Supracoronary ascending aortic replacement in patients with acute aortic dissection type A: What happens to the aortic root in the long run?

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Objective: Our objective was to determine long-term outcome predictors for patients with acute aortic dissection type A (AADA) and aortic root involvement.

Methods: From 2001 through 2009, 119 of 152 patients operated on for AADA at a tertiary medical center underwent supracoronary ascending aortic replacement (52 women; mean age, 61 ± 15 years). Those with at least 1-year follow-up ($n = 97$) were retrospectively assessed for preoperative aortic root disease. Follow-up data were assessed for evidence of new-onset aortic root disease by computed tomography and echocardiography, and for reoperation for aortic root disease.

Results: Median follow-up was 33.8 months (range, 0-112 months). Twenty-six (27%) patients had new-onset aortic root disease at 4.4 ± 2.6 years after the initial procedure (range, 1.0-8.2 years) and 10 required aortic root reoperation. Severe aortic dissection with extension to pelvic arteries was an independent predictor for new-onset aortic root disease ($P < .01$). Dissection of all aortic sinuses during the initial procedure was an independent predictor ($P < .05$) for aortic root reoperation. Mean rate of aortic root expansion after supracoronary repair was 0.6 ± 1.1 mm per year. Preoperative aortic root diameter and aortic sinus dissection did not affect survivals. Five-year survivals were similar in patients with and without new-onset aortic root disease (91% vs 89%; $P = .79$).

Conclusions: In patients with AADA, dissection of 3 aortic sinuses is an independent predictor for need of reoperation, whereas dissection extension into the iliac arteries is a predictor of secondary aortic root disease. Long-term follow-up at close intervals is warranted in patients with supracoronary ascending aortic replacement to reduce mortality caused by new onset of aortic root disease. (J Thorac Cardiovasc Surg 2013;146:285-90)

Acute aortic dissection type A (AADA) remains a life-threatening disease.^{1,2} First-line therapy usually comprises emergency surgery aiming at preserving life with the lowest perioperative risk profile possible. Therefore, supracoronary ascending aortic replacement constitutes the most common surgical procedure for AADA.²⁻⁵

Complete resection of the intimal tear and prosthetic replacement of the ascending aorta with reapproximation of the proximal and distal edges are considered standard in AADA surgery. In patients with severe disruption of the sinus of Valsalva and with an aortic sinus diameter greater than 50 mm or severe aortic insufficiency, more extensive

surgery with aortic root replacement is warranted. However, the surgical strategy for patients with moderate aortic root involvement remains controversial, especially in those with serious perioperative risk owing to advanced age or comorbidities. It remains unknown whether ascending aortic replacement with no or reconstructive surgery of the aortic root predisposes patients with AADA who have moderate aortic root involvement to new-onset aortic root disease and a need for reoperation in the late postoperative period.

Therefore, we sought to investigate risk factors of new-onset aortic root disease with and without the need for reoperation in patients with AADA who underwent supracoronary ascending aortic replacement.

METHODS

Patient Population

This retrospective study was approved by the institutional review board. The need for informed consent was waived. From 2001 through 2009, 152 patients (52 women; mean age, 61 ± 15 years) with AADA underwent emergency surgery at our institution. Of the 119 patients who underwent supracoronary aortic replacement, 7 (6%) were lost to follow-up after discharge, 9 (8%) patients died within 30 days after surgery, and 6 patients died within 1 year after surgery. Thus 97 patients with supracoronary aortic replacement and at least 1 year of follow-up comprised our final study population. Five (4%) patients received a diagnosis of Marfan syndrome

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Abbreviations and Acronyms

AADA = acute aortic dissection type A
CT = computed tomography

postoperatively. These patients were included into the analysis. Descriptive characteristics of the study population are presented in [Table 1](#).

Surgical Management

According to our institutional policies, surgery on the ascending aorta was limited to supracoronary aortic replacement in patients with normal aortic root diameters, absent or mild aortic insufficiency, and no known genetic connective tissue disorders. In patients with moderate aortic root involvement (defined as aortic root diameter of 40-49 mm or with dissection of the aortic sinus wall), the surgical regimen was a case-to-case decision. In patients with sinus dissection we routinely use BioGlue (CryoLife Inc, Kennesaw, Ga) to seal dissected layers of the aorta. Fourteen patients underwent hemiarch replacement and 7 total arch replacement.

Aortic Root Dimension and Extent of Dissection

Aortic root dimensions were assessed by computed tomography (CT) data sets using multiplanar reformatted reconstructions. To assess the aortic sinus dimensions, we took caliper measurements from each sinus to the opposing commissure and then averaged them. The extent of dissection into the 3 sinuses was noted from CT images and surgical reports.

Patient Follow-up

Retrospective analysis comprised patient data obtained from our institutional database, including inpatient and outpatient data. Data obtained until April 2011 were included in the analysis. In addition, for patients not undergoing follow-up at our institution, the primary care physician was contacted and imaging data retrieved.

The follow-up protocol included postoperative CT angiography before discharge, clinical examination and CT angiography 6 and 12 months postoperatively, and annually thereafter according to current guidelines.⁶ Median follow-up was 33.8 months (interquartile range, 0-112 months). Thirty-two of 97 patients underwent the primary aortic operation within the last 5 years of data inclusion. Thus 5-year survival data were available for 65 of 97 patients.

Study End Points

Our primary end points were new-onset aortic root disease or reoperation for aortic root disease. New-onset aortic root disease was defined as mean growth rate of the aortic root greater than 2 mm per year, suture aneurysm, severe aortic valve insufficiency, or recurrent dissection of aortic sinus.

Statistical Analysis

Statistics were summarized as the frequency and percentage for categorical variables and the mean and standard deviation for continuous variables. The influences of different variables (listed in [Tables 1](#) and [2](#)) on new-onset aortic root disease were analyzed separately by logistic regression. Logistic regression was performed for each variable, adjusting for age and sex in each case. Age and gender were separately analyzed using univariate regression analysis. The same analysis was used to test for influence of different disturbance variables (see [Table 2](#)) on reoperation on the aortic root. Kaplan-Meier curves were calculated for survival of all patients and for survival of those with and without new-onset aortic root disease. Survival was defined as time from the operation date to the date of death or to June 15 of the year in which the observation stopped. A log-rank test was estimated to compare survival times between patients with and without new-onset aortic root disease. Because this is an explorative study, the term

“statistically significant” should be interpreted with care. There was no formal adjustment for the number of performed tests. Analysis was performed with SAS software, version 9.2 (SAS Institute, Inc, Cary, NC).

RESULTS

Survival

Overall 5-year survival was 89.2% (58/65) and influenced by neither preoperative aortic root diameter nor aortic sinus dissection. Survivals for patients with and without new-onset aortic root disease were 91% versus 89% at 5 years ($P = .79$). Kaplan-Meier estimates of survival for all patients and for those having new-onset aortic root disease are illustrated in [Figure 1, A and B](#), respectively.

New-Onset Aortic Root Disease

During the study period, 26 (27%) patients showed evidence of new-onset aortic root disease: aortic root expansion in 15 (13%), suture aneurysm in 6 (5%), recurrent dissection in 3 (3%), and aortic valve insufficiency in 3 (3%) patients. New-onset aortic root disease was diagnosed within 4.4 ± 2.6 years after the initial procedure (range, 1.0-8.2 years). We observed a correlation between severe aortic dissection with extension to iliac arteries and new-onset aortic root disease (odds ratio, 3.57; 95% confidence interval, 1.36-9.35; $P < .01$). However, no association was found between age, gender, dissection of all aortic sinuses, and new-onset aortic root disease ([Table 2](#)).

Patients with new-onset aortic root disease revealed a more extensive pattern of aortic initial dissection with more frequent extension of dissection to supra-aortic vessels (35% vs 30%; $P = .8$), the infradiaphragmal aorta (62% vs 41%; $P = .12$), and a significantly higher frequency of dissection into the iliac arteries (54% vs 24%; $P = .01$) when compared with patients without evidence of new-onset aortic root disease. Mean rate of aortic root dilation was 0.6 ± 1.1 mm per year in the entire study cohort. Dissection and procedural characteristics of patients with and without new-onset aortic root disorder are listed in [Table 1](#).

Aortic Root Reoperation

Of the 26 patients with a new-onset aortic root disorder, 10 required aortic root reoperation at a mean interval of 5.4 ± 3.3 years after the initial procedure (range, 0.6-9.2 years). Reoperation was performed in 7 patients electively and in 3 with urgency. Indications for reoperation were severe aortic valve insufficiency ($n = 4$), suture aneurysm ($n = 2$), severe aortic valve insufficiency and suture aneurysm ($n = 3$), and dilatation of the sinus of Valsalva with aortic valve insufficiency ($n = 1$). Of the 10 patients who underwent aortic root reoperation, 1 died in the hospital of multiple organ dysfunction syndrome and another after 2 months of a suture aneurysm on the proximal aorta, which led to cardiac insufficiency and sepsis. Patient characteristics are listed in [Tables 3](#) and [4](#).

TABLE 1. Demographics, clinical and dissection characteristics, and follow-up aortic root structure for the entire cohort and for patients with and without new-onset aortic root disease

	All (n = 97)	New-onset aortic root disease (n = 26)	No new-onset aortic root disease (n = 71)	P value
Demographics				
Age, y	61.2 ± 13.8	59.2 ± 13.4	62.0 ± 14.0	.37
Female, n (%)	32 (33.0)	8 (30.8)	24 (33.8)	.78
Clinical presentation, n (%)				
Hypertension	85 (87.6)	24 (92.3)	61 (85.9)	.33
Marfan syndrome	5 (5.2)	1 (3.9)	4 (5.6)	.53
Previous cardiac surgery	4 (4.1)	1 (3.9)	3 (4.2)	
Bicuspid aortic valve	0	1 (3.9)	1 (1.0)	.99
Iatrogenic dissection	4 (4.1)	1 (3.9)	3 (4.2)	.94
Shock	8 (8.3)	3 (11.5)	5 (7.0)	.48
Malperfusion				
Neurologic	16 (16.5)	5 (19.2)	11 (15.5)	.68
Cardiac	5 (5.2)	1 (3.9)	4 (5.6)	.59
Visceral	4 (4.1)	0	4 (5.6)	.98
Peripheral	6 (6.2)	1 (3.9)	5 (7.0)	.55
Involvement of aortic dissection, n (%)				
Aortic arch	67 (69.1)	21 (80.8)	46 (64.8)	.23
Supra-aortic vessels	30 (30.9)	9 (34.6)	21 (29.6)	.77
Descending thoracic aorta	51 (52.6)	18 (69.2)	33 (46.5)	.08
Descending abdominal aorta	45 (46.4)	16 (61.5)	29 (40.8)	.12
Iliac vessels	31 (32.0)	14 (53.9)	17 (23.9)	.01
Aortic root at presentation				
Diameter, mm	41.7 ± 5.8	42.0 ± 5.9	41.6 ± 5.9	.75
Severe aortic valve regurgitation, n (%)	10 (10.3)	4 (15.4)	6 (8.5)	.37
Dissection of 3 sinuses, n (%)	32 (33.0)	10 (38.5)	22 (31.0)	.35
Surgical management				
ECC time, min	181.7 ± 48.3	182.1 ± 46.9	181.6 ± 49.1	.99
Aortic crossclamp time, min	83.4 ± 30.1	82.7 ± 32.7	83.7 ± 29.4	.66
Antegrade cerebral perfusion time, min	27.8 ± 21.0	21.8 ± 15.6	29.9 ± 22.4	.18
Sinus of Valsalva dimensions on follow-up CT				
Diameter, mm	41.8 ± 6.3	46.0 ± 7.4	40.2 ± 5.0	.0003
Growth rate, mm/y	0.6 ± 1.1	1.3 ± 1.3	0.2 ± 0.7	.02
Outcome, n (%)				
Five-year survival	58/65 (89.2)	19/21 (90.5)	39/44 (88.6)	.79

Differences between both groups were evaluated using regression analysis adjusted for age and gender. The influence of age and gender on incidence of new-onset aortic root disease was calculated by univariate regression analysis. *ECC*, Extracorporeal circulation; *CT*, computed tomography.

Multivariate analysis revealed dissection of all aortic sinuses at the time of the initial procedure as an independent predictor ($P < .05$) of aortic root reoperation. Neither aortic valve regurgitation nor aortic root diameter predicted the need for aortic root reoperation (Table 2). Kaplan-Meier estimate of freedom from reoperation in patients after supracoronary ascending replacement is shown in Figure 1, C.

DISCUSSION

To minimize the perioperative risk in patients with AADA, surgeons may choose to limit the extent of surgery involving supracoronary ascending aortic replacement with valve resuspension.² An alternative is more aggressive, involving aortic root replacement using a composite graft or a valve-sparing procedure. Although the more extensive surgery may be associated with higher

perioperative risk, it eliminates the risk of future aneurysmal dilatation and redissection of the aortic root or aortic valve incompetence.^{7,8} However, the risk of proximal false aneurysm and infection requiring redo surgery remains.⁹ Inasmuch as the optimal surgical regimen for patients with AADA who have moderate aortic root involvement is not yet established, we sought to analyze our experience in patients who underwent a limited surgical approach and supracoronary replacement to identify predictive factors for unfavorable outcome.

Survival

Advances in diagnostic modalities and refinements in surgical strategies have improved AADA surgery outcomes over the past decade.^{10,11} Published data from the International Registry of Acute Aortic Dissection reported

TABLE 2. Analysis of risk factors for new-onset aortic root disease and reoperation

Risk factors	New-onset aortic root disease			Reoperation on the aortic root		
	OR	95% CI	P value	OR	95% CI	P value
Age	0.98	0.95-1.02	.33	0.99	0.95-1.04	.66
Gender	1.06	0.38-2.95	.91	0.45	0.12-1.69	.24
Aortic root diameter	1.02	0.93-1.11	.75	1.05	0.92-1.20	.48
Dissection of all aortic sinuses	1.28	0.49-3.37	.62	6.01	1.34-26.9	<.05
Severe aortic valve regurgitation	1.90	0.48-7.56	.37	1.21	0.13-11.4	.87
Dissection extension to pelvic arteries	3.57	1.36-9.35	<.01	1.65	0.41-6.64	.48

Age and gender were analyzed univariately, and aortic root diameter, dissection of aortic sinuses, and severe aortic valve regurgitation were analyzed multivariately according to age and gender. *OR*, Odds ratio; *CI*, confidence interval.

an in-hospital mortality rate of 26% after surgical repair in patients enrolled to the registry between 1996 and 1998.¹² The latest report from the German Registry of Aortic Dissection Type A describes a 30-day mortality rate of 17% in patients treated between 2006 and 2009.¹³ Despite these advances, AADA remains a catastrophic event associated with a high hospital mortality rate and significant postoperative morbidity in survivors. Encouragingly, the in-hospital mortality in our series of patients with supracoronary ascending aortic replacement is very low (8%) even though we tend to perform this type of operation in older patients. Five-year survival was similar in patients with and without new-onset aortic root disease. Those with new-onset aortic root disease were scheduled to a follow-up protocol at closer intervals (3-6 months), which enabled us to operate on them early enough to prevent further serious complications that might have proved fatal. These findings highlight the need for annual aortic imaging by CT or magnetic resonance as recommended in the latest guidelines for the management of patients with thoracic aortic disease.⁶

New-Onset Aortic Root Disease

During the follow-up, CT revealed various aortic root diseases, the most common being progressive dilatation of the remaining native aorta. In our series, the average growth rate of the sinus of Valsalva's diameter was 0.6 mm per year. Whenever a tendency to root enlargement is diagnosed, one must shorten the interval for the next diagnostic imaging examination to 6 or even 3 months. According to Kobuch and associates,¹⁴ the native aorta's dimensions may remain constant for years and then suddenly increase for unknown reason(s), perhaps an effect of hypertonic episodes. Our cohort's second most common aortic pathologic condition was suture aneurysm. It is a rare but serious and complex complication usually requiring surgical repair. Patients with aortic dissection show a high incidence of suture

FIGURE 1. Kaplan-Meier estimates of survival for the entire cohort (A) and for patients with new-onset aortic root disease (B) and freedom from reoperation (C).

aneurysm, probably owing to increased tissue fragility in the suture line. However, this complication is not limited to patients with AADA. Suture aneurysm and subsequent suture line rupture are widely known from surgery on the ascending aorta.¹⁵⁻¹⁸ Residual dissection and progressive aortic valve incompetence were equally frequent in our patients.

TABLE 3. Demographics and indication for redo surgery

Patients	Age, y	Time between initial and secondary procedure, y	Sinus Valsalva diameter, mm	Severe aortic valve insufficiency	Suture aneurysm	Priority of procedure
1	79	1.8	44	1	0	Elective
2	62	9.3	67	1	0	Elective
3	74	8.8	44	1	1	Urgent
4	80	7.8	38	0	1	Urgent
5	55	4.3	42	1	0	Urgent
6	55	8.2	38	1	1	Elective
7	75	6.3	45	0	1	Elective
8	70	1.3	47	1	0	Elective
9	30	6.0	48	1	0	Elective
10	67	4.5	38	1	1	Elective

We are the first to demonstrate that dissection of the entire aorta at the time of the initial procedure constitutes a risk factor for aortic root complications in the long run. Dissection of the entire aorta extending to the aortic branches suggests generalized aortic tissue vulnerability in these patients. Thus both aortic root involvement and the extent of antegrade dissection demand consideration in patients with AADA when determining the surgical strategy.

More than a quarter of patients investigated in this study received a diagnosis of new-onset aortic root disease, underlining the general importance of this entity. The average time interval between the initial procedure and occurrence of aortic root disorder was 4 years. These findings demonstrate convincingly that long-term follow-up is mandatory, as recommended by current guidelines.⁶

Reoperation on Aortic Root

In this series, almost half of the patients identified with new-onset aortic root disease required reoperation. Our 10% reoperation rate among all patients with supracoronary aortic replacement resembles that in previous reports.^{14,19} Although all reoperations took place without significant procedural difficulties and revealed an acceptable in-hospital mortality rate, the postoperative course was rather long and involved extensive resource use.

Previously reported predisposing factors for conditions requiring reoperation are incomplete excision of the tear, failure to obliterate the false lumen, and severe aortic valve regurgitation.²⁰⁻²² In our series we also demonstrate that patients with dissection of all aortic sinuses carry an increased risk for reoperation on the aortic root after conservative proximal repair. Importantly, dissection of just 1 or 2 sinuses was safely repaired using reconstruction and supracoronary replacement without showing an increased risk of new-onset root disease. Thus established risk factors for new-onset aortic root disease and reoperation must be considered whenever deciding between a limited or more aggressive surgical approach in patients with AADA who have moderate aortic root involvement.

We found no association between age at the time of dissection and new-onset aortic root disease or reoperation on the aortic root. However, given the “relatively” short median follow-up period of 33.8 months, larger studies with longer follow-up data in young patients are warranted to provide more insights into the role of age at the time of dissection and long-term outcome.

CONCLUSIONS

Patients with AADA who undergo supracoronary ascending aortic replacement carry a high risk of late aortic root

TABLE 4. Resource use and outcome in patients who underwent redo surgery

Patients	Revision for bleeding	Ventilation, h	Cerebrovascular accident	ICU stay, d	Hospital stay, d	In-hospital mortality	One-year mortality
1	0	96	1	11	27	0	0
2	0	24	0	3	17	0	1
3	1	190	0	8	8	1	1
4	0	20	0	2	20	0	0
5	0	21	0	2	21	0	0
6	0	28	0	3	10	0	0
7	0	118	0	11	21	0	0
8	0	6	0	2	14	0	0
9	1	44	0	4	49	0	0
10	0	6	0	2	9	0	0

ICU, Intensive care unit.

reoperation. According to the data from this monocentric investigation, dissection of 3 aortic sinuses is an independent predictor for need of reoperation, whereas dissection extension into the iliac arteries is a predictor of secondary aortic root disease. These risk factors must be considered when opting for a surgical approach limited to ascending aortic replacement and warrant close long-term follow up with cross-sectional imaging.

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