, i.e. a patient exclusively with massive coronary thrombosis of the IRA. In 2021, D. Luo et al. [18] conducted a study to determine whether the DCAS strategy could demonstrate a reduction in the development of the "slow/no-reflow" phenomenon and show an advantage in relation to MACE in patients with STEMI and TTG 3–5. According to the results obtained, the incidence of the “slow/no-reflow” phenomenon was statistically significantly lower in the DCAS group as displayed by achieving the myocardial perfusion MBG 2-3 in 100% of DCAS patients versus 53.1% in he ICAS group ($p<0.01$) [18, 19]. In our study, in the group of patients with DCAS, the angiographic primary endpoints were significantly better than in the ICAS, namely, higher TIMI and MBG scores. Another significant criterion that we were guided by in our study was the conduct of a delayed control CAG at least 5–6 days later followed by the stent implantation in case of angiographically significant stenosis delayed control CAG since it becomes clear that the period from the primary intervention to repeated CAG should be long enough, and this helps to improve clinical outcomes [20]. The optimal time interval made various groups of pharmacological drugs (anticoagulants, disaggregants, statins) pose their effect on the thrombus to the full, which contributed to the complete resorption of thrombotic masses in the IRA and stabilize the structure of the unstable plaque. To create optimal coagulation environment, the glycoprotein IIb/IIIa receptor inhibitors

were administered, since the use of glycoprotein IIb/IIIa receptor inhibitors in patients with STEMI is associated with a decrease in the overall mortality mainly caused by recurrent ischemic events [21]. Also, as part of complex therapy, high doses of statins were prescribed upon admission and before discharge, which makes it possible to influence the unstable atherosclerotic plaque, as well as improve the functional state of the endothelium and reduce the blood thrombogenic potential, and, equally important, statins demonstrate a lower incidence of MACE development after PCI [22].

In a recent randomized study by A.M. Magdy et al. [23] aimed at the treatment of patients with STEMI using DCAS and ICAS techniques, a delayed endovascular intervention demonstrated a definite advantage in achieving final coronary blood flow TIMI 3 and myocardial perfusion MBG 2 ($p=0.019$ and $p<0.001$). Moreover, the incidence of 6-month MACE was significantly higher in the ICAS group than in the DCAS group ($p=0.029$). In our study, we also obtained an obvious advantage in achieving myocardial perfusion according to angiography assessment; and the incidence of MACE tended to be lower in the DCAS group, but no statistically significant difference was achieved in overall mortality, the incidence of recurrent MI and target vessel revascularization.

## Conclusions

1. Application of the delayed coronary artery stenting technique in patients with acute ST segment elevation myocardial infarction caused by massive thrombosis (TTG 3–5) of the infarct-related artery demonstrates an advantage in the rate of achieving the optimal myocardial perfusion according to angiography assessments (TIMI, MBG) after the primary PCI (compared to the immediate coronary artery stenting group (88% vs. 69.2%, $p=0.005$).

2. The use of delayed coronary artery stenting in patients with acute ST-segment elevation myocardial infarction caused by massive thrombosis (TTG 3–5) of the infarct-related artery compared to immediate coronary artery stenting does not provide an obvious advantage in reducing overall mortality (9.3 % vs. 11.7%); however, when the incidence of adverse cardiovascular events has been analyzed, there is a trend towards a clinical advantage in the delayed coronary artery stenting group compared with the immediate coronary artery stenting group (13.3% vs. 23.1 %, p=0.1).)

## References

1. Boytsov SA, Shakhnovich RM, Erlikh AD, Tereschenko SN, Kukava NG, Rytova YK, et al. Registry of acute myocardial infarction. REGION-MI – Russian registry of acute myocar-dial infarction. *Kardiologiia.* 2021;61(6):41-51. (In Russ.). https://doi.org/10.18087/cardio.2021.6.n1595

2. Yamamoto MH, Kondo S, Mizukami T, Yasuhara S, Wakabayashi K, Kobayashi N, et al. TACTICS investigators. Rationale and design of the TACTICS registry: optical coherence tomography guided primary percutaneous coronary intervention for patients with acute coronary syndrome. *J Cardiol.* 2022;80(6):505–510. PMID: 35907707 https://doi.org/10.1016/j.jjcc.2022.07.002

3. Xiao Y, Fu X, Wang Y, Yanming F, Yanqiang W, Wenlu W, et al. Effects of different strategies on high thrombus burden in patients with ST-segment elevation myocardial infarction undergoing primary percutaneous coronary catheteri-zation. *Coron Artery Dis.* 2019;30(8):555–563. PMID: 30998610 https://doi.org/10.1097/MCA.0000000000000743

4. Russian Society of Cardiology. Clinical practice guidelines for Acute ST-segment elevation myocardial infarction. *Russian Journal of Cardio-logy.* 2020;25(11):4103. (In Russ.). https://doi.org/10.15829/1560-4071-2020-4103

5. Schwartz BG, Kloner RA. Coronary no reflow. *J Mol Cell Cardiol.* 2012;52(4):873–882. PMID: 21712046 https://doi.org/10.1016/j.yjmcc.2011.06.009

6. Caiazzo G, Musci RL, Frediani L, Umińska J, Wanha W, Filipiak KJ, et al. State of the art: no-reflow phenomenon. *Cardiol Clin.* 2020;38(4):563-573. PMID: 33036718 https://doi.org/10.1016/j.ccl.2020.07.001

7. Choo EH, Kim PJ, Chang K, Ahn Y, Jeon DS, Lee JM, et al. The impact of no-reflow phenomena after primary percutaneous coronary intervention: a time-dependent analysis of mortality. *Coron Artery Dis.* 2014;25(5):392–398. PMID: 24625688 https://doi.org/10.1097/MCA.0000000000000108

8. Alkhalil M, Kuzemczak M, Zhao R, Kavvouras Ch, Cantor WJ, Overgaard ChB, et al. Prognostic role of residual thrombus burden follo-wing thrombectomy: insights from the TOTAL trial. *Circ Cardiovasc Interv.* 2022;15(5):e011336. PMID: 35580203 https://doi.org/10.1161/CIRCINTERVENTIONS.121.011336

9. Harrison RW, Aggarwal A, Ou FS, Klein LW, Rumsfeld JS, Roe MT, et al. Incidence and outcomes of no-reflow phenomenon during percutaneous coronary intervention among patients with acute myocardial infarction. *Am J Cardiol.* 2013;111(2):178–184. PMID: 23111142 https://doi.org/10.1016/j.amjcard.2012.09.015

10. Choo E. Long-term prognostic impact of no-reflow phenomenon after primary percutaneous coronary intervention in patients

with ST-segment elevation myocardial infarction. *Circulation.* 2013;128(22):A15199.

11. Kelbæk H, Høfsten DE, Køber L, Helqvist S, Kløvgaard L, Holmvang L, et al. Deferred versus conventional stent implantation in patients with ST-segment elevation myocardial infarction (DANAMI 3-DEFER): an open-label, randomized controlled trial. *Lancet.* 2016;387 (10034):2199–2206. PMID: 27053444 https://doi.org/10.1016/S0140-6736(16)30072-1

12. Harbaoui B, Motreff P, Lantelme P. Delayed versus immediate stenting during STEMI: towards a «tailored» strate-gy for primary PCI? *Arch Cardiovasc Dis.* 2016;109(6–7):373–375. PMID: 27173055 https://doi.org/10.1016/j.acvd.2016.03.001

13. Ibanez B, James S, Agewall S, Antunes MJ, Bucciarelli-Ducci Ch, Bueno H, et al. 2017 ESC Guidelines for the management of acute myocardial infarction in patients presenting with ST-segment elevation: The Task Force for the management of acute myocardial infarction in patients presenting with ST-segment elevation of the European Society of Cardiology (ESC). *Eur Heart J.* 2018;39(2):119–177. PMID: 28886621 https://doi.org/10.1093/eurheartj/ehx393

14. Ganyukov VI. Deferred stent implantation in infarct related coronary artery in patients with ST-segment elevation myocardial infarction. *Russian Journal of Endovascular Surgery.* 2017;4(1):18–25. (In Russ.). https://doi.org/10.24183/2409-4080-2017-4-1-18-25

15. Azarov AV, Semitko SP, Glezer MG, Akhramovich RV, Maloroev AI, Melnichenko IS, et al. The results of delayed endovascular intervention in ST elevation acute myocardial infarction due to thrombotic occlusion of coronary artery. *Cardiovascular Therapy and Prevention.* 2017;16(1):40–45. (In Russ.). https://doi.org/10.15829/1728-8800-2017-1-40-45

16. Isaaz K, Gerbay A. Deferred stenting in acute ST elevation myocardial infarction. *Lancet.* 2016;388(10052):1371. PMID: 27707488 https://doi.org/10.1016/S0140-6736(16)31739-1

17. Harbaoui B, Courand P-Y, Besnard C, Dauphin R, Cassar E, Pierre L. Deferred vs immediate stenting in ST elevation myocardial infarction: potential inte-rest in selected patients. *Presse Med.* 2015;44(11):e331–e339. PMID: 26474832 https://doi.org/10.1016/j.lpm.2015.06.013

18. Luo D, Hu X, Sun S, Wang Ch, Yang X, Ye J, et al. The outcomes in STEMI patients with high thrombus burden treated by deferred versus immediate stent implantation in primary percutaneous coronary intervention: a prospective cohort study. *Ann Transl Med.* 2021;9(7):573. PMID: 33987271 https://doi.org/10.21037/atm-21-1130

19. Azarov AV, Semitko SP, Zhuravlev AS, Ioseliani DG, Kamolov IKh, Melnichenko IS, et al. Delayed endovascular surgery in patients with acute ST-segment elevation myocardial infarction due to massive culprit arterial thrombosis in the prevention of «slow/no-reflow» phenomenon. *Cardiovascular Therapy and Prevention.* 2021;20(5):2761. (In Russ.). https://doi.org/10.15829/1728-8800-2021-2761

20. Azarov AV, Glezer MG, Zhuravlev AS, Babunashvili AM, Semitko SP, Rafaeli NR, et al. The role of deferred stenting in the treatment of ST-elevation myocardial infarction: a systematic review and meta-analysis. *Almanac of Clinical Medicine.* 2022;50(2):77–93. (In Russ.). https://doi.org/10.18786/2072-0505-2022-50-018

21. Karathanos A, Lin Y, Dannenberg L, Parco C, Schulze V, Brockmeyer M, et al. Routine glycoprotein IIb/IIIa inhibitor therapy in ST-segment elevation myocardial infarction: a meta-analysis. *Can J Cardiol.* 2019;35(11):1576–1588. PMID: 31542257 https://doi.org/10.1016/j.cjca.2019.05.003

22. He W, Cao M, Li Z. Effects of diffe-rent doses of atorvastatin, rosuvastatin, and simvastatin on elderly patients with ST-elevation acute myocardial infarction (AMI) after percutaneous coronary intervention (PCI). *Drug Dev Res.* 2020;81(5):551–556. PMID: 32142170 https://doi.org/10.1002/ddr.21651

23. Magdy AM, Demitry SR, Hasan-Ali H, Zaky M, El-Hady MA, Ghany MA. Stenting deferral in primary percutaneous coronary intervention: exploring benefits and suitable interval in heavy thrombus burden. *Egypt Heart J.* 2021;73(1):78. PMID: 34499263 https://doi.org/10.1186/s43044-021-00203-3

**Information about the authors**

Alexey V. Azarov, Cand. Sci. (Med.), Associate Professor of the Interventional Cardioangiology Department of the Institute of Professional Education, I.M. Sechenov First Moscow State Medical University (Sechenov University); Head of the Department of Endovascular Treatment of Cardiovascular Diseases and Rhythm Disorder, Leading Researcher, Moscow Regional Research and Clinical Institute n.a. M.F. Vladimirskiy, https://orcid.org/0000-0001-7061-337X, azarov_al@mail.ru

30%, development of the study design, review of publications on the topic of the article, analysis of the data obtained, writing the text of the manuscript

Maria G. Glezer, Prof., Dr. Sci. (Med.), Professor of the Cardiology, Functional and Ultrasound Diagnostics Department of the Institute of Clinical Medicine n.a. N.V. Sklifosovsky, I.M. Sechenov First Moscow State Medical University (Sechenov University); Moscow Regional Research and Clinical Institute n.a. M.F. Vladimirskiy, https://orcid.org/0000-0002-0995-1924

20%, development of the study design, manuscript writing

Andrey S. Zhuravlev, Resident of the Interventional Cardioangiology Department of the Institute of Professional Education, I.M. Sechenov First Moscow State Medical University (Sechenov University); Junior Researcher of the Department of Endovascular Surgery, Moscow Regional Research and Clinical Institute n.a. M.F. Vladimirskiy, https://orcid.org/0000-0002-9130-707X

10%, analysis of the data obtained

Ionatan R. Rafaeli, Dr. Sci. (Med.), Cardiovascular Surgeon of the Scientific and Practical Center for Interventional Cardioangiology, I.M. Sechenov First Moscow State Medical University (Sechenov University), https://orcid.org/0000-0002-0495-2645

10%, manuscript editing

Sergey P. Semitko, Dr. Sci. (Med.), Professor of the Interventional Cardioangiology Department of the Institute of Professional Education, Director of the Scientific and Practical Center for Interventional Cardioangiology, I.M. Sechenov First Moscow State Medical University (Sechenov University), https://orcid.org/0000-0002-1268-5145

10%, analysis of the data obtained

Karen V. Gyulmisaruyan, Endovascular Surgeon of the Scientific and Practical Center for Interventional Cardioangiology, I.M. Sechenov First Moscow State Medical University (Sechenov University); https://orcid.org/0000-0002-8985-2220

10%, obtaining data for analysis

Sergey A. Kurnosov, Researcher of the Department of Endovascular Surgery, Moscow Regional Research and Clinical Institute n.a. M.F. Vladimirskiy, https://orcid.org/0000-0001-6820-1536

10%, manuscript editing

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