the rigorous prospective data collection in our study are unique and allowed for detailed analysis of repair failure due to MS and its management. We believe that this strength outweighs the limitations.

Webcast

You can watch a Webcast of this AATS meeting presentation by going to: https://aats.blob.core.windows.net/media/20AM/Presentations/Observations%20from%20Reoperations%20for%20M.mp4.

Conflict of Interest Statement

The Icahn School of Medicine at Mount Sinai receives royalty payments from Edwards Lifesciences and Medtronic for intellectual property related to Dr Adams' involvement in the development of 3 mitral valve repair rings and a tricuspid valve repair ring. All other authors reported no conflicts of interest.

The *Journal* policy requires editors and reviewers to disclose conflicts of interest and to decline handling or reviewing manuscripts for which they may have a conflict of interest. The editors and reviewers of this article have no conflicts of interest.

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Key Words: mitral valve repair, mitral valve replacement, mitral valve stenosis, mitral valve regurgitation

Discussion

Presenter: Dr Ahmed El-Eshmawi

Dr Y. Joseph Woo *(Stanford, Calif)*. Ahmed, thank you for an outstanding presentation. It is a privilege to discuss this paper. I congratulate you, David Adams, and the entire team for yet another impactful, scholarly investigation of a highly specific aspect of your exceptional clinical skills and experience. Your research will guide both technical

considerations during the primary repair operations and the evaluation of postrepair mitral stenosis patients.

I have 4 lines of inquiry within which are embedded discussion topics and questions. Let's cover these one by one. My first line of inquiry is on the influence of the primary operation on the subsequent development of mitral stenosis. Are there specific characteristics of that operation, such as the way in which the abundance of existing leaflet tissue is treated, via resection or preservation, band versus ring, ring size, ring types, such as a Physio II, which has a greater AP diameter, versus say, Profile 3D, which has a narrower AP diameter? Also, coaptation length, which potentially could contribute to your funnel effect, and finally, mean gradient postop—do any of these factors, in your opinion. Contribute more or less to the propensity for developing mitral stenosis?

Dr Ahmed El-Eshmawi *(New York NY)*. Thanks, Joseph. I should say that we based our analysis of the initial mitral repair details primarily on the available surgical notes. If there were any missing parameters not mentioned in the surgical notes, like exactly how much resection done or how much tissue left, and postrepair gradients, we could not correlate that to our findings at reoperation.

However, I should say we had a very detailed description of the annuloplasty device type and size used during the primary repair. As you know, most of these patients—over 80%—had complete ring annuloplasty, with a median size of 28. We also looked at the type of rings. Basically, we were looking specifically to see if Duran rings were used. As you know, based on Dr Tirone David's previous report on the possible association of Duran rings and post repair mitral stenosis; however, I could not find such an association giving the small number of patients. Also, those were a mix of different types of rings and bands, ranging from classical Carpentier's ring, flexible bands, rigid rings, 3D rings, etc. So I don't think the ring type was a predominant factor in those patient groups. However, the use of a small complete ring annuloplasty might have been be a contributing factor.

Dr Woo. The next line of inquiry relates to findings during reoperation. Are there specific features that you believe are more conducive to the ability to re-repair, and is there a distinct difference between those patients who had primary regurgitation or secondary regurgitation at the time of their initial operation?

Dr El-Eshmawi. As regards the first part of the question, and because of the small number of patients, it is hard to make clear specifications. But you know that in our Mitral Center of Excellence, we are very interested in mitral re-repair. So our bias is to re-repair valves that have potential for durability, as in case of good quality of leaflet tissue, in the absence of calcification, good subvalvular apparatus, especially in young patients with degenerative valves who still have plenty of tissue, as opposed to elderly patients who have annular calcification or left ventricular dysfunction.

As for the second part of the question, yes, patients who had previous mitral repair due to functional mitral regurgitation and developed mitral stenosis due to aggressive undersizing or leaflet restriction, our bias is to replace those valves due to underlying ventricular disease as opposed to patients with primary regurgitation.

Dr Woo. Next is a technical question. We have all learned from the Mitral Conclave that when we are attempting a mitral re-repair that we really should take down everything and thoroughly examine the valve and then start anew. And that typically begins with the removal of the prior annuloplasty. When you do that, you often have a deep groove that is left over, and I saw you in the video debriding some of that groove material. Can you give us some advice on how to use or treat that area of tissue for the subsequent re-repair? Do you inlay the new ring inside that groove? Do you close and overlay? Or do you try to peel and debride all of it and start anew?

Dr El-Eshmawi. We start our reoperations by careful removal of the annuloplasty device and all suture materials, taking care to not injure the underlying leaflet tissue before formal valve analysis. Regarding the trough or the deep groove left behind after ring or band removal, we completely ignore it, because sometimes the device was implanted on the leaflet or the left atrium as opposed to the actual annulus. We never close the trough, because this might create leaflet restriction, which would be counterproductive and exacerbate mitral stenosis. We place the new annuloplasty sutures on the anatomic annulus, which might be the same trough or nearby.

After we take down the repair, we reassess the tissues left, and then make a decision as to whether we're happy with the amount and quality of the leaflet tissue. If so, then we go ahead with the re-repair if you have good experience with valve re-repair. But if there is any doubt about the durability of re-repair, then we proceed with a valve replacement. Particularly, as you know, lots of those patients have calcification, radiation disease, etc, as I mentioned earlier and in detail in the paper.

Dr Woo. A complementary question related to the technical aspects involves the leaflets themselves. If there is fibrosis or pannus growing down onto the leaflets or impingement of the hinge point, have you ever found the ability to peel this material away and preserve the tissue you need?

Dr El-Eshmawi. Yes, we have had a few cases where we could peel the leaflet. But again, this is a very meticulous technique and unless you can see a transparent leaflet after you do the peeling without injuring the leaflet, it would be very difficult to trust that valve on the long term. But to answer the question, yes, leaflet peel as well as pannus debridement are the first steps in trying to mobilize the leaflet to attempt a valve re-repair. We also do aggressive

chordal cutting of restrictive secondary and sometimes even primary chords and use Gore-Tex NeoChord to further mobilize leaflets.

Dr Woo. My last line of inquiry is related to the fact that we are going to see more and more of these patients as time goes along. Everyone is trying to repair patients with mitral regurgitation. What would be your advice to less experienced surgeons and centers facing this scenario? Would you advise that they send all these patients to a center of excellence? Would you advise them against simply reoperating and replacing all these patients? Or is there some more nuanced approach where you could guide less experienced groups on finding ways to discern those patients who might be re-repairable and should be referred versus those who should simply undergo a redo replacement?

Dr El-Eshmawi. Thank you Jo for your excellent question. As you know, this is very difficult to answer, however, there are a few observations that I found important. First, those patients are often sick, with baseline heart failure symptoms, pulmonary hypertension, and atrial fibrillation. Also, those reoperations are challenging, valve exposure is often difficult, so we tend to expose the valve via a transseptal approach in complex reoperations. As I mentioned in the paper, there is also quite often extensive fibrosis and a small valve orifice, which might be challenging to oversize the prosthesis. So those are not just redo mitral replacements but tend to be a more technically challenging reoperation and are better be done by a surgeon with expertise with this field, since complications of valve replacement are not forgiving.

Regarding repair or replacement, I think this is less of an issue as in general, valve re-repair is only done in centers with expertise in valve re-repair, so I, think valve replacement is not an unreasonable option in many situations, as I discussed earlier.

However, I would also encourage low-volume surgeons who see young patients with a failed degenerative repair to consider re-repair owing to the overall survival advantage in repair patients even if this involves transfer to a valve reference center, as we saw in this study population. The decision has to be individualized, based on available local expertise and access to valve reference centers, as well as patient-related factors and wishes.

Finally, there's no right or wrong answer. Mitral stenosis is such a bad disease and the long-term outcomes are worse. I guess the main focus should be on how we can prevent iatrogenic post repair mitral stenosis from happening at the beginning. And also, if we can identify specific techniques that we should avoid to prevent leaving a culprit lesion or a substrate for the development of mitral stenosis, such as using small ring annuloplasty in combination with aggressive leaflet resection or edge-to-edge repairs. I would be happy to hear from the panel, as well. Thank you.

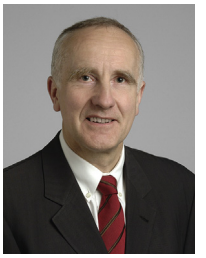
Dr Woo. Thank you. I commend you again on the clinical expertise and the impact of your research.

Dr El-Eshmawi. Thank you.

Dr Patrick McCarthy *(Chicago, Ill).* I have a brief comment. Ahmed, another great presentation, a year after I discussed your previous AATS presentation. You show great results in this interesting and underreported difficult patient group. I'm especially interested in the pannus ingrowth. I doubt that it is related to the size of the ring, the type of the ring, or the anatomy. I'll tell a brief story. I had a patient who developed stenosis over a year out after repair. She needed a replacement. Later we found out that she had a silicone allergy, and of course there is silicone in the repair rings. We don't ever check these patients for a physiologic cause of the pannus. Now I test a patient with pannus ingrowth for an allergy to the ring components. Perhaps that group of patients has sensitivity to the implantable that we put there. Have you ever seen or recognized something like that?

Dr El-Eshmawi. Thanks, Dr McCarthy, We suspected it in maybe 1 patient in 10 years, but you know a lot of the pathology studies on the explanted valve pannus, showed that this is a nonimmune granulomatous inflammatory reaction, basically a foreign body reaction to the annuloplasty device. However, this must be also multifactorial, since pannus dose not happen in every patient even when small rings are used, so there might be other factors that could explain this, as you mentioned in your patient. I would definitely consider the allergic history of patients undergoing valve repair or even replacement. I remember a patient who had a history of a porcine skin graft rejection and needed a valve replacement, so we used a bovine pericardial valve for him. Those are very rare situations, but an excellent observation.

Dr McCarthy. I think there must be something physiologic that we don't recognize yet. This patient had a 36-mm ring, so it wasn't due to a small ring.



Dr Gosta B. Pettersson *(Cleveland, Ohio).* Congratulations on bringing this problem up. Pat is correct: this is the tip of an iceberg. We don't know the denominator. I see a fair number of patients and agree that in most of these patients, you have to replace the valve. It requires a very careful debridement to open that annulus up so that you can get a good size valve in. A group of patients to be very cautious about putting rings in are those with radiation heart disease. I've seen patients develop stenosis very soon after ring repairs—fibrous reaction with scar tissue that doesn't fully mature, but sort of fleshy and edematous. Again, congratulations on bringing this difficult topic up.

Dr El-Eshmawi. Thank you.