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The Ross procedure versus repair for treatment of a unicuspid aortic valve in adults[†]

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Key question

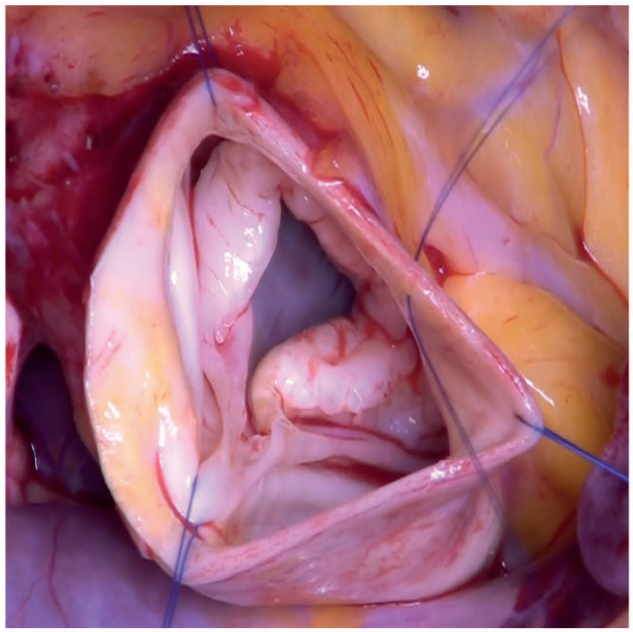
What is the durability of repair versus the Ross procedure for the treatment of the unicuspid aortic valve in adults?

Key finding(s)

Repair durability was best in younger patients (i.e. 18–25 years) with 84% at 10 years.

Take-home message

Repair can serve as a bridge to Ross for younger patients. In older patients, a Ross should be considered instead.



Abstract

OBJECTIVES: Aortic stenosis or regurgitation in patients with a unicuspid valve morphology requires interventions early in life. We have performed either primary valve repair or the Ross procedure. The goal of this study was to compare the midterm results of repair and pulmonary autograft replacement.

METHODS: Between December 1998 and April 2022, a total of 345 patients (77% male; mean age 34 ± 9.7 years) underwent treatment of a unicuspid aortic valve. Patients were excluded if they were <18 years (n = 84) or >54 years (n = 3) at the time of the operation. The remaining cohort was divided into 2 groups: 167 (64%) patients underwent valve repair; 91 (36%) patients underwent pulmonary autograft replacement.

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The indications for surgery were aortic regurgitation (n = 104), aortic stenosis (n = 45), combined disease (n = 103) and endocarditis (n = 6). Fifty-one patients had root dilatation (>43 mm) with aortic regurgitation (repair n = 23; Ross n = 28). Mean follow-up was 5.9 years (SD: 5 years) [range 0.1–22.3 years].

RESULTS: There were 1 early and 3 late deaths; 47 patients required reintervention. Survival at 10 years was 95% in the Ross group and 97% after valve repair (P = 0.769). Freedom from reintervention at 10 years was 98% in the Ross group and 80% after valve repair (P = 0.012). A receiver operating characteristics curve analysis showed a trend towards better durability in patients < 26 years.

CONCLUSIONS: The ideal treatment of the unicuspid aortic valve remains debatable. Repair of a unicuspid valve can be considered a bridge to pulmonary autograft replacement, at least in younger patients. The appropriate times to replace and to repair require further investigation.

INTRODUCTION

The unicuspid valve is a relatively rare variant of the aortic valve even though its prevalence is likely underestimated at the time of echocardiography or aortic valve surgery [1, 2]. The ideal treatment therefore remains unknown and is exclusive to expert centres. The mechanical features of unicuspid valves are deficient from birth with a variable extent of stenotic and regurgitant components [1, 2]. Many patients with unicommissural unicuspid aortic valves develop severe stenosis, often combined with valvular regurgitation during early adulthood and require surgical treatment predominantly in their third to fifth decade of life [3] (i.e. 20–30 years earlier than for a tricuspid and 10 –20 years earlier than for a bicuspid aortic valve [3, 4]. Others may remain haemodynamically stable for decades before they require treatment for relevant regurgitation and/or stenosis [1]. Aortic dilatation may be an associated finding, as it is in bicuspid valves [5], and the presence of unicuspid anatomy predisposes the patient to the development of aortic dissection more often and at a younger age than bicuspid anatomy [5]. However, there have been no further recent studies analysing this concept. In most cases, aortic dilation occurs at the level of the functional annulus, whereas root dilation is less commonly diagnosed compared to bicuspid valves [2].

Surgical treatment is generally required at a younger age. Mechanical valve replacement is chosen by many surgeons. It is possibly the most durable option even though valve-related complications (i.e. pannus ingrowth, paravalvular leak) are relevant, varying between 1.1% and 4.5% per patient-year [6, 7]. Thus, there is excess mortality, which is higher in younger patients [8, 9]. Long-term studies have reported mortality rates between 20% and 30% at 15 years [8, 9]. Similarly, results of biological valve replacement in the younger patient population show limited durability in particular due to valve-related complications (i.e. structural deterioration, non-structural valve dysfunction, infective endocarditis, patient–prosthesis mismatch and thromboembolism) [10]. Such complications result in an excessive number of deaths, which has recently been reported to be up to 31% at 15 years in patients aged 45 to 54 years [8]. An approach using autologous tissue, either by repair [11] or pulmonary autograft replacement, has become increasingly popular.

Repair is one alternative; the durability of unicuspid valve repair in a younger patient population has been suboptimal [2, 12, 13], and reoperations have been primarily related to patch degeneration [2, 3, 12, 14]. The Ross procedure has become of interest in the last decade, in particular as a replacement option for valves that cannot be repaired [9, 15, 16]. Few studies have analysed the durability of the Ross procedure in unicuspid aortic valves [11, 17, 18]. Although midterm survival and durability were similar between different valve morphologies [17], a trend towards a higher increase in autograft size progression was shown for unicuspid valves [18]. In paediatric patients, a comparative study between repair and the Ross procedure showed similar survival and freedom from reoperation [11]. The results in adult patients remain unclear.

Thus, the purpose of this study was to assess results (freedom from reoperation and survival) of valve repair compared to pulmonary autograft replacement for the unicuspid aortic valve in adults. An attempt to determine the most appropriate age for repair or pulmonary autograft replacement was made.

PATIENTS AND METHODS

Ethics statement

The investigation was approved by the Saarland Regional Ethics Committee (CEP 202/19, CEP 203/19), and individual patient consent was waived for the analysis and publication in an anonymized fashion.

Patients

We conducted a retrospective analysis of patients who underwent treatment of a unicuspid aortic valve at Saarland University Medical Center between December 1998 and April 2022.

To avoid age bias, patients were excluded if they were younger than 18 years (n = 84; 24%) or older than 54 years (n = 3; 1%) at the time of the operation (Fig. 1); the age of the oldest patient to have a pulmonary autograft replacement was 54 years.

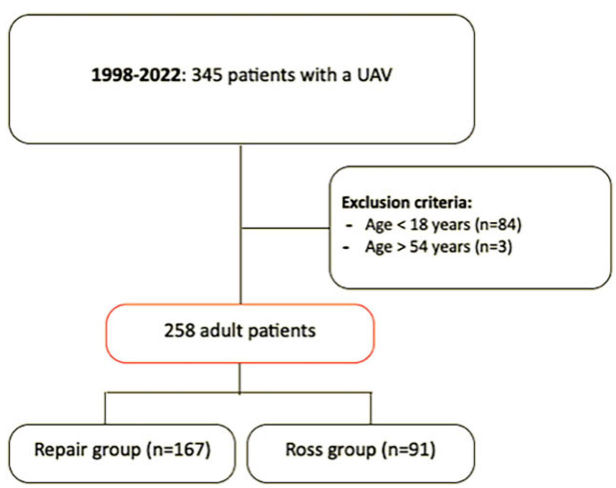

Figure 1: Flow chart of the study population. UAV: unicuspid aortic valve.

The remaining cohort (n = 258; 75%) was divided into 2 groups: 167 (64%) patients underwent valve repair and 91 (36%) patients underwent pulmonary autograft replacement.

Surgical technique

Surgery was performed through a median sternotomy. Technical details have been described in detail elsewhere [19]. Root remodelling and ascending aortic replacement were used for patients with a sinus diameter > 43 mm and an ascending aortic diameter >45 mm. The aorta was opened by a transverse aortotomy 5 to 10 mm above the sinotubular junction.

Valve morphology and cusp mobility were assessed. Geometric height (gH) was measured on the pliable tissue of the left and non-coronary cusps. A gH of 20 mm or more of both cusps was considered sufficient for bicuspidization [19]. If it measured <20 mm, a pulmonary autograft replacement was performed (Table 3A). A new commissure of normal height, i.e. the posterior commissure (always higher than the right coronary orifice), was marked in the aortic root. This commissure was initially created on the rudimentary anterior (right or non-coronary) commissure. Starting in 2007 [19], it was placed in a position opposite to that of the posterior commissure for symmetric orientation [19]. Two triangular patches are prepared to bridge the gaps between preserved left or non-coronary cusp tissue and the new commissure, most commonly using glutaraldehyde-fixed autologous pericardium [20], decellularized xenogeneic tissue (Matrix Patch; Auto Tissue Berlin GmbH, Berlin, Germany) or expanded polytetrafluoroethylene (PTFE) membranes (Gore Preclude Pericardial Membrane; W.L. Gore & Assoc., Newark, DE, USA) [12] (Table 3A). Six patients underwent root remodelling with cusp nadir relocation and without the use of patch material.

If indicated, tubular ascending aortic replacement (n = 72) or root remodelling (n = 23) with a Dacron graft (according to body surface area) with two symmetric tongues was performed.

A pulmonary autograft replacement was performed as a full-root replacement according to the judgement of the surgeon. The technique has been described in detail elsewhere [21]. In addition, starting in 2009, a basal ring diameter >26 mm triggered the later use of annuloplasty for both repair and pulmonary autograft replacement procedures [20, 21], irrespective of the surgical indication.

Follow-up

All patients were seen regularly by their referring cardiologists or in our clinic. Echocardiograms from our institution and from referring cardiologists were reviewed. All patients were followed prospectively both clinically and echocardiographically (at discharge, 3 months, 1 year and yearly thereafter). Systolic gradients were measured using continuous-wave Doppler. Aortic regurgitation (AR) was determined using colour Doppler according to European guidelines.

Statistical analyses

Non-normally distributed continuous variables are presented as median (interquartile range), and continuous variables are presented as mean (SD). They were compared using analysis of variance with post hoc tests and the Bonferroni correction for normally distributed data and the Kruskal–Wallis test for non-normally distributed data. Categorical variables are expressed as frequencies (%). Time-dependent data were analysed using the Kaplan–Meier method. Differences were assessed using the log-rank test. Reinterventions were also analysed using competing risk analysis, with mortality as a competing risk. The Gray test was used to compare groups. Survival and freedom from reintervention were calculated at 1, 5, 10 and 12 years. All statistical tests were two-sided, and P-values of <0.05 were considered statistically significant for all analyses. Statistical analyses were performed using SPSS 28.0 (SSPS, Chicago, IL, USA) and R version 4.2.2 (R Foundation, Vienna, Austria).

RESULTS

We conducted an analysis of 345 patients (74% male, mean age 33.5 (SD: 9.7 years). At the time of the operation, the main indications were isolated aortic stenosis (AS) in 45 patients (repair n = 25, 15%; Ross n = 20, 22%; P = 0.114), isolated AR in 104 (repair n = 85, 51%; Ross n = 19, 21%; P = 0.001, Table 1) and combined disease in 103 (repair n = 56, 34%; Ross n = 47,52%; P = 0.02) (Table 1). Patients with AR had concomitant root dilatation (>43 mm) in 51 instances (repair n = 23, 14%; Ross n = 28, 31%; P = 0.061). The mean systolic gradient was 20 mmHg (SD: 12) in the repair group and 39 mmHg (SD: 22) in the Ross group (P = 0.05) (Table 1).

In the repair group, 20 (12%) patients had undergone 1 to 3 previous cardiac interventions—including balloon valvuloplasty.

Table 1: Patient characteristics according to repair or Ross procedure

	Repair (n = 167)	Ross procedure (n = 91)	*P-value*
Male sex, n (%)	128 [77]	65 [76]	0.212
Age, mean (SD), years	32(9.4)	37(9.3)	<0.001
BSA, mean (SD),%	1.9 ± 0.4	1.7 ± 0.7	0.659
Cardiovascular risk factors, n (%)			
Arterial hypertension	43(26)	14(15)	0.083
Coronary artery disease	0(0)	0(0)	
Intravenous drug abuse	0(0)	0(0)	
Surgical indication, n (%)			
Isolated aortic stenosis	25(15)	20(22)	0.114
Isolated aortic regurgitation	85(50)	19(21)	0.001
Combined disease	56(34)	47(52)	0.02
Endocarditis	2 (1)	4(4)	0.456
Aortic root dilatation +/- AR	23(13)	28(31)	0.061
Prior aortic valve operation, n (%)			
Valve replacement	0(0)	0(0)	
Valve repair/ commissurotomy	20(12)	18 (19)	0.567
LVEF <50%, mean (SD), n (%)	51(25)	62(11)	0.053
LVEDd, mean (SD), mm	49(16)	54(9)	0.587
Aortic root diameter (sinus), mean (SD), mm	35 (6)	31 (13)	0.74
Geometric height, mean, mm	15	23	0.004
Mean systolic gradient (SD), mmHg	39 (22)	20 (12)	0.04

AR: aortic regurgitation; BS: body surface area; LVEF: left ventricular ejection fraction; LVEDD: left ventricle end-diastolic diameter; SD: standard deviation.

In the Ross group, 18 patients had undergone prior valve commissurotomy.

Patients who underwent valve repair were younger [mean 32 (SD: 9.7) years] than patients who underwent a Ross procedure [mean 38 (SD: 9.7) years] ($P = 0.061$).

A total of 100 patients (29%) had a concomitant procedure, most commonly ascending aortic replacement (Ross $n = 31$; repair $n = 41$).

The most common patch material used was glutaraldehyde-fixed autologous pericardium ($n = 98$) [20], decellularized xenogeneic tissue (Matrix Patch, Auto Tissue Berlin GmbH, Berlin, Germany) ($n = 46$) or expanded PTFE membranes (Gore Preclude Pericardial Membrane, W.L. Gore & Assoc.) ($n = 6$) [12] (Table 3A).

As patch material, autologous pericardium (18–25 years, $n = 31$; 26–30 years, $n = 22$; 31–40 years, $n = 29$; 41–54 years, $n = 19$; $P = 0.863$), heterologous pericardium (18–25 years, $n = 16$; 26–30 years, $n = 9$; 31–40 years, $n = 14$; 41–54 years, $n = 7$; $P = 0.912$) and synthetic material (18–25 years, $n = 3$; 26–30 years, $n = 1$; 31–40 years, $n = 1$; 41–54 years, $n = 1$; $P = 0.777$) were distributed equally among all age groups (Table 3A).

Tubular ascending aortic replacement was performed in 72 cases and root remodelling, in 23. In addition, 118 patients had an annuloplasty irrespective of the surgical indication (for AR, $n = 77$; combined lesion, $n = 27$; AS, $n = 14$).

All patients were followed prospectively both clinically and echocardiographically. Median and mean follow-up examinations occurred at 5.1 [2.5–9] years and 5.9 (SD: 4.5) years [repair: 7.1 (0.1–15.7) years; Ross: 2.5 (0.1–22.3) years]. Follow-up was 95% complete (1512 patient-years).

Early

Only 1 early death occurred after valve repair. The patient was operated on for endocarditis, with cerebral and abdominal embolisms preoperatively, and in a cardiopulmonary unstable condition. Additionally, he developed pneumonia postoperatively and died of sepsis after 41 days.

There was no myocardial infarction or ventricular dysfunction and no new neurological complications. No patients required permanent pacemaker implants (Table 2).

There were 2 early reoperations in the repair group (1.2%). In these 2 cases, a PTFE patch was used, which led to dehiscence in both patients.

Late Survival

Three patients died during follow-up at 3 months to 4.1 years postoperatively (repair, $n = 2$; Ross $n = 1$). One patient died of cardiac arrhythmia 3 years postoperatively with persistent left ventricular dysfunction. The second patient died of oropharyngeal cancer 4.1 years postoperatively, and 1 cause of death remains unknown.

Overall survival was 98% at 10 years. Ten-year survival was identical after valve repair (97%) and pulmonary autograft replacement (95%) ($P = 0.769$) (Fig. 2).

Haemodynamic parameters

Aortic regurgitation. In the *repair* group, 3 patients (1.8%) had AR ≥ 2 at discharge. Two of them required early reoperation

Table 2: Perioperative data

	Repair (n = 167)	Ross procedure (n = 91)	*P-value*
Technique			
Full-root replacement	–	91 (100)	
Bicuspidization	167(100)	–	
New commissure on rudimentary anterior commissure (2005–2007)	33(20)	–	
Symmetric orientation (2007–)	136(81)	–	
Effective height (2004–), suture annuloplasty (2009–)	111(66)	42(46)	0.205
Patches			
Autologous pericardium	91(66)	–	
Decellularized matrix patch	46(28)	–	
Synthetic material	10(6)	–	
Other	22(13)	–	
Concomitant procedure, n (%)			
Root remodelling	23(13)	–	
Ascending aortic replacement	41(25)	31(34)	0.056
Hemiarch using circulatory arrest	0(0)	4(4)	0.43
Right coronary transfer	0(0)	1(1)	0.83
Perfusion time, mean (SD), min	81(35)	108(31)	<0.001
Myocardial ischaemia, mean (SD), min	60(19)	85(17)	<0.001
Perioperative complications			
Bleeding	3(2)	2(2)	0.856
Permanent pacemaker implant	0(0)	0(0)	
Ventricular dysfunction	0(0)	0(0)	

Table 3(A): Preoperative anatomical data used according to age group and patch material

Preoperative	Age group				
	18–25 (n = 53)	26–30 (n = 36)	31–4 (n = 45)	41–54 (n = 33)	*P*-value
Root size (sinus; mean, mm)	33	34	38	41	0.76
Geometric height (mean, mm)	23	24	23	24	0.93
Mean systolic gradient (SD)	13 (9)	26 (17)	28 (22)	22 (17)	0.09
Isolated AR (%)	45 (85)	13 (36)	17 (38)	16 (48)	0.07
Patch material	**18–25 (n = 53)**	**26–30 (n = 36)**	**31–4 (n = 45)**	**41–54 (n = 33)**	***P*-value**
Autologous pericardium	31 (58)	22 (61)	29 (64)	19 (58)	0.86
Decellularized matrix patch	16 (30)	9 (25)	14 (31)	7 (21)	0.91
Synthetic material	3 (6)	1 (3)	1 (2)	1 (3)	0.78

Table 3(B) Anatomical data at last follow-up

Postoperative	Repair (n = 167)	Ross (n = 91)	*P-Value*
Aortic root diameter (sinus), mean (SD), mm	30 (6)	34 (5)	0.08
Mean systolic gradient (SD), mmHg	15 (7)	4 (3)	0.04
AR ≥ 2	17	2	0.003

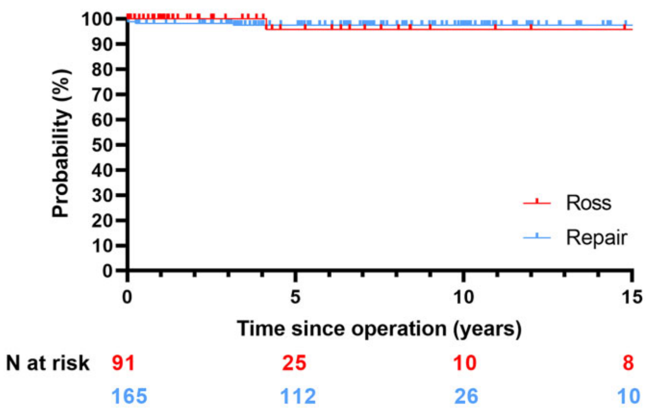

Figure 2: Survival comparing valve repair and pulmonary autograft replacement. N: number.

for suture dehiscence at the implanted PTFE patch. One of them has remained stable. Fourteen patients (8.4%) developed AR ≥ 2 between 4 months and 12 years postoperatively. Four of those remained stable at AR = 2; in 10 (6%) of those, AR progressed and required a reoperation (Table 3B).

In the Ross group, no patient had AR = 1 or AR = 2 at discharge. Two patients (2%) developed AR >2 between 6 months and 18 years postoperatively and required reoperations (Table 3B).

Gradient. In the repair group, the systolic mean gradient was 8.5 mmHg (SD: 3) at discharge. In the Ross group, the systolic mean gradient was 4.4 mmHg (SD: 3) at discharge and at the last follow-up (Table 3B).

Reinterventions

Forty-seven patients (18%; repair *n* = 44; Ross *n* = 3) underwent reoperation between 0.3 and 19 years after the index procedure (median: 7.8 years). Of those, 4 patients who underwent root remodelling required reoperations.

In the repair group, the findings at reoperation were suture line dehiscence of the patch (*n* = 17; 10%) or patch and valve degeneration (*n* = 20; 12%). In the Ross group, indications included autograft dilatation with (*n* = 1) or without relevant AR (*n* = 1). In 1 additional instance, endocarditis was suspected because of a localized perivalvular cavity resembling an endocarditic abscess. Reoperation included elimination of this cavity, and the cultures remained negative. No reoperations were necessary on the right ventricular conduit.

Reoperations in the repair group comprised recurrent valve repair (*n* = 14; 8%), pulmonary autograft replacement (*n* = 14; 8%), mechanical valve replacement (*n* = 14; 8%) and biological valve replacement (*n* = 2; 1%).

The reoperations in the Ross group were exclusively valve sparing (root remodelling, *n* = 2; isolated repair, *n* = 1). Of the patients who underwent supported pulmonary autograft replacement, none required another operation at the last follow-up.

Overall freedom from reoperation was 75% at 10 years (70% in the repair group and 98% in the Ross group; *P*=<0.001; Fig. 3A). In the repair group, freedom from reoperation before the application of suture annuloplasty was 60% at 10 years (Fig. 3B) and improved after applying suture annuloplasty with 80% at 10 years (Fig. 3C). Freedom from reoperation after root remodelling was 100% at 10 years.

In the repair group, reoperation-free survival was 77% at 10 years. The cumulative incidence of reoperation was 21% at 10 years, and the cumulative incidence of death was 2%.

In the Ross group, reoperation-free survival was 94% at 10 years with a cumulative incidence of reoperation of 2% and cumulative incidence of death of 4%.

The effect of patient age at the time of the operation was analysed. In the repair group, patients between 18 and 25 years of age showed an improved freedom from reoperation of 84% at 10 years compared to older patients (ages 26–30: 54%; ages 31–40: 75%, ages 41–54: 66%) (*P* = 0.347) (Fig. 4). In the Ross group, freedom from reoperation at 10 years was similar (between 94% and 96%) among all age groups (*P* = 0.934). A receiver operating characteristics curve analysis was performed, which showed a trend towards the best durability in patients younger than 26 years.

There was a difference in freedom from reoperation between different patch materials (at 10 years, 65% with autologous pericardium and 85% with heterologous patch material; at 5 years, 50% with synthetic material) (*P*=<0.001) (Fig. 5).

Upon the analysis of surgical indication, freedom from reoperation was better in patients with AR (73%) compared to those with AS (64%; *P* = 0.378). Recurrent stenosis was the indication for reoperation in 30% of patients who underwent repair for AS.

DISCUSSION

The unicuspid aortic valve is an apparently rare congenital valve malformation [2, 3], existing as a commissural or unicommissural variant [3, 12, 19]. In the unicommissural variant, the cusp tissue between the 2 hypoplastic commissures is dysplastic from birth and prone to early calcification [3]; the cusp tissue adjacent to the "normal" commissure remains (usually) pliable and functionally intact into adulthood [3]. The prevalence (ranging from 0.02%–4.9%) [1, 2, 25] is probably underdiagnosed [22, 23] due to lack of attention to precise anatomical features [24, 26]. Patients with a unicuspid aortic valve require surgery at an even younger age [1] compared to those with bicuspid valves [1, 2, 4].

Surgical treatment often consists of conventional aortic valve replacement (AVR). Mechanical valves are probably the most

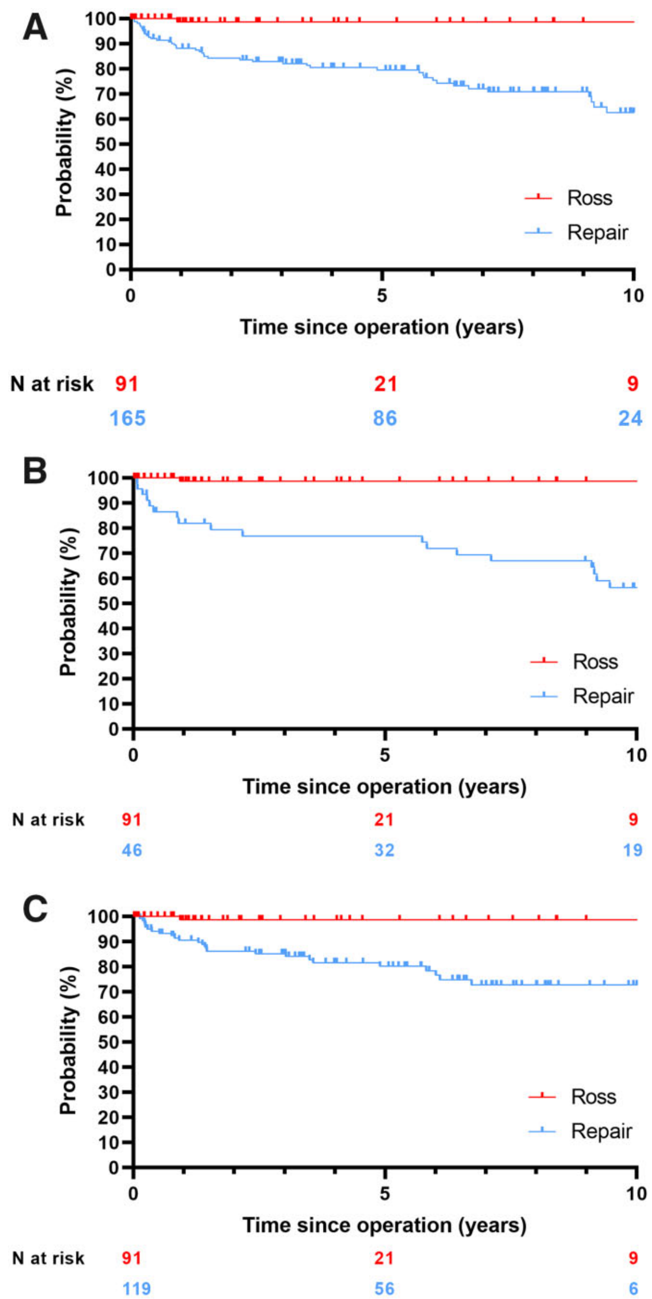

Figure 3: (**A**) Freedom from reoperation comparing valve repair and the Ross procedure. (**B**) Freedom from reoperation comparing repair, before applying suture annuloplasty, and the Ross procedure. (**C**) Freedom from reoperation comparing repair, after applying suture annuloplasty, and the Ross procedure. N: number.

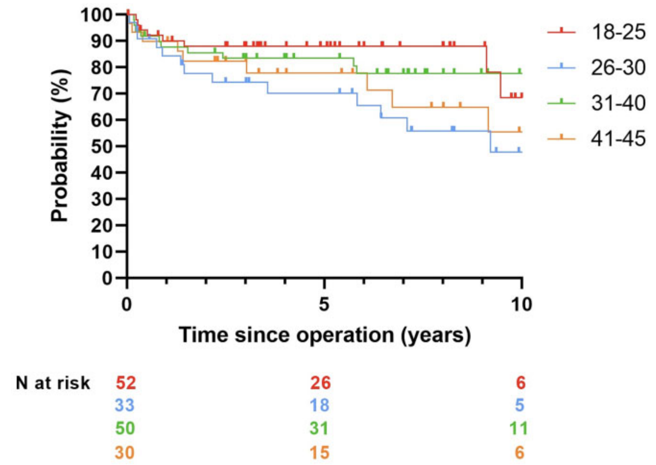

Figure 4: Effect of patient age on freedom from reoperation in patients having undergone aortic valve repair. N: number.

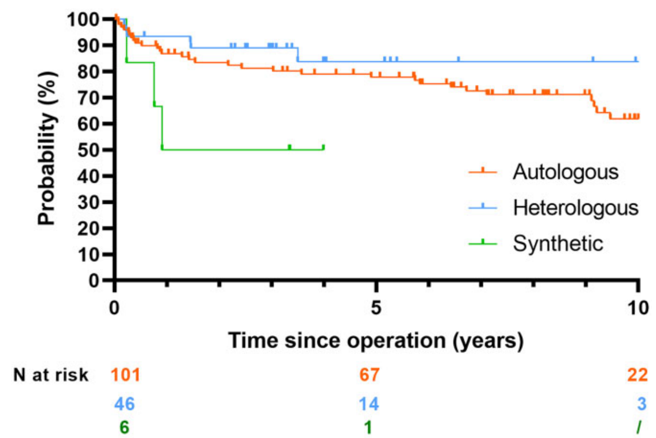

Figure 5: Freedom from reoperation according to different patch materials. Autologous pericardium was compared to heterologous pericardium (i.e. Matrix Patch). N: number

durable option; however, there is a relevant incidence of valve-related and bleeding complications [6, 7]. Biological AVR results in suboptimal durability [9, 10]. More importantly, both procedures are associated with an excess number of deaths [8]. Thus, treatment by repair [11] or pulmonary autograft replacement has become increasingly popular. Pulmonary autograft replacement is a relatively complex procedure involving 2 valves; valve repair appears as the comparatively less complex procedure. We have developed a repair approach of bicuspidization, which is reproducible and creates a functioning valve configuration [19, 20] with adequate haemodynamic valve performance [19, 20]. In most instances, patch material has to be added for the creation of a second commissure. Only a subset of patients has the anatomical features (i.e. a height of the anterior commissure of at least 15 mm) to create a second commissure through root remodelling alone [27]. Freedom from reoperation has been improved by applying the concept of intraoperative gH measurement [19, 28] and by using external suture annuloplasty [20]. Durability of valve repair has mainly been limited by the risk of reoperation due to patch degeneration [2, 3, 12, 14].

With these components in our learning curve, durability improved over time. The question now remains whether to repair or to replace unicuspid aortic valves (UAVs) with a pulmonary autograft. The Ross procedure also bears the probability of reoperation for root dilatation, AR and possible right ventricular conduit degeneration [9]. So far, only a few studies have assessed the difference between the 2 procedures in UAVs [11, 14, 29]. A recent study in paediatric patients compared repair to pulmonary autograft replacement for the treatment of UAVs [11]. Freedom from reoperation at 10 years was similar between repair and pulmonary autograft replacement. In adult patients, however, the results remain poorly defined.

In our study, survival was excellent both after repair (95%) and after the Ross (97%) procedure, similar to results in other studies [11, 17]. Freedom from reoperation in our current study after the Ross procedure was 98% at 10 years. It was better than we had previously found in a mixed cohort of patients with UAVs (79% at 10 years) [18] and in patients with the Ross procedure as a reoperation [15]. This may be due to our current concept of external root stabilization; without external root stabilization, even more patients required reoperation (10 year freedom from reoperation was 63%) [18]. Few other studies, if any, have focused on long-term results of the Ross procedure for UAVs [13, 17].

For repair, freedom from reoperation is dependent on different factors, such as the use of annuloplasty and the type of patch material. Our current study shows that the addition of suture annuloplasty resulted in a better freedom from reoperation (81% with annuloplasty at 10 years versus 71% without annuloplasty). An annuloplasty was used, depending on the diameter (>26 mm) of the annulus irrespective of the cusp pathology. Generally, patients with aortic stenosis have fewer issues with annular dilatation. Patch degeneration, in our experience, is highly dependent on the type of patch material [12]. Synthetic material (i.e. PTFE membranes) showed an inferior freedom from reoperation at 5 years (50%). Although autologous pericardium showed better durability at years 10 (65%), it was inferior to Matrix patches (85%). In addition, patients with preoperative AR had a better freedom from reoperation (at 10 years 73% in AR and 64% in AS); however, the difference was not significant.

An additional predictor for reoperation was patient age. In our study, patients between 18 and 25 years of age showed better freedom from reoperation at 10 years compared to the older patients. In younger patients, the process of secondary cusp degeneration is limited as opposed to older patients. Further, gH is higher in younger adults, leaving them with more tissue that is pliable. Thus, smaller patches are required for repair than in older patients. Older patients may also show a trend towards a higher degree of fibrosis of parts of the left/non-coronary cusp, leaving them with essentially less pliable—and functioning—cusp tissue. Larger patches are then required, which have been associated with a higher risk of repair failure [30]. Although the available data do not yet allow for generalization, we use repair as a first line option for patients younger than 18 years. For patients between 18 to 35 years, the decision should be made individually, depending on the extent of of calcification, the degree of fibrosis and the gH. Thus, in patients older than 35 years, a Ross procedure is the most probable option. Beyond the age of 50, a Ross procedure (or mechanical AVR) should always be performed. Thus, repair durability appears acceptable in younger patients, in whom the Ross procedure may be used for cases of repair failure.

LIMITATIONS

The main limitation of this study is its observational design. Although data of consecutive procedures were obtained prospectively, the analysis was performed retrospectively, and treatment allocation was not randomized. The reproducibility of our findings may be limited due to a highly experienced surgeon in a high-volume centre performing the procedures. Despite these limitations, this study is 1 of 2 studies comparing repair and pulmonary autograft replacement for the treatment of unicuspid aortic valves.

CONCLUSION

Bicuspidization of the UAV with external annuloplasty creates a functioning valve configuration. Patch degeneration after repair remains a limiting factor for long-term durability. The incidence of reoperation after the Ross procedure is low but remains poorly defined for UAVs. Thus, for patients younger than 25, repair may be used as a bridge to pulmonary autograft replacement, reserving the Ross procedure for repair failures. For older patients, a primary Ross procedure may be advantageous.

DATA AVAILABILITY

The data underlying this article will be shared on reasonable request to the corresponding author.

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