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Aortic Valve–Sparing Repair with Autologous Pericardial Leaflet Extension Has Low Long-Term Mortality and Reoperation Rates in Children and Adults

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ABSTRACT

Objectives. We sought to establish whether there was a difference in outcome after aortic valve repair with autologous pericardial leaflet extension in pediatric and adult populations.

Methods. In our study, 128 patients (pediatric and adult) underwent valvular pericardial extension repair at our institution from 1997 through 2006. The patients were divided into either the pediatric group (≤18 years of age; n = 54/128, 42%), with a mean age of 8.4 ± 5.4 (range, 0-17 years), or the adult group (n = 74/128, 58%), with a mean age of 48.9 ± 19.7 (range, 19-85 years). The endpoints of the study were mortality and reoperation rates.

Results. Thirty-day mortality for the adult group was 0, and for the pediatric group it was 1/54 (1.8%), with no statistical difference ($P = .1$) between the groups. Late mortality for the pediatric group was 2/54 (3.7%) and in the adult group was 2/74 (2.7%). There was no statistical difference ($P = .12$) between the groups. In the pediatric group, there were 6 total reoperations (6/54) in 5 patients, with one patient undergoing reoperation twice. From these 6 cases, 3 were re-repair and 3 had aortic valve replacement; the mean interval between original repair and reoperation was 4.3 ± 2.5 years (range, 0.1-7.7 years). In the adult group, there were 5 total reoperations (5/74). From these 5 cases, 3 had aortic valve replacement and 2 re-repair; the mean interval between original repair and reoperation was 3.5 ± 3 years (range, 0.1-7 years). There was no statistical difference in the reoperation rate between the 2 groups ($P = .38$). At late follow-up, 82% of all patients in the adult group had no aortic regurgitation or only a trace (grades 0 and 1) and 78% of all patients in the pediatric group had no aortic regurgitation or only a trace (grades 0 and 1). There was no statistical difference in either aortic regurgitation ($P = .06$) or aortic stenosis ($P = .28$) between the 2 groups.

Conclusions. Aortic valve repair with autologous pericardial leaflet extension has low mortality and morbidity rates, as well as good mid-term durability in both the pediatric and the adult groups.

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INTRODUCTION

The ideal surgical approach to the diseased aortic valve depends on etiology, morphology (stenosis, regurgitation, or both), patient's age, and other factors. Duran described in 1988 a technique to repair the aortic valve using leaflet extension with pericardium previously treated with glutaraldehyde solution. The pericardium is then used to increase the height of the leaflets and commissures, thus creating an additional area of coaptation. During the last decade, various studies had been done to elucidate the long-term durability of this technique [Duran 1988, 1995a, 1995b, 1995c; Grinda 2002; Bozbuga 2004; Odim 2005]. We sought to contribute to this effort with this study.

PATIENTS AND METHODS

Between January 1997 and June 2006, 128 patients underwent reparative aortic valve surgery at the University of California, Los Angeles. Clinical, operative, and outcome data were collected retrospectively. We have published [Duran 1995] the results of a short-term follow-up in patients who had pericardial leaflet extension for congenital valvular disease. In the current study, we report on 66 additional patients that underwent aortic valve repair in the last three years. We now have follow-up data on 95% of the patients. We also now report findings in both pediatric and adult patients. Our cohort was divided into 2 subgroups depending on the patient's age: the pediatric group (54/128 patients, 42%), with a mean age of 8.4 ± 5.4 years (range, 0-17 years), and the adult group (74/128 patients, 58%), with a mean age of 48.9 ± 19.7 years (range, 19-85 years) (Table).

The diagnoses in the pediatric group were bicuspid valve (27/54, 52%), neonatal truncus arteriosus (3/43, 7%), Shone's complex (2/43, 4.6%), transposition of the great

Patient Demographics

	Pediatric Group	Adult Group	*P*
n	54/128 (42%)	74/128 (58%)	.61
Age, y	8.4 ± 5.4 (range, 0-17)	48.9 ± 19.7 (range, 19-85)	.5
Male/female	49/25	35/19	.5

vessels (2/43, 4.6%), hypoplastic left heart syndrome (1/43, 2.3%), tetralogy of Fallot (1/43, 2.3%), double-chambered ventricle (1/43, 2.3%), Marfan's syndrome (1/43, 2.3%), ventricular septal defect (8/43, 18.6%), which was subdivided as supracristal (3/8), perimembranous (2/8), subarterial (1/8), restrictive (1/8), and effect of valve traction by the sutures (1/8), subaortic stenosis (3/43, 10%), restrictive/deficient (1/43, 2.3%), and dilatation/annular (1/43, 2.3%). The diagnoses in the adult group were bicuspid valve (11/74, 15%), subaortic stenosis (4/74, 5%), dilatation of the annulus (25/74, 32%), redundant leaflet (5/75, 7%), restrictive/deficient (25/74, 34%), rheumatic heart disease (1/74, 1%), and endocarditis (3/74, 4%). Combined procedures included mitral valve repair (11/74, 14%), tricuspid valve repairs (2/74, 3%), coronary revascularization (5/74, 7%), aortic aneurysm wrap (3/74, 4%), aortic aneurysm surgery (15/74, 20%), and ventricular septal defect closure (4/74, 5%).

The decision for the reparative technique with autologous pericardial leaflet extension rather than replacement was made after an informed consent process with the patient or the family or both, who ultimately decided in favor of aortic valve repair. The endpoints of the study were mortality and reoperation rates. The Institutional Review Board at the University of California, Los Angeles, approved this study.

Surgical Technique

Surgery was performed under general endotracheal anesthesia with the patient in the supine position. After heparinization, the vessels were cannulated and the patient was connected to extracorporeal circulation and the blood was cooled to 24°C. The aorta was cross clamped and the heart was arrested with cold blood cardioplegia. The ascending aorta was opened obliquely, and the aortic valve was exposed. Pericardial patches were harvested from under the sternum and treated with glutaraldehyde for 9 minutes. For clinical use, the University of California, Los Angeles, Medical Center pharmaceutical technology laboratory locally prepared the glutaraldehyde solution under aseptic conditions by ultrafiltration and tested the solution for sterility by culturing before use. The preparation constitutes sterile glutaraldehyde 0.625% with a phosphate buffer (pH 7.4) and fluorescein 0.02% formulation. To shape the pericardial patches in the appropriate fashion, the width of each of these patches was 15% greater than the diameter of the aorta. The reduction in the pericardial leaflet free-edge width from a purse-stringing effect with a running polypropylene suture necessitates the 15% additional length. The height of the pericardial leaflet was measured to bring the extensions just below the sinotubular junction where all extended cusps may naturally coapt in the center of the aorta. The attachments were then extended up to the wall of the aorta, thus creating commissures to provide coaptation of the leaflets approximately 4 to 5 mm from the edge of the valve commissures. The leaflets were then trimmed and attached at the proximal portion with through-and-through sutures through the aortic wall that were then passed through external pledgets and tied. The valve leaflets were assessed to assure coaptation. The incision was extended down to the annulus to slightly enlarge the ascending aorta to prevent narrowing due to the extra valve tissue. After the patient was weaned from bypass, a transesophageal echocardiogram was done to confirm aortic valve competency and evaluate and ventricular function (Figure 1). Most of the time, the congenitally bicuspid valve was converted to a natural trileaflet configuration using autologous pericardial leaflet extensions.

Anticoagulation

Patients were placed on aspirin 100 mg daily. None of the patients were anticoagulated.

Follow-up

Follow-up echocardiograms and medical records were obtained in 121 of 128 patients (95%), 71/74 patients (96%) in the adult group and 50/54 patients (94%) in the pediatric group. The mean follow-up period was 2.5 ± 2 years (range, 0-7.7 years postoperatively) for the adult group and 3.5 ± 2.5 years (range, 0-7.9 years) for the pediatric group.

Statistical Method

We used nonparametric statistics to study the intra- and inter-group variation. All statistical results were obtained using the Statistics Online Computational Resource (www.SOCR.ucla.edu) [Dinov 2006] and the Stattucino Logistic Regression applet (www.stattucino.com). To assess

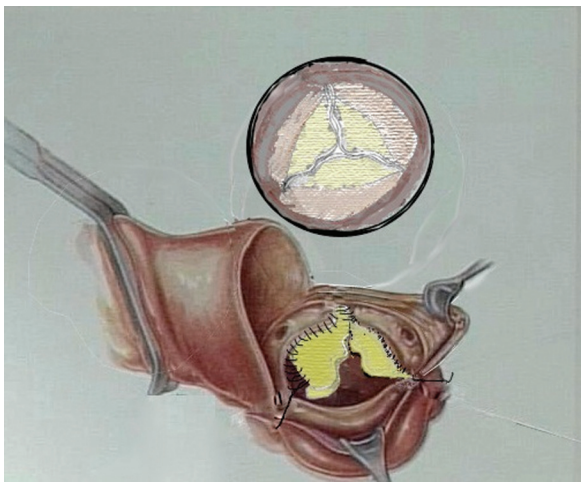

Figure 1. Glutaraldehyde-treated pericardium is fashioned into correct shapes. The pericardial leaflet is sutured to the edge of the native leaflet using a running suture. Attachments were extended up to the wall of the aorta, creating commissures to provide cusp cooptation of the leaflet approximately 4 to 5 mm from the edge of the valve. Aortic valve leaflets were now coaptated with each other.

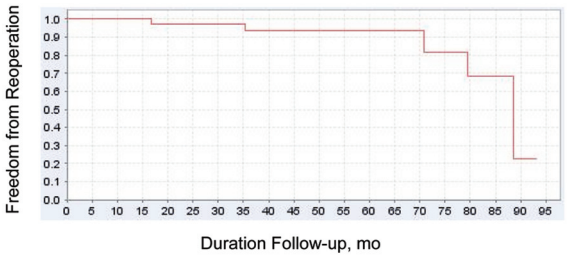

Figure 2. Freedom from reoperation in the pediatric group.

differences in proportion we again used a distribution-free test, the Binomial test for proportions.

RESULTS

Early Mortality

Early mortality was defined as death occurring within 30 days of the valve surgery; there was no statistical difference ($P = .1$) between the groups.

In the adult group, the early mortality rate was 0/74; for the pediatric group, it was 1/54 (1.8%), the early mortality occurred in a 2.5-year-old boy with critical bicuspid aortic stenosis. The preoperative echocardiogram showed a peak gradient of 89 mmHg and a mean gradient of 36 mmHg, with a left ventricular ejection fraction of 64%. He underwent aortic valve repair with aortic valve leaflet extension and creation of a trileaflet valve. Intraoperative transesophageal echocardiography confirmed a competent aortic valve, and no complications were detected during the first postoperative day. Later on, the echocardiography study demonstrated a tricuspid aortic valve with minimal aortic regurgitation and mild stenosis. The peak and mean aortic gradients were 28 and 15 mmHg, respectively. On postoperative day 4, the patient had a cardiopulmonary arrest caused by feeding aspiration. Resuscitation and extracorporeal membrane oxygenation support were established. The patient succumbed with a diagnosis of severe anoxic brain injury and multiorgan failure. A postmortem examination confirmed intact reconstruction of the aortic valve, diffuse cerebral edema, and multiorgan ischemia.

Late Mortality

The total late mortality for the pediatric group was 2/54 (3.7%), with no statistical difference between the groups ($P = .12$). The first case was reported as a cardiac arrest of unexplained etiology. The other case was during the follow-up of the present study, and there is no information about the cause of death. In the adult group, the late mortality was 2/74 (2.7%). Both late deaths occurred at home and there was no autopsy or further medical information.

Reoperation

Aortic valve related. In the pediatric group, there were 6 (6/54, 11%) total reoperations in 5 patients, with one patient undergoing reoperation twice. From these 6 cases, 3 were re-repair and 3 had aortic valve replacement. The first case was a 1-year-old patient, diagnosed with truncus arteriosus that required re-repair one year after the first surgery because of a severe aortic stenosis (grade 4). A second re-repair was required 2 years later because of moderate aortic insufficiency (grade 2 and 3). A second patient with a diagnosis of truncus arteriosus underwent re-repair because of a moderate aortic valve insufficiency and stenosis. The remaining 3 patients with an initial diagnosis of bicuspid valve underwent aortic valve replacement because of narrowing of the ascending aorta. In the pediatric group, the mean interval between original repair and first reoperation was 4.3 ± 2.5 years (range, 0.1-7.7 years) (Figure 2).

In the adult group, there were 5 total reoperations (5/74, 6.7%). From these 5 cases, 3 underwent aortic valve replacement and 2 re-repair. One patient with an initial diagnosis of bicuspid valve underwent replacement 4 years after the first operation because of the narrowing of the ascending aorta. Four patients needed reoperation because of dilatation of the aortic sinuses and sinotubular junction; all 4 patients had an initial diagnosis of restrictive/deficient aortic valve. In the adult group, the mean interval between original repair and reoperation was 3.5 ± 3 years (range, 0.1-7 years) (Figure 3).

There was no statistical difference in the reoperation rate between the 2 groups ($P = .38$).

Non–aortic valve related. There were 5 non–valve-related reoperations in the pediatric group at a mean interval between valve repair and non–valve-related reoperation of 1 ± 2 months (range, 0.1-4 months). Two patients underwent reoperation for postoperative bleeding, 2 patients with respiratory failure that required extracorporeal membrane oxygenation and one patient for wound debridement after sternal infections.

In the adult group, there was one case of non–valve-related reoperation because of postoperative bleeding. The interval between the operations was 0.2 months.

No valve thrombosis, thromboembolism, neurologic events, or renal failure were observed.

Valve Function

In the pediatric group, preoperative aortic regurgitations by echocardiogram were 3.4±0.5, with 79% of the patients presenting with severity grades of 3 and 4. The mean severity grade of postoperative aortic regurgitation was 0.45. At late follow-up, 78% of all patients had no aortic regurgitation or only a trace (grades 0 and 1). Nine patients (18%) had mild aortic regurgitation (grade 2), 2 patients (4%) had moderate aortic regurgitation, and none severe (grade 4). Ninety-two

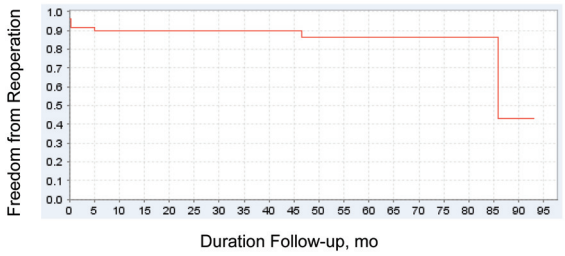

Figure 3. Freedom from reoperation in the adult group.

percent of the cohort had no or mild preoperative aortic stenosis, 4 patients had moderate aortic stenosis, and none had severe aortic stenosis. At late follow-up, 98% of the patients had no aortic stenosis and one patient had mild aortic stenosis.

In the adult group, preoperative aortic regurgitations by echocardiogram were 3.2 ± 0.1 with 84% of the patients presenting with severity grades of 3 and 4. The mean severity grade of postoperative aortic regurgitation was 0.32. At late follow-up, 82% of all patients had no aortic regurgitation or only a trace (grades 0 and 1). Four patients (5.6%) had mild aortic regurgitation (grade 2), 3 patients (4.2%) had moderate aortic regurgitation, and none severe (grade 4). Ninety-three percent of the cohort had no or mild preoperative aortic stenosis, 5 patients had moderate aortic stenosis, and none had severe aortic stenosis.

There was no statistical difference in either aortic regurgitation ($P = .06$) or aortic stenosis ($P = .28$) between the 2 groups. Classification was accomplished using the 2006 ACC/AHA Guidelines for the management of patients with valvular heart disease

DISCUSSION

Aortic valve repair is a slowly evolving technique that can delay and sometimes avoid limitations of other surgical techniques like biological constraints of growing children, pregnancy, tissue antigenicity, calcium metabolism, and bleeding and thromboembolic complications caused by synthetic valve substitutes, prosthesis-patient mismatch, calcification, and degeneration that might influence the long-term durability [Sade 1988; Bradley 1997].

The ideal material for the leaflet extension remains unclear. Previous studies with autologous and bovine pericardium [Dahm 1990] have been done. Duran et al [Duran 1998, 1995a, 1995b, 1995c] described the use of autologous pericardium to increase the height of the leaflets and commissures, thus creating an additional area of coaptation. In 2002, Grinda et al reported an actuarial survival at 5 years of 96%, and 92% were free of reoperation; their cohort consisted of 89 patients and was affected with rheumatic disease. In 2004, Bozbuga et al reported on 46 patients (mean age, 32 years) with an actuarial survival of 98% ± 2% at 8.6 years, but with a high reoperation rate (20%). The explanation for the high reoperation rate was rheumatic disease as the main etiology in their cohort. Long-term durability of this technique is becoming clearer. In 2005, Halees et al reported on 92 patients (mean age, 30 years) with an overall reoperation-free survival of 47% ± 6% at 16 years. In the same year, Odim et al reported on 62 patients (mean age, 25 ± 20 years) with good mid-term results with 2-year freedom from valve-related reoperation; for patients with congenital heart disease this was 92%, and for pediatric patients ≤18 years of age this freedom from valve-related reoperation was 100% at 2 years.

The pericardium, previously treated with glutaraldehyde solution, provides the resistance to retraction and degeneration and maintains the intrinsic tissue pliability. Immunologic responses need to be elucidated [Odim 2005].

This technique demonstrates good long-term survival and low reoperation rate in both the pediatric and adult group. Our experience showed improvement in both aortic regurgitation and stenosis in the long-term follow-up when using aortic valve repair with autologous pericardial leaflet extension in severe defective congenital diseased valves. This procedure can delay until a much later and mature date potentially significant complications in the growing child that may arise when using alternative strategies like pulmonary autograft, prosthetic valve, and allograft.

There are some limitations in this nonrandom and retrospective study. Since our institute functions as a referral center and the patients are only followed-up by the primary physician, identification of all the etiologies of late mortality is unworkable.

Multivariate analysis is not applicable when comparing the adult and pediatric groups since the primary etiologies are heterogeneous. This issue may impact long-term results.

In conclusion, aortic valve repair with autologous pericardial leaflet extension has low mortality and morbidity rates, as well as good mid-term durability in both the pediatric and adult groups.

REFERENCES

Bradley SM, Sade RM, Crawford FA. 1997. Anticoagulation in children with mechanical valve prostheses. Ann Thorac Surg 64:30-6.

Bozbuga N, Erentug V, Kirali K, Akinci E, Isik O, Yakut C. 2004. Midterm results of aortic valve repair with the pericardial cusp extension technique in rheumatic valve disease. Ann Thorac Surg 77:1272-6.

Dahm M, Lyman WD, Factor SM, Frater RW. 1990. Immunogenicity of glutaraldehyde-tanned bovine pericardium. J Thorac Cardiovasc Surg 99:1082-90.

Duran CM, Alonso J, Gaite L, et al. 1988. Long term results of conservative repair of rheumatic aortic valve insufficiency. Eur J Cardiothorac Surg 2:217-23.

Duran C, Gometza B, Kuma N, Gallo R, Bjonastad K. 1995. From aortic cusp extension to valve replacement with stentless pericardium. Ann Thorac Surg 60:S428-32.

Duran CMG, Gometza B, Kuma N. 1995. Aortic valve replacement with freehand autologous pericardium. J Thorac Cardiovasc Surg 110:511-6.

Duran C, Gometza B, Kuma N, Gallo R, Bjonastad K. 1995. Treated bovine and autologous pericardium: surgical technique. J Cardiac Surg 10:1-9.

Grinda JM, Latremouille C, Berrebi A, et al. 2002. Aortic cusp extension valvuloplasty for rheumatic aortic valve disease: midterm results. Ann Thorac Surg 74:438-43.

Halees Z, Shahid M, Sanei A, Sallehudin, Duran C. 2005. Up to 16 years follow-up of aortic reconstruction with pericardium: a stentless readily available cheap valve? Eur J Cardiothorac Surg 28:200-5.

Dinov I. 2006. SOCR: Statistics Online Computational Resource: socr.ucla.edu, Statistical Computing & Graphics 17:11-5.

Odim J, Laks H, Allada V, Child J, Wilson S, Gjertson D. 2005. Results of aortic valve sparing and restoration with autologous pericardial leaflet extension in congenital heart disease. Ann Thorac Surg 80:647-54.

Robbins RC, Bowman FO, Malm JR. 1988. Cardiac valve replacement in children: a twenty-year series. Ann Thorac Surg 45:56-61.

Sade RM, Crawford FA, Fyfe DA, Ginn G. 1988. Valves prostheses in children: a reassessment of anticoagulation. J Thorac Cardiovasc Surg 95:553-61.