Routine chordal transposition during degenerative mitral valve repair to prevent systolic anterior leaflet motion

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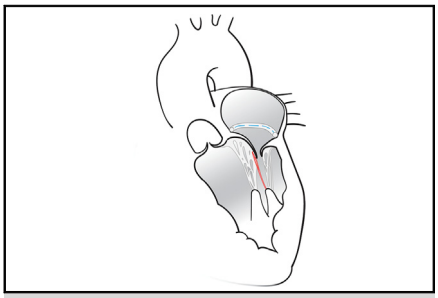


Transposed chords tether the anterior mitral leaflet away from the LVOT, thus preventing SAM.

CENTRAL MESSAGE

Routine use of posterior chordal transposition is an effective technique to prevent SAM following mitral valve repair.

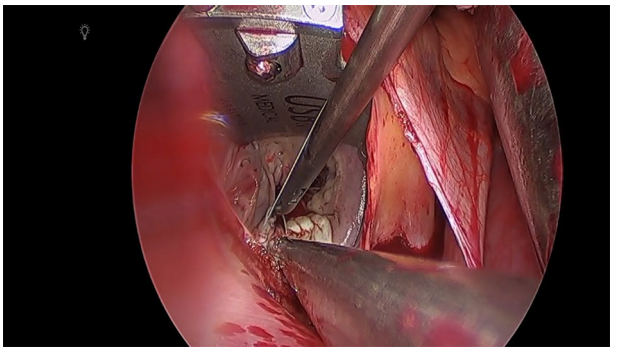
Video clip is available online.

Systolic anterior motion (SAM) of the mitral valve complicates 5% to 10% of mitral valve repairs.[1-3] SAM can generate severe left ventricular outflow tract obstruction (LVOT) and/or severe mitral regurgitation, leading to significant clinical and hemodynamic consequences. As such, apart from identifying risk factors for its development preoperatively, 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 ventricle dynamics.[2] Chordal transposition is among many techniques to address SAM; Sternik and Zehr[4] demonstrated excellent results in 6 patients with severely myxomatous mitral valves. 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

More than 90% of all isolated mitral valve repairs at our center are performed using a right anterolateral minithoracotomy approach with direct visualization. Cardiopulmonary bypass (CPB) is established using percutaneous, ultrasound-guided femoral arterial (most commonly 21Fr) and multistage femoral venous cannulation (most commonly 29Fr) (Bio-Medicus, Medtronic) with predeployment of Perclose ProGlide (Abbott) devices. We do not use separate superior vena cava cannulation. The ascending aorta is crossclamped using a transthoracic Scanlan Chitwood Debakey clamp 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 1, *A*). 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 1, *B*). The island of posterior leaflet is transposed en bloc to the free edge of A2 using interrupted 4-0 Tycron sutures spaced 1 to 2 mm apart (Figure 1, *C*). 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 (Figure 1, *E*).[4] 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



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. Video available at: https://www.jtcvs.org/article/S2666-2507(23)00291-2/fulltext.

(Figure 1, *C*). A semirigid, complete annuloplasty ring (most common size, 34) is used to stabilize the annulus (Figure 1, *D*). The patient is weaned from CPB, and intraoperative transesophageal echocardiography is used to assess the repair and ensure the absence of residual mitral regurgitation and SAM (Figure 2).

Since 2016 this technique has been used routinely 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 (W.L. Gore and Associates) sutures. The routine use of this technique has essentially eliminated SAM following mitral valve repair in our practice (Table E1).

DISCUSSION

In our experience, chordal transposition is an effective technique to prevent SAM following mitral valve repair. The benefits of this technique are 3-fold. First, it allows

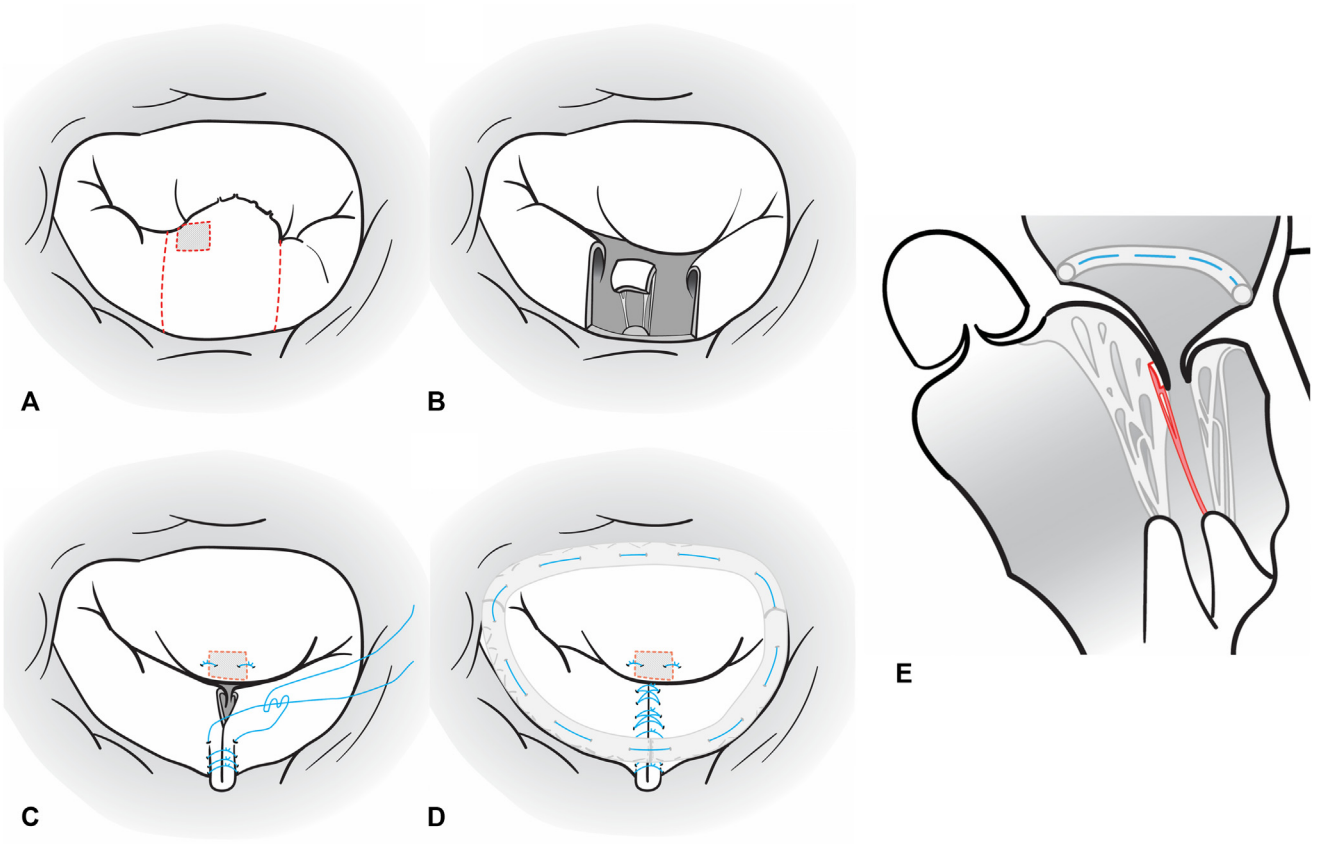


FIGURE 1. Routine approach to mitral valve repair at our center. A, A quadrangular resection of P2 is performed and healthy secondary chordae are identified. B, Secondary chordae and an island of the posterior leaflet are kept intact and transposed en bloc to the ventricular surface of A2 between the 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 left ventricular outflow tract during systole.

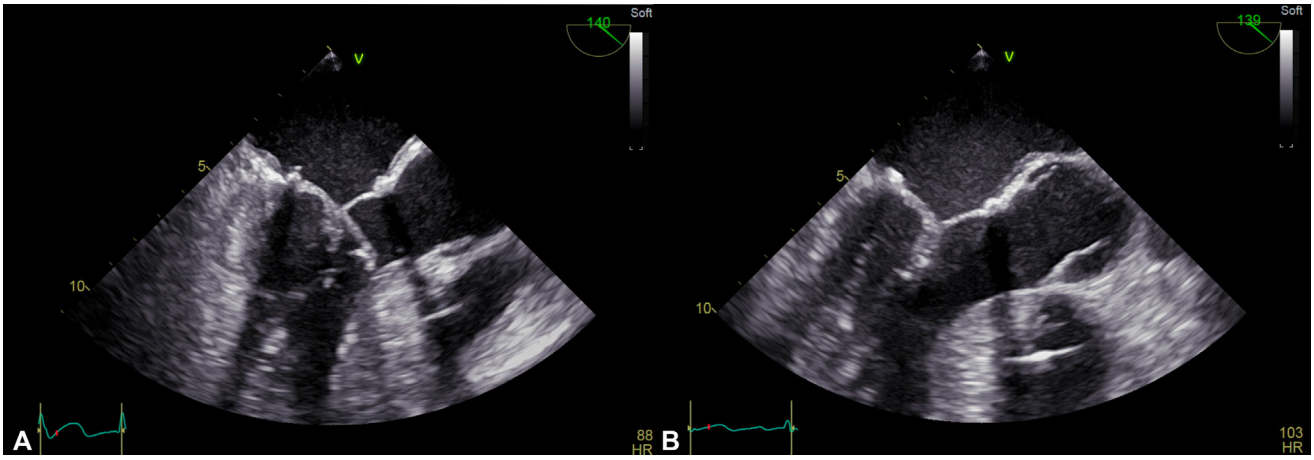


FIGURE 2. Intraoperative transesophageal echocardiogram post repair (midesophageal long-axis views). This is a case of Barlow's disease with bileaflet (predominantly posterior leaflet) prolapse, initially repaired with P2 quadrangular resection, chordal transfer from P2 to P3, placement of artificial chordae on A2 and ring annuloplasty. A, Demonstrates significant systolic anterior leaflet motion (*SAM*) after separating from cardiopulmonary bypass. B, The valve repair was simply revised 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.

for preservation of the subvalvular 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.

Among 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.[2,5] As such, we endorse routine chordal transposition as a valuable technique for preventing SAM.

Conflict of Interest Statement

The authors reported no conflicts of interest.

The *Journal* policy requires editors and reviewers to disclose conflicts of interest and to decline handling manuscripts for which they may have a conflict of interest. The editors and reviewers of this article have no conflicts of interest.

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TABLE E1. Practice data. Brief overview of the surgeon's experience and practice data for the preceding 12 months

Case volume	68 minimally invasive MV repairs by a single surgeon
Reintervention for failed MV repair	0 cases
Rearrest for SAM with revision	1 case*
Mean cardiopulmonary bypass time	119 min
Mean crossclamp time	93 min

MV, Mitral valve; *SAM*, systolic anterior leaflet motion. *This case is the subject of Figure 2, which was among 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.