ORIGINAL ARTICLE

Multinational and Cross-Sectional Survey on Valve-Sparing Aortic Replacement Controversies

Encuesta multinacional y transversal sobre las controversias del reemplazo de la raíz aórtica con conservación valvular

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ABSTRACT

Background: The valve-sparing aortic root replacement (VSAR) has been established as a successful procedure for aortic root aneurysms, Marfan's syndrome, bicuspid valves, and aortic dissections. However, there is a need for a consensus opinion regarding key aspects of VSAR.
Methods: A literature review was performed regarding the most frequent debates and controversies in VSAR. An online survey was developed based on this information, and sent to surgeons with known expertise in VSAR regarding their opinion on patient-related factors, technical aspects, echocardiography, research, training, and the future of VSAR.
Results: Twenty surgeons completed the survey. The reduction of left ventricular ejection fraction was considered a contraindication to VSAR when severe by 14/20 surveyed. The aortic annulus diameter cutoff point for the remodeling was heterogenous among participants. All of them felt that VSAR is safe for the Marfan´s syndrome population and bicuspid valves. For type A dissections, 11/20 preferred this procedure only in young patients. Regarding to graft sizing, the height of the interleaflet triangle (8/20) and the sino-tubular diameter (7/20) were the more frequent considered parameters. Surgeons reported a 7% of failure rate, leading to conversion to Bentall surgery, and a 26% change of strategy intraoperatively. A minimally invasive approach was not considered to improve results. Most of the surgeons agreed that VSAR should be performed by high-experienced surgeons.
Conclusions: The VSAR has been accepted as a treatment option for the aortic root´s aneurysms, and even though there is still not possible to reach a final consensus, a valuable experience from the most relevant surgeons in the field is presented.

Keywords: Aortic Valve Insufficiency - Heart Valve Prosthesis Implantation - Cross-Sectional Studies - Surveys and Questionnaires - Argentina

RESUMEN

Introducción: El reemplazo de la raíz aórtica con conservación valvular (*valve-sparing aortic root replacement, VSAR*) se ha consolidado como un procedimiento eficaz para el tratamiento del aneurisma de la raíz aórtica, el síndrome de Marfan, la válvula bicúspide y la disección aórtica. Sin embargo, es necesario llegar a una opinión unánime sobre los aspectos clave del VSAR.
Material y métodos: Se realizó una revisión bibliográfica de los debates y controversias más frecuentes del VSAR. A partir de esta información se elaboró una encuesta en línea que se envió a cirujanos con experiencia comprobada en VSAR para conocer su opinión sobre los factores relacionados con los pacientes, los aspectos técnicos, la ecocardiografía, la investigación, la formación y el futuro del VSAR.
Resultados: Veinte cirujanos completaron la encuesta. Según 14 de cada 20 encuestados, la fracción de eyección grave se consideró una contraindicación para el llevar a cabo este procedimiento. El límite del diámetro del anillo aórtico para la remodelación fue heterogéneo entre los participantes. Todos ellos consideraron que el VSAR es un procedimiento seguro para los pacientes con síndrome de Marfan y válvula bicúspide. En el caso de disección de tipo A, 11 de cada 20 prefirieron este procedimiento solo para los pacientes jóvenes. En lo que respecta al tamaño del injerto, la altura del triángulo intervalvar (8/20) y el diámetro sinotubular (7/20) fueron

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los más frecuentes. Los cirujanos informaron una tasa de fracaso del 7% en la conversión al procedimiento de Bentall, y un cambio de estrategia intraoperatoria del 26%. No se consideró que un abordaje mínimamente invasivo mejorara los resultados. La mayoría de los cirujanos coincidieron en que el VSAR lo deben realizar cirujanos con mucha experiencia.
Conclusiones: El VSAR ha sido aceptado como una opción terapéutica para el aneurisma de la raíz aórtica, y, aunque todavía no es posible llegar a un consenso definitivo, se presenta la valiosa experiencia de los cirujanos más destacados en este campo.

Palabras clave: Insuficiencia de la Válvula Aórtica - Implantación de Prótesis de Válvulas Cardíacas -Estudios Transversales - Encuestas y Cuestionarios - Argentina

INTRODUCTION

Following the first descriptions by Tirone David and Magdi Yacoub (1,2) the valve-sparing aortic replacement (VSAR) has been established as a successful procedure for aortic root aneurysms.

There are specific advantages of VSAR when compared to conventional aortic root replacement with a valved conduit, and include decreased possibility of valve thrombosis, thromboembolism, bleeding events associated with anticoagulation, structural valve deterioration, and endocarditis. (3,4) Preservation of the native aortic valve has become an attractive option to avoid these undesirable events.

There are mainly two types of VSAR techniques: reimplantation and remodeling. In both, the aortic root is excised preserving the native valve, but there are differences in terms of technical aspects. In reimplantation, the Dacron graft is attached at the level of the aortic annulus, giving support to this structure. In remodeling, the graft is sutured at the level of the aortic sinuses. This last one requires less time and is easier, but there is a lack of aortic annulus support, increasing the rate of aortic regurgitation during the follow-up. Adding external support for the annulus (i.e., ring, suture, etc.) can solve this disadvantage.

The VSAR technique has become an accepted operation for patients with Marfan's syndrome and other connective tissue disorders as well as for patients with aortic dissection. It has also gained increasing use in patients with bicuspid aortic valves. (5-9)

Over the years several modifications have been proposed and opinions differ amongst surgeons regarding technical aspects, indications, and the future of VSAR.

We believe there is a need for a consensus opinion regarding key aspects of VSAR, as well as what skills are necessary for a surgeon to safely and effectively perform VSAR.

This survey of surgeons with known expertise in VSAR operations provides a summary of their views.

METHODS

A literature review was performed regarding the most frequent debates and controversies in VSAR. List of relevant questions was prepared and evaluated by experts. Authors with known expertise in VSAR operations were identified and asked to participate in the project. A survey was developed, and questions were reviewed and chosen by the authors (GF, MM, TD, CF, EL, RM). Inclusion criteria required that surgeons have performed VSAR with a minimum of 25 cases, either reimplantation or remodeling technique.

A total of 25 surgeons with known experience in this field spanning 10 countries and 15 different institutions were identified and selected. They were contacted through email and asked to participate voluntarily in the survey. In total, 5 participants´ answers were excluded for incomplete/inconsistent survey responses. An online platform was developed using 46 multiple-choice questions. The questions were focused on:

1. Indications and patient-related factors,
2. Technical and anatomy-related aspects
3. Echocardiography findings
4. Research, training, and the future.

RESULTS

Of the 20 responders, 13 (65%) have ≥ 100 VSAR in their expertise, 3 (15%) more than 50, and 4 (20%) between 25 and 50. Everyone accepted to participate voluntarily in this financially unfunded project.

Indications and patient-related factors (Table 1) (Fig. 1)

(Q.4) Severe left ventricular dysfunction was a contraindication for VSAR: 14/20 of the responders.

(Q.5) The aortic annulus diameter cutoff for the remodeling procedure was heterogenous between the options: 8/20 believe there is no limit for a remodeling technique; however, 3/20 prefer this method for small annulus (20-22 mm), 4/20 would consider the cutoff in 24-26 mm and 5/20, ≥28 mm.

(Q.6) Severity of aortic regurgitation (AR) was not considered a limitation for the VSAR.

(Q.7-8) 11/20 (55%) responders decided to perform prophylactic VSAR in Marfan group when the aorta measured ≥ 5 cm and 8/20 when it was ≥ 4.5 cm. Moreover, everyone (100%) considered the VSAR as a safe operation for this population.

(Q.9-10) 12/20 responders are willing to bicuspid valves especially if the surgeon has expertise in the field; besides 14/20 considered that cusps anatomy (type 0 vs 1) as a predictor of AR recurrence.

(Q.11-12) There was a strong tendency to avoid VSAR in type III lesions (17/20). In acute aortic dissections, more than half (11/20) preferred to perform the VSAR only in patients consider younger or below 50 years; nonetheless, 18/20 accept this procedure when is feasible even in this scenario.

Technical and anatomy-related aspects (Table 2) (Fig. 2)

(Q.13-16) Of the asked surgeons, 9/20 believe that the lack of neo-sinuses in the reimplantation technique adds stress to the cusps but does not affect the general results. Interesting, half of the participants think it is useful to standardize an external ring in the remodeling technique, and most of them use Hegar when tying to maintain annular size.

Table 1. Indications and patient-related factors

Question number	Option A	Option B	Option C	Option D
1. Please select the region of your place of work	North America: 6 (30%)	Latin America: 4 (20%)	Europe: 9 (45%)	Asia: 1 (5%)
2. ¿How many VSAR have you performed in your experience?	≥ 25-50: 4 (20%)	50-100: 3 (15%)	100 -200: 5 (25%)	>200: 8 (40%)
3, This is an unfunded project, and there is no conflict of interest. ¿Are you willing to participate voluntarily in this project?	Yes:20 (100%)	No: 0 (0%)		
4. ¿Do you consider the severity of LV dysfunction as a contraindication for VSAR?	Yes, with mild LVEF: 0 (o%)	Yes, with moderate LVEF: 0 (0%)	Yes, with severe LVEF: 14 (70%)	No: 6 (30%)
5. ¿What is the aortic annulus diameter cutoff you consider for a remodeling procedure?	20-22mm: 3 (15%)	24-26mm: 4 (20%)	28-34mm: 5 (25%)	No limit: 8 (40%)
6. ¿What degree of preoperative AR would make you hesitant to try to preserve the valve?	AR 1+: 0 (0%)	AR 2+: 0 (0%)	AR 3+: 1 (5%)	AR is not a limitation: 19 (95%)
7. ¿When do you recommend performing prophylactic VSAR in the asymptomatic Marfan population?	With ascending aorta diameter ≥ 4.5 cm: 8 (40%)	With ascending aorta diameter ≥ 5 cm: 11 (55%)	With ascending aorta diameter ≥ 5.5 cm: 1 (5%)	
8. Some authors suggest that in the Marfan group a composite conduit replacement is the indication because fibrillin deficits affect the leaflets. ¿Do you consider that VSAR is a safe procedure for this population?	Yes: 20 (100%)	No, I prefer a Bentall/ other procedure: 0 (0%)		
9. ¿Should a bicuspid valve with aortic root aneurysm be repaired initially?	Yes, always try to do it when is possible: 15 (75%)	Yes, but only in young patients: 2 (10%)	Only by experienced surgeon. If not, Bentall/other: 3 (15%)	No: 0 (0%)
10. ¿Do you think that cusps anatomy in bicuspid valve (type 0 vs 1), is predictor of AR recurrence?	Yes: 13 (65%)	No: 7 (35%)		
11. In type III lesion, ¿do you consider initially to perform/indicate a VSAR?	Yes, and try concomitant decalcification/ shaving / patch extension: 3 (15%)	No, Type III lesions have unsatisfactory results in VSAR: 17 (85%)		
12. ¿Would you recommend VSAR in acute aortic dissections?	Always try to do it: 7 (35%)	Only in patients ≤ 50 years or considered young: 11 (55%)	No, I prefer a Bentall/ other procedure: 2 (10%)	

AR: aortic regurgitation; LVEF: left ventricle ejection fraction; VSAR: valve sparing aortic replacement.

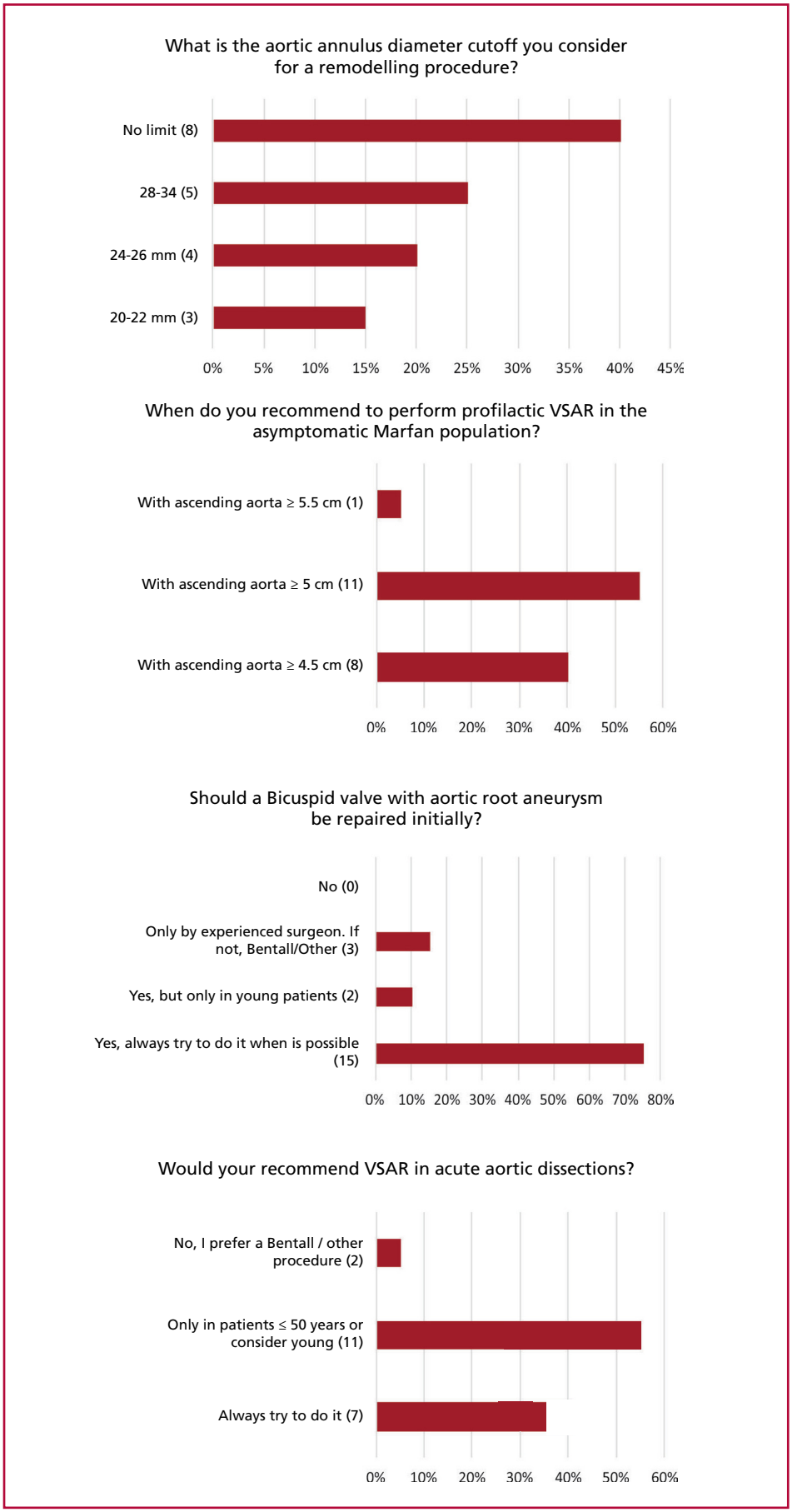


Fig. 1. Indications and patient-related factors.

(Q. 17-18) The majority (13/20) believed that a minimum target of cusps effective height to assume successful the procedure must be >8 mm. When asked if annulo-aortic ectasia is a contraindication for remodeling, 14 preferred to do reimplantation; however, 7 of them still prefer a remodeling with external stabilization.

(Q. 19-22) Notoriously, almost half of the responders assured that a Dacron non-compliant graft increases the risk of distal aortic disruption, and 11 out of 20 prefer a Dacron rather than a Valsalva graft. More than half (65%) use mid-leaflet plication for excessive valve prolapse.

(Q. 23) According to graft sizing, the height of the interleaflet triangle as a basis for graft sizing (8/20) and the measure of the sino-tubular junction with a Hegar (7/20) were the most selected choices.

(Q. 24) Regarding stabilization of the aortic annulus in the remodeling technique, only the group of surgeons who perform this technique answered this question, and 7/20 use an extra-aortic ring for stabilization.

(Q. 25-27) When there are more than 2 leaflets with fenestration, 80% will not try to preserve the valve, and for those who accepted to repair a calcified valve, the major part will only do it if it is mild.

(Q.28) Eleven out of twenty don´t use the caliper routinely.

(Q. 29-31) Most of the participants agree that in bicuspid valves, the tricuspidization is reasonable only if the commissure presents orientation near 120º, and shaving is the most frequent technique used for the raphe (14/20). Moreover, 15 out of 20 are convinced that the pericardial patch used for cusp restoration after raphe resection is not advisable.

(Q. 32) The surgical strategy decided preoperatively changed due to intraoperative findings in 29% on average.

(Q. 33) The estimated VSAR failure rate, with conversion to a Bentall procedure was almost 7%.

(Q. 34) Sixty percent of the responders would consider switching to a Bentall procedure when the post-VSAR echocardiography reveals AR ≥ mild.

(Q. 35) In redo operation in failed VSAR, a minority (3/20) are willing to re-repair the valve, but the majority prefer a Bentall/aortic valve replacement.

Echocardiography Findings (Table 3) (Fig. 3)

(Q. 36-38) The majority of the participants (16/20) think that echocardiography provides accurate anatomy assessment and is predictive of valve repairability; however, they still need to re-check intraoperatively to decide definitively what to do. Additionally, for fifteen of the responders, the echocardiography findings correlate with the intraoperative findings.

(Q. 39-40) With regard to the AR predictors, most of the participants have chosen the effective height, coaptation length, and immediate post-VSAR residual AR as the most important factors.

Research, training, and the future (Table 3) (Fig. 3)

(Q. 41) Most of the surgeons believed that doing this procedure with a resident does not affect the results.

(Q. 42) Interestingly, almost all the responders (19/20) affirmed that a minimally invasive approach (MICS) doesn't improve the postoperative results or even make any difference.

(Q. 43) Most of the surgeons assured that VSAR must only be performed either by high-volume centers or by experienced surgeons.

(Q. 44-46) 75% of the participants think that 3D printing could be helpful sometimes or even is the future for preoperative decisions, and 16 out of 20 considered that the intention to repair the aortic valve should be the standard for all candidates for a VSAR.

DISCUSSION

Both re-implantation and remodeling techniques have been shown to adequately preserve aortic valve function in patients with aneurysms of the aortic root, Marfan´s syndrome, and type A aortic dissection. (2,9-12)

This survey mirrors the controversies regarding indications, technical aspects, echocardiography use, and the future.

Even though a broad variety of experienced surgeons worldwide have participated in this questionnaire, it is still difficult to reach a final consensus on some key aspects of VSAR operations. However, we believe that the opinion based on the clinical experience of the most experienced surgeons of the world on this topic has a fundamental value. The broad spectrum of the results reflects the different surgeon-specific criteria when performing VSAR.

It has been demonstrated that aortic annular dilatation is a risk factor for early and late failure. (13) Hanke et al. proved that patients who underwent remodeling technique with an aortic annulus greater than 28-30 mm presented worse results at follow-up compared to those who underwent reimplantation. (14) Notoriously, 8/20 participants (40%) will proceed with a remodeling technique regardless of the aortic annulus diameter, undoubtedly due to the personal preference for one technique over the other one, but more importantly, this could be explained because surgeons who prefer the remodeling technique, have performed the ¨modified remodeling¨ which includes the external aortic annulus support with the aim to avoid the AR during the follow-up. The lack of this annulus support was the Achilles heel in aortic annulus greater than 28 mm.

While more than 90% don´t believe that preoperative AR is a limitation, David and colleagues have suggested that patients with preoperative severe AR are not good candidates since they often have damaged cusps. (10)

Contrary to surgeons' thoughts decades ago, most now feel (100% in this survey) that VSAR is a safe procedure for the Marfan's syndrome population. There

Table 2. Technical and Anatomy-Related Aspects

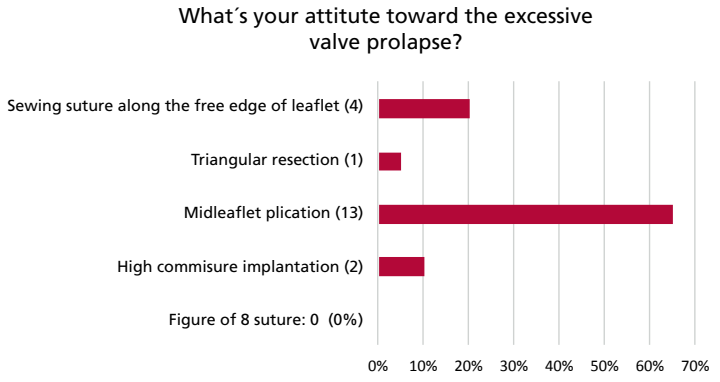
Question number	Option A	Option B	Option C	Option D	Option E
13. ¿Which cardioplegia do you think is more reasonable to use in VSAR?	Bretschneider: 2 (10%)	Cold blood: 10 (50%)	Del Nido: 6 (30%)	Other: 2 (10%)	
14. In the reimplantation technique, ¿does the lack of neosinuses add stress to cusps?	Yes, that is why I prefer a remodeling technique: 4 (20%)	No: 7 (35%)	Yes, but the general result/follow-up are not affected: 9 (45%)		
15. ¿Do you think is useful to standardize in remodeling technique the use of an external ring?	Yes: 11 (55%)	No: 9 (45%)			
16. ¿Do you use Hegar within the aortic annulus while tying?	Yes, it´s mandatory to maintain annular size and adequate LVOT: 12 (60%)	No: 8 (40%)			
17. ¿What is your minimum target of cusps effective height to assume successful the procedure?	6-8 mm: 5 (25%)	8-10 mm: 12 (60%)	≥10 mm: 3 (15%)		
18. ¿Is the annulo-aortic ectasia a contraindication for remodeling?	Yes, a reimplantation technique should be used always:13 (65%)	No, I prefer a remodeling technique with external aortic annulus stabilization: 7 (35%)			
19. ¿Does a Dacron rigid non-compliant graft increase the risk of distal aorta disruption?	Yes: 9 (45%)	No, there is no evidence: 11 (55%)			
20. ¿What´s your attitude toward the excessive valve prolapse?	Figure of 8 suture: 0 (0%)	Sewing suture along the free edge of leaflet: 4 (20%)	High commissure implantation: 2 (10%)	Midleaflet plication: 13 (65%)	Triangular resection: 1 (5%)
21. ¿Which kind of prosthesis do you prefer or use routinely?	Straight Dacron graft: 11 (55%)	Valsalva: 9 (45%)	Other grafts (0%)		
22. ¿Do you believe that Valsalva graft combines the ¨best of both reimplantation and remodeling¨?	Yes: 7 (35%)	No: 13 (65%)			
23. Graft sizing: ¿what do you prefer or use routinely?	Height of the interleaflet triangle corresponding to the external diameter of the STJ: 8 (40%)	Distance between commissural posts and choosing a graft 15% greater than the average distance between commissural posts: 1 (5%)	Height of each aortic valve cusp, take the average, and multiply it by two: 1 (5%)	Measure the STJ with a Hegar (+ 4 mm added in reimplantation): 3 (15%)	Correlation with BMI: 7 (35%)
24. ¿What do you prefer for stabilizing the aortic annulus in the remodeling technique?	Extra-aortic ring: 7 (35%)	Suture with PTFE: 4 (20%)	Suture with Teflon felt: 2 (10%)	I don´t stabilize the annulus: 0 (0%)	I don´t perform the remodeling technique: 7 (35%)

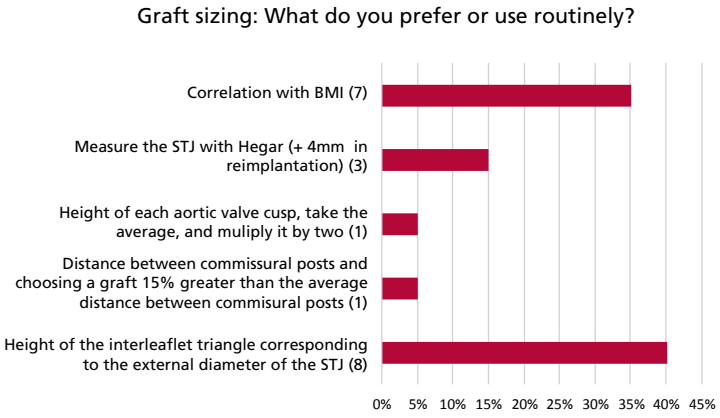
(continue)

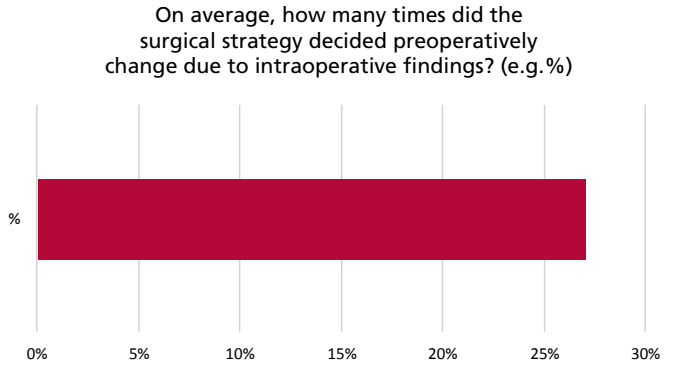
(continuation)

Question number	Option A	Option B	Option C	Option D	Option E
25. Would you contraindicate the VSAR in the presence of leaflets fenestrations?	Yes, always: 1 (5%)	With 2 leaflets affected: 3 (15%)	With 3 leaflets affected: 13 (65%)	Always repair regardless of number: 3 (15%)	
26. What is the limit accepted to repair a calcified valve?	Never, I rather perform a Bentall/other procedure: 5 (25%)	Mild calcification (small spots): 12 (60%)	Moderately calcification (multiple large spots): 3 (15%)	Heavily calcified: 0 (0%)	
27. Which kind of repair do you prefer in fenestrations?	Suture only:5 (25%)	Suture & patch: 8 (40%)	None: 7 (35%)		
28. Do you use routinely the caliper in VSAR?	Yes: 9 (45%)	No: 11 (55%)			
29. In bicuspid valves: ¿do you perform tricuspidization?	Yes, always try to do it:1 (5%)	VSAR is not a good procedure for bicuspid valves: 0 (0%)	Only if commissures present orientation near the 120º degrees: 19 (95%)		
30. In bicuspid valves. ¿which technique do you use for raphe more frequently?	Shaving: 14 (70%)	Resection with direct reapproximation: 4 (20%)	Resection with a pericardial patch: 2 (10%)		
31. Should the pericardial patch be used for cusp restoration after raphe resection?	Yes, when is necessary: 5 (25%)	No, the results are not good in the follow-up: 15 (75%)			
32.On average, how many times did the surgical strategy decided preoperatively change due to intraoperative findings? (e.g, %)	26 %				
33. On average, what is your estimated VSAR failure rate with conversion to a Bentall procedure? (e.g.%)	7 %				
34. After the VSAR, the intra-op TEE shows AR. Which severity do you consider necessary to perform a Bentall procedure?	Regardless the severity, try to re-repair / cusp repair: 8 (40%)	Mild: 1 (5%)	Moderate: 11 (55%) Ross: 0 (0%)		
35. In your experience with redo operations in failed VSAR, what procedure did you perform more frequently to solve this problem?	AVR: 10 (50%)	Bentall´s: 7 (35%)		Re-repair: 3 (15%)	

AR: aortic regurgitation. AVR: aortic valve replacement. BMI: Body mass index. LVOT: left ventricle outflow tract PTFE: Polytetrafluoroethylene. STJ: sinotubular junction. TEE: transesophageal echocardiography. VSAR: valve sparing aortic replacement.







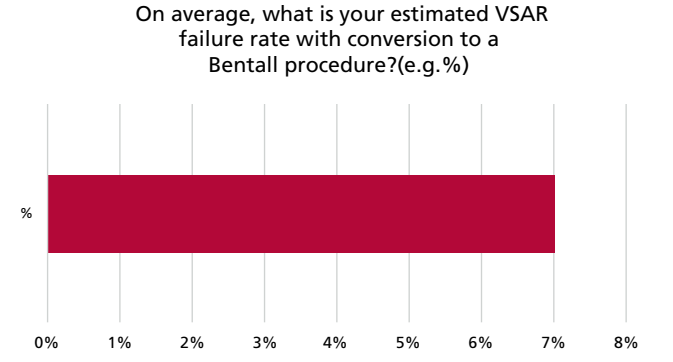


Fig. 2. Technical and anatomy-related aspects

is a discrepancy between European and American guidelines regarding when to treat the Marfan population. The ESC 2014 guidelines consider treating after ≥5 cm in the Marfan population (Ic) and 4.5 cm with risk factors (IIa), whereas 2018 AATS guidelines recommend treating at 5 cm with risk factors (IIa). In this survey, almost half and half have chosen one of those options, most likely related to where they do their practice. (15,16)

All the participants believe in treating the aortic root in bicuspid valves whenever feasible. Boodhwani and colleagues (17) presented freedom from aortic valve reoperation for bicuspid valve repair at 5 and 8 years of 94% and 83% respectively. The ACC/AHA 2020 guidelines established for the first time the valve repair with/without reimplantation technique (IIb) in bicuspid aortic valves by experienced centers. (18)

Interestingly, 15% would take an aggressive approach to type III injuries or at least consider treating them initially. We believe this is a challenging scenario and should only be performed by highly experienced surgeons.

Regarding VSAR in acute type A dissections (ATAD), the majority (55%) will prefer to do this procedure in young patients only, and another 35% will try it always when possible. This shows how surgeons have gained confidence with this technique, even in undesirable situations like ATAD. Khachatryan and the Leipzig group have shown excellent results with the David technique in ATAD with in-hospital and 30-day mortality of 4% and 9% respectively. (19) Mosbahi, et al. (20) also showed that the David procedure was superior to the Bentall technique for the ATAD population after analyzing 27 studies with a total of 3058 patients. David procedure was superior in terms of in-hospital mortality (2% vs 8%), midterm survival (99% vs 81%), early postoperative stroke (2.7% vs 5.1%) and thromboembolic events(0.5% vs 4.9%).

The association of valve plication on previously diagnosed prolapse reflects the combination of lesions commonly observed (annuloectasia, sinus dilation, and proper valve disease; type 1 and type 2 lesions on Carpentier classification).(21)

The minority of the participants uses routinely the Valsalva graft; however, it has been shown by some authors (22) in a finite element study that re-creation of the sinuses reduces leaflet stress during valve closure, consequently improving leaflet long-term durability.

It is worth mentioning the significance of the effective height (eH) and coaptation area to achieve good postoperative results.

An eH range between 7 -12 mm is believed to be normal for adults (23)

It has been shown by Bierbach and colleagues (24) that 96% of all patients with moderate or more severe AR had an eH of less than 9 mm.

One of the most relevant aspects of these techniques is graft sizing. Since the original method based on the Feindel-David formula (2), several different methods have been proposed and surgeons tend to use whatever they feel is more reliable as we can see in this survey.

Most of these formulas are based on relative proportions of the normal aortic root, but patients requiring the VSAR no longer have normal root anatomy; therefore, choosing the size of the graft based merely on fixed normal aortic valve dimensions, may generate mistakes.

One of the most relevant answers collected from this study is related to the failure rate of VSAR, with conversion to Bentall (7%) and the change of strategy intraoperatively (26%), especially since surgeons may feel uncomfortable when asked about the results.

Although 7% is not a negligible number (certainly biased by surgeons' experience), VSAR has demonstrated so many advantages that proves to be an excellent surgery for aortic root aneurysms. (3,10,20).

Some authors as Lansac (21) have proposed a useful lesion classification by echocardiography, to standardize surgical management and planning. Overall, almost all the responders accept the importance of the pre and intraoperative echocardiography assessment. However, there are aspects to consider. For instance, this may not always be clearly visible by echocardiography or could be inaccurate (eg. measure of effective height) and the caliper could be helpful in this scenario; therefore, these tools allow further standardization of valve repair by supporting the surgeon in his assessment of cusp prolapse. Additionally, it is mandatory on these cases to have a high-experienced echo operator for aortic valve and root pathology.

Interestingly, the MICS approach was not considered at all to improve results or even make any difference; however, more than half of the surgeons confessed that patients ask for it. Why has it not prospered? It could be that today's surgeons do not wish to adopt MICS techniques because they are more complex, take more time and there is a lack of data showing real benefits for the mini-David procedure.

The need of a long learning curve and advanced surgical expertise present a certain disadvantage for the VSAR. For such reasons, it should be performed in specialized cardiac centers with enough experience in the field.

There are still groups that opt for one variant over the other one; nonetheless, we believe that it should be adapted to every single case while taking care of the minimal technical aspects and details.

Finally, in the most comprehensive long-term analysis performed to date of the surgical management of aortic root dilation by Ouzounian et al., (25) it has been shown the superiority of VSAR when compared to tissue-Bentall or mechanical-Bentall at long-term follow-up (15 years) in terms of major adverse valve-related events (18.9% vs. 38.5% vs 35%, $p<0.001$), anticoagulation-related hemorrhage (6.3 %vs. 2.4 % vs. 11.6%,$p<0.001$), and with a risk of reoperation similar between VSAR and mechanical-Bentall, but

Table 3. Echocardiography Findings & Research, Training and the Future

Question number	Option A	Option B	Option C	Option D	Option E
36. ¿Do you think that pre-operative TTE provides a highly accurate anatomic assessment and is strongly predictive of valve repairability and postoperative success?	Yes: 17 (85%)	No, I mostly trust what I see intraoperatively: 3 (15%)			
37. ¿Do you think that a functional classification provided by echo for pre-operative decision is useful?	Yes, is a strong predictor of outcome and/or repairability: 7 (35%)	Sometimes: 9 (45%)	Not necessary, the most important is what I see intraoperatively: 4 (20%)		
38. ¿In which proportion the echocardiography findings correlated with the intraoperative findings?	Always: 3 (15%)	Most of times: 15 (75%)	Sometimes: 2 (10%)	I don't trust in the pre-op echo: 0 (0%)	Immediate post-VSAR residual AR: 11
39. In your experience, ¿which was the most frequent AR predictor? Could be more than 1 option	Effective height: 8	Aortic annulus/STJ diameters: 2	Coaptation length: 8	Degree of cusp billowing: 1	
40. ¿Which was the most frequent mechanism of recurrent AR?	Dysfunction Type I: 5 (25%)	Dysfunction Type II: 10 (50%)	Dysfunction Type III: 5 (25%)		
41. ¿Do you believe that performing this procedure with a resident as a first assistant might impair the result?	Yes: 2 (10%)	No: 18 (90%)			
42. ¿Do you think that a MICS approach for VSAR improves postoperative results?	Yes, MICS in VSAR may be performed with good results: 1 (5%)	Yes, MICS in VSAR could improve even more the results than conventional surgery: 0 (0%)	No. It´s only aesthetic but my patients ask for it: 11 (55%)	No: 8 (40%)	
43. There are some differences in the results between high-volume and low-volume centers. ¿Do you believe that VSAR must be performed ONLY in high-volume centers?	Yes: 10 (50%)	No: 5 (25%)	Low-volume centers may perform these procedures BUT only by experienced surgeons: 5 (25%)		
44. Cusps geometry could be difficult to measure preoperatively by echo. In the future, ¿what role do you think 3D printing may have for the preoperative plan?	None: 5 (25%)	Pre-operative 3D printing is the future for preop decision: 4 (20%)	It could be helpful sometimes: 11 (55%)		
45. Mitral valve repair is the standard in myxomatous degeneration. ¿Do you consider that it should be the same for VSAR?	Yes: 16 (80%)	No: 4 (20%)			
46. ¿Do you think that establishment of multi-institutional databases and standardized surgical mentoring courses are required?	Yes, the procedure requires long-term training and continue research (100%)	No, it would not produce any difference (0%)			

AR: aortic regurgitation. MICS: minimally invasive cardiac surgery. STJ: sino-tubular junction. TTE: transthoracic echocardiography. VSAR: valve sparing aortic replacement.

Fig. 3. Technical and anatomy-related aspects

inferior with tissue-Bentall (4.6 % vs 20 %, p<0.001). VSAR procedures were associated with reduced cardiac mortality and valve-related morbid events compared to tissue or mechanical Bentall at 15 years (15.8 % vs. 23.7% vs. 25.3%, p 0.04).

These estimates of time-related freedom from valve-related complications are certainly superior to those obtained with bioprosthetic or mechanical valves.

CONCLUSION

These results suggest that VSAR, regardless of variants, has been accepted as a treatment option for aortic root aneurysm when the valve is feasible to preserve with remarkable results. Although it is not yet possible to reach a final consensus, this survey showed that technical aspects are the most critical factors in achieving outstanding results. Nonetheless, the personal preference of the surgeon based on his own experience will also determine which technique will use.

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Conflicts of interest

None declared.

(See authors' conflict of interests forms on the web/Additional material.)

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