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Acute aortic dissection involving the root: operative and long-term outcome after curative proximal repair†

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Abstract

OBJECTIVES: The aim of the study was to evaluate operative and long-term results after surgery of acute aortic dissection involving the root, in which the proximal repair consisted of curative resection of all dissected aortic sinuses and was performed using either valve-sparing root repair or complete root replacement with a valve conduit.

METHODS: Between August 2002 and March 2013, 162 consecutive patients (mean age 63 ± 14 years) underwent surgery for acute type A aortic dissection. Eighty-six patients with an involvement of the aortic root underwent curative surgery of the proximal aorta consisting of valve-sparing root repair (n = 54, 62.8%) or complete valve and root replacement using composite valve grafts (n = 32, 37.2%). In patients with root repair, all dissected aortic walls were resected and root remodelling using the single patch technique (n = 53) or root repair with valve reimplantation (n = 1) was performed without the use of any glue. All perioperative data were collected prospectively and retrospective statistical examination was performed using univariate and multivariate analyses.

RESULTS: The mean follow-up was 5.2 ± 3.5 years for all patients (range 0–12 years) and 6.1 ± 3.3 years for survivors. The 30-day mortality rate was 5.8% (5 patients), being considerably lower in the repair sub-cohort (1.9 vs 12.5%). The estimated survival rate at 5 and 10 years was 80.0 ± 4.5 and 69.1 ± 6.7%, respectively. No patient required reoperation on the proximal aorta and/or aortic valve during the follow-up time and there were only two valve-related events (both embolic, one in each group). Among those patients with repaired valves, the last echocardiography available showed no insufficiency in 40 and an irrelevant insufficiency (1+) in 14.

CONCLUSIONS: Curative repair of the proximal aorta in acute dissection involving the root provides favourable operative and long-term outcome with very low risk of aortic complications and/or reoperations, regardless if a valve-sparing procedure or replacement with a valve conduit is used. Valve-sparing surgery is frequently suitable, providing excellent outcome and very high durability.

Keywords: Aortic dissection • Aortic root surgery • Valve-sparing root repair • Aortic root replacement • Composite aortic valve graft

INTRODUCTION

Aortic root replacement is considered to be associated with high mortality and morbidity [1] and is therefore frequently avoided in cases of acute aortic dissection for fear of increased surgical risk. Admittedly, approximation of the aortic wall layers within the dissected sinuses of Valsalva with a biological glue and subsequent supracoronary aortic replacement offers a simple and efficient method of preserving the native valve and abolishing the aortic insufficiency when it is caused by the distortion of root anatomy [2]. However, this technique is still a matter of debate because the non-curative root repair can result in late development of several pathologies, which, especially after use of glue, necessitate challenging redo surgeries (Fig. 1). The aim of the study was to evaluate operative and long-term results after surgery of the acute aortic dissection involving the root, in which the proximal repair consisted of curative resection of all dissected aortic sinuses and was performed using either valve-sparing root repair (VSRR) or complete root replacement (CRR) with a valve conduit.

PATIENTS AND METHODS

Between August 2002 and March 2013, 162 consecutive patients (mean age 63 ± 14 years) underwent surgery for acute type A aortic dissection at our centre. In 95 (58.6%) patients, the dissection involved the aortic root. In 9 of them, a non-curative root repair using tissue glue was performed at the surgeon's discretion. The latter patients were excluded from evaluation, as were the remaining 67 patients without root involvement, in whom a supracoronary ascending aortic replacement was performed. In

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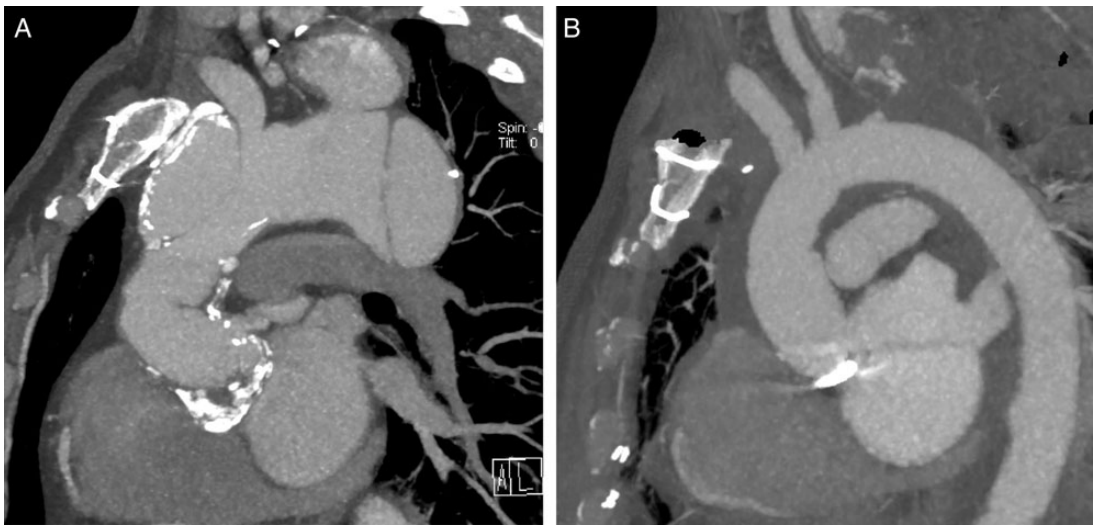

Figure 1: (**A**) multiplanar reconstruction of contrast-enhanced, multisliced CT scan (angio-CT) showing severely calcified false aneurysm of the aortic root and proximal aortic arch after previous supracoronary ascending aortic replacement with aortic wall reinforcement at proximal and distal anastomosis using tissue glue. Additionally, a large aneurysm of the left sub-clavian artery and a progressive aneurysm of a chronic dissected descending aorta are visible. (**B**) postoperative angio-CT of the same patient after complete thoracic aortic replacement via clamshell thoracotomy. Valve-sparing root repair was not possible because of glue-related calcification of the aortic leaflets and, therefore, complete root replacement with a valve composite graft was performed. CT: computed tomography.

the examined patients, either CCR (32) or VSRR (54) was carried out, resulting in a 63% valve preservation rate in curative repair of the dissected aortic root. The choice between root repair or replacement was made at the surgeon's discretion, considering such aspects as aortic valve (leaflet) pathology, clinical condition and surgical experience.

Aortic diagnostics for all patients were based on computed tomography angiography, which, if appropriate, was completed by coronary artery visualization through heart catheterization or cardiac computed tomography. During surgery, transoesophageal echocardiography was performed to assess the function of the aortic valve and to recognize its pathology. In 49 patients (57%), there was a relevant aortic insufficiency of at least grade 2+, and 12 patients (14.0%) presented a bicuspid aortic valve [5 (9.3%) in the VSRR vs 7 (21.9%) in the CRR sub-cohort]. The detailed patient characteristics are given in Table 1, whereas the extent of dissection and site of intimal tears are presented in Table 2.

Table 1: Preoperative patient characteristics

Characteristics	No (%) or mean ± SD (range)		
	All; 86 (100)	VSRR; 54 (62.8)	CRR; 32 (37.2)
Age (years)	59 ± 15 (56–63)	63 ± 15 (59–67)	53 ± 13 (49–58)
Sex male	64 (74.4)	34 (63.0)	30 (93.8)
Hypertension	16 (18.6)	8 (14.8)	8 (25.0)
COPD	9 (10.5)	5 (9.3)	4 (12.5)
Previous cardiac surgery	9 (10.46)	4 (7.4)	5 (15.6)
Unconscious/intubated	13 (15.1)	5 (9.3)	8 (25.0)
Malperfusion	15 (17.4)	12 (22.2)	3 (9.4)
Cerebral	8 (9.3)	7 (12.9)	1 (3.1)
Myocardial ischaemia	6 (6.9)	3 (5.6)	3 (9.4)
Aortic valve defect			
Insufficiency	65 (75.6)	41 (75.9)	24 (75.0)
Mixed/stenosis	5 (5.9)	2 (3.7)	3 (9.4)
Artificial valve	3 (3.5)	0 (0)	3 (9.4)
Marfan syndrome	7 (8.1)	2 (3.7)	5 (15.6)

COPD: chronic obstructive pulmonary disease (requiring long-term therapy in anamnesis); SD: standard deviation.

Surgical technique

The curative aortic root repair was achieved by complete valve and root replacement using a composite valve graft or VSRR. In patients with root repair, all dissected aortic wall was resected and root remodelling using the single-patch technique (53) or root repair with valve reimplantation (1) was performed without use of any glue, using techniques described previously [2, 3]. In short, the proper aortic graft size was chosen by measuring the aortic annulus with a valve sizer and defined as the same size as the biggest sizer that could pass through the aortic valve. Because this passing is not possible in bicuspid valves or in pronounced septal hypertrophy, the sizer was only placed on the valve, and the appropriate size was judged visually. The tube with the same diameter as the aortic annulus or a slightly bigger (1–2 mm) tube was chosen. The dissected sinuses of Valsalva were excised (one sinus in 33, two sinuses in 16 and all three sinuses in 5 patients), leaving a minimal rim of aortic wall attached to the aortic valve. Depending on the number of sinuses that had to be replaced, one to three patches were excised from the vascular graft and trimmed to teardrop shapes matching the size of the respective valve cusps. Even if the sizing is based on an eyeball judgement, the determination of the proper size of neo-sinuses is much easier when they are cut out from the chosen vascular graft, keeping in mind that the sum of the sinuses' widths has to be equal to the circumference of the tube. Until 2006, we used a standard straight woven polyester graft (InterGard) for the root repair, and thereafter, a special graft with an uncrimped proximal part ('InterGard Woven Aortic Thoracic Graft'; InterVascular, MAQUET Cardiovascular, La Ciotat, France) because cutting the patches from the uncrimped tube facilitates the determination of their proper size and shape and improves the tightness of the suture line by eliminating leaks between the folds of Dacron [2, 3]. In one case with dissection of all three

Table 2: Aortic pathology

Variables	No (%)		
	All; 86 (100)	VSRR; 54 (62.8)	CRR; 32 (37.2)
Extent of dissection			
D-a	22 (25.6)	13 (24.1)	9 (28.1)
D-ab	24 (27.9)	16 (29.6)	8 (25.0)
D-abc	40 (46.5)	25 (46.3)	15 (46.9)
Involvement of supra-aortic arteries	29 (33.7)	18 (33.3)	11 (34.4)
Involvement of iliac arteries	27 (31.4)	17 (31.5)	10 (31.3)
Site of intimal tears			
E-a	65 (75.6)	39 (72.2)	26 (81.3)
E-ab	8 (9.3)	6 (11.1)	2 (6.3)
E-abc	1 (1.2)	1 (1.9)	0 (0)
E-b	9 (10.5)	6 (11.1)	3 (9.4)
E-bc	1 (1.2)	0 (0)	1 (3.1)
E-c	2 (2.3)	2 (3.7)	0 (0)

VSRR: valve-sparing root repair; CRR: complete root replacement; D: extent of dissection; E: entry localization; a: ascending aorta; b: aortic arch; c: descending aorta.

Table 3: Surgical strategy

Variables	No (%)		
	All; 86 (100)	VSRR; 54 (62.8)	CRR; 32 (37.2)
Cannulation site			
Aorta	6 (7.0)	4 (7.4)	2 (6.3)
FA	7 (8.1)	2 (3.7)	5 (15.6)
CAA left	26 (30.2)	14 (25.9)	12 (37.5)
CAA right	29 (33.7)	23 (42.6)	6 (18.8)
IA	1 (1.2)	1 (1.9)	0 (0)
CAA left + FA[a]	11 (12.8)	6 (11.1)	5 (15.6)
CAA right + FA[a]	6 (7.0)	4 (7.4)	2 (6.3)
Cerebral protection			
UCP	73 (84.9)	48 (88.9)	25 (78.1)
BCP	0 (0)	0 (0)	0 (0)
Straight CA	7 (8.1)	3 (5.6)	4 (12.5)
No arch repair	6 (7.0)	3 (5.6)	3 (9.4)

FA: femoral artery; CCA: common carotid artery; IA: innominate artery; UCP: unilateral cerebral perfusion; BCP: bilateral cerebral perfusion; CA: circulatory arrest; DHCA: deep hypothermic circulatory arrest; SA: sub-clavian artery; VSRR: valve-sparing root repair; CRR: complete root replacement.
[a]Double cannulation was preferably used in dissections involving supra-aortic arteries.

sinuses, the reimplantation technique was performed with this graft for demonstration [2, 3]. The patches were sewn to the rim of the aortic wall with a 5-0 polypropylene running suture passing through the aortic annulus rather than the remnants of the dissected aortic wall. In cases in which the coronary sinuses were replaced, coronary buttons were implanted using a technique described by Kouchoukos *et al.* [4]. In 10 VSRR patients, additional procedures on the cusps such as free margin plication, cusp patch plasty or others completed the aortic root repair, if necessary.

A complete valve and root replacement was performed with a modified self-assembled composite graft consisting of a mechanical or biological aortic valve prosthesis. The assembly of modified composite grafts has been described previously [5, 6]. In brief, a conduit was assembled during surgery using a collagen-coated woven polyester vascular graft (InterGard or InterGard Aortic Thoracic Graft; InterVascular, MAQUET Cardiovascular, La Ciotat, France). In 25 patients, a mechanical valve prosthesis (St Jude Regent; St Jude Medical, St Paul, MN, USA) and in 7 patients a biological valve prosthesis (SPV Toronto; St Jude Medical, St Paul, MN, USA, in 3 patients; and Carpentier Edwards Perimount; Edwards Lifesciences, Irvine, CA, USA, in 4 patients, respectively) was used. The xenograft was placed inside the vascular prosthesis and attached ∼3–5 mm above the proximal end of the tube with a continuous 4-0 polypropylene mattress suture. The conduit was then anastomosed to the annulus with interrupted pledgeted mattress sutures passing them through the aortic annulus from the ventricular side and through the rim of the tube graft rather than through the sewing cuff of the prosthetic valve. Coronary buttons were implanted in the usual manner [3].

Because curative resection of all dissected tissue was always performed, glue was used neither after VSRR nor after CRR for the reinforcement of the aortic wall and the sutures.

Warfarin was given postoperatively in patients having a mechanical valve prosthesis and patients with atrial fibrillation or other specific indications.

Surgical strategies and operative data are presented in Tables 3 and 4, respectively. Categorical variables are expressed in the tables and text as frequency (percentage) and continuous variables as mean ± standard deviation (range).

All operative data were collected prospectively. Early mortality was considered for the postoperative time of 30 and 90 days as well as for in-hospital stay, conforming to reporting guidelines [7]. The patients were followed up by echocardiography and, if necessary, by CT angiography performed in our outpatient clinic or by their cardiologist, from whom written documents and images, if available, were requested and reviewed. Overall survival was estimated by the Kaplan–Meier method. A retrospective statistical evaluation was performed after the study was approved by the Institutional Review Board of the Rhön Clinic Campus Bad Neustadt.

RESULTS

Early mortality and morbidity

There were 7 early deaths in total, resulting in 5.8% 30-day mortality, 7.0% in-hospital mortality and 8.1% 90-day mortality. The 30-day mortality was considerably lower in the VSRR sub-cohort (1.9 vs 12.5%), in which only 1 patient died on the 26th postoperative day due to multiorgan failure caused by heparin-induced thrombocytopenia and multiple embolisms. The causes of early deaths after CRR were stroke in 2, myocardial infarction in 1 and bowel ischaemia in 1. In addition, 1 patient (84-years old) died in hospital but beyond the 30-day time range because of pneumonia, and 1 patient with persisting distal dissection died suddenly after discharge but within the 90-day time range (Table 5).

New permanent neurological deficit occurred in 2 patients (3.7%) after VSRR and in 3 patients (9.3%) after CRR, resulting in overall neurological morbidity of 5.8%.

Rethoracotomy due to bleeding or delayed chest closure was necessary in 9 patients (10.5%), and a further 9 patients needed temporary dialysis after surgery.

Table 4: Operative data

Variables	No (%) or mean ± SD (range)		
	All; 86 (100)	VSRR; 54 (62.8)	CRR; 32 (37.2)
Arch repair			
Total/subtotal (also ET)	39 (45.3)	26 (48.1)	13 (40.6)
Hemiarch	41 (47.7)	25 (46.3)	16 (50.0)
CABG/CAIG	14 (16.3)	10 (18.5)	4 (12.5)
CPB duration (min)	204 ± 56 (69–377)	187 ± 52 (69–377)	234 ± 51 (123–328)
Cross-clamp time (min)[a]	125 ± 36 (38–240)	116 ± 33 (38–214)	141 ± 36 (78–240)
CA time (min)	37 ± 21 (3–105)	34 ± 21 (3–105)	41 ± 22 (12–100)
CP (min)	41 ± 24 (11–135)	40 ± 25 (11–135)	43 ± 23 (12–100)
Lowest rectal temperature (°C)	29 ± 3 (19–34)	29 ± 2 (21–34)	28 ± 3 (19–34)

AVR: aortic valve replacement; ET: elephant trunk; CABG: coronary artery bypass grafting; CAIG: coronary artery interposition graft (due to ostial pathology); CPB: cardiopulmonary bypass; CA: circulatory arrest; CP: cerebral perfusion.
[a]Including circulatory arrest.

Table 5: Operative outcomes

Variables	No (%)		
	All; 86 (100)	VSRR; 54 (62.8)	CRR; 32 (37.2)
Mortality			
30-day	5 (5.8)	1 (1.9)	4 (12.5)
90-day	7 (8.1)	1 (1.9)	6 (18.8)
In-hospital[a]	6 (7.0)	1 (1.9)	5 (15.6)
New permanent neurological deficit	5 (5.8)	2 (3.7)	3 (9.3)
Resternotomy	9 (10.5)	6 (11.1)	3 (9.4)
Reintubation	10 (11.6)	6 (11.1)	5 (12.5)
Tracheotomy	12 (14.0)	7 (13.0)	5 (15.6)
Dialysis	9 (10.5)	3 (5.6)	6 (18.8)

[a]Including 30- or 90-day mortality, if appropriate.

The most frequent postoperative complication, which occurred in 17 patients (19.8%), was respiratory insufficiency necessitating prolonged ventilation or reintubation. Twelve of these patients (14.0%) required tracheotomy (Table 5).

Survival

Clinical and echocardiographic follow-up data were available for all patients. The mean follow-up time was 5.2 ± 3.5 years for all patients (range 0–12 years) and 6.1 ± 3.3 years for survivors. A further 13 late deaths occurred (Table 6), on average, 42 months after surgery (range 5–112) at a median patient age of 78 years (range 50–91 years).

No death was related to the aortic valve or aortic root. There were 3 cardiac deaths after VSRR: one male patient died of congestive heart failure 44 months after surgery at the age of 79 years; another, 78 years old, died due to the same reason 81 months after surgery. A third patient (male, 64 years) suffering from coronary heart disease, died 11 months after surgery due to acute myocardial infarction despite catheter intervention. After CRR, there were 2 cardiac deaths, which occurred 37 and 68 months after surgery at the ages of 85 and 56 years, respectively. Both were caused by congestive heart failure.

Table 6: Late mortality and morbidity[a]

Variables	No (%)		
	All; 86 (100)	VSRR; 54 (62.8)	CRR; 32 (37.2)
Mortality	13 (15.1)	9 (16.7)	4 (12.5)
Sudden/unknown death	1 (1.2)	0	1 (3.1)
Cardiac death	5 (5.8)	3 (5.6)	2 (6.3)
Valve-related deaths	0	0	0
Other death[b]	7 (8.1)	6 (11.1)	1 (3.1)
Valve-related morbidity			
Embolism	2 (2.5)	1 (1.19)	1 (3.1)
Aortic reoperation			
Aortic root/valves	0	0	0
Arch and distal	2 (2.5)	2 (3.7)	0

[a]Excluding 90-day mortality and/or in-hospital mortality.
[b]Peritonitis in 1 at age 82, cancer in 1 at age 78, pneumonia in 5 at ages 68, 77, 65, 82 and 91.

The linearized death rate was 4.5%/year, and the estimated survival rate at 5 and 10 years was 80.0 ± 4.5 and 69.1 ± 6.7%, respectively. Analysis of separate survival curves in specific sub-cohorts demonstrated a beneficial survival after VSRR in the early postoperative phase, which disappeared over time because the VSRR patients were, on average, 10 years older than the CRR patients (Fig. 2).

Valve-related morbidity and reoperations

No patient required reoperation on the proximal aorta and/or aortic valve during the entire follow-up time. There were no bleeding episodes and only two embolic episodes (one in each sub-cohort) were reported. After VSRR, one stroke occurred in an 81-year old patient who, despite a competent aortic valve, suffered from numerous episodes of atrial fibrillation. In the CRR sub-cohort, one peripheral embolism (treated conservatively) occurred in a 59-year old patient a few months after implantation of a mechanical valve composite graft and did not recur during the further follow-up duration of 136 months.

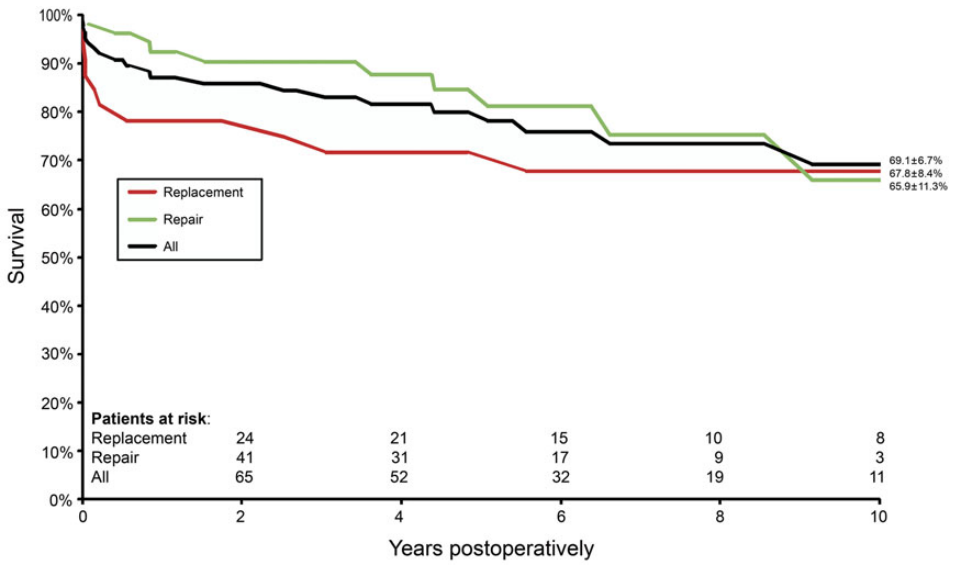

Figure 2: Graphic demonstration of survival curves after curative surgery of dissected aortic root for the entire cohort and both sub-cohorts. Survivals were calculated using the Kaplan–Meier method starting with the procedure.

In the VSRR sub-cohort, 2 Marfan patients underwent successful conventional replacement of the descending aorta (2.5 and 8 years after primary surgery, respectively) and are still alive with competent aortic valves and unchanged aortic roots. There were no distal aortic surgeries reported after CRR; however, 2 sudden deaths in patients with persistent dissection of the distal aorta were noted.

Functional data

At the last echocardiography performed, on average, 4.9 ± 3.5 years after surgery, no pathological alterations of the aortic root, especially, no leaks, false aneurysm formations or an increase in aortic root diameter, were noticed in any patient. Among those patients with repaired valves, the echocardiography showed no insufficiency in 40 and an irrelevant insufficiency (1+) in 14. The longest duration of echocardiographic follow-up was 136 months. Among the recipients of biological valve composite grafts, no patient revealed any valve deterioration during the follow-up. At the last follow-up, 3 patients were still alive (134, 72 and 54 months, respectively) showing well-functioning valve prostheses (SPV Toronto in 1 and Carpentier Edwards Perimount in 2).

DISCUSSION

There are many reasons why the surgical management of the aortic root in acute dissection remains controversial. The most important reason is a lack of evidence-based assessments. A randomization of cases treated with different methods seems to be impossible due to the life-threatening nature of the disease and a myriad of anatomo-pathological and clinical presentations. Nevertheless, a statement like 'acute aortic dissection is a life-threatening disease and one of the greatest challenges in cardiac surgery' can be found in almost each publication regarding this topic, and consequently, the majority of the patients undergo 'less risky' surgery following the attitude that the supreme aim of ... 'our job is to produce a live patient' [8]. The recently published reports of two large registries revealed that the supracoronary ascending aortic replacement is the most frequent type of proximal aortic surgery in acute aortic dissection and the rate of root replacements in dissection involving the root could have even been lower if other pathologies (such as valve defect, connective tissue disorder etc.) had not required its complete replacement [9, 10]. Nevertheless, the data of the International Registry of Acute Aortic Dissection demonstrated that the results after CRR, even in such high-risk clinical scenarios as acute aortic dissection, are not associated with higher early mortality than supracoronary aortic replacements [10].

There is no doubt that preservation of a well-functioning aortic valve should be preferable to its replacement, but the problem is that the valve is mostly preserved without curative replacement of all dissected aortic walls of the aortic root, which, at least from a technical point of view, is always achievable. The recent meta-analysis of aortic valve-preserving surgery in acute type A aortic dissection containing 2402 patients from 19 observational studies revealed that, in 95% of the patients, the surgery consisted of conservative root management and supracoronary aortic replacement, while only 5% underwent a curative root repair by VSRR (reimplantation or remodelling) [11]. This led to a linearized reintervention rate on the aortic valve and/or root of 2.1%/year and very poor results quo ad vitam with 5- and 10-year mortality rates of 58 and 34%, respectively. This aspect can be emphasized by the fact that even in our centre, where we generally recommend curative repair, in almost 10% of the patients with aortic root dissection, a non-curative root repair using tissue glue was performed at the surgeon's discretion. One of the patients died shortly after surgery due to aortic root rupture (confirmed by autopsy) and 2 developed a false aneurysm and/or an aortic regurgitation. Even if this small group was excluded from evaluation, it seems to prove the point already addressed by us and others [12–16].

Even if the poor outcomes were acknowledged by the authors of the meta-analysis mentioned above [11], they emphasized that the linearized composite rate of thromboembolism and bleeding was 1.4%/year and 'lower than what would be expected with a mechanical valve replacement' and concluded eventually

that 'preservation and repair of the aortic valve is associated with a moderate risk of reoperation but a low risk of thromboembolism' [11]. Given that such linearized thromboembolism and bleeding rate after an implantation of a mechanical valve composite graft was similar or even lower in several studies [17, 18] and, especially, that the biological valve composite graft is already a widely established surgical method, we cannot agree with their conclusions. This meta-analysis clearly demonstrates that aortic valve preservation without a curative repair of the dissected aortic root is associated with poor survival and an increased risk of proximal reoperation although the risk of thromboembolism and bleeding does not exceed those reported after the Bentall procedure with mechanical valve prosthesis. Additionally, it demonstrates that VSRRs are not commonly used in acute aortic dissection surgery [11]. The same is clearly visible in other reports. Recently, Badiu *et al.* compared different techniques of aortic root replacement. Among 65 patients with an acute aortic dissection, the rate of VSRR was ~26%, while the remaining 74% underwent the Bentall procedure using either a mechanical or a biological valve prosthesis. During a relatively short follow-up period, 2 VSRR patients (12%) required valve replacement because of recurrent aortic regurgitation [19]. Admittedly, it demands a lot of surgical experience to properly assess the root and valve, ensuring there are no additional leaflet pathologies and that a challenging and time-consuming surgery will result in a curative albeit VSRR. Nevertheless, CRR with a valve composite graft offers a reproducible and standardized technique, which offers the possibility of curative root replacement, not only in case of its dissection but also in concomitant pathologies like aortic valve defect or connective tissue disorder combined with root dilatation [17–19]. Consequently, the patients receiving VSRR or CRR are not really comparable. DeNino *et al.* recently described their results after VSRR using the valve reimplantation technique and CRR with a biological valve conduit [20]. Because the ages of the patients were extremely different, the authors matched the groups according to age. The authors stated that the matched patients containing 16 VSRRs and 15 bio-conduits were similar in terms of baseline demographics and differed only in concomitant bypass grafting (2 in the VSRR group vs 7 in bio-conduit patients, $P = 0.036$) and acute aortic dissection (0 in the VSRR group vs 3 in the bio-conduit group, $P = 0.101$). Even considering a low statistical power, the groups showed a significant difference between the postoperative aortic insufficiency but, because the operative mortality and morbidity were similar, the authors stated that VSRR is an effective alternative to the bio-conduit for aortic root aneurysm [20]. In our opinion, it should be interpreted that the CRR using a mechanical or biological valve prosthesis is a valuable option in any pathological, clinical or surgeon-related situations, in which VSRR is not suitable.

For this reason, we do not compare the two techniques. On the contrary, we are aware that the patients are completely different. There can be several factors like the patient's general condition or the surgeon's experience and/or disposition that can impact the choice of technique and reflect surgical outcomes [12]. The different late survival in our report also seems to be caused by the difference between both sub-cohorts. Because the VSRR patients were, on average, 10 years older, there were more late deaths observed in this sub-cohort, and most of them were clearly age-related (Table 6).

The lack of randomization can be considered as a limitation of the study; however, we are convinced that the variety of the aortic root and valve pathologies as well as the clinical parameters demand individual surgery, which is essential for optimal outcome. It could even be questionable if the randomization of patients with dissected aortic root for a curative or a non-curative repair could be justified from an ethical point of view. Hence, our retrospective analysis concentrates on operative and long-term outcomes after a curative root repair, regardless if it was a valve-sparing or replacement surgery.

There is no doubt that survival is the supreme aim of acute dissection surgery, but the therapeutic aim of modern cardiac surgery should exceed operative survival and also include long-term survival, for which prevention of high-risk reinterventions is of utmost importance.

Curative repair of the proximal aorta in acute dissection involving the root, even if it does not completely eliminate the risk of such reinterventions, provides favourable operative and long-term outcomes with very low risk of aortic complications and/or reoperations, regardless if a valve-sparing procedure or replacement with valve conduit is used. A curative VSRR is frequently suitable and, in selected patients, offers very good outcomes and long-term durability, while root replacement, as a well-recognized and reproducible standard, can be used whenever the feasibility of valve-sparing albeit curative surgery is questionable.

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APPENDIX. CONFERENCE DISCUSSION

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Dr E. Quintana *(Barcelona, Spain):* So the matter of how aggressive we have to be on the aortic root in the setting of type A aortic dissection is still a matter of debate, and we have seen it here today. I have just a couple of questions to ask you.

The first one is, what made you choose between one technique and the other? Can you comment a little bit more on the technical aspects, and what were the findings that made you go for one or the other?

Dr Urbanski: I think the most important aspect which limits the feasibility of the valve-sparing procedure is the quality or pathology of the valve leaflets.

I have to admit it is not easy to evaluate the valve inside a dissected aortic root and to decide to perform a very challenging and time-consuming surgery in critical patients.

But there are many situations, especially in older patients, where a curative root repair is feasible. The aetiology of dissection in elderly patients is atherosclerotic, and in these patients, you have normally good aortic root anatomy, and the dissection very often spares the left coronary sinus. Maybe this is the reason why our repair group was ten years older than the Bentall group.

We published last year a paper about this technique, and we saw that in acute dissection, in only 10–15% of patients, replacement of all three sinuses of Valsalva was necessary. Most frequently, only one or two sinuses are involved, not all three.

And it is this technique of partial remodelling that is, in my opinion, easier and better, in acute dissection. Even if we keep in mind that this surgery is not very frequent – there are very few centres worldwide, which have been published, about 20 or more than 20 valve-sparing repairs a year - you have to start, or to try to repair the valve because it is much easier to replace later the valve within the repaired root, than to re-operate a root which was bricked up with felt and glue.

Dr Quintana: The second question touches on the reproducibility of this approach. You've shown very good results. Some of our proportion, a significant proportion of these patients had important surgery as well in the aortic arch.

So, we've been told that the objectives of surgery in acute type A aortic dissection is to get the patient alive at the end of the procedure. So, what are your thoughts on reproducibility, and that is the question that comes here. How many surgeons are involved in this series, and what is the expertise they had, I mean, how many years of experience? Is that something that should be advised to every single surgeon on call anywhere around the world? That's my question.

Dr Urbanski: It's an excellent question but also very provocative. Last year I dealt with this topic during our meeting. We demonstrated that the most important predictor of mortality is not clinical or pathological situation but the surgeon. And for this reason, we have to try to organise our aortic teams in each centre.

At the time of the evaluation of the study in our centre, the aortic team took care for ∼50% of the patients. Our aim was to increase it, and at this moment the aortic team cares for about 80–90% of acute dissections.

But if you want concrete data, we have nine surgeons in our centre but only three would perform extensive aortic surgery containing a root repair, and concomitant complete arch repair. Currently, these three surgeons cover ∼80% of the on-call time for aortic dissections.

Dr Quintana: I think that's a very important point you answered.

Dr T. Schachner (Innsbruck, Austria): You used this very elegant method of isolated sinus replacement. Do you also use the same technique for bicuspid valves, or do you then go for a re-implantation procedure?

Dr Urbanski: I described the technique in the late '90s, and I perform this kind of root repair exclusively. Of course, also for bicuspid valves. You can take for bicuspid valves just two neo-sinuses if there is no rudimentary commissure, but you have to plicate the half round margin as you saw it in this presentation.

In tricuspid, you set just three applications. If you take two pseudo-sinuses for the entire root in bicuspid, you have to set about seven applications to build a perfect bulged form of the sinus.

Dr Schachner: How often do you add additional valve leaflet repair in aortic dissections?

Dr Urbanski: Very frequently. Isolated root pathology without leaflet pathology is extremely seldom, maybe 10 patients a year in our centre. You can only increase the number of repairs if you address the leaflets.