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Long-Term Results of Pericardial Autologous Patch Enlargement of the Aortic Annulus Using the Manouguian Technique

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ABSTRACT

Background: The management of a small aortic root at the time of aortic valve replacement is controversial. In cases in which the aortic root is very small the choice of aortic valve type and of root-enlargement method is difficult. The technical challenge of the small aortic root has instigated the creation of methods for annular enlargement. Severe mismatch as a predictor of overall 30-day mortality or midterm mortality reports about long-term results of aortic valve replacement using autologous pericardial patch are scarce. Moreover, no reports about patient series are present in the English medical literature. This retrospective study was designed to address this gap in evidence.

Methods: Twenty consecutive patients undergoing aortic valve replacement (with or without mitral valve replacement and/or coronary artery bypass grafting) at Başkent University Adana Medical Center between June 30, 1999 and April 10, 2006 were retrospectively evaluated. All clinical and echocardiographical data belonging to this population were specified. Their perioperational data were assessed.

Results: Twenty patients operated using the Manouguian technique for narrow aortic root from June 1999 to April 2006 were followed for 8.54 ± 3.35 years. Fourteen patients were alive at the end of the follow-up. Six patients had died. Early mortality rate was 5% and late mortality after 8.54 ± 3.35 years was 30%. Late mortality related to cardiac reasons was 5%. Only one death could be attributed to a cardiac cause which occured in a 36-year-old male patient 3 years and 6 months after the operation. 70% of the patients were alive after a mean follow-up period of 8.54 ± 3.35 years.

Conclusion: The main finding of the present study is that aortic root enlargement using untreated fresh autologous pericardium in Manouguian type operations is a durable option, especially in conditions when homograft or stentless valve use is difficult or economically not feasible. We found that no patient had aneurysmal dilatation or mitral regurgitation after a mean follow-up of 8.54 ± 3.35 years with autologous untreated pericardium as the enlargement patch.

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INTRODUCTION

The management of a small aortic root at the time of AVR (aortic valve replacement) has been discussed in cardiac surgery for decades and still remains contentious [Zhong 2010].

It is not uncommon for patients with aortic stenosis who require valve replacement to have a small aortic annulus precluding an appropriate size prosthetic valve insertion, especially in women. Implantation of a small valve prosthesis in the aortic annulus will result in high transvalvular gradients, which will further increase during exercise and may predispose to thrombosis, hemolysis, or bleeding complications [Ardal 2006; Eghtesady 2002; Pibarot 2006]. Therefore aortic valve replacement with a small prosthetic valve can cause persisting or increasing left ventricular hypertrophy and dysfunction, and shortened long-term survival [Ardal 2006]. Patients with PPM are likely candidates for a possibly risky future reoperation [Vural 2014].

The mortality and morbidity of isolated aortic valve replacement is low [Rao 2000]. In cases in which the aortic root is very small the choice of aortic valve type and of root-enlargement method is difficult. Despite careful preoperative planning unexpected challenges do occur. The technical challenge of the small aortic root has instigated the creation of methods for annular enlargement including the Konno, the Nicks, the Nuñez, and the Manouguian techniques. Nicks, Nuñez, and Manouguian techniques involve posterior aortic root enlargements; the Konno method is in fact aortoventriculoplasty [Losenno 2013]. The Nicks procedure offers only one-size larger prosthesis because in this method the enlargement incision cannot be extended across the mitral annulus, whereas in the Manouguian technique this is possible. We preferred the Manouguian technique because it offers at least 1 to 2 sizes of upsizing and has favorable long-term results in the literature [Zhong 2010].

Severe mismatch is a predictor of overall 30-day mortality or midterm mortality independent from the presence of poor ejection fraction [Urso 2009]. Patient-prosthesis mismatch (PPM) is present when the effective orifice area of the inserted prosthetic valve is too small in relation to body size [Pibarot 2006]. PPM is common (20-70% of aortic valve replacements). Its pertinent hemodynamic consequence is to generate higher than expected gradients across functioning prosthetic valves [Pibarot 2006]. Rahimtoola was the first to describe PPM in 1978 [Rahimtoola 1978]. Rahimtoola emphasized that this is a type of obstruction to ventricular outflow and/or inflow with significant clinical implications

[Rahimtoola 1978]. In such patients even a small amount of additional tissue ingrowth or thrombus is likely to produce critical stenosis, which may ocur suddenly, causing acute deterioration in cardiac hemodynamics. As Rahimtoola and many others have pointed out, this may account for some instances of prosthetic valve thrombosis and sudden death [Rahimtoola 1978; Pibarot 2006; Rao 2000].

In a series of 2154 patients Rao et al reported a statistically significant higher 30-day mortality in patients with PPM [Rao 2000]. Moreover Tully et al also reported a discrete mortality risk attributable to moderate and severe PPM in elderly patients and in those with impaired left ventricular ejection fraction [Tully 2013]. As Mothy et al noted, moderate PPM is associated with increased late mortality in patients with left ventricular dysfunction [Mothy 2009].

Therefore it is a primary task of the surgeon to avoid PPM. The surgeon usually has a limited time in assessing options for the small aortic root, especially when the aorta has already been opened and the patient is on cardiopulmonary bypass (CPB).

In the literature there has been some reports about late outcomes of aortic valve replacement with Manouguian type of posterior root enlargement performed using prosthetic material, mainly Dacron [Zhong 2010; Hashimoto 2006]. However, reports about long-term results of aortic valve replacement using autologous pericardial patch are scarce. Moreover, no detailed reports about this particular aspect exist in the English medical literature. This retrospective study was designed to address this gap in evidence.

MATERIALS AND METHODS

Patient Selection

Twenty consecutive patients undergoing aortic valve replacement (with or without mitral valve replacement and/or coronary artery bypass grafting) at Başkent University Adana Medical Center between June 30, 1999 and April 10, 2006 were retrospectively evaluated (Table 1). All clinical and echocardiographical data belonging to this population were specified. Their perioperational data were assessed (Table 2). Fifteen of the patients were women (75%), a fact in accordance with results shared in the literature.

The follow-up of this report was terminated on March 15, 2013. The mean follow-up was 8.54 ± 3.35 years (range, 0.085-13.75 years). Echocardiography was performed preoperatively, at the time of hospital discharge, and at 6 months and annually postoperatively.

Table 1. Demographic and Preoperative Data*

Patient	Age	Sex	Weight, kg	Height, cm	DM	HT	Date of operation	Pathology	Aortic Root, mm
ES	17	M	64,5	165	0	0	12.11.2003	AS	2.0
HT	44	F	54	153	1	0	10.30.2001	AS+AI	2.4
KFB	75	F	64	159	0	1	08.23.2004	AS	2.4
MC	12	M	57	164	0	0	07.10.2002	AI	2.0
NS	57	F	83	154	0	0	01.18.2006	AS+MS	2.1
KY	76	F	67	150	0	1	07.01.2002	AS	2.7
FK	45	F	72	155	0	0	05.14.2001	AI+MS	2.6
FÖ	17	F	54	156	0	0	12.27.2001	AI+MS	2.47
YD	52	F	70	155	0	0	06.12.2002	AI+MS	2.9
AD	16	M	64	172	0	0	08.26.2003	AS+AI	2.1
HMİ	57	F	68	152	1	1	10.17.2002	AS	3.4
MV	78	F	65	140	0	0	06.19.2003	AS	2.9
DÜ	72	F	59	154	1	1	06.30.2003	AS+MS	2.6
AC	65	M	89	162	0	0	06.08.2005	AS+CAD	2.0
SB	36	M	65	173	0	0	12.21.2005	AS	2.3
İÖ	72	F	64	143	1	0	12.04.2000	AS+CAD	2.5
FKm	49	F	60	155	0	0	06.30.1999	AY+MS	2.5
ŞT	50	F	65	150	0	0	12.11.2003	AY+MS	2.0
MCn	41	F	86	160	1	1	04.10.2006	AY+MS	3.1
DT	41	F	90	161	0	0	04.20.2003	AY+MS	2.7

*Patients are noted using the first letters of their first and last names. DM indicates diabetes mellitus; HT, hypertension.

In March 2013 there were 14 patients alive. These patients were called for a control echocardiographic examination. The records of the 6 deceased patients were reevaluated, including their last echocardiographic studies. The causes of their deaths were established from records.

Surgical Technique

To permit replacement of the aortic valve with a suitable prosthesis, the aortic incision was extended about 20 mm across the fibrous origin of the mitral ring downwards into the aortic leaflet of the mitral valve. A transverse aortic incision was made into the commissure between the left and the noncoronary semilunar valves. The incision was then extended through the intervalvular trigone and the fibrous origin of the mitral ring and into the anterior mitral leaflet up to its free margin. The attachment of the left atrial wall to the aortic root was detached. The incision in the left atrial wall at the aortic root was extended cranially in order to increase surgical accessibility.

A fusiform patch was sutured to the V-shaped defect thus formed in the aortic leaflet of the mitral valve and the aortic annulus using continuous sutures, also fixing the sewing ring of the aortic prosthesis as described by Manouguian and Seybold-Epting [Manouguian 1979]. This procedure permits the replacement of the aortic valve by a suitable prosthesis. The estimated enlargement of the aortic root ranges from 10 to 25 mm.

Manouguian's aortic root enlargement technique is essentially a patch augmentation of the aortic annulus. The enlargement is centered in the fibrous continuity between the aortic and mitral valves [Sundt 2006]. In the Manouguian technique the incision is placed into the anterior leaflet of the mitral valve squarely at the center of the anterior leaflet.

This aortic incision lies at the commissure between the left coronary cusp and noncoronary cusp. This incision is most easily applied when one has opened the aorta transversely rather than using a so-called hockey-stick incision into the noncoronary cusp. Most surgeons favor this transverse incision, which can be extended to provide a wide and symmetric view of the aortic valve. A transverse aortotomy also prevents the tendency for accidental tearing of the aortotomy, as the valve sutures are tied.

At variance from the original Manouguian technique we used a wedge-shaped autologous pericardial patch inserted

Table 2. Operative Data*

Patient	Type of operation	Cross-clamp, min	CPB, min	PPM value reached after enlargement	ICU stay, d	Intubation time, h
ES	M+AVR(B)	80	109	1.48	1	8.5
HT	M+AVR+MVR	116	148	1.68	2	9.5
KHB	M+AVR(B)	95	132	1.19	2	14.3
MC	M+AVR	68	83	1.58	2	5.8
NS	M+AVR+MVR	159	180	1.35	8	13.8
KY	M+AVR(B)	76	96	1.2	2	17
FK	M+AVR+MVR+TP	102	140	1.14	2	10.7
FÖ	M+AVR+MVR+TP	127	168	1.31	2	14.5
YD	M+AVR+MVR	123	140	1.46	3	8.75
AD	M+AVR	90	105	1.45	1	5
HMİ	M+AVR	81	104	1.19	2	5.2
MV	M+AVR(B)+CABG	155	175	1.6	2	15.4
DÜ	M+AVR(B)+CABG	88	107	1.27	2	12
AC	M+AVR+CABG	90	101	1.27	2	5.75
SB	M+AVR	60	75	1.44	2	10
İÖ	M+AVR+CABG	107	150	1.26	2	14
FKm	M+AVR+MVR	185	197	1.25	2	11
ŞT	M+AVR+MVR+TP	85	125	1.54	3	13.3
MCn	M+AVR+MVR	99	111	1.3	2	7
DT	M+AVR+MVR	154	175	1.27	2	6

*Patients are noted using the first letters of their first and last names. M indicates Manouguian's aortic root enlargement technique; (B), biologic valve; AVR, aortic valve replacement; MVR, mitral valve replacement; CABG, coronary artery bypass graft operation; TP, tricuspid plasty; CPB, cardiopulmonary bypass time; PPM, patient-prosthesis mismatch; ICU, intensive care unit.

into the partially split anterior mitral leaflet and the ascending aorta thereby widening the aortic annulus.

We used autologous pericardium in patients who underwent the Manouguian procedure rather than a prosthetic patch because significant mitral regurgitation resulting from mitral prolapse has been reported due to use of prosthetic material for enlargement [Imanaka 1998]. On the other hand, the use of synthetic material causes poor mobility of the basal segment of the anterior mitral leaflet [Eghtesady 2002]. This problem causes restriction in the movement of the patch with a possibility of increasing the tension on the suture lines. As reported by Molina et al, continued pliability and mobility of the anterior mitral leaflet ensues after the use of pericardial patch for Manouguian's procedure [Molina 2002]. Uçak et al suggest that the use of pericardial patch may prevent risk of increased tension on the suture lines, which may be associated with separation of the patch from the leaflet tissue [Uçak 2010].

Measurements

Using the indexed effective orifice area method, PPM was considered as nonsignificant if greater than 0.85 cm^2/m^2; as moderate if greater than 0.65 cm^2/m^2 and less than or equal to 0.85 cm^2/m^2; and as severe if 0.65 cm^2/m^2 or less [Cotoni 2011; Pibarot 2006].

Echocardiographic Studies

All patients underwent transthoracic echocardiography preoperatively and 1 day before discharge. All patients except the deceased ones underwent echocardiographic evaluation at the cut-off point in the study, which was March 2013 (GE Vivid 7 Ultrasound machine, GE Healthcare, Milwaukee, WI, USA).

Statistical Analysis

Data are expressed as frequency distributions and simple percentages. Continuous variables are expressed as mean ± standard deviation and categorical variables as percentages.

Data were retrospectively collected from the clinical records, operative reports, and preoperative patient examinations. Data were analysed using the SPSS 18.0 statistical software package (SPSS, Chicago, IL, USA). The Kaplan-Meier method was used to calculate estimates for survival in all patients.

RESULTS

Twenty patients operated using the Manouguian technique for narrow aortic root from June 1999 to April 2006 were followed for 8.54 ± 3.35 years (range, 1 month to 11 years and 9 months). The follow-up was ended in March 15, 2013.

Indications for surgery were aortic valve stenosis for 9 patients (45%), aortic valve insufficiency for one patient (5%), aortic valve stenosis and insufficiency for one patient (5%), and aortic valve stenosis and mitral valve stenosis for 9 patients (45%). In addition to these valve pathologies two patients who had aortic valve stenosis also underwent operation for coronary artery disease in the same session.

We reached a safe average PPM value of 1.36 ± 0.16 (range, 1.14-1.54) after Manouguian aortic root enlargement.

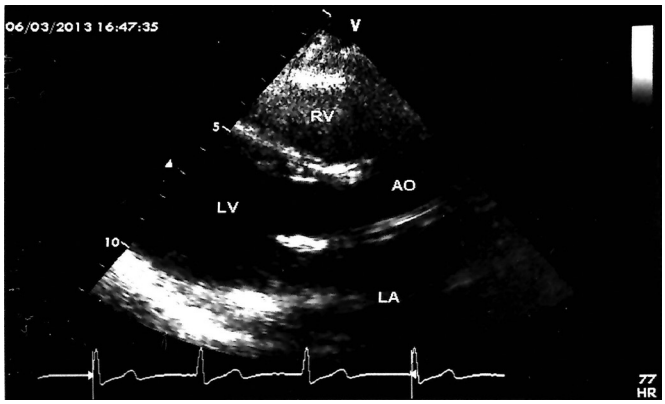

Figure 1. Parasternal long axis control ecocardiogram 11 years and 2 months after operation of a female patient (FÖ), aged 17 at the time of operation, showing enduring enlargement of the aortic valve with no restriction or anomaly related to the aortic root. No aortic or mitral regurgitation was present. The patient had undergone Manouguian type aortic enlargement, aortic valve replacement, mitral valve replacement, and De Vega tricuspid valve plasty. LV indicates left ventricle; RV, right ventricle; LA, left atrium; Ao, ascending aorta.

Mean CPB times were 131.05 ± 35 minutes and mean cross-clamp times were 107 ± 33.9 minutes. This is comparable to CBP values in patients undergoing AVR [Mohty 2009].

Mean intubation time was 10.38 ± 3.8 hours and mean ICU stay was 2.3 ± 1.42 days (Table 3).

Echocardiograpy upon latest follow-up revealed normally functioning valves in all patients who were still alive (Figure 1). Of the 14 patients who were alive at the latest follow-up, 11 had no mitral regurgitation (79%), 1 had 1/4 (7%), and 2 had 2/4 mitral insufficiency (14%). No patients had clinically significant mitral regurgitation.

Fourteen patients were alive at the end of the follow-up. Six patients had died (Table 3). One patient died 9 years after the operation due to a brain tumor, and another 75-year-old female patient died 5 years and 9 months after the operation because of a cerebrovascular accident. She died due to a hemorrhagic cerebral infarct after undergoing pericardial autologous patch enlargement of the aortic annulus using the Manouguian technique and aortic valve replacement using a 21 mm Hancock II Porcine Valve (Medtronic, Minneapolis, MN, USA). She was not under anticoagulation at the time of the cerebrovascular event. She was only using 80 mg per day of antiplatelet agent acetylsalicylic acid at that time. The third patient was a 57-year-old female patient who died 2 years and 2 months after the operation due to gastrointestinal bleeding. The fourth mortality occured due to renal failure. The fifth mortality was also due to a cerebrovascular accident 8 years and 6 months after the operation. The patient was a 72-year-old female who underwent aortic valve replacement, pericardial autologous patch enlargement of the aortic annulus using the Manouguian technique, and coronary artery bypass graft operation for critically stenosed left anterior descending and circumflex coronary arteries. The left internal thoracic artery and a saphenous vein graft were the respective bypass conduits. The patient suffered an ischemic cerebrovascular

Table 3. Postoperative Data*

Patient	Time of follow-up	Status	NYHA Class
ES	9 years 2 months	Alive	1
HT	9 years	Exitus brain tumor	
KHB	5 years 9 months	Exitus CVAcc	
MC	10 years 7 months	Alive	1
NS	2 years 2 months	Exitus GIBleeding	
KY	1 month	Exitus Renal Failure	
FK	11 years 9 months	Alive	2
FÖ	11 years 2months	Alive	1
YD	10 years 8 months	Alive	1
AD	9 years 6 months	Alive	1
HMİ	10 years 10 months	Alive	1
MV	9 years 8 months	Alive	1
DÜ	9 years 8 months	Alive	1
AC	7 years 8 months	Alive	1
SB	3 years 6 months	Exitus cardiac	
İÖ	8 years 6 months	Exitus CVAcc	
FKm	13 years 8 months	Alive	1
ŞT	9 years 2 months	Alive	2
MCn	6 years 8 months	Alive	1
DT	9 years 10 months	Alive	1
Mean	8.54 ± 3.35 years		

*Patients are noted using the first letters of their first and last names.
NYHA indicates New York Heart Association Class; CVAcc, cerebrovascular accident.

infarct despite being within normal range INR level (3.26) while on warfarin sodium 13 months after the operation. Her aortic valve had been replaced with a 21 mm mechanical Medtronic Hall prosthetic heart valve (Medtronic, Minneapolis, MN, USA). Her computerized tomography showed an acute ischemic infarct from the level of her left lentifom nucleus to the semioval center (centrum semiovale). She had global aphasia and right hemiplegia that gradually improved giving her full-range mobility with a slight limp. However, 7 years and 5 months later a recurrent ischemic cerebral infact caused her death. Only one death could be attributed to a cardiac cause, which occured in a 36-year-old male patient 3 years and 6 months after the operation. This patient died in another institution and the cause was noted as cardiac without further details.

Twelve of the 14 patients alive (86%) were in NYHA class I in their latest follow-up controls. The remaining 4% were in NYHA class II (Table 3).

Early mortality rate was 5% and late mortality after 8.54 ± 3.35 years was 30%. Late mortality related to cardiac reasons was 5%.

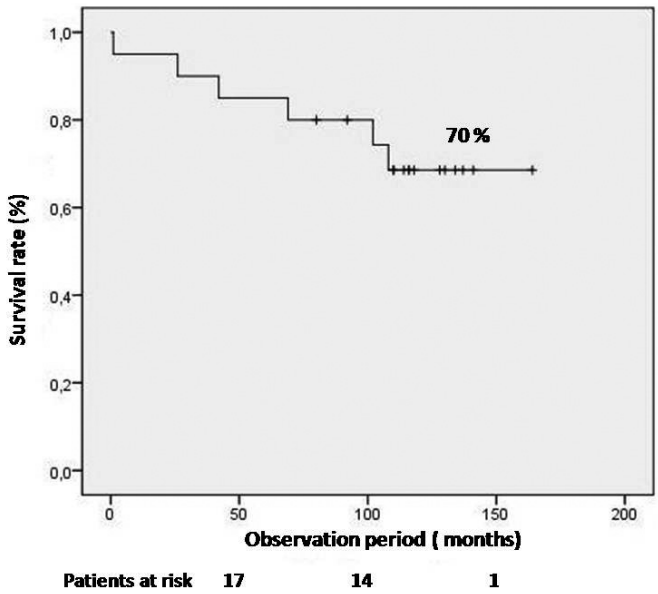

Figure 2. Kaplan-Meier survival curve.

70% of patients were alive after a mean follow-up period of 8.54 ± 3.35 years (Figure 2).

DISCUSSION

It is a foremost task of the surgeon to avoid PPM. The surgeon usually has a limited time in assessing options for the small aortic root because the aorta may be open and the patient already on CPB. Swift action is warranted.

If PPM is anticipated upon observation intraoperatively, the surgeon will have the following options:

Option 1: Implant, if possible, another type of prosthesis with a larger EOA such as a stentless bioprosthesis, a new generation mechanical prosthesis, or an aortic homograft.

Option 2: Enlarge the aortic root to accommodate a larger prosthesis of the same and/or available type.

Option 3: Accept PPM due to other overwhelming circumstances.

Left ventricular mass regression begins early after aortic valve replacement, most probably due to reduction of transvalvular gardients and left ventricular stress [Christakis 1996]. Transvalvular gradients have to be low postoperatively. Therefore it is important to avoid PPM during AVR at all costs.

We used aortic valve enlargement in cases in which we encountered small aortic root unexpectedly and had to devise an alternative to a much costlier and logistically impossible stentless valve or homograft implantation. Stentless valve or homograft implantation are difficult alternatives. Sometimes they may be inadvisable or logistically and economically unavailable [Borowski 2008]. These 20 cases we operated on using the Manouguian technique were those patients in which the small aortic root was found after the cross-clamp had been placed and the patient was already on cardiopulmonary bypass. The Manouguian's technique

accomodates a prosthetic valve one or two sizes larger than the original narrow annuli in patients with small aortic annuli [Manouguian 1979], and it can be applied quickly and efficiently. So we chose the Manouguian technique.

Use of pericardium without gluteraldehyde fixation was the only viable alternative at the time. Pericardial fixation was not carried out because there was not sufficient time for it; we wanted to expediently perform the valve replacement and this was the method employed for all 20 patients.

No surgical bleeding or postoperative bleeding was observed. Late mortality after 8.54 ± 3.35 years was 30%, only 5% related to cardiac causes. This 5% mortality rate is similar to those found by Ardal et al and Aliazadeh Ghavidel and colleagues [Ardal 2006; Alizadeh Ghavidel 2014].

Complications after Manouguian's procedure include late mitral regurgitation, left atrial to aorta fistula, hemolysis secondary to the use of Dacron patch material, and prosthetic valve-related morbidities such as paravalvular leak and endocarditis. Detachment or separation of prosthetic patch presenting with significant mitral regurgitation is a dramatic yet infrequent early postoperative complication [Uçak 2010]. We encountered no such complications.

No cases of postoperative prosthetic valve endocarditis were detected. No paravalvular leakage was observed. We observed no patch related early or late complication. No case of aneurysmal dilatation, leak, early or late calcification or pseudoaneurysm formation of the pericardial patch was seen. Other possible disadvantages of autologous pericardial patch use are fibrotic thickening, contraction, and calcification or late aneurysm formation. [Eloakley 1994]. No such complications related to pericardial patch were seen in our paients.

The Manouguian's technique allows prevention of a possible reoperation obviating use of small aortic prostheses [Molina 2002]. In accordance with these earlier findings none of our patients required reoperation for valve-related pathology.

Postoperative control echocardiograms revealed no abnormality in the mitral valve related to the procedure. Synthetic material may cause poor mobility of the basal segment of the anterior mitral leaflet [Uçak 2010; Eghtesady 2002]. Some degree of mitral regurgitation was observed in some series [Imanaka 1998]. This problem was not encountered in any of our patients.

Autologous pericardium as opposed to bovine or prosthetic patch material is frequently used in surgical treatment of congenital defects like atrial septal defect closure and enlargement of the right ventricular outflow tract and aortic root. The advantage lies in the fact that autologous pericardium has more pliability, resistance to infection, and is non-immunogenic [Marco 2013]. Autologous pericardium is resilient, strong, and readily available with expansile potential, making it an ideal aortic patch material [Haluck 1990].

Aortic root enlargement can be readily performed without needing special valves or equipment, which may not always be available because of logistical or economic reasons [Sundt 2006].

Borttolotti et al described aortic annulus enlargement with gluteraldehyde-fixed bovine pericardium during aortic valve replacement. They reported that gluteraldehyde-fixed bovine pericardium used as a patch material showed no tendency to aneurysmal dilatation with progression of time at a maximum follow-up of 30 months [Bortolotti 1998]. We found that no patient had aneurysmal dilatation or mitral regurgitation after a mean follow-up of 8.54 ± 3.35 years with autologous untreated pericardium as the enlargement patch.

Tully et al reported an independent mortality risk attributable to moderate or severe PPM in elderly patients and in those with left ventricular dysfunction [Tully 2013]. As 4 of our patients had concomittant CABG and 9 patients underwent double valve replacement, we think that we also avoided this kind of possible morbidity and mortality thanks to our aortic root enlargement.

All of our patients who required annular enlargement had rheumatic disease. Incidence of rheumatic disease has decreased dramatically, lessening the need for annular enlargement. Introduction of high-performance (larger EOA) valves also reduced the need for aortic root enlargement. Nevertheless, posterior aortic root enlargement using Manouguian's technique with autologous fresh pericardium is a durable option in cases we may encounter.

Study Limitations

The number of patients in the study is limited primarily because of a decrease in the need for posterior root enlargement in recent years. The retrospective character of the study is an additional limiting factor.

Conclusion

The main finding of the present study is that aortic root enlargement using untreated fresh autologous pericardium in Manouguian type operations is a durable option, especially in conditions when homograft or stentless valve use is difficult or economically not feasible. We also report an actuarial freedom from death of 70% at 8.54 ± 3.35 years.

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