Masters of Cardiothoracic Surgery

Isolated aortic valve repair—how to do it and long-term results: suture annuloplasty

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Introduction

Today, isolated repair of the regurgitant aortic valve is an increasingly accepted alternative to replacement. Since its first description more than 2 decades ago (1), marked progress in understanding of normal function and configuration of aortic valve and root has been made. Different predictors for repair failure have been identified, such as dilatation of the basal ring (2,3), in particular in bicuspid aortic valve (BAV) repair (2). This was supported by experimental studies focusing on the interrelation of annular diameter and valve competence (4).

In addition, the definition of the aortic annulus is inconsistent and anatomically challenging. There is a discrepancy between the anatomic aortoventricular junction, that is, the transition of ventricular myocardium and aortic wall, and the virtual basal ring at the level of nadirs of the sinuses (5). A high aortoventricular junction with myocardium extending into the sinus is a frequent finding in the presence of a BAV, but is also found in unicuspid (UAV) and tricuspid aortic valves (TAV). From a surgical perspective the basal ring should be considered as the aortic annulus and should be addressed by any annuloplasty device.

We have applied a suture annuloplasty (6) at the level of the basal in ring in addition to isolated aortic valve repair over the last 10 years.

Surgical technique

Preparation

The patient is placed in supine position under general anesthesia. Preoperative transesophageal echocardiography (TEE) reveals annular dilatation. The short axis view allows for identification of valve morphology and possible cusp calcification whereas aortic root dimensions are determined in long axis view. In the presence of preserved root dimensions (sinus <42–45 mm) isolated valve repair is pursued.

Exposure

The chest is opened via a median sternotomy. After longitudinal incision of the pericardium, extracorporeal circulation is established by aortic and right atrial cannulation.

Operative technique

After cross-clamping, the aorta is opened transversally 5 to 10 mm above the sinotubular junction and blood cardioplegia is given directly into the coronary ostia. Stay sutures are placed through the commissures and fixed to the patient's chest wall maintaining the valve's circumferential orientation. Subsequently, aortic valve morphology is carefully studied as well as the structural integrity of the cusps. Endocarditic perforations, cusp retraction, excessive fibrosis and calcification need to be taken into account for evaluation of repair stability. In addition, congenital fenestrations may be present. They do not necessarily need to be addressed during repair unless they are involved in the mechanism of cusp prolapse.

Systematic cusp assessment is essential for successful prolapse correction and repair stability. Initially, geometric height (gH) (7) is measured evaluating adequate substrates for repair. A gH of more than 18 mm in TAVs and at least 20 mm in BAVs generally allows for valve preservation. Subsequently, effective height (eH) (8) is measured objectifying the degree of cusp prolapse (eH <9–10 mm). In BAV repair, both measurements are only done in the non-fused cusp.

The diameter of the basal ring is evaluated by direct intubation with graded Hegar dilators. In our experience it is usually 3 to 4 mm larger compared to the dimensions measured by TEE.

Annuloplasty

Prior to cusp repair, a suture annuloplasty (6) is added whenever the basal ring exceeds 26 to 27 mm. First, a plane is developed between pulmonary trunk and aorta and left atrial tissue is mobilized outside the noncoronary sinus. To ensure integrity of the circumflex artery, a tunnel is created between the left main coronary artery and aortic sinus wall by blunt dissection. This is important, especially in patients with a short left main coronary artery which is a frequent finding in the presence of a BAV.

A strong expanded polytetrafluorethylene (PTFE) suture (Gore-Tex CV-0; WL Gore and Associates, Munich, Germany) is placed through septal myocardium outside the right/left commissure. Subsequently, the posterior arm of the suture is passed through the tunnel created previously underneath the left main coronary artery. The anterior arm is inserted through connective tissue outside the nadir of the right coronary sinus and finally, both arms are placed through connective tissue outside the nadir of the noncoronary sinus. The annuloplasty is finally tied around a graded Hegar dilator according to body surface area (<1.8 m^2: 21 mm, 1.8–2.0 m^2: 23 mm, >2.0 m^2: 25 mm).

Cusp repair

Once the annuloplasty is completed, correction of cusp prolapse is performed according to the techniques described previously (9,10). It can mostly be done by plication of the central part of the cusp carrying the lowest diastolic stress. Cusp plication is pursued until an eH of 9 to 10 mm in all cusps is ensured by repeated measurement and visual comparison of the cusps.

If calcification or dense fibrosis requires partial cusp resection it is done in triangular fashion with subsequent readaptation. Whenever the created tissue defect does not allow for direct closure a pericardial patch is used for partial cusp replacement. Autologous pericardium is harvested, placed under tension and fixed in glutaraldehyde (1.5% for 3 minutes, followed by rinsing in normal saline for 3 minutes). Subsequently, the patch is trimmed and inserted into the tissue defect using continuous polypropylene sutures (Prolene 5-0 or 6-0, Ehicon, Hamburg, Germany). If necessary, pericardial patches are also used for closure of defects or fenestrations.

Completion

Once adequate valve configuration is established the aorta is closed in two layers, the heart is de-aired and the cross-clamp removed. Assessment of aortic valve function by TEE is most efficient at this point of the procedure due to the low left ventricular diastolic pressure. If valve competence is ensured by TEE weaning from extracorporeal circulation is pursued and the procedure is finished in usual fashion.

Comment

The first attempts of aortic valve repair had already been made in the 1950s and 1960s. Despite the fact that those procedures were limited to a small and selected group of patients, some of them (11) already addressed annular dilatation supposedly causative for valve failure. In the early 1990s, Cosgrove and colleagues described their initial experience with isolated repair of the regurgitant aortic valve with promising short-term stability (1,12).

While valve analysis initially only consisted of visual assessment of cusp prolapse, today we rely on a more sophisticated analysis of valve configuration and dysfunction. The introduction of the eH concept (8) has allowed for objective analysis of cusp prolapse and subsequent correction. Additionally, systematic valve assessment was supported by data on normal tissue height, that is, gH (7), identifying adequate substrates for repair.

Throughout longer follow-ups, deteriorating stability of isolated aortic valve repair has been observed, especially after BAV repair (2). This has prompted us and others to identify predictors of failure. Annular dilatation has been found to be one of the strongest predictors both in BAV (2) and TAV (3) repair. This goes along with experimental data describing the interrelation of basal ring diameter and valve competence (4).

In 1966, subcommissural plication for annular stabilization had already been proposed (13). In more recent studies, it was not only shown to lead to insufficient stabilization (2,3). Moreover, its negative impact on repair stability has been described (2). We have made similar observations in UAV repair.

Different annuloplasty concepts have been described with either internal or external application. We feel that an external device is most likely superior because of better stress distribution and avoidance of interference with the aortic valve cusps. Of the external devices, different rings have been employed (14,15). In the presence of a high aortoventricular junction the implantation of an external ring may be difficult and might lead to anatomic distortion or would require deep circumferential dissection (15).

Ten years ago, we started applying a suture annuloplasty inspired by the technique proposed by Taylor *et al.* (11) and addressing the basal ring independent of the location of the aortoventricular junction (6). Initially, a braided polyester suture had been used and the annuloplasty was inserted from the inside of the aortic root. Due to local complications (i.e., occlusion of the circumflex artery), erosion of the membranous septum and complete atrioventricular (av)-block, the material was switched to PTFE providing less local trauma. In addition, the annuloplasty was furthermore applied from the outside only allowing more surgical precision and avoidance of anatomic interferences. Since then, no ventricular septal defect or av-block has occurred. Interference with the circumflex artery was not observed in the last 500 patients.

In a first study focusing on BAV repair, a trend towards improved repair stability could be described after the addition of suture annuloplasty (16). Moreover, we illustrated a higher amount of completely competent aortic valves postoperatively (16). With longer follow-up and in a larger patient population we finally found an impressively improved valve stability after BAV repair (17). After PTFE annuloplasty, a freedom from reoperation of more than 95% could be achieved. This stability continues until today both for BAV and TAV repair.

Conclusions

Isolated aortic valve repair leads to excellent stability if done with respect to all components of aortic valve and root. Stepwise correction of pathologic alterations needs to be performed according to systematic analysis. Correction of basal dilatation using a suture annuloplasty has drastically improved the stability of isolated BAV repair with a very low incidence of related complications.

Acknowledgments

None.

Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

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