EDITORIAL

Preoperative Selection of Patients for Aortic Valve Repair

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Although aortic valve repair has been performed since the early days of cardiac surgery, there has been a renewed interest in this type of procedure thanks to the development of aortic valve sparing operations and a better understanding of the functional anatomy of the aortic root. In addition, the introduction of transesophageal echocardiography (TEE) facilitated the identification of potential candidates for operations designed to preserve the native aortic valve and allowed assessment of aortic valve function soon after discontinuation of cardiopulmonary bypass in the operating room. Indeed, TEE is the best diagnostic tool to study the mechanism of aortic insufficiency (AI) and the morphology of the aortic root. Each component of the aortic root must be carefully interrogated, in particular the aortic cusps. The number of cusps, their thickness, the appearance of the free margins, and the excursion of each cusp during the cardiac cycle must be examined in multiple views. Cusps' coaptation level within the aortic root as well as cusps' coaptation length is also important information pre- and postoperatively. The direction and size of regurgitant jets should be recorded in multiple views. The coaptation lines should be examined by color Doppler imaging. In addition, information regarding the morphologic features of the aortic annulus, aortic sinuses, sinotubular junction, and ascending aorta should be obtained by TEE.

The concept that AI can occur in patients with normal aortic cusps is not new and was first described by Corrigan in 1832 in an article titled "Permanent patency of the mouth of the aorta" in which he described dilatation of the sinotubular junction as a cause of AI in patients with normal aortic cusps.[1] In 1986 Frater[2] reported on 5 cases in which the AI was abolished by correcting the dilated sinotubular junction. However, chronic ascending aorta aneurysms and dilated sinotubular junction may cause elongation of the free margin of one or more aortic cusps.[3] In addition, stress fenestrations may appear in the commissural areas of the cusps because of excessive stretch. Simple adjustment of the diameter of the sinotubular junction will result in cusp prolapse and persistent or new jet of AI. Preoperative recognition of this potential problem by TEE is difficult and the result of the procedure will depend largely on the surgeon's ability of recognize cusp prolapse during the reconstruction of the aortic root. If one or more cusps prolapse after adjusting the diameter of the sinotubular junction, their free margins can be shortened by plication of its central portion along the nodule of Arantius, or by weaving a double layer of a fine Gore-Tex (W.L. Gore & Associates, Langstaff, AZ, USA), without adverse effect on the durability of the repair.[3,4] We reserve the use of Gore-Tex to reinforce the free margin of cusps with stress fenestration.[4]

The transverse diameter of the aortic annulus in men with normal aortic valves ranges from 20.7 (2.4) mm to 24.8 (1.8) mm for body surface areas of 1.51 to 2.60 m^2 respectively.[5] It is approximately 10% smaller in women.[5] These measurements were carried out in aortic valve homograft with Hegar dilators.[5] In TEE study[6] on 32 patients with normal aortic valves with a mean age of 54 years and body surface area of 1.92 (0.21) m^2, the aortic annulus diameter was 21 (3) mm and did not change during the cardiac cycle. Since the diameter of the aortic annulus is a function of the patient's body surface area,[5] the definition of dilatation of the aortic annulus has to take into account the size and gender of the patient. To make matters more complicated, patients with aortic root aneurysm and those with congenital bicuspid aortic valves and isolated AI often have cusps larger than normal. Thus, since the diameter of the aortic orifice is a function of the size of the cusps, patients with larger cusps will have larger aortic annulus, which probably should be considered normal.

Dilatation of the aortic annulus or annulo-aortic ectasia can also cause AI with normal cusps. However, when the aortic annulus is really dilated

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the free margins of one or more cusps are frequently elongated and the mechanism of AI is more complicated than simple outward displacement of the nadir of the cusps. We have learned that in annulo-aortic ectasia the sub-commissural triangles are flattened with consequent reduction in the heights of the commissures. Since annulo-aortic ectasia is a connective tissue disorder, flattening of the sub-commissural triangles is more evident beneath the commissures of the non-coronary cusp because this cusp is attached entirely in fibrous tissue. Gross annulo-aortic ectasia is easily recognized by TEE, particularly with incompetent bicuspid aortic valves, but subtle dilations are more difficult to recognize because of the relationship with cusp size. It may be even difficult for the surgeon, and here again, experience plays an important role in the decision making on the type of procedure and what needs to be done to correct the anatomic abnormality of the annulus as well as of the aortic cusps. Patients with dilated aortic annulus require reduction of the diameter of the aortic annulus either by a sub-annular Dacron band or reimplantaton of the aortic valve inside a cylindrical structure as it is done.[7] The purpose of either technique is to increase the height of the sub-commissural triangles and reduce the lengths of their bases. This maneuver increases cusps coaptation. After surgical correction of the dilated annulus, one or more cusps may prolapse because of the relatively long free margin for the newly created aortic orifice. Shortening of free margin of one or more cusps is often necessary during aortic valve sparing operations. In a consecutive series of 220 patients with aortic root aneurysm who had aortic valve sparing operations, prolapse of one or more cusps was surgically evident in 80 patients (36%) and correction was accomplished by plication of the central portion of the cusps along the nodule of Arantius and/or with fine Gore-Tex sutures along the free margin.[8]

Isolated dilatation of the aortic sinuses does not cause AI.[9] That is the reason children with congenital aortic sinus aneurysm or even ruptured aortic sinus aneurysm into the right atrium or right ventricle have entire competent aortic valve. However, the presence of aortic sinuses in semilunar valves reduces the velocity of opening and closure of the cusps[10] and this may translate in longer durability of the reconstructive procedure but we could not demonstrate any effect during the first year of follow-up following aortic valve sparing operations.[8]

Finally, abnormal aortic cusps are the most common cause of aortic valve dysfunction. TEE is an excellent tool to interrogate the anatomy and function of the cusps. Cusp repair by means of shortening of its free margin by plication of the central portion or by weaving a double layer of a fine Gore-Tex suture has been shown to be effective and durable procedures.[4,8] Cusp extension or segmental replacement of one or more cusps with glutaraldehyde-fixed autologous or bovine pericardial patches expands the feasibility of aortic valve repair to patients with more advanced disease of the cusps.[11,12] The long term results of these techniques remain largely unknown and they will have to provide equal or better results than those obtained with aortic valve replacement with bioprosthetic or biological valves to be justifiable.

In this issue of *Revista Española de Cardiología*, Gallego García de Vinuesa and colleagues[13] published a study whereby they reviewed the TEE of 66 patients with aortic insufficiency equal or greater than grade 2 and made correlations with the surgical findings and operative procedures performed. "Three anatomical forms of dilated aorta were described" by the surgeon: ascending aorta aneurysm, aortic root aneurysm, and annulo-aortic ectasia. Isolated ascending aorta aneurysm without dilatation of the sinotubular junction does not cause "functional" AI. Another mechanism was at play if AI was present. Similarly, isolated dilatation of the aortic sinuses does not cause AI either, unless the cusps are abnormal. The arbitrary surgical definition of annulo-aortic ectasia based on annulus diameter >25 mm is not supported by the current knowledge of functional anatomy of the aortic root as discussed above. The surgical definitions of "absolute" and "relative" prolapse is probably related to the concept described above, i.e. a cusp may appear normal when examined in a dilated root but it will prolapse when the diameter of the sinotubular junction is corrected and the inter-commissural distance is reduced. The observation that TEE was able to predict "reparability" of the aortic valve in a high proportion of patients is consistent with our experience. However, if the AI is truly "functional" (normal cusps) the probability of aortic valve sparing operation should be close to 100%. TEE was predictive of aortic valve replacement in 90% of patients with thickened and calcified cusps and up to 100% in perforated cusps in Gallego García de Vinuesa's study.[13] We agree that patients with advanced disease of the cusps should have aortic valve replacement, but there is an increasing number of surgical reports describing various techniques of reconstruction of these valves by adding patches of glutaraldehyde-fixed pericardium.[11,12]

TEE remains an indispensable diagnostic tool to clinicians and surgeons who care for patients with heart valve diseases, particularly when valve repair is contemplated. As shown in Gallego García de Vinuesa's study, it is highly accurate in assessing aortic root morphology and the mechanism of AI. One of remaining problems in the preoperative assessment of patients with aortic root aneurysm with

or without AI is the presence of stress fenestrations, which are often not detected by echocardiography. Three-dimensional echocardiography may improve the accuracy in detecting this cusp abnormality in the future. TEE is also indispensable in the operating theatre during performance of reconstructive heart valve procedures. In addition to assess valve function after discontinuation of cardiopulmonary bypass, echocardiography is useful in predicting the durability of the reconstructive aortic valve repair.[14,15] Low level of cusps coaptation and short coaptation lengths (<4 mm) are predictive of recurrent AI after aortic valve reconstructive procedures.[14,15]

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