A surgical armamentarium for correcting systolic anterior motion with re-repair rather than replacement

Whitney Fu, MD, Catherine Wagner, MD, Gurnoordeep Pawar, BS, Nicolas Ceniza, BS, Matthew A. Romano, MD, Gorav Ailawadi, MD, MBA, and Steven F. Bolling, MD, on behalf of the Michigan Mitral Research Group, Ann Arbor, Mich

From the Department of Cardiac Surgery, University of Michigan, Ann Arbor, Mich.

This study was reviewed and deemed exempt from informed consent by the University of Michigan Institutional Review Board (Protocol Number: HUM00148119, initial approval 8/7/2018, most recent amendment approval 4/20/2023).

Received for publication Dec 15, 2023; revisions received March 14, 2024; accepted for publication March 19, 2024; available ahead of print April 18, 2024.

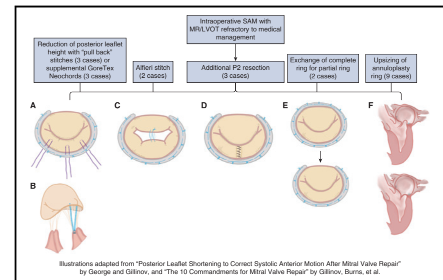
Address for reprints: Whitney Fu, MD, Department of Cardiac Surgery, University of Michigan, 5163 Frankel Cardiovascular Center, SPC 5864, 1500 E. Medical Center Dr, Ann Arbor, MI 48109 (E-mail: fuwh@med.umich.edu).

JTCVS Open 2024;19:91-3

2666-2736

Copyright © 2024 The Author(s). Published by Elsevier Inc. on behalf of The American Association for Thoracic Surgery. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

https://doi.org/10.1016/j.xjon.2024.03.010



Surgical techniques used for correction of intraoperatively identified SAM and re-repair.

CENTRAL MESSAGE

SAM is repairable with simple surgical techniques aimed at reducing posterior leaflet "height." Correction of SAM should be attempted with re-repair rather than replacement.

Systolic anterior motion (SAM) occurs in up to 10% of mitral valve repairs.[1] Most cases resolve with medical intervention (volume expansion, discontinuation of inotropes, β-blockers); however, some refractory cases with continued left ventricular outflow tract (LVOT) obstruction and residual mitral regurgitation (MR) require return to bypass and additional surgery. Unfortunately, refractory SAM often is reflexively treated with mitral valve replacement before attempts to re-repair have been made. We outline our armamentarium of surgical re-repair techniques used for the correction of intraoperatively identified SAM and the outcomes of these techniques. We aim to demonstrate that the correction of SAM can be achieved with these safe and relatively simple re-repair techniques.

PATIENTS AND METHODS

Patients who underwent primary mitral valve surgery for degenerative MR from 2007 to 2022 at the University of Michigan and had intraoperatively identified SAM were included. Hypertrophic obstructive cardiomyopathy cases and concomitant valve operations were excluded. Primary outcomes were incidence of severe SAM (ie, evidence of continued LVOT obstruction and any residual MR despite optimal medical management) identified intraoperatively, repair rate, operative mortality, and need for reoperation for SAM or recurrent MR. Median length of follow-up was 2 years (interquartile range, 3.1 years). The Institutional Review Board of the University of Michigan approved the study protocol and publication of data with a waiver of consent (HUM00148119, initial approval 8/7/2018, most recent amendment approval 4/20/2023).

RESULTS

The incidence of SAM requiring intraoperative re-repair was 0.7% (17/2217). Only 3 patients required a second repeat crossclamp (ie, 3 total crossclamps) to repair SAM. The ultimate intraoperative repair rate was 100% with no patients requiring replacement for SAM. The median total bypass time was 212 minutes (interquartile range, 150 minutes), and median crossclamp time was 159 minutes (interquartile range, 119 minutes). There was no operative mortality and no clinically significant mitral stenosis identified during the follow-up period. Two patients (12%) required eventual reoperation for late recurrent SAM (<3 months postoperatively), but both were able to be re-repaired. One patient developed recurrent MR more than 2 years after the initial operation, unrelated to SAM, and underwent mitral valve replacement. Long-term survival in these re-repaired patients with SAM matched patients without SAM who received mitral valve repair.

SAM is often related to posterior leaflet "height." Primary techniques for the correction of SAM focus on reducing excessive posterior leaflet length (ie, shortening the "height" of the posterior leaflet over the plane of the anterior leaflet) and moving the malpositioned zone of coaptation posteriorly.[2-4] A "pull-back" technique, performed by placing 3 total stitches with 1 through each posterior leaflet segment and anchored to the ring or just posterior to the ring on the left atrial wall, was used in 3

cases (Figure 1, *A*). The placement of 2 additional sets of Gore-Tex Neochords through the posterior leaflet to mimic shortened posterior leaflet chordae was performed in 3 cases (Figure 1, *B*). The intent of both of these techniques is to reduce the displacement of the anterior leaflet into the LVOT by a relatively "too tall" posterior leaflet. Additional P2 resection was performed in 3 cases to remove redundant leaflet tissue (Figure 1, *C*). Upsizing of the ring was performed in 9 cases (mean "upsize" difference 3.6 mm ± 1.3 mm) (Figure 1, *D*), and a complete ring was exchanged for a partial ring in 2 cases to minimize potential bulging of the posterior leaflet and narrowing of the aortic-mitral angle (Figure 1, *E*). A central Alfieri stitch (edge-to-edge suture) coapting the tips of A2 and P2 was performed in 2 cases to limit the mobility of the anterior leaflet toward the LVOT (Figure 1, *F*). This technique is appropriate when the anterior leaflet is observed to be long and redundant. It should be noted that a combination of these techniques may be required to achieve satisfactory re-repair.

For the 2 cases of late SAM requiring operative intervention, repeat P2 or P3 resection was undertaken with undermining of the remaining P2 and P3 segments from the annulus, followed by reattachment to the annulus. This achieves further reduction of posterior leaflet height.

CONCLUSIONS

The rate of intraoperatively identified SAM requiring repair was 0.7% in the study cohort of more than 2000 patients undergoing mitral valve surgery. The re-repair rate for patients with intraoperatively identified refractory SAM or recurrent SAM postoperatively was 100%. Other groups have discussed algorithms for the intraoperative medical management of SAM and reviewed operative approaches focusing on the anterior leaflet.[1,5] We add to the existing body of SAM literature by outlining several relatively simple techniques aimed at reducing posterior leaflet "height" that have demonstrated safety and efficacy at our institution. With a well-developed armamentarium of surgical techniques, SAM can be re-repaired without the need for valve replacement.

Conflict of Interest Statement

Dr Romano is a consultant for Edwards Lifesciences, Medtronic, and AtriCure. Dr Ailawadi is a consultant for

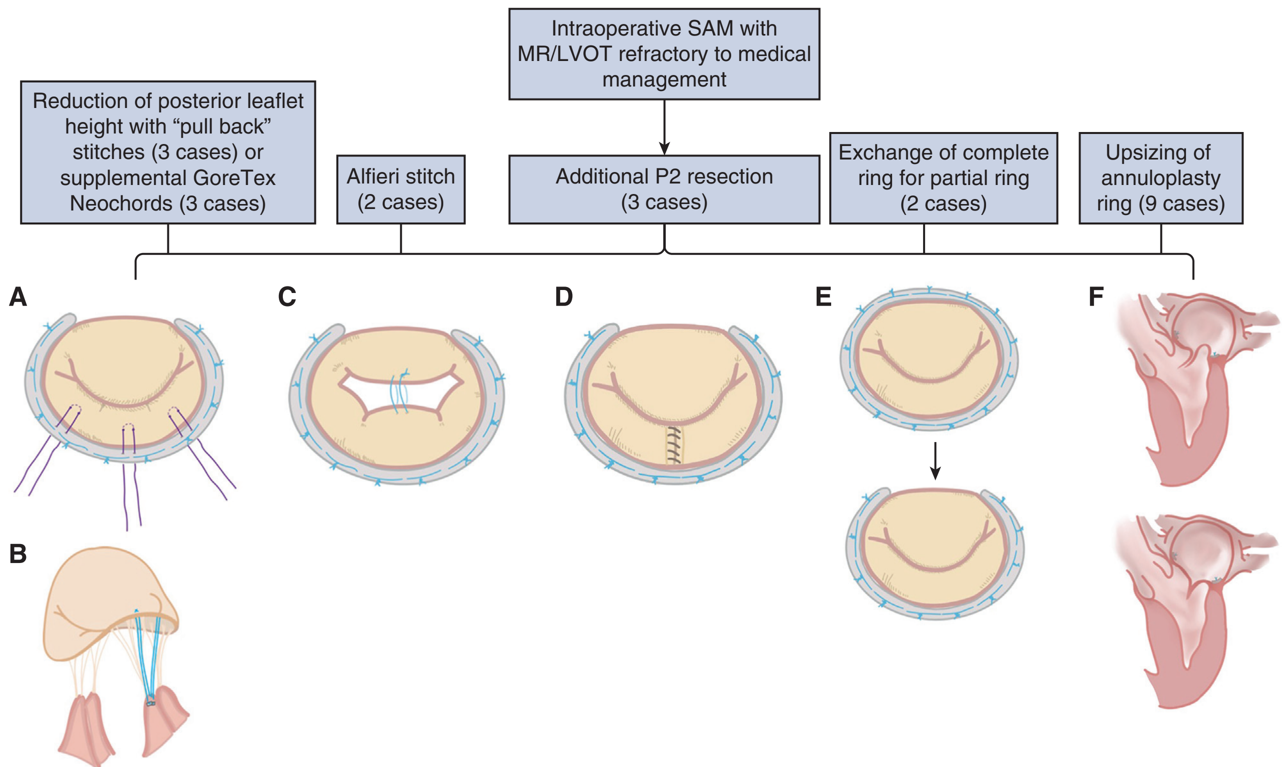


FIGURE 1. Schematic of the surgical techniques used successfully for re-repair in 17 cases of intraoperatively identified SAM. A, Three-stitch pull-back technique to reduce posterior leaflet height. B, Placement of supplemental posterior leaflet Gore-Tex neochords. C, Alfieri stitch between the anterior and posterior leaflets. D, Additional P2 resection. E, Exchange of a complete annuloplasty ring for a partial ring. F, Upsizing of the annuloplasty ring. *SAM*, Systolic anterior motion; *MR*, mitral regurgitation; *LVOT*, left ventricular outflow tract.

Abbott Laboratories, Edwards Lifesciences, Medtronic, Anteris Technologies, AtriCure, and Gore Medical. Dr Bolling is a consultant for Abbott Laboratories, Edwards Lifesciences, Medtronic, AtriCure, and Gore Medical. Dr Wagner received salary support through the Institute of Healthcare Policy and Innovation as a part of the National Clinician Scholars Program. Dr Fu received salary support through the National Heart, Lung, and Blood Institute T32 Multidisciplinary Training Program in Lung Disease (T32HL007749). All other authors reported no conflicts of interest.

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

References

1. Varghese R, Anyanwu AC, Itagaki S, Milla F, Castillo J, Adams DH. Management of systolic anterior motion after mitral valve repair: an algorithm. *J Thorac Cardiovasc Surg*. 2012;143(4 Suppl):S2-S7.
2. Gillinov M, Burns DJP, Wierup P. The 10 commandments for mitral valve repair. *Innovations (Phila)*. 2020;15(1):4-10.
3. George KM, Gillinov AM. Posterior leaflet shortening to correct systolic anterior motion after mitral valve repair. *Ann Thorac Surg*. 2008;86(5):1699-1700.
4. Ibrahim M, Rao C, Ashrafian H, Chaudhry U, Darzi A, Athanasiou T. Modern management of systolic anterior motion of the mitral valve. *Eur J Cardiothorac Surg*. 2012;41(6):1260-1270.
5. Usui A, Mutsuga M. Surgical management for systolic anterior motion (SAM) of the mitral valve in obstructive hypertrophic myopathy. *Ann Thorac Cardiovasc Surg*. 2022;28(4):239-248.