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REPLY FROM AUTHOR: DOES PAPILLARY MUSCLE APPROXIMATION BENEFIT BOTH THE MITRAL VALVE AND THE LEFT VENTRICLE IN THE REPAIR OF FUNCTIONAL MITRAL REGURGITATION?

Reply to the Editor:

We thank Nappi and colleagues[1] for their response to our work published in the *Journal*. Their argument that subvalvular repair for functional mitral regurgitation (FMR) is coming of age is valid, and as with anything entering adulthood, there is lot to be learnt and a tremendous opportunity to grow. Papillary muscle approximation (PMA), the specific subvalvular repair technique in discussion, is rather simple to implement and has a strong physiological basis for it to yield better outcomes than mitral annuloplasty (UMA). Zhan-Moodie and colleagues from our group recently quantified the effect of PMA on mitral valve chordal force balance and valve kinematics in relation to different sizes of UMA, demonstrating a relief of tethering forces by PMA than UMA cannot achieve.[2] Systolic leaflet mobility and coaptation were improved, and reduction in the regurgitation fraction was better with PMA than UMA. Our more recent work by Xu and colleagues[3] demonstrates that not only does PMA benefit the valve, but it enables left ventricular reverse remodeling and improves cardiac function than UMA. These benefits of PMA were demonstrated in controlled animal models, with a well-defined infarction size, comparable ventricular damage, and similar extent of mitral valve tenting and regurgitation between the groups.

It would be logical to conclude from our preclinical data that PMA has a positive impact and thus should be considered enthusiastically. We share in that enthusiasm but highlight our perspectives on our findings: (1) Is better ventricular remodeling after PMA owed to complete and durable reduction of FMR compared with UMA? In this controlled swine model, complete and durable correction of FMR was achieved with both PMA and UMA for the study duration. Thus, the differences in ventricular remodeling cannot be attributed to differences in repair effectiveness. (2) Is better ventricular remodeling after PMA owed to a restraining effect that it imposes on the left ventricle? We do not think so, as we approximated the papillary muscle tips together, which are unlikely to have a biomechanical effect on the left ventricle in diastole. In the clinically used technique described by Hvass and colleagues[4] and adopted by Nappi and colleagues[5] and Benjo and colleagues,[6] a polytetrafluoroethylene conduit is inserted around the bases of the papillary muscles, which may have a restraining effect. Thus, we believe that better left ventricular remodeling with PMA cannot be attributed to the procedure itself. (3) When controlling for all factors, why then does PMA yield a better reverse ventricular remodeling than UMA? Our animal data indicate that when the volume overload from FMR is removed, the chamber wall stresses are reduced and reverse remodeling is a clear possibility. Our biomechanics data indicate that PMA corrects FMR and does not have any other beneficial or adverse effect on the LV, thus allowing remodeling and functional recovery to occur. Contrastingly, although UMA eliminates the volume overload from FMR, it still does not yield reverse remodeling, owed to the adverse biomechanics that it imposes on the left ventricle. Twist and torsion are reduced after UMA, and basal wall mechanics are restrained, resulting in a hunch back configuration of the left ventricular free wall.

Thus, our message is that the repairing FMR with UMA comes at the cost of deforming and adversely impairing left ventricular mechanics. We hypothesize that the smaller the UMA ring compared with the LV size, the worse is this adverse biomechanical effect on the chamber. As "repair" and "annuloplasty" have become synonymous in this clinical field, it is likely time to rethink our approach and veer focus on alternative and better approaches for mitral valve repair. PMA is a technique that is simple to implement, safe, and durable and likely does not impose other adverse biomechanical effects on the surrounding structures. These developments in mitral valve repair need to continue, despite surgical mitral valve replacement dominating the dialogue since publication of the Cardiothoracic Surgical Trials Network trial.[7] Careful analysis of data in this trial reveals that patients with a viable repair had the best survival and

ventricular functional recovery than patients who had a replacement. In conclusion, we need to appreciate first the harm that annuloplasty could do to the left ventricle, before we explore the benefits of other subannular repairs.

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