Routine Chordal Transposition During Degenerative Mitral Valve Repair to Prevent Systolic Anterior Leaflet Motion

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GLOSSARY OF ABBREVIATIONS
SAM – systolic anterior leaflet motion; LVOT – left ventricular outflow tract; MR – mitral regurgitation; CPB – cardiopulmonary bypass

CENTRAL PICTURE LEGEND
Transposed chords tether the anterior mitral leaflet away from the LVOT, thus prevent SAM.

CENTRAL MESSAGE
Routine use of posterior chordal transposition is an effective technique to prevent systolic anterior leaflet motion (SAM) following mitral valve repair.
INTRODUCTION

Systolic anterior motion (SAM) of the mitral valve complicates 5-10% of mitral valve repairs\(^1\)-\(^3\). SAM can generate severe left ventricular outflow tract obstruction (LVOT) and/or severe mitral regurgitation (MR), leading to significant clinical and hemodynamic consequences. As such, apart from identifying risk factors for its development pre-operatively, surgeons must routinely consider ways to prevent SAM after mitral valve repair. Mechanisms predisposing the development of SAM include structural abnormalities, distorted geometry, and left ventricular dynamics\(^2\). Chordal transposition is one of many techniques to address SAM; Sternik and Zehr demonstrated excellent results in 6 patients with severely myxomatous mitral valves\(^2,4\). A similar technique is routinely used at our center with excellent results. As such, we assert that the routine use of chordal transposition is a very effective technique to prevent SAM following mitral valve repair.

SURGICAL TECHNIQUE AND RATIONALE

Greater than 90% of all isolated mitral valve repairs at our center are performed using a right anterolateral mini-thoracotomy approach with direct visualization. Cardiopulmonary bypass (CPB) is established using percutaneous, ultrasound-guided femoral arterial (most commonly 21 Fr) and multi-stage femoral venous cannulation (most commonly 29 Fr; Bio-Medicus™, Medtronic, Dublin, Ireland) with pre-deployment of Perclose ProGlide™ (Abbott, Chicago, USA) devices. We do not use separate SVC cannulation. The ascending aorta is cross-clamped using a transthoracic Scanlan® Chitwood Debakey clamp (Scanlan International, Inc, Saint Paul, Minnesota, United States) and cold blood del Nido cardioplegia is delivered antegrade to
minimize the frequency of redosing. The mitral valve is exposed through a standard interatrial approach.

Video 1 shows the mitral valve repair technique. A quadrangular resection of P2 is performed (Figure 1A). In the setting of posterior leaflet prolapse, this allows for resection of redundant posterior leaflet tissue. In the setting of anterior leaflet prolapse, this line of coaptation moves posteriorly to accommodate the larger, redundant anterior leaflet. During the quadrangular resection of P2, healthy secondary chordae (not elongated, free of myxomatous changes) are kept intact with an island of posterior leaflet just larger than the base of the chordal attachment (Figure 1B). The island of posterior leaflet is transposed en bloc to the free edge of A2 using interrupted 4-0 Tycron sutures spaced 1-2 mm apart (Figure 1C). As others have described, this technique works by tethering the anterior leaflet more posteriorly, thereby preventing it from being dragged into the LVOT during systole\(^4\) (Figure 1E). The quadrangular resection is subsequently repaired by plicating the posterior annulus and reapproximating the posterior leaflet using interrupted 2-0 and 4-0 Tycron sutures (Figure 1C). A semirigid, complete annuloplasty ring (most common size: 34) is used to stabilize the annulus (Figure 1D). The patient is weaned from CPB, and intraoperative transesophageal echocardiography is used to assess the repair and ensure the absence of residual MR and SAM (Figure 2).

Since 2016 this technique has been used consistently in patients undergoing mitral valve repair, including those with isolated anterior leaflet, posterior leaflet, commissural, and bileaflet prolapse. In these cases, if there are multiple healthy chordae identified from the P2 segment, they are transposed separately to other prolapsing segments (A1, A3, P1, or P3). If there are insufficient chordae to transpose, neochordae are created using GoreTex sutures. The routine use of this technique has essentially eliminated SAM following mitral valve repair in our practice.
DISCUSSION

In our experience, chordal transposition is an effective technique to prevent SAM following mitral valve repair (Supplemental Table 1). The benefits of this technique are three-fold. First, it allows for preservation of the sub-valvular apparatus, which is crucial for maintaining left ventricular geometry. Second, it minimizes, and in most cases eliminates, the need to resect any anterior leaflet. Finally, tethering the anterior leaflet posteriorly allows for sizing a complete annuloplasty ring, as appropriate, to facilitate a larger coaptation length while mitigating the concern of SAM.

One of the main challenges with this technique is that in the setting of isolated posterior leaflet prolapse, it requires intervening on the anterior leaflet, which is not primarily involved. Furthermore, posteriorly directed tethering of the anterior leaflet can theoretically impede mitral valve inflow, although we have not seen any evidence of elevated gradients in our practice. Finally, this technique entails some degree of surgical complexity, at least in comparison to rescue techniques like edge-to-edge repair. However, we argue that this technique is no more complex than others proposed for preventing SAM, including posterior leaflet sliding-plasty; which may have the benefit of moving the coaptation point posteriorly, but lacks the additional security of tethering the anterior leaflet away from the LVOT. As such, we endorse routine chordal transposition as a valuable technique for preventing SAM.
REFERENCES


LEGENDS

**Video 1. Operative technique for degenerative mitral valve repair with chordal transfer.**
This intraoperative video demonstrates our standard approach to mitral valve repair; in this case, in the setting of P2 prolapse.

**Figure 1. Routine approach to mitral valve repair at our center.** (A) A quadrangular resection of P2 is performed and healthy secondary chordae are identified. (B) Secondary chordae and an island of the posterior leaflet are kept intact and transposed _en bloc_ to the ventricular surface of A2 between the free margin and the insertion of the secondary anterior chordae. (C) The quadrangular resection is repaired by plicating the posterior annulus and reapproximating the remaining posterior leaflet using interrupted 2-0 and 4-0 Tycron sutures. (D) A semirigid, complete annuloplasty ring is used to stabilize the annulus. (E) Transposed posterior chordae tether the anterior leaflet more posteriorly, thereby preventing it from being dragged into the LVOT during systole.

**Figure 2. Intraoperative transesophageal echocardiogram post-repair (mid-esophageal long axis views).** This is a case of Barlow’s disease with bileaflet (predominantly posterior leaflet) prolapse, initially repaired with P2 quadrangular resection, chordal transfer from P2 to P3, placement of artificial chordae on A2 and ring annuloplasty. (A) Demonstrates significant systolic anterior leaflet motion (SAM) after separating from cardiopulmonary bypass. (B) The valve was simply re-repaired by transferring the island of P2 chordae, previously transferred to
P3, to A2 and placing artificial chordae on the redundant P3. Demonstrates resolution of SAM after separating from cardiopulmonary bypass the second time.

**Supplementary Table 1. Practice data.** Brief overview of the surgeon’s experience and practice data for the preceding 12 months.
<table>
<thead>
<tr>
<th>Case volume</th>
<th>68 minimally invasive mitral valve repairs by a single surgeon</th>
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<tr>
<td>Re-intervention for failed MV repair</td>
<td>0 cases</td>
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<tr>
<td>Re-arrest for SAM with revision</td>
<td>1 case*</td>
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<tr>
<td>Mean cardiopulmonary bypass time</td>
<td>119 minutes</td>
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<td>Mean cross clamp time</td>
<td>93 minutes</td>
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*This case is the subject of Figure 2, which was one of the only cases in which chordal transposition was not initially performed. The revision simply involved chordal transposition from P2 to A2, which resolved the SAM.*