Successful valve-sparing in aortic root reconstruction under endoscopic guidance

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Received 8 September 1999; received in revised form 28 December 1999; accepted 11 January 2000

Abstract

Objective: Aortic insufficiency (AI) associated with ascending aneurysm can be corrected by valve-sparing aortic root reconstruction (‘David’ reimplantation, ‘Yacoub’ remodeling). Intraoperative endoscopic evaluation in the aortic root may help to clarify the procedure and to access competence of the preserved valve.

Methods: Following cross-clamping of the ascending aorta, an endoscopy was inserted into the proximal aortic root. Perfusion of crystalloid cardioplegia enabled the visualization of the pressure-loaded valve in the closed position. Conventional macroscopic evaluation would have overlooked valve prolapse because of a release from perfusion pressure. Valve coaptation was imaged directly before and after the valve-sparing procedure. A total of 17 patients underwent aortic root reconstruction under endoscopic guidance. Indications of the valve-sparing were determined with endoscopic findings. The degree of AI before and after the surgery was evaluated by aortography and scored (0, none; 1 trivial; 2, mild; 3, moderate; 4, severe).

Results: Remodeling was employed to eight patients and reimplantation to four. The other five patients were replaced with prosthetic valved-conduit. There was no early and late mortality. Before and after the valve-sparing surgery, grades of AI were significantly reduced. Three patients who underwent reimplantation procedure required late valve replacement for late progression of AI, however, none of the patients with remodeling required reoperation.

Conclusion: Introduction of an endoscopy successfully reduced postoperative AI and clarified indications and limitations of valve-sparing aortic root operations. © 2000 Elsevier Science B.V. All rights reserved.

Keywords: Aortic insufficiency; Valve-sparing; Ascending aneurysm; Endoscopy

1. Introduction

It is apparent that in some patients who have ascending aneurysm and aortic annular dilatation, aortic insufficiency can be surgically corrected while preserving native aortic valve. There are two procedures to spare the native aortic valve. A procedure described by David and Feindel [1] excises the aortic sinuses and reimplants the skeletonized aortic root into the vascular graft; this is termed ‘reimplantation’. Another procedure proposed by Sarsam and Yacoub [2] restores the normal geometry of the root using a scallop shaped vascular graft; this is termed ‘remodeling’. Both procedures require sophisticated techniques with precise understanding of the aortic root geometry.

The following questions were raised. (1) Is macroscopic evaluation reliable for intraoperative assessment of the native and preserved valve? (2) How can postoperative AI be minimized? These questions have motivated us to introduce aortic root endoscopy into valve-sparing root reconstructive surgery. It avoids the technical pitfalls associated with relying on macroscopic evaluation. After aortotomy, the valves are unloaded and released from perfusion pressure, thus coaptation is easily manipulated and it becomes easy to overlook prolapsed and stretched valve, thus overestimating the feasibility of valve-sparing. A reliable measure is required for accurate inspection of the native and preserved valve. Since April 1995, we have introduced the intraoperative endoscopic evaluation into all cases who needed aortic root reconstruction. The results of our experiences with aortic root endoscopy are reported.

2. Patients and methods

procedures were performed by a single surgeon, a senior author (T.I.). All patients had ascending aneurysmal dilatation (mean diameter 65 ± 14 mm). The underlying pathology was acute aortic dissection in one patient and chronic aneurysm in the others. Clinical manifestations of Marfan’s syndrome were present in three (17.6%) patients. In all patients, aortography was performed to evaluate the degree of aortic regurgitation before and after the surgery; this was assessed semiquantitatively as follows: 0, none; 1, trivial; 2, mild; 3, moderate; 4, severe. Intraoperatively, transesophageal echography (TEE) was performed to assess perioperative changes of AI in every case. Follow-up was carried out clinically and with transthoracic echography every 6 months after surgery. The cumulative follow-up period was 272 months with minimum of 3.2 months and a maximum of 47.3 months (mean ± SD = 23 ± 14 months).

Methods of intraoperative endoscopic observation were previously described [3]. Immediately after cross-clamping of distal ascending aorta, an endoscopy (Fujinon Video Laparoscope Systems, Fujinon, Saitama, Japan) was inserted into the aortic root. With perfusion pressure of crystalloid cardioplegia, the aortic valve is pressure-loaded and directly imaged. The final decision to preserve native aortic valve was determined based on endoscopic findings. Even in cases with severe AI it was possible to distend the aortic root by adjusting flow of cardiopulmonary bypass. By decreasing atrial pump flow and increasing venous drainage, the left ventricle was collapsed so that the proximal aorta was easily distended under perfusion pressure of crystalloid.

Fig. 1. Preoperative aortography and an intraoperative endoscopic finding in a representative case who had severe AI.

Fig. 2. Coaptation of valves with minor prolapse at non-coronary cusp was improved by performing remodeling; (left) before remodeling, (right) after remodeling, (arrow) site of valve prolapse. Minor prolapse is not a contraindication of valve-sparing operations.
cardioplegia. Venting of the left ventricular is necessary to prevent its over-distension. Aortography and endoscopic images in a representative case are shown in Fig. 1.

2.1. Statistical analysis

Continuous variables are expressed as mean ± one standard deviation (SD), actuarial data are reported as mean probability estimates. The statistical significance of differences in AI between preoperative and postoperative aortography was tested using a paired Student’s t-test. A P-value of <0.05 was considered significant.

2.2. Surgical technique and endoscopic evaluation

The procedure performed in this series included remodeling, reimplantation and valved-conduit replacement (graft-exclusion technique). Myocardial protection was employed as antegrade and retrograde cold blood cardioplegia following the initial endoscopic inspection. The technique used for aortic root reimplantation into a tubular graft was similar to that described by David [1]. The diameter of the conduit was determined according to the formula suggested by David [1]. The technique used for remodeling of the aortic root using a scalloped graft was similar to that described by Sarsam and Yacoub [2]. The size of the graft used for remodeling was the same as the diameter of the left ventricular outflow. Then the graft was sutured to the aortic rim using continuous 4-0 polypropylene suture. After the valve-sparing procedure, when lack of valve coaptation appeared significant, additional valve repair of the Trusler stitch [4] was performed to improve coaptation and then endoscopic observation was repeated. Trusler stitch was carried out by placing a pledgetted mattress suture at the elongated free margin of the prolapsed leaflet close to the commissure, so that the free margin of both the prolapsed and normal leaflet was positioned at the same level. When the endoscopy found severe malcoaptation of the preserved valve, the procedure was intraoperatively converted to valved-conduit replacement. The mean diameter of graft used for valve-sparing procedure was 27.3 ± 0.3 mm. The Bentall procedure was performed by the graft-exclusion technique with mechanical valved-conduit. In all patients, reanastomosis of coronary ostia was carried out in button fashion reinforced with a doughnut-shaped felt pledget.

3. Results

Of all 17 patients, five patients underwent valve-conduit replacement and in the other 12 patients the native aortic valve was successfully preserved. No patient died in hospital or during follow-up. Intraoperative variables are presented in Table 1. With endoscopic assessment, immediately after aortic cross-clamping, valve-sparing operations were considered feasible and were attempted in 13 patients. However, one patient who had Marfan’s syndrome was intraoperatively converted to valved-conduit replacement, because valve coaptation after remodeling was not satisfactory from the endoscopic images. Therefore, in 12 patients native valves were eventually preserved. Four patients underwent ‘reimplantation’ and eight patients ‘remodeling’. Choice of valve-sparing technique (remodeling or reimplan-

![Fig. 3. Changes in degree of AI before and after valve-sparing (n = 12).](image-url)
tation) was altered during the course of the study, based on the surgeon’s decision, which was not in a randomized fashion.

Endoscopic findings of the preserved valve included central malcoaptation, symmetrical leaflets and absence of severe calcification. The presence of minor prolapse or slight thickening of leaflet edge was not a contraindication of valve-sparing (Fig. 2). In patients who preserved the aortic valve (n = 12), grade of AI was reduced significantly from 3.3 ± 0.7 preoperatively to 0.6 ± 0.7 postoperatively (P < 0.0001) (Fig. 3). The endoscopic findings of patients who had to replace the valves included bicuspid AI (n = 2), bicuspid stenosis and regurgitation (n = 1) and severe leaflet elongation (n = 3) and severe prolapse (n = 3). All of the bicuspid valves in this series were asymmetric and severely prolapsed, therefore valve-sparing was considered inappropriate. Endoscopic findings of preserved valves predicted the degree of postoperative AI, and were correlated with those obtained from TEE.

A representative case who underwent remodeling is presented. The maximum diameter of the ascending aorta was 80 mm and the size of the aortic annulus was 28 mm. Initial assessment of aortic valve demonstrated a central lack of coaptation without severe valve prolapse, thus indicating valve-sparing. After remodeling, endoscopy identified distorted valve configuration, and then additional repair of Trusler stitch was performed. Improved coaptation was confirmed with repeated endoscopic evaluation (Fig. 4). Postoperative angiography in this patient showed no AI (grade 0).

In all patients with remodeling, aortic valve function remained stable during follow-up with no (n = 3), trivial (n = 5) and mild (n = 1) AI. No patients who underwent remodeling required reoperation. On the other hand, three patients who underwent reimplantation procedure developed progressive AI during follow-up periods and eventually were reoperated on 17, 24, 24 months (grade III) after the surgery. In these three patients at the time of the initial operation, it was noted that the native valve had moderately prolapsed and elongated and that after reimplantation distortion of the leaf-

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Fig. 4. Endoscopic findings suggested the need for additional intraoperative repair of Trusler stitch. Improved coaptation of preserved valves was confirmed by repeated endoscopic evaluation; (left) before additional repair, (right) after, (arrow) site of resuspension.

Fig. 5. Endoscopic images of early valve failure after performing reimplantation. Lacerations of the free margin of the right coronary cusp accounted for severe AI in both patients.
lets in a tubular vascular graft was observed by endoscopy in spite of improved coaptation. Postoperative aortography showed trivial to mild AI in these three patients which became severe during the follow-up. At the reoperations, the valve became thickened and retracted with morphological changes of hyaline and myxoid degeneration in one patient as previously reported [5]. In the other two patients, lacerations of the free margin of the right-coronary cusp were found on the endoscopic image (Fig. 5). Mechanical valve replacement was performed within the Dacron prosthesis in the patients without difficulties. All patients recovered from the second operation.

4. Discussion

Valve-sparing aortic root reconstruction offers many advantages over prosthetic valved-conduit replacement. It is expected that valve-sparing operations enable the reduction of late valve-related complications and superior hemodynamics to the other valve substitutes. However, the indications and limitations of valve-sparing operations remain unclear. The degree of postoperative AI depends on both valve morphology and surgical technique. The valve-sparing operations required sophisticated techniques with precise understanding of aortic root geometry. Usually, intraoperative valve inspection was carried out with macroscopic evaluation. After aortotomy, the native aortic valves become unloaded from perfusion pressure, thus the presence of severe valve prolapse or elongation could be overlooked. Another reliable measure of intraoperative valve inspection is needed to cope with individual anatomical diversity.

With the aid of aortic root endoscopy, intraoperative assessment of the aortic valve becomes more accurate. Perfusion pressure of crystalloid cardioplegic solution into the root simulates a pressure-loading environment of the aortic root. Endoscopic evaluation has many advantages over TEE, which must require declamping of the ascending aorta and weaning from the cardiopulmonary bypass. Before declamping the aorta, evaluation of preserved valve coaptation would not be feasible with TEE. TEE provides only cross-sectional images, which are inferior to direct images for intraoperative assessment of valve coaptation. In patients with acute aortic dissection who need root reconstruction, the valves should be normal enough to be preserved. Valve-sparing in acute dissection can be theoretically advantageous because it avoids permanent administration of the anticoagulants that may influence late patency of the dissected lumen. Endoscopy was applicable to the limited patient with acute aortic dissection (n = 1), only when intraoperative direct aortic echo confirmed the location of the intimal tear at the distal ascending aorta. Aortic cross-clamping must be placed proximal to the intimal tear to prevent infusion of crystalloid cardioplegia into dissected aortic lumen.

Endoscopy demonstrated complicated etiology of AI associated with ascending aortic and root aneurysm. It includes dilatation of sinotubular junction, minor to major prolapse, leaflet asymmetry and elongation, and combinations of these. Patients who have normal leaflet are scarce. Endoscopic images provide valuable information of how to recreate normal root geometry, which may lead to better durability of the preserved valve. When etiology of AI in a patient is multifactorial, valve replacement rather than valve-sparing is indicated. The repeated endoscopic evaluation may suggest the need for additional repair and the evaluation of its effect on valve competence, which may lead to better function of the preserved valve. When coaptation of the preserved valve is not satisfactory, the decision to convert the procedure to the Bentall operation can be quickly made during aortic cross-clamping.

Early and mid-term results of remodeling and reimplantation have been encouraging [6–8]. Yacoub et al. [9] achieved excellent long-term results from remodeling operations over 15 years, in which the actuarial survival at 10 years of 68 patients with Marfan’s syndrome was 81.9%, demonstrating a rationale of indications of valve-sparing to Marfan’s syndrome. On the other hand, several investigators [5,10] suggested early valve failure after reimplantation and remodeling. The long-term follow-up is mandatory after valve-sparing operations to identify the factors associated with late repair failure. Experimental endoscopic investigation of the beating heart model may help to elucidate functional implications of preserved valves [11]. Any residual AI greater than grade II soon after the surgery can be a major risk factor for repair durability. Accurate intraoperative assessment under pressure loading condition is important for reduction of persistent aortic regurgitation.

In conclusion, aortic endoscopy in valve-sparing aortic surgery enables one to observe directly aortic valves under perfusion pressure. Endoscopic assessment helps to judge if the valves can be preserved and to evaluate the competence of the preserved valve. Minor prolapse is not a contraindication for valve preservation. The technique allows surgeons to perform appropriate adjustment of valve coaptation, and to determine the necessity of conversion of the procedure, particularly before decamping of the aorta, which would not be feasible with TEE. By minimizing early postoperative AI, aortic root endoscopy may improve the long-term results of valve-sparing operations.

References

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Appendix A. Conference discussion

Dr K. Zehr (Rochester, MN, USA): Very elegant pictures concerning root reconstruction. You showed that this is a nice descriptive way of looking at the valve. Does this add anything to your ability to make decisions and affect what you are doing intraoperatively? I believe that surgeons who do these procedures, do them based on what they are comfortable with, be it the remodeling or the reimplantation technique, and not necessarily do one procedure for one type of value pathology and one for another. Does this endoscopic way of analyzing the root allow you to choose a superior technique for each individual patient.

Dr Ohtsubo: Your question is selection?

Dr Zehr: I am wondering whether this endoscopic evaluation provides you any ability to make clinical decisions concerning your operation?

Dr Ohtsubo: Whether reimplantation or remodeling?

Dr Zehr: Exactly, or just do a Bentall.

Dr Ohtsubo: That is the significance of this study. We think, as we have shown in the slide, remodeling creates more physiologic geometry which appears like a Mercedes-Benz sign, however, most of the patients we encounter in this majority of patients with ascending aneurysm have large sinuses. We found if the patient has a bigger size of aortic sinuses, the morphology of the valve has been more progressed. I think determination of whether repair or replacement is based on detecting valve morphology, which is highly associated with the large size of aortic sinuses. I think our indication of replacement is of very large aortic sinuses with severe elongation and severe prolapse of the valve.

Dr Zehr: Don’t you feel that you can make these decisions by intraoperative transesophageal echocardiography and not by endoscopy?

Dr Ohtsubo: I think transesophageal echo is a very strong tool for assessing the valve, however, TEE requires a cardiac beat. During cardiac arrest, TEE is not useful, it is not available. Also, we think macroscopic evaluation is disadvantageous because of unloading from perfusion pressure.

Particularly, intraoperative assessment is very important in this technique. If you overlook the presence of severe prolapse, the result is miserable. So I think we need a pressure-loading condition for assessment of the valve. TEE is not a useful intraoperative assessment during cardiac arrest.

Dr F. Wellens (Aalst, Belgium): Your reimplantation technique, the David operation, was somewhat disappointing in the Marfan patient. Did you use also a kind of reduction annuloplasty in order to reduce the annulus in these patients?

Dr Ohtsubo: No. Actually the three patients who underwent a reimplantation procedure includes only one Marfan syndrome, however, we didn’t perform annular reduction. The annulus size was less than 30 mm in these patients. So we decided it is not necessary to perform annular reduction.

Dr Wellens: There is always some discussion in younger patients about what to do with a bicuspid valve. Do you have any experience and can you give any opinion about using the valvesparing operation in patients with an Aortic bicuspid valve?

Dr Ohtsubo: In this study three patients have a bicuspid valve, but what we found with endoscopic evaluation in these cases, is that the bicuspid valve is always asymmetric, has a severe prolapse, and we consider it an inappropriate case for preserving the valve. But I understand this is a very small volume of the patients, and if we gather the patient volume, we may find some very good candidates for valve preservation with a bicuspid valve. But so far we have not found a good candidate with a bicuspid valve.

Dr H. Borst (Munich, Germany): I think your point was very well made that it is quite easy to correct minor asymmetries of the free margin of valves. That is also our experience. One certainly should not resort to a Bentall if one sees a chance of correcting a minor asymmetry and leakage. Do you find it that more frequent in the reimplantation or in the remodeling, that you have to do a little additional surgery?

Dr Ohtsubo: I think in our case we have conducted additional valve repair in two patients which were both Trusler stitches. I think if you employ the reimplantation procedure, valve coaptation itself is complete and there should be no regurgitation, but in the remodeling procedure, we consider that more beautiful geometry can be created. I think the reimplantation procedure may have more frequently valve distortion, so then intraoperative additional valve repair should be performed more in the reimplantation procedure.

Dr. Borst: I agree with that. Our experience has been that in reimplantation this is somewhat more frequent because it is not so easy to achieve perfect symmetry of the valve within a tube graft instead of replacing of sinuses.

Dr Wellens: Did you use this technique in controlling valve repair after acute Type A dissection, sticking this through the prosthesis, for example? Do you use this technique after acute dissection?

Dr Ohtsubo: I think it is applicable and very useful, and we experienced only one case.

Dr S. Moray (Cairo, Egypt): I would like to know the rate of failure of aortic repair and how many needed reoperation.

Dr Ohtsubo: Out of 12 patients who preserved native aortic valve, we have experienced three late progressions of aortic regurgitation. So all of them were replaced with mechanical valves.

Dr. Moray: This is how much in percent?

Dr. Ohtsubo: Twenty-five percent.