Long-term outcomes of artificial chordal replacement with tourniquet technique in mitral valve repair: A single-center experience of 700 cases

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Objective: Artificial chordal replacement has been shown to be effective and durable, with numerous techniques reported. However, the outcomes of each technique have remained poorly defined. We report the long-term outcomes of the tourniquet technique.

Methods: We reviewed the data from 700 patients who had undergone mitral valve repair with the tourniquet technique from 1992 to 2010. We analyzed the operative outcomes, long-term survival rate, freedom from reoperation, and freedom from recurrent moderate or severe mitral regurgitation (MR). We also performed Cox regression analysis to explore the predictors of recurrent MR after mitral valve repair using the tourniquet technique.

Results: The mean age was 54.7 ± 14.9 years; 212 patients (30.3%) had anterior leaflet prolapse, 142 (20.3%) had posterior leaflet prolapse, and 346 (49.4%) had bileaflet prolapse. Operative mortality was 1.3%. In 26 cases (3.7%), mitral valve repair was unsuccessful and was converted to replacement. Of those successfully repaired, the 12-year survival rate, freedom from mitral reoperation, freedom from recurrent moderate or severe MR, and freedom from recurrent leaflet prolapse was 85.9%, 88.7%, 72.3%, and 89.0%, respectively. The significant predictors of recurrent MR were anterior leaflet prolapse, age, New York Heart Association class III or IV, left ventricular end-systolic dimension, no annuloplasty ring or band, and postoperative residual mild or greater MR.

Conclusions: The tourniquet technique is a simple and effective method to repair leaflet prolapse, with a low incidence of recurrent prolapse. The incidence of recurrent MR was high in the anterior leaflet prolapse group. Age, no annuloplasty ring or band, and residual MR were strong predictors of recurrent MR. (J Thorac Cardiovasc Surg 2014;148:2033-8)

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Mitral valve repair has been the reference standard therapy for severe degenerative mitral regurgitation (MR). Artificial chordal replacement using expanded polytetrafluoroethylene (ePTFE) sutures was introduced in the 1980s[1] and has been widely performed since then. The decision regarding the length of the artificial chordae will be critical for successful repair, and numerous techniques have been developed to determine the appropriate length of the artificial chordae. Although artificial chordal replacement has been shown to be effective and durable, the outcomes of each technique have not been well reported.

The tourniquet technique was introduced by Kasegawa and colleagues[2] in 1992 as a simple method to determine the artificial chordal length. We have been using this technique for artificial chordal replacement since then. In the present study, we analyzed the early and late outcomes of mitral valve repair using the tourniquet technique and evaluated the effectiveness and durability of this technique. We also explored the predictors of recurrent MR after mitral valve repair using this technique.

METHODS

Study Design and Patient Data

The present study was a retrospective cohort study. The institutional review board of Sakakibara Heart Institute approved the study and waived the requirement for informed consent.

From January 1992 to December 2010, 1112 adult patients underwent mitral valve repair for type II MR at our institution. Of the 1112 patients, 700 underwent mitral valve repair using the tourniquet technique. We excluded pediatric patients <18 years old at surgery from the present study.

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Abbreviations and Acronyms

CI = confidence interval
ePTFE = expanded polytetrafluoroethylene
HR = hazard ratio
MR = mitral regurgitation
TTE = transthoracic echocardiography

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We reviewed the perioperative data and postoperative follow-up information.

The outcome measures included operative mortality, intraoperative conversion to mitral valve replacement, residual mild or greater MR on the predischarge transthoracic echocardiogram (TTE), long-term survival, freedom from mitral reoperation, freedom from recurrent moderate or severe MR, and freedom from recurrent mitral leaflet prolapse. All long-term and echocardiographic outcomes were analyzed, excluding 26 patients who had undergone mitral valve replacement in their primary surgery. Operative mortality was defined as death within 30 days after surgery or before discharge. Survival was calculated from surgery until death, and patients alive were censored at the point of last contact. The mean follow-up period was 80 ± 55 months after surgery, and 94% of patients had complete follow-up data available.

Operative Technique and Intraoperative TEE

Surgery was performed through a median sternotomy or right minithoracotomy. All surgery was performed using cardiopulmonary bypass and cardioplegic arrest. The mitral valve was accessed through a superior transseptal approach in median sternotomy cases and through a standard left atriotomy in minithoracotomy cases. Mitral annuloplasty using a ring or band was routinely performed; however, a few patients did not undergo mitral annuloplasty in the early study period. Posterior leaflet prolapse was primarily repaired with leaflet resection with or without sliding valvuloplasty, and artificial chordae were added as a supplementary procedure, if necessary. In this cohort, only a few patients underwent artificial chordal replacement without resection of the posterior leaflet. Anterior leaflet prolapse was primarily repaired with artificial chordal replacement using the tourniquet technique.

To implant artificial chordae, we first fixed CV5 ePTFE sutures (L. Gore & Associates, Inc, Flagstaff, Ariz) on the correspondent papillary muscle head in a pledgeted mattress fashion. Next, we passed 2 ends of the suture through the prolapsing segment of the leaflet. After seating the annuloplasty ring or band, we placed small tourniquets on each pair of artificial chordae, held them at a specific length by approximating the normal adjacent chordae, and assessed the leaflet competency by injecting saline into the left ventricle (Figure E1). We monitored the left ventricular volume using TEE and filled the left ventricle to the approximate end-systolic volume. If the saline testing showed poor competency, we would readjust the length by sliding the tourniquet and reassess the leaflet competency with saline testing. Once we had confirmed good competency, we gently clamped the ePTFE sutures just below the lower end of the tourniquet with a right-angled clamp, removed the tourniquets, and tied the sutures. We used a very thin and light tourniquet tube for this technique (Figure E2). The tourniquet tube we have used is 1.0 mm in inner diameter, 1.7 mm in outer diameter, and 1 g in weight. If the tourniquet is too thick or too heavy, it will deform the valve during saline testing, making it difficult to assess leaflet competency.

After the repair, the mitral valve was evaluated using intraoperative TEE. Repeat repair or mitral valve replacement with chordal preservation was performed at the same operation if the intraoperative TEE showed significant residual MR after repair. For quick screening of residual MR, the MR jet area was measured. Our indication for a second cardiopulmonary bypass pump run for repeat repair or replacement was >2.0 cm^2 of MR jet area before 2006 and >1.0 cm^2 since 2006.

TEE Study

TTE studies were performed before surgery, before discharge, and during follow-up. The mean TEE follow-up period was 64 ± 56 months, and 662 patients (98.2%) underwent ≥1 TTE after discharge. We reviewed 3424 TEE studies. The left ventricular ejection fraction was calculated using the biplane Simpson method. The left ventricular end-systolic dimension was measured from the 2-dimensional parasternal long-axis view. An effective MR orifice area was calculated as the ratio of MR flow to regurgitant velocity using the proximal isovelocity surface area method. The MR grade was quantitatively determined according to the American College of Cardiology/American Heart Association 2006 guidelines.[3] When the quantitative assessment of MR was not applicable, MR severity was determined semiquantitatively using other parameters such as the vena contracta and MR jet area.[4] Residual MR was defined as mild or greater MR on the postoperative predischarge TTE. Recurrent MR was defined as moderate or severe MR on any TTE after surgery.

Statistical Analysis

Continuous variables are expressed as the mean ± standard deviation if normally distributed or as the median otherwise. For the time-to-event outcomes (survival, cardiac adverse event-free rate, and freedom from recurrent MR), the interval to a first event was compared using the log-rank test, and the Kaplan-Meier method was used to estimate the absolute risk of each event for each group. Stepwise Cox regression models were used to explore the predictors of recurrent MR. We included the following variables in the model: anterior leaflet prolapse, posterior leaflet prolapse (bileaflet prolapse was the reference for prolapse location), age, hypertension, atrial fibrillation, New York Heart Association class III or IV, a history of endocarditis, ejection fraction, left ventricular end-systolic dimension, no annuloplasty ring or band used, and postoperative residual MR. The hazard ratios (HRs) and 95% confidence intervals (CIs) were estimated. All comparisons were planned, and the tests were 2-sided. All statistical analyses were performed by using PASW 18.0 (SPSS Inc, Chicago, Ill).

RESULTS

Preoperative Characteristics

The mean age of all patients was 54.7 ± 14.9 years, and 230 patients (32.9%) were women. Isolated anterior leaflet prolapse was present in 212 patients (30.3%), isolated posterior leaflet in 142 (20.3%), and bileaflet prolapse in 346 patients (49.4%). The preoperative characteristics of the patients are listed in Table 1.

Operative Results

The operative data are listed in Table 1. In the present cohort, 661 cases (94.4%) were performed by way of a median sternotomy and 39 cases (5.6%) using a right minithoracotomy. Concomitant cardiac procedures were performed in 260 patients (37.1%). For mitral valve repair, we performed artificial chordal placement using the tourniquet technique in all cases, and the median number of leaflet segments in which artificial chordae were placed was 2 segments (range, 1-7). We also performed concomitant mitral annuloplasty with a ring or band in 680 patients (97.1%), and leaflet resection with or without sliding valvuloplasty in 473 patients (67.5%). We repeated the cardiopulmonary