Contemporary application of the edge-to-edge repair

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Introduction

The edge-to-edge technique was introduced into the surgical armamentarium of mitral valve repair in the early 1990s. From the beginning, it appeared to be an attractive approach because of its simplicity, reproducibility and effectiveness even in complex settings. Several institutions around the world adopted this surgical method in selected patients with mitral regurgitation due to different causes and mechanisms (1-8). More recently, the edge-to-edge concept has also become the basis of the most widespread percutaneous method of correcting mitral regurgitation (9).

Unlike traditional repair techniques, which aim for an anatomical reconstruction of the diseased valve, the basic concept behind the edge-to-edge approach is that the competence of the mitral valve can be effectively restored with a ‘functional’ rather than an ‘anatomical’ repair. Appropriate patient selection is crucial and transesophageal echocardiography (TEE) provides all the anatomical and functional features that are essential to decide whether this surgical option is suitable for a specific case. In particular, important details are given by the TEE regarding the cause and mechanism of mitral regurgitation, the degree of annular dilatation (which has important implications for the risk of stenosis after repair), the presence of annular calcification, the precise site and extension of the regurgitant jet and the likelihood of postoperative systolic anterior motion (SAM). The location of the regurgitant jet is particularly important because the free edge of one leaflet is sutured to the corresponding edge of the opposing leaflet at exactly the same level in order to restore mitral valve competence. When the regurgitation originates in the central part of the valve, the edge-to-edge repair produces a mitral valve with a double orifice configuration (double orifice repair). On the other hand, when mitral insufficiency occurs near a commissure, the edge-to-edge leads to a surgical closure of the commissure (‘paracommissural edge-to-edge repair’). Under these circumstances, the mitral valve will have a single orifice with a relatively smaller area when compared with the preoperative value.

The suture has to be placed in exact correspondence with the regurgitant jet and has to be as short as possible in order to eliminate mitral regurgitation without inducing stenosis. Valve distortion has to be carefully avoided as well. A ring annuloplasty should be used and a final mitral valve area of at least 2.5 cm² should be left in normal sized patients. The edge-to-edge technique is usually performed through a conventional midline sternotomy or a minimally invasive approach, with excellent results (10,11).

Surgical techniques

We present the case of a 49-year-old male, asymptomatic for dyspnea, with good left ventricular function and a left ventricular end diastolic diameter of 54 mm, affected by severe mitral regurgitation due to degenerative disease. He was referred to our center for an isolated prolapse of the central scallop of the anterior mitral leaflet (A2) with coexisting annular dilatation. The isolated prolapse with flail of the anterior leaflet could be appreciated on preoperative transesophageal echocardiogram. It causes severe mitral regurgitation, with an asymmetric jet and coanda effect in the left atrium, seen in color-Doppler. Once the heart is arrested, valve analysis confirms a degenerative disease involving the central scallop of the anterior leaflet, with flail.

The anterior leaflet is redundant and can be easily mobilized. It is affected by significant prolapse of the medial aspect of A2, with flail due to chordal rupture, clearly evident when it is compared with the corresponding portion...
of the posterior leaflet, which is free from prolapse.

Now, the chordae of P3 are inspected with a nerve hook. The medial scallops of both leaflets A3 and P3 are also compared again in order to verify that there are no other prolapses.

The medial portion of the central scallop of the anterior leaflet, the target area, is subsequently addressed to perform the edge-to-edge correction. The repair is elegantly carried out using a 4-0 single polypropylene suture, passed around 5 mm away from the free margins, in order to anchor the anterior leaflet to the posterior one, without the use of pledgets. Attention should be given to take big bites of leaflet tissue with this suture, to provide strength to the repair and to reduce the leaflet height.

A double orifice valve conformation is then created.

The sutures are passed one by one through the prosthetic band and carefully tied. The competence of the reconstructed valve is finally assessed by injection of saline solution into the left ventricle, demonstrating only a little oozing. Indeed, when the posteromedial and after the anterolateral orifices are evaluated, they show a wide area and total continence of the mitral valve, without any evidence of residual prolapse.

After weaning from cardiopulmonary bypass, intraoperative TEE is performed to check the valve competence, with fine calculation of the planimetric area, the transmitral flows and the morphologic analysis of the double orifice valve. In patients with mitral regurgitation due to segmental anterior leaflet prolapse, the correction with edge-to-edge repair combined with annuloplasty is excellent, as recently reported by our group in the publication of very long-term clinical and echocardiographic outcomes (12). The prolapse or flail of the anterior leaflet illustrated in this video is one of the current indications of the edge-to-edge mitral valve repair. In the setting of degenerative mitral regurgitation this approach can be effectively used to also treat bileaflet prolapse and commissural lesions with excellent long-term outcomes.

**Outcomes of mitral valve repair using the edge-to-edge**

**Segmental prolapse of the anterior leaflet**

A very good indication for the edge-to-edge technique is severe mitral regurgitation due to segmental prolapse of the anterior leaflet involving only one scallop. This mechanism of mitral regurgitation can be typically found in patients with anterior leaflet chordal elongation or rupture in the setting of degenerative mitral valve disorder (myxomatous disease or fibroelastic deficiency) or post-endocarditis mitral regurgitation. If only one scallop (usually A2) is prolapsing, the edge-to-edge repair is very effective in restoring mitral valve competence in a rapid, standardized and easily reproducible manner. Long-term results are very satisfactory, with a freedom from reoperation at 10 years of 96%±2.3% and a recurrence rate (by echocardiography) of mitral regurgitation 3+ or more of 2.2% at a mean follow-up of 4.5±3.12 years (range, 1 month-13.2 years). Stenosis has never been reported in this subgroup of patients immediately after surgery or at follow-up.

Interestingly, these results were comparable to those obtained in patients submitted to standard quadrangular resection for prolapse of the posterior leaflet (8).

Our group also published the outcomes of these patients at 17 years. The actuarial survival was 72.4%±7.89% and freedom from reoperation was 89.6%±2.74%. The recurrence of MR grade ≥3+ was documented in 17 patients (17 of 135, 12.5%). Freedom from MR grade ≥3+ at 17 years was 80.2%±5.86%. On multivariate analysis, the predictors of MR recurrence grade ≥3+ were residual MR greater than mild at hospital discharge (hazard ratio, 7.4; 95% confidence interval, 2.5-21.2; P=0.0001) (12).

Indeed, in patients with MR due to segmental anterior leaflet prolapse, the long-term results of the edge-to-edge repair combined with annuloplasty were excellent.

However, it is important to emphasize that, if the prolapsing or flailing lesions involve more than one scallop, the edge-to-edge repair alone may not be sufficient to obtain a perfectly competent valve. In this situation, a long suture would be required with the consequent risk of inducing mitral stenosis. An anatomical repair like artificial chordae implantation would be more appropriate in this setting in order to eliminate incompetence without excessively reducing the mitral valve area.

**Bileaflet prolapse of facing segments in Barlow’s disease**

The clinical and echocardiographic long-term results of the edge-to-edge repair for bileaflet prolapse are now available. At 12 years, freedom from recurrence of mitral regurgitation 3+ or more was 86.3%±3.54%. Mitral stenosis
requiring reoperation was detected in only one patient (1/128 patients, 0.7%). The only predictor of recurrence of mitral regurgitation 3+ or more at follow-up was residual regurgitation greater than mild at hospital discharge (P=0.007) (13). Those results achieved at a mean follow-up of 11.5±2.53 years (range, 1.1-17.6 years) are at least comparable to, if not better than, those described in other series with similar follow-up length (14-18) and confirm that the double orifice technique combined with ring annuloplasty provides excellent late outcomes in patients with degenerative mitral regurgitation and bileaflet prolapse.

Percutaneous edge-to-edge repair
The edge-to-edge concept of mitral valve repair is the basis of the most currently widespread percutaneous method of correcting mitral regurgitation. The MitraClip system (Evalve, Menlo Park, California, USA) allows the implantation of one or more clips at the site of regurgitation, reproducing the surgical edge-to-edge repair (19).

Contraindications
Despite this great versatility, clinical and echocardiographic results have progressively demonstrated that there are specific subgroups of patients in whom the edge-to-edge technique leads to suboptimal results. Unsatisfactory outcomes have been reported in patients with rheumatic mitral regurgitation and in those who did not receive a concomitant annuloplasty (2,20). In the aforementioned conditions edge-to-edge repair does not represent the technique of choice.

Due to the risk of inducing stenosis, the edge-to-edge technique should not be used in patients with small mitral valve area and rheumatic mitral regurgitation. In addition, its application is not indicated in the case of bileaflet prolapse if the mitral lesions involve non-facing segments of the anterior and posterior leaflets. Finally, it should be avoided in the presence of a heavily calcified annulus and whenever annular dilatation cannot be corrected by a concomitant annuloplasty for whatever reason. Indeed, the absence of annuloplasty is likely associated with increased stresses on the suture and on the valve apparatus, leading to accelerated failure of the repair. As a matter of fact, freedom from reoperation is lower when annuloplasty is for some reason omitted (2,20).

Summary
Twenty years after its introduction, the edge-to-edge technique remains an effective and versatile method to treat mitral regurgitation due to different causes and mechanisms. Simplicity, reliability and reproducibility are the main advantages of this method and have led to its increasingly widespread application in the surgical community. Very long-term durability has recently been definitely demonstrated. The current indications and contraindications of the edge-to-edge repair, substantiated by the surgical results, have been outlined in this manuscript. If the well-established technical aspects of the procedure are respected and the indications previously described are observed, results with this type of repair are similar or even superior to those obtained with other reconstructive techniques.

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References
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