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Editorial

Aortic Root Enlargement—Is It a Safe and Effective Approach to Prevent Patient-Prosthesis Mismatch and Is It for Everyone?

Harold L. Lazar, MD

Division of Cardiac Surgery, the Boston University School of Medicine, Boston, Massachusetts, USA

See article by Yu et al., pages 782–790 of this issue.

When an aortic valve is surgically replaced, the effective orifice area (EOA) is always smaller than that of the native aortic valve. This is especially true for stented bioprosthetic values, where the residual gradient can be significantly higher in a small root. The EOA for each prosthetic valve is obtained directly from the manufacturer and is indexed for the body surface of each patient. Patient prosthetic mismatch (PPM) occurs when the EOA is less than 1. It is considered to be moderate when the EOA is 0.85-0.65 cm^2/m^2 and severe when the EOA is <0.65 cm^2/m^2.

Detimental Effects of PPM

High residual gradients after surgical aortic valve replacement (SAVR) have been associated with decreased valve durability and the need for reoperations, decreased long-term survival, and an increased incidence of readmissions for congestive heart failure (CHF).[1-4] When faced with a patient with an aortic root that will result in severe PPM if a stented bioprosthetic valve is inserted, the surgeon can elect to use a homograft, a stentless xenograft, or a sutureless valve. However, the implantation of these prostheses can be technically more demanding, are not always available, are more expensive, and may require a full root replacement, a procedure with a higher operative mortality than the insertion of a stented bioprosthesis. The simplest and most reproducible technique to insert a larger bioprosthesis and avoid PPM is to perform an aortic root enlargement (ARE). This can be done by extending the aortotomy incision through the annulus at the base of the noncoronary sinus (Nick's procedure),[5] which allows for the implantation of a prosthesis that is 2 mm larger, or by continuing the incision toward the centre of the fibrous trigone of the anterior mitral leaflet (Manougian procedure),[6] which increases the prosthesis size by 4 mm. In both techniques, a tear-shaped patch (usually bovine pericardium) is sutured to the base of the widened annulus, the valve is anchored directly to the patch that forms the new annulus in this expanded area, and the rest of the patch is incorporated into the aortotomy closure. A recent review of the STS database of isolated aortic valve replacements (AVRs) from 2004 to 2014 found that the incidence of PPM had decreased from 13.8% to 6.2% and only 11% were severe.[7] However, compared with patients with no PPM, the risk of mortality over 10 years was 8% higher with moderate PPM and 32% higher with severe PPM. Patients with either moderate or severe PPM had decreased long-term survival, increased admissions for CHF, and an increased incidence of reoperations for structural valve deterioration. Patients aged < 75 years and those with a body mass index > 30 kg/m^2 had the greatest risk. Despite these increased risks for adverse events, only 3.2% of patients with PPM underwent an ARE at the time of AVR.

Why Are Surgeons Reluctant to Perform an ARE for PPM?

There are 3 reasons why surgeons are reluctant to perform an ARE for PPM: (1) ARE increases cross-clamp times from 10 to 20 minutes and bypass times from 20 to 30 minutes. This may result in increased morbidity and mortality for higher risk patients and those in whom concomitant procedures are also necessary, such as valve and coronary artery bypass graft surgery. (2) There is concern for increased bleeding, especially in patients with a calcified or fibrotic annulus. If bleeding occurs at the base of the patch in the annulus, visualization of the bleeding site may be impossible without re-establishing bypass and in some cases, rearresting the heart. (3) Controversy exists as to whether ARE actually improves short- or long-term outcomes. Dhareshwar et al.[8] found that adding an ARE to isolated AVRs was safe and negated the increased mortality that was observed in patients receiving a 19-mm or 21-mm prosthesis without an ARE. Kitamura et al.[9] found a decrease in operative mortality in patients in a 19-mm prosthesis who received an ARE and

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Corresponding author: Dr Harold L. Lazar, 80 East Concord Street, Boston, Massachusetts 02118, USA. Tel.: +1-617-833-0452.

E-mail: harold.l.lazar@gmail.com

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significantly increased freedom from recurrent CHF and improved long-term survival. However, Kulic et al.[10] found that although ARE significantly decreased postoperative PPM, it did not result in any difference in operative mortality and did not improve long-term survival or freedom from recurrent CHF.

In this issue of the *Canadian Journal of Cardiology*, Yu et al.[11] report that the addition of an ARE to SAVR does not significantly increase operative mortality, the incidence of bleeding, a myocardial infarction, or the need for a permanent pacemaker despite adding an additional 14 minutes of cardioplegic arrest and 20 minutes of cardiopulmonary bypass. They feel that these outcomes support the increased use of ARE during SAVR to facilitate valve-in-valve transcatheter aortic valve replacement (V-in-V TAVR). V-in-V TAVR results in residual gradients that are related to the size of the original surgical prosthesis. Patients in whom a V-in-V TAVR procedure is performed for a #19-mm SAVR have significantly higher in-hospital mortality, increased morbidity, and higher residual gradients.[12] The conclusions reached by Yu et al. were derived from 9 observational studies; only 5 provided long-term outcome data. Not all of the studies had a complete data set; outcomes for late mortality were based on only 25% of the study population. No data were available regarding the incidence of left ventricular (LV) fibrosis or hypertrophy and whether there was actual regression of LV mass after ARE. Long-term echo data were not reported to determine whether the initial decline in PPM was maintained in patients undergoing an ARE. It would be wrong to conclude from this meta-analysis that ARE should be performed in all patients with PPM to improve outcomes for a future V-in-V TAVR. Why is there so much conflicting data regarding ARE for SAVR, who are the patients who will benefit from ARE, and in whom should it be avoided? Unfortunately, these questions cannot be answered by the study from Yu et al. However, there are data from the literature to guide us in answering these questions.

Factors Influencing the Outcomes After ARE for PPM

One of the reasons for the conflicting data on the benefits of ARE is that the definition of ARE varies amongst the studies. In some studies, it includes all patients with an EOA < 0.85 cm^2/m^2; in others, just < 0.65 cm^2/m^2. Some defined PPM as the inability to insert a 19-mm prosthesis, whereas others included both 19-mm and 21-mm prostheses. Most importantly, the vast majority of studies did not include long-term echo data to determine whether the decrease in EOA persisted over time and whether it was associated with LV mass regression and decreased LV hypertrophy. Existing and persistent changes in the LV myocardium, such as fibrosis and massive hypertrophy, may be responsible for the diastolic dysfunction seen in patients with PPM and small aortic roots. Therefore, placing a larger prosthesis in these patients may not improve survival or reduce episodes of CHF, especially in those older patients in whom these irreversible changes already exist. In addition, LV afterload may also play an important role in postoperative PPM and reverse LV remodelling. Ito et al.[13] found that in patients undergoing an AVR with 19-mm and 21-mm pericardial bioprostheses, in addition to EOA, valvuloarterial impedence, an echocardiographic-derived measure of global LV afterload, may also play an important role in PPM. Studies in TAVR patients have found that failure to reduce LV afterload, as assessed by valvuloarterial impedence, increases long-term mortality.[14] Postoperative antihypertensive therapy after SAVR enhances LV mass regression and may be just as important as ARE in enhancing long-term survival in patients with PPM.[15,16]

The potential benefits and disadvantages for ARE in SAVR have been best documented by the surgeons from the University of Toronto. In 1997, they reported their initial experience with ARE in 98 patients undergoing an AVR with the Hancock II bioprosthesis.[17] Compared with non-ARE patients, cross-clamp time was increased by an average of 11 minutes. ARE was associated with an increase in operative mortality (7.1% vs 3.5%; $P = 0.10$) and an increased rate of reoperation for bleeding (10.2% vs 6.7%; $P = 0.23$). In 2007, this same group of surgeons compared their earlier ARE outcomes from 1995 to 2000 (group I) to their most recent series from 2001 to 2005 (group II).[18] Operative mortality was significantly decreased from 7.2% (group I) to 2.9 % (group II); $P = 0.01$. Group II patients had significantly less concomitant mitral and tricuspid procedures, although 50% of group II patients still had a concomitant procedure. There was no difference in mortality between patients with an ARE and those without an ARE in group II (3.3% ARE vs 2.9% no ARE; $P = 0.5$). However, patients with an ARE in 2001-2005 had significantly less angina, CHF, chronic obstructive pulmonary disease, reoperations, mitral valve disease, and an New York Heart Association (NYHA) class of 3 or 4. The authors felt that increased comfort and experience with the ARE technique was responsible for the improved outcomes. However, the technique of ARE remained the same, but clearly the comorbidities of their patients had decreased giving credence to the adage that "good patients make good surgeons." The authors concluded that "ARE should be used judiciously in selected patients most likely to derive maximal benefit." Recently, the Toronto group reported their latest series on ARE.[19] From 1990 to 2014, 26% of the 7039 AVRs underwent an ARE. In the entire series, operative mortality was increased in the patients with an ARE (4.3% vs 3.0%; $P = 0.008$). However, in those patients undergoing only an isolated AVR, there was no difference in operative mortality (1.7% ARE vs 1.1% no ARE; $P = 0.28$). On multivariable analysis, ARE was not found to be associated with increased operative mortality. This experienced, highly talented group of surgeons concluded that "ARE is best performed in active, young patients with a high body surface area who may ultimately require a V-in-V TAVR."

Inclusion/Exclusion Criteria for ARE for PPM

Is ARE safe and should it be performed in all patients to eliminate PPM? Younger patients (< 70 years) undergoing an isolated AVR, with minimal comorbidities and a life expectancy > 10 years, in whom their aortic annulus would not allow the implantation of a prosthesis with an EOA > 0.65 cm^2/m^2, stand to benefit the most from an ARE. This is a Class IB recommendation from the 2013 aortic valve and ascending aortic guidelines.[20] Patients in whom an ARE is more likely to increase perioperative morbidity and mortality,

and less likely to improve long-term survival or freedom from CHF include: (1) older patients (> 75 years), (2) any patient with a calcified or extremely fibrotic aortic annulus in whom the risk of bleeding is significantly increased, (3) patients with multiple comorbidities who are not likely to live > 10 years and therefore outlive their bioprosthesis, and (4) those patients undergoing an AVR with other concomitant procedures in whom an ARE will significantly increase cross-clamp and bypass times contributing to increased perioperative morbidity and mortality.

Future Directions

Finally, the issue of PPM after SAVR may ultimately be a moot point. If ongoing studies in low-risk patients demonstrate that TAVR is equivalent or superior to SAVR, cardiologists will be more likely to refer asymptomatic aortic stenosis patients with high gradients for a TAVR before they develop massive hypertrophy and fibrosis. PPM will less likely be an issue in these patients because a TAVR prosthesis invariably results in a higher EOA compared with a surgical stented bioprosthesis.

Disclosures

The author has no conflicts of interest to disclose.

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