

Conflict of Interest Statement

Dr Cox: Atricure consultant, Chairman, Scientific Advisory Board, stockholder. Dr McCarthy: Edwards Lifesciences: consultant and royalties; Abbott: Advisory Board; Atricure: Honorarium Dr Malaisrie: Edwards: speaker and consultant; Abbott: speaker. All other authors have nothing to disclose with regard to commercial support.

References

1. Nishimura RA, Otto CM, Bonow RO, Carabello BA, Erwin JP III, Guyton RA, et al. 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.
2. Nishimura RA, Otto CM, Bonow RO, Carabello BA, Erwin JP III, Fleisher LA, et al. 2017 AHA/ACC focused update of the 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 clinical practice guidelines. *Circulation.* 2017;135:e1159-95.
3. Lim E, Ali ZA, Barlow CW, Hosseinpour AR, Wisbey C, Charman SC, et al. Determinants and assessment of regurgitation after mitral valve repair. *J Thorac Cardiovasc Surg.* 2002;124:911-7.
4. Suri RM, Clavel MA, Schaff HV, Michelena HI, Huebner M, Nishimura RA, et al. Effect of recurrent mitral regurgitation following degenerative mitral valve repair: long-term analysis of competing outcomes. *J Am Cardiol.* 2016;67:488-98.
5. Rizza A, Sulcaj L, Glauber M, Trianni G, Palmieri C, Mariani M, et al. Predictive value of less than moderate residual mitral regurgitation as assessed by transesophageal echocardiography for the short-term outcomes of patients with mitral regurgitation treated with mitral valve repair. *Cardiovasc Ultrasound.* 2007;5:25.
6. Sakaguchi T, Kagiya N, Toki M, Hiraoka A, Hayashida A, Totsugawa T, et al. Residual mitral regurgitation after repair for posterior leaflet prolapse—importance of preoperative anterior leaflet tethering. *J Am Heart Assoc.* 2018;7.
7. Fix J, Isada L, Cosgrove D, Miller DP, Savage R, Blum J, et al. Do patients with less than “echo-perfect” results from mitral valve repair by intraoperative echocardiography have a different outcome? *Circulation.* 1993;88:II39-48.
8. Goldstone AB, Cohen JE, Howard JL, Edwards BB, Acker AL, Hiesinger W, et al. A “repair-all” strategy for degenerative mitral valve disease safely minimizes unnecessary replacement. *Ann Thorac Surg.* 2015;99:1983-91.
9. Gardner MA, Hossack KF, Smith IR. Long-term results following repair for degenerative mitral regurgitation - analysis of factors influencing durability. *Heart Lung Circ.* October 17, 2018 [Epub ahead of print].
10. David TE, Armstrong S, McCrindle BW, Manlhiot C. Late outcomes of mitral valve repair for mitral regurgitation due to degenerative disease. *Circulation.* 2013;127:1485-92.
11. Castillo JG, Anyanwu AC, Fuster V, Adams DH. A near 100% repair rate for mitral valve prolapse is achievable in a reference center: implications for future guidelines. *J Thorac Cardiovasc Surg.* 2012;144:308-12.

Key Words: degenerative mitral valve regurgitation, mitral valve repair, residual mitral regurgitation

Discussion



Dr Gilles D. Dreyfus (*Monte Carlo, Monaco*). We all try our best to avoid residual recurrent MR, and your data show excellent results, as you reached 99.5% freedom from reoperation with no MR and 96.9% with only mild MR at 10 years.

Before getting more into details, I would like to ask you 2 questions. You are reporting your

14-year experience, including 1155 patients, but your median clinical follow-up was 4.7 years and your echo follow-up was a mean of 3.3 years. Can you explain your methodology to reach reliable results in 10 years?



Dr Bartłomiej Imielski (*Chicago, IL*)

Although we have not looked at the year-to-year rate of MV repair, we have noticed a trend at Northwestern toward having a higher volume of MV repairs more recently as opposed to before, and this likely reflects local referral patterns.

Dr Dreyfus. My second question refers to postoperative MR quantification. As you know, we all try to stick to quantitative methods to indicate surgery, and unfortunately after all these years we keep referring to 0 to 4+ MR in the postoperative period, which is a mix of semiquantitative and quantitative assessment, which really doesn't make it very precise.

On your central picture from the article and the one you showed displayed on the screen, you had 0 as nontrivial, 1 as mild, then I guess 2+ MR is moderate, so 3+ is what, is moderate severe and 4+ is severe. I would like to know if you do believe that we should agree to use a more precise grading in our follow-up studies as we do currently?

Dr Imielski. I concur in that any standardization and clarification of these criteria would be beneficial. In our center, all of our echocardiograms were performed by our echocardiography trained cardiac anesthesiologists, so that standardizes it within our group. We tried to take a look at the echocardiographic data; however, we had some patients who, of course, were lost to follow-up at other centers, for the remaining, we had reports, we could not review all the imaging, and so at this point I cannot clarify those. But absolutely, more standardized nomenclature would definitely help everybody.

Dr Dreyfus. You think we should use a quantitative method that is applied preoperatively or another one?

Dr Imielski. Dr McCarthy, do we have any input on that?



Dr Patrick M. McCarthy (*Chicago, Ill*). Gilles, it would be great to get the quantitative data. It's just so hard to get the data from the echocardiographers in the real world, especially when you are looking at trivial and mild MR. The judgment of trivial usually has to be a small jet that doesn't travel beyond the ring, and mild just barely will travel beyond the ring.

Dr Dreyfus. This was not specifically for your study but was generally speaking more broadly to all studies dealing with long-term results with mitral repair.

Now, chasing mild MR is rare, but even more rare is that some MR will disappear with time, and as shown from your

data, in 66 patients with mild residual MR after repair, 24% got better with time and turned to no MR at all. As I have never seen that in such evolution, can you speculate what happened in these patients who I would say by magic got no MR after being graded higher grades before that?

Dr Imielski. I think part of it is when you are coming off pump, you still might not have full recovery of your ejection fraction, and so you might have a bit of residual regurgitation at the line of coaptation. Additionally, when we started reviewing the limited echocardiographic data that we had, we saw that the only signal that tended to show significance was that in patients who had recovery of their ejection fraction, their regurgitation tended to improve. So I think this really means that the patients who undergo remodeling are those who likely will have improvement of their regurgitation with time.

Dr Dreyfus. If we come back to your differences between the no MR group (94%) and mild MR group (6%), you rightly mention emergency as a risk factor but also A3 prolapse. Can you tell us how you fix A3 prolapse in the posterior commissure in your routine practice?

Dr Imielski. For most of our repairs, we tend to perform a posterior leaflet resection, which may unmask a small jet at the interleaflet commissure, which in turn may require a simple stitch to close this.

Dr McCarthy. For the A3 prolapse, it typically would be a little magic stitch, 1 or 2. Occasionally, someone might have a small resection or an imbrication of A3, occasionally chord transfers. We have a variety of the usual techniques.

Dr Dreyfus. As you know, residual MR within the closure line is more difficult to address than those within the leaflets or at the annular level. In the 6% of 73 patients with mild MR, were you able to even retrospectively segregate residual regurgitation location within the line of coaptation—and, by the way, do you have the data about your coaptation height after weaning from bypass—or outside the closure line within the leaflet itself or at the annular level, and did you find a predominant location for mild MR?

Dr Imielski. The main limitation to reporting on the entire cohort for this was that long-term echocardiographic data were not complete, especially with some patients lost to other centers. Twenty patients in our series initially had greater than mild regurgitation, which was re-repaired, and they were in the no or trivial regurgitation group afterward.

In general, we believe that mild residual MR that comes from the coaptation line is the type that can be safely left and less likely to progress. We have certain tricks that we use to ensure that this is the case. For example, when using

bulb insufflation, we mark the line of coaptation so that when the valve deflates and the ventricle deflates, you can measure and see how much coaptation you have left to ensure that it is actually a reasonable amount. Do you mind repeating the second portion of that?

Dr Dreyfus. Basically, were you able to localize where your mild MR was coming from, mostly from the closure line or from inside, either repair of suture leaflets or at the annular level?

Dr Imielski. Unfortunately, we were not able to because of lack of full echocardiographic data. There was 1 patient of those 2 who underwent early reoperation, and that was due to a leaflet perforation, and that happened on postoperative day 6.

Dr Dreyfus. To clarify for the audience, you are in the resect or the respect group?

Dr Imielski. In general, I would say that we definitely tend to do a resection with an annuloplasty ring.

Dr Dreyfus. So basically we can go home saying that we should not worry about mild MR because overall, this will resolve in 43% and 37% will remain the same. So I think it's a great message, and we have to fight against moderate MR during the surgery.



Dr Richard J. Shemin (*Los Angeles, Calif*). My question is focused on the intraoperative TEE measurement. We know the impact of anesthesia coming off bypass; volume afterload can affect that result. Obviously, you must have a strict protocol of how you adjust the hemodynamics to be able to get a good intraoperative evaluation. Can you share that with us?

Dr Imielski. I am going to ask Dr McCarthy to just further clarify.

Dr McCarthy. The next article is on exactly that algorithm.

Dr Shemin. Do you also do a predischarge echo?

Dr McCarthy. Yes, everyone gets a predischarge echo on day 3. It's our routine and always has been.

Dr Shemin. And the concordance between the 2 are good?

Dr McCarthy. Actually, it has been very high. We still see quite a few patients who are downgraded, but they are going from transesophageal to transthoracic. But another aspect is that patients who come off pump may have somewhat reduced contractility and ejection fraction. As this improves, they get better coaptation of the leaflets. Our echocardiographers thought that change may explain the reduction in MR.