Aortic valve repair in type A aortic dissection

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Abstract: The role of valve sparing operations in patients with the acute type A aortic dissection (AAAD), is still matter of debate. Many different factors should be evaluated on root management in AAAD including clinical status, aortic anatomy and expertise of the centre. In this review article we sought to analyse and report the experience and results of current available series on aortic valve and root repair in AAAD. Early and long-term data will be reported and discussed in terms of survival and aortic valve function.

Keywords: Acute dissection; valve sparing; David procedure

Received: 06 July 2019; Accepted: 05 September 2019; Published: 30 September 2019.

doi: 10.21037/jovs.2019.09.04

View this article at: http://dx.doi.org/10.21037/jovs.2019.09.04

Introduction

Acute type A Aortic dissection (AAAD) continues to be one of the most complex and life-threatening pathology of the thoracic aorta and is still considered a challenge for cardiothoracic surgeons (1).

In AAAD, the extension of aortic replacement and the management of the dissected aortic root continue to represent two aspects on which there is no convergence of opinions. The primary goal of AAAD surgery is to save the patient's life (2) and the magnitude of the aortic intervention depends on various factors that include clinical and anatomical criteria in addition to the surgical experience and skills. In light of this, it is also important to consider that, in young patients, it is also necessary to avoid early reintervention on the proximal aorta.

Supra-coronary ascending aortic replacement is commonly used when the dissections does not involve the aortic root (3-5). If the aortic root is affected or dilated, composite replacement with a valved conduit remains the treatment of choice. However, root replacement risks anticoagulation related complications in cases of mechanical valve conduits and reoperation for structural valve deterioration in cases of bioprosthetic valves. It is also true that the use of the valve sparing repair in AAAD is still controversial (6). Nevertheless, the surgical and functional results after the use of both reimplantation and remodeling techniques performed in this setting by experienced centres are encouraging (7-9).

Even though valve sparing root replacement can potentially avoid the complications associated with prosthetic valves, it is a technically demanding procedure, requiring longer aortic cross-clamp times, especially in emergency settings.

In this review of the literature, we describe the rationale and outcome of the valve sparing operation in patients with AAAD.

Patients selection

The technique used for the surgery of the aortic root depends not only by the presence of a dissection but is driven also by the patients' characteristics. In fact, young patients with no major co-morbidities are more likely to be subjected to an extensive repair of the thoracic aorta than the older ones, even if the final decision is determined by

Figure 1 Valve sparing procedure in bicuspid aortic valve (10). Available online: http://www.asvide.com/watch/32951

the entry tear location. The ascending aorta is the portion of the thoracic aorta that most frequently experiences rupture, therefore a prompt replacement is mandatory.

In these patients, a dilated aortic root or the presence of the intimal flap close to or around the coronary ostia can be considered an indication for an aortic root replacement, especially in presence of severe aortic regurgitation. Valve sparing operations could be considered if the aortic leaflets are judged to be unaffected and anatomically satisfactory to obtain a successful outcome (*Figure 1*). Surgical experience and skill are equally important. Valve sparing operation should be considered within the context of the patient`s premorbid life expectancy, quality of life, others associated procedures on the aortic arch and, last but not least, the extension of the dissection in the downstream aorta.

Patients with extensive involvement of the downstream aorta can benefit more from not using warfarin during the postoperative course and in the long term, since the patent false lumen in the distal aorta leads to an increase of the aortic diameter and, consequently, to an increase of the re-intervention rate in the distal aorta (11-14).

It is clear that the use of mechanical valve can potentially negatively influence the patency of the false lumen as well as for the biological conduit with the use of the warfarin therapy during the first three postoperative months.

On the other hand, performing a valve sparing operation means also a longer clamping time, and this has to be strongly considered especially in acute settings. Patients with coronary malperfusion and/or low ejection fraction may not benefit from this technique. In such cases a technique with a shorter clamping time such as supra-coronary aortic replacement or, if necessary, a standardized root replacement should be considered.

Technical considerations

Considering that lack of consensus or clear recommendations about root management in AAAD, the treatment decision should be based on the previously mentioned aspects.

In general, in the presence of an aortic root dilatation >45 mm, in patients younger than 60 years, the valve sparing operation can be considered.

An important aspect about the use of the valve sparing techniques in this setting is the presence of dissected sinus and detached commissures, especially for the reimplantation technique.

Normally a valve sparing operation requires a deeper and more accurate root dissection and this can be very challenging, especially in case of large false lumen or in case of more than one dissected sinus.

The preparation of the root requires experience by the surgeon, since in AAAD the anatomical relationship with the surrounding structures can be altered: in particular, the detachment of the coronary ostia and left atrial roof from the aortic root can be problematic, in case of dilated false lumen and for the presence of the surrounding hematoma that frequently involves the pulmonary artery and the pericardial fat over the right ventricle. In addition, the preservation of the adventitia while carrying out the preparation of the root is necessary for a good result and it represents also another technical challenge.

On the other hand, the effect of commissure detachment due to dissection on valve durability is still unknown. Tanaka *et al.* (9) in their report describing their experience with the valve sparing operation in AAAD, included also patients with commissure detachment for aortic dissection. Among 5 patients who underwent late reoperation, 3 of them presented with detachment of commissure that was repaired with buttress sutures and GRF glue at the initial operation. The histopathologic results showed that 2 patients developed tissue necrosis, which may have partly been caused by the GRF glue. In another patient, hyalinization and fibrosis were observed at the detached commissures, and the re-detached commissure was probably caused by loose adhesion of the glue and by a tear in the dissection flap that was supported only by Teflon felt buttress suture (9).

This problem reported by the authors should not be underestimated, since it may lead to a prolapse of the commissure and consequently of the leaflets. Taking this into consideration, the risk for a worse mid-long term result, should be carefully evaluated during the decision

making process, especially for young patients.

The aortic root remodelling is another option for valve sparing operations, however there are very few reports in the literature about the results with this technique in acute settings as the AAAD.

Leyh *et al.* (15) have reported a high failure rate in AAAD and have also reported that the reimplantation technique provides a superior valve durability than remodelling. Similar to Tanaka *et al.* (9), they showed that the main cause of late failure in the remodelling was commissure detachment.

On the other hand, Kunihara *et al.* (16) reported better results, in terms of valve durability, of the remodelling technique in AAAD. They described the surgical technique for the repair of detached commissures, by carefully placing stitches through the dissected inner layer and adventitia. However, as evidenced in an editorial comment by Okita (17), the technique proposed by Kunihara *et al.* (16) presented an important limitation since that, often, the aortic dissection extends beyond the aortic cusp attachment and runs deeply into the aorto-ventricular junction posteriorly. In this case the authors did not report the use of a polytetrafluoroethylene reinforcement or biological glue and therefore this technique was considered not reproducible by every surgeon. In addition, the editorial comment reported that the rate of postoperative bleeding was higher if compared with other series reported in the literature, and last but not least it can be avoided by the reimplantation technique that includes the whole dissected tissue with double-layer sutures (17).

Methods

Literature search criteria

Selection of literature articles was performed using PubMed databases from inception to June 2019, using 'aortic valve repair' OR 'aortic valve repair in acute aortic dissection' OR 'valve sparing in acute aortic dissection' OR 'root reconstruction in acute aortic dissection' as either keywords or MeSH terms. Case reports, editorial and expert opinion or recommendations types of publication were excluded as well as review articles because of potential doubling of results. Among series coming from the same group we selected the most recent.

Objectives

Primary endpoints included early recurrence of aortic insufficiency and hospital mortality as well as late outcomes in terms of survival rate, freedom from aortic reintervention and aortic insufficiency.

Results

Table 1 summarizes retrospective studies that analyzed aortic valve repair and root sparing operations in type A aortic dissection. We selected 10 studies from 2010 to 2019 with a number of patients ranging from 24 to 307 from single centers experiences (7,9,18-25). Patient population was young, ranging from 49 years of Tanaka *et al.* (9) at Kobe University to the oldest 62±14 mean age of Yacoub population in the Leipzig experience (19).

The favorite technique for aortic valve repair and valve resuspension was the aortic commissuroplasty with additional sino-tubular junction reconstruction. The aortic root was often spared using the reimplantation technique in 5 studies and a complete or partial remodeling 4. Aortic valve repair in bicuspid or Marfan patients was not often performed (<5%), just Tanaka (9) reported a 29% rate of Marfan disease in his series.

Perioperative outcomes were acceptable and hospital mortality, ranging from 1% to 21.5%, was mostly related to the underlying aortic pathology, associated different arch procedures and emergency status.

In *Table 2* we grouped the data related to late outcomes. Mean follow up time goes from 36 months (24) to 10 years (7,24), with a good survival rate that ranged from a minimum of 64% (21) to a peak of 100% at 5 years (9). The longest follow-up period was reported in the 20-years' experience coming from Hannover (7) and Mayo Clinic (20) series. In particular, the Rochester experience (20) in 112 patients, showed a freedom from reoperation on the aortic root or valve at 10 and 20 years of 91.5%±2.3% and 79.3%±6.1%, respectively. Only, 8 patients (8.9%) required a reoperation in the root repair group (none in the remodeling or reimplantation group). Any difference was observed compared to those who received a complete aortic root replacement (P=0.605) (20).

An overall low rate of aortic valve reintervention was reported also in the other series. The lowest freedom from aortic valve reoperation up to 10 years follow-up time was 65% (9).

The oldest series (18) reported the experience of 121 patients at St. Antonius Hospital in Nieuwegein (The Netherlands). The mean age of this group was 59±11 years and 70 (58%) were men. Techniques used for reconstruction

Table 1 Results of the principal observational studies reporting early outcomes after aortic valve repair after type A aortic dissection

Author/year	Institution	Number patients	Age	BAV (%)	Marfan (%)	Type of AV repair (%)	Root reconstruction	Operative time (min)	In-hospital mortality
Casselman, 2000 (18)	St. Antonius, Nieuwegein (Netherlands)	121	59±11	NA	1.7	Commissuroplasty: 100	NA	CPB: 150; ACC: 81	21.5%
Subramanian *et al.*, 2012 (19)	Leipzig heart Center (Germany)	78	David: 53±15; Yacoub: 62+14	David: 0; Yacou:2	David: 7; Yacoub: 0	0	David: 34.6; Yacoub: 65.4	David: CPB: 220; ACC:145. Yacoub: CPB:192; ACC: 84	David: 15%; Yacoub: 16%
Wang *et al.*, 2014 (20)	Mayo Clinic, Minnesota (USA)	112	64±13	2.9	0.9	Commissural suspension: 77	David: 3.6; Yacoub: 1.8	CPB: 150; ACC: 81	19.6%
Tang *et al.*, 2016 (21)	Changhai Hospital, Shanghai (China)	151	51±9.8	NA	0	Resuspension: 100	Sandwich: 100	CPB: 181; ACC: 112	6.6 %
Beckmann *et al.*, 2017 (7)	Hannover Medical School, (Germany)	109	54±12	3	5	NA	David I: 100	CPB: 239; ACC: 158	11.0%
Tanaka *et al.*, 2018 (9)	Kobe University (Japan)	24	49±11	4	29	Central plication: 8	David I: 100	CPB: 286; ACC: 205	0%
Irimie *et al.*, 2019 (22)	Bad Neustadt, (Germany)	100	63±13	5	7	Free margin plication; Cusp patch plasty	1 sinus replacement: 61; 2 sinus replacement: 32; 3 sinus replacement: 7	CPB: 186; ACC: 113	1.0 %
Rosenblum *et al.*, 2019 (23)	Emory University, Atlanta (USA)	59	43±11	NA	NA	Commissure plasty: 2; Free margin plication: 9; Combination: 5	David V: 100	CPB: 283; ACC: 238	3.4 %
Urbanski *et al.*, 2019 (24)	Bad Neustadt, (Germany)	31	64±15	13.6	NA	Free margin plication; Cusp patch plasty	1 sinus replacement: 71.0; 2 sinus replacement: 22.6; 3 sinus replacement: 6.5	CPB: 169; ACC: 104	5.7 %
Yang *et al.*, 2019 (25)	Ann Arbor, Michigan (USA)	307	61	2.9	0	NA	Resuspansion	CPB: 203; ACC: 229	8.0 %

NA, not applicable; BAV, bicuspid aortic valve; AV, aortic valve; CPB, cardiopulmonary bypass; ACC, aortic cross clamp.

Table 2 Results of the principal observational studies reporting follow-up outcomes

Author/year	FU time	Survival 1 years	Freedom from reoperation	Freedom from aortic regurgitation >2+
Casselman *et al.*, 2000 (18)	43 months	1 year 72%; 5 years 64%; 10 years 53%	1 year 95%; 5 years 89%; 10 years 69%	NA
Subramanian *et al.*, 2012 (19)	3 years	1 year 69%; 5 years 66%; 8 years 55%	1 year 95%; 5 years 95%; 9 years 95%	NA
Wang *et al.*, 2014 (20)	9.7 years	10 years 55%; 20 years 24%	10 years 92%; 20 years 79%	NA
Tang *et al.*, 2016 (21)	52.7 months	1 year 100%; 5 years 89%; 10 years 70%	1 year 100%; 5 years 100%; 10 years 100%	1 year 100%; 5 years 100%; 10 years 100%
Beckmann *et al.*, 2017 (7)	8.3 year	1 year 94%; 5 years 90%; 10 years 78%	1 year 96%; 5 years 88%; 10 years 85%	NA
Tanaka *et al.*, 2017 (9)	7 years	1 year 100%; 5 years 100%; 10 years 100%	1 year 100%; 5 years 82%; 10 years 65%	1 year 100%; 5 years 82%; 10 years 65%
Irimie *et al.*, 2019 (22)	70 months	5 years 89%; 12 years 69%	5 years 100%; 10 years 100%	5 years 100%; 10 years 100%
Rosenblum *et al.*, 2019 (23)	1 year	1 year 95%; 5 years 92%; 9 years 92%	1 year 100%; 5 years 100%; 10 years 100%	1 year 100%; 5 years 100%; 10 years 100%
Urbanski *et al.*, 2019 (24)	70 months	5 years 82%; 10 years 57%	5 years 100%; 10 years 100%	5 years 100%; 10 years 100%
Yang *et al.*, 2019 (25)	5.8 years	10 years 62%; 15 years 43%	10 years 93%; 15 years 89%	NA

NA, not applicable.

were valve resuspension in all patients and additional reinforcement of the aortic root with Teflon felts (n=21), gelatin-resorcinol-formaldehyde-glue (n=103), or fibrinous glue (n=5). Freedom from aortic root reoperation was 95%±2% at 1 year, 89%±4% at 5 years, and 69%±9% at 10 years. Independent risk factor for aortic root reoperation appeared to be the use of fibrinous glue (RR =8.7; P=0.03) as well as the presence of an aortic valve annulus more than 27 mm (RR =4.2; P=0.04) (18).

On the other hand, the most recent series on valve-sparing anatomical aortic root reconstruction in acute dissection was reported by Irimie *et al.* (22) in 100 consecutive patients. Twenty-eight patients presented with severe (3+ or 4+), 37 with mild to moderate (2+), and 24 with mild (1+) insufficiency.

In all patients, a replacement of 1, 2, or all 3 dissected aortic sinuses was necessary in 62, 32, and 6 patients, respectively (22). Concomitant cusp repair was used in 18 patients. Thirty-day mortality was 1.0%. No patient required reoperation on the aortic valve or root during the follow-up period of 70±50 months. Moreover, freedom from aortic valve insufficiency >2+ at 12 years was also 100%.

The largest experience (25) in this review analysis was reported by the University of Michigan Hospital in 307 patients (median age 56 years). Of them, 45 (24%) received a valve-sparing root reconstruction (Yacoub in 5 and David technique in 40). In-hospital mortality was 8.2%. The 15-year cumulative incidence of reoperation was 11% in the aortic root repair. The primary indication of reoperation in the aortic root repair group (n=9) was aortic root aneurysm (0.5% per year), the median interval time between type A aortic dissection repair and reoperation was 6 years.

Discussion

The possibility to repair the aortic valve and to spare the root in AAAD is an attractive option, however, is still a challenge for cardiac surgeons, and some principles are to be evidenced as key points.

The correct indication and patients' selection are mandatory, according to valve and root anatomy. Only well preserved aortic leaflets, with no calcification or fibrosis should be considered for aortic valve preservation. The anatomical features of the dissection should be carefully considered and analyzed. The involvement of more than one sinus along with the detachment of the commissures can

negatively influence the mid-long term results. In addition, the patients' clinical conditions have to be considered in order to choose if performing a longer clamping time or not, since that AAAD often carries related malperfusion syndrome, that is a well-known risk factor for mortality (26).

Patient age is currently not considered as an absolute limitation. However, what should be included in the decision making process is the patient's life expectancy and quality of life (27).

In our experience we always prefer to replace the root in AAAD, since we also faced the problem of the detached commissures that required late re-operations. In Bologna University we are very selective for valve sparing operations, especially in acute settings. We usually use this technique in young patients with retrograde acute dissection, when the root is dilated but not dissected or when there is only one sinus involved or no detachment of the commissures are evident, and finally in patients with connective tissue disorders.

The results reported in this review are encouraging and suggest non-inferior outcomes related to the incidence of postoperative recurrence or reoperations when compared to elective cases.

Another interesting point is the possibility to preserve the entire or partial aortic root, since some series reported in this review reported results only about partial replacement of the Valsalva sinus (1 or 2). The choice between the two options is contradictory. Leaving diseased aortic wall could require future aortic reinterventions due to progressive dilatation or false aneurysms formation especially in patients with connective tissue disorders. A complete root replacement, on the other hand, is time consuming and requires extensive skills in ensuring satisfactory restoration of the valve geometry.

What should be kept in mind is that the main objective of surgery for AAAD is always to save patients' life and, if necessary, the root replacement is still the gold standard therapy. However, from what we have seen so far in the literature, all the centers that reported their experience with valve sparing operations in acute settings, were very experienced in aortic surgery and a clear example is the experience reported by the Hannover group (7). They started to preserve the aortic valve in acute dissection in 1993 having a global experience in elective David I operation of 473 patients. During the last twenty years the authors reported that all the emergency operations were performed by sixteen different senior surgeons who had gained the necessary expertise with this technique in elective cases. This is an important message that underlines how skill and expertise are necessary in order to perform this operation in AAAD.

According to our review analysis there are still several limitations on this topic related to the lack of large series in the literature, limited number of patients reported by each center, heterogeneity of surgical techniques used in the different experiences reported and the lack of studies comparing the results of these emergent cases with those of elective patients.

Acknowledgments

Funding: None.

Footnote

Provenance and Peer Review: This article was commissioned by the Guest Editors (Filip Casselman and Johan van der Merwe) for the series "Aortic and Mitral Valve Innovative Surgery" published in *Journal of Visualized Surgery*. The article has undergone external peer review.

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at http://dx.doi.org/10.21037/jovs.2019.09.04). The series "Aortic and Mitral Valve Innovative Surgery" was commissioned by the editorial office without any funding or sponsorship. DP serves as an unpaid editorial board member of *Journal of Visualized Surgery* from Dec 2017 to Nov 2019. The authors have no other conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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doi: 10.21037/jovs.2019.09.04
Cite this article as: Leone A, Murana G, Di Marco L, Botta L, Berardi M, Costantino A, Pacini D. Aortic valve repair in type A aortic dissection. J Vis Surg 2019;5:79.