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ALGORITHM FOR THE DIAGNOSTIC SEARCH OF STRUCTURAL AND FUNCTIONAL CHANGES IN THE MITRAL VALVE IN MITRAL INSUFFICIENCY OF ISCHEMIC GENESIS

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Established features of diagnostic data that influence the choice of surgical tactics for mitral valve correction. It was found that myocardial infarction was present in the anamnesis significantly more often in patients of the control group (p=0.04, χ^2=4.09). More pronounced structural and anatomical changes of the mitral valve were established, which had statistical significance in patients of the control group, namely: prolapse of the leaflets: anterior (p=0.04; χ^2=4.0) and both leaflets (p=0.02; χ^2=5.24); frequency of calcinosis (p=0.006; χ^2=7.58); calcinosis of the ring (p=0.01; χ^2=5.58); reverse blood flow of a pronounced degree: (++)/(+++), (p=0.002; χ^2=10.03) and very pronounced (+++)/(++++), (p=0.04; χ^2=4.03) and severe mitral valve insufficiency (p=0.03; χ^2=4.69).

Key words: ischemic heart disease, mitral regurgitation, myocardial infarction, mitral insufficiency, operations on the mitral valve.

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АЛГОРИТМ ДІАГНОСТИЧНОГО ПОШУКУ СТРУКТУРНО-ФУНКЦІОНАЛЬНИХ ЗМІН МІТРАЛЬНОГО КЛАПАНУ ПРИ МІТРАЛЬНІЙ НЕДОСТАТНОСТІ ІШЕМІЧНОГО ГЕНЕЗУ

Встановлені особливості діагностичних даних, які впливають на вибір хірургічної тактики корекції мітрального клапана. З'ясовано, що інфаркт міокарду був наявний в анамнезі достовірно частіше у пацієнтів контрольної групи (p=0,04, χ^2=4,09). Установлені більш виражені структурно-анатомічні зміни мітрального клапана, які мали статистичну значимість у пацієнтів контрольної групи, а саме: пролапс стулок: передньої (p=0,04; χ^2=4,0) та обох стулок (p=0,02; χ^2=5,24); частоти кальцинозу (p=0,006; χ^2=7,58); кальциноз кільця (p=0,01; χ^2=5,58); зворотній тік крові вираженого ступеню: (++)/(+++), (p=0,002; χ^2=10,03) та дуже вираженого (+++)/(++++), (p=0,04; χ^2=4,03) та недостатність мітрального клапана вираженого ступеню, (p=0,03; χ^2=4,69).

Ключові слова: ішемічна хвороба серця, мітральна регургітація, інфаркт міокарда, мітральна недостатність, операції на мітральному клапані.

The study is a fragment of the research work "To develop and improve the surgical treatment of combined mitral-aortic-tricuspid defects in the conditions of artificial blood circulation", state registration No. 0124U000184.

Mitral valve (MV) insufficiency of ischemic origin refers to complicated forms of coronary heart disease (CHD). According to many authors, the frequency of ischemic mitral regurgitation (MIR) is 20–25 % and most often develops after a myocardial infarction (MI), when clinical manifestations of heart failure (HF) appear in more than 50 % of patients [1, 3, 8, 9]. A pronounced degree of MV insufficiency in patients with CHD increases the risk of surgical intervention by almost five times [11].

The presence of MIR has an unfavorable prognostic trend regarding patient survival. Mortality during the first year after an MI in the presence of an MVI reaches 40–70 %. And also, according to many clinicians, the clinical manifestation of HF and evident progression of MIR are independent predictors of the development of sudden cardiac death [2, 11]. In patients with hemodynamically significant MV insufficiency in combination with CHD, according to the data of the leading cardiac surgical centers, the highest mortality rates, both in the early postoperative period and within a year after surgery, are established, which range from 6 % to 22 % [4, 10]. An important difference of MV insufficiency with the accompanying course of CHD is the clinical variability of the severity of MIR, which in turn depends on the functional and morphological state of the papillary muscles.

Echo-cardiography (Echo-CG) is the gold standard for assessing myocardial insufficiency, the state of subvalvular structures, the contractility of the myocardium, and other functional states of the myocardium. According to Echo-CG data, it is important to timely assess the presence of a decrease in the contractility of the myocardium, which is characterized by a low ejection fraction (EF), in patients with MIR and CHD. In turn, pulmonary hypertension will join the pathological process, and signs of congestive HF will appear in the patient's clinical condition. It was found that the one-year survival rate after complex surgical correction of MIR by performing reconstructive operations on the MV and ensuring myocardial revascularization reaches 82 % [10]. There are also data on the increase in the mortality of patients in age groups over 70 years old after MV prosthetics [5, 6].

Therefore, the pathogenetic basis of the development of MIR due to the presence and long clinical course of CHD prompt scientists and practicing cardiovascular surgeons to develop a diagnostic search algorithm for mitral insufficiency of ischemic origin. The high incidence of CHD and the significant frequency of its complications in the form of MIR, high patient mortality and significant intraoperative risks only emphasize the importance of timely adequate diagnosis to perform appropriate surgical intervention to obtain optimal clinical results in patients with CHD and myocardial insufficiency and determine the urgency of carrying out further scientific research.

The purpose of the study was to establish the peculiarities of diagnostic indices for the purpose of effective surgical correction of mitral valve in patients with coronary heart disease.

Materials and methods. The study included patients with MIR who underwent myocardial revascularization and plastic/prosthesis MV (n=140), both male (n=99, 70.7 %) and female (n=41, 29.3 %). The age range of the participants of this sample was from 45 to 84 years, the average age was 65.9±4.0 years.

The material for the analysis was the data from the primary accounting medical documentation: medical history, clinical and instrumental examination data, as well as surgical intervention protocols. Depending on the surgical intervention performed on the MV due to MIR, the patients were divided into two groups: the experimental group (n=69), which included patients who underwent organ-preserving operation of the MV – its plasticity, and the control group (n=71) – patients underwent prosthetics MV.

The research was carried out in compliance with the main provisions of the "Rules of Ethical Principles of Scientific Medical Research with Human Participation" approved by the Declaration of Helsinki (1964–2013), ICH GCP (1996), EU Directive No. 609 (from November 24, 1986), orders of the Ministry of Health of Ukraine No. 690 dated 23.09.2009, No. 944 dated 14.12.2009, No. 616 dated 03.08.2012. Patients participated in the study entirely of their own free will, which is confirmed by personally signing the appropriate informed consent. Each patient was personally informed about the responsibilities and rights and the possibility to end the study at any time without any consequences and explaining the reasons for their actions.

Statistical analysis of the reliability of differences was performed between study groups at a significance level of 0.05, determined by the χ^2 test with Yates correction.

Results of the study and their discussion. As mentioned above, the study sample included 140 people with CHD and its complication MIR. All study patients underwent a full range of diagnostic tests provided for inpatient treatment and reconstructive operations on the MV and myocardial revascularization. As mentioned in the introduction, one of the reasons that causes MIR or increases the impression of MV insufficiency is the presence in the anamnesis of patients with CHD and MI. Therefore, the first step of our study was to determine the frequency of MI in this patient cohort and its frequency in the study groups.

It was established that 55.7 % of patients had MI in their medical history. Its frequencies in the study groups were determined, which were: 64.8 % among patients of the control group and 45.7 % in the experimental group, the difference in the indicated frequencies was characterized by statistical reliability, $p=0.04$, $\chi^2=4.09$. The second step of the study was to find out the frequency of structural and functional changes in the MV according to the Echo-KG data during the diagnostic examination when patients were admitted to inpatient treatment for the purpose of surgical correction of the Mv and revascularization of the myocardium, Table 1.

It is clear from the presented data that the most common structural and functional defect of the MV is the prolapse of its leaflets, which leads to backflow of blood. The reason for the development of prolapse of the MV can be a myxomatous lesion, as a result of a congenital abnormality of the development of the heart and blood vessels (volumetric excess, scalloping and thickening of the leaflets) or genetically determined weakness of the connective tissue. The hilums, of course, are stretched and widened by the thinning and enlargement of the mucoid substance, and the chordae become thinner and longer. In the patients of this study, prolapse of the MV occurred significantly more often among patients of the control group – 28.2 % compared to its frequency in the experimental group – 13.0 %, $p=0.04$; $\chi^2=4.0$. It should be noted that the prolapse of the anterior leaflet of the MV was presented only in patients of the control group with a frequency of 8.4 %, $p=0.04$; $\chi^2=4.21$. As well as the prolapse of the MV of both leaflets, its frequency in the control group was 9.9 %, in the patients of the experimental group it did not occur, $p=0.02$; $\chi^2=5.24$. But in the experimental group, the frequency of prolapse of the posterior leaflet of the MV was higher than in the control group – 10.6 % and 2.8 %, respectively, but it was not characterized by statistical reliability, $p\geq0.05$. As for the separation of the chordae of the MV leaflets, their frequencies were similar in the groups of this study, $p\geq0.05$.

Another important factor that determines the structural and functional changes of the MV is the deposition of calcium on its anatomical structures. As a result of the analysis of the presence of calcification of the MV on its anatomical structures, it was established that the calcification of the MV ring was significantly more common in the control group, p=0.01; χ^2=5.58, and compared to other calcium deposits, it was most abundant on the MV ring, on average, at 55.0±4.2 %.

Table 1

Analysis of structural and functional lesions of the MV before surgical treatment (n=140)

Index/ factor	Study group, n=69	Control group, n=71	p, χ^2
	n, (%)		
Prolapse MV			
Prolapse of the posterior leaflet MV	7 (10.6)	2 (2.8)	p≥0.05
Prolapse of the posterior leaflet and partial separation of the chordae MV	2 (2.9)	5 (7.0)	p≥0.05
Prolapse of the anterior leaflet MV	-	6 (8.4)	p=0.04; χ^2=4.21
Prolapse of both MV leaflets	-	7 (9.9)	p=0.02; χ^2=5.24
All prolapse	9 (13.0)	20 (28.2)	p=0.04; χ^2=4.0
Separation of the chordae MV			
Detachment of the chords of the anterior flap of MV	3 (4.3)	-	p≥0.05
Detachment of the chords of the posterior flap of MV	-	3 (4.2)	p≥0.05
Detachment of chords MV of all	3 (4.3)	3 (4.2)	p≥0.05
Calcinosis			
Calcinosis of the MV ring	31 (43.8)	47 (66.2)	p=0.01; χ^2=5.58
Calcinosis of the MV ring with spread to the MV leaflets	2 (2.8)	3 (4.2)	p≥0.05
Calcinosis of MV leaflets	2 (2.8)	-	p≥0.05
All calcinosis	35 (49.3)	53 (74.6)	p=0.006; χ^2=7.58
Reverse flow MV			
(+)	7 (9.9)	3 (4.2)	p≥0.05
(+)/(++)	3 (4.2)	5 (7.0)	p≥0.05
(++)	27 (38.0)	3 (4.2)	p=0.0001; χ^2=23.29
(++)/(+++)	7 (9.9)	24 (33.8)	p=0.002; χ^2=10.03
(+++)	12 (16.9)	21 (29.6)	p≥0.05
(+++)/(++++)	4 (5.6)	13 (18.3)	p=0.04; χ^2=4.03
(++++)	3 (4.2)	-	p≥0.05
Pressure gradients and calculated MV values			
Pressure gradient on MV mm Hg (maximum)	9.7±3.5	9.1±3.4	p≥0.05
Pressure gradient on MV mm Hg (average)	4.0±2.3	4.5±2.4	p≥0.05
Estimated diameter of MV, mm	2.8-M 2.0	2.6-M 1.8	p≥0.05
The area of the MV opening, mm2	0.8	0.9	p≥0.05

Next, conduct an analysis of the quantitative characteristics of the reverse flow of blood during MIR. It was found that the reverse blood flow of a moderate degree (++) was significantly more often presented in the experimental group – 38.0 %, compared to the corresponding frequency in the control group – 4.2 %, p=0.0001; χ^2=23.29. At the same time, more reverse blood flow of a pronounced degree: (++)/(+++) was more often presented among patients of the control group – 33.8 %, compared to the frequency in the study group – 9.9 %, the difference in frequencies was characterized statistical reliability, p=0.002; χ^2=10.03. It was also established that another statistical probability of a very pronounced backflow of blood (+++)/(++++), which was also inherent in the participants of the control group – 18.3 %, while among the participants of the experimental group the corresponding frequency was only – 5.6 %, p=0.04; χ^2=4.03.

In addition, comparisons were made of pressure gradients on the MV (maximum and average) and calculated values: the diameter of the MV and the area of its opening, but the determined differences of the specified values between the study groups were not characterized by statistical probability, p≥0.05.

Next, we analyzed the presence of MV insufficiency in the anamnesis of the study participants and its degree of severity, which is a significant adverse prognostic factor in patients with MIR against the background of the clinical course of CHD, table 2.

According to the results of the data presented in Table 2, the patients of the study were diagnosed with MV insufficiency of various degrees of severity. It was established that the insufficiency of MV of a significant degree of severity occurred with a frequency of 85.5 % in the experimental group and 97.2 % in

the control group, the difference in the determined frequencies was characterized by statistical reliability (p=0.03; χ^2=4.69). The moderate degree of MV insufficiency was significantly higher among the patients of the experimental group, its frequency was 13.0 %, while in the control group the corresponding frequency was 2.8 %, the differences in the determined frequencies were characterized by probability, p=0.05, χ^2=3.74.

Table 2

Analysis of the frequency of MV insufficiency in the study groups (n=140)

Index/ factor	Study group, n=69	Control group, n=71	p, χ^2
	M±m, (%)		
Presence of MV insufficiency	66 (95.7)	71 (100.0)	p≥0.05
MV deficiency of a moderate degree	9 (13.0)	2 (2.8)	p=0.05; χ^2=3.74
Lack of MV of a pronounced degree	59 (85.5)	69 (97.2)	p=0.03; χ^2=4.69
Without MV deficiency	3 (4.3)	-	p≥0.05

As a result of the analysis of the history of CHD and its clinical course and complications, it was found that MI occurred in 55.7 % of patients in this sample. Other researchers have determined that the presence of MI in the anamnesis is a prognostically unfavorable factor for the life of patients with CHD and MI and increases the intraoperative risk up to five times [1, 3, 7, 8, 10, 11]. The results obtained in our study indirectly confirm the data of other authors. It was established that MI in the anamnesis was significantly more common in the control group (p=0.04, χ^2=4.09), that is, patients who underwent MV prosthetics.

Therefore, a higher frequency of MI is associated with more severe structural and functional changes of the MV. In order to confirm this assumption, the obtained results and their addition to the results of other authors were analyzed structural and functional changes of MV according to Echo-CG data and compared their frequencies between the research groups.

In favor of more pronounced structural and functional changes in the MV among the obtained results, the determination of: the frequency of prolapse of the MV leaflets: anterior leaflet (p=0.04; χ^2=4.0); anterior and posterior leaflets (p=0.02; χ^2=5.24); frequency of MV calcification (p=0.006; χ^2=7.58) and frequency of calcium lesions of the MV ring (p=0.01; χ^2=5.58); of backflow of blood of a pronounced degree (++)/(+++), (p=0.002; χ^2=10.03) and a very pronounced degree (+++)/(++++), (p=0.04; χ^2=4.03); and also, a significantly larger number of patients with a pronounced degree of MV insufficiency (p=0.03; χ^2=4.69).

Thus, the obtained statistically significant regularities prove that the patients from the control group had irreversible structural and functional changes in the MV, which made it impossible to perform organ-preserving surgery – MV plastics, and led to irreversible changes in the anatomy of the MV, which conditioned the performance of MV prosthetics.

Conclusions

1. It was found that MI was present in the anamnesis significantly more often in patients of the control group (p=0.04, χ^2=4.09).

2. More pronounced structural and anatomical changes of the MV were established, which had statistical significance in patients of the control group, namely: prolapse of the MV leaflets: anterior (p=0.04; χ^2=4.0) and both leaflets (p=0.02; χ^2=5.24); MV calcification frequency (p=0.006; χ^2=7.58); calcinosis of the MV ring (p=0.01; χ^2=5.58); of backflow of blood of a pronounced degree (++)/(+++), (p=0.002; χ^2=10.03) and a very pronounced degree (+++)/(++++), (p=0.04; χ^2=4.03); as well as severe MV insufficiency (p=0.03; χ^2=4.69).

3. The results obtained during our scientific search demonstrate that in patients who underwent MV prosthetics, there were more significant structural and anatomical changes of the MV, which determined the choice of the surgeon regarding the method of surgical intervention on the MV.

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QUANTITATIVE EVALUATION OF THE MITRAL VALVE BY MULTI-SLICE COMPUTED TOMOGRAPHY FOR PLANNING MINIMAL INVASIVE OR PERCUTANEOUS INTERVENTIONS

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24 healthy patients vs22 patients with functional mitral regurgitation (grade II/III) who had undergone ECG-gated computed tomography angiography were retrospectively evaluated. Mean age was 47±11 vs 63±7 years ($p<0.05$), male gender 75 % vs 68 % (ns), BMI 26±2.8 kg/m² versus 26±3.5 kg/m² (ns), left ventricular ejection fraction 72±6 % vs 31±9 % $p<0.05$). The mean mitral saddle-shaped annular area averaged 12±2 cm² in the control group, 14.6±0.52 cm² in patients with functional mitral regurgitation, the D-shaped annular area 10.3±1.6 cm² vs. 12.7±0.5 cm², respectively, being significantly different between two groups and both approaches. This study showed that there are significant differences in the mitral annular morphology between the two groups, as well as several changes between sizing approaches of the mitral annulus throughout the cardiac cycle. Our study showed that with good optimization of procedure protocol and postprocessing process, computed tomography is a feasible method for precise preprocedural evaluation of mitral valve dimensions.

Key words: mitral valve, mitral annulus, functional mitral regurgitation, computed tomography, transcatheter mitral valve replacement.

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КІЛЬКІСНА ОЦІНКА МІТРАЛЬНОГО КЛАПАНУ ЗА ДОПОМОГОЮ БАГАТОЗРІЗОВОЇ КОМП'ЮТЕРНОЇ ТОМОГРАФІЇ ДЛЯ ПЛАНУВАННЯ МІНІМАЛЬНО ІНВАЗИВНИХ АБО ЧЕРЕЗШКІРНИХ ВТРУЧАНЬ

Було проведено ретроспективне обстеження 24 здорових пацієнтів порівняно з 22 пацієнтами з функціональною мітральною регургітацією II/III ступеня, яким було проведено комп'ютерну томографію серця. Середній вік становив 47±11 проти 63±7 років ($p<0,05$), чоловіча стать – 75 % проти 68 % (ns), ІМТ – 26±2,8 кг/м² проти 26±3.5 кг/м² (ns), фракція викиду лівого шлуночка 72±6 % проти 31±9 % ($p<0,05$). Середня площа сідлоподібного мітрального кільця склала в середньому 12±2см² у контрольній групі, 14,6±0,52 см² у пацієнтів з функціональною мітральною регургітацією, площа D-подібного кільця 10,3±1,6 см² проти 12,7±0,5 см² відповідно, що значно відрізнялося у двох групах та за обох підходів. Це дослідження показало, що існують значні відмінності у морфології мітрального кільця між двома групами, а також відмінності у розмірах мітрального кільця сідлоподібної та D-подібної форми протягом усього серцевого циклу. Наше дослідження показало, що при достатній оптимізації протоколу процедури та процесу постобробки комп'ютерна томографія є ефективним методом точної передпроцедурної оцінки розмірів мітрального клапана.

Ключові слова: мітральний клапан, мітральне кільце, функціональна мітральна регургітація, комп'ютерна томографія, транскатетерне протезування мітрального клапана.

Mitral valve (MV) disease is one of the most prevalent valvular heart diseases causing significant mortality and morbidity. The mitral valve consists of the three-dimensional, non-circular, saddle-shaped, highly dynamic mitral annulus, anterior and posterior mitral valve leaflets, highly individualized subvalvular apparatus (fibrous tendinous chords and the papillary muscles), left ventricle (LV) and left atrium (LA) [3]. Reduction or elimination of the normal systolic coaptation between mitral leaflets due to