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The results of surgical treatment of patients with many valve defects in combination with coronary pathology

P. M. Semeniv
Amosov National Institute of Cardiovascular Surgery of the National Academy of Medical Sciences of Ukraine, Kyiv

The objective: **to analyze the impact of various surgical management on the duration of the ischemic period and the quality of myocardial protection during simultaneous combined correction of two-three heart valves and myocardial revascularization.**
Materials and methods**. The results of the treatment of single-stage multivalve correction in combination with coronary artery bypass grafting in 93 patients, which was performed at the M.M. Amosov National Institute of Cardiovascular Surgery for the period from 2014 to 2021, were studied.**
Depending on the methods and the sequence of surgical manipulations, the patients were divided into three groups. I group – 42 patients who had the correction of heart valves firstly and then aortocoronary shunting in conditions of pharmaco-cold cardiac arrest, II group – 36 patients who first had aortocoronary bypass surgery, then valve correction in conditions of pharmaco-cold cardiac arrest, III group – 15 patients, who at the first stage had coronary artery bypass grafting on a working heart, then - correction of valve damage in conditions of pharmaco-cold cardiac arrest.
Results**. The use of the technique of primary restoration of coronary blood flow by shunting coronary arteries in a working heart before clamping the aorta (before pharmaco-cold cardiac arrest and the start of artificial blood circulation) allows to reduce the duration of artificial blood flow and ischemic time, which positively affects the heart rhythm in the postoperative period.**
Conclusions**. The technique of performing aortocoronary shunting on a working heart is more effective than when performing aortocoronary shunting in conditions of pharmaco-cold cardiac arrest. This technique requires more time to perform and is technically more difficult, but it can statistically significantly reduce the time of myocardial ischemia, which reduces the frequency of severe heart failure and the frequency of postoperative complications.**
Keywords: *valvular defects, ischemic heart disease, myocardial ischemia.*

Результати хірургічного лікування пацієнтів з багатоклапанними вадами у поєднанні з коронарною патологією

П. М. Семенів

Мета дослідження: аналіз впливу застосування різних хірургічних тактик на тривалість ішемічного періоду та якість захисту міокарда при одномоментній комбінованій корекції двох-трьох клапанів серця та реваскуляризації міокарда.
Матеріали та методи. Досліджено результати лікування одномоментної багатоклапанної корекції у поєднанні з аортокоронарним шунтуванням у 93 хворих, яке виконувалося в Національному інституті серцево-судинної хірургії імені М. М. Амосова за період з 2014 до 2021 рр.
Залежно від тактичних прийомів і послідовності хірургічних маніпуляцій хворі були розподілені на три групи. І група – 42 пацієнти, яким спочатку проводили корекцію клапанів серця, а потім – аортокоронарне шунтування в умовах фармакохолодової зупинки серця, ІІ група – 36 пацієнтів, яким спочатку проводили аортокоронарне шунтування, потім – корекцію клапанів в умовах фармакохолодової зупинки серця, ІІІ група – 15 пацієнтів, яким на першому етапі виконували аортокоронарне шунтування на працюючому серці, потім – корекцію ураження клапанів в умовах фармакохолодової зупинки серця.
Результати. Застосування методики первинного відновлення коронарного кровотоку шляхом шунтування коронарних артерій у працюючому серці до перетискання аорти (до фармакохолодової зупинки серця та початку штучного кровообігу) дозволяє скоротити тривалість штучного кровотоку та ішемічний час, що позитивно впливає на серцевий ритм у післяопераційний період.
Висновки. Методика виконання аортокоронарного шунтування на працюючому серці виявилася більш ефективною, ніж при виконанні аортокоронарного шунтування в умовах фармакохолодової зупинки серця. Ця методика потребує більше часу для виконання та технічно складніша, але може статистично достовірно скоротити час ішемії міокарда, що зі свого боку зменшує частоту тяжкої серцевої недостатності та частоту післяопераційних ускладнень.
Ключові слова: *клапанні вади, ішемічна хвороба серця, ішемія міокарда.*

The prevalence of coronary heart disease in patients with valvular heart disease ranges from 25 to 75% [1, 2, 3, 19, 20]. Prosthetics of heart valves in combination with coronary artery bypass grafting is a standard treatment strategy for this category of patients [4–10, 23, 25]. One of the most important tasks is to ensure adequate intraoperative protection of the myocardium during prolonged work on a stopped heart [7–9]. This problem is relevant in patients who require cardiac surgery such as one-time combined correction of two or three heart valves and myocardial revascularization, when to achieve adequate surgical correction, a long time of aortic compression is required [10–13, 21, 24].

There is no single, generally accepted protocol for correcting the combination of multivalvular lesions with coronary heart disease. That is why the problem of reducing the negative impact of the hypoxic period on the contractile ability of the myocardium is relevant in patients of this category, and to achieve adequate surgical correction requires a long time of aortic compression [14–18, 22].

The objective: evaluate the impact of the use of different surgical tactics on the duration of the ischemic period and the quality of myocardial protection with simultaneous combined correction of two or three heart valves and revascularization of the myocardium.

MATERIALS AND METHODS

The work is based on the analysis of the results of one-step multi-valve correction in combination with coronary artery bypass grafting (CA) in 93 patients, which was performed for the period from 2014 to 2021 at the Amosov Institute. The mean age of the operated patients was 63.2±13.6 years. There were 65 (69.8%) men, average age 63.2±12.6 years, women – 28 (30.2%) average age 64.7±12.9. The vast majority of operated patients had one or more myocardial infarctions and were in NYHA functional class III–IV.

Depending on the tactical approaches and the sequence of surgical manipulations, patients were divided into three groups. Group I – «Patients who first performed heart valve correction and then coronary artery bypass grafting in cardioplegia» (n=42), Group II – «First coronary artery bypass grafting, then valve correction in cardioplegia» (n=36) and Group III – «The first stage was coronary artery bypass surgery on the working heart, then correction of heart valves» (n=15).

All 93 patients underwent one-step surgeries: valve correction and CA bypass surgery. Variants of surgical manipulations are given in table 1.

In 38 out of 93 cases (40.8%) one-time prosthetics of aortic and mitral valves were performed. Only one patient (1.7%) of the entire sample underwent one-step prosthesis of 3 valves. A total of 134 heart valve prostheses were sewn: of which 87 aortic valve prostheses and 47 mitral prostheses. Used bivalve prostheses: St. Jude Medical Regent, ATS, On-X.

34 support rings were implanted in the mitral position (ATS, St. Jude). Suture plastics were performed in 12 patients: semi-acid plastics and Reed plastics, Allfieri. Amosov-De Vega annuloplication was performed in 30 patients.

Manipulations on the aortic valve, which did not require further prosthetics: removal of vegetations of the aortic valve – was performed in the 1st patient of the first group; valvulotomy, also to the 1st patient of the 2nd group; decalcification of the aortic valve was performed in two patients of the 1st group. Re-prosthesis of the aortic clan was performed in 3 patients (1 in the first group and 2 in the second), including 2 patients underwent aortic root plastic surgery. Also, aortic root plastic surgery was performed to 1 patient of the 3rd group.

Elimination of subaortic stenosis (myectomy) Morrow's operation was performed in 2 patients of the 2nd group. Internal suture surgery of the left atrium was performed in 7 patients. Left atrial appendage was sutured and ligated in 47 patients of the entire sample, and two patients underwent additional removal of thrombi from the left atrium.

All patients underwent direct myocardial revascularization by coronary artery bypass grafting. A total of 193 distal anastomoses were performed in the entire study

Table 1

List of surgical manipulations in the study groups

Manipulations	I Group, n=42	II Group, n=36	III Group, n=15	Together, n=93
Aortic valve prosthesis	39	34	14	87
Mitral valve prosthesis	28	15	4	47
Tricuspid valve prosthesis	1	-	-	1
Mitral valve plastics support ring	12	13	9	34
Mitral valve suture plastic	2	8	6	12
Anuloplication of the tricuspid valve	19	7	4	30
Removal of vegetations of the aortic valve	1	-	-	1
Valvulotomy of the aortic valve	-	1	-	1
Decalcification of the aortic valve	2	-	-	
Plastics of the aortic root	1	1	1	3
Left Atrial Plastic (Internal)	5	2	-	7
Left atrial appendage ligation	22	17	8	47
Morrow operation	-	2	-	2
Reprosthesis of the aortic valve	1	2	-	3
Removal of blood clots from the ear of the left atrium	1	1	-	2

Note: Morrow operation – myectomy, removal of subaortic stenosis; AV – aortic valve.

group. Of which 184 were performed using auto-venous grafts and 9 – using left internal thoracic artery (LITA). The index of myocardial revascularization in the whole study group was 2.1.

More than half of the patients (57 of 93) required bypass surgery of two or more coronary arteries. Single coronary artery bypass grafting was performed in 36 patients (39%). 4 bypass surgery was performed in 7 patients (8%).

RESULTS AND DISCUSSION

Patients had access to the heart according to standard methods: longitudinal middle sternotomy with parallel preparation of auto-venous and LITA. The division of patients into observation groups was based on the use of tactical approaches and the sequence of surgical manipulations.

In the first study group (n=42), a surgical sequence was used, when after antegrade and retrograde administration of the solution, valves were corrected and only then distal anastomoses were applied and cardioplegic solution was injected into these shunts. Anastomoses were placed on the aorta after removal of the clamp and restoration of heart function.

In the II study group (n=36) the introduction of cardioplegic solution was performed after aortic compression and aortotomy in the mouth of the coronary arteries and retrograde, then in sequentially superimposed shunts, and then corrected valvular defects.

In the third group of observations (n=15) myocardial revascularization included the following tactical stages: isolation of the internal thoracic artery with parallel preparation of venous grafts, and in some patients (n=6) shunts were sutured to the aorta. First of all, collateralized coronary arteries were shunted (more often these are subocclusive CA, perfusion of which was carried out through collaterals from the pool of another CA).

Depending on the hemodynamic situation during the operation, it was decided to perform coronary artery bypass surgery completely without artificial circulation (n=13) or on parallel perfusion (n=2). In 2 cases, conversion to auxiliary artificial circulation was performed due to unstable hemodynamics and part of the anastomoses was performed on parallel perfusion (without cardioplegic arrest). When performing artificial circulation in parallel perfusion, taking into account mitral valve insufficiency, low contractility and dilatation, passive drainage of the left ventricle through the right pulmonary vein was mandatory. In cases of registration of signs of myocardial ischemia, intracoronary shunts were used.

Another feature of the tactics of surgical treatment of patients of group III was that at the stage of aortic dissection to correct heart valves cardioplegic solution was injected not only into the mouth of the coronary artery and coronary sinus, but also in shunts sewn in the previous stage. After cooling the patient to a temperature of 28–30 °C, the aorta was squeezed, aortotomy was performed and cardioplegic solution was injected into the mouth of the coronary artery, shunts and retrogradely into the coronary sinus, surgical correction of valvular heart disease was performed. Additional administration of cardioplegic solution depended on the duration of aortic compression.

The results of the duration of artificial circulation, ischemia and total duration of surgery are summarized in table 1. As can be seen from the data presented in table 2, the average value of the duration of artificial circulation for group I was 279.3±69.8 minutes, and the time of compression of the aorta – 190.3±47.5 minutes. In the second group, these indicators did not differ statistically significantly from the first, but significantly exceed those in the third group. Also, the time of artificial circulation in group III was affected by the fact that two patients underwent bypass surgery.

As can be seen from Table 1, surgical treatment required a fairly long time of the operation itself, due to the technical difficulties and scope of surgery. In all three groups, a fairly long time of artificial circulation and ischemic heart time was recorded, which significantly exceeded the critical time, which according to the literature is 120 minutes. [9].

In the third observation group, the shortest duration of artificial circulation and the shortest time of aortic compression were recorded. According to Student's test, the differences were statistically significant: in comparison with the I (p=0.001) and II (p=0.001) groups. This is due to the implementation of part of the main stage in the third group – coronary artery bypass grafting on the working heart, in contrast to the first and second groups.

After the operation, patients were transferred to the intensive care unit for further treatment. The early postoperative period was characterized by manifestations of decreased cardiac function. Signs of acute heart failure were registered in some patients. The severity of heart failure was assessed by the level of inotropic support required to ensure an adequate level of hemodynamics after cessation of artificial circulation and surgery, guided by the criteria of the ESC Committee for Practice Guidelines (2010): ≤3 μg/kg.min – low re-

Table 2

Duration of stages of surgical intervention in observation groups (n=93)

Indicator	Group I, n=42	Group II, n=36	Group III, n=15
Total duration of operation	440,2±240,2	436,3±94,6	476,4±121,3
Duration of artificial circulation (minutes)	279,3±69,8	268,4±64,2	179,2±38,9
Aortic compression time (minutes)	190,3±47,5	183,4±44,6	132.2±22,4
Indicator	**the difference between groups I and II**	**the difference between groups I and III**	**the difference between groups II and III**
Total duration of operation	0,467	0,313	0,140
Duration of artificial circulation	0,242	0,001	0,001
Aortic compression time	0,276	0,001	0,001

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Table 3

Doses of inotropic support directly upon delivery to the intensive care unit,%

Indicator Doses of inotropic support	Group I, n=42	Group II, n=36	Group III, n=15
< 3 microkg/kg.min	8 (19)	7 (19,4)	6 (40)
3–5 microkg/kg.min	20 (47,6)	17 (47,3)	5 (33,4)
6> microkg/kg.min	14 (33,4)	12 (33,3)	4 (26,6)

Table 4

Dynamics of the level of markers of myocardial damage in the study groups (units per liter)

Indicator	Reference values after cardio-surgical interventions	Values		
		Group I, n=42	Group II, n=36	Group III, n=15
CPK-MB	30–60 (90 at prosthetics of the valve)	110,2±80,3	99,8±71,7	80±54,3
Total CPK	90–900	2034,1±682,3	1901,1±663,2	1804±591
LDH	420–1200	597,3±157,6	599,7±140,8	634,6±240,3
ACT	6–120	122±60,2	112,7±56,5	101,1±54,7
ALT	6–60	52,2±28,4	47,4±27,5	44,7±21,6

nal dose; 3–5 mcg/kg.min – average, positive inotropic effect; 6≥ μg/kg.min – large, which has a positive vasopressor effect. Indicators of average doses of inotropic support are given in table 2.

As can be seen from Table 3, almost all patients after the main stage of surgery needed inotropic support. It was found that the most frequent registration of large doses of mimetics was registered in the I and II observation groups, and, accordingly, the least frequent registration of minimum doses. In the third observation group, the registration of minimum doses was typical in 40% of patients, which was twice as high as in the first and second observation groups. Despite of the difference in the frequency of registration of small, medium and large doses of inotropic support between groups, statistically significant differences between groups were absent (χ^2=0.102).

Clinical observations of myocardial damage characterizing the need for inotropic support were confirmed in the laboratory by the dynamics of markers of myocardial damage in the early postoperative period. The degree of myocardial damage was assessed by the level of enzyme activity in the serum 12–14 h after surgery compared with their reference values in patients after cardiac surgery (Table 4).

As can be seen from Table 3, in patients of both groups, the level of total CPK and its CF fraction significantly exceeded the reference values of these indicators in patients after cardiac surgery. The level of ALT, AST, LDH in the vast majority of patients were within the reference values. Despite the absence of statistically significant differences for each individual marker of damage between the observation groups, the increase in enzyme levels was more pronounced in groups I and II.

Heart failure, including lethal, which developed in the early postoperative period, was regarded by us as the main manifestation of inadequate myocardial protection. Cardiac complications of the early postoperative period are summarized in table 5.

The difference in the frequency of complications between the observation groups allows us to conclude that the proposed method of myocardial protection used in the third observation group was more effective than in the first and second groups.

Postoperative myocardial infarction was registered in 3 patients, 2 patients of the first group and one patient of the second group, which was confirmed by an increase in the level of biochemical markers (see Table 5).

Intra-aortic balloon counterpulsation (IABP) was used in 2 patients of group I and 1 patient of group II. Cardiac arrhythmias occupied a special place among the disorders of the cardiac system. The highest frequency of registration of heart rhythm disorders was registered in the first study group. Irreversible ventricular fibrillation was reported in 3 patients of group I and 3 patients of group II. Group III was characterized by the lowest incidence of cardiac arrhythmias in the postoperative period.

The most significant number of complications was the group of complications that characterized myocardial damage and could indicate the adequacy of intraoperative protection. As can be seen from the presented table, the highest number and frequency of cardiac complications

Table 5

Cardiac complications of the early postoperative period,%

Indicator	Group I, n=42	Group II, n=36	Group III, n=15	Together, n=93
Heart failure II–III	35 (83,3)	29 (80,5)	9 (60)	73 (78,4)
P/o myocardial infarction	2 (4,7)	1 (2,7)	-	3 (3,2)
Using (IABP)	2 (4,7)	1 (2,7)	-	3 (2,1)
including lethal heart failure	3 (7,1)	3 (8,3)	-	6 (6,4)
Arrhythmia	33 (78,5)	25 (69,4)	8 (53,3)	66 (70,9)

was observed in the first study group. Among the causes of acute heart failure as the main cause of postoperative mortality was observed in 4 cases, exclusively in groups I and II, when coronary artery bypass grafting was performed in conditions of cardioplegic arrest. No cases of fatal heart failure have been reported with shunt heart surgery.

CONCLUSIONS

Correction of combined multi-valve pathology with coronary heart disease requires long-term artificial circulation and ischemic heart time, which requires reliable protection of the myocardium, which is difficult to do in the presence of coronary artery stenosis.

The tactics of surgical treatment proposed in the III study group were more effective in comparison with the I and II groups. This technique requires much more time to perform and is more technically complex, but can significantly reduce myocardial ischemic time, which in turn reduces the level of heart failure and postoperative complications, which were statistically significantly higher in the first and second study groups.

Correction of combined valvular and coronary pathology in cardioplegic arrest increases the ischemic time above the critical time, which is associated with more frequent development of specific complications and the development of acute heart failure.

Information about author

Semeniv P. M. – MD, PhD-student, Cardiac Surgeon, Department of Surgical Treatment of Heart Pathology With Multiple Organ Failure, State Institution «Amosov National Institute of Cardiovascular Surgery of the National Academy of Medical Sciences of Ukraine», Kyiv; tel.: (099) 622-39-35. E-*mail: semeniv1989@ukr.net*

ORCID: 0000-0001-8382-925X

Відомості про автора

Семенів Петро Михайлович – аспірант, кардіохірург, відділ хірургічного лікування патології серця з поліорганною недостатністю, ДУ «Національний інститут серцево-судинної хірургії імені М. М. Амосова НАМН України», м. Київ; тел.: (099)622-39-35. *E-mail: semeniv1989@ukr.net*

ORCID: 0000-0001-8382-925X

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