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Repair surgical techniques in degenerative cardiac valve disease

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Abstract

Background: Re-evaluation of reconstructive possibilities in the correction of degenerative mitral valve disease is of great clinical necessity nowadays.
Material and methods: Analyzing the nature of the pathologies that determined the development mechanism of valve insufficiency, 136 cases of anterior cusp prolapse and 152 cases of posterior cusp prolapse were determined.
Results: Cord rupture was established in 79 (58.9%) patients, cusp defects ("Cleft") were appreciated in positions A1, A2, A3 – 15 cases (5.9%) and in P1, P2, P3 – in 92 (86.6%) cases. The surgical techniques performed were separated into: (1) resection – for the anterior and posterior cusps – 45 cases and accompanied by the slide – in 30 cases; (2) with Gore-Tex neo-chordal implantation – 115 cases, with cord transfer – 30; (3) Cusp enlargement with autologous pericardium – 5 cases, Alfieri procedure – 8. Implantation of a support ring required 130 (97.0%) patients. The correction of the associated valve disease required 125 patients (De Vega – 89.1%, ring – 8). Coronary bypass was required – 16 patients. There were no postoperative fatal cases.
Conclusions: Based on the data obtained, reconstructive repair surgery can be can recommend for valves of degenerative, post-traumatic, ischemic, post-endocardial etiology as effective and sustainable techniques over time, being a superior alternative to replacement with prosthetic valves.
Key words: mitral valve repair, degenerative valve disease, cardiac valve surgery.

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Introduction

Evaluation of reconstructive possibilities in the correction of degenerative mitral valve disease is of great clinical necessity nowadays.

Pathogenically, depending on the lesion type, several operative reconstructive techniques successfully applied in mitral valve insufficiency are determined (tab. 1).

Being an important component of the etiology of mitral regurgitation, tissue dysplasia conjunctivitis is a version of a morphologically modified valve structure, leading to functional insufficiency. Synonyms of this pathology are myxomatous mitral valve disease, endocarditis, chronic degenerative valve disease, chronic valve fibrosis [1, 2]. In the pathogenesis of myxomatous lesions of the mitral valve, a special place is occupied by the anatomical and functional concept – mitral valve prolapse (MVP). The MVP symptom reflects the behavior and position of the mitral valve (MV) in the left atrial cavity at the time of left ventricular systole. It is worth noting that degenerative mitral injury due to valve prolapse does not always mean the development of hemodynamically important insufficiency. True regurgitation of the MV occurs in 40-60% of cases of valve dysplasia, more often in women. Morphologically, mitral degenerative disease is reflected in two different nosological entities: fibroelastic deficiency and Barlow's syndrome [3].

Barlow's syndrome reflects a myxomatous proliferative state with excessive tissue, often with involvement of the mitral annulus (dilation), with an echocardiographic pattern referred to as a "floating valve", characterized by an annulus diameter >36 mm and possible periannular valve fibrosis, but also more often calcification of the anterior mitral leaflet. Barlow's disease is characterized by affecting young people with an average age of 30-40 years. Histologically, myxomatous degeneration is characterized by the deposition of polysaccharides (primarily in the spongy layer of the valve cusps), excessive fibrosis, but also inflammatory infiltrate. Macroscopically, valve degeneration begins with the appearance of nodules on the free edges of the valve cusps, which later merge and contribute to the thickening of the leaflets as well as the elongation of the tendinous cords. With the evolution of the disease, the free edges of the valves sink into the cavity of the left atrium, and as a result, mitral insufficiency develops. In the later stages, united fibrosis can cause shortening of the valves, thickening and degeneration of the chordae tendineae with their eventual rupture [4].

Fibroelastic deficiency is a condition associated with a deficiency of fibrous connective tissue, as well as with stretching, lengthening, thinning and rupture of tendon cords, usually without annular damage, with the average age of patients varying between 60-80 years. Echocardiography

Table 1. Mitral valve repair surgical techniques

Type of injury	Surgical technique
Normal mobility	
Annular dilatation Malposition of papillary muscles Perforation of the leaflets	Annuloplasty Annuloplasty Suture/patch
Increased mobility	
Elongated chords	Sliding of papillary muscles Repositioning of the head of the papillary muscle Looping, chords transposition Artificial chords Leaflet resection
Rupture of chords	Resection of the leaflet Chord transposition Artificial strings
Redundant tissue (prolapse, billowing)	Leaflet resection Edge-to-edge technique (Alfieri)
Elongation of the papillary muscles, malposition	Repositioning of the papillary muscles
Rupture of papillary muscles	Reimplantation
Decreased mobility	
Fusion of the commissures	Commissurotomy
Thickening, fusion of the commissures	Commissurotomy Resection Shaving the cusps
Retraction of chords	Splitting of pillars Resection
Thickening of the subvalvular apparatus	Splitting of pillars
The retraction of the leaflet	The sectioning of the secondary chords Widening of the leaflet
Thickening of the papillary muscles Calcifications	Splitting of pillars Resection, debridement

shows isolated cord damage and isolated or combined leaflet thinning [5]. Patients with degenerative MV pathology who develop mitral regurgitation (MR) symptoms have a poor prognosis, and the annual mortality rate is up to 34%. Mitral valve repair can be considered in patients with MR caused by papillary muscle rupture, degenerative and ischemic mitral regurgitation, or in patients with failed repair attempts undergoing reoperation [6].

MV prolapse reflects the behavior and position of the left ventricle (LV) valves in the left atrial cavity at the time of left ventricular systole. MVP is a syndrome determined by the prolapse of one or both valves in the left atrial cavity during left ventricular contraction, associated in most cases with mitral regurgitation [7-9].

The prevalence of MVP among the population varies depending on the author and the diagnostic criteria used – data range from 1.3% to 38% [10].

Material and methods

The study group included 136 patients with degenerative mitral regurgitation (DMR) in the involvement of a cusp undergoing complex mitral valve repair. Considering the severity of the regurgitation, 4 degrees of mitral insufficiency are distinguished: I grade – mild mitral regurgitation; grade II – moderate mitral regurgitation; grade III – pronounced mitral regurgitation; grade IV – severe mitral regurgitation.

The "gold standard" of the quantification of mitral lesions as well as the result of the plastic surgery is the transthoracic and intraoperative transesophageal echocardiography (fig. 1).

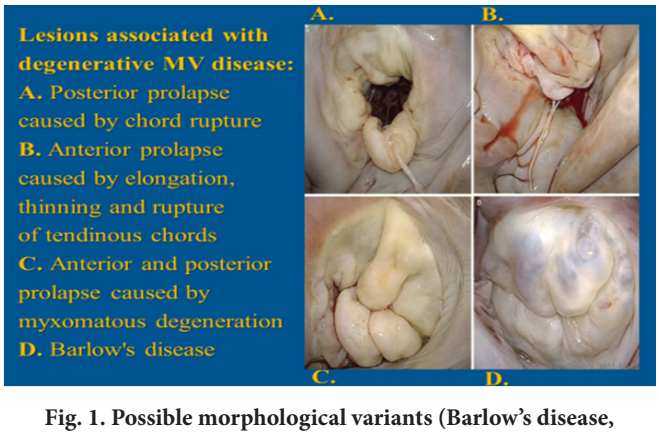

Fig. 1. Possible morphological variants (Barlow's disease, myxomatous degeneration)

Postoperative results

Analyzing the nature of the pathologies that determined the appearance of significant volumetric mitral insufficiency, the following can be mentioned:

– Mitral valve anterior cusp prolapse was dominant in 136 cases with scallop involvement in A1, A2, A3 and both commissures;

– Mitral valve posterior cusp prolapse was dominant in 152 cases; scallops in P1, P2, P3 and anterior and posterior commissure were involved (tab. 2). The scallops A1, P2 were most frequently affected (fig. 2).

Table 2. Operative techniques of mitral valve plastic surgery

Operative techniques	Nr
Support Ring	
26	3
28	22
30	43
32	35
34	19
36	8
Cusp resection	
anterior	1
posterior	44
sliding	30
Neochord	
A_1	13
A_2	30
A_3	19
P_1	8
P_2	28
P_3	17
1	35
2	17
3	13
4	2
Chord transfer	
A_1	6
A_2	9
A_3	10
P_1	1
P_2	1
P_3	3
Secondary-primary	10
Contralateral	5
Cleft suture	
A_1	4
A_2	5
A_3	6
P_1	16
P_2	43
P_3	33
Paracommissural	31
Cusp enlargement with autopericardium	5
Alfieri	8
Commissurotomy, pappilotomy	4

Chord rupture confirmed in the operative field was determined in 34 patients with damage to scallops A1 – 6, A2 – 18, A3 – 10. The most frequent chord suture was

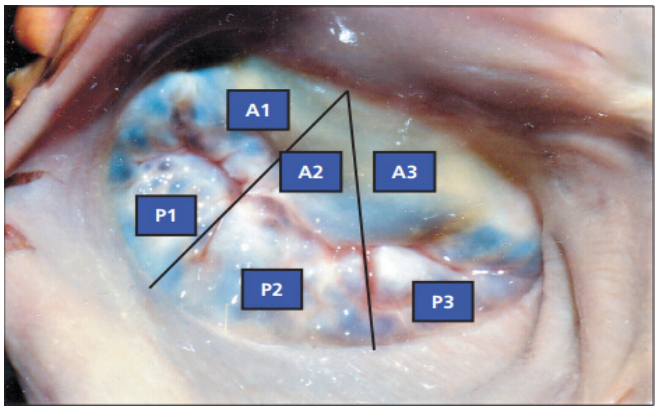

Fig. 2. The conventional division of mitral valve segments into scallops at the anterior (A1, A2, A3), posterior (P1, P2, P3) and commissure (anterior, posterior) cusps, to define the so-called"prolapse score"

established in scallop P2 – 25 cases, followed by scallop P1 – 6 cases and P3 – 14 cases (total 45 patients). Dysplasia were observed, the partial separation of the cusp fragments (cleft) occupying 1-2 scallops, cases that required corrections (application of sutures) to restore the proper coaptation of the valvular complex. The most frequently affected were P1-P2 – 26 cases and P2-P3 – 45 cases, less often the scallops A1-A2 – 2 and A2-A3 – 18 cases (tab. 3).

Table 3. Pathologies diagnosed in cusp prolapse

	Nr
Anterior valve prolaps	102
A_1	24
A_2	64
A_3	39
Comissure	9
Posterior valve prolaps	123
P_1	28
P_2	67
P_3	48
Comissure	9
Chord rupture	79
A_1	6
A_2	18
A_3	10
P_1	6
P_2	25
P_3	14
Cleft	89
A_1-A_2	2
A2-A3	18
P_1-P_2	26
P_2-P_3	43

For the correction of valve diseases, predominantly degenerative, several operative techniques were performed, which aimed to restore valve competence, promote various resection procedures to remove the surplus of redundant tissues according to the planning of the operation and

stabilize the construction with a support ring that was applied according to size depending on the diameter of the hole.

To restore the competence of valve complex, several cleft variants were sutured in positions A1, A2, A3 – 15 and P1, P2, P3 – 92. In all cases, annuloplasty with a support ring was performed. The technique of placing a ring is similar for most types, following a certain algorithm. The procedure begins with the identification of the two fibrous trigones: anterior and posterior and the placement of simple sutures through the valve ring, at this level. The distance between the two trigones is measured, as well as the surface of the anterior area according to this distance, choosing the right size of the ring to be implanted. Sutures are then placed along the entire circumference of the mitral annulus. Due to the proximity of the mitral valve to the circumflex artery, to the anterior aortic valve and to the atrio-ventricular node, the sutures will be made in such a way as to avoid injury to these structures. The wires passed through the mitral ring will then be passed through the annuloplasty ring, after which it is lowered and the wires are tied. The implantation technique is usually standard, the measurement of the diameter of the fibrous ring is respected, and the phenomena of hypercorrection, systolic anterior motion (SAM)> p.8, excessive tensions that can cause dehiscence of the support ring are avoided. Support rings with a diameter of 26 – 3, 28 – 22, 30 – 45, 32 – 35, 34 – 19, 36 – 8 cases were implanted on separate sutures. The device was Medtronic Profile – Future, Carpentier-Edwards – Physio 1, 2, 3, St. Jude medical Saddle Ring, LivaNova Memo (fig. 3).

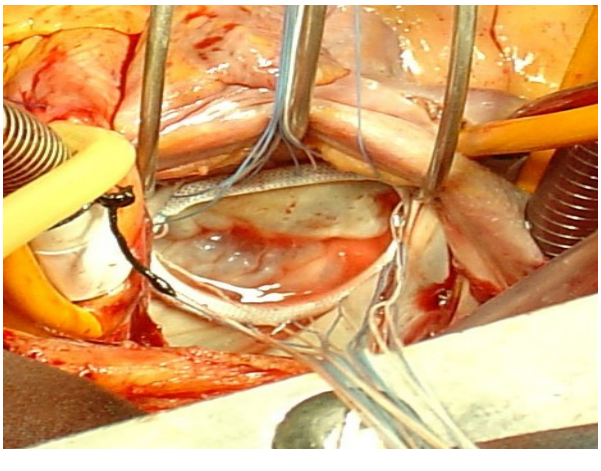

Fig. 3. Mitral annuloplasty with support ring

Annuloplasty with semicircular sutures (3-suture technique) was used as alternative surgical techniques in single cases. Resection techniques (resects) were applied to 1 patient with chord rupture at the anterior cusp, in 44 patients (32.8%) at the posterior cusp. Procedures to lower the coaptation point, sectoral cusp resections, the application of the Sliding technique to avoid the phenomenon of systolic anterior motion were performed in 30 cases.

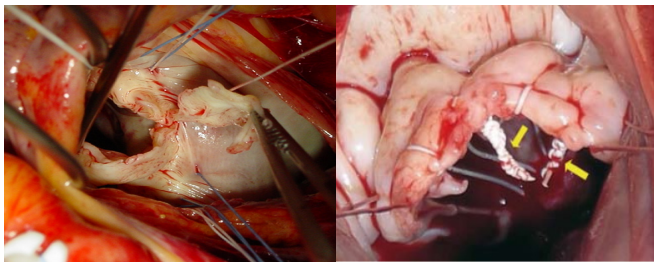

Fig. 4. Resection techniques and the application of neo chord in mitral valve repair

Neochordoplasty techniques (respect) were performed in 62 cases for the anterior scallops and 53 for the posterior ones. Numerically, 35, 17, 13, 4 neochordae were applied using different implantation techniques (fig. 4).

The transfer of native cords was carried out depending on the functional anatomy of the valve disease, the possibilities of replacing affected cords in positions A1, A2, A3 – 25 native cords were transferred, in positions P1, P2, P3 – 5. In 10 cases it was followed the transfer scheme from the secondary-primary position, in 5 – using the contralateral position of the placement of the native cords by performing measurements related to the point of ripening of the valve cusps. In 5 patients, the operative technique was completed with the application of a widening patch from the autopericardium, 8 patients benefited from the so-called Alfieri Sutures (fig. 5). In 4 cases of extensive rheumatic damage, closed mitral commissurotomy with papillotomy was performed to mobilize the valve cusps more effectively.

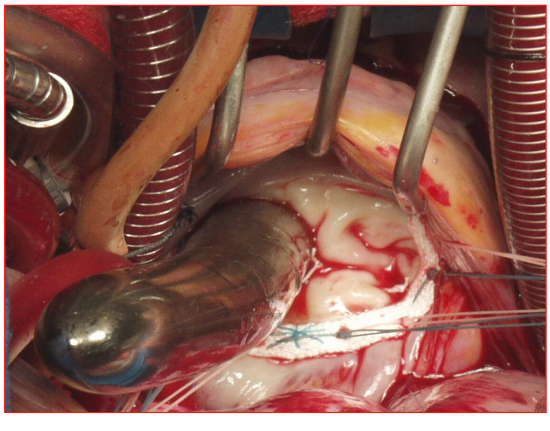

Fig. 5. Application of Alfieri sutures in mitral valve repair

In order to elucidate the most frequent anatomical variants of valve reconstructions, the operative techniques applied in the group of patients with degenerative valve diseases were validated both numerically and cumulatively.

The tricuspid valve presents with moderate fibrous ring dilation in 11 cases (8.0%), with excessive dilatation – in 62 (44.9%), with giant fibrous ring – in 50 cases (42.8%). De Vega (Cabrol) tricuspid valve annuloplasty was performed in 125 cases (89.1%), with support ring – 8 cases (30 mm – 1, 32 mm – 2, 34 mm – 6). Additional tricuspid valve techniques were performed in 39 cases

(cleft suturing – 24 cases, neo chord – 2, Alfieri – 13). In 24 cases with excessive dilatations of the annulus fibrosus, with the formation of a cleft with complex regurgitation mechanisms, separate sutures were applied to restore valve competence. Indications for the application of a widening patch with autopericardium were placed in patients with cusp tethering, in one patient the papillary muscle approximation technique was performed (tab. 4).

Table 4. Additional valve repair techniques

	Nr
Tricuspid annuloplasty	128
De Vega	18
De Vega+Cabrol	102
Support ring	8 (N30-1; N32-2; N34-5)
Cleft suture	24
Neo chord	1
Cusp enlargement with autopericardium	1
Alfieri	13
Coronary bypass	23 (LIMA-11; VENA-12)
ASD, PFO, abnormal drenage	21
Auricula suture	82
Left atrioplasty	12
Thrombectomy	8
Pappilary muscle approximation	6
Ablation	6
Aortic valve repair	3
Secondary chord resection	12

As additional technical procedures, left atrioplasty can also be mentioned in patients with atriomegaly (10 cases), left atrial thrombectomy (4). Carrying out a totalization of the postoperative results that characterize the group of patients who underwent mitral valve reconstruction, some statistical data are taken into account. Thus, at the postoperative examination, it was determined that the diameter of the fibrous ring was – 50 mm (41.1±6.28). The surgical approach through the left atrium was preferred in 127 cases (92.0%), trans-septal – in 11 cases. The aortic valve required correction in 3 cases (annuloplication – 3, cuspoplication – 3, cuspopexy – 1). Coronary bypass was performed in 16 patients (11.6%), including left anterior descending artery (LAD) – 10, diagonal artery (DIA) – 1, autologous vein – 10 cases.

The operations were performed under conditions of extracorporeal circulation with superficial hypothermia – 30-30°, crystalloid cardioplegia was performed in 116 patients (83.3%), blood cardioplegia – in 10, antegrade perfusion distribution was performed in 129 patients. Evaluating the protection of the myocardium during the cardiopulmonary bypass (CPB) period, it can be noted that the spontaneous restoration of the heart rhythm was performed in 91 (63.9%) patients, by single defibrillation in 31 (21.7%), multiple defibrillations – in 8 (5.8%). In the postoperative period, pump assistance was applied in 31 cases, which manifested over a period of time with signs of arterial hypotension, central venous pressure (CVP) increase, tachyarrhythmia or atrioventricular (AV) block with dependence on electro-cardio-stimulator (ECS), cardiotonic and vasopressor treatment. In 87 patients, sources of hemorrhage up to 1000 ml were monitored, average – 351±126.6 ml; 4 patients required resternotomy, 2 with source of hemorrhage and 2 others without. Heart failure was manifested by 36 (34.5%) patients; vasopressors were administered in 75 cases (60.5%), inotropes – in diuretic doses in 45 (32.2%) cases, diuretic doses – in 32 (25.8%) patients. Application of a temporary ECS was performed in 104 (78.6%) patients, permanent implantation required 2 patients. Respiratory insufficiency was manifested by 10 patients (7.8%), hepatorenal – 2, purulent complications or wound infections were not recorded. 6 patients had exudative pericarditis, in 2 cases pericardial drainage was needed. Pleurisy with drainage of the pleural cavity required 5 patients. Pneumonia was recorded in 7 cases (5.1%), stroke – in 3 cases, myocardial infarction, prosthetic endocarditis were not recorded. Postoperative mortality accounted for 1 case (0.7%), the cause of death included a series of postoperative complications, low cardiac output syndrome, hemorrhage, and acute renal failure. At discharge, 67 patients (63.0%) were in sinus rhythm, 44 (31.2%) with atrial fibrillation, 2 (1.4%) with atrial flutter. AV block grade I was recorded in 11 (8%) patients, grade II – in 10 (7.2%). New York Heart Association (NYHA) functional class II was established in 98 (68.8%) cases, functional class III – in 16 (11.6%) cases.

Discussion

Myxomatous degeneration is manifested by elastic fragmentation of collagen, accumulations of spongy connective tissue. Apparently, the dysfunction of the mitral apparatus is a mechanical problem that can be solved surgically, with mitral repair – replacement as the techniques of choice. The rate of reconstructions is increasing in recent years – 51-74% [11-13], and in dedicated centers the individual rate of repair is higher – 92-96%. In the therapeutic attitude, the risk/benefit ratio prevails, the "Respect rather than resect" postulate is well known, the surgical timing is much discussed and recommended for standardization [14-16]. The advantages of repair surgery in prosthetics: fewer bed days; low rate of attributed complications; specific complications (thromboembolism, hemorrhages, prosthetic dysfunctions) reduced; reduced mortality; higher survival rate; pump function preserved. Some retrospective studies determined that compared with other etiologies of mitral regurgitation, degenerative disease is the easiest to repair and has the best survival rate with postoperative longevity equal to the general population [2, 17-21].

Mitral valve repair techniques are perfected over time, which leads to long-lasting results with good functionality. To overcome some of the challenges, it is important that

reconstructive techniques are performed by an experienced team with dedicated, recognized skills. In this study >80% of operations were performed by 1-2 surgeons with more than 25 years of experience in cardiac surgery [9, 22-24].

The mechanisms underlying the survival advantage in patients undergoing correction vs prosthesis are: reduced intraoperative mortality; reservation of the pumping function of the myocardium; low rate of complications attributable to the mitral valve; rate of complications attributed to the procedure. In the description of the study group, the clinical postulations were confirmed with statistical data having confirmed veracity. For a repair that can fail – the following are important: underestimated primary correction, suture dehiscence, systolic anterior motion syndrome, residual mitral regurgitation, hemolysis [20, 25, 26].

The factors that are associated with a higher rate of re-intervention in patients with mitral repair are: mitral regurgitation > moderate postoperatively; annuloplasty ring dehiscence; unjustified intraoperative shortening of tendinous cords; anterior cusp plasty applying resection techniques [27-29].

Anterior repair accompanied by coronary bypass was of longer duration (122±53 vs 109±43 min, P<0.001), the degree of residual regurgitation was greater for the anterior cusp, the cumulative survival index of the patients did not differ among the mentioned groups, the reoperation rate over time (15 years) was 7.5% versus 4.9% after posterior cusp repair (Gray test P=0.26) [30, 31]. Looking at the techniques in which both cusp resections were performed, with cord repair a better preservation of left ventricle (LV) function was obtained for the posterior cusp [16, 22]. In all cases, the prolapse of this cusp was removed; a wide surface of the mitral orifice was obtained, avoiding cases of SAM and residual regurgitation [14, 32]. Similar results were obtained in this study group. Comparing 2 other operative techniques comprising 186 cases (24.9%) of isolated use of neo chords and 560 (75.1%) applying resection techniques, it was found that the probability of a residual regurgitation (20 years of follow-up) was much less in the group with neo chords [10, 31]. In the given study group, there were no cases of dehiscence or rupture of implanted cords. Of great importance to ensure the stability of reconstructive surgical techniques is the observance of an adequate length of the coaptation line, which after implantation of neo chords made up 89-65% vs 11-29% after resection techniques (P<0.001) [22].

Conclusions

Based on the data obtained, reconstructive repair surgeries can be recommended for valves of degenerative, post-traumatic, ischemic, post-endocardial etiology as effective and sustainable techniques over time, being a superior alternative to replacement with prosthetics.

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VVM conceptualized the idea, conducted literature review, collected the data, interpreted the data, and wrote the manuscript.

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Ethics approval and consent to participate
The study was approved by the Research Ethics Committee of the Institute of Cardiology, protocol No 3 of 16.03.2015. An informed consent was received from every patient.

Conflicts of interest
No competing interests were disclosed.