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ОПЕРАЦИИ НА РАБОТАЮЩЕМ СЕРДЦЕ ПРИ ПОРАЖЕНИИ СТВОЛА ЛЕВОЙ КОРОНАРНОЙ АРТЕРИИ ПРИ ОСТРОМ КОРОНАРНОМ СИНДРОМЕ

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Цель. Изучить безопасность и эффективность операций на работающем сердце у пациентов с поражением ствола левой коронарной артерии (стЛКА) и острым коронарным синдромом (ОКС), определить оптимальные сроки оперативного вмешательства. ***Материал и методы.*** Работа основана на анализе обследования и лечения 62 пациентов с поражением стЛКА. Пациенты разделены на 2 группы в зависимости от вида хирургического вмешательства: первой группе пациентов (n=31) операция выполнялась в условиях искусственного кровообращения (ИК), второй группе (n=31) – на работающем сердце. Группы были сопоставимы по основным клинико-демографическим показателям. Для оценки риска неблагоприятного исхода использована шкала EuroSCORE II. ***Результаты.*** Использование вмешательства на работающем сердце у пациентов с поражением стЛКА и ОКС позволило снизить время операции (253,44±36,84 против 188,13±45,37 мин, p=0,0001), кровопотерю в послеоперационном периоде (607,00±432,34 мл против 413,21±167,08 мл, p=0,03), частоту использования препаратов крови (47,62% против18,18%, p=0,04). Однако, полнота реваскуляризации была выше в группе ИК (2,93±0,8 против 2,29±0,82, p=0,005). Более поздние сроки операции в условиях ИК (14-30 суток) ассоциировались с повышением летальности. При операциях на работающем сердце летальных исходов не было. ***Выводы.*** Операции на работающем сердце у пациентов с поражением стЛКА безопасны и эффективны в ранний период после возникновения ОКС. Оптимальным сроком операции при использовании искусственного кровообращения является 7-14 суток. Летальность и послеоперационные осложнения при операциях на работающем сердце в сроки до 7 суток, 7-14 суток, позднее 14 суток не различались.

Ключевые слова: *поражение ствола левой коронарной артерии; острый коронарный синдром; коронарное шунтирование на работающем сердце; ишемическая болезнь сердца.*

OPERATIONS ON WORKING HEART IN LESION OF LEFT MAIN CORONARY ARTERY IN ACUTE CORONARY SYNDROME

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Aim. To study safety and effectiveness of operations on the working heart in patients with damage to the left main coronary artery (LMCA) and with acute coronary syndrome (ACS), to determine the optimal time for operation. ***Materials and Methods***. The work was based on the

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analysis of examination and treatment of 62 patients with damage to LMCA. Patients were divided to 2 groups depending on the kind of surgery: in the first group of patients (n=31) the operation was performed under cardiopulmonary bypass (CPB), in the second group (n=31) – on the working heart. The groups were comparable by the main clinico-demographic parameters. The risk for unfavorable outcome was determined on EuroSCORE II scale. ***Results.*** Operation on the working heart in patients with damage to LMCA and ACS permitted to reduce the time of operation (253.44±36.84 against 188.13±45.37 min, p=0.0001), blood loss in postoperative period (607.00±432.34 ml against 413.21±167.08 ml, p=0.03), frequency of use of blood preparations (47.62% against 18.18%, p=0.04). However, the revascularization efficiency was higher in the group operated under CPB (2.93±0.8 against 2.29±0.82, p=0.005). Operations under CPB performed at later time (14-30 days) were associated with increased lethality. In operations on the working heart no lethal outcomes were reported. ***Conclusion.*** Operations on the working heart are safe and effective in the early period after development of ACS. The optimal operation time under CPB is 7-14 days. Lethality and postoperative complications in operation on the working heart before 7 days, within 7-14 days, and after 14 days did not differ.

Keywords: *damage to the left main coronary artery; acute coronary syndrome; bypass surgery on the working heart; ischemic heart disease.*

Damage to the left main coronary artery (LMCA) remains one of the most complicated fields of surgical revascularization of the myocardium. With the appearance of coronarography in the beginning of 1960s, patients with stenosis of LMCA started to be referred to a high risk group with poor prognosis and survival rate [1]. With timely medicinal treatment, the 5-year survival rate is 60%, here the patients usually have a high functional class of angina pectoris and cardiac insufficiency [1]. Therefore, damage of LMCA >50% identified by coronarography, is an absolute indication for surgical treatment [2].

In the opinion of many experts, the coronary artery bypass surgery remains the 'golden standard' of care for patients with damage to the LMCA with IA evidence-based level according to modern clinical recommendations [3]. However, the modern European and American recommendations contain no indications concerning the choice of revascularization method (off-pump or on-pump), so this question requires further investigation.

The necessity and safety of surgical treatment in case of damage to LMCA is no longer of doubt [3,4]. In the literature there exist numerous studies for comparison of surgery with extracorporeal circulation and surgery on the beating heart in patients with stable ischemic heart disease with damage to LMCA. Most studies report effectiveness and safety of both methods [5]. However, hemodynamic instability that may develop in surgery on the beating heart is often the reason for refusal from the off-pump procedure in critical stenosis of LMCA [6].

One more disadvantage of the surgery on the beating heart is incomplete revascularization of the myocardium. M. Murzi, et al. in their research showed that the volume of revascularization in damage to LMCA in *off-pump* group as compared to *on-pump* group was 88.3 against 92.0%; a tendency to reduction of 1-year, 5-year and 10-year survival rate in the *off-pump* group was noted (*off-pump*: 96.2, 87.2 and 70.5% against *on-pump*: 97.6, 89.9, and 74.2%, respectively, p>0.05) [7]. M. Yeatmen, et al. reported a considerable increase in the revascularization index in cardiopulmonary bypass surgery in patients with lesion of LMCA, however, there were no statistically significant differences in mortality [8].

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On the other hand, surgery on the working heart permits to improve the results of high risk patients. The extensive research CORONARY and CRISP reported the lower incidence of myocardial infarction (MI), stroke and renal failure is lower with use of *off-pump* technique [9]. P. Cavallaro, et al., in their study of high risk patients also noted reduction of perioperative strokes and respiratory complications in surgery on the beating heart. However, mortality rate was practically the same [10].

The question that remains unclear is safety and effectiveness of coronary artery bypass in surgery on the beating heart and with use of extracorporeal circulation in acute coronary syndrome (ACS) in patients with damage to LMCA. Besides, in the literature there is insufficient data concerning tactics of management of patients with damage to LMCA in acute MI ((concerning the extent of urgency of revascularization of the myocardium, reasonability of and indications for mechanical support of circulation – intraaortic balloon counter pulsation (IABC) in management of patients in the early postoperative period)).

As a rule, in most cases of acute MI, stenting of infarct-related coronary artery (CA) is performed. In stenting, the condition of the patient and necessity for complete revascularization of the myocardium are taken into account [11]. In GRACE register it is noted that coronary bypass surgery is conducted only on 10% of patients with ACS without elevation of ST segment, who need the surgery in the given hospitalization (damage to LMCA, multivascular damage) [12]. Therefore the most important problems in ACS in patients with damage to LMCA is determination of the time and method of operation.

Aim – to study safety and effectiveness of surgery on the beating heart in case of lesion of the left main coronary artery in patients with acute coronary syndrome and to determine the optimal time for surgical intervention.

Materials and Methods

Results of retrospective analysis of 62 patients with ACS and atherosclerotic lesion of LMCA with >50% stenosis confirmed by selective coronarography, are presented. The patients were examined and treated in the cardiosurgery department of Yaroslavl Regional Clinical Hospital in the period from January 2009 to December 2018. All of them were operated on in the early period of ACS (in the given hospitalization within 7 days, 7-14 days, 14-30 days after occurrence of ACS).

Finally, 32 patients with unstable angina were included into the study, of them 21 with MI with no elevation of ST segment (MINEST) and 9 with MI with elevation of ST segment (MIEST).

Table 1

Distribution by Nosology and Time of Operation in Analyzed Cohort of Patients

Time of Operation	Unstable Angina	MINEST	MIEST	In Total
N	32	21	9	62
Within 7 days	8 (25.00%)	2 (9.52%)	0 (0%)	10 (16.13%)
7-14 days	6 (18.75%)	3 (14.29%)	6 (66.67%)	15 (24.19%)
after14 days	18 (56.25%)	16 (76.19%)	3 (33.33%)	37 (59.68%)

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Criteria for exclusion were: damage to LMCA <50%, existence of valvular heart defects, time of operations >30 days from the moment of development of ACS.

Statistical analysis was conducted using Statistica 10.0.program (Stat Soft Inc., USA). Analysis of categorical variables was evaluated using χ^2 criterion. With less than 5 observations, Fischer exact test was used. Variables of normal distribution were compared using unpaired Student's test; for comparison of variables with other than normal distribution Mann-Whitney U-test was used. The difference was considered statistically significant at $p<0.05$.

All patients were divided to two groups depending on the technique of surgery. In the first group (*on-pump*, n=31) the cardiopulmonary bypass surgery was performed with hypothermic crystalloid cardioplegia. The second groups of patients were operated on the beating heart. Two patients in the first group (6.45%) were operated on before the 7th day, 4 patients (12.90%) – in the period from 7 to 14 days, 25 patients (80.65%) – after 14 days. 8 Patients of the second group were operated before the 7th day (25.81%), 11 patients (35.48%) – в периn the period from 7 to 14 days, 12 patients (38.71%) – after 14 days.

The average age in the group with coronary bypass surgery was considerably lower (60.97±7.84 years) in the *off-pump* group – 64.90±7.83 years (p=0.06). The patients were comparable by sex, body mass index (BMI) and by related pathology (Table 2). EuroScore II index in *on-pump* group was 2.67±1.31, and in *off-pump* group – 3.87±2.50 (p=0.03).

Table 2

Clinico-Demographic Characteristics of Patients in Studied Group

Parameter	**On-pump,** n=31	**Off-pump,** n=31	**p**
Age, years	60.97±7.84	64.90±7.83	0.05
Sex, female, n (%)	5 (16.13%)	8 (25.81)	0.34
BMI, kg/m^2	27.30±5.21	26.9±4.09	0.68
Diabetes mellitus, n (%)	4 (12.90)	7 (22.58)	0.50
Arterial hypertension, n (%)	30 (96.77)	29 (93.55)	0.55
Renal failure, n (%)	0 (0)	2 (6.45)	0.49
COPD, n (%)	1 (3.23)	1 (3.23)	1
Significant damage of BCA, n (%)	3 (9.86)	5 (16.13)	0.70
Damage to vessels of lower limbs, n (%)	4 (12.90)	2 (6.45)	0.67
TIA/stroke in history, n (%)	2 (6.45)	1 (3.23)	0.50
Euroscore II, %	2.67±1.31	3.87±2.50	0.03

Note: COPD – chronic obstructive pulmonary disease, BCA – brachiocephalic arteries, TIA – transient ischemic attack.

The degree of lesion of LMCA in the *on-pump* group was 67.33±16.07% and was statistically lower than in the *off-pump* group – 76.38±16.80% (p=0.035).The amount of damaged CA in the group with bypass surgery was 3.26±0.57, and in *off-pump* group – 2.55±0.72 (p=0.004). The left type of coronary circulation associated with higher parameters of postoperative complications and lethality in lesion of LMCA, was in one patient of the first group

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and in one of the second group. The left ventricular ejection fraction (LVEF) in the first group was 55.00±10.69%, and in the second – 52.60±10.69%, p=0.25.

Preventive installation of IABC was statistically lower in the first group (37.93%) than in the second group (64.52%) (p=0.04). The average degree of damage to LMCA with use of IABC was 80.29±14.50%, with lower and upper quartiles 70 and 95%, respectively. The average LVEF was 48.93±10.69%, lower quartile – 40.00%. The mean Euro Score II value with use of IABC – 4.02±2.22. All parameters statistically differed from those of patients with no installation of IABC. Earlier dates of operation were associated with a more frequent use of IABC in the preoperative period. In case of MIEST, IABC was installed in 77.78% of cases. In 2 cases IABC was installed in connection with unstable hemodynamics and with use of vasopressor support before the operation.

Results sand Discussion

The mean operation time in the first group was longer and made 253.44±36.84 min, in the second – 188.13±45.37 min (p=0.0001). The time of use of cardiopulmonary bypass and the time of aortic compression in the first group were 89.37±26.37 and 45.04±15.79 min, respectively. Conversion to cardiopulmonary bypass in one case in the second group was due to hemodynamic instability in a patient with a critical lesion of LMCA. Revascularization index was higher in the group with bypass surgery – 2.93±0.81, and was 2.29±0.82 in the *off-pump* group (p=0.005). The conduit in the first and second groups was the internal thoracic artery in 29 (93.54%) and 31 patients (100%), radial artery – in 9 (29.03%) and 5 patients (16.12%), the great saphenous vein – in 31 (100%) and 31 patients (100%). Y-graft bimammary bypass surgery on the beating heart was conducted in one patient. Complete coronary revascularization in cardiopulmonary bypass surgery was insignificantly higher (74.19%) than in surgery on the beating heart (70.97%, p=0.77, Table 4).

Up to date there exist numerous research works showing both the absence and the existence of influence of complete revascularization on the prognosis and survival rate of patients with stable ischemic heart disease [13,14]. Revascularization volume in ACS remains one of debatable questions in surgical revascularization of the myocardium. It was shown by some authors that reduced shunting in no way influences the postoperative parameters, but reduces the time of anoxia during operation and the time of extracorporeal circulation [15].

In our study the clinical symptoms of angina were managed in all cases irrespective of whether revascularization was complete or incomplete. Incomplete coronary revascularization did not produce any influence on the development of postoperative complications in both groups. The main causes of incomplete coronary revascularization were the diameter of the artery less than 1.5 mm and diffuse lesion of the artery.

Use of vasopressor support in the early postoperative period in the first group was insignificantly higher – in 15 patients (55.56%), in the second group – in 13 patients (44.83%), p=0.42. Blood loss in drainage on the first day after the operation with extracorporeal circulation was 607.00±432.34 mL, in the *off-pump* group – 413.21±167.08 mL (p=0.03); the frequency of transfusion of blood preparations was also higher in the first group – in 10 patients (47.62%), against 4 patients in the second group (18.18%), p=0.04. The time of artificial ventilation of lungs (AVL) did not show any statistical differences (12.24±8.73 h in *on-pump* against 10.6±5.9 h in *off-pump*, p=0.89). The period of treatment in the resuscitation department was statistically longer in the first group 2.38±1.69 days (in the second – 1.48±0.94 days, p=0.02). However, the total time of stay in the hospital practically did not differ (12.65±3.70 and 12.06±3.80 days, respectively, p>0.05, Table 3).

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Table 3

Course of Postoperative Period in Studied Groups

Parameter	On-pump, n=31	Off-pump, n=31	p
Use of IABC, n (%)	12 (40.00)	19 (65.52)	0.04
Use of vasopressor support, n (%)	15 (55.56)	13 (44.83)	0.42
Blood loss through drainages, mL	607.00±432.34	413.21±167.08	0.03
Time of AVL, h	12.24±8.73	10.60±5.90	0.89
Number of days in resuscitation department, days	2.38±1.69	1.48±0.94	0.02
Transfusion of blood preparations, n (%)	10 (47.62)	4 (18.18)	0.04
Number of days after surgery, days	12.65±3.70	12.06±3.80	0.60

As laboratory parameters, the levels of lactate, oxygen, carbon dioxide in the arterial blood were measured intraoperatively, in 3 hours after the operation, in the evening at 11 p.m. or in extubation, at 6 a.m. (only lactate level was evaluated). Lactate level had a higher statistical significance in cardiopulmonary bypass surgery in 3 hours after the operation and in the evening and it was 2.38±1.32 and 2.89±1.56 mmol/L against 1.31± 0.51 and 1.69±0,66 mmol/L in operation on the beating heart ($p<0.05$). The blood oxygenation parameter showed statistically significant differences only intraoperatively and was higher of carbon dioxide did not show any statistical differences in all periods. The elevated level of lactate was most likely to be connected with reduction of perfusion of tissues and with shifting of cells to anaerobic metabolism. In operations on the beating heart there was adequate perfusion of cells therefore the level of lactate was within the norm.

Despite a higher Euro Score II parameter (2.67±1.31 in *on-pump* group against 3.87±2.5 in *off-pump* group, p=0.03), a higher degree of damage to LMCA (67.33±16.07% against 76.38±16.8%, respectively, p=0.035), some insignificant predomination of aged patients in *off-pump* group, (60.97±7.84 years and 64.90±7.83 years, respectively, p=0,06), cardiopulmonary bypass operations were marked with a higher lethality in the early postoperative period (16.13% in *on-pump* against 0% in *off-pump* group, p=0.02). This evidences the patients with a higher surgical risk having an advantage in operations on the beating heart, especially in case of existence of severe related pathology [16] and of ACS. Here, the later operation dates (14-30 days) were associated with increase in lethality. One patient died in the operation before the 7^{th} day, 3 patients – in the operation on the 14^{th}-30^{th} day. There were no lethal outcomes in operations conducted on the 7^{th}-14^{th} day.

In operations on the beating heart made within 1 month after occurrence of ACS, no statistical differences in hospital lethality and in postoperative complications were noted. Therefore, in patients with higher surgical risk, the operation on the beating heart may be suspended to enable the multidisciplinary team to make a decision. The time of the operation should be chosen individually with taking into account symptoms, hemodynamics, anatomy of the coronary circulation, signs of ischemia.

Postoperative complications are presented in Table 4.

Causes of satisfactory results in operations on the beating heart in our research are most likely to be associated with unfavorable effect of extracorporeal circulation that provokes systemic inflammatory response, oxidative stress and reperfusion myocardial

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Table 4

Postoperative Complications in Studied Groups

Parameter	On-pump, n=31	Off-pump, n=31	p
Perioperational MI, n (%)	2 (6.45)	0 (0)	0.23
TIA, n (%)	0 (0)	0 (0)	1
Stroke, n (%)	1 (3.23)	0 (0)	0.50
Renal failure, n (%)	4 (12.90)	0 (0)	0.045
Hemodialysis, n (%)	1 (1.32)	0 (0)	0.50
Infectious diseases, n (%)	0 (0%)	1 (3.23)	0.50
GIH, n (%)	0 (0%)	1 (3.23)	0.55
Pulmonary complications, n (%)	4 (12.90)	1 (3.23)	0.17
Postpericardiotomic syndrome, n (%)	7 (22.58)	5 (17.24)	0.60
Repeated operations, n (%)	3 (10.00)	0 (0)	0.11

Note: TIA – transient ischemic attack, GIH – gastrointestinal hemorrhage.

syndrome, especially pronounced in patients of high risk [17]. Therefore, refusal from extracorporeal circulation in case of presence of ACS and lesion of LMCA improves the results in the early postoperative period.

Conclusion

Surgery on the beating heart in case of damage to the left main coronary artery in the early period after occurrence of acute coronary syndrome permits to reduce the duration of the procedure, intrahospital mortality, rate of hemorrhages, use of blood transfusions, and duration of stay in resuscitation department.

The optimal date for operation with application of extracorporeal circulation is 7-14 days.

In surgery on the beating heart, lethality and postoperative complications in the periods up to 7 days, on 7^{th}-14^{th} days and after 14 days did not show differences.

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