The edge-to-edge technique as a trick to rescue an imperfect mitral valve repair

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Abstract

Objective: The edge-to-edge (E-to-E) technique in mitral valve repair (MVR) is promising especially to correct mitral insufficiency (MI) caused by complex mitral valve lesions. We tested this technique to improve residual MI straight after conventional MVR. Methods: From September 1998 to January 2002, 108 consecutive patients underwent MVR with current techniques for pure MI. Intraoperative transesophageal echocardiography was performed before and after MVR. At the end of cardiopulmonary bypass (CPB), 11 patients presented residual mitral regurgitant jet area (MRA) $\geq 2.0$ cm$^2$. The E-to-E technique was used to improve this residual MI, without taking down the original MVR. Results: There were no hospital deaths. One patient died of non-valve-related cardiac death about 6 months after hospital discharge. At intraoperative ecocardiography, residual MRA improved from $3.0 \pm 0.8$ cm$^2$, after conventional MVR, to $0.7 \pm 0.9$ cm$^2$, after the E-to-E technique ($P = 0.00014$). Additional CPB time of $14.9 \pm 2.8$ min was needed. These echocardiographic results were confirmed at follow-up of $13.8 \pm 8.1$ months. Conclusions: The E-to-E technique is a simple, rapid, effective, and durable option to reduce residual MI and rescue an imperfect conventional MVR. © 2002 Elsevier Science B.V. All rights reserved.

Keywords: Mitral valve repair; Residual mitral insufficiency; The edge-to-edge technique; Transesophageal echocardiography

1. Introduction

Mitral valve repair (MVR) offers concrete advantages over mitral valve replacement [1]. Intraoperative transesophageal echocardiography has demonstrated that important residual mitral insufficiency (MI) is among the more frequent causes of immediate failure of MVR [2]. Because the goal of MVR for MI must be to achieve, at the end of cardiopulmonary bypass (CPB), MI equal to zero or trivial, a further repair or replacement during the same operation is required.

Recently, Alfieri and colleagues proposed the edge-to-edge (E-to-E) technique as an effective alternative approach that can be a useful addition to the surgical armamentarium in MVR [3]. MVR using the E-to-E technique is promising, especially for correction of MI caused by complex mitral valve lesions [4]. The E-to-E technique is useful also when adopted in selected patients or in special situations [5–13].

We systematically used the E-to-E technique to improve residual MI straight after conventional MVR when, at intraoperative echocardiography, only marginal reduction of original MI was achieved.

2. Materials and methods

From September 1998 to January 2002, at our Department, 108 consecutive patients underwent MVR for pure MI. Mitral valve surgical procedures included the Cosgrove-Edwards annuloplasty system implantation (100%), the Bolling undersized annuloplasty repair (31.5%), quadrangular resection and sliding of the posterior leaflet (65.7%), anterior leaflet repair (5.6%), posterior leaflet decalcification (3.7%), and/or chordal repair (3.7%).

Intraoperative transesophageal echocardiographic examinations were performed after induction of general anesthesia but before sternotomy, after MVR before decannulation, and at sternal closure, all at similar mean aortic pressures and echocardiographic instrument settings. The grade of MI was visually quantified on a four-point scale (0–3), according to the left atrial extent of the mitral regurgitant jet area (MRA) detected by biplane color Doppler flow mapping: MRA $<2.0$ cm$^2$ correspond to no or trivial MI (grade 0), MRA $\geq 2.0$ cm$^2$ but $<4.0$ cm$^2$ to mild MI (grade 1), MRA...
Immediately after MVR, competence of the reconstructed mitral valve was evaluated by means of a forceful injection of saline solution into the left ventricle. No or trivial residual MI assessed by this manual hydraulic test was obtained in all 108 patients. However, in 11 (10.2%) patients, mild or moderate residual MI was identified by transesophageal echocardiography after weaning from CPB. The E-to-E technique was used to improve this residual MI, without taking-down the primary MVR. Our target was to achieve MRA <2.0 cm².

Mean age of these 11 patients (three women and eight men) was 65.2 ± 9.6 years (range, 48–74 years). At admission, nine (81.8%) patients were in New York Heart Association (NYHA) functional class 4, one was in class 3, and one was in class 2. Degenerative heart disease was the cause of MI in four patients, ischemic heart disease in two, combined degenerative and ischemic heart disease in three, and Barlow disease in two patients. Severe MI was present in all patients. Posterior leaflet prolapse was the mechanism of MI in four patients, anterior leaflet prolapse in one, bileaflet prolapse in three, posterior commissural prolapse in one, restricted motion of the posterior leaflet in one, and severe annular dilatation in one patient.

Patients were placed on normothermic CPB through a conventional midline sternotomy using bicaval cannulation and intermittent antegrade cold blood cardioplegia. Coronary artery bypass grafts were performed in five patients, always before MVR. The mitral valve was approached through the left atrium, with the incision done in the interatrial groove. Initial MVRs performed for treatment of MI are summarized in Table 1. After the manual hydraulic test demonstrated an apparently successful repair, patients were weaned from CPB and transesophageal echocardiography was repeated. If residual MRA was greater than 2.0 cm², a second normothermic CPB was started to perform the E-to-E technique, through the same left atrial approach. According to Alferi, at the site of residual MI, the anterior leaflet was approximated to the corresponding point on the posterior leaflet and sutured with a running 4-0 polypropylene suture [3,11]. The choice of site of Alferi stitch was exclusively echo-guided. Because the manual hydraulic test failed to find any residual MI after initial MVR, it was not repeated. The valve area was measured with Hegar dilators passed through the two orifices: a global valve area greater than 2.5 cm² was considered acceptable. At the end of this CPB, intraoperative echocardiographic examination was repeated.

Transesophageal echocardiography was performed right before hospital discharge and at follow-up.

Values are expressed as the mean ± standard deviation, or as percentage. Variables were compared by Student’s t-test. Statistical significance was considered present with a P value less than 0.05.

### 3. Results

There were no hospital deaths. Ten patients with central regurgitant jet had central double-orifice repair and one patient with posterior paracommissural regurgitant jet had paracommissural repair. Second CPB and aortic cross-clamping times were 14.9 ± 2.8 and 9.2 ± 2.4 min, respectively (Table 1). Early reoperation for residual MI or new mitral stenosis was never required. Grade of residual MI improved from 1.2 ± 0.4, after conventional MVR, to zero, after the E-to-E technique (P = 0.00088). Residual

<table>
<thead>
<tr>
<th>Patient No.</th>
<th>Initial MVR</th>
<th>The E-to-E technique</th>
<th>2nd CPBt (min)</th>
<th>2nd Ao-X-t (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technique</td>
<td>Annuloplasty</td>
<td>Posterior mitral leaflet</td>
<td>Type of repair</td>
<td>2nd CPBt (min)</td>
</tr>
<tr>
<td>CEAS diameter (mm)</td>
<td>Quadrangular resection Sliding</td>
<td>Central double-orifice</td>
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<td>8</td>
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<td>1</td>
<td>Standard 30</td>
<td>P2</td>
<td>P1-P3</td>
<td>15</td>
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<td>2</td>
<td>Standard 32</td>
<td>P2</td>
<td>P1-P3</td>
<td>15</td>
</tr>
<tr>
<td>3</td>
<td>Central double-orifice</td>
<td>16</td>
<td>8</td>
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<td>4</td>
<td>Standard 32</td>
<td>P2</td>
<td>P1-P3</td>
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<td>Standard 32</td>
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<td>P1-P3</td>
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<td>P2</td>
<td>P1-P3</td>
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<tr>
<td>11</td>
<td>Standard 28</td>
<td>P2</td>
<td>P1-P3</td>
<td>Central double-orifice</td>
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</tbody>
</table>

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* 2nd Ao-X-t = second aortic cross-clamping time; CEAS = Cosgrove-Edwards Annuloplasty System; 2nd CPBt = second cardiopulmonary bypass time; E-to-E = edge-to-edge; MVR = mitral valve repair; P1 = lateral scallop of the posterior mitral leaflet; P2 = central scallop of the posterior mitral leaflet; and P3 = medial scallop of the posterior mitral leaflet.

b The Bolling undersized annuloplasty.
MRA improved from 3.0 ± 0.8 cm², after conventional MVR, to 0.7 ± 0.9 cm², after the E-to-E technique ($P = 0.00014$). At the end of operation, residual MRA was always less than 2.0 cm². No patient had postoperative mitral stenosis: the postoperative mitral valve area was always greater than 2.5 cm², also in the four patients (three females and one male with body surface areas less than 1.6 m²) who had a size 28 ring implanted. The postoperative mean mitral gradients at rest were always less than 3.0 mmHg. These echocardiographic results were confirmed at hospital discharge.

One patient died of myocardial infarction about 6 months after operation. At follow-up (mean = 13.8 ± 8.1 months, range: 4.3–24.2 months), in the ten survivors, residual MRA improved from 0.7 ± 0.7 cm², right before hospital discharge, to 0.6 ± 0.8 cm² ($P = $ not significant), even if transesophageal echocardiographic examination showed mild residual MI (MRA = 2.2 cm²) in one patient. According to echocardiographic data, NYHA functional class improved from 3.7 ± 0.6, preoperatively, to 1.2 ± 0.4 ($P = 0.00033$).

4. Discussion

The Carpentier’s concept of conservative surgical approach to insufficient mitral valve is the basis of the conventional MVR currently adopted in the whole world [15]. Because repair of an insufficient mitral valve is superior to mitral valve replacement, providing lower hospital mortality, longer survival, better preservation of ventricular function, fewer thromboembolic complications, and reduced risk of endocarditis, MVR has presently become the preferred method for correcting MI [1].

The most frequent causes of immediate failure of MVR are left ventricular outflow tract obstruction due to systolic anterior motion of the anterior mitral leaflet and residual MI [2]. Immediate important residual MI requiring further repair or replacement during the same operation has variable incidence [14,16,17], depending on mitral valve pathology, mechanism of MI, technique of repair, and surgeon’s expertise and ability.

Of a series of 108 consecutive patients who underwent MVR at our Department, 10.2% had immediate important residual MI. This is a rather excessive rate, apparently. Actually, we performed MVR in all cases of MI undergoing cardiac operation (independently of mitral valve pathology and of etiology and mechanism of MI) and, although our target to achieve MRA <2.0 cm² after repair was demanding, yet residual MI often was equal to zero. Furthermore, at over 2-year mean follow-up, three patients only had recurrent MI greater than mild: moderate in two and severe in one. Reoperation (mitral valve replacement) was performed in these patients only; traumatic chronic hemolysis, bacterial endocarditis, and symptomatic worsening due to severe recurrent MI were the causes of reoperation.

This group of immediate failure of MVR is quite heterogeneous and, apparently, the mitral valves that underwent failed MVR did not differ significantly from the successfully repaired valves.

Intraoperative transesophageal echocardiography is the most sensitive method for detection and quantification of residual MI following MVR and has become essential to the effectiveness of this procedure [14,16,17]. In patients undergoing MVR at our Department, intraoperative color Doppler transesophageal echocardiographic examination is systematically performed, before sternotomy, to confirm MI and evaluate mitral valve morphology and the mechanism of regurgitation, after MVR, to assess mitral valve reconstruction, and, at sternal closure, to make sure of successful repair. In this series of 11 patients, transesophageal echocardiography was decisive to find important residual MI after conventional MVR (while manual hydraulic test resulted negative for residual regurgitation), to show site and mechanism of regurgitation, to decide on the surgical strategy to correct this immediate failure, and to test the E-to-E technique to rescue imperfect original MVR. Also the choice of the right site for the approximation of leaflets and of the appropriate extension of the suture was echo-guided.

According to intraoperative echocardiographic images, the mechanisms of residual MI after initial MVR were insufficient coaptation depth of mitral leaflets or limited bulging of the free margin of mitral leaflet into the left atrium. In seven patients mitral regurgitant jet was centrally directed and perpendicular to mitral annulus, in four patients it was directed towards the left pulmonary veins. Imperfect sizing of annuloplasty system, use of a flexible rather than rigid ring as annuloplasty system, anterior mitral leaflet non-resection, severe preoperative retraction and restricted motion of posterior mitral leaflet, excessive posterior mitral leaflet resection, and unrepaired chordae are some hypothetical causes of residual MI. MI could occur mostly in patients who have a flexible ring because of supposed incapacity to reduce the antero-posterior diameter of the mitral annulus. Nevertheless, our incidence of mitral stenosis at rest equal to zero could be due to the use of a flexible rather than rigid ring.

Since its introduction, the E-to-E technique has been utilized to treat MI secondary to degenerative heart disease [8], Barlow disease [11], infective endocarditis [7], and ischemic heart disease [8,9]; early and midterm results are satisfactory. The E-to-E technique is useful as well to correct MI in patients with end-stage cardiomyopathy [5,6] or with chronic hemodialysis [13], or to perform a transaortic MVR [12]. However, the E-to-E technique is very promising especially for patients with severe MI caused by complex mitral lesions requiring demanding (although effective) surgical techniques for correction or with an expected lower probability of successful repair: prolapse of both leaflets, prolapse of the anterior leaflet, prolapse of the posterior leaflet in the presence of an extensively calcified annulus, restricted leaflet motion caused by
rheumatic or ischemic disease, or erosion of the free edge of the leaflets [4].

We adopted the E-to-E technique as a trick to rescue an imperfect conventional MVR because it is simple and can be carried out in a short period of time, as demonstrated by the duration of second CPB and aortic cross-clamping times in this series. This is particularly convenient when associated procedures have been performed and in patients with poor preoperative conditions or with advanced left ventricular dysfunction. If transesophageal echocardiography, after MVR but before decannulation, shows important residual MI, there are three options only: to accept this partial correction and bring operation to conclusion (if possible), to try to perform a new MVR, or to replace mitral valve. In the first case, the initial target to achieve MI equal to zero or trivial is not hit; the second option is frequently challenging and sometimes even impossible; in the third case, native mitral valve is sacrificed. Further mitral repair or replacement requires a long period of time and taking-down the initial MVR, during the same operation.

As demonstrated by the transesophageal echocardiographic examinations performed intraoperatively, right before hospital discharge, and at early follow-up, the E-to-E technique is an effective and durable option to reduce residual MI after conventional MVR.

The E-to-E technique could be adopted not only to improve residual MI straight after conventional MVR, but also to correct recurrent MI, perhaps through a minithoracotomy with the Heartport system for CPB.

According to Alfieri [4], on the basis of mechanism of the original MI, we should have performed the E-to-E technique at the beginning in at least six (54.5%) (bileaflet prolapse with the Heartport system for CPB. We adopted the E-to-E technique as a trick to rescue an imperfect conventional MVR because it is simple and can be carried out in a short period of time, as demonstrated by the duration of second CPB and aortic cross-clamping times in this series. This is particularly convenient when associated procedures have been performed and in patients with poor preoperative conditions or with advanced left ventricular dysfunction. If transesophageal echocardiography, after MVR but before decannulation, shows important residual MI, there are three options only: to accept this partial correction and bring operation to conclusion (if possible), to try to perform a new MVR, or to replace mitral valve. In the first case, the initial target to achieve MI equal to zero or trivial is not hit; the second option is frequently challenging and sometimes even impossible; in the third case, native mitral valve is sacrificed. Further mitral repair or replacement requires a long period of time and taking-down the initial MVR, during the same operation.

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References