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Letters to the Editor

Is overreduction of the mitral annulus for valve competence considered mitral valve repair? Addressing prosthesis-patient mismatch

To the Editor:

We read with great interest Kawamoto and colleagues' article on prosthesis-patient mismatch (PPM) due to small ring annuloplasty in patients with degenerative mitral insufficiency [1]. The size of the ring or band for mitral annuloplasty has a great impact on the hemodynamic function of the mitral valve. The authors based the size of the ring or band on the size of the anterior leaflet. Mitral annuloplasty should maintain a proper annular length (proper valve area, low transvalvular pressure) and a sufficient coaptation height (competent valve). In normal humans with an average height of 1.66 m, the average annular length of the anterior leaflet (intercommissural distance) is 32 ± 1.3 mm and that of the posterior leaflet is 55 ± 2.2 mm [2,3]. Here, commissures mean the boundaries between the anterior leaflet and both commissural leaflets. Some semi-rigid rings or bands, such as Physio ring (Edwards Lifesciences, Irvine, CA, USA) and Colvin-Galloway Future band (Medtronic Inc, Mineapolis, Minn, USA), have a size that is appropriate for these annular lengths. Thus, 32-mm band or ring is the average size for normal humans. In a previous report, most patients (>70%) used Physio rings that were 30–34 mm [4], and we have most commonly used 32-mm Colvin-Galloway Future bands in our recent 25 patients who underwent mitral annuloplasty. Therefore, the 26-mm and 28-mm bands and rings the authors used in 70% of subjects were too small for the adult patients. They performed annular overreduction to increase the coaptation height for valve competence. It is the main cause of the PPM. The appearance is similar to making a frame (annuloplasty ring) on a manhole cover (anterior leaflet). The size of the ring or band should be determined based on the intercommissural distance (equal to the annular length of the anterior leaflet), because the annulus of the anterior leaflet is not significantly dilated. As the leaflet coaptation is formed with the two mitral leaflets, the posterior leaflet height must be also considered. In normal humans, the heights of the anterior and posterior leaflets are 23 ± 0.9 mm and 14 ± 0.9 mm, respectively, and the average coaptation height is 8 ± 1.1 mm in the middle line and 4 ± 0.5 mm in the near-commissural portion [2,3]. Prior to mitral annuloplasty, the coaptation height can be readily predicted from the sum of the heights of the anterior and posterior leaflets and the vertical dimension of the selected semi-rigid prosthesis, as follows: coaptation height = (sum of the heights of the two leaflets − vertical dimension of the selected band or ring) ÷ 2. The 32-mm Physio ring or Colvin-Galloway Future band has a vertical dimension of 21 mm; thus, the sum of the heights of the anterior and posterior leaflets should be ≥37 mm to create a coaptation height of 8 mm (8 mm × 2 + 21 mm = 37 mm). In our experience, 14% of patients who underwent mitral repair (22/156 patients) had insufficient leaflet heights. For mitral annuloplasty, first, the appropriate size of the annuloplasty prosthesis should be determined based on the annular length of the anterior leaflet. Second, the coaptation height can be predicted from the vertical dimension of the selected prosthesis and the sum of the heights of the two leaflets. If the combined height of the two leaflets is too short to achieve a coaptation height of 8 ± 1 mm, a semi-rigid ring or band with less vertical dimension, such as the classic Carpentier-Edwards ring (Edwards Lifesciences, Irvine, CA, USA), may be used instead of the Physio ring or Colvin-Galloway Future ring. Using an undersized Physio ring results in needless over-reduction of the transverse dimension of the valve. Posterior leaflet augmentation using an elliptical pericardial patch may increase the combined height of the two leaflets, while maintaining the height of the augmented posterior leaflet <20 mm to prevent systolic anterior motion [5]. Even when a low-height anterior leaflet causes poor coaptation, it can be readily resolved with posterior leaflet augmentation. To avoid PPM, the size of the ring or band should be based on the annular length of the anterior leaflet (intercommissural length), and to prevent recurrent regurgitation, a sufficient coaptation height should be created, using different-type rings with less vertical dimension or posterior leaflet augmentation when necessary. The goal of mitral valve repair is not to reduce the valve annular circumference excessively to achieve valve competence; rather, the object is to restore the normal geometry of the mitral valve.

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Prosthesis selection for repair of degenerative mitral valve disease

Mitral valve repair has become the first-line treatment for degenerative mitral valve disease due to low surgical mortality, low incidence of late adverse events, and no need for anticoagulation. Excellent long-term durability has resulted in surgeons favoring repair over replacement of the mitral valve. According to the Japanese Association for Thoracic Surgery annual reports, the number of mitral valve procedures has increased 1.6 times in a decade, and repair rates increased from 43% to 60% [1]. Guidelines for performing mitral valve surgery have been expanded to include patients without symptoms [2].

Recently, the quality of valve repair has been under focus, especially in relation to prolapsed leaflets, and repair techniques are changing [3–7]. For example, the size of cut has been modified for resection and suture, moving from quadrangular resection to triangular resection. The sliding leaflet technique and its modifications have been used to prevent systolic anterior motion by decreasing the height of posterior leaflets in combination with a larger annuloplasty ring. The concept of "respect rather than resect" using the loop technique has been widely proposed, even for posterior leaflets, and has been supported by excellent results. The goal of all these modifications has been to decrease residual mitral regurgitation, increase mitral orifice area, and improve long-term durability. However, prosthesis selection or prosthesis size selection have been less frequently discussed. Prosthesis-patient mismatch (PPM) has been more widely explored in patients undergoing aortic valve replacement than in patients undergoing mitral valve surgery.

Our report presented in the *Journal of Cardiology* showed that the standard resection and suture technique for posterior prolapse, and chordal replacement for anterior prolapse with ring annuloplasty achieved excellent durability with a 10-year reoperation rate of 3%. However, it should be noted that a small ring may cause functional mitral stenosis regardless of the repair technique selected [8]. Functional mitral stenosis, equivalent to PPM, was defined as more than 5 mmHg of mean transmitral pressure gradient and developed in approximately 15% of patients. Although prosthesis size was selected based on the length between trigons or anterior leaflet size in our cohort, smaller size prostheses seemed to be selected, perhaps (psychologically) in order to gain enough coaptation depth. Their opinion that the purpose of ring annuloplasty is to restore the annulus but reduce the annular length is correct. As a result, we found small prosthesis selection was an independent risk factor for PPM. Recently, we reported additional data in which mitral PPM induced higher tricuspid regurgitant pressure gradient and increased left atrial diameters, implying pulmonary hypertension and remodeling of left atrium [9,10]. These factors were linked to late onset of atrial fibrillation and freedom from reoperation. Thus, when repairing mitral valves with additional degenerative changes, more attention should be paid to the selection of the correct size of prosthesis to avoid PPM. Since this discovery, our practice has changed to select larger prostheses. While agreeing with our opinion, Lee et al. described that 8 mm of the coaptation length for middle part of mitral valve leaflet, and 4 or 5 mm length for lateral and medial parts was sufficient for good coaptation and that overreduction of the mitral annulus can be harmful in mitral valve repair for degenerative mitral valve disease.

However, the concept that fixed coaptation length may avoid recurrence of mitral regurgitation suggests full ring prosthesis should be selected, especially for patients with anterior lesions. Long-term durability of anterior lesion repair was reportedly inferior to that of posterior lesion repair. Our recent data showed that there was no difference in long-term durability between full ring and partial band repair in patients with posterior lesions [11], however, a difference was observed in patients with anterior lesions. Increased recurrence was observed in the medial side in patients with partial band repair of anterior lesions. It is not clear what the reason for this difference is, but it could be due to tethering or annular dilatation. As a result, full ring annuloplasty is recommended for repairing anterior lesions. It should also be noted that the mitral annulus moves from a flat to a saddle shape during the cardiac cycle. Avoiding fixation of the anterior annulus, allowing the aortic curtain to move during the cardiac cycle, may result in a wider diastolic mitral orifice, which could help prevent functional mitral stenosis.

In conclusion, prosthesis selection is important for repairing the mitral valve in patients with degenerative mitral valve disease. Larger prostheses are recommended as long as enough coaptation depth can be gained. Partial band may be beneficial to avoid PPM, but this choice should be made carefully in patients with anterior lesions.

Conflict of interest

The authors declare that there is no conflict of interest.

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