EARLY SURGICAL MYOCARDIAL REVASCULARIZATION AS AN EFFECTIVE METHOD OF TREATING PATIENTS WITH ACUTE CORONARY SYNDROME

SHNEIDER YU.A., TSOI V.G., FOMENKO M.S.

Federal Centre of High Medical Technologies, RF Ministry of Public Health, Kaliningrad, Russia

Background. One of the main methods of treating patients with acute coronary syndrome (ACS) is percutaneous coronary intervention (PCI), however in patients with multivascular, abnormal, or technically complicated coronary lesions, early surgical myocardial revascularization is more promising. Despite modern development of surgical and interventional techniques, the application of one strategy for all patients with acute coronary syndrome is problematic and should be based on the heart team's decision and patient data.

Objective. The study was aimed at assessing the results of early surgical myocardial revascularization in patients with acute coronary syndrome.

Patients and methods. Retrospectively with continuous sampling the study included 342 patients who underwent surgical treatment of acute coronary syndrome at the Federal Centre of High Medical Technologies from January 1st, 2014 to December 31st, 2018. Myocardial revascularization using two internal thoracic arteries was performed in 220 (64.3%) cases. The mean age of the patients was 64.2±10.8 years. Prevailing in the study were men – 69.3%. The average number of affected vessels amounted to 3.1±0.9. Fifty-six (16.4%) patients had cardiogenic shock at the time of operation, with 9 (2.6%) patients diagnosed as having severe mitral insufficiency and 5 (1.5%) with interventricular septal defect. All patients were on antiplatelet therapy.

Results. In-hospital mortality was 5.2% (18 patients). The mean time of operation amounted to 205.3±58.9 min, with that of artificial circulation to 57.9±13.2 min. Such complication as postoperative haemorrhage was observed in 20 cases (5.8%). The average volume of drainage losses amounted to 507.3±66.7 ml. The average length of stay in the ICU was 3.8±1.4 days, with that of hospital stay being 16.6±2.1 days. Twenty-seven (7.9%) patients after removal of drainages were diagnosed as having exudative pericarditis which resolved on the background of medicamentous therapy.

Conclusions. Early surgical myocardial revascularization in patients with acute coronary syndrome may be performed safely and effectively, and should be considered individually in each patient by the heart team.

Key words: *coronary artery disease, acute coronary syndrome, coronary artery bypass grafting, percutaneous coronary intervention, heart failure.*

INTRODUCTION

In the modern world, one the main causes of death according to the WHO is cardiovascular disease (CVD). But the leading role in the group of CVD according to the world statistics has increasingly been assumed by coronary artery disease (CAD) [1]. This is attributable to manifestation of CAD in the majority of cases as acute coronary syndrome (ACS) [2, 3]. Despite various manifestations of ACS as unstable angina pectoris or ST-segment elevation or non-ST-segment elevation myocardial infarction (MI), the main cause is acute impairment of blood flow through coronary arteries [1, 4–6]. Given (Taking into account) the pathogenesis, myocardial ischaemia remains the main problem of this pathology causing death of cardiomyocytes, consequently resulting in life-threatening arrhythmias, decreased myocardial contractility and chronic heart failure, also influencing patient's survival [1]. Considering all the above mentioned, the main policy and purpose of treating this patient cohort are aimed at restoring blood flow in the ischaemia zone and preventing damage of extensive myocardial zones using various methods [1, 2].

Based on the results of numerous studies and according to guidelines on myocardial revascularization in patients with ACS, the most promising and recommended method remains percutaneous coronary intervention (PCI) within the infarct-related zone, however, the policy of blood flow restoration depends not only on the degree of myocardial damage, the presence of ST-segment elevation, but also on the decision of the heart team [7, 8]. Thus, performing primary PCI in patients with ST-segment elevation remains indisputable by recommendations, and therapeutic policies in patients

with non-ST-elevation are more diverse. Some authors consider ischaemia less critical in unstable angina and non-ST-segment elevation ACS than in ST-segment elevation ACS, and hence manage the patients less aggressively, performing in this patient cohort delayed coronary artery bypass grafting (CABG), demonstrating a decrease in perioperative risks. This is based on the fact that patients without ST-segment elevation are older, having more concomitant diseases and a more pronounced atherosclerotic lesions of coronary arteries, whereas the strategy of CABG proved more effective than that of PCI [2, 4]. However, in patients with ST-segment elevation impossibility of performing primary PCI or failed PCI, abnormal of multivessel lesions of the coronary bed, the development of cardiogenic shock or valvular pathology lead to performing CABG as the only way out. Previously published studies demonstrated possibility of performing CABG procedure in this patient cohort with good clinical outcomes, but using these operations has been considered to be limited and the choice to perform CABG is left to the heart team's discretion in each individual case [7, 8].

Our study demonstrated retrospective results of surgical treatment of patients with ACS. It was aimed at assessing the results of early surgical myocardial revascularization in patients with ACS.

PATIENTS AND METHODS

At the Federal Centre of High Medical Technologies of the city of Kaliningrad, between January 1st, 2014 and December 31st, 2018, a total of 12 249 operative interventions on coronary arteries (PCI and CABG) were performed. Elective interventions on coronary arteries were carried out in 9122 (74.5%) cases and emergency or urgent interventions in 3127 (25.5%) cases, respectively. We retrospectively evaluated the group of patients who underwent operative interventions for emergency or urgent indications. The inclusion criteria were patients with ACS subjected to open operation – CABG. Mortality was defined as the primary endpoint. Surrogate endpoints for analysis were as follows: acute myocardial infarction (AMI), acute cerebrovascular accidents (ACVA), and infectious wound complications. For the study, we selected 342 patients subjected to emergency or urgent CABG (Fig. 1).

The indications for surgical treatment were based on the guidelines on myocardial revascularization. Taking into account the principles of Good Clinical Practice (GCP) outlined in the Declaration of Helsinki, the patients were informed on the forthcoming scope of surgical treatment, having signed the informed consent for the operation and processing of the personal data in the study.

The main anthropometric and clinical characteristics of the patients are shown in Table 1. The patients

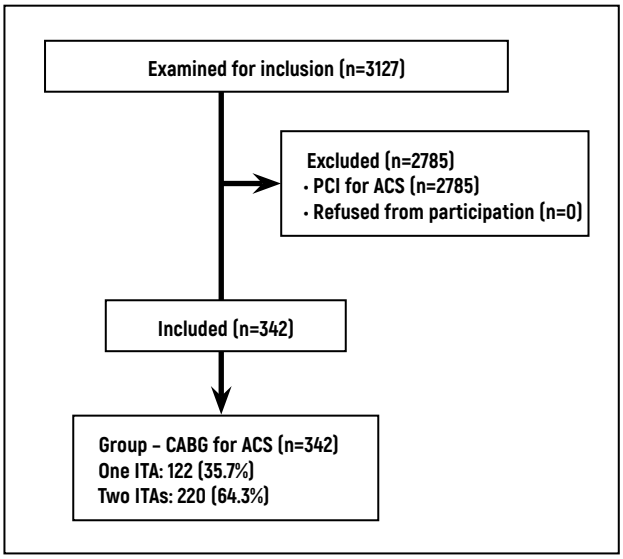

Fig. 1. Diagram of movement of patients in the study

Table 1

Anthropometrical and clinical characteristics of patients

Parameters	CABG in ACS (n=342)
Age, M±SD, years	64.2±10.8
Gender – male, %	237 (69.3%)
BMI, M±SD	30.5±5.1
Average number of affected vessels, M±SD	3.1±0.9
EuroSCORE II, M±SD	5.8±1.9%
Severe MR, %	9 (2.6%)
IVSD, %	5 (1.5%)
EDV, M±SD, ml	80.2±24.4
LVEF, M±SD,%	46.5±5.1
Cardiogenic shock IABP ECMO	56 (16.4%) 24 (7%) 12 (3.5%)
Concomitant pathology	
COPD	15 (4.4%)
CKD	11 (3.2%)
Diabetes mellitus	48 (14%)

Note: CABG – coronary artery bypass grafting, ACS – acute coronary syndrome, BMI – body mass index, MR – mitral regurgitation, IVSD – interventricular septal defect; EDV – end-diastolic volume, LVEF – left ventricular ejection fraction, IABP – intra-aortic balloon pump, ECMO – extracorporeal membrane oxygenation, COPD – chronic obstructive pulmonary disease, CKD – chronic kidney disease.

who required cardiological support with one or more agents at average doses at the time of hospitalization were assigned to the group of cardiogenic shock (56 (16.4%) patients). During preoperative preparation, 9 (2.6%) patients had been diagnosed with severe mitral insufficiency and 5 (1.5%) with interventricular septal defect (IVSD). The findings of electrocardiogram revealed ST-segment elevation in 91 (26.6%) patients. Of concomitant pathology, the most common was diabetes mellitus registered in 48 (14%) cases. Predicted

Table 2

Results of intraoperative period of CABG

Parameters	CABG in ACS (n=342)
Mean operative time, M±SD, min	205.3±58.9
Average AC duration, M±SD, min	57.9±13.2
One ITA, %	122 (35.7%)
Two ITAs, %	220 (64.3%)
Closure of IVSD, %	5 (1.5%)
MV plasty, %	9 (2.6%)
In conditions of AC and cardioplegia	245 (71.6%)
Parallel AC	66 (19.3%)
Off-pump	31 (9.1%)
CABG combined with CAE (simultaneously)	26 (7.6%)
Time elapsed from symptom onset of to CABG: <12 hours from 12 hours to 7 days from 7 days to 14 days	 21 (6.1%) 75 (21.9%) 246 (72%)

Note: AC – artificial circulation; ITA – internal thoracic artery, IVSD – interventricular septal defect, MV – mitral valve, CEA – carotid endarterectomy.

mortality by the EuroSCORE II scale amounted to 5.8±1.9%. Analysis of unfavourable outcome was assessed by the GRACE scale (Global Registry of Acute Coronary Events) and severity of lesions of coronary arteries by the SYNTAX (Synergy between Percutaneous coronary intervention with Taxus and Cardiac Surgery) score, which amounted for the entire group of patients to 125.7±31.2 and 29.8±11.5, respectively.

SURGICAL TECHNIQUES

Operations were performed via median sternotomy in all cases. The selection of conditions for carrying out the operation: off-pump/in conditions of parallel artificial circulation (AC)/in conditions of AC and cardioplegia was based on the patient's state, severity of coronary artery lesions, and ultrasonographic parameters of the heart. In a stable condition of the patient and good anatomy of coronary arteries, the operation was performed in off-pump conditions, and vice versa, in large dimensions of the heart, critical lesion of the coronary bed, instability of haemodynamics the procedure was carried out in conditions of parallel AC or AC with cardioplegia. The del Nido solution was used for cardioplegia. Internal thoracic arteries (ITA) were exposed according to the technique of skeletonization using diathermocoagulation in 100% of cases. A venous graft was harvested in a fascial flap in 100% of patients. Myocardial revascularization using two ITAs was carried out in 220 (64.3%) cases, sequential bypass grafting and formation of T/Y shunts were performed in 49 (14.3%) and 33 (9.6%) patients, respectively (Fig. 2). With the slightest uncertainty as to patency of shunts, we performed cardiac echocardiography and coronary bypass angiography.

STATISTICAL ANALYSIS

The data were analysed using the software package Stata/SE 13.0 (StataCorp LP, USA). Statistical hypotheses on the type of distribution were tested by means of the Shapiro–Wilk's criterion W. The results were expressed as arithmetic mean and standard deviation (M±SD) for continuous variables, with categorical variables presented as units and percentages (proportions).

RESULTS

We analysed the immediate outcomes of treatment of patients with ACS who underwent open myocardial revascularization.

Of the 342 eligible patients, in 246 (72%) subjects operative intervention was performed from the time of admission on day 7–14, in 75 (21.9%) patients from 12 hours to 7 days and in 21 (6.1%) patients within

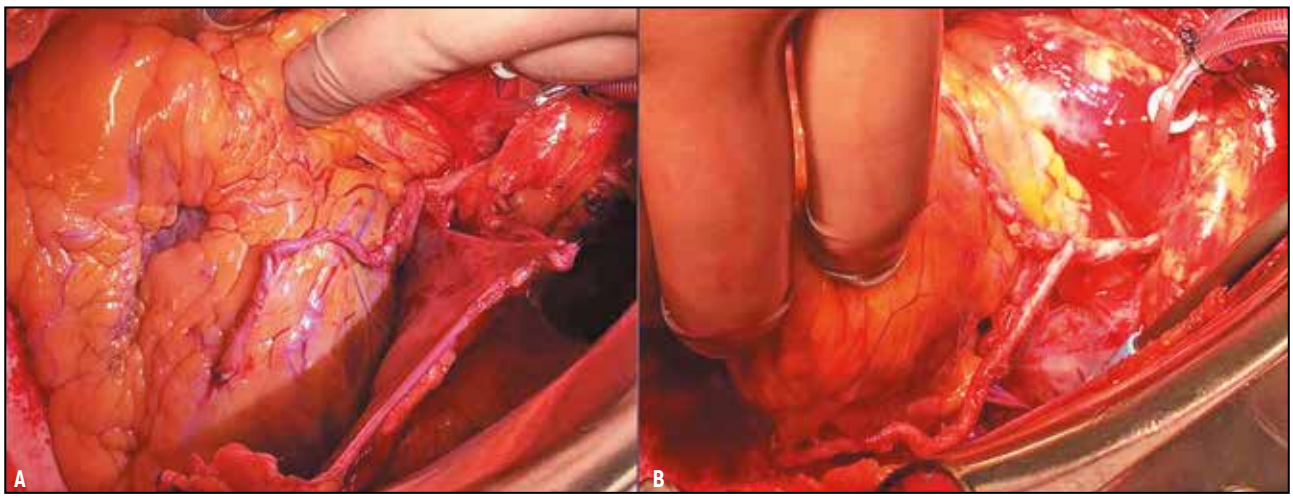

Fig. 2. Intraoperative image. A – sequential bypass grafting; B – T/Y shunt

the first 12 hours. The average time of operation and AC amounted to 205.3±58.9 min and 57.9±13.2 min, respectively (Table 2).

During CABG, 5 (1.5%) patients additionally underwent closure of IVSD and 9 (2.6%) patients underwent correction of mitral regurgitation (MR) resulting from the development of postinfarction IVSD and MR. Given concomitant lesions of the coronary and brachiocephalic basins, in 26 (7.6%) cases CABG was supplemented by carotid endarterectomy performed from the respective basin. Other peculiarities of the intraoperative period are shown in Table 2.

There were 18 (5.2%) in-hospital lethal outcomes. Analysing lethal outcomes according to the carried out operations demonstrated that the majority of lethal outcomes occurred in patients subjected to operative intervention within the first 12 hours (17 patients). In this group, all patients had ACS with ST-segment elevation and cardiogenic shock, 10 patients received intra-arterial balloon counterpulsation and 7 patients extracorporeal membrane oxygenation. All operations were carried out according to vital indications. Despite successful operations, 14 patients on POD 4–7 developed multiple organ failure followed by a lethal outcome, and in 3 cases the postoperative period was complicated by severe ACVA which also resulted in unfavourable outcomes. The group of patients subjected to operative treatment within the period from 12 hours and more demonstrated minimal mortality. This was most likely accounted for by a more stable state of patients.

Analysing the results of operations and their complications demonstrated the absence of perioperative myocardial infarction, however to completely exclude this possibility is difficult, taking into account the fact that all patients at the time of surgery had elevated troponin I, whose subsequent elevation was regarded as a clinical course of ACS. The most common in the postoperative period was acute kidney failure encountered in 21 (6.1%) patients. Thirty-nine (11.4%) patients in the early postoperative period were found to have an increased rate of discharge on drainages, however after haemostatic therapy only 20 (5.8%) patients required resternotomy, and 10 (2.9%) patients required connection to the Cell Saver device. The characteristics of the postoperative period are shown in Table 3.

Despite antiplatelet therapy at the time of operation: 146 (42.7%) patients on monotherapy, 196 (57.3%) patients on dual therapy, and 256 (74.8%) patients additionally receiving low-molecular weight heparins, the average volume of drainage losses did not significantly increase (Table 3.). Twenty-seven (7.9%) patients after removal of the drainages were diagnosed with exudative pericarditis which resolved on the background of medicamentous therapy. At discharge, the average detachment of pericardial leaflets amounted to 5±3 mm.

Table 3

Postoperative period of CABG

Parameters	CABG for ACS (n=342)
ACVA in early postoperative period, %	5 (1.4%)
AKF in early postoperative period, %	24 (7%)
MOF in the postoperative period, %	21 (6.1%)
Haemotrasfusions, %	71 (20.7%)
Resternotomy for haemorrhage, %	20 (5.8%)
Average volume of drainage losses, M±SD, ml	507.3±66.7
Infectious sternal complications, %	11 (3.2%)
Mean ICU length of stay , M±SD, days	3.8±1.4
Average length of hospital stay, M±SD, days	16.6±2.1
Mortality, %	18 (5.2%)
Depending on time elapsed from onset of event to CABG: <12 hours from 12 hours to 7 days from 7 to 14 days	 17 1 0

Note: ACVA – acute cerebrovascular accident, AKF – acute kidney failure; MOF – multiple organ failure, MOF - multiple organ failure.

DISCUSSION

In our work we presented the results of a single-centre retrospective study demonstrating possibilities of performing CABG in patients with ACS.

PCI remains the gold standard of revascularization in ACS, being in the majority of cases a rapid, efficient and widely available method. However, timely and complete myocardial revascularization is a pledge of patients' survival in the remote period, improving quality of life and increasing social adaptation. Taking into account this circumstance, the method of revascularization should also be based on the degree, severity and extension of the lesion of the coronary bed. CABG in patients with multivascular lesions has an additional advantage in relation to the remote results [1, 2, 7, 8].

High mortality in a natural course of ACS calls for performing myocardial revascularization within the shortest terms. Analysing international guidelines on revascularization of patients with ACS does not provide clear-cut algorithms of treatment and the European guidelines leave the choice of the method of revascularization in patients only with non-ST-elevation ACS to the discretion of the heart team with due regard for the degree of coronary artery lesions and patient's comorbidity. Taking into account the above mentioned, in surgery of ACS there are debates regarding the time of carrying out the operation. The majority of studies demonstrated increased risks of urgent and emergency operative interventions in these groups of patients and consequently high rates of mortality [7–9].

Based on analysing the obtained findings, the patients in our study were divided according to the time between onset of event and surgery: <12 hours, from 12 hours to 7 days and form 7 to 14 days. In this analysis we did not distribute the patients into groups of ACS (with/without ST-segment elevation). The results of this analysis confirmed increased risk of operation and, certainly, high rates of mortality in patients exposed to operative intervention within the first 24 hours, however operations within the first 24 hours were carried out in patients with critical lesions of coronary arteries, being on cardiotonic support. The work of M.A. DeWood, et al. in the early 1980s demonstrated advantages of early CABG in this patient cohort, however, cardiac surgery in this field has undergone evolution in both technologies of carrying out the operations and support thereof, having improved the results of treating ACS [10].

Subsequent retrospective works demonstrated advantages of CABG postponed by 3 days and more, if possible, in patients after AMI. Thus, D.S. Lee, et al. based on the findings of the database of the New-York State demonstrated that the risk of early CABG within 3 days was considerably higher and mortality increased two-fold as compared with similar analogous operations performed later [11, 12]. P. Voisine, et al. in their work concluded that CABG is desirable to be postponed to 7 days after AMI [13].

First studies were carried out in the epoch before wide implementation of PCI and thrombolysis in ACS. And early CABG had positive correlation between mortality and transmural myocardial lesions. Furthermore, with the development of technologies, the majority of works demonstrated advantages of delayed operative intervention. Recent retrospective works showed no difference between the early and delayed invasive policy [3, 14, 15]. Thus, L. Bonello, et al. having conducted a meta-analysis revealed no time-related difference in mortality or recurrent MI between the groups [14]. In 2019, R. Yoshida, et al. concluded that early invasive strategy was associated with lower risk of mortality, the development of life-threatening arrhythmias and recurrent MI in the remote period of follow up, even in patients with concomitant diseases [15]. From these works were excluded the patients with cardiogenic shock and surgically significant lesions of heart valves, which, in our opinion, may be meaningful only for an identical patient cohort.

Our findings demonstrated relatively satisfactory results of CABG in patients with ACS, not dividing into groups (with/without ST-segment elevation). The use of two ITAs makes it possible to hope for better remote results than PCI. Besides, mention should be made that early revascularization decreases the time of myocardial ischaemia. Nevertheless, there are studies associating early CABG after AMI with high operative mortality [3, 7, 8]. This may be related to surgical difficulties during CABG at an early stage of AMI due to oedema, induration, and fragility of myocardial tissue, thus leading to heart injuries even in gentle handling.

CONCLUSION

At the present stage of treatment of ACS, early surgical myocardial revascularization may be performed relatively safely and efficiently, and should be considered in each patient individually by the heart team. The use of modern methods of operative treatment, advanced anaesthesiological support and postoperative algorithms for management of patients makes it possible to improve the immediate results of treatment. The best results were obtained in patients without cardiogenic shock when the operation was performed later than 12 hours after the onset of AIM.

LIMITATION

This was a single-centre, retrospective study. According to the obtained findings, the results may be considered for an identical group. Completeness of the study requires assessment of remote results.

Conflict of interest: none declared.

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Адрес для корреспонденции:
Фоменко М.С.
Тел.: +7 (961) 218-30-98
E-mail: fomenko.ms@kldcardio.ru

Correspondence to:
Fomenko M.S.
Tel.: +7 (961) 218-30-98
E-mail: fomenko.ms@kldcardio.ru