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MitraClip does not correct the underlying LV substrate responsible for IMR. Focusing on the subvalvular apparatus and on the continued development of less invasive surgical and percutaneous approaches to addressing the MV unit is of paramount importance.¹³⁻¹⁵

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References

1. Badhwar V, Alkhouli M, Mack MJ, Thourani VH, Ailawadi G. A pathoanatomic approach to secondary functional mitral regurgitation: evaluating the evidence. *J Thorac Cardiovasc Surg.* 2019;158:76-81.
2. Penicka M, Linkova H, Lang O, Fojt R, Kocka V, Vanderheyden M, et al. Predictors of improvement of unpaired moderate ischemic mitral regurgitation in patients undergoing elective isolated coronary artery bypass graft surgery. *Circulation.* 2009;120:1474-81.
3. Goldstein D, Moskowitz AJ, Gelijns AC, Ailawadi G, Parides MK, Perrault LP, et al; CTSN. Two-year outcomes of surgical treatment of severe ischemic mitral regurgitation. *N Engl J Med.* 2016;374:344-53.
4. Stone GW, Lindenfeld J, Abraham WT, Kar S, Lim DS, Mishell JM, et al. Transcatheter mitral valve repair in patients with heart failure. *N Engl J Med.* 2018;379:2307-18.
5. Obadia JF, Messika-Zeitoun D, Leurent G, Iung B, Bonnet G, Piriou N, et al; MITRA-FR Investigators. Percutaneous repair or medical treatment for secondary mitral regurgitation. *N Engl J Med.* 2018;379:2297-306.
6. Grayburn PA, Sannino A, Packer M. Proportionate and disproportionate functional mitral regurgitation: a new conceptual framework that reconciles the results of the MITRA-FR and COAPT trials. *JACC Cardiovasc Imaging.* 2019;12:353-62.
7. 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.
8. Nappi F, Lusini M, Spadaccio C, Nenna A, Covino E, Acar C, et al. Papillary muscle approximation versus restrictive annuloplasty alone for severe ischemic mitral regurgitation. *J Am Coll Cardiol.* 2016;67:2334-46.
9. Bothe W, Timek TA, Tibayan FA, Walther M, Daughters GT, Ingels NB Jr, et al. Characterization of 3-dimensional papillary muscle displacement in in vivo ovine models of ischemic/functional mitral regurgitation. *J Thorac Cardiovasc Surg.* 2019;157:1444-9.
10. Mihos CG, Capoulade R, Yucel E, Xydias S, Nappi F, Williams RF, et al. Mitral valve and subvalvular repair for secondary mitral regurgitation: rationale and clinical outcomes of the papillary muscle sling. *Cardiol Rev.* 2018;26:22-8.
11. Timek TA, Lai DT, Tibayan F, Liang D, Daughters GT, Dagum P, et al. Ischemia in three left ventricular regions: insights into the pathogenesis of acute ischemic mitral regurgitation. *J Thorac Cardiovasc Surg.* 2003;125:559-69.
12. Nappi F, Nenna A, Spadaccio C, Lusini M, Chello M, Fraldi M, et al. Predictive factors of long-term results following valve repair in ischemic mitral valve prolapse. *Int J Cardiol.* 2016;204:218-28.
13. Nappi F, Avatar Singh SS, Santana O, Mihos CG. Functional mitral regurgitation: an overview for surgical management framework. *J Thorac Dis.* 2018;10:4540-55.
14. Mihos CG, Capoulade R, Yucel E, Melnitchouk S, Hung J. Combined papillary muscle sling and ring annuloplasty for moderate-to-severe secondary mitral regurgitation. *J Card Surg.* 2016;31:664-71.
15. Nappi F, Spadaccio C, Fraldi M. Reply: papillary muscle approximation is an anatomically correct repair for ischemic mitral regurgitation. *J Am Coll Cardiol.* 2016;68:1147-8.

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REPLY: PATHOANATOMIC CONSIDERATIONS FOR ISCHEMIC MITRAL REGURGITATION: HIGHLIGHTING THE

IMPORTANCE OF ANATOMIC AND PHYSIOLOGIC ASYMMETRY

Reply to the Editor:

Badhwar and colleagues¹ have proposed a pathoanatomic classification for ischemic mitral regurgitation (IMR) that categorizes degrees of annular dilatation, ejection fraction, and leaflet tethering; assigns grades of pathology; and aims to simplify and guide open surgical and catheter-based interventions. To that end, I have highlighted² a recent concept proposed by Grayburn and colleagues³ of further distinguishing physiologic or nonphysiologic (disproportionate) IMR.

The comments of Nappi and associates^{4,5} help us to refocus on anatomy and the variable presentations of IMR, including the effect of revascularization. This group,^{4,5} along with others,^{6,7} have noted that distinguishing symmetric from asymmetric posterolateral tethering, with the associated differential vectors and inter-papillary muscle distance; infarction of myocardium adjacent to the papillary muscle; the shape as well as the size of the tethering area (>3 cm²); the tenting height (>11 mm); and the left ventricular end-diastolic dimensions are important in selecting more individualized, effective, and durable therapies for IMR. They point out that therapies that focus on the mitral valve annulus alone (for example, an undersized annuloplasty ring) or only on the valve (for example, either MitraClip [Abbott Vascular, Santa Clara, Calif] or edge-to-edge repair) and that fail to address the asymmetric subvalvular and subannular tethering are associated with much higher longer-term failure rates. Conversely, although series of subvalvular repair are small, it appears that such approaches can be performed safely with no added mortality and that they may enhance the longer-term durability of IMR interventions. In meta-analyses, although New York Heart Association functional classes were similar, the incidence of greater than moderate mitral regurgitation and the mitral regurgitation grade were significantly lower (relative risk,

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0.43; $P < .001$) when subvalvular pathology was addressed with papillary muscle approximation and muscle slings, and left ventricular reverse remodeling (as assessed by left ventricular end-diastolic volume diameter) were improved (mean diameter of 3.6 mm; $P < .001$).⁷

The challenge for clinicians assessing patients with IMR is how best to assess proportionate and disproportional physiology (degree of IMR as an index of left ventricular end-diastolic volume), as well as asymmetric anatomies, in a highly heterogeneous patient population. The first goal is to distinguish patients who will benefit from a mitral valve intervention from those who will not. The second goal is to select the most appropriate approach. It is unclear what the overlap between alternative pathoanatomic grading and progression schemata mean and whether these schemata are mostly complementary or offer subtle distinctions in specific subsets of patients. Increased awareness of variable asymmetric anatomy and further detailed studies and analyses should help us to discern and direct adjunctive individualized therapies in a rapidly evolving field. Finally, in patients with very advanced grades (very low ejection fraction, enlarged ventricles, nonreversible myocardial damage) such schemes should also help to refocus treatments away from mitral valve intervention and toward end-stage heart failure therapies.

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References

1. Badhwar V, Alkhouli M, Mack MJ, Thourani VH, Ailawadi G. A pathoanatomic approach to secondary functional mitral regurgitation: evaluating the evidence. *J Thorac Cardiovasc Surg.* 2019;158:76-81.
2. Aldea GS. Commentary: reassessing efficacy of treatment strategies for secondary mitral regurgitation—combining pathoanatomic and pathophysiologic perspectives. *J Thorac Cardiovasc Surg.* 2019;158:84-5.
3. Grayburn PA, Sannino A, Packer M. Proportionate and disproportionate functional mitral regurgitation: a new conceptual framework that reconciles the results of MITRA-FR and COAPT trials. *JACC Cardiovasc Imaging.* 2019;12:353-62.
4. Nappi F, Lusini M, Avtaar Singh SS, Santana O, Chello M, Mihos CG. Risk of ischemic mitral regurgitation recurrence after combined valvular and subvalvular repair. *Ann Thorac Surg.* 2019;108:536-43.
5. Nappi F, Avtaar Singh SS, Santana O, Mihos CG. Functional mitral regurgitation, an overview for surgical management framework. *J Thorac Dis.* 2018;10:4540-55.
6. Mihos CG, Capoulade R, Yucel E, Xydias S, Nappi F, Williams RF, et al. Mitral valve and subvalvular repair for secondary mitral regurgitation: rationale and clinical outcomes of the papillary muscle sling. *Cardiol Rev.* 2018;26:22-8.
7. Mihos CG, Xydias S, Yucel E, Capoulade R, Williams RF, Mawad M, et al. Mitral valve repair and subvalvular intervention for secondary mitral regurgitation: a systematic review of randomized controlled and propensity matched studies. *J Thorac Dis.* 2017;9(Suppl 7):5582-94.

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REPLY: SURGICAL AND

TRANSCATHETER THERAPY FOR SECONDARY MITRAL REGURGITATION

Reply to the Editor:

Recent clinical trials have added valuable information, as well as controversy, for the surgical and transcatheter management of secondary mitral regurgitation (MR). One thing is clear, secondary MR is not a binary disease state. It is not present or absent. It is a pathoanatomic continuum. Based on the evidence, a recent grading system has been proposed to suggest targeted surgical and transcatheter therapy of secondary MR based on pathoanatomy and comorbid risk.¹

The experience of Nappi and colleagues² with a subvalvular adjunct to restrictive annuloplasty informed a recent letter to the Editor.² They make a few important points. First, they re-emphasize the importance of revascularization in ventricular remodeling and suggest potential improvement of secondary MR when viable myocardium is noted. Second, they attest that for patients with nonviable myocardium, a restrictive annuloplasty combined with a subvalvular sling repair should be considered. Finally, by the title of their letter they suggest that a proposed grading system for mitral valve (MV) intervention forfeits the opportunity for MV repair as an important therapy. Each of these points will be reviewed.

The importance of myocardial revascularization for viable myocardium is the cornerstone for the management of ischemia whenever appropriate targets exist. For patients with ischemic cardiomyopathy undergoing surgery for secondary MR, incomplete revascularization is a marker of mortality,³ but evidence that it influences residual MR in all patients remains lacking. For example, patients with chronic severe secondary MR often have papillary muscle fibrosis and the subsequently tethered MV apparatus is unlikely to improve regardless of the revascularization strategy. This is similar to the point that Nappi and colleagues² make when discussing their approach to patients with nonviable myocardium. Although their experience with subvalvular papillary muscle repositioning or polytetrafluoroethylene tube reapproximation is compelling, widespread reproducibility of this technique remains limited.

The nomenclature and assessment of MR is clear.⁴ Prolapse is defined in a patient with primary MR when leaflet motion extends above the annular plane in systole. There is no such entity in secondary MR, as the authors may suggest.^{2,5} In the case of a tethered posterior leaflet following myocardial infarction remodeling, a posteriorly directed jet of MR may be commonly misinterpreted as anterior leaflet prolapse and primary MR when it is in fact