Edge-to-edge repair for prevention and treatment of mitral valve systolic anterior motion

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Background: The edge-to-edge technique has been proposed to prevent systolic anterior motion (SAM) of the mitral valve. There is limited clinical data available on outcomes of this technique for this indication. We reviewed the midterm results of this technique for SAM prevention and treatment.

Methods: A total of 2226 patients had mitral valve repair between 2000 and 2011, 1148 of which were for myxomatous mitral regurgitation. Beginning in 2000, predictability of postrepair SAM based on the prebypass, intraoperative transesophageal echocardiogram arose in our program. The edge-to-edge technique was used in 65 patients (5.7%) for SAM management, in 53 patients preemptively for transesophageal echocardiogram-based SAM prediction, and in 12 patients for postrepair SAM treatment.

Results: There was no operative mortality. Postoperative mitral regurgitation was significantly improved in all patients compared with the preoperative grade ($P < .001$). SAM was completely eliminated, the mean mitral regurgitation grade in the postoperative period was 0.7 ± 0.9, and the mean transmitral gradient was 1.3 ± 2.2 mm Hg. During a mean follow-up of 26 months, 1 patient in the SAM treatment group presented late recurrence of SAM and no patients developed mitral stenosis (mean transmitral gradient, 2.0 ± 2.6 mm Hg; $P = .12$). Without SAM prediction and preemptive edge-to-edge technique, the expected rate of SAM would have been 5.7%; however, the observed rate was 1% (12 of 1148 patients).

Conclusions: Initiating an expectation for prebypass SAM prediction, combined with a surgical SAM prevention strategy, resulted in a reduced prevalence of SAM compared with our model of observed to-expected-ratios and to published norms. (J Thorac Cardiovasc Surg 2013;146:836-40)

ACD

In mitral valve (MV) repair for myxomatous prolapsed valves, there is the potential for creating systolic anterior motion (SAM) of the anterior mitral leaflet and consequent obstruction of the left ventricular outflow tract (LVOT), which can add significant morbidity and the need for a second exposure to cardiopulmonary bypass (CPB).[1,2]

Although the standard MV repair techniques, including quadrangular resection and sliding plasty to reduce the height of the posterior leaflet and ring annuloplasty, are usually sufficient to eliminate regurgitation and minimize the risk of SAM, it can still occur after repair. We previously reported our initial experience in using the edge-to-edge (E2E) technique in preventing SAM in patients at high risk based on prebypass pre-MV repair echocardiographic criteria or when it developed after MV repair.[3] Because of this experience, during 2000 we initiated an expectation that intraoperative, prebypass transesophageal echocardiography (TEE) examinations would include a SAM prediction, which if repaired would lead to a very low prevalence of postrepair SAM.

This report expands on a previous study focusing on our early and medium-term experience with the E2E technique in MV repair in patients at high risk of SAM based on known preoperative assessment of SAM potential, or SAM after MV repair.

METHODS

Study Design

This study is a retrospective review of all patients who underwent surgical MV repair between 2000 and 2011 at our institution, in whom E2E was used to manage SAM. The study was approved by the Brigham and Women's Hospital Institutional Review Board, and patient consent was waived.

The primary outcome measure was the recurrence of SAM. Secondary outcomes were development of mitral stenosis, the need for MV reoperation, or significant mitral regurgitation.

Surgical Technique

All patients undergoing MV repair had intraoperative pre-CPB TEE and the MV was evaluated for anatomic causes of mitral regurgitation and the potential to develop SAM after the repair. The operative approach to MV repair was through a median sternotomy, which was limited to a lower hemisternotomy in isolated MV repairs, and through the left atrium after establishing CPB. The valve was inspected intraoperatively to confirm the

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Abbreviations and Acronyms

A2 = middle scallop of the anterior mitral leaflet
CPB = cardiopulmonary bypass
E2E = edge-to-edge
LVOT = left ventricular outflow tract
MV = mitral valve
SAM = systolic anterior motion
TEE = transesophageal echocardiography

echocardiographic findings and to identify any additional lesions. A variety of techniques were used to achieve a competent MV before using the E2E to manage SAM. A majority of patients underwent a posterior leaflet quadrangular resection with a modified sliding annuloplasty or folding valvuloplasty of a prolapsing posterior leaflet.[4] All but 1 patient received a prosthetic annuloplasty ring. The E2E repair was used in 2 principal circumstances to manage SAM: to prevent SAM in patients deemed at high risk of developing SAM after MV repair, based on intraoperative prerepair TEE assessment of the mitral valve before CPB was instituted, and to treat SAM in patients in whom SAM was identified by TEE after initial termination of CPB after MV repair. The E2E stitch was placed to prevent SAM of the anterior mitral leaflet in the LVOT at the coaptation point of middle scallop of the anterior mitral leaflet (A2) and middle scallop of the posterior mitral leaflet. Mitral valve calipers were used to ensure that each of the 2 residual orifice areas was >2 cm^2, as described previously.[3] The E2E stitch was a 2-0 multifilament suture placed in a figure of 8 suture mode from anterior to posterior leaflet.

Patients who had SAM after MV repair that was not satisfactorily responsive to the usual medical maneuvers (ie, volume resuscitation, beta blockade, and avoiding inotropes) were managed surgically by a second bypass run and placement of an E2E stitch.

Prediction of SAM Potential

The MV was determined to have SAM potential based on both preoperative TEE exam and surgical assessment upon direct inspection. Diagnostic elements contributing to the prediction of SAM consisted of 1 or more of the following: the presence of SAM in the prebypass period; interaction between the anterior leaflet and the subvalvular apparatus using the Maslow semiquantitative estimation of SAM potential[5] (coaptation-septal distance ≤25 mm increases risk of SAM); asymmetry of the anterior leaflet, in which the anterolateral portion of A2 is larger than the posteromedial A2 (this measurement was reported previously.[3] Asymmetry measured on TEE was validated by direct surgical measurement of anterior leaflet lengths using a modified MV sizer [see Figure 1]. Asymmetry [lateral A2 height minus medial A2 height ≥5 mm] led to prediction of moderate-to-high risk of SAM with risk proportional to the degree of asymmetry); insertion location of A2 secondary chords, also reported previously[3]; and degree of override of the mitral annulus over the LVOT (override of A2 over LVOT >20% increases SAM risk in proportion to percentage override. Percentage override and the aorto/mitral angle measurement assess the same anatomical condition).

The cardiac anesthesiologist reported a high, moderate, or low potential for SAM to the surgeon before initiation of CPB. Criteria used for combined TEE and surgical assessment of significant SAM potential are summarized in Table 1. In addition to optimizing the height of middle scallop of the posterior mitral leaflet and sizing the annuloplasty band based on the height of the A2 segment from annulus to leaflet edge, surgical modifications mitigating high SAM risk included midline or offset E2E suture (Figure 2). E2E offset was guided by TEE and/or surgical evidence of A2 asymmetry.

Statistical Analysis

Statistical analyses were performed with SPSS software (2010, version 19; SPSS Inc, Chicago, Ill). Data are presented as mean ± standard deviation. Continuous variables were analyzed with the Student *t* test, or the related samples Wilcoxon signed rank test when appropriate, and categorical variables using the χ^2 test or the Fisher exact test when appropriate. Actuarial estimates were calculated using the Kaplan-Meier method and differences between curves assessed by the log-rank test. The prevalence of E2E used for prevention or treatment SAM in the entire cohort of myxomatous MV repairs was considered as the expected rate of SAM; the prevalence of E2E used for SAM treatment in the same cohort of patients was considered as the observed rate of intraoperative SAM; finally, the prevalence of E2E for SAM treatment or late development of SAM was used as the observed rate of overall SAM. Differences between expected and observed rates of SAM were compared using the Fisher exact test. All statistical tests were 2-tailed.

RESULTS

Patient Characteristics

A total of 2226 patients had MV repair between October 2000 and July 2011 at our institution, 1148 of which were for myxomatous mitral regurgitation. The E2E stitch was used in 65 patients (5.7%) for SAM management, in 53 patients for prevention of postrepair high risk of SAM, and in 12 patients for postrepair SAM treatment. Mean age at repair was 57 ± 11 years and 36 (55.4%) were men. The mean New York Heart Association Functional Class at admission was 1.8 ± 0.8, and mean left ventricular ejection fraction was 61% ± 11%. Patient baseline characteristics are summarized in Table 2. Based on our SAM prediction algorithm, the expected rate of SAM was estimated at 5.7% (65 of 1148 patients). With implementation of prebyass SAM prediction combined with surgical SAM prevention, the observed rate of intraoperative SAM was reduced to 1% (12 of 1148) ($P < .0001$).

Operative Characteristics

Operative details are summarized in Table 3. All but 1 patient had ring annuloplasty (98.5%), mostly with the Cosgrove-Edwards band (Edwards Lifesciences LLC, Irvine, Calif). The mean ring size was 36.1 ± 2.2 mm, 2.7 mm larger in the SAM prevention group compared with the SAM treatment group ($P < .001$). Not surprisingly, patients in the SAM treatment group had longer CPB and aortic cross-clamp times, by 33 and 19 minutes, respectively ($P = .005$ and $P = .02$, respectively), due to the second bypass run after MV repair to correct SAM.

Outcomes

There was no operative mortality in either E2E groups, and 6 patients (0.5%) died in the overall myxomatous MV repair cohort. Early postoperative mitral regurgitation was significantly improved in all patients compared with the preoperative grade, from a mean mitral regurgitation grade of 3.9 ± 0.3 (severe) prerepair to 0.8 ± 0.9 (none to trivial) ($P < .001$). The mean transmitral gradient was