Advances in valve repair for rheumatic mitral stenosis

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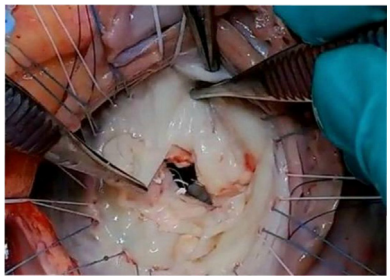
Rheumatic mitral valve disease is still a major challenge worldwide. Mitral valve repair has been proven to be a preferred treatment over valve replacement, especially for degenerative valve disease.[1-4] However, for rheumatic valve disease, the overview outlook seems to be less favorable compared with a degenerative valve entity. Although good long-term mitral valve repair results for rheumatic mitral regurgitation have been demonstrated by Carpentier and colleagues and others[5-7] for rheumatic mitral stenosis, it is still a dilemma and pessimistic. Nevertheless, it is this particular group of patients who demand most for mitral valve repair. Many of them are young and of childbearing age, have poor medication compliance, and live in suboptimal healthcare environments. To insert a mechanical valve, the risks of life-threatening complications are real and dreadful. The challenging questions are how to improve the results of valve repair for rheumatic mitral stenosis and make it another gold standard. This article summarizes the current advances of valve repair for rheumatic mitral stenosis, which is based on a better understanding of the mitral valve complex and dynamics. The pathophysiology triad described by Carpentier and colleagues[8] is of paramount importance and paves the way to correctly impose an effective strategy and approach. The surgical techniques will be elaborated in this review.



Peeling is one of the major advances and becomes an integral part of current rheumatic valve repair.

CENTRAL MESSAGE

Rheumatic mitral stenosis is challenging in valve surgery. A recent innovative approach has shown its efficacy in repairing the valve dysfunction. This article reviews the current strategy and techniques.

CARPENTIER'S PATHOPHYSIOLOGICAL TRIAD

Carpentier and colleagues' functional classification[1] describes the functional disturbance of the mitral valve. The classification generalizes this important issue for surgeons to capture the valve malfunction. Carpentier and colleagues' pathophysiology triad pushes forward for deeper perception of how each etiology can affect the mitral valve and cause a pathologic lesion that results in dysfunction in the end. With this guidance, a surgical strategy and effective techniques can be implemented to improve surgical results. For rheumatic mitral stenosis, the mitral lesions are the consequence of a widespread rheumatic inflammatory response that affects several organs, including the heart. The major mitral valvular lesions are commissural fusion, leaflet thickening, retraction, and deformation of the valve leaflets. The subvalvular apparatus is often fused with shortened and thickened chords. Annular involvement is often underestimated. It is often fibrosed, rigid, and deformed. These lesions significantly interfere with annular dynamic and its geometry. Once calcification is seen, it signifies a long-standing rheumatic disease of the valve. Calcification imposes a significant burden for valve repair and drastically reduces the chance of success. With the attempt and refinement of surgical techniques, this end-stage valve lesion became amenable for repair with acceptable results.[9] All of these mitral valve lesions seriously affect not only the valve opening but also the valve closing. In essence, the dysfunction of rheumatic mitral stenosis includes both diastolic and systolic function by the damage caused by the rheumatic disease process to mitral complex. This understanding dictates an effective surgical strategy and integrated techniques to achieve better and successful results in this complex clinical setting.

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ADVANCES IN VALVE REPAIR FOR RHEUMATIC MITRAL STENOSIS

Strategy

1. Holistic repair: repair for all parts of mitral valve.
2. Correct both diastole and systole.
3. Full and physiologic commissurotomy.
4. Abolish problematic restrictive and obstructive chords.
5. Achieve functional mobility type I for all valve segments.
6. Restore pliability of leaflet and subvalvular apparatus.
7. Ensure adequate quantity and geometry of leaflets.
8. Achieve good coaptation.
9. Effective type and size of annuloplasty ring.

SURGICAL TECHNIQUES

The paramount strategy in rheumatic valve repair for mitral stenosis must be a holistic repair for the mitral valve complex. Rheumatic disease affects every segment of the mitral valve and creates a primary lesion that results in primary dysfunction. These primary consequences will be followed by secondary lesions and dysfunction from continuous damage. The goals of this holistic repair are restoration of normal diastolic and systolic function as much as possible. With better understanding of the relationship between mitral anatomy and dynamics, surgical techniques gradually emerged to accomplish these goals.

Diastolic Function

For normal diastole, the mitral valve must be maximally open. This depends on several parameters.

1. Leaflets must be able to open the orifice along its full length of commissure.
2. The movement of the leaflets must not be hindered by any obstruction from subvalvular structure beneath.
3. The diastolic inflow from the left atrium to the left ventricle must comprise both central orifice and collateral vessels through numerous fenestrated channels. This architecture of flow passage will facilitate and ensure normal diastolic flow through the valve.
4. Pliability of leaflets and subvalvular structures is crucial for normal diastolic dynamics of the valve. Leaflet peeling and fenestration are useful and become integral techniques in repairing a rheumatic, stenotic mitral valve. The details of these techniques will be described.
5. Annular dynamics are vital for normal diastole. Although numerous patients have severe damage of annular function, surgeons must thoroughly assess and identify the condition of the structure and its dynamics. This will pave the way to the appropriate choice of valve ring for good outcomes for both the immediate and long term.

TECHNIQUES

1. Commissurotomy is the first step. The line of commissure usually can be identified by pulling the anterior leaflet downward to show both trigone areas. A few millimeters below are the origin of commissures. The commissure will run from the central orifice and end a few millimeters before the annulus.
2. Fan-shaped chordal insertion should be restored and maintained. This special anatomic character is unique with an important functional implication. It allows the commissural leaflet to move perpendicular to the anterior and posterior leaflets. The mitral valve opening will be maximal and least stressful in this manner.
3. In many situations, when the commissure is badly damaged, the magic stitch, advocated by Carpentier,[5] provides a reliable remedy to achieve commissural competency.
4. Once commissurotomy is complete, the next step is to mobilize the leaflets. Usually, because of severe subvalvular involvement, most of them are type III. Mobilization involves resection of obstructive chords that can be primary, secondary, or tertiary. Resection should be done first to the posterior leaflet because it is close to the surgeon and problematic chords can be identified easily. Mobilization of anterior leaflet subsequently can be done with the same approach.
5. Fenestration, advocated by Carpentier and colleagues,[1] has now become an integral part of the repair technique to restore good diastolic function. It provides important collateral channels for diastolic flow in addition to the main mitral orifice. The technique in combination with papillotomy creates fenestrated spaces for diastolic flow in addition to the central mitral orifice. This significantly improves diastolic function.
6. Most mobility dysfunction of mitral stenosis is Carpentier's functional type III A. The subvalvular chords are usually thickened, fused, and shortened due to rheumatic disease. These chords cause both obstruction during diastole and restriction in systole. Precise resection of all of these problematic chords is essential and will gradually correct leaflet mobility back to normal type I. An appropriate chordal repair technique may be needed at the end of extensive resection to the unsupported valve area.
7. Peeling plasty, introduced for rheumatic mitral valve repair by Kumar and colleagues[10] to restore the pliability of leaflets, has become an integral part of advanced rheumatic mitral valve repair. The technique usually starts at the hinge part of the posterior leaflet with blunt dissection by 2 forceps. Once the plane of the thick layer of the rheumatic membrane is identified, peeling usually can move toward the rough zone of the leaflet. At the

rough zone, no further dissection can be continued because there is no tissue plane. The same procedure is carried out at the anterior leaflet by the same manner as previously described. A sharp cut to the membrane is done to accomplish the peeling technique.[11] Peeling is not feasible if fibrosis and calcification involve the full thickness of the leaflet. In that situation, resection and tissue repair with pericardium are needed. Leaflet injury may occur during peeling, but it usually can be solved by simple suture.

SYSTOLIC FUNCTION TECHNIQUES

8. Once mitral valve repair aimed for diastolic function is complete, the focus is now shifted to systolic function. The prerequisites for optimal systole are the mobility functional class I of mitral leaflets, a pliable leaflet with adequate tissue and good geometry, favorable annular dynamics, and adequate coaptation with good left ventricular function and geometry.
9. To achieve functional class I mobility, the lengths of the primary, secondary, and tertiary chords are crucial and must be optimal. Those chords that are shortened will be restrictive during systole and need to be resected. This step requires precision to resect the chords without compromise. Chordal repair with the appropriate technique may be used for the unsupported valve area in cases with extensive chordal resection.[12,13]
10. An adequate quantity of leaflet with good geometry and pliability is crucial for mitral valve competency and optimal coaptation. In rheumatic mitral stenosis, leaflets are often retracted, thickened, deformed, or calcified. Leaflet repair will be required if tissue is inadequate, severely deformed, or full-thickness calcified. Tissue repair with autologous or bovine pericardium is usually satisfactory with acceptable results.
11. Tissue repair to the mitral leaflets can be done to the anterior or posterior leaflet, or both if necessary.[14,15] However, because the anterior leaflet plays a major role in mitral function, the repair of the anterior leaflet alone is usually adequate for satisfactory valve function. Tissue repair to the anterior leaflet starts by incising the leaflet at the middle part approximately 2 mm from the leaflet and annulus junction. The incision is extended to both sides toward the commissure. It is advisable to extend the incision across the commissural line to approximately half of the leaflet. In this way, the tissue repair will include both commissures, which are commonly affected as well. An ellipsoidal pericardial patch treated with 0.65% glutaraldehyde solution for 5 minutes is sutured with 5-0 Prolene suture to repair the leaflet. The goals are to repair both the quantity of leaflet tissue and the leaflet geometry. The same procedures are used for the posterior leaflet if needed.
12. The last step is mitral annuloplasty and must be emphasized. It strengthens valve repair procedures, prevents further annular dilatation, remodels the annular frame for optimal mitral valve function, and ensures long-term durability.
13. The choice of valve ring is often a debatable issue in mitral annuloplasty. Although there is still no perfect valve ring compared with the natural mitral annulus, to make the best choice, surgeons have to pay attention to certain important points, that is, proper ring size, annular suturing technique, and selection of valve ring type. Major considerations are optimal mitral orifice opening, adequate coaptation surface, and remodeling of annular deformity. The surgeon's experience and preference are important in choosing the type of valve ring to ensure good long-term results.[16-18]
14. Transesophageal echocardiography is used for assessment of mitral valve and repair results the same way as in other types of mitral valve. Both diastolic and systolic parameters as well as coaptation depth are measured for acceptability, prediction of success, and durability of the repair.
15. The feasibility and results of valve repair for rheumatic mitral stenosis have improved recently[9,19,20]; however, certain limitations exist. In patients with severe valve pathology and calcification, and in elderly patients with comorbidity, mitral valve replacement is still a viable choice.
16. Future challenges are improvement of the repair techniques and tissue substitute. These will facilitate valve repair for complex cases. Advances in prosthetic and transcatheter valve technologies are hopeful areas for future treatment.

CONCLUSIONS

With the current knowledge of mitral valve anatomy and dynamics, plus state-of-the-art valve repair techniques, repair of rheumatic mitral stenosis is becoming feasible and promising. The innovative approaches have been introduced with encouraging results. Follow-up of valve repair with this approach is mandatory.

Conflict of Interest Statement

The author reported no conflicts of interest.

The *Journal* policy requires editors and reviewers to disclose conflicts of interest and to decline handling or reviewing manuscripts for which they may have a conflict

of interest. The editors and reviewers of this article have no conflicts of interest.

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