https://doi.org/10.30702/ujcvs/24.32(03)/PB050-5157
UDC 616.126.42:616.31-001]-089.168

Volodymyr V. Popov, Ph.D., Doctor of Medical Science, Professor, Head of the Department of Surgical Treatment of Acquired Heart Diseases, https://orcid.org/0000-0002-2851-5589

Oleksandr O. Bolshak, Ph.D., Senior Research Fellow of the Department of Surgical Treatment of Acquired Heart Diseases, https://orcid.org/0000-0002-6089-9594

National Amosov Institute of Cardiovascular Surgery of the National Academy of Medical Sciences of Ukraine, Kyiv, Ukraine

Left Atrial Plasty in Surgical Treatment of Combined Mitral-Aortic-Tricuspid Valve Diseases Complicated by Left Atrial Dilation

Abstract

The aim. To study the possibilities of various techniques of the left atrial (LA) plasty in the correction of combined mitral-aortic-tricuspid valve diseases (cMATVD) in the presence of left atrial dilation (LAD).

Materials and methods. The analysis included the results of surgical treatment of 360 patients with cMATVD combined with LAD, who were operated on at the National Amosov Institute of Cardiovascular Surgery from January 1, 2006 to January 1, 2023. The main group consisted of 73 patients who underwent cMATVD correction combined with original triangular plasty of LA. The comparison group included 287 patients who underwent only cMATVD correction in the presence of concomitant LAD.

Results. Of the 73 operated patients in the main group, 3 died at the hospital stage (mortality rate 4.1%). The dynamics of echocardiographic parameters at the stages of treatment were as follows: left ventricular (LV) end-systolic index (ml/m^2): 69.1 ± 12.1 (before surgery), 59.3 ± 8.5 (after surgery), and 48.4 ± 9.5 (long-term period); LV ejection fraction (%): 51.0 ± 5.0 (before surgery), 54.0 ± 5.0 (after surgery), and 56.0 ± 4.0 (long-term period); LA diameter (mm): 64.8 ± 4.1 (before surgery), 50.3 ± 2.1 (after surgery), and 51.2 ± 2.2 (long-term period). Of the 287 operated patients in the comparison group, 9 died (mortality rate 3.1%). The dynamics of echocardiographic parameters at the stages of treatment were as follows: LV end-systolic index (ml/m^2): 68.3 ± 11.3 (before surgery), 60.4 ± 9.3 (after surgery), and 52.7 ± 7.2 (remote period); LV ejection fraction (%): 52.0 ± 5.0 (before surgery), 53.0 ± 5.0 (after surgery), and 50.0 ± 4.0 (remote period); LA diameter (mm): 65.5 ± 3.7 (before surgery), 64.1 ± 3.3 (after surgery), and 72.5 ± 2.8 (remote period).

In the remote period, thromboembolic complications occurred in 5 (7.7%) patients of the main group (1 severe, 1 mild, and 3 fatal) and 25 (9.3%) patients of the comparison group (10 severe, 6 mild, and 9 fatal). The thromboembolic complications rates indicate the advisability of LA plasty simultaneously with resection of its appendage.

Conclusions. In the correction of LAD, all plastic reconstructions of the dilated LA are low-traumatic and effective procedures that lead to a significant improvement in the morphometry of the LA both at the hospital stage and in the remote period. The methods are associated with low risk of hospital mortality, as well as a low level of thromboembolic complications in the remote period. In all methods of LA plasty, its appendage was resected, which also excluded conditions for thrombus formation.

Keywords*: triangular left atrial plasty, mitral and aortic valve replacement, tricuspid valve plasty, mitral valve plasty, cardiopulmonary bypass.*

Introduction. Left atrial dilation (LAD) is a clinically significant risk factor for surgical treatment of patients with combined mitral-aortic-tricuspid valve diseases (cMATVD), occurring in 15-23% of cases [1,2,3,4]. In patients with LAD, in particular those with atriomegaly, there is compression of the posterobasal segment of the left ventricle (LV), the lower and middle lobes of the right lung and the main bronchus on the left. The abovementioned malformations lead to significant respiratory disorders and heart failure [5,6,7,8,9]. In the postoperative period, uncorrected LAD leads to an increase in the manifestations of cardiorespiratory failure, and increased risk of thromboembolic complications [1,2,3,7,10]. Dilated left atrium (LA) is a factor that prevents the restoration of sinus rhythm, causing thromboembolic complications both at the hospital stage and in the long term [2,10,11,12,13,14]. Considering that in the presence of cMATVD and concomi-

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tant LAD, there is no regression of its diameter, it is advisable to reduce it surgically in order to reduce the risk of thromboembolic complications, create optimal conditions for restoring the correct rhythm [13,14,15,16]. There are various ways to reduce the LA diameter [17]. However, despite the various proposed options for LA reduction, interest in studying this category of patients does not wane [6,10,15,16]. We proposed correction of cMATVD combined with original methods of LA plastic surgery. These developments have proven themselves to be a low-traumatic and effective intervention. At the same time, they allowed to significantly improve the morphometry of the LA in the postoperative period. In addition, they are accompanied by a low risk of hospital mortality and specific complications, and are desirable procedures for the correction of LAD.

The aim. To study the possibilities of various techniques of the LA plasty in the correction of cMATVD in the presence of LAD.

Materials and methods. The analysis included data from 360 patients with cMATVD and LAD, operated on at the National Amosov Institute of Cardiovascular Surgery of the National Academy of Medical Sciences of Ukraine from January 1, 2006 to January 1, 2023. All the patients were diagnosed with mitral-aortic valve disease requiring surgical correction, in combination with LAD. The leading etiologic cause of valve damage was rheumatism combined with lipoidosis. The mean age of the operated patients was 54.8 ± 9.3 years. There were 203 women (56.5%), 157 men (43.5%). The distribution of patients depending on the initial New York Heart Association functional class was as follows: 125 (34.8%) in class III, 235 (65.2%) in class IV. Atrial fibrillation (AF) was present in 87% of patients. Patients with concomitant aorto-coronary bypass grafting were excluded from the study.

The patients were divided into 2 groups: the main group, where the correction of LA was performed during the correction of cMATVD (n = 73), and the comparison group (n = 287), where reconstructive intervention on the LA was not performed. Preoperative echocardiographic parameters in the main group were: LV end-systolic index 69.1 ± 12.1 ml/m^2, LV ejection fraction 51.0 ± 5.0%, LA diameter 65.8 ± 4.1 mm. In the comparison group : LV end-systolic index 68.3 ± 11.3 ml/m^2, LV ejection fraction 52.0 ± 5.0%, LA diameter 66.5 ± 3.7 mm (p > 0.05). LAD diagnostics were also performed using computed tomography (Fig. 1).

Gross changes in the LA wall (calcification) were noted in 9 (2.5%) patients (Fig. 2).

The operations were performed under artificial circulation and moderate hypothermia (28-32 °C). Myocardial protection was provided under retrograde, ante-retrograde pharmaco-cold cardioplegia (custodiol) combined with external cooling. Mechanical bicuspid prostheses used were St. Jude Medical, ATS, On-X, Carbomedics, Edwards-Mira (n = 318), bioprostheses (n = 9) were implanted in the mitral and aortic positions, and support rings for mitral valve plastic surgery (n = 33) were also used.

Fixation of prostheses was carried out with separate U-shaped seams with 13-18 Teflon pads. Tricuspid valve plastic surgery was performed with the help of support ring in 75 patients, and Amosov-De Vega suture plastic surgery was performed in 285 patients. LA fragmentation operation ("labyrinth") to restore sinus rhythm was performed in 57 (15.8%) patients. In 17 (4.7%) patients, there was a massive thrombosis of the LA (the level of deposition of thrombotic masses was not less than 1/3 of the volume of the LA, not counting the appendages). LA plastic surgeries are presented in Table 1. LA appendage resection was performed in all the plasties.

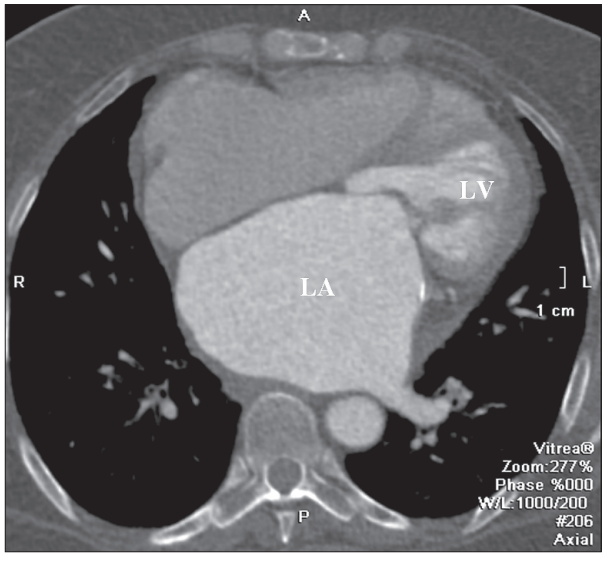

Fig. 1. *Computer diagnostics of left atrial dilation*

Fig. 2. *Calcified wall of the LA*

Table 1

Structure of interventions and various LA plasty techniques

LA plasty	MAVR + TV plasty, n (%)	AVR + MV plasty + TV plasty, n (%)	MAVR + TV plasty + Maze, n (%)	AV plasty + MVR + TV plasty, n (%)	MV plasty + AV plasty + TV plasty, n (%)	Total, n (%)
Main group						
Paraannular	0 (0.0)	0 (0.0)	5 (100.0)	0 (0.0)	0 (0.0)	5 (100.0)
Arch	18 (53.3)	7 (46.7)	0 (0.0)	0 (0.0)	0 (0.0)	15 (100.0)
Triangular	29 (56.9)	20 (39.2)	0 (0.0)	2 (3.9)	0 (0.0)	51 (100.0)
W-shaped	0 (0.0)	2 (100.0)	0 (0.0)	0 (0.0)	0 (0.0)	2 (100.0)
Total	38 (52.1)	27 (37.0)	5 (7.0)	2 (2.8)	1 (1.4)	73 (100.0)
Comparison group	163 (56.8)	118 (41.1)	5 (5.3)	3 (3.1)	3 (1.0)	287 (100.0)

MAVR, double mitral-aortic valve replacement; TV, tricuspid valve; AVR, aortic valve replacement; MV, mitral valve; AV, aortic valve; MVR, mitral valve replacement.

The LA reduction began with external ligation and subsequent LA appendage resection (Fig. 3).

In case of moderate dilation of LA within 5.5-6.0 cm, the paraannular or arched techniques are optimal (Fig. 4 and 5). The disadvantage of the paraannular technique is the lack of constriction between the pulmonary veins.

For LAD within 6.0-8.0 cm, triangular plasty is optimal (Fig. 6). Triangular LA plasty was performed as follows: the first stage was paraannular plication of the posterior wall of the LA, which was the base of the triangle. Then, along converging lines from the site of paraannular plasty, 2 sections of the LA between the right and left pulmonary veins were plicated, connecting at the apex with each other, completing the formation of the triangle. Prolene 3-0 thread was used for plasty.

The disadvantage of the technique is the risk of cutting through the fixing sutures and possible bleeding. In this regard, we proposed an option to eliminate this complication by strengthening the fixing suture by using an autopericardial leaflet approximately 13 mm wide (Fig. 7). This made it possible to eliminate the bleeding factor, especially in case of extreme atriomegaly.

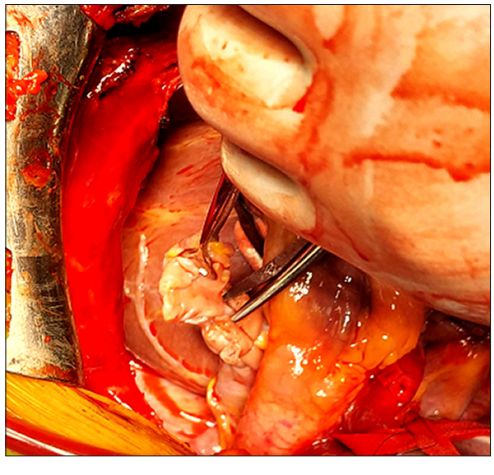

Fig. 3. *Resection of the LA appendage*

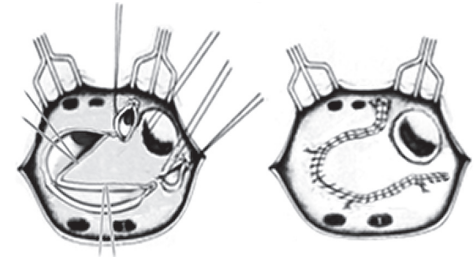

Fig. 4. *Arch plasty of the LA performed by professor V.V. Popov [17]*

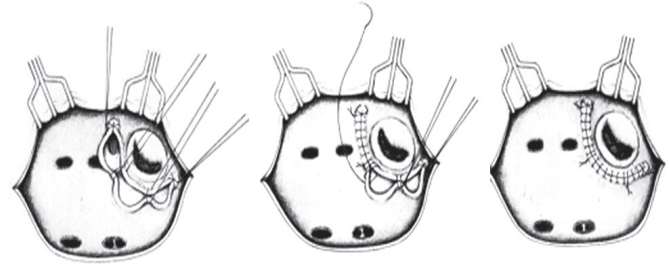

Fig. 5. *Paraannular plasty of the LA*

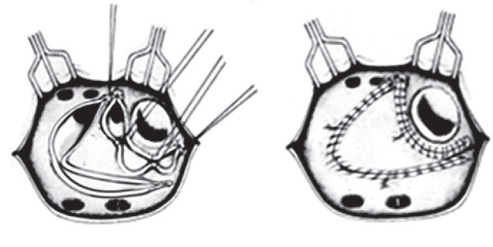

Fig. 6. *Triangular LA plastic surgery performed by professor V.V. Popov [17]*

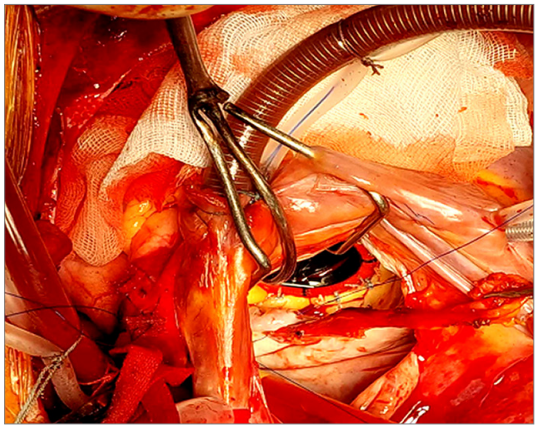

Fig. 7. *The use of autopericardial patch through the method by professor V.V. Popov [17]*

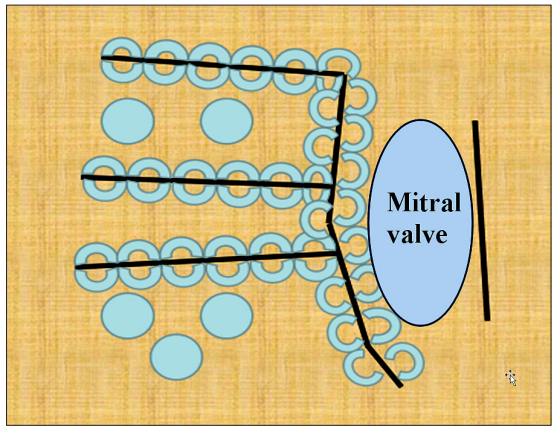

Fig. 8. *W-shaped LA plastic surgery performed by professor V.V. Popov [17]*

In case of LA marginal atriomegaly within more than 8.0 cm, the optimal method is to use the W-shaped LA plasty (Fig. 8). Another disadvantage of this technique is the risk of cutting through the fixing sutures and possible bleeding. Here, the implantation of an autopericardial flap is also routinely used.

There were no technical problems during the correction. With left atriomegaly, a longer time is required for aortic clamping, which requires more attention to protect the myocardium. The aortic clamping time was: 138.9 ± 25.5 minutes in the main group and 103.6 ± 13.3 minutes in the comparison group ($p < 0.05$). At the hospital stage, complications associated with the technique of performing the operation in the main group were not noted.

Results and discussion. In the main group, 3 out of 73 patients died at the hospital stage (hospital mortality 2.8%). The causes of death were pneumonia (n = 2) and multiple organ failure (n = 1). Inotropic support (dobutamine) was within 3-4 mcg/kg/min during the first 72 hours. The patients were discharged 11.4 ± 2.1 days after surgery without clinically significant complications. Blood loss during the hospital stage was within 350.0 ml, therefore, 15 (20.3%) patients did not use donor blood components throughout the hospital period.

The dynamics of echocardiographic parameters in patients of the main group were as follows: LV end-systolic index (ml/m^2): 69.1 ± 12.1 (before surgery), 59.3 ± 8.5 (after surgery), and 48.4 ± 9.5 (long-term period); LV ejection fraction (%): 51.0 ± 5.0 (before surgery), 54.0 ± 5.0 (after surgery), and 56.5 ± 4.0 (long-term period); LA diameter (mm): 65.8 ± 4.1 (before surgery), 52.3 ± 2.1 (after surgery), and 53.5 ± 2.2 (remote period).

In the main group, the results of 65 patients (92.8%, n = 65/70 of those discharged) were monitored in the remote period (on average 6.7 ± 0.9 years, from six months to 10 years).

Good and satisfactory results were observed in 48 patients (73.8%), and unsatisfactory results were observed in 10 patients (15.4%). Unsatisfactory results were due to tachiform of AF (n = 4), hypertension (n = 2), coronary heart disease (n = 2), and residual effects after acute cerebrovascular accident (n = 2). In the late period, 7 patients (11.2%) died. The causes of death were: cerebral thromboembolism (n = 2), hypertensive crisis, atherosclerosis (n = 2), progressive coronary heart disease (n = 1), prosthesis thrombosis (n = 1), unknown cause (n = 3). Sinus rhythm was maintained in 27 patients (41.5%). In total, thromboembolic complications occurred in 5 patients (7.7%): severe (n = 1), mild (n = 1), fatal (n = 3).

Of the 287 operated patients in the comparison group, 9 died at the hospital stage (hospital mortality 3.2%). The causes were: heart failure (n = 4) and multiple organ failure (n = 3), cerebrovascular accident (stroke) (n = 2). Inotropic support (dobutamine) was within 3-4 mcg/kg/min during the first 72 hours. The patients were discharged 10.2 ± 2.1 days after the operation without clinically significant complications, but moderate decompensation and respiratory failure persisted. Blood loss at the hospital stage was within 350.0 ml, due to which 25 (8.7%) patients did not receive donor blood products throughout the hospital stage. The dynamics of echocardiographic parameters were as follows: LV end-systolic index (ml/m^2): 68.3 ± 11.3 (before surgery), 60.4 ± 9.3 (after surgery), and 52.7 ± 7.2 (remote period); LV ejection fraction (%): 52,0 ± 5.0 (before surgery), 53.0 ± 5.0 (after surgery), and 50.0 ± 4.0 (remote period); LA diameter (mm): 66.5 ± 3.7 (before surgery), 64.5 ± 3.3 (after surgery), and 73.5 ± 2.8 (remote period).

In the comparison group, the patients were followed up in the remote period for an average of 10.1 ± 1.4 years (from six months to 15 years).

Results were obtained in 269 patients (96.7% of the number of discharged patients). Good and satisfactory results were noted in 163 (60.6%), unsatisfactory

in 36 (13.6%) patients. Unsatisfactory results were due to: residual effects after stroke (n = 16), tachiform of AF (n = 4), cardiorespiratory failure (n = 6), crisis course of hypertension (n = 4), ischemic heart disease (n = 6). During 15 years of observation, the leading causes of death in 72 (25.2%) deceased patients were: progressive cardiorespiratory failure (n = 28), cerebral thromboembolism (n = 9), prosthesis thrombosis (n = 2), hypertensive crisis, atherosclerosis (n = 6), progressive coronary heart disease (n = 12), arrhythmia (n = 4), pneumonia (n = 4), cancer (n = 4), and unknown cause (n=3). Sinus rhythm was not registered in any of the patients. Overall, thromboembolic complications occurred in 25 (9.3%) patients: severe (n = 10), mild (n = 6), and fatal (n = 9).

Actuarial curves of freedom from thromboembolic complications in both groups are presented in Fig. 9.

According to the data presented in Fig. 9, by the 7th year of observation, low level of thromboembolic complications in main group were observed, indicating the advisability of performing LA plasty.

Actuarial curves of survival in the both groups are presented in Fig. 10.

According to the data presented in Fig. 10, by the 7th year of observation, high level of survival in the main group

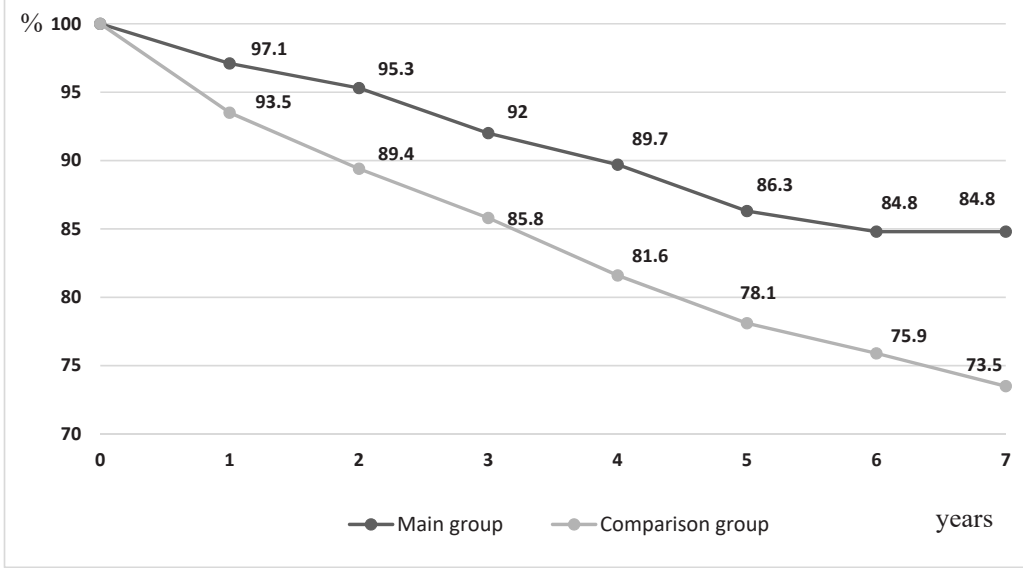

Fig. 9. *Actuarial analysis of freedom from thromboembolic complications in both groups*

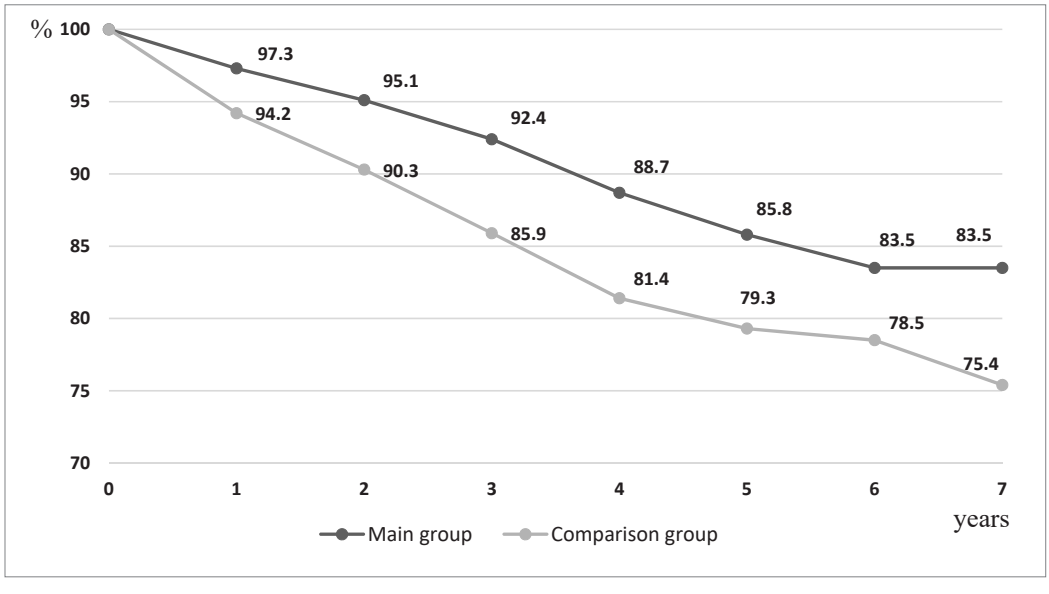

Fig. 10. *Actuarial analysis of survival in the remote period in both groups*

was observed, indicating the advisability of performing LA plasty.

With cMATVD correction, the LAD factor is clinically significant at the hospital stage, but to a greater extent in the remote period. The level of thromboembolic complications, as well as the level of cardiopulmonary failure, in the group without LAD correction in the remote period reaches a critical risk value, especially in combination with poorly corrected long-standing AF. The damping chamber of the dilated LA in the presence of tachiform of AF, which is an indispensable companion of subsequent thromboembolism, despite anticoagulant therapy, contributes to the formation of thrombi in the dilated cavity of the LA. The unligated appendage of the LA is also an important cause of thromboembolic complications in the comparison group. In the comparison group, compression of the bronchi, trachea, posterior wall of the LV by the dilated LA leads to progressive cardiorespiratory failure, reducing survival and stability of good results. This predetermined the worst results of the remote period in patients of the comparison group. If the treatment results in the two groups at the hospital stage do not differ significantly, then the differences at the stage of 7 years or more after the surgery become statistically significant. Of course, the presence of left atriomegaly combined with AF is an indication for LA plastic surgery and restoration of the correct rhythm, and the plastic surgery option in the treatment of cMATVD is one of them, which has proven its feasibility over 7 years.

Conclusions. Surgical treatment of cMATVD complicated by LAD, combined with the proposed techniques of LA reduction plastic surgery, is a desirable procedure in patients with LAD. The introduced technique is a low-traumatic and effective procedure leading to a significant improvement in LA morphometry, accompanied by a positive clinical effect both at the hospital stage and in the late periods after surgery.

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Пластика лівого передсердя при хірургічній корекції поєднаних мітрально-аортально-тристулкових вад серця, ускладнених дилатацією лівого передсердя

Попов В. В., д-р мед. наук, професор, завідувач відділу хірургічного лікування набутих вад серця

Большак О. О., канд. мед. наук, старший науковий співробітник відділу хірургічного лікування набутих вад серця

ДУ «Національний інститут серцево-судинної хірургії імені М. М. Амосова НАМН України», м. Київ, Україна

Резюме

Мета – вивчення можливостей будь-яких варіантів методик пластики лівого передсердя в корекції поєднаних мітрально-аортально-тристулкових вад (пМАТВ) за наявності дилатації лівого передсердя.

Матеріали та методи. До аналізу включено результати хірургічного лікування 360 пацієнтів із пМАТВ у поєднанні з дилатацією лівого передсердя (ЛП), які були прооперовані у НІССХ ім. М. М. Амосова за період з 01.01.2006 до 01.01.2023 р. Основну групу становили 73 пацієнти, яким було виконано корекцію пМАТВ у поєднанні з оригінальною методикою трикутної пластики ЛП. До групи порівняння увійшли 287 пацієнтів, яким виконано лише корекцію пМАТВ за наявності супутньої дилатації ЛП.

Результати. Із 73 оперованих пацієнтів основної групи на госпітальному етапі померли 3 (летальність 4,1 %). Динаміка ехокардіографічних показників на етапах лікування становила: кінцево-систолічний індекс лівого шлуночка (ЛШ) (мл/м^2) – 69,1 ± 12,1 (до операції), 59,3 ± 8,5 (після операції), 48,4 ± 9,5 (віддалений період); фракція викиду ЛШ (%): 51,0 ± 5,0 (до операції), 54,0 ± 5,0 (після операції) та 56,0 ± 4,0 (віддалений період). Діаметр ЛП (мм) становив: 64,8 ± 4,1 (до операції), 50,3 ± 2,1 (після операції) та 51,2 ± 2,2 (віддалений період). З 287 оперованих пацієнтів групи порівняння померли 9 (летальність 3,1 %). Динаміка ехокардіографічних показників на етапах лікування становила: кінцево-систолічний індекс ЛШ (мл/м^2) – 68,3 ± 11,3 (до операції), 60,4 ± 9,3 (після операції), 52,7 ± 7,2 (віддалений період); фракція викиду ЛШ (%): 52,0 ± 5,0 (до операції), 53,0 ± 5,0 (після операції) та 50,0 ± 4,0 (віддалений період). Діаметр ЛП (мм) становив: 65,5 ± 3,7 (до операції), 64,1 ± 3,3 (після операції) та 72,5 ± 2,8 (віддалений період).

У віддаленому періоді в основній групі у 5 хворих (7,7 %) виникли тромбоемболічні ускладнення: тяжкі (n = 1), легкі (n = 1), летальні (n = 3). У групі порівняння у 25 (9,3 %) хворих у віддалені терміни виникли тромбоемболічні ускладнення: тяжкі (n = 10), легкі (n = 6), летальні (n = 9). Частота тромбоемболічних ускладнень свідчить про доцільність пластики лівого передсердя одночасно з резекцією його вушка.

Висновки. При корекції дилатації ЛП усі пластичні реконструкції дилатованого ЛП є малотравматичними та ефективними процедурами, що призводять до значного покращення морфометрії ЛП як на госпітальному етапі, так і у віддалений період. Методики супроводжуються низьким ризиком госпітальної летальності, а також низьким рівнем тромбоемболічних ускладнень у віддалений період. За всіх методик пластик ЛП його вушко резектували, що також виключало умови для тромбоутворення.

Ключові слова: *дилатація лівого передсердя, трикутна пластика лівого передсердя, протезування мітрального та аортального клапанів, пластика тристулкового клапана, пластика мітрального клапана, штучний кровообіг.*

Стаття надійшла в редакцію / Received: 06.08.2024
Після доопрацювання / Revised: 01.09.2024
Прийнято до друку / Accepted: 16.09.2024