15. Benedetto U, Melina G, Angeloni E, Refice S, Roscitano A, Comito C, et al. Prophylactic tricuspid annuloplasty in patients with dilated tricuspid annulus undergoing mitral valve surgery. *J Thorac Cardiovasc Surg.* 2012;143:632-8.
16. Porter A, Shapira Y, Wurzel M, Sulkes J, Vaturi M, Adler Y, et al. Tricuspid regurgitation late after mitral valve replacement: clinical and echocardiographic evaluation. *J Heart Valve Dis.* 1999;8:57-62.
17. Kim JB, Yoo DG, Kim GS, Song H, Jung SH, Choo SJ, et al. Mild-to-moderate functional tricuspid regurgitation in patients undergoing valve replacement for rheumatic mitral disease: the influence of tricuspid valve repair on clinical and echocardiographic outcomes. *Heart.* 2012;98:24-30.
18. Taramasso M, Vanermen H, Maisano F, Guidotti A, La Canna G, Alfieri O. The growing clinical importance of secondary tricuspid regurgitation. *J Am Coll Cardiol.* 2012;59:703-10.
19. Dreyfus GD, Corbi PJ, Chan KM, Bahrami T. Secondary tricuspid regurgitation or dilatation: which should be the criteria for surgical repair? *Ann Thorac Surg.* 2005;79:127-32.
20. Ro SK, Kim JB, Jung SH, Choo SJ, Chung CH, Lee JW. Mild-to-moderate functional tricuspid regurgitation in patients undergoing mitral valve surgery. *J Thorac Cardiovasc Surg.* 2013;146:1092-7.
21. Shinn SH, Schaff HV. Evidence-based surgical management of acquired tricuspid valve disease. *Nat Rev Cardiol.* 2013;10:190-203.
22. He J, Shen Z, Yu Y, Huang H, Ye W, Ding Y, et al. Criteria for determining the need for surgical treatment of tricuspid regurgitation during mitral valve replacement. *J Cardiothorac Surg.* 2012;7:27.
23. Stulak JM, Schaff HV, Dearani JA, Orszulak TA, Daly RC, Sundt TM III. Restoration of sinus rhythm by the maze procedure halts progression of tricuspid regurgitation after mitral surgery. *Ann Thorac Surg.* 2008;86:40-4; discussion 4-5.
24. Bonow RO, Carabello BA, Kanu C, de Leon AC Jr, Faxon DP, Freed MD, et al. ACC/AHA 2006 guidelines for the management of patients with valvular heart disease: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (Writing Committee to revise the 1998 Guidelines for the Management of Patients With Valvular Heart Disease); developed in collaboration with the Society of Cardiovascular Anesthesiologists; endorsed by the Society for Cardiovascular Angiography and Interventions and the Society of Thoracic Surgeons. *Circulation.* 2006;114:e84-231.
25. Vahanian A, Baumgartner H, Bax J, Butchart E, Dion R, Filippatos G, et al. Guidelines on the management of valvular heart disease: the Task Force on the Management of Valvular Heart Disease of the European Society of Cardiology. *Eur Heart J.* 2007;28:230-68.
26. Groves PH, Lewis NP, Ikram S, Maire R, Hall RJ. Reduced exercise capacity in patients with tricuspid regurgitation after successful mitral valve replacement for rheumatic mitral valve disease. *Br Heart J.* 1991;66:295-301.
27. Suri RM, Vanoverschelde JL, Grigioni F, Schaff HV, Tribouilloy C, Avierinos JF, et al. Association between early surgical intervention vs watchful waiting and outcomes for mitral regurgitation due to flail mitral valve leaflets. *JAMA.* 2013;310:609-16.

EDITORIAL COMMENTARY

“Forgotten” valve or “enigmatic” valve? Further insights into the tricuspid valve in patients undergoing mitral valve surgery

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See related article on pages 1957-62.

Commonly referred to as the “forgotten valve,” the tricuspid valve (TV) has received increasing attention in recent years.¹ Functional tricuspid regurgitation (fTR) was often overlooked in the past, both because correction of left-sided valvular pathology was thought to sufficiently ameliorate fTR and because the optimal TV repair technique was unknown. We now know that fTR does not always improve after left-sided surgery and that residual

tricuspid regurgitation (TR) imparts a poor long-term prognosis. Residual TR is associated with a 2-fold risk of heart failure¹ and a 50% decrease in 5-year survival.² Residual TR is also progressive, with one-half of all patients having progression by more than 2 grades 5 years after surgery.³ In addition, isolated TV surgery for TR is associated with unacceptably high morbidity and mortality after mitral valve (MV) surgery.⁴

In light of these findings, some investigators have argued strongly for concomitant TV repair for patients with any amount of fTR—or even for those with isolated tricuspid annular dilation without fTR—when they undergo left-sided valvular surgery.⁵ Several different tricuspid annuloplasty rings have been designed for fTR, with none demonstrating clear clinical superiority to date. Some evidence suggests, however, that flexible rings may be associated with a lower risk of dehiscence relative to rigid rings.⁶ Determining which criteria should be applied to performing TV repair in patients undergoing MV surgery remains a topic of debate.

Current guidelines recommend that severe TR should be addressed at the time of MV surgery,^{7,8} because TV

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repair does not add significantly to perioperative morbidity or mortality and is associated with a minimal increase in myocardial ischemic time.^{3,9} TV repair is also recommended for patients undergoing MV surgery when they have mild or moderate fTR and either TV annular dilation or evidence of right heart failure, although this is a lower class of recommendation.^{7,8} These recommendations are based on studies that have shown that patients with greater than 40 mm TV annular diameter on preoperative echocardiography or greater than 70 mm anteroposterior commissural diameter measured during direct intraoperative inspection are at risk for residual TR and progression after MV surgery.^{3,10}

Within this context, Rajbanshi and colleagues¹¹ sought, in the study published in this issue of the *Journal*, to further investigate late fTR after MV surgery for degenerative mitral regurgitation. Their cohort consisted of 683 patients who underwent isolated MV repair and 64 who underwent MV replacement between 1995 and 2006. Patients undergoing MV surgery who had severe TR or moderate TR with right heart failure symptoms, structural abnormalities of the TV, dilated right atrium and ventricle, severe pulmonary hypertension, or atrial fibrillation underwent concomitant TV repair and were therefore excluded. Furthermore, patients who had pacemaker or defibrillator leads placed before or after surgery were excluded. Within this study cohort, 5% of patients had no preoperative fTR, 80% had trace or mild fTR, and 15% had moderate fTR. Mean follow-up was 7 years, and patients were divided into 3 groups according to the length of echocardiographic follow-up: less than 1 year, 1 to 5 years, and longer than 5 years.

Although this study addresses an important clinical dilemma, namely optimal management of fTR in patients undergoing MV surgery, it does have several key limitations. The division of patient follow-up into 3 time periods substantially decreases its power and thereby increases the risk of a type II statistical error. For longitudinal studies, Kaplan-Meier curves and adjustment for competing risks (such as death and TV repair) would be more appropriate. Additionally, excluding patients who received pacemakers after surgery (the number of patients excluded for this reason is unknown) seems inappropriate given that the decision to repair the TV must be made before surgery. Furthermore, the incomplete follow-up in the less than 1 year and 1 to 5 years follow-up groups (both <50%) could introduce selection bias, making interpretation of these results difficult.

The most important insights that can be ascertained from this study come from those patients who underwent echocardiographic follow-up more than 5 years after MV surgery. Within this subgroup, only 12 patients (6%) developed severe TR, and a further 4 patients required TV surgery at some time during the follow-up period.

Unfortunately, preoperative TV annular dimensions and extent of tricuspid leaflet tethering were not reported. Not surprisingly, Rajbanshi and colleagues¹¹ were unable to demonstrate a significant effect of MV repair versus replacement on the development of subsequent TR. With these limitations in mind, it appears that patients with degenerative MV disease and moderate or less TR without the previously mentioned indications for TV repair have a low incidence of severe TR 5 years after MV surgery. Rajbanshi and colleagues¹¹ were unable to identify any variables associated with development of late TR on multivariate analysis. Although they concluded that timing of MV repair in degenerative MV disease may influence progression of fTR, this conclusion was based on univariate analysis showing higher pulmonary arterial pressures and larger left atrial size in patients with TR progression, variables that were not significant on multivariate analysis. Further data are required in order to support such a hypothesis.

In conclusion, the risk of development of significant TR appears to be low in highly selected patients undergoing mitral procedures for degenerative disease, and this risk is not affected by the choice to perform MV repair versus replacement. The critical question of when to perform TV repair in patients with moderate or less fTR remains controversial and requires further study. Perhaps it is time to start addressing the TV as the “enigmatic valve,” rather than as the “forgotten valve.”

References

1. Ruel M, Rubens FD, Masters RG, Pipe AL, Bédard P, Mesana TG. Late incidence and predictors of persistent or recurrent heart failure in patients with mitral prosthetic valves. *J Thorac Cardiovasc Surg.* 2004;128:278-83.
2. Di Mauro M, Bivona A, Iacò AL, Contini M, Gagliardi M, Varone E, et al. Mitral valve surgery for functional mitral regurgitation: prognostic role of tricuspid regurgitation. *Eur J Cardiothorac Surg.* 2009;35:635-9; discussion 639-40.
3. Dreyfus GD, Corbi PJ, Chan KM, Bahrami T. Secondary tricuspid regurgitation or dilatation: Which should be the criteria for surgical repair? *Ann Thorac Surg.* 2005;79:127-32.
4. Kwon DA, Park JS, Chang HJ, Kim YJ, Sohn DW, Kim KB, et al. Prediction of increase in patients undergoing surgery for severe tricuspid regurgitation following mitral valve surgery and role of tricuspid annular systolic velocity. *Am J Cardiol.* 2006;98:659-61.
5. Benedetto U, Melina G, Angeloni E, Refice S, Roscitano A, Comito C, et al. Prophylactic tricuspid annuloplasty in patients with dilated tricuspid annulus undergoing mitral valve surgery. *J Thorac Cardiovasc Surg.* 2012;143:632-8.
6. Pfannmüller B, Doenst T, Eberhardt K, Seeburger J, Borger MA, Mohr FW. Increased risk of dehiscence after tricuspid valve repair with rigid annuloplasty rings. *J Thorac Cardiovasc Surg.* 2012;143:1050-5.
7. Nishimura RA, Otto CM, Bonow RO, Erwin JP 3rd, Guyton RA, O’Gara PT, et al., American College of Cardiology; American College of Cardiology/American Heart Association; American Heart Association. 2014 AHA/ACC guideline for the management of patients with valvular heart disease: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines. *J Thorac Cardiovasc Surg.* 2014;148:e1-132.
8. Vahanian A, Alfieri O, Andreotti F, Antunes MJ, Barón-Esquivias G, Baumgartner H, et al., ESC Committee for Practice Guidelines (CPG); Joint Task Force on the Management of Valvular Heart Disease of the European Society of Cardiology (ESC); European Association for Cardio-Thoracic Surgery (EACTS). Guidelines on the management of valvular heart disease

- (version 2012): The Joint Task Force on the Management of Valvular Heart Disease of the European Society of Cardiology (ESC) and the European Association for Cardio-Thoracic Surgery (EACTS). *Eur J Cardiothorac Surg*. 2012;42:S1-44.
9. Tang GH, David TE, Singh SK, Maganti MD, Armstrong S, Borger MA. Tricuspid valve repair with an annuloplasty ring results in improved long-term outcomes. *Circulation*. 2006;114(1 Suppl):I577-81.
 10. Chopra HK, Nanda NC, Fan P, Kapur KK, Goyal R, Daruwalla D, et al. Can two-dimensional echocardiography and Doppler color flow mapping identify the need for tricuspid valve repair? *J Am Coll Cardiol*. 1989;14:1266-74.
 11. Rajbanshi BG, Suri RM, Nkomo VT, Dearani JA, Daly RC, Burkhart HM, et al. Influence of mitral valve repair versus replacement on the development of late functional tricuspid regurgitation. *J Thorac Cardiovasc Surg*. 2014; 148:1957-62.