21. Dumont E, Gillinov AM, Blackstone EH, Sabik JF III, Svensson LG, Mihaljevic T, et al. Reoperation after mitral valve repair for degenerative disease. *Ann Thorac Surg.* 2007;84:444-50.
22. Maisano F, Cioni M, Seeburger J, Falk V, Mohr FW, Mack MJ, et al. Beating-heart implantation of adjustable length mitral valve chordae: acute and chronic experience in an animal model. *Eur J Cardiothorac Surg.* 2011;40:840-7.
23. Seeburger J, Rinaldi M, Nielsen SL, Salizzoni S, Lange R, Schoenburger M, et al. Off-pump transapical implantation of artificial neo-chordae to correct mitral regurgitation: the TACT Trial (Transapical Artificial Chordae Tendinae) proof of concept. *J Am Coll Cardiol.* 2014;63:914-9.
24. Jensen H, Jensen MO, Waziri F, Honge JL, Sloth E, Fenger-Gron M, et al. Transapical neochord implantation: is tension of artificial chordae tendineae dependent on the insertion site? *J Thorac Cardiovasc Surg.* 2014;148:138-43.
25. Rucinskas K, Janusauskas V, Zakarkaitė D, Aidietiene S, Samalavicius R, Speziali G, et al. Off-pump transapical implantation of artificial chordae to correct mitral regurgitation: early results of a single-center experience. *J Thorac Cardiovasc Surg.* 2014;147:95-9.
26. Roberts WC, Vowels TJ, Ko JM, Hebel RF Jr. Gross and histological features of excised portions of posterior mitral leaflet in patients having operative repair of mitral valve prolapse and comments on the concept of missing (= ruptured) chordae tendineae. *J Am Coll Cardiol.* 2014;63:1667-74.

Key Words: mitral valve prolapse, mitral valve repair, mitral neochordoplasty, suture length, finite element models

EDITORIAL COMMENTARY

Tugging on heart strings

Patrick M. McCarthy, MD

From the Division of Cardiac Surgery, Northwestern University, Chicago, Ill.

Disclosures: P.M.M. receives remuneration from Edwards Lifesciences (consultancy, royalties, intellectual property) and is the inventor of the Edwards MC3 Ring and dETlogix Ring and coinventor of the IMR Etlogix Ring. P.M.M. also receives remuneration from Abbott Vascular (consultancy). Author has nothing additional to disclose with regard to commercial support.

Received for publication Aug 4, 2015; accepted for publication Aug 8, 2015; available ahead of print Sept 1, 2015.

Address for reprints: Patrick M. McCarthy, MD, Executive Director of the Bluhm Cardiovascular Institute, Chief of the Cardiac Surgery Division, Heller-Sacks Professor of Surgery at the Northwestern University Feinberg School of Medicine, Northwestern University, Division of Cardiac Surgery, 201 E Huron St, Suite 11-140, Chicago, IL 60611-2908 (E-mail: pmccart@nmh.org).

J Thorac Cardiovasc Surg 2015;150:1312-3

0022-5223/\$36.00

Copyright © 2015 by The American Association for Thoracic Surgery

<http://dx.doi.org/10.1016/j.jtcvs.2015.08.013>

The Achilles' heel of mitral valve repair has been the risk for immediate failure from uncorrected (residual) mitral regurgitation (MR) or the development of recurrent MR late after an apparently initially successful repair. The causes for recurrent MR are varied and include progression of native valve disease, endocarditis, ring dehiscence, scar tissue, and potentially leaving neochords too short or too long.^{1,2} The use of neochords seems to be increasing, judging by the literature (not easy to confirm from any national database as of now), and neochord techniques are varied. Many surgeons consider this approach an art. With the mean number of mitral operations per year per surgeon being much fewer than 10 per year in the United States, it is hard to perfect a technique that demands experience and precise execution of the art of surgery.³

In this issue of the *Journal*, Sturla and colleagues⁴ from Italy report their identification of a more subtle potential source for failure. They posit that chord forces and leaflet

stresses may be clinically relevant even when apparently successful repairs without residual regurgitation have been achieved. From their data, these initially "subclinical" stresses appear to be more common when a single neochord is used or when multiple chords are used but create asymmetric configurations. Even with relatively small differences in chord length and symmetry (± 2 mm), patients with echocardiographically successful repairs and no MR have a less than "ideal" repair. The study is primarily based

Patrick M. McCarthy, MD

Central Message

Mitral valve repair that uses neochords may appear to be successful but later fail because of subtle differences in leaflet tension.

See Article page 1303.

on mathematic modeling derived from a small number of patients who underwent cardiac magnetic resonance imaging both before and after the operation to investigate mitral valve biomechanics. Is this a radiographic finding of little clinical relevance, or is this a new technique to distinguish patients who have an apparently good repair that may later fail? Are the differences observed by Sturla and colleagues⁴ within the boundaries of acceptable clinical variability, reaching statistical significance but not clinical significance? Time will tell.

Literature reports indicate that patients with neochord repair have a rate of recurrent moderate or more mitral regurgitation of 8% to 22% from 5 to 10 years after surgery.⁵⁻⁹ Perhaps one of the mechanisms for recurrence in these patients relates to asymmetric stress on the leaflet tissue? The data in the article by Sturla and colleagues⁴ are hypothesis generating and thought provoking. But they are not definitive. A message for surgeons could be cautiously interpreted from this article; perhaps to use fewer single chords and to be mindful of a potential, and as yet still theoretic, source of failure from asymmetric configurations when using multiple chords. This study also has implications for the developing new procedure of using transapical neochords placed off pump on a beating heart.¹⁰ If even 2-mm differences can account for late clinical failures, this is important information. But perhaps this risk could be turned to an advantage if real-time 3-dimensional echocardiography, or other imaging, could be used to achieve the “ideal repair,” not just the resolution of MR, through the precise deployment of tension in the beating heart.

The data in this study are provocative, and they are encouraging because this finding can be tested going forward

with larger numbers of patients followed up for a longer period. I look forward to hearing more about these studies and potentially ways that we may be able to improve our late results of mitral valve repair.

References

1. Gillinov AM, Cosgrove DM, Lytle BW, Taylor PC, Stewart RW, McCarthy PM, et al. Reoperation for failure of mitral valve repair. *J Thorac Cardiovasc Surg.* 1997;113:467-73; discussion 473-5.
2. Ibrahim M, Rao C, Athanasiou T. Artificial chordae for degenerative mitral valve disease: critical analysis of current techniques. *Interact Cardiovasc Thorac Surg.* 2012;15:1019-32.
3. Bolling SF, Li S, O'Brien SM, Brennan JM, Prager RL, Gammie JS. Predictors of mitral valve repair: clinical and surgeon factors. *Ann Thorac Surg.* 2010;6:1904-11; discussion 1912.
4. Sturla F, Votta E, Onorati F, Pechlivanidis K, Pappalardo OA, Götting L, et al. Biomechanical drawbacks of different techniques of mitral neochordal implantation: when an apparently optimal repair can fail. *J Thorac Cardiovasc Surg.* 2015;150:1303-12.
5. Ragnarsson S, Sjögren J, Sanchez R, Wierup P, Nozohoor S. Polytetrafluoroethylene neochordae is noninferior to leaflet resection in repair of isolated posterior mitral leaflet prolapse: a multicentre study. *Interact Cardiovasc Thorac Surg.* 2014;19:577-83.
6. Lawrie GM, Earle EA, Earle N. Intermediate-term results of a nonresectional dynamic repair technique in 662 patients with mitral valve prolapse and mitral regurgitation. *J Thorac Cardiovasc Surg.* 2011;141:368-76.
7. David TE, Armstrong S, Ivanov J. Chordal replacement with polytetrafluoroethylene sutures for mitral valve repair: a 25-year experience. *J Thorac Cardiovasc Surg.* 2013;145:1563-9.
8. Tabata M, Kasegawa H, Fukui T, Shimizu A, Sato Y, Takanashi S. Long-term outcomes of artificial chordal replacement with tourniquet technique in mitral valve repair: a single-center experience of 700 cases. *J Thorac Cardiovasc Surg.* 2014;148:2033-8.e1.
9. Hata H, Fujita T, Shimahara Y, Sato S, Ishibashi-Ueda H, Kobayashi JA. 25-year study of chordal replacement with expanded polytetrafluoroethylene in mitral valve repair. *Interact Cardiovasc Thorac Surg.* 2015;20:463-8; discussion 468.
10. Rucinskas K, Janusauskas V, Zakarkaitė D, Aidietienė S, Samalavicius R, Speziali G, et al. Off-pump transapical implantation of artificial chordae to correct mitral regurgitation: early results of a single-center experience. *J Thorac Cardiovasc Surg.* 2014;147:95-9.