Recanalization of coronary arteries in patients with acute myocardial infarction

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Abstract. The work is devoted to the study of early and delayed postoperative angiographic results in patients with acute myocardial infarction (AMI). The survey included 626 patients with AMI without ST elevation, who underwent diagnostic and therapeutic interventional procedures for this pathology in the Angiographic Department of National Amosov Institute of Cardiovascular Surgery of the National Academy of Medical Sciences of Ukraine. The average age of patients was 66.96 ± 1.81 years; the average weight was 86.5 ± 1.44 kg. The area of the left ventricular (LV) myocardial infarction in the calculation of the QRS index was an average of 20.4 ± 1.2%. 438 patients (69.97%) were with II KC heart failure by T. Killip. Primary transcutaneous transluminal balloon angioplasty (PTTBA) was performed in 332 patients who were examined at the early stages of AMI, and 294 patients underwent surgical stenting of the infarctrelated artery (IRA) with single-stent implantation. The research has showed that primary stenting was the most effective method for recanalization compared with emergency or delayed IRA stenting, manifested in a more significant decrease in the area of primary AMI compared with emergency stenting and delayed intervention. In the group of patients who underwent IRA stenting, a correlation relationship was found between the development of residual coronary artery stenosis of more than 30% and baseline LV ejection fraction, baseline IRA blood flow and the ratio between the coronary artery diameter and the implantable stent diameter. In a statistically equal number of cases of clinical success, hospital mortality was higher upon IRA stenting by 3% compared with PTTBA. However, the delayed results of the three-month follow-up showed the benefits of stenting over PTTBA in terms of lower rates of myocardial infarction reocclusion (by 11.3%) and lower rates of delayed three-month lethality (by 6.7%).

Keywords: recanalization; acute myocardial infarction; coronary arteries.

Currently coronary heart disease (CHD) is the most common pathology in the world [1]. So, according to the American Heart Association, one out of every three deaths in the United States is associated with cardiovascular disease [1].

Recently CHD-associated primary disability parameters have been consistently ranked first among the causes of primary disability in the adult population of Ukraine and recorded almost at the same level (20.1% in 2009, 19.9% in 2010, 20.1 % in 2011, and 19.5% in 2012) [2, 3].

Endovascular recanalization of the infarct-related artery (IRA) is one of the effective ways to reduce the percentage of fatal CHD outcomes [4]. Indeed, primary percutaneous coronary intervention with stent implantation is currently standard therapy for patients with acute ST-elevation myocardial infarction (STEMI) [5]. However, despite the introduction of new technologies and techniques in the interventional therapy of AMI, the use of modern stents and balloons, development of effective methods of pharmacological support for X-ray and endovascular recanalization, as well as accumulation of experience of specialists, the percentage of periprocedural complications in patients with AMI remains high [5].

Recent research focuses on the reduction of negative periprocedural clinical events, including ischemia, bleeding, and mortality [6]. However, according to Qiao J. et al., modern studies demonstrate inconsistency of approaches not only to the strategy but also to the temporary tactics of stenting [4].

The **purpose** of this work was to study early and postponed postoperative angiographic results during X-ray and endovascular recanalization of coronary arteries in patients with acute myocardial infarction.

Materials and methods of the study

The study included 626 patients with acute myocardial infarction without ST elevation, who underwent diagnostic and therapeutic interventional procedures for this pathology in the X-Ray Angiographic Department of National Amosov Institute of Cardiovascular Surgery of the National Academy of Medical Sciences of Ukraine.

The age of patients ranged from 62 to 73 years (on average 66.96 ± 1.81 years). The average weight was 86.5 ± 1.44 kg (from 67 kg to 102 kg).

All patients were examined in accordance with the protocol adopted by National Amosov Institute of Cardiovascular Surgery of the National Academy of Medical Sciences of Ukraine for this category of patients.

AMI was diagnosed on the basis of clinical data (an intensive angina attack is not stopped for more than 30 minutes); ECG data (ST segment depression from the isoline by no less than 2 mm, T-wave inversion); complete blood count parameters: leucocytosis, increased serum enzymes (troponin I, CPK-MB, AST, LDH)); heart ultrasound findings (detection of akinetic regions).

The average time of admission of patients to the department from the onset of AMI symptoms was 115.4 ± 37.4 min.

The area of left ventricular (LV) myocardial damage in the calculation of the QRS index was on average 20.4 ± 1.2%. 438 patients (69.97%) were with II KC heart failure by T. Killip.

Radial access was used in 94.1% of cases, femoral – in 5.9% of patients. Occlusion of the arterial lumen more than 50% was considered hemodynamically significant.

332 subjects examined at the early stages of myocardial infarction (MI) underwent primary balloon angioplasty in IRA, and 294 patients underwent IRA stenting concomitantly with implantation of stents in different coronary arteries. The total number of implanted stents was 415 (an average of 1.4 ± 0.3 per patient).

The procedure for X-ray-endovascular stenting was performed according to standard procedures. Routine therapy during angioplasty included nitrates, clopidogrel, and heparin. Each operator individually determined the technical aspects of the procedure, including the choice of the stent and balloon, the duration of inflation and pressure. In 26.9% of cases, X-ray endovascular interventions were combined with thromboaspiration in connection with the detection of coronary artery thromboses.

The statistical processing of the results was carried out using Excel 2007 programs for Microsoft Office and Statistica 6.0, using statistical methods that included parametric and non-parametric tests, regression analysis. The obtained results were statistically significant at p <0.05.

Results and discussion

70.4% of the patients underwent primary stenting, 18.7% of the patients underwent emergency stenting, and 10.9% of the subjects underwent delayed stenting (Table 1). The order of stenting was determined by the time of admission of the patients at the surgical department. At the same time, with a total mortality of 5.1%, the number of fatal results in primary stenting was by 13.1% less compared with emergency stenting and by 11.1% – compared with delayed stenting (p <0.01) (Table 1).

The comparative characteristic of primary, emergency and delayed stenting outcomes is shown in Table 1.

Table 1

Primary, emergency and delayed stenting outcomes in patients with AMI

Stenting type	Number of patients		Fatal outcome	
	n	%	n	%
Primary stenting	207	70.4	3	1.4^{1}*/1.02^{2}
Emergency stenting	55	18.7	8	14.5^{1}/ 2.7^{2}
Delayed stenting	32	10.9	4	12.5^{1}/1.4^{2}
Total	294	100	15	/5.1^{2}

Note. [1] – percentage relative to the number of patients in their group; [2] – percentage relative to the total number of patients who underwent stenting; * - p <0.01 relative to the parameters of the parallel group.

The highest percentage of fatal cases was observed in patients who had clinically confirmed myocardial ischemia for more than 90 minutes and who then underwent emergency stenting of the IRA (Table 1). A significant percentage of fatal outcomes was recorded in the group of patients with delayed stenting of coronary arteries (CAs), which, however, was 2% less than in the group of emergency stenting (p> 0.1) (Table 1).

In spite of endovascular coronary revascularization, the initial AMI, which was diagnosed initially during hospitalization of patients in the clinic, had the form of large-focal MI in 0.97% of cases (2 patients) after primary stenting, a similar pattern was observed in 7 patients (12.7% of cases) after emergency stenting and, this form of MI was reported in 4 patients (12.5% of cases) after delayed stenting (Fig. 1).

After angioplasty, the initial MI decreased to small-focal in 61 of the patients (29.5% of cases) after the primary intervention, which was by 23.2% less compared with the group of patients who underwent emergency stenting (52.7% of the cases (29 patients)) (p = 0.00247). Compared with patients who underwent delayed interventions, this parameter was lower by 36.1% (p = 0.00139) (Fig. 1). The difference between the emergency and delayed stenting groups in terms of small-focal MI was 12.9% in favour of the emergency stenting group (p = 0.00145) (Fig. 1).

It is interesting to note that the absence of ECG-signs of myocardial infarction was mainly observed in 69.5% of patients after the primary stenting procedure, in 34.4% of cases – after the emergency procedure and 29.1% - after the delayed procedure (Fig. 1).
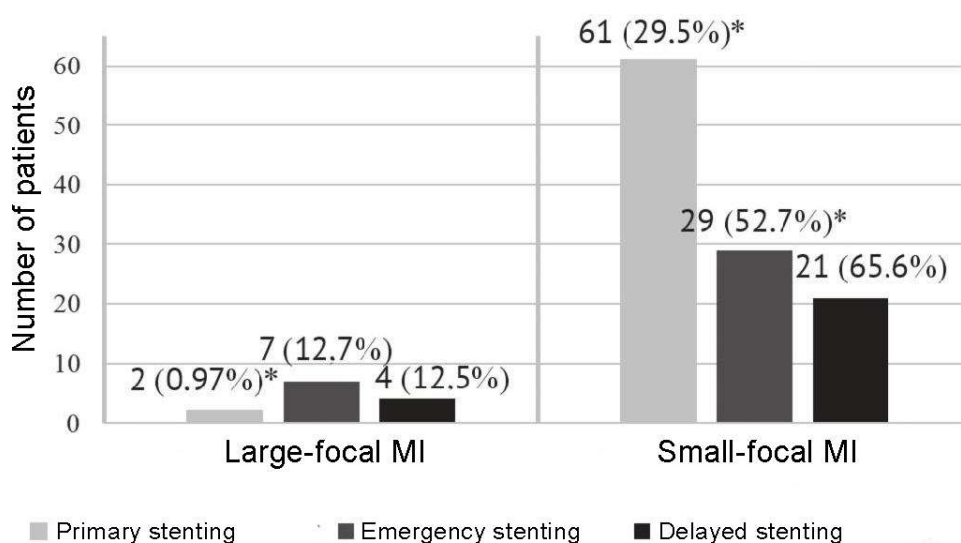

Fig. 1. The course of initial AMI after endovascular intervention in the examined groups

Note. * – p <0.05

In the group of patients who underwent emergency stenting, in 5.5% of cases (3 patients), acute stent thrombosis was observed in the first 4-12 hours after the X-ray endovascular intervention and in 1.8% of cases (1 patient) – on day 2 of the disease. Two patients (3.6% of cases) with stent thrombosis underwent mechanic recanalization and repeated transcutaneous transluminal balloon angioplasty (TTBA) of the occlusion (one patient with repeated MI underwent mechanic recanalization of subacute stent thrombosis, which was unsuccessful), and in one case with a fatal outcome the attempt to perform a repeated TTBA failed.

In the group of patients with delayed stenting, in the first hours after the endovascular recanalization of the CA, 6.2% of the cases (2 patients) showed acute stent thrombosis, requiring repeated TTBA, with a positive effect. Another two patients developed subacute stent thrombosis, which in one case caused a fatal outcome, and in the other – caused the development of MI relapse.

Thus, comparing the characteristics of the complications that arose during stenting carried out at different times after MI development (emergency stenting, primary stenting, delayed stenting), it can be concluded that primary stenting was the most effective method for restoring blood flow in the ischemic zone of the myocardium.

In the course of our work, we conducted a cross-correlation analysis to identify possible risk factors for the development of residual stenosis during IRA stenting procedures in patients with AMI. The analysis showed a moderate positive correlation relationship between the development of residual CA stenosis of more than 30% and parameters such as baseline left ventricular ejection fraction ($r = 0.425$; $p = 0.0025$), baseline blood flow along the IRA ($r = 0.418$; $p = 0.0047$), and the ratio between the diameter of the coronary artery and the diameter of the implanted stent ($r = 0.523$; $p = 0.0031$) in the group of patients who underwent IRA stenting.

The angiographic examination of the lateral branches with bifurcation IRA damage demonstrated that during primary and delayed stenting, bifurcation IRA damage was detected in 28.6% of cases (84 patients) and in 32.3% of cases (95 patients), respectively. However, stenting resulted in occlusion of the lateral branch ($p > 0.05$) only in 40 (13.6% of cases) and 32 (10.9% of cases) of the patients. With TTBA, occlusion of the lateral branch after the procedure was observed in 17.8% of cases (59 patients).

Thus, in the course of X-ray-endovascular coronary angioplasty (both with TTBA, and with stenting), in most cases, there was no occlusion of the lateral branches originating from the site of the procedure. At the same time, occlusive

damage of lateral branches was observed in a lesser percentage of cases with IRA stenting compared with TTBA.

It should be noted that in the vast majority of cases, occlusion of the lateral branches following X-ray endovascular procedures was not accompanied with negative ECG changes with the expanded damage zone or negative clinical changes. This can be explained by the fact that there was no effective blood flow in these branches from the very beginning, since they were distal to the occlusive IRA damage, and the restoration of their functional activity only occurred after the IRA recanalization.

In a large number of patients, endovascular procedures determined the stabilization of the clinical condition and absence of angina attacks. However, a comparative analysis between a group of patients who underwent stenting and patients who underwent balloon angioplasty showed that in the group of patients following stenting, the absence of angina was reported 7.5% more often than in the group of patients following TTBA (p = 0.04328) (Table 2).

Table 2. Clinical outcomes reported in patients with AMI after X-ray endovascular procedures

Parameter	Stenting (n=294)	TTBA (n=332)
No angina	122 (41.5%)*	113 (34%)
Thrombosis/reocclusion (TIMI 0-1)	8 (2.7%)	17 (5.1%)
Re-intervention (TTBA, stenting, CABG)	26 (8.8%)*	14 (4.2%)
Clinical success	255 (86.7%)	271 (81.6%)
Hospital mortality (10 days)	15 (5.1%)*	7 (2.1%)
Repeated MI in the IRA territory	16 (5.4%)*	55 (16.7%)
Delayed mortality (3 months)	12 (4.1%)*	36 (10.8%)

Note. * – p< 0.05

Complications in the form of IRA thrombosis/reocclusion were reported 2.4% less with stent implantation (p = 0.1729), and the number of repeated interventions was twice lower in patients following balloon angioplasty (p = 0.0041) (Table 2)

With the statistically same number of cases of clinical success (p = 0.6751), hospital mortality was 3% higher with CA stenting (p = 0.0137) (Table 2). However, the remote results of the three-month follow-up showed the benefits of stent implantation in terms of lower frequency of recurrent MI in the IRA territory, which was 11.3% more frequent in patients with balloon angioplasty (p = 0.01328). In addition, the rates of delayed three-month mortality were 6.7% lower in the stenting group compared with the TTBA group (p = 0.01159) (Table 2, Figure 2).
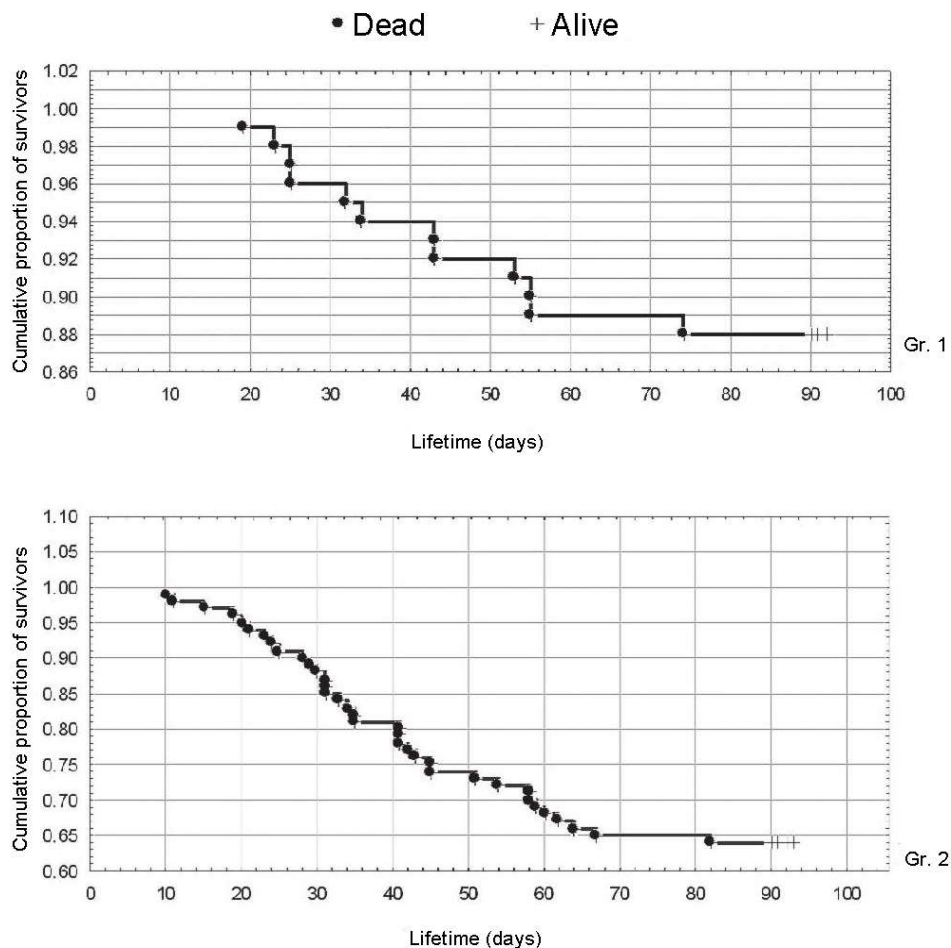
Fig. 2. Curves of cumulative survival in the delayed period in the subjects

Note. Group 1 – Cumulative survival curve in the delayed period in patients with AMI who underwent CA stenting; Group 2 – Cumulative survival curve in the delayed period in patients with AMI who underwent TTBA

Conclusions

1. Primary stenting was the most effective recanalization method compared with emergency or delayed stenting of the infarct-related artery, which was manifested in a more significant decrease in the area of primary AMI compared with emergency stenting and delayed intervention.

2. There was a correlation relationship between the development of residual stenosis of the coronary artery of more than 30% and baseline left ventricular ejection fraction, baseline blood flow along the infarct-related artery, and the ratio between the diameter of the coronary artery and the diameter of the implanted stent in the group of patients who underwent stenting of the infarct-related artery.

3.With the statistically same number of cases of clinical success, hospital mortality was 3% higher with stenting of the infarct related artery compared with transcutaneous transluminal balloon angioplasty. However, the remote results of the three-month follow-up showed the benefits of stenting over transcutaneous

transluminal balloon angioplasty in terms of lower frequency of recurrent MI (by 11.3%) and lower rates of delayed three-month mortality (by 6.7%).

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