Cardiovascular Topics

Long-term experience of the modified David V re-implantation technique for valve-sparing aortic root replacement

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Abstract

Objective: The modified David V technique is one of the valve-sparing aortic root replacement (V-SARR) techniques, which is an alternative to traditional composite valve graft root replacement techniques. We aimed to analyse our long-term experience with the modified David V re-implantation technique for the treatment of aortic root aneurysm and significant aortic valve insufficiency.

Methods: From March 2009 to November 2021 the modified David V re-implantation technique, one of the V-SARR techniques, was performed on 48 patients in our centre. The results were analysed retrospectively. Two different-sized grafts were used in all patients. The grafts used in the proximal position were larger than the distal grafts. We performed both intra-operative and post-procedural transoesophageal echocardiography on each patient. All patients were followed by means of transthoracic echocardiography. The mean follow-up period was 5.7 ± 3.1 years.

Results: The mean age of this cohort was 56.3 ± 14.3 years (24–79) and the majority were men (75%). The mean aortic root diameter was 5.1 ± 0.6 cm. The mean diameter for the assending aorta was 5.4 ± 2.1 cm. The in-hospital mortality rate was 4.2% ($n = 2$). One patient needed aortic valve replacement in the early postoperative period. Two (4.2%) patients died in the early postoperative period and four (8.3%) died in the late postoperative period. Overall survival was 91 ± 4 and 86 ± 5% at one and five years, respectively. Aortic valve insufficiancy was at moderate levels postoperatively. Freedom from moderate to severe residual aortic insufficiency was 89.6% at 10 years. None of the patients needed late re-operation of the aortic valve postoperatively. Freedom from valve re-operation was 100% at the end of the follow up.

Conclusions: Our study shows that the David V technique is associated with excellent long-term durability, a remarkably low rate of valve-related complications, and it protects the re-implanted native aortic valve from a second operation. Additionally this technique could be safely implemented in patients with a bicuspid aortic valve and acute type A aortic dissection without leaflet deformity.

Keywords: aortic valve-sparing root replacement, David procedure, re-implantation

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In aortic root aneurysm surgery, if the aortic valve integrity is intact and in a good condition, valve-sparing aortic root replacement (V-SARR) is an alternative technique that is more attractive than other techniques and offers a good quality of life. However, the Bentall de Bono technique, which was first defined 50 years ago, is still the gold-standard technique.[1-3]

Possible problems related to a mechanical or bioprosthetic valve in the composite graft encouraged pioneers to search for alternative methods.[4-6] Therefore, different techniques and modified forms have been described in the literature to protect the aortic valve. V-SARR techniques, defined in the literature over the years, are remodelling (Yacoup procedure, David III) and re-implantation techniques (David IV and David V).[5-8]

Recently, the David V re-implantation technique has become one of the most preferred V-SARR techniques. The same-size grafts are used in the proximal and distal positions. In the David V, a pseudo-sinus is created by narrowing the proximal graft both at the top and the bottom. In addition, a Stanford modification was described in the David V re-implantation technique. In the Stanford modification (a modified David V), a larger size graft (10–12 mm) is used in the proximal position rather than in the distal site. It is intended to create a neo-sinus by using two grafts with different sizes to mimic a natural aortic root and sinus of Valsalva.[8] The neo-sinus ensures long-term durability of the transferred aortic valves.[8,9]

V-SARR techniques are technically challenging to perform, therefore, they require a cardiac centre and an operator with a high amount of experience with the procedure. This may be the reason why the use of the technique has remained limited.[7] In our opinion, aortic root repair could be performed as commonly as mitral valve repairs, especially for modified V-SARR techniques. For this reason, we publish this case series

on patients undergoing the modified David V procedure, and share our long-term experience with the procedure.

Methods

This retrospective cohort study with unidentified patient data was approved by the review ethics board of our hospital and a waiver of consent was obtained (approval no: 2023.02.655).

Our hospital database was analysed retrospectively for patients who underwent the modified David V procedure between 2009 and 2021. Forty-eight patients were included in our study and they were operated on with only the modified David V technique. Other V-SARR techniques were excluded. In our centre, all of these operations were performed by a single surgical team. Operations by other surgical teams were excluded from the study.

Indications for the modified David V technique included aortic root aneurysm with or without significant aortic regurgitation (AR), as recommended by the guidelines,[10,11] dystrophic AR with annulo-ectasia or acute aortic dissection. Two different-sized grafts were used in all patients. The grafts used in the proximal position were larger than the distal grafts.

Electrocardiogram, echocardiogram and BT angiography screening were performed for all patients pre-operatively. If there was a discrepancy in the aortic measurements between the BT angiogram and echocardiography, the BT angiogram measurement was used. A transoesophageal echocardiography (TEE) was performed on all patients at the beginning of the surgery and after the cardiopulmonary bypass (CPB) was ended. Aortic insufficiency (AI) characteristics and aortic dimensions were obtained from intra-operative TEE.

For elective operations, detailed pre-operative screening was performed for any underlying chronic diseases. Five patients (10.5%) were operated on urgently due to acute type A aortic dissection (ATAAD). The data obtained from the medical history were included in the data.

Intubations lasting more than 24 hours postoperatively or re-entubations were defined as respiratory failure. Acute neurological pathologies, diagnosed with central nervous system imaging, were defined as cerebrovascular events. A concomitant surgical ablation was performed for the patients who had pre-operative atrial fibrillation. In the post-operative period, atrioventricular (A-V) block events requiring only pacemaker implantation were defined as a rhythm disorder. In order to evaluate bleeding complications, the need for massive blood transfusions and mediastinal exploratory surgery was investigated. Early mortality was defined as any death occurring during hospital stay or during the first 30 days after the operation, while any other death was considered as late mortality.[12]

We used standard straight grafts to reconstruct the root for all patients. Our re-implantation technique was performed with CPB, moderate hypothermia and intermittent antegrade and retrograde cold-blood cardioplegia. In one arch case, antegrade cerebral perfusion was used throughout the period of hypothermic systemic circulatory arrest and deep hypothermia was performed.

After starting the CPB, a part of the external aortic root was carefully dissected with electrocautery. An aortic cross-clamp was inserted and cardioplegic arrest of the heart was achieved. A horizontal aortotomy 1 cm above the sinotubular junction (STJ) was performed and the valve was carefully examined. Once the other part of the external aortic root dissection was completed, the aortic sinuses were excised, leaving an average of a 5-mm suture rim and the coronary buttons were prepared. At the end of all three commissures, 4-0 pledgeted prolene sutures were placed to determine the angular position and the height of the commissures.

The aortic graft was sized similarly to principles described by Khachatryan *et al*.[13] We used the aortic biological valve-sizer instrument to determine the proximal graft size. The pledgeted commissural sutures were lifted in the vertical position and abutted against the outer surface of the biological valve sizer (Fig. 1). This region corresponds to the imaginary circular STJ. This allows the measurements to be made with the help of the biological valve sizer. We added 4–7 mm to the measured value and this corresponded to the proximal graft size (Fig. 2). This method gave us the advantage of observing the coaptations of

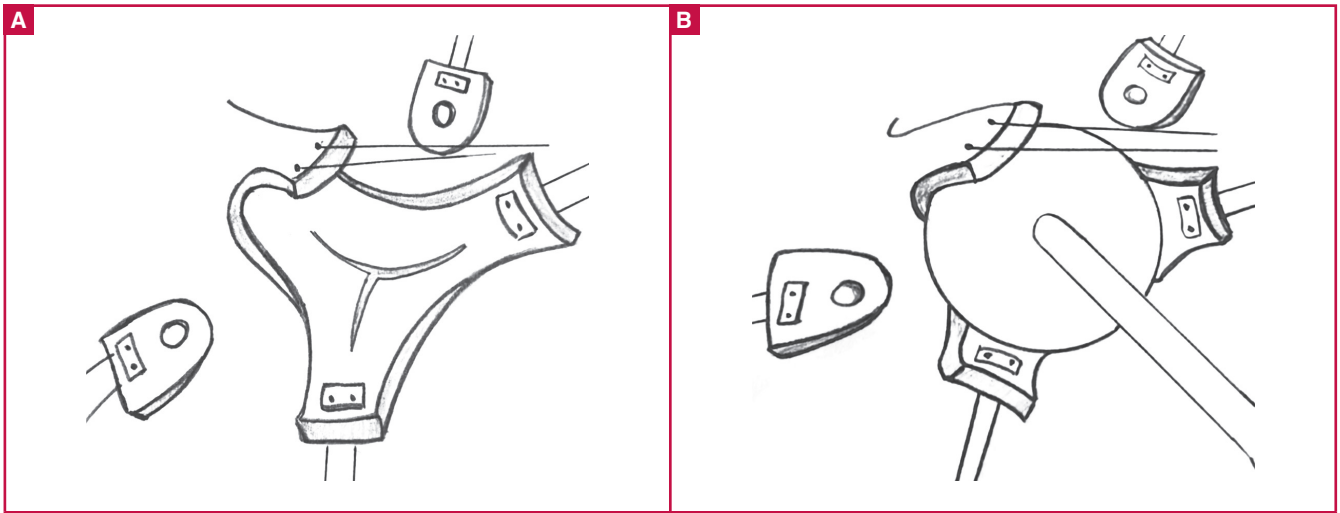

Fig. 1. A: Sizing of the sinotubular junction diameter that will result in optimal aortic valve cusp coaptation. B: The diameter of the imagined circle at the level of the synotubular junction is measured and added to this value by 4 to 7 mm for the modified David V procedure.

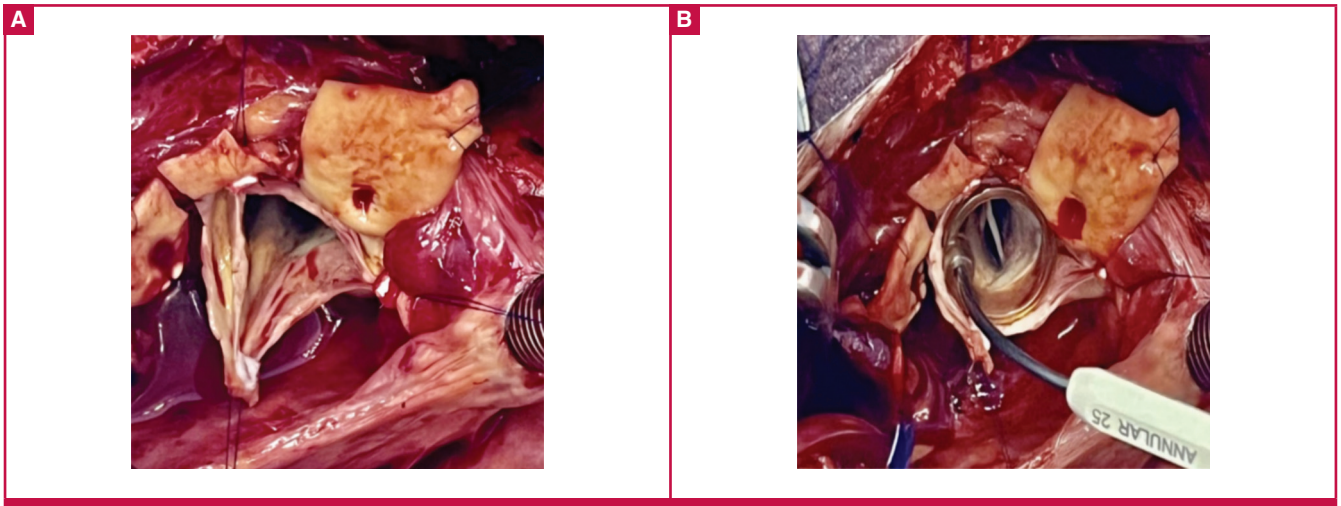

Fig. 2. A. Measuring position of the diameter of the STJ for optimum valve coaptation. B. The modified David V intra-operative proximal graft sizing; in this case, the imaginary STJ is approximately 25 mm. Adding 5 mm to this value, the total value is the proximal graft size.

the aortic cusps from the circular cavity of the biological valve sizer.

The proximal part of the graft was implanted at the ventriculo-aortic junction (VAJ) with 10–12 mattress sutures with/without pledgetes and the proximal graft was narrowed in this plane. Subsequently, the aortic cusps were continuously sutured with 5-0 prolene to the inner part of the stretched graft in a vertical position. Coronary buttons were anastomosed to the graft with 6-0 prolene. A graft that was smaller than the proximal graft was chosen as the distal graft. The two grafts were then anastomosed to each other with 4-0 prolene. The proximal graft was also narrowed in this plane. Hence, the pseudo-sinus was created (Fig. 3).

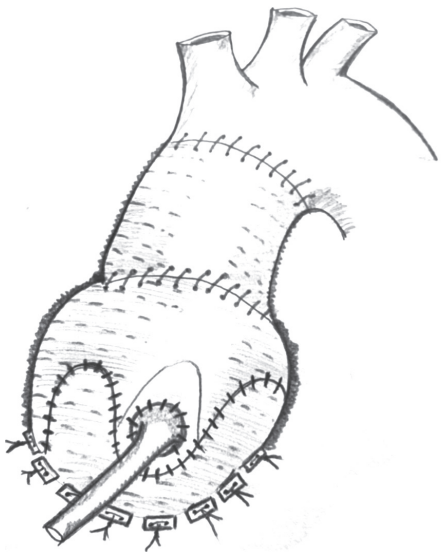

Fig. 3. The completed modified David V procedure is shown. Two different-sized grafts are used in this technique. The graft used in proximal position is always larger than the distal graft.

In TEE after CPB, a prerequisite for a successful repair is a coaptation length of at least 5 mm in the middle of the free border and an effective height of 8–10 mm. The presence of residual moderate AR or mild eccentric AR was an indication for re-exploration of the aortic valve.[14,15]

Transthoracic echocardiography (TTE) was performed on all patients in the early postoperative stage and after discharge, during follow up. Aortic valve insufficiency was evaluated using recent literature and international guidelines. Aortic valve insufficiency was categorised as: trace or trivial (0); mild (1); moderate (2); moderate–severe (3); or severe (4+). When the regurgitant volume was used to grade AI, 0 indicated no regurgitation; 1+ was a regurgitant volume < 30 ml; 2+ was a regurgitant volume of 30–44 ml; 3+ was a regurgitant volume of 45–60 ml; and 4+ was a regurgitant volume > 60 ml.

Postoperative length-of-stay calculations excluded patients who had died in hospital. Two (4.2%) of the patients died within the first 30 days postoperatively and were included as early mortalities. Therefore, data from these two patients were excluded when calculating the median postoperative length of stay.

Intra-operative conversion to a valve-replacing procedure because of severe valve dysfunction was considered repair failure.[16] One patient had severe AI at postoperative day one and we had to perform an aortic valve replacement (AVR).

The clinical follow up extended from 2.5 months to 9.8 years with a mean of 5.7 ± 3.1 years. The follow up was ended on 31 April 2022. The contact information of 45 live patients was obtained. These patients were contacted at six-month intervals and the data obtained were recorded. All of the patients were followed up every year as out-patients. Results were evaluated in terms of overall survival, incidence of re-operation, degree of residual aortic valve insufficiency and incidence of postoperative complications.

Statistical analyses

Statistical analyses were performed utilising SPSS version 23 software (SPSS, Inc, Chicago, IL, USA). The conformity of

variables to a normal distribution was examined via visual (histogram and probability graphics) and analytical methods (Kolmogorov–Smirnov or Shapiro–Wilk tests). The definitive analysis was obtained using frequency tables for categorical variables and mean and standard deviation for normally distributed variables. Intensive care unit stay and discharge time were not normally distributed. They are given as median and interquartile range. Survival and freedom from re-intervention on aortic valve data were obtained from life table analyses and are presented with standard error.

Results

The mean age of this cohort was 56.3 ± 14.3 years (24–79) and the majority were men (75%). Sixteen (33.5%) of the patients were obese and five of these patients were morbidly obese. Five (10.41%) of the 48 patients had ATAAD, four (8.3%) had Marfan syndrome and five (10.41%) had bicuspid aortic valve (BAV). The mean aortic root diameter was 5.1 ± 0.6 cm (3.7–6.8) and the mean diameter for the assending aorta was 5.4 ± 2.1 cm (3.4–8.1). Forty-six patients (95%) had at least moderate AR. Two of the patients with BAV had grade 4+ AI, two had grade 3+ AI and one had grade 1+ AI. Twenty-eight patients (58.3%) had symptoms graded as New York Heart Association (NYHA) class II or higher. Table 1 summarises the pre-operative data of these patients.

In 28 (58.3%) of the 48 patients, the isolated modified David V technique was performed. In 20 (41.7%) of the patients, the modified David V and additional surgical procedures were performed simultaneously. Mean aortic cross-clamp time and CPB time were 165 ± 35 minutes (100–227) and 205 ± 30 minutes (135–420), respectively. The mean proximal and distal graft sizes were 33.4 ± 0.9 mm (30–34) and 29.4 ± 1.1 mm (26–32), respectively.

In pre-operative echocardiography, > grade 2 mitral insufficieny was detected in six patients and concomitant mitral valve repair was performed. In pre-operative screening, coronary artery disease was seen in 11 patients and complete revascularisation was performed concomitantly. Three patients needed additional leaflet repair to the aortic cusps because the non-coronary cusp of the aortic valve was prolapsing. Free margin plication was performed in one patient and free margin resuspension was performed in the other two patients.

In five patients (10.54%) with BAV, no additional leaflet repair was required on the aortic valves and only the David V re-implantation technique was performed. Two patients had

Table 1. Pre-operative data (n = 48)

Characteristics	*Results*
Gender (male)	36 (75)
Age (years)	56.3 ± 14.3 (24–79)
BMI (kg/m^2)	28.4± 5.2 (18–46)
Associated diseases	
Hypertension	31 (64.6)
Diabetes mellitus	10 (20.8)
COPD	14 (29.2)
CAD	11 (20.8)
Renal insufficiency	5 (10.4)
Marfan syndrome	4 (8.3)
BAV	5 (10.4)
Electrocardiography	
Sinus rythm	46 (95.8)
Ascending aorta pathological condition	
ATAAD	5 (10.4)
Aneurysm without dissection	43 (89.5)
Echocardiographic values	
LVEF (%)	59.2 ± 9.7 (30–65)
LVESD (cm)	3.7 ± 0.9 (2.6–6.3)
LVEDD (cm)	5.5 ± 0.9 (4.2–7.6)
LVH	5 (10.5)
BAV	5 (10.4)
Aortic insufficiency, n (%)	
0 (trace, or trivial)	1 (2.1)
1+ (mild)	1 (2.1)
2+ (moderate)	21 (43.8)
3+ (moderately severe)	17 (35.4)
4+ (severe)	8 (16.7)
Diameters (cm ± SD)	
Aortic annulus	2.9 ± 0.4 (1.9–4)
Sinus of Valsalva	5.1 ± 0.6 (3.7–6.8)
STJ	5.2 ± 0.7 (3.7–8)
Ascending aorta	5.4 ± 2.1 (3.4–8.1)
NYHA classification	
Class I	20 (41.6)
Class II	18 (37.5)
Class III	4 (8.3)
Class IV	6 (12.5)
Previous sternotomy	0

Values are presented as mean ± standard deviation or frequencies (%).
BMI: body mass index, COPD: chronic obstructive pulmonary disease, CAD: coronary artery disease, LVEF: left ventricular ejection fraction, LVESD: left ventricular end-systolic diameter, LVEDD: left ventricular end-diastolic diameter, LVH: left ventricular hypertrophy, BAV: bicuspid aortic valve, STJ: sinotubular junction, ATAAD: acute type A aortic dissection; NYHA: New York Heart Association.

Table 2. Operative data

Operation type	*Number*	*ACCT (min)*	*CPBT (min)*
Isolated mDav V	28 (58.3)	157 ± 26 (120–221)	210 ± 57 (152–420)
mDav V + extra leaflet repair	3 (6.3)	162 ± 31 (158–169)	192 ± 9 (181–201)
mDav V + aortic arch replacement	1 (2.1)	180	230
mDav V + MVRx	3 (6.3)	164 ± 34 (160–171)	195 ± 10 (184–205)
mDav V + MVRx + ablation	1 (2.1)	127	193
mDav V + CABG + ablation	1 (2.1)	145	180
mDav V + MVRx + CABG	2 (4.2)	207 ± 38 (180–234)	251 ± 29 (230–272)
mDav V + CABG	8 (16.7)	176 ± 42 (100–227)	213 ± 47 (135–286)
mDav V + ASD repair	1 (2.1)	160	180
Total	48	165 ± 35 (100–227)	205 ± 30 (135–420)
Graft diamaters (mm ± SD)			
Proximal graft	33.4 ± 0.9 (30–34)		
Distal graft	29.4 ± 1.1 (26–32)		
Hypothermic circulatory arrest used	1 (2)		
Circulatory arrest time, min	25		
With antegrade cerebral perfusion	1 (2)		
Antegrade cerebral perfusion time, min	24		

Values are presented as mean ± standard deviation or n (%).
ASD: atrial septal defect, ACCT: aortic cross-clamping time, CABG: coronary artery bypass graft, CPBT: cardiopulmonary bypass time, mDav V: modified David V procedure, MVRx: mitral valve repair, SD: standard deviation.

atrial fibrillation in the pre-operative screening and concomitant surgical ablation was performed. In one patient with aortic dissection, the dissection flap reached the aortic arch. Total arch replacement and the David V were performed concomitantly. One patient had secundum type atrial septal defect (ASD) with a 1-cm diameter. ASD repair and the David V technique were performed concomitantly. Table 2 describes the operative data.

Two (4.2%) of the elective patients died in the early postoperative period. The first was a 76-year-old patient with a hypertrophic left ventricle. Low-cardiac-output syndrome occured in the early postoperative period, from which the patient did not recover. The David V technique, coronary revascularisation and mitral valve repair procedures were performed concomitantly on the second patient. Severe intracranial haemorrhage was seen in the postoperative period and the patient died due to this complication. There was no mortality in patients who were operated on urgently. Postoperative data and complications are presented in Table 3.

One patient (2.1%) presented with aortic valve calcification, and concurrent decalcification was performed. This patient had a low diastolic pressure on postoperative day one. Severe AI was observed on TTE and a re-operation was needed in the early stage. Severe leaflet perforation was noticed in the site where decalcification was performed. A mechanical aortic prosthetic valve was implanted inside the existing graft and the patient was discharged nine days later.

Four (8.3%) of the patients died in the late stage. The first patient died on postoperative day 61, due to pneumosepsis. The second patient had chronic obstructive pulmonary disease and diabetes mellitus pre-operatively and died due to an unknown reason in the postoperative third month. The third patient died due to massive gastrointestinal bleeding three years after the surgery. The fourth patient's left ventricular ejection fraction (LVEF) was 35% and the left ventricular end-diastolic diameter (LVEDD) was 7.2 cm pre-operatively. The patient was admitted to another centre with resistant ventricular fibrillation four years after the surgery and died.

Only one patient (the third patient) (2.1%) had a major bleeding complication and died because of it. In contrast to that, no thromboembolic events occured in any of our patients. The median follow up for five patients with BAV was 5.3 ± 3.7 years (0.2–9.5) and none died. No aortic stenosis or ≥ 2+ AI was detected in their follow up.

Table 3. Postoperative data

Variables	*Results*
LCOS	1 (2.1)
CVE	2 (4.2)
Respiratory failure	8 (16.7)
Bleeding	4 (8.3)
Pericardial tamponade	2 (4.2)
Sternal dehiscence	3 (6.3)
Rythm disorder	1 (2.1)
Early repair failure (intra-operative conversion to AVR)	1 (2.1)
ICU stay (day ± SD)	2 ± 2 (1–51)
Hospital stay (day ± SD)	9 ± 8 (5–51)
30-day mortality	2 (4.3)

Values are presented as mean ± standard deviation or frequencies (%).
AVR: aortic valve replacement, CVE: cerebrovascular event, ICU: intensive care unit, LCOS: low-cardiac-output syndrome, SD: standard deviation.

A total of six patients died during follow up. One patient needed an AVR procedure in the early period. In other words, procedure failure occured in only one patient who had undergone AVR. Actual survival rate at one year was 91 ± 4% and at 10 years it was 86 ± 5%. The overall survival rate for all patients is shown in Fig. 4.

At the end of our follow up, no more than moderate AI was detected in any of the patients. Five (10.4%) of the patients had moderate AI, 13 (27.03%) had mild AI, and 20 (41.6%) had no AI. Freedom from moderate to severe residual AI was 89.6% at 10 years (Fig. 4). None of our patients needed an aortic valvular re-intervention in the late term. Additionally, no deformities were seen in our re-implanted aortic valves. Freedom from valve re-operation was 100% at the end of follow up.

Discussion

As evident from recent studies, the long-term results of the V-SARR technique are better than composite graft replacements. Despite this, composite graft replacement is still the preferred technique.[7,17,18] The reason for this might be that when both techniques are compared, V-SARR (especially the David V) is a multi-stage operation with more parts to be sutured, and it needs precise mathematical measurements. It also needs experienced surgical staff and dedicated cardiac centres. The duration of the operation is also longer and there are few studies on the technique in the literature. Because of this, V-SARR techniques are less popular.

Studies need to be conducted at cardiac centres with experienced surgeons and high patient volumes in order to provide more adequate scientific data in order to evaluate

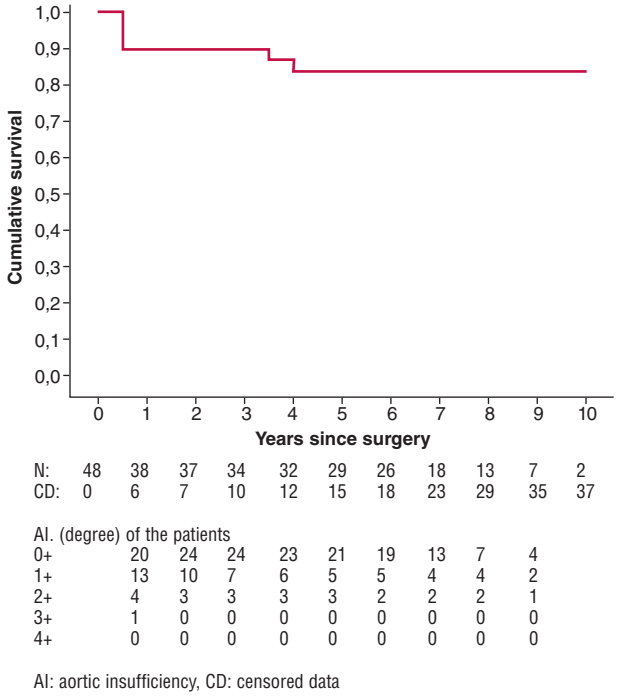

Fig. 4. Freedom from death and degree of aortic insufficiency of the patients.

V-SARR more effectively. More studies on V-SARR would also allow more cardiac surgeons to acquire experience in these procedures.

In the modified David V technique (Stanford modification), two different grafts are used in order to create an artificial neo-sinus.[13] The artificial sinus allows the valves to remain durable in the long term. The modified David V technique stands out among other V-SARR techniques because of its known positive effects on aortic valve physiology.[19-22] In our case series on the modified David V procedure, no symptomatic AI due to aortic cusp deformity was observed. Hence, none of our patients needed a second operation on the aortic valve. This may have been due to the neo-sinuses that were created and the low volume of leaflet repairs needed in our patients.

In the past, various methods have been described for the selection of graft size in the David procedure. The original method is based on the Feindel–David formula.[6] Later, David himself described using grafts that were approximately twice the mean heights of the valve cusps for the David V procedure.[23] In addition to these graft-selection criteria, there are many methods described in the literature.

The majority of currently available complex formulae for graft sizing are based on relative dimensions of the normal aortic root.[24] However, it should not be forgotten that there is no normal aortic root anatomy, especially in patients with large aneurysms or BAV. Therefore, choosing the graft size based on fixed normal aortic valve sizes only, such as annular diameter, may be misleading.[13] The main purpose of sizing is to obtain an appropriate aortic cusp coaptation site and length, while at the same time avoiding prolapse.

We did not use these formulae to determine proximal graft size in this series. We measured the imaginary STJ distance at which the aortic valves were coapted and there was no prolapse with a valve-measuring instrument. We then determined the graft size by adding an average of 4–7 mm to this value. This method is similar to the method used by Khachatryan *et al*.[13]

The percentage of a second operation for AI would be slightly higher in a case series with larger numbers of BAV and aortic leaflet repair. In a study by Mastrobuoni *et al*., regarding re-operation on the aortic valve, they reported freedom from re-operation of more than 90% at 10 years.[25] David and colleagues reported freedom from re-operation of more than 95% at 10 years.[26] The reason for the disparity in these two studies is explained by the different percentage of patients with BAV and the need for additional valve repair. Besides, in the first study, it was observed that more additional leaflet repair was also needed in other patients without BAV.[25]

Another problem in patients with BAV is the possibility of developing aortic stenosis after the operation during follow up. Also, in patients with BAV accompanied by a genetic syndrome, the risk of developing aortic dissection after the operation should not be forgotten.[27,28] We have not observed aortic stenosis or aortic dissection in our patients with BAV during follow up.

It has been reported that when BAV involvement is present, surgeons are skeptical and favour conventional techniques.[17] However, pioneers point out that BAV involvement is not a contra-indication for V-SARR techniques and recommend re-implantation techniques if indicated.[29] Furthermore, long-term results of patients with bicuspid and tricuspid aortic valves who underwent re-implantation techniques were similar.[8] In our case series, five patients had BAV. In their follow up, none of these patients died and no more than ≥ 2+ AI was detected.

An aortic valve conduit graft may be an option in the case of early AI development in patients who had V-SARR techniques implemented.[9] A similar pathology only occured in one of our patients. We performed a mechanical AVR into the graft of the David V and the patient was discharged without any complications. We therefore believe that, in similar situations, the application of AVR into the graft may be simple and sufficient.

In recent studies, the operative mortality rate of V-SARR techniques was below 2% in centres with experienced surgeons.[8,17,29-32] However with these techniques becoming more popular, in-hospital mortality rates increased up to 6% in some European centres.[33] The causes of mortality in these cases were mostly cerebrovascular events, low cardiac output, multi-organ failure, and less frequently, bleeding.[9,29,30,33-36] In our series, in-hospital mortality occurred in two (4.2%) patients. In some publications, the mortality rate was higher in aortic dissection or emergency operations,[33,34,37-39] however, in our series, five patients (10.4%) were operated on urgently. There were no mortalities in any of these patients who were operated on for ATAAD.

Some authors suggest that V-SARR surgeries should be performed only in centres where the 10-year freedom from valve re-operation or mortality exceeds 90%.[8] In our series, the mean follow-up period was 5.7 ± 3.1 (0.2–9.8) years. Six patients (12.5%) died. One (2.1%) patient was re-operated on because of a severe AI that ocurred in the early postoperative period. A stage 3+ AI was present in only one patient in the first year of surgery. This patient had primary hypertension and the patient's angiotensin-converting enzyme inhibitor medication was increased gradually to the maximum dosage. This patient was under follow up for five years and the patient's AI grade was 2+ at the last TTE check up.

At the end of our follow up, none of our patients had > grade 2+ AI on TTE. Thirty-six (75%) patients had normal aortic valve function or grade 1+ AI and five (10.4%) had moderate AI. In other words, freedom from moderate to severe residual AI was 89.6% (43 patients) at 10 years.

In an article written by David in 2010, freedom from moderate to severe aortic insufficiency at 12 years was reported as 91.0 ± 3.8% after re-implantation.[18] In a prospective study of 83 patients, by Coselli *et al*. on aortic root aneursym, it was reported that the grade of AI would remain stable postoperatively.[12] Similarly, no progression of AI was observed in our case series and ≤ grade 2+ AI was well tolerated in these patients unless a deep bradycardia occurred.[7] We agree with this opinion and believe that, especially in older patients, β-blocker treatment should be initiated after a good evaluation.

Study limitations

This study has several important limitations, including those inherent in retrospective reviews. The mean follow-up period in this study was 5.7 ± 3.1 years, so the longer-term durability of the modified David V technique cannot be inferred from our findings. Another limitation is that the study had a small sample size.

Conclusions

In our experience, this study shows that the modified David V technique can be effective, with excellent long-term durability,

it protects the re-implanted native aortic valve from a second operation, and it offers a better quality of life. Even so, follow up remains necessary to evaluate the long-term durability of V-SARR. We also found that this technique could safely be applied in BAV and ATADD patients without leaflet deformity. In our opinion, the technique is an important option that precludes complications arising from mechanical/biological valves of the composite graft. A large number of studies are nevertheless needed to prove the effectiveness of the technique and promote more widespread use.

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