COAPT (Cardiovascular Outcomes Assessment of the MitraClip Percutaneous Therapy for Heart Failure Patients With Functional Mitral Regurgitation) showed that TEER, while having no RA effects, improved mitral regurgitation but failed to arrest ventricular dilation and did not lead to reverse remodeling.\textsuperscript{5,12} Furthermore, in studies of PMA plus restrictive annuloplasty by Nappi and colleagues\textsuperscript{5} and Hvass and Joudinaud\textsuperscript{8} reverse remodeling occurred and LV contractility improved suggesting PMA can inhibit LV dilation and allow reverse remodeling, that RA alone fails to achieve. The success of accepted therapies for ischemic MR have largely been based on their effect on diminishing leaflet tenting which impacts severity of MR more than left ventricular dysfunction, but this effect may be limited with isolated leaflet/annular interventions.\textsuperscript{4,6,11,13}

Comparison of PMA outcomes with other therapies as evidenced by animal studies, retrospective and prospective randomized trials demonstrate an advantage of PMA in allowing reverse remodeling and improvement in left ventricular ejection fraction (LVEF),\textsuperscript{7-9} but long-term survival is not different to that of RA and overall survival of all therapies remain suboptimal. Nappi and colleagues reported a significant decrease in major adverse cardiac and cerebrovascular events in the PMA group, demonstrating its long-term protective effect on the ventricle, but they found no significant difference in all-cause mortality at 5 years with 22.9\% for the PMA group and 29.2\% for the RA group.\textsuperscript{9} The COAPT trial reported a 19\% mortality at 1 year for TEER and 23\% for medical management and a 2-year all-cause mortality risk of 29.1\% in the TEER arm.\textsuperscript{6} Importantly the preintervention severity of MR in the PMA trial was 4+(severe), whereas 52.2\% of patients in the COAPT trial had 3+MR.\textsuperscript{5,9} The Cardiothoracic Surgical Trials Network ischemic MR repair versus replacement trial showed a nonstatistically difference in 2-year mortality for repair versus replacement (19\% vs 23.2\% respectively).\textsuperscript{11} Longer follow-up is needed to understand the benefit of PMA. One can then hypothesize that TEER allows early- and mid-term (up to 2 years) improvement of MR and survival because it improves the recurrent injury from MR, improves tenting height, maintaining a small posterior and anterior leaflet angle, and delaying LV dilation. RA fails during mid-term follow-up (up to 1 year) because it does not delay or prevent LV dilation. PMA has improved long-term LV remodeling (at 5 years) because it addresses both components of functional MR.\textsuperscript{9} Recurrence of moderate or worse mitral regurgitation in the PMA trial numerically favored PMA but was not statistically different between the PMA and RA arms until the fifth year, when a true difference occurred (27\% vs 55.9\%, respectively $P = .013$). The reoperation rate for the entire follow-up period was 6.2\% for PMA versus...
14.6% for the RA group but not statistically significant.\textsuperscript{9} One can hypothesize that PMA fails to improve survival and quality-of-life metrics compared with RA alone because of the accompanying downsizing of the annulus. True sizing of the annulus has shown favorable short-term results.\textsuperscript{8,14}

The degree of preoperative LV depression and LV dilation under which PMA is effective are not well delineated, but based on the PMA trial, a size of <60 mm LV end-diastolic diameter and LVEF >40%.\textsuperscript{9} PMA combined with annuloplasty fails to yield a favorable result in those with mitral tethering other than the posteromedial papillary muscle restriction, profoundly depressed LVEF, and in those with overtly large ventricles. Should mitral valve replacement be the approach of choice in these nonresponders to PMA and TEER? Should mitral valve replacement be performed along with PMA? Will this ultimately lead to improved long-term results?

The aforementioned cited positive PMA results, absent intense medical optimization, and stringent patient selection present in a major transcatheter mitral repair trial, suggest there is a role for PMA in the management of ischemic MR and that it should be compared with the newly adopted percutaneous mitral therapies. As more data become available, better selection of patients would also lead to better longer-term outcomes for PMA. A necessary question is whether PMA should be accompanied by a RA or a true-sized annuloplasty. Additionally, would addressing the functional MR ventricle with PMA plus annuloplasty at earlier stages in the disease process improve survival and quality of life? It is time for prospective trials comparing transcatheter mitral therapies with surgery to include minimally invasive mitral surgery.

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\textbf{References}

1. Bolling SF, Pagani FD, Deeb GM, Bach DS. Intermediate-term outcome of mitral reconstruction in cardiomyopathy. \textit{J Thorac Cardiovasc Surg}. 1998;115: 381-8.
2. Wu AH, Aaronson KD, Bolling SF, Pagani FD, Welch K, Koelling TM. Impact of mitral valve annuloplasty on mortality risk in patients with mitral regurgitation and left ventricular systolic dysfunction. \textit{J Am Coll Cardiol}. 2005;45:381-7.
3. McGee EC, Gillinov AM, Blackstone EH, Rajswaran J, Cohen G, Najam F, et al. Recurrent mitral regurgitation after annuloplasty for functional ischemic mitral regurgitation. \textit{J Thorac Cardiovasc Surg}. 2004;128:916-24.
4. Acke MA, Purides MK, Perraull PT, Moskowitz AJ, Gelijns AC, Voisine P, et al. Mitral valve repair versus replacement for severe ischemic mitral regurgitation. \textit{N Engl J Med}. 2014;370:23-32.
5. Ciarka A, Braun J, Delgado V, Versteegh M, Boersma E, Klautz R, et al. Predictors of mitral regurgitation recurrence in patients with heart failure undergoing mitral valve annuloplasty. \textit{Am J Cardiol}. 2010;106:395-401.
6. Stone GW, Lindenfeld J, Abraham WT, Kar S, Lim DS, Mihos CG, et al. Transcatheter mitral-valve repair in patients with heart failure. \textit{N Engl J Med}. 2018;379:2307-18.
7. Xu D, McBride E, Kalra K, Wong K, Guyton RA, Sarin EL, et al. Undersizing mitral annuloplasty alters left ventricular mechanics in a swine model of ischemic mitral regurgitation. \textit{J Thorac Cardiovasc Surg}. November 6, 2020 [Epub ahead of print].
8. Hvass U, Joulinaud T. The papillary muscle sling for ischemic mitral regurgitation. \textit{J Thorac Cardiovasc Surg}. 2010;139:418-23.
9. Nappi F, Lusini M, Spadaccio C, Nenna A, Covino E, Acrul C, et al. Papillary muscle approximation versus restrictive annuloplasty alone for severe ischemic mitral regurgitation. \textit{J Am Coll Cardiol}. 2016;67:2343-46.
10. Nappi F, Spadaccio C. The use of subvalvular repair for ischemic mitral regurgitation: is it finally coming of age? \textit{J Thorac Cardiovasc Surg Open}. 2021;8:290-1.
11. Goldstein D, Moskowitz AJ, Gelijns AC, Ailawadi G, Purides MK, Perraull PT, et al. Two-year outcomes of surgical treatment of severe ischemic mitral regurgitation. \textit{N Engl J Med}. 2016;374:344-53.
12. Asch FM, Grayburn PA, Siegel RJ, Kar S, Lim DS, Zaroff JG, et al. Echocardiographic outcomes after transcatheter leaflet approximation in patients with secondary mitral regurgitation: the COAPT trial. \textit{J Am Coll Cardiol}. 2019;74:2969-79.
13. Yiu SF, Enriquez-Sarano M, Tribouilloy C, Seward JB, Tajik AJ. Determinants of the degree of functional mitral regurgitation in patients with systolic left ventricular dysfunction: a quantitative clinical study. \textit{Circulation}. 2000;102:1400-6.
14. Santana O, Selenkova NV, Pineda AM, Mihos CG, Lamelas J. Minimally invasive papillary muscle sling placement during mitral valve repair in patients with functional mitral regurgitation. \textit{J Thorac Cardiovasc Surg}. 2014;147:496-9.

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