Original Article

Strategies for Treatment of Acute Aortic Dissection with Involvement of Sinus of Valsalva

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Objective: The aim of this study was to assess the outcome of 3 different surgical approaches for treatment of acute aortic dissection type A (AADA) with involvement of the aortic root.
Materials and Methods: From November 2002 to December 2007, 51 consecutive patients underwent emergency surgical intervention for AADA with involvement of the aortic root. Supracommissural replacement (SCR) of the ascending aorta was applied to 33 of these patients; 12 cases received a Bentall procedure, and 6 underwent partial remodeling technique in which as much as the dissected aortic root was resected, leaving a rim of 10 mm above the noncoronary annulus and 5 mm above the coronary ostia and commissures. Woven Dacron graft tailored in a scallop-shaped configuration to match the noncoronary sinus was then anastomosed to the proximal aortic stump.
Results: Overall hospital mortality was 16% and showed no significant differences among groups. SCR showed a trend toward higher aortic root morbidity. Mean operation time, cardiopulmonary bypass time, and cardiac ischemia time were significantly longer for the Bentall procedure.
Conclusions: In AADA involving aortic root, a partial remodeling technique may be considered the surgical treatment of choice at our institution in suitable patients. (Ann Thorac Cardiovasc Surg 2009; 15: 382–388)

Key words: acute aortic dissection type A involving aortic root, supracommissural replacement, Bentall procedure, partial remodeling technique, aortic root morbidity

Introduction

The priority in operations for an acute aortic dissection type A (AADA) is operative survival.[1)] Supracommissural replacement (SCR) of the ascending aorta with conservative aortic root reconstruction is an established surgical technique for the treatment of AADA involving the sinus of Valsalva.[2)] However, failure of the repair at the proximal aorta is an important cause of morbidity and mortality following surgical treatment of AADA with involvement of the aortic root.[3)]

Recently, composite replacement (Bentall) of the aortic valve and ascending aorta and valve-sparing techniques for the ascending aorta gained attention for use in AADA involving the aortic root.[3–5)] Complete removal of diseased tissue is a clear advantage for treatment of the aortic root pathology. However, whether to use theses techniques in emergency patients remains debatable. Prolonged operation times and the demanding technique applied under emergency conditions may bear an additional risk for the patient, who might benefit from a short and simple operation because of this unstable status.[2)] Last year, we adopted

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Table 1. Preoperative data of patients with acute aortic dissection involving aortic root, subdivided by treatment method

	A (SCR)	B (Bentall)	C (AVS)	Overall	P	Test method
Patients	33	12	6	51		
Gender, male (%)	17 (52)	7 (58)	3 (50)	27 (52)	0.804	Chi-square
Age (y)	67 ± 10	65 ± 15	67 ± 12	67 ± 12	0.910	One-way Anova
Marfan syndrome (%)	0 (0)	1 (8)	0 (0)	0 (2)	0.191	Chi-square
Visceral malperfusion (%)	3 (9)	0 (0)	1 (17)	4 (8)	0.49	Chi-square
AMI (%)	2 (6)	3 (25)	0 (0)	5 (10)	0.116	Chi-square
Cerebral infarction	1 (3)	0 (0)	0 (0)	1 (2)	0.757	Chi-square
Neurological symptoms (%)	2 (6)	0 (0)	0 (0)	2 (4)	0.567	Chi-square
Cardiogenic shock (%)	14 (42)	4 (33)	2 (33)	20 (39)	0.817	Chi-square
Pericardial effusion (%)	21 (64)	8 (67)	4 (67)	33 (66)	0.977	Chi-square

SCR, supracommissural replacement; AVS, aortic valve sparing; AMI, acute myocardial infarction.

the partial remodeling technique (aortic-valve sparing [AVS]) introduced by David et al.[6] and Kazui et al.[7] This technique is much easier than the usual remodeling[8] or reimplantation[9] of the aortic root.

Thus the aim of the study was a comparison of the established technique (SCR) with Bentall procedure and the partial remodeling technique in regard to perioperative and midterm follow-up. We analyzed the data of 51 consecutive patients admitted to our institution with AADA involving aortic root, intending to answer questions for a better surgical strategy.

Materials and Methods

Patients

From November 2002 to December 2007, a total of 51 consecutive patients underwent emergency surgical interventions for AADA with involvement of the aortic root. All clinical data were obtained by retrospective reviews of hospital records. Follow-up was complete for all patients. For analysis, these patients were divided into 3 subgroups by surgical intervention: 33 underwent SCR of the ascending aorta (conservative root reconstruction: A group), 12 were treated with Bentall procedure (Bentall: B group), and 6 underwent a partial remodeling technique (AVS: C group).[6,7] Three groups were analyzed and statistically compared with one another. Preoperative characteristics and demographic data showed high homology among the groups. Only a trend toward high frequency of acute myocardial infarctin (AMI) was observed for Bentall (25%, 3/12), compared with SCR (6%, 2/33) and AVS (0%, 0/0: P = 0.116). Other factors such as visceral malperfusion and neurological symptoms showed no statistically significant differences among groups. Detailed clinical data and patient demographics are listed in Table 1. One patient of B group had undergone previous aortic valve replacement. Another of B group had typical Marfan syndrome.

Surgical technique

Median sternotomy was performed. A cardiopulmonary bypass (CPB) was established mainly with the right axillary arterial cannulation and the femoral arterial one, and with two caval venous drainages. We avoided aortic cross-clamping; that is, we cooled the patient down to a rectal temperature of 28°C, at which point the CPB was discontinued. We then installed the antegrade selective cerebral perfusion (ASCP) and subsequently protected the heart with repetitive doses of blood K cardioplegia, first administered directly into the coronary ostia and then in a retrograde method through the coronary sinus. To inspect the aortic arch, we used moderate hypothermic circulatory arrest with ASCP. Depending on the expansion of the dissection, the diseased aortic wall was reconstructed with galatine-resorcinal-formaldehyde (GRF) glue and with Teflon felt strip reinforcement of both the inside and outside of the aorta for an open distal aortic anastomosis, or the dissected aorta was removed and the arch replaced by a Dacron prosthesis. In the event of more extensive distal dissection, an elephant-trunk extension of the arch prosthesis into the proximal descending aorta was used. Once the eventual arch procedure or distal ascending aortic anastomosis was performed, antegrade perfusion was resumed through a side arm of the clamped prosthesis. Attention was then directed to the aortic root procedure. The decision favoring SCR, Bentall procedure, or partial remodeling technique (AVS) depended on the morphological appearance of the cusps and root geometry. If a contraindication for

Table 2. Intraoperative data for patients with AADA involving aortic root treated with different surgical methods

	A (SCR)	B (Bentall)	C (AVS)	Overall	P	Test method
Operation time (min)	474 ± 156	687 ± 213	437 ± 116	517 ± 190	0.002	One-way Anova
Cardiopulmonary time (min)	274 ± 77	387 ± 73	233 ± 27	295 ± 88	<0.001	One-way Anova
Cardiac Ischemia time (min)	116 ± 34	197 ± 43	125 ± 18	136 ± 49	<0.001	One-way Anova
Total arch replacement (%)	12 (36)	6 (50)	2 (33)	20 (39)	0.675	Chi-square
Partial arch replacement (%)	20 (61)	6 (50)	4 (67)	30 (59)	0.748	Chi-square
Elephant trunk (%)	7 (21)	5 (41)	2 (33)	14 (27)	0.374	Chi-square
CABG (%)	2 (6)	2 (17)	0 (0)	4 (8)	0.276	Chi-square

SCR, supracommissural replacement; AVS, aortic valve sparing; CABG, coronary artery bypass grafting.

SCR and AVS was observed by direct inspection, such as cusp degeneration, involvement of the aortic bulb by the intima tear, or severe coronary dissection, we implemented Bentall procedure and/or coronary artery bypass grafting (CABG). In case of dissection of the root without severe coronary dissection but with feasibility of conservative valve reconstruction, the wall layers were readapted with GRF glue and reinforced with Teflon felt strip at both the inside and outside walls of the sinotubular junction. If necessary, partially dissected coronary artery ostia were conservatively constructed using GRF glue. For SCR of the ascending aorta, the aorta was resected 5 mm above the commissures, and a Dacron prosthesis was sawn with a running suture to the remaining reinforced aortic root.

For the Bentall procedure, the aortic valve and the aortic root were resected to the annulus, and the valved conduit or the Freestyle Xenograft was anchored in the aortic annulus using pledgetted 2-0, everting mattress sutures. Reimplantation of coronary ostia was then performed either by the Carrel patch technique or Piehler's method.

In the partial remodeling technique, as much as possible of the dissected aortic root was resected, leaving a rim of 10 mm above the noncoronary annulus and 5 mm above the coronary ostia and commissures. The dissected remaining wall layers were readapted with GRF glue and reinforced with Teflon felt strip at both the inside and outside walls. Woven Dacron graft tailored in a scallop-shaped configuration to match the noncoronary sinus was then anastomosed to the proximal aortic stump.

Neck vessels were reconstructed during the subsequent rewarming.

Follow-up

Postoperative follow-up was significantly different among groups (P <0.01, respectively). It was longer for SCR (37 ± 20 months, 3 to 63 months, November 2002 to February 2008) than for Bentall (21 ± 13 months, 4 to 39 months, November 2004 to February 2008: P <0.01). It was significantly shorter for AVS (3 ± 0.4 months, 2 to 4 months, November 2007 to February 2008: P <0.01). Follow-up was obtained by telephone communication with the patients. After Bentall procedure, patients treated with a valved conduit were anticoagulated with coumadin, and patients receiving a Freestyle Xenograft were on aspirin and Anplag for 3 months. Performance of patients was assessed in regard to classification by the New York Heart Association (NYHA).

Statistical analysis

The differences in various preoperative factors, hospital mortality, and occurrence of major postoperative complications were compared among the 3 subdivided groups. Statistical variance was tested with the chi-square and one-way Anova; probability values of less than 0.05 were considered significant. Actuarial curves for late event-free survival rates were constructed by the Kaplan-Meier linearized product method and compared among groups.

Results

Perioperative results

Mean operation times, CPB times, and cardiac ischemia times were significantly different among the groups. Bentall took longer than SCR and AVS (P <0.002). A trend toward more need for CABG is observed for Bentall (17%, 2/12), compared with SCR (6%, 2/33) and AVS (0%, 0/6, P = 0.276). The needs for total arch replacement, partial replacement, and elephant trunk extension into the descending aorta were equally distributed among groups (Table 2).

In all patients, noncoronary sinus was dissected completely or nearly completely to the annulus. Table 3 shows

Table 3. Extent of aortic root dissection in addition to noncoronary sinus

	A (SCR)	B (Bentall)	C (AVS)	Overall	P (Chi-square)
L or R affected completely or partially (%)	10 (30)	10 (83)	1 (17)	21(41)	0.003
L or R affected completely (%)	1 (3)	3 (25)	0 (0)	4 (8)	0.04
R affected completely or partially (%)	3 (9)	6 (50)	1 (17)	10 (20)	0.003
R affected completely (%)	0 (0)	2 (17)	0 (0)	2 (4)	0.034
L & R affected completely or partially (%)	7 (21)	4 (33)	0 (0)	11 (22)	N.S. (0.268)
L & R affected completely (%)	1 (3)	1 (8)	0 (0)	2 (4)	N.S. (0.627)
Coronary dissection in L or R affected completely (%)	1 (3)	3 (25)	0 (0)	4 (8)	0.04

SCR, supracommissural replacement; AVS, aortic valve sparing; L, left coronary sinus; R, right coronary sinus; N.S., not significant. Completely includes nearly completely.

Table 4. Perioperative results for patients with AADA involving sinus of Valsalva treated with different surgical methods

	A (SCR)	B (Bentall)	C (AVS)	Overall	P	Test method
Early mortality (%)	5 (15)	3 (25)	0 (0)	8 (16)	N.S. (0.420)	Chi-square
Rethoracotomy (%)	4 (24)	1 (8)	0 (0)	6 (8)	N.S. (0.143)	Chi-square
Neurological complications (%)	1 (3)	0 (0)	0 (0)	1 (2)	N.S. (0.757)	Chi-square
Prolonged need for respirator (> 7 days: %)	14 (42)	1 (8)	0 (0)	15 (29)	0.042	Chi-square
Need for hemodyalysis (%)	6 (17)	4 (33)	0 (0)	10 (20)	N.S. (0.230)	
Hospitalization (days)	52 ± 50	40 ± 42	29 ± 20	47 ± 46	N.S. (0.449)	One-way Anova

SCR, supracommissural replacement; AVS, aortic valve sparing; N.S., not significant.

the extent of aortic root dissection. In comparison to noncoronary sinus, other sinuses were significantly more often affected in Bentall. Two SCR patients had a rupture of the aortic root (noncoronary sinus) during weaning from CPB after completion of SCR of the ascending aorta and arch replacement, and eventually they underwent additional Bentall procedure. In terms of the extent of aortic root dissection, one showed that only the noncoronary sinus was affected completely, and he survived. The other had all sinuses affected completely, and she died of cardiac failure resulting from AMI nearly 1 day postoperatively.

Overall, early (hospital) mortality was 16% (8/51) and did not differ significantly among groups. A trend toward higher mortality is observed for Bentall (25%, 3/12), compared with SCR (15.1%, 5/33) and AVS (0%, 0/6) (P = 0.42). Three patients of Bentall died of left ventricular failure as a result of AMI. All of them had more than two sinuses of Valsalva affected completely, and one had a right coronary artery detached. Reasons for early mortality of SCR have been abdominal ischemia because of malperfusion in 4 patients and cerebral infraction, which occurred preoperatively, in 1 patient.

No significant differences were observed among groups regarding a need for rethoracotomy, postoperative neurological complications, a need for hemodyalysis, or length of hospitalization. A prolonged need for mechanical ventilation (> 7 days) was found to be the only significant difference among groups. SCR had a more prolonged need for ventilation (P = 0.042). Perioperative results are listed in Table 4.

The frequency for use of the 3 techniques has been changed over years, as graphically shown in Fig. 1. Although SCR was the most-used treatment in the first 3 years, the Bentall technique was first applied in 2004 and the AVS treatment in 2007, taking a higher percentage, up to half in that year, of all operations performed on patients with AADA involving sinus of Valsalva.

Postoperative follow-up

Survival (including hospital mortality) was comparable among groups. Because of shorter follow-up for AVS, statistical comparison was performed between SCR and

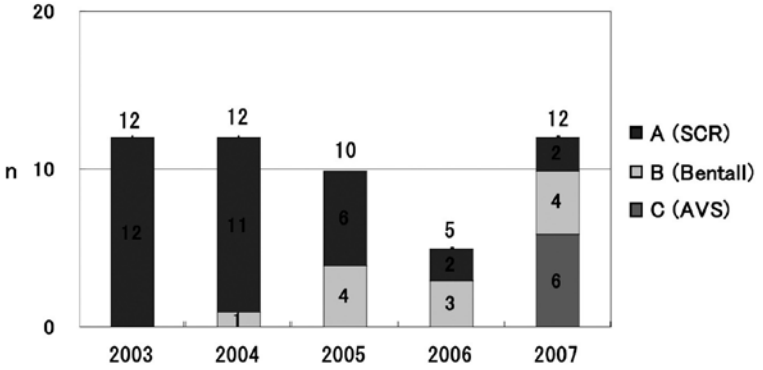


Fig. 1. Patient distribution by year according to treatment method.

Bentall. Actuarial survival at 5 years was 67 ± 8% for SCR and 75 ± 13% for Bentall (log rank: P = 0.338). Actuarial survival is graphically shown in Fig. 2. Currently, no patient from Bentall or AVS has died during follow-up. The reasons for late death, shown only in the SCR patients, have been abdominal aortic rupture, pneumonia, and mediastinitis. Because autopsies were refused, the reason for death was unclear in 3 SCR patients.

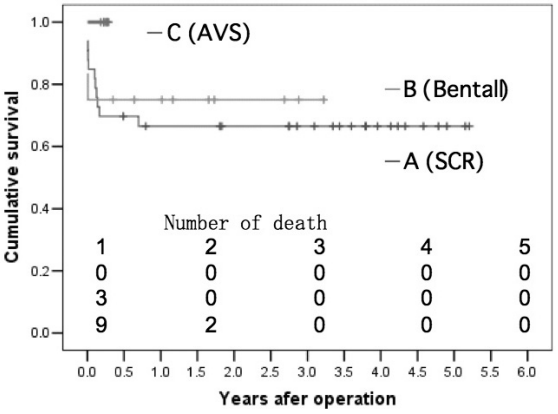
During follow-up, 2 patients from SCR have had the aortic root reoperated on because of redissection with subsequent aortic root dilatation and aortic regurgitation. Both of them underwent redo-Bentall procedure 17 months and 19 months postoperatively. Including intraoperative conversion from SCR to Bentall procedure because of aortic root rupture and uncontrollable bleeding, 4 patients of A group underwent reoperations on the sinus of Valsalva. Further, 2 SCR patients developed a dilated aortic root measuring more than 50 mm, a limit that is currently considered an operative indication.[10] Altogether, 6 patients from SCR had aortic root morbidity (including conversion during operation). Freedom from aortic root morbidity after 5 years was 71 ± 10% for SCR and 100% for Bentall (log rank: P = 0.349). Actuarial freedom from aortic root morbidity is shown in Fig. 3.

Two SCR patients and 1 Bentall patient required reoperations on the downstream aorta within 1 year. Elephant-trunk extension had been performed in all 3 patients in the first operations.

Discussion

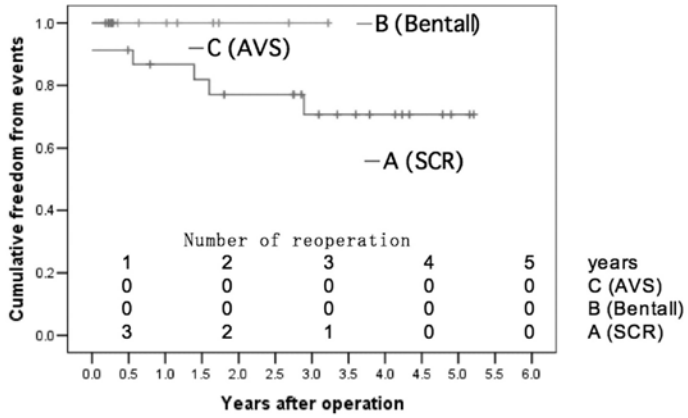
Although it is generally recognized that the disintegration of the aortic root as a result of aortic dissection should be treated in patients with AADA involving sinus of Valsalva, the surgical technique to be applied for aortic root reconstruction remains a subject of debate.[7] Unquestionably, reconstruction of the aortic root with GRF glue and SCR of the ascending aorta represent probably the easiest and quickest approach, but diseased aortic tissue is then left in place, ignoring the underlying aortic wall pathology. Possible redissection or aneurysm formation may bear a vital risk for the patient and may require further operation of the proximal ascending aorta.[2] This aortic root morbidity is the main reason for reoperations because of the development of relevant aortic regurgitation with an incidence rate ranging from 10% to 40%.[11–13] Aortic root replacement using composite graft prosthesis has been described as a radical treatment for AADA with satisfactory outcomes.[3] More recently, favorable midterm results of valve-sparing aortic root replacements[2,4,14] have been introduced by David's reimplantation technique.[6] However, these techniques are more technically demanding and time consuming than XCR in the different entity of AADA in an emergency situation. Because the dissection process always involved the noncoronary sinus in our series, our current approach is a partial remodeling technique in which as much as possible of the dissected aortic tissue, mainly of noncoronary sinus, was resected. This technique is much easier than Bentall or valve-sparing aortic root replacement because coronary reimplantation is not necessary.[7]

The most important determinant with which to judge a surgical technique is early mortality and survival.[1] Overall hospital mortality in our series was 16% and is comparable to that in recent reports by others.[2,14,15] Early mortality for patients undergoing Bentall was high, 25% compared to SCR (15%) and AVS (0%), though this difference failed to show statistical significance (P = 0.42). Despite high homology among the groups, a trend toward



Cumulative survival	C	B	A
1 years	100 %	75±13 %	67±8 %
3 years	—	75±13 %	67±8 % log rank p=0.338
5 years	—	75±13 %	67±8 %

Fig. 2. Actuarial survival for patients with AADA involving aortic root. Hospital mortality included.



Cumulative Freedom	C	B	A
1 years	100 %	100 %	87±7 %
3 years	—	100 %	71±10% log rank p=0.349
5 years	—	100 %	71±10%

Fig. 3. Freedom from aortic root morbidity.
Intraoperative conversion from SCR to Bentall is included.

the high frequency of AMI was observed in Bentall (25%) compared with SCR (6%) and AVS (0%), and aortic root integrity was affected significantly more in patients from Bentall than from SCR and AVS. But it is important to stress that a major drawback of Bentall is its operation time, which is longer that those of SCR and AVS.

During follow-up, survival was favorable after 5 years and did not differ among treatment groups. The reported high aortic root morbidity in SCR is confirmed by our findings. Although there is only a trend toward more aortic root morbidity (log rank: P = 0.349), we experienced aortic root rupture in 2 SCR patients intraoperatively, and 2 reoperations from SCR, considering Bentall or reimplantation procedure more appropriate in patients with AADA involving aortic root and adopted Bentall procedure in 2004. But Bentall required a significantly longer opera-

tion time. Although the partial remodeling technique (AVS) cannot be compared with the other groups because of shorter follow-up in this study, it may be considered that aortic root morbidity will be reduced compared with SCR because less-diseased aortic root tissue is left in place. Follow-up for patients from AVS is limited and allows only an interpretation of short-term results. In further long-term studies, it must be proven if long-term survival and aortic root morbidity are superior compared to SCR.

Conclusions

We report the outcome of 51 consecutive patients who have undergone operations for AADA involving aortic root with 3 different surgical strategies. SCR showed a trend toward higher aortic root morbidity. Despite clinical results comparable to SCR, Bentall required a significantly longer operation time than SCR. Today, the partial remodeling technique represents the surgical technique of choice at our institution for the treatment of AADA involving aortic root in patients judged to be suitable.

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