Pericardial patch augmentation for repair of incompetent bicuspid aortic valves at midterm

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Abstract

Objective: Reoperation rates after repair of bicuspid aortic valves are higher than for mitral valve reconstruction. Satisfactory results have been reported for patch augmentation for tricuspid aortic valves. We have applied this technique for the repair of bicuspid aortic valves.

Methods: Autologous pericardium is sutured to the free edge of the prolapsing bicuspid leaflet. A large coaptation surface is created and competence of the bicuspid valve is achieved. Forty patients underwent reconstruction of their bicuspid aortic valves by pericardial patch augmentation. Patients were followed up at regular intervals by echocardiography in yearly intervals.

Results: There were no perioperative deaths. One year postoperatively, one patient died due to endocarditis. Seven patients (17.5%) had aortic regurgitation grade I, and the other 33 patients had non or trivial aortic regurgitation at discharge. At 4.2/3.6 ± 3.1 years postoperatively, only four patients (10%) had aortic regurgitation grade I. There were no cases of progression of regurgitation. Planimetric effective orifice areas ranged above 2 cm². Mean aortic gradients dropped from 8.2 ± 4.8 mmHg at discharge to 3.8 ± 3 at four years and the mean height of coaptation surface from 14.7 ± 2 mm to 12.3 ± 4, respectively.

Conclusions: The pericardial patch augmentation technique increases coaptation surface, and thus provides reliable early and midterm competence of reconstructed bicuspid aortic valves.

Keywords: Aortic; Valve; Repair; Midterm; Follow-up

1. Introduction

In 1991, Cosgrove and co-workers published their technique of valvuloplasty for bicuspid valve insufficiency, involving resection of the prolapsing leaflet, annular plication at the commissure and resection of a raphe when present [1]. The midterm follow-up data of this series, published in 1999 by Casselman et al., revealed that this technique was associated with a reoperation rate of 13%, with an additional 6% of patients retaining significant residual aortic regurgitation of grade III to IV [2].

Our own experiences with the Cosgrove technique confirmed that the intraoperative results were rarely predictable and that there is a high reoperation rate within the first postoperative year [3]. After this early critical phase the results of the reconstructed native aortic valves were astonishingly stable. This spurred us to continue focusing our attention on the reconstruction of bicuspid aortic valves, in an attempt to make the technique more reliable. This report documents our midterm experience, using the pericardial patch augmentation technique for the reconstruction of incompetent bicuspid aortic valves.

2. Methods

A total of 40 patients, out of 1200 aortic valve procedures, underwent reconstruction of their incompetent bicuspid aortic valves, using the pericardial patch augmentation technique, between November 2002 and February 2005. There were 33 male and seven female patients, with a mean age of 39.3 ± 13.6 years (range 17—62 years). In all patients aortic regurgitation was caused by leaflet prolapse confirmed by preoperative echocardiography and intraoperative inspection of the valve. Also a raphe of the fused rudimentary commissure was identified in all patients. Dilatation of the ascending aorta was present in all patients. None of patients had signs of endocarditis in the leaflets or the aortic root at the time of operation.

Indications for the procedure were incompetent bicuspid valves with only minor calcifications at the raphe or the free edge of the leaflets, which were amenable to leaflet shaving. Contraindications were patients with calcific aortic valve stenosis, dilatation of the aortic annulus and patients with Marfan syndrome.
3. Aortic valve reconstruction technique

Our technique of pericardial patch augmentation has been described previously [4]. In short, access to the heart was gained via a median sternotomy. We routinely used aortoatrial cannulation for extracorporeal circulation, antegrade and retrograde cold blood cardioplegia, CO₂ insufflation of the thorax and moderate hypothermia. The aortic valve was approached through a transverse aortotomy. After the placement of three stay sutures the bicuspid valve was examined. In all cases the prolapsing leaflet and a raphe were identified. Frequently secondary changes of the leaflets could be observed (n = 24). Thickening of the free edge of leaflets was shaved. The raphe was mobilised to its origin in the aortic wall and resected. Then a triangular resection of the fused leaflet was carried out in all patients to excise thickened tissue on the one hand and secondly to achieve a slight bulging of the native leaflet. To optimise cusp symmetry, a triangular resection of the prolapsing non-fused leaflet was then carried out when necessary (n = 8).

To obtain a greater area of leaflet coaptation, a strip of autologous glutaraldehyde fixed pericardium was used to enhance the free edge of the fused leaflet. Our experience taught us that the ideal length of the strip corresponds to half the circumference of the sinotubular junction. The height of the strip was adjusted according to the desired area of coaptation, but was left slightly higher than the native non-fused leaflet edge. The pericardial strip was sutured to the free edge of the reconstructed aortic leaflet using 5-0 Cardionyl (Cardionyl™, Peters Laboratories, Bobigny-Cedex, France) suture. The suture line was extended slightly beyond the height of the native commissures and to the contralateral side. This was done to achieve overlap and optimal coaptation at the commissures.

Annular plication was only performed in exceptional cases, when the commissures had severely drifted apart.

The concomitant dilatation of the ascending aorta was corrected by taking larger bites at the transverse aortotomy, thus achieving a reduction in diameter at the sinotubular junction. To treat the dilatation of the remaining ascending aorta, a longitudinal incision from the aortotomy to the aortic clamp was performed, additionally an elliptical portion of the aortic wall just proximal of the cross-clamp was resected. A reduction aortoplasty was then carried out with a double layered suture line using a 4-0 Prolene mattress suture and securing it with an additional 4-0 Prolene running suture.

4. Assessment of reconstruction

The success of aortic valve repair was assessed intraoperatively by transoesophageal echocardiography. Special attention was focused on leaflet motion, valve geometry, coaptation surface, transvalvular gradients, residual aortic regurgitation and effective orifice area. Additionally the dimensions of the aortic annulus, sinus of Valsalva, sinotubular junction and ascending aorta were noted. Trivial to mild residual aortic valve regurgitation was considered a successful repair. As none of the patients had moderate regurgitation or higher, reexploration of the aortic valve to improve the repair, was not necessary.

After discharge from hospital, patients were followed up by transthoracic echocardiograms at regular intervals.

5. Results

The mean follow-up was 4.2 ± 3.1 years. All but one patient were alive and well at follow-up (NYHA I). There were no perioperative deaths. One patient died within the first postoperative year. He developed endocarditis and subsequent acute cardiac failure. In all patients, attempted aortic valve reconstruction was successful, with none of the patients requiring intraoperative revision or postoperative reexploration of the reconstructed aortic valve. At latest follow-up, no reoperations occurred. There were also no cases of thromboembolism, bleeding complications or conduction disturbances.

The degree of aortic regurgitation was trivial at the most, as confirmed by intraoperative transoesophageal echocardiography and transthoracic echocardiography at discharge, in seven patients. At latest follow-up only four patients showed trivial regurgitation. All other valves were competent. During the postoperative follow-up period, we did not observe new aortic regurgitation or an increase in the degree of regurgitation. None of the valves were stenotic postoperatively. Planimetric effective orifice area was 2.8 ± 1 cm². The mean transvalvular gradients was 8.2 ± 4.8 mmHg at discharge and 3.8 ± 3 mmHg at four years and the mean height of coaptation surface from 14.7 ± 2 mm to 12.3 ± 4 mm, respectively. The mean postoperative ejection fraction was 54.8 ± 6%. The spherical belly shape of the aortic leaflets was restored and a large coaptation surface was achieved for all patients, as confirmed echocardiographically.

Results at discharge and four years are summarised in Table 1.

The early and late dimensions of the aortic root remained unchanged in all patients who underwent pericardial patch augmentation (aortic annulus: 25 ± 4 mm and 26 ± 3 mm respectively, sinus of Valsalva: 31 ± 4 mm and 31 ± 5 mm, respectively, sinotubular junction: 28 ± 3 mm and 29 ± 4 mm, respectively, ascending aorta: 27 ± 4 mm and 28 ± 3 mm, respectively).

Per protocol, patients were not anticoagulated postoperatively. In the course of follow-up, none of the patients

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Discharge (n = 40)</th>
<th>Four years (n = 39)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mortality</td>
<td>None</td>
<td>N = 1</td>
</tr>
<tr>
<td>Reoperation</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Endocarditis</td>
<td>None</td>
<td>N = 1</td>
</tr>
<tr>
<td>Conduction disturbance</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Aortic regurgitation grade 0</td>
<td>N = 33</td>
<td>N = 35</td>
</tr>
<tr>
<td>Aortic regurgitation grade 0−1</td>
<td>N = 7</td>
<td>N = 4</td>
</tr>
<tr>
<td>Aortic regurgitation grade &gt;1</td>
<td>N = 0</td>
<td>N = 0</td>
</tr>
<tr>
<td>Mean aortic gradient (mmHg)</td>
<td>8.2 ± 4.8</td>
<td>3.8 ± 3.3</td>
</tr>
<tr>
<td>Peak aortic gradient (mmHg)</td>
<td>10.9 ± 5.5</td>
<td>7.6 ± 5.5</td>
</tr>
<tr>
<td>Effective orifice area (cm²)</td>
<td>2.8 ± 0.67</td>
<td>2.8 ± 0.1</td>
</tr>
<tr>
<td>Planimetric orifice area (cm²)</td>
<td>3.7 ± 0.61</td>
<td>3.6 ± 0.1</td>
</tr>
<tr>
<td>Ejection fraction (%)</td>
<td>50.3 ± 7.1</td>
<td>54.8 ± 6</td>
</tr>
<tr>
<td>Height of coaptation surface (mm)</td>
<td>14.7 ± 2.1</td>
<td>12.3 ± 4</td>
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showed progression of aortic root dilatation postoperatively. Histologic evaluation of the ascending aorta did not show cases of Marfan syndrome, cystic media necrosis or Erdheim-Gsell disease.

6. Discussion

The bicuspid aortic root is characterised by a distinct asymmetry. The non-fused leaflet is usually greater in size than the fused leaflet. The base of the non-fused leaflet is often displaced downwards into the left ventricular outflow tract [3]. Often commissural distension occurs and in more than 50% of patients dilatation of the ascending aorta is present [5]. Successful repair of the bicuspid valve therefore needs to incorporate all of the above mentioned pathologies, so that a stable and reliable result is achieved. Due to the documented superiority of corrective surgery over replacement in atrioventricular valves there has been a renewed interest in the repair of aortic valves [6]. Bicuspid aortic valve disease is one of the main causes for isolated aortic regurgitation and occurs predominantly in young patients [7]. Biological prostheses in this age group are associated with suboptimal durability. Mechanical valves on the other hand, necessitate life long anticoagulation, with its associated thromboembolic and bleeding complications [8]. Therefore, repair remains an attractive alternative in this group of patients, given that mid- and long-term durability is acceptable.

Several techniques of aortic valve repair have been described [9]. In our own experience with the Cosgrove type repair of the aortic valve, a high rate of intraoperative conversions and early reoperations occurred [2,3]. In our own analysis, this sort of reconstruction results in a geometrically unfavourable shallow shape of the aortic leaflets. The characteristic belly shape, that is known to display an ideal stress distribution at the lowest tension of the cusps, is not achieved.

To improve our early and midterm results, we chose to augment the height of the fused cusp with autologous pericardium, commonly known as leaflet extension. With this technique the bicuspid morphology of the valve is retained, the free edge of the fused leaflet is enhanced and deliberate overcorrection significantly increases coaptation height and the belly shape of the fused leaflet is restored, thus providing optimal stress distribution. At the commissures an overlap can be created with the pericardial strip, thereby ensuring optimal coaptation and addressing the commissural separation.

Our midterm results show that this type of repair is associated with excellent midterm durability with no cases of late increase of regurgitation.

Preservation of the bicuspid nature of the valve may bear the risk of subsequent dilatation of the ascending aorta [10]. In our group of patients, aggressive aortoplasty of the ascending aorta was carried out, and no secondary dilatation of the ascending aorta or aortic root occurred.

In large clinical series, excellent early results were reported for bicuspid repair [2,9,11]. Midterm results however, show a significant rate of reoperations within the first five years. Apart from triangular cusp resection no specific risk factor for failure was identified. However, progression of aortic root dilatation may be an important mechanism for valve failure in the presence of bicuspid anatomy. Therefore root remodelling has been proposed for incompetent bicuspid aortic valves and concomitant aortic dilatation. Schäfers et al. report excellent 5–10-year data, showing the stability of remodelling in the presence of bicuspid aortic valves [11].

The principle of pericardial patch augmentation is overcorrection, which in turn results in an increased reliability and an operative outcome that is more predictable. The increased coaptation height can accommodate secondary dilatation of the aortic root and a certain degree of geometric mismatch. It therefore provides a more reliable repair.

Some authors have indicated that leaflet extension is associated with a higher degeneration rate of the repair. Haydar et al. describe that it is essential to trim the pericardial patches very precisely to avoid any excess tissue that causes fluttering of the pericardial extension [9]. They conclude that leaflet extension remains a palliative procedure, and aortic repair without the use of additional tissue is more likely to result in a durable cure. Our midterm results however, disprove this assumption, and we can say that excess tissue provides an additional margin of safety, that in turn leads to a more stable result.

In conclusion, midterm results of alternate forms of aortic repair still are not comparable to reconstructive surgery of the atrioventricular valves. We feel that our technique provides a step towards making aortic valve repair more durable.

References


Appendix A. Conference discussion

Dr M. Emara (Cairo, Egypt): Maybe the age of your patient is different than ours. We tried to use this because this was based on Al Halees’ work in Saudi
Arabia for the advancement of the free edge for the aorta, and our problem was the pericardium couldn’t withstand. Our patients were younger than yours definitely.

And I’m really astonished, how can the pericardium withstand the stress? Do you treat the pericardium with glutaraldehyde or use the native? Can you give me any point about that?

Dr H. Schafers (Homburg, Germany): So in other terms, details of the pericardium used.

Dr Emara: That’s it.

Dr Doss: Right. We have autologous pericardium, and we fix it with glutaraldehyde at 0.2%, and we fix it for about 10 min, and that will give us these results.

I mean, when this program was started, we also had doubts whether the pericardium would withstand. I mean, those questions are not really answered. And as you said, in the literature, pericardium has failed in this type of surgery.

But what we try to do is not to put pericardium at the highest stress points. Basically by recreating the belly shape of the leaflet, you reduce the stress, and perhaps that is the key why this pericardium could withstand.

Dr Schafers: Two short questions. You pointed out the difference between the almost 180 degrees type of bicuspid valve and the 120 degrees that has an almost tricuspid root. Did you do anything different to these types or were they all treated the same? That’s question number one.

Number two, I tried to calculate the linearised incidence of endocarditis. If one assumes the first case to be endocarditis, which you mentioned, we run at a linearised incidence of 2% per patient year, which is higher than commonly known for valve repair and even higher than known for valve replacement. Could you comment on that?

Dr Doss: Yes. On your first question whether it is a 180-degree or a 120-degree configuration of the bicuspid valve, it didn’t change the operative technique. So in the 180-degree technique, if you had calcifications or prolapse, that was resected same as in the 120-degree.

With regards to endocarditis, it’s just something that we found. As I said, in the first patient that actually died, the question was raised. We thought that might be an explanation why this patient would develop sudden heart failure. And in the second patient definitely endocarditis occurred.

I wouldn’t say that the pericardium per se is an additional risk for endocarditis, but I’ve seen in the literature that other groups have also described one or two cases of endocarditis in their series.

Dr A. Moritz (Frankfurt, Germany): Maybe this can answer your technique question. The point is that in fact it’s not really changed, the technique, whether there is a 120-degree or 180. The only difference is you have to adjust for the length of the patch. Because in one case, you’re exactly in the centre of the circle and the other you’re offset. That’s the only point, and you have to adjust for this. Otherwise, you get a wrong length of the free edge of the cusp.