The 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.

NYU Langone Health
New York, NY

References

1. Nappi F, Singh SSA. A right track stems from the right learning. *J Thorac Cardiovasc Surg.* 2022;162:e177-8.
2. Braun J, Bax JJ, Versteeg MI, Voigt PG, Holman ER, Klautz RJ, et al. Preoperative left ventricular dimensions predict reverse remodeling following restrictive mitral annuloplasty in ischemic mitral regurgitation. *Eur J Cardiothorac Surg.* 2005;27:847-53.
3. Goldstein D, Moskowitz AJ, Gelijns AC, Ailawadi G, Parides MK, Perrault LP, et al. Two-year outcomes of surgical treatment of severe ischemic mitral regurgitation. *N Engl J Med.* 2016;374:344-53.
4. Onohara D, Corporan DM, Kono T, Kumar S, Guyton RA, Madala M. Ventricular reshaping with a beating heart implant improves pump function in experimental heart failure. *J Thorac Cardiovasc Surg.* September 3, 2020 [Epub ahead of print].
5. Grossi EA, Patel N, Woo YJ, Goldberg JD, Schwartz CF, Subramanian V, et al. Outcomes of the RESTOR-MV trial (Randomized evaluation of a surgical treatment for off-pump repair of the mitral valve). *J Am Coll Cardiol.* 2010;56:1984-93.
6. Carrick R, Ge L, Lee LC, Zhang Z, Mishra R, Axelm L, et al. Patient-specific finite element-based analysis of ventricular myofiber stress after coapsys: importance of residual stress. *Ann Thorac Surg.* 2012;93:1964-71.

<https://doi.org/10.1016/j.jtcvs.2021.01.102>

REPLY: THE ISSUES TO ADDRESS WHEN REPAIRING ISCHEMIC MITRAL REGURGITATION

Reply to the Editor:

The optimal intervention for patients with moderate ischemic mitral regurgitation has been controversial. The letter by Nappi and colleagues¹ emphasizes the importance of optimal myocardial revascularization in addition to mitral valve repair using effective valvular and subvalvular techniques. The lack of predictable long-term outcomes of revascularization combined with mitral valve repair on the long-term outcomes have led to the impression highlighted by a randomized trial that, especially with severe ischemic mitral regurgitation, mitral valve replacement yields better results than mitral valve repair.² This serves to highlight the importance of optimal repair techniques as described by Nappi and colleagues and their references, especially the value of anterior leaflet augmentation, a technique highlighted first by Kincaid and colleagues³ for ischemic mitral regurgitation repair. The further clarification of the complex mechanisms causing

The author 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.

ischemic mitral regurgitation and the importance of using valvular and subvalvular techniques combined with complete revascularization highlight the complexity that needs to be addressed to achieve effective surgical repair.

Vincent R. Conti, MD
Department of Surgery
University of Texas Medical Branch
Galveston, Tex

References

1. Nappi F, Singh SSA. A right track stems from the right learning. *J Thorac Cardiovasc Surg.* 2022;162:e177-8.
2. Acker MA, Parides MK, Perrault LP, Moskowitz AJ, Gelijns AC, Voisine P, et al. Mitral-valve repair versus replacement for severe ischemic mitral regurgitation. *N Engl J Med.* 2014;370:23-32.
3. Kincaid EH, Riley RD, Hines MH, Hammon JW, Kon ND. Anterior leaflet augmentation for ischemic mitral regurgitation. *Ann Thorac Surg.* 2004;78:564-8; discussion 568.

<https://doi.org/10.1016/j.jtcvs.2021.01.133>

REPLY: THE TRACK LESS TRAVELED: SUBVALVULAR TECHNIQUES AND ANTERIOR LEAFLET AUGMENTATION IN ISCHEMIC MITRAL

REGURGITATION

Reply to the Editor:

The points raised by Nappi and Singh in their recent insightful commentary about the surgical treatment of ischemic mitral regurgitation (IMR) are very timely.¹ Indeed, IMR is a disease of the left ventricle, and thus surgical repair of IMR should aim for postoperative left ventricular (LV) reverse remodeling; in its absence, mitral regurgitation (MR) can recur due to persistent LV dilation and leaflet tethering.² However, reverse remodeling can only occur with viable myocardium.² In patients with a large burden of nonviable myocardium, revascularization, although important, is likely futile in terms of substantial MR reduction, and durable mitral valve (MV) repair also is unlikely sustainable.³ Indeed, chordal-sparing MV replacement is a more suitable option in patients with severe

The 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.

IMR, especially those with dilated ventricles.³ Nappi and Singh do emphasize that IMR can be related to multiple lesions affecting the MV apparatus and left ventricle.¹ Although myocardial viability alone did not seem to affect the survival advantage of revascularization in the extended follow-up of STICH,⁴ comprehensive preoperative assessment of myocardial viability is paramount for identifying the underlying mechanism of and best surgical approach for IMR.

As noted by Nappi and Singh, the use of restrictive mitral annuloplasty (RMA) is associated with recurrence of MR in nearly 60% of patients at 2 years postoperatively.^{1,3} RMA increases the distance between the leaflets and papillary muscles, thereby leading to persistent leaflet tethering and less durable MV repair.² Therefore, it is important to also assess preoperative leaflet tethering to identify patients in whom RMA would be unsuitable.² Leaflet tethering occurs from LV remodeling, papillary muscle displacement, and resultant increased chordal tension.² Two main tethering patterns can arise: symmetric and asymmetric. The former is defined by an anterior-to-posterior tethering angle ratio ≥ 0.76 .⁵ The posterior leaflet is primarily tethered in asymmetric tethering, whereas there is significant anterior leaflet involvement in symmetric tethering.⁵

In the context of symmetric tethering pattern, concomitant subvalvular intervention (SVI) may be valuable (Figure 1),^{6,7} although Nappi and Singh suggest that SVI is more appropriate for asymmetric tethering.¹ Although their experience with papillary muscle approximation failed to demonstrate significant benefit in patients with symmetric tethering,⁵ other SVIs that target the restricted anterior leaflet have demonstrated promising outcomes.^{6,7} Resection of the second chordae attached to the restricted anterior leaflet in patients exhibiting symmetric tethering showed a reduced risk of MR recurrence and cardiac-related readmissions.⁶ Similarly, papillary muscle relocation toward the aorto-mitral continuity resulted in an 89% freedom from mortality at 3 years postoperatively.⁷ Nappi and Singh also discussed the potential benefit of anterior leaflet augmentation (ALA) provided that it results in the correction of leaflet tethering.¹ ALA + RMA is more effective than isolated RMA, as evidenced by the 91% freedom from MR grade $\geq$ II at 2 years postoperatively, without increasing the risk of systolic anterior leaflet motion.⁸ The addition

FIGURE 1. Treatment strategies for severe ischemic mitral regurgitation. LV, Left ventricle.

of chordal cutting to ALA + RMA also may be an option for patients with restricted anterior leaflet mobility; not only does ALA promote coaptation, but chordae resection also reduces anterior leaflet tethering, thus leading to a potentially more durable repair in patients with symmetric tethering.⁹

The use of SVI and ALA in IMR evidently shows promise, yet the benefit over conventional repair requires validation in a larger series of patients with a longer follow-up period. A limitation of these techniques remains the potential challenge in reproducibility. Finally, their value over transcatheter therapies and how they fit in the MV repair armamentarium of the transcatheter era remain unclear.¹⁰

Maria Servito, BHSc^a

Malak Elbatarny, MD^b

Stephen E. Fremes, MD, MSc, FRCSC^c

^aSchool of Medicine

Queen's University, Kingston, Ontario, Canada

^bDivision of Cardiac Surgery

Department of Surgery

University of Toronto

Toronto, Ontario, Canada

^cDivision of Cardiac Surgery

Schulich Heart Centre

Department of Surgery

Sunnybrook Health Sciences Centre

University of Toronto

Toronto, Ontario, Canada

References

1. Nappi F, Singh SSA. A right track stems from the right learning. *J Thorac Cardiovasc Surg.* 2022;162:e177-8.

- Gelsomino S, Lorusso R, De Cicco G, Billè G, Caciolli S, Rostagno C, et al. Does preoperative tethering symmetry affect left ventricular reverse remodeling after restrictive annuloplasty? *Int J Cardiol*. 2010;141:182-91.
- Goldstein D, Moskowitz AJ, Gelijns AC, Ailawadi G, Parides MK, Perrault LP, et al. Two-year outcomes of surgical treatment of severe ischemic mitral regurgitation. *N Engl J Med*. 2016;374:344-53.
- Panza JA, Ellis AM, Al-Khalidi HR, Holly TA, Berman DS, Oh JK, et al. Myocardial viability and long-term outcomes in ischemic cardiomyopathy. *N Engl J Med*. 2019;381:739-48.
- Nappi F, Spadaccio C, Nenna A, Lusini M, Fraldi M, Acar C, et al. Is subvalvular repair worthwhile in severe ischemic mitral regurgitation? Subanalysis of the papillary muscle approximation trial. *J Thorac Cardiovasc Surg*. 2017;153:286-95.e2.
- Calafiore AM, Refaie R, Iacò AL, Asif M, Al Shurafa HS, Al-Amri H, et al. Chordal cutting in ischemic mitral regurgitation: a propensity-matched study. *J Thorac Cardiovasc Surg*. 2014;148:41-6.
- Furukawa K, Yano M, Nakamura E, Matsuyama M, Nishimura M, Kawagoe K, et al. Comparison of mitral competence after mitral repair with papillary muscle approximation versus papillary muscle relocation for functional mitral regurgitation. *Heart Vessels*. 2018;33:72-9.
- Kincaid EH, Riley RD, Hines MH, Hammon JW, Kon ND. Anterior leaflet augmentation for ischemic mitral regurgitation. *Ann Thorac Surg*. 2004;78:564-8.
- Calafiore AM, Totaro A, De Amicis V, Pelini P, Pinna G, Testa N, et al. Surgical mitral plasticity for chronic ischemic mitral regurgitation. *J Card Surg*. 2020;35:772-8.
- Nappi F, Antoniou GA, Nenna A, Michler R, Benedetto U, Avtaar Singh SS, et al. Treatment options for ischemic mitral regurgitation: a meta-analysis. *J Thorac Cardiovasc Surg*. May 27, 2020 [Epub ahead of print].

<https://doi.org/10.1016/j.jtcvs.2021.02.018>

REPLY FROM AUTHORS: ANATOMICAL OR

FUNCTIONAL REPAIR FOR ISCHEMIC MITRAL REGURGITATION: FIND THE RIGHT ANTIDOTE!

Reply to the Editor:

We appreciate the thoughtful feedback provided by Nappi and Singh¹ on our editorial commentary.² They echo our proposal regarding the use of anterior mitral valve leaflet (MVL) patch augmentation as an effective strategy for repairing ischemic mitral regurgitation (IMR). A fundamental lesson learned from the Cardiothoracic Surgical Trials Network multicenter randomized investigations is the nonexistence of a universal repair method that fits all types of patients with severe IMR.² We cannot agree more with

Nappi and colleagues¹ that IMR is a dynamic disorder influenced by multiple pathological factors. It in turn demands combined, as well as individualized, surgical therapies. Primarily, we can never overemphasize the importance of complete revascularization of the viable myocardium. Regarding mitral valve repair, the slight difference in our perspectives from the proposal made by Nappi and colleagues^{1,3} may warrant further discussion.

The traditional surgical repair strategy for IMR involves restrictive mitral annuloplasty (ie, implantation of an artificial ring 2 sizes smaller than the native annulus), which aims to improve leaflet coaptation by reducing annular dilatation secondary to myocardial infarction-induced adverse left ventricle (LV) remodeling. In addition to this conventional approach, Nappi and colleagues^{1,3} advocated subannular repair (namely, papillary muscle approximation), which indeed seems more logical, although the real survival benefit of this technique remains unproven. Taken together, the general concept involves overcorrection or anatomical repair; that is, an attempt to restore the diseased parts (annular or subannular) to normal. Through clinical observations accumulated over decades, we now know that this approach works only in a minority of patients (probably those without a significantly enlarged LV).^{3,4} Moreover, the durability of such an anatomical correction appears to be far from adequate, as reflected by a 2-year postoperative MR recurrence rate of almost 60% in the Cardiothoracic Surgical Trials Network severe IMR trial.⁴

Accordingly, we propose a radical modification of the repair concept in patients with IMR with significant LV enlargement: The principle of repair could be “coup with the LV” rather than overcorrection.² This functional repair strategy would include MVL patch augmentation and true-sized annuloplasty.² Although in our own hands, anterior MVL augmentation is often the procedure of choice,² we also perform posterior MVL patch augmentation (Figure 1) in patients with severe posterior leaflet tethering (usually at the P3 segment).

Some technical and other details deserve clarification. First, in contrast with the technique described by Nappi

FIGURE 1. Posterior mitral valve leaflet patch augmentation with true-sized annuloplasty in patients with severe ischemic mitral regurgitation due to significant posterior leaflet tethering. A, A commissure-to-commissure incision is made along the posterior mitral annulus (dashed line). B, A prepared CardioCel (LeMaitre Vascular, Burlington, Mass) patch slightly larger than the space area succeeding the fall of the posterior mitral leaflet and, mimicking its shape and curvature, is sutured on the leaflet followed by true-sized semirigid ring annuloplasty.