Survival of young patients after abdominal aortic aneurysm repair

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Purpose: **This study assessed the cardiovascular disease, perioperative results, and survival after surgical abdominal aortic aneurysm repair in young patients (≤ 50 years) compared with randomly selected older patients who also underwent abdominal aortic aneurysm repair.**

Methods: **We reviewed hospital records to identify young and randomly selected control patients (3 for each young patient, ≥ 65 years, matched for year of operation) with degenerative (atherosclerotic) abdominal aortic aneurysms undergoing repair between Jan 1, 1988, and Mar 31, 2000. Patients with congenital aneurysms, pseudoaneurysms, aortic dissections, post-coarctation dilations, aortic infection, arteritis, or aneurysms isolated to the thoracic aorta were excluded. Mortality data and cause of death were obtained from medical records and the National Death Index.**

Results: **Among 1168 patients who underwent abdominal aortic aneurysm repairs, 19 young patients (1.6%) and 57 control patients were identified. The mean age was 48.4 years in the young group and 72.2 years in the control group. There were no differences in sex or race between the two groups. When comparing existing cardiovascular disease between the groups, there were no differences in the incidence of earlier coronary revascularization (26% vs 16%) or non-cardiac vascular surgery (5% vs 9%), but aneurysms were more commonly symptomatic in young patients (53% vs 21%; $P < .01$). Aneurysmal disease was limited to the infrarenal aorta in similar proportions of patients (89% vs 88%). No statistically significant differences were seen in the incidence of perioperative deaths (16% young vs 9% control; $P = .40$) or postoperative complications (37% young vs 26% control; $P = .38$). The estimated survival rate of the young group was not different from that of the control group (3-year survival rate, 73% vs 69%; $P = .32$) or the entire cohort of patients (older than 50 years; n = 1101) who underwent repair of abdominal aortic aneurysms during the study period (3-year survival 73% vs 75%; $P = .63$).**

Conclusion: **After abdominal aortic aneurysm repair, young patients had perioperative results and follow-up mortality rates similar to those of control patients. Cardiovascular disease was the predominant cause of death after abdominal aortic aneurysm repair in the young patients. When compared with an age older than 50 years at the time of abdominal aortic aneurysm repair, young age alone was not associated with increased survival. (J Vasc Surg 2002;35:94-9.)**

Abdominal aortic aneurysms (AAAs) are thought to be a disease of the elderly.[1] Whether evaluated by means of necropsy[2,3] or screening ultrasound scanning,[4,5] the prevalence of AAA increases with age. Operative repairs of AAAs are also more common in the elderly.[6] However, AAAs in young patients are rare, and patients younger than 50 years have been excluded from population-based AAA studies.[5,7]

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Symptomatic atherosclerosis in young patients is associated with premature cardiovascular death.[8] An increased risk of death has been reported for young patients with severe aortoiliac disease,[9,10] cerebrovascular disease,[11,12] and atherosclerotic infrainguinal disease.[9,13-15] However, data describing the survival patterns for young patients treated for AAA are incomplete.

The purpose of this study was to describe the associated cardiovascular disease, perioperative results, and survival rate after surgical repair of degenerative (atherosclerotic) AAA in young patients (≤50 years) compared with those of a randomly selected comparison group of older patients who also underwent AAA repair. In addition, survival rates and causes of death in the young patients were compared with those of the entire patient cohort who underwent AAA repair during the study period.

METHODS

Patient data. We reviewed hospital records to identify all patients who had operative repair of an AAA at Wake Forest University Baptist Medical Center between Jan 1, 1988, and Mar 31, 2000. Medical records were reviewed for patients ≤50 years at the time of operation and for randomly selected control patients (3 control subjects for each

Table I. Patient demographics and atherosclerotic risk factors

	Young patients (n = 19)	*Control patients (n = 57)*	P *value*
Demographics			
Age (y, mean ± SD)	48.4 ± 1.9	72.2 ± 4.9	
Sex (male)	15 (76%)	43 (75%)	1.0
Race (white)	15 (79%)	52 (91%)	.21
Atherosclerotic risk factors*			
Tobacco use	18 (95%)	48 (86%)	.43
Hypertension	15 (79%)	46 (81%)	1.0
Dyslipidemia	10 (53%)	19 (35%)	.16
Obesity (BMI > 25 kg/m^2)	9 (53%)	28 (56%)	.82
Diabetes mellitus	2 (11%)	6 (11%)	.71
Family history			
Coronary artery disease	5 (26%)	18 (32%)	.63
AAA	1 (5%)	3 (5%)	1.0

*Atherosclerotic risk factors as defined by Rutherford RB, Baker JD, Ernst C, et al. Recommended standards for reports dealing with lower extremity ischemia: revised version. J Vasc Surg 1997;26:517-38.
BMI, Body mass index; *AAA,* abdominal aortic aneurysm.

younger patient, 65 years or older, matched for year of operation). A random number chart was used as a means of randomly selecting the control patients from the entire cohort of patients undergoing AAA repair during the study period. Patients with congenital aneurysms, anastamotic or traumatic pseudoaneurysms, acute or chronic complications of aortic dissections, post-coarctation dilations, arteritis, infectious aneurysms, or aneurysms isolated to the thoracic aorta were excluded from analysis.

With published reporting standards, we abstracted data including demographics, atherosclerotic risk factors and cardiovascular disease, family history of aneurysmal or coronary artery disease, and comorbid conditions.[16,17] Aneurysm size and extent were determined with abdominal computed tomography or ultrasound scanning and the operative note. Complex repair was defined as repair of an aneurysm involving the juxtarenal or suprarenal aorta or AAA repair combined with renal revascularization. Postoperative complications were recorded according to recommended standards,[16] and pathology reports from aortic wall specimens were reviewed.

Mortality data and cause of death were obtained from the medical records and a National Death Index (NDI) search. The NDI is a computerized database containing death record information from state vital statistics offices and, at the time of our search, contained information for all deaths in the United States between January 1979 and December 1998. Mortality and cause of death data for patients undergoing AAA repair after December 1998 (latest NDI data) were obtained from a medical record review. The survival and cause of death for the entire cohort of patients undergoing repair of a degenerative AAA between January 1988 and December 1998 were also analyzed.

Statistical analysis. The risk factors and perioperative course of both groups were compared by using the chi-square test and Fisher exact test. Mortality data were analyzed by using life-table methods, compared with the log-rank test and depicted graphically with Kaplan-Meier product-limit estimates.[18] The effect of atherosclerotic risk factors and associated cardiovascular disease on survival was assessed with multivariate Cox proportional hazards models.[19] A backward stepwise elimination technique was used with all factors of interest included in the first step. Only the factors significant at the .10 level were included in the final analysis.[19] All statistical tests were considered significant when the *P* value was less than .05.

RESULTS

Patients. A total of 1168 patients met the inclusion criteria for repair of AAA during the study period. From this group, 19 young patients (1.6%) and 57 control patients were identified (Table I). The mean age was 48.4 years (range, 44-50 years) in the young group and 72.2 years (range, 65-86 years) in the control group. There were no significant sex (76% men vs 75% men; $P = 1.0$) or racial (79% white vs 91% white; $P = .22$) differences between the young and control groups.

The prevalence of atherosclerotic risk factors was similar between the two groups (Table I). When comparing the young group with the control group, no differences were seen in the prevalence of diabetes mellitus (11% vs 11%; $P = 1.0$), tobacco use (95% vs 86%; $P = .43$), hypertension (79% vs 81%; $P = 1.0$), or dyslipidemia (53% vs 35%; $P = .16$). No differences were noted between the young and control groups for the prevalence of familial AAA (5% vs 5%; $P = 1.0$) or familial cardiac disease (26% vs 32%; $P = .63$).

Overall, cardiac disease was significantly less common in young patients than in control patients (42% vs 68%; $P = .04$; Table II). When analyzed by means of severity of disease, no significant differences between the young and control groups were seen in the prevalence of severe (0% vs 5%; $P = .42$) or moderate (26% vs 32%; $P = .61$) cardiac disease. Mild cardiac disease was less prevalent in the young patients (21% vs 52%; $P = .04$). However, there was

Table II. Associated diseases at the time of abdominal aortic aneurysm repair among the young and control patients*

	Young patients (n = 19)	*Control patients (n = 57)*	P *value*
Cardiac disease	8 (42%)	39 (68%)	.04
Severe cardiac disease	0	3 (5%)	.42
Moderate cardiac disease	5 (26%)	17 (32%)	.61
Mild cardiac disease	3 (21%)	19 (52%)	.04
Carotid disease	5 (26%)	24 (43%)	.20
Earlier myocardial revascularization	5 (26%)	9 (16%)	.32
Earlier non-cardiac revascularization	1 (5%)	5 (9%)	1.0
Renal disease	5 (26%)	17 (30%)	.71
Pulmonary disease	10 (53%)	40 (71%)	.13

*Associated diseases as defined by Rutherford RB, Baker JD, Ernst C, et al. Recommended standards for reports dealing with lower extremity ischemia: revised version. J Vasc Surg 1997;26:517-38.

Table III. Summary of perioperative mortality for young and control groups

Sex/age (y)	*Diagnosis*	*Operation*	*Cause of death*
Young group			
Male/45	Infrarenal AAA	AAA repair	Pneumonia/GI bleed/ARF
Male/48	Infrarenal AAA/RA stenosis	AAA repair/RA bypass grafting	Hemorrhage/MSOD
Male/50	Ruptured infrarenal AAA	AAA repair	MSOD
Control group			
Male/67	Ruptured TAA	TAA repair	Myocardial infarction
Female/68	Ruptured infrarenal AAA	AAA repair	MSOD
Male/75	Juxtarenal AAA	AAA repair	MSOD
Male/78	AAA/aortoduodenal fistula	AAA repair	MSOD
Female/86	Ruptured infrarenal AAA	AAA repair	Ischemic bowel/ARF

AAA, Abdominal aortic aneurysm; *MSOD,* multiple system organ dysfunction; *RA,* renal artery; *ARF,* acute renal failure; *GI,* gastrointestinal; *TAA,* thoracoabdominal aneurysm.

no difference between the proportion of young patients and control patients with earlier myocardial revascularization (26% vs 16%; $P = .32$) or non-cardiac vascular surgery (5% vs 9%; $P = 1.0$). Finally, the presence of carotid disease was not significantly different between the young and control groups (26% vs 43%; $P = .20$). Aneurysms were more commonly symptomatic in young patients than in control patients (53% vs 21%; $P < .01$), and all patients with symptoms had emergency or urgent AAA repair. In the young patients, symptoms included rupture (16%), pain (21%), and lower-extremity ischemia (16%). Symptoms in the control group were rupture (9%), pain (11%), and gastrointestinal bleeding from a primary aortoduodenal fistula (2%). However, no differences were noted between the young and control groups for aneurysm size (5.6 ± 1.6 cm vs 6.0 ± 1.7 cm; $P = .18$) or extent (89% infrarenal vs 88% infrarenal; $P = 1.0$). All patients had open AAA repair, and the need for complex AAA repair was not significantly different between the young and control groups (32% vs 23%; $P = .36$).

Outcome. Table III summarizes the procedures and perioperative deaths among the young patients and the control patients. The incidence of perioperative deaths was not significantly different between the young and control groups (16% vs 9%; $P = .40$).

Table IV describes the perioperative morbidity of the two groups. No significant differences were seen in length of stay (intensive care unit or hospital) or perioperative complications (major, moderate, or minor). Acute renal failure developed in four patients (three young and one control), and all died in the perioperative period. Three young patients were transiently dialyzed, and one patient (an 86-year-old woman) did not receive dialysis support. In the control group, three patients (4.2%) were discharged to temporary rehabilitation hospitals, and one patient (1.4%) returned to her nursing home after surgery, whereas all young patients were discharged home.

Follow-up data were available for all patients in the young and control groups. For the entire cohort of patients undergoing AAA repair during the study period, data were available for 96% for a mean period of 45 months. The estimated survival rate of the young group was not significantly different from that of the control group (Fig 1). Moreover, when the young group was compared with the group of all patients older than 50 years who underwent AAA repair during the study period (1101 patients), the survival distribution was again very similar (Fig 2).

Causes of death are summarized in Table V. Death was caused by cardiovascular diseases in 80% of the young patients, 50% of the control group ($P = .28$), and 62% of patients older than 50 years at the time of AAA repair ($P = .52$, compared with the young group). There was complete agreement between deaths (date and cause)

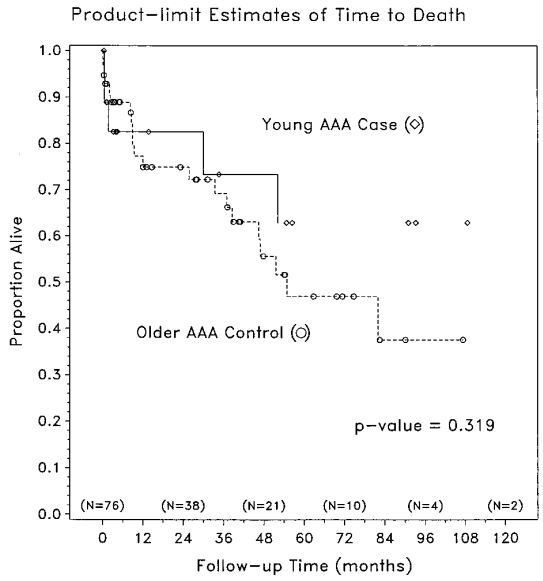

Fig 1. Product-limit estimates of time to death for young patients (n = 19) and control patients (n = 57) after AAA repair. The survival rate is not different between the two groups.

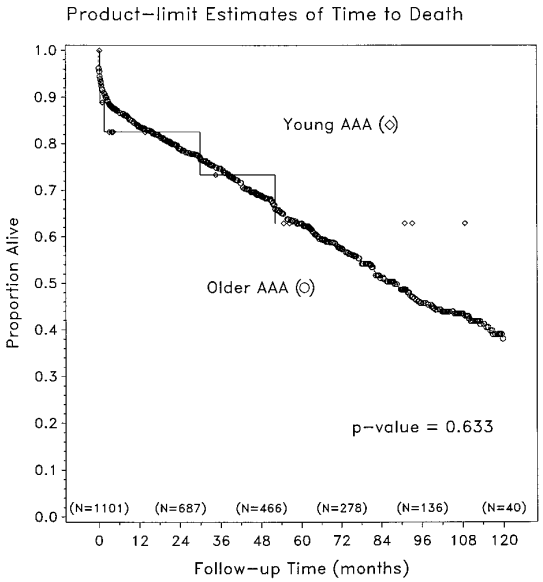

Fig 2. Product-limit estimates of time to death after AAA repair for young patients (n = 19) and the entire cohort of patients older than 50 years during the study period (n = 1101). The survival rate is not different between the two groups.

determined by means of medical record review and the NDI search.

When atherosclerotic risk factors, markers of cardiovascular disease, and age were examined in the young and control groups, no factors were identified that demonstrated significant association with death by means of either univariate or multivariate analysis. However, when the entire cohort of patients undergoing AAA repair during the study period was examined by using univariate analysis, age was found to be a significant predictor of death during follow-up ($P < .0001$). This finding was influenced by the patients older than 80 years at the time of AAA repair (intact or ruptured), who had a 12-month survival rate of 57%.

DISCUSSION

AAAs are rare in patients 50 years old or younger. This series describes 19 young patients with degenerative (atherosclerotic) aneurysms that required operative repair. These young patients were compared with 57 control patients also undergoing AAA repair. The two groups demonstrated comparable rates of atherosclerotic risk factors present at the time of AAA repair. Moreover, there were similar rates of moderate and severe cardiac disease, carotid disease, and earlier revascularization (both cardiac and non-cardiac) at the time of operation. Follow-up mortality of the young patients was similar to that of the control patients and the entire cohort of patients undergoing repair of AAA during the study period, with cardiovascular disease being the predominant cause of death. When compared with patients older than 50 years, young age at the time of AAA repair did not protect patients from subsequent cardiovascular mortality.

Because AAAs in young patients are unusual, data describing this population are limited.[20] Muluk et al[20] described a series of 26 patients aged 50 years or younger with aortic aneurysms requiring operative repair. In that group, 77% of aortic aneurysms were degenerative, and 23% had other causes including Marfan and Cogan's syndromes and Takayasu's arteritis. Forty-six percent of the young patients had aneurysms proximal to the infrarenal aorta, significantly more than the 18% found in a group of randomly selected older control patients ($P < .01$). The young and control patients had comparable rates of diabetes mellitus, hypertension, and cardiac disease at the time of operation. Similar to the results of the present study, Muluk and colleagues[20] found that 46% of the young patients and 6.7% of the control patients had symptoms at the time of operation ($P < .001$). Although the authors suggested that the survival rate of the young patients was similar to that of the control group, follow-up was available for less than two thirds of patients, and life-table methods were not used as a means of estimating survival.[20]

Aortoiliac occlusive disease in the young has been more extensively described.[9,10] Mingoli et al[10] examined the clinical course of 68 patients younger than 45 years with atherosclerotic aortoiliac occlusive disease requiring revascularization. Compared with a randomly selected control group of older patients undergoing aortoiliac reconstruction, the young patients had a higher prevalence of tobacco abuse, hypertension, and dyslipidemia and similar

Table IV. Summary of the postoperative course for young and control patients

	Young patients	*Control patients*	P *value*
ICU length of stay (d)			.99
Mean ± SD	6.1 ± 7.4	6.1 ± 8.5	
Median	3	3	
Hospital length of stay (d)			.40
Mean ± SD	15.0 ± 12.5	12.7 ± 9.9	
Median	10	9	
Perioperative morbidity			
Major complication*	4 (21%)	5 (9%)	.22
Moderate complication*	3 (20%)	10 (19%)	1.0
Mild complication*	0	3 (7%)	1.0

*Rutherford RB, Baker JD, Ernst C, et al. Recommended standards for reports dealing with lower extremity ischemia: revised version. J Vasc Surg 1997;26:517-38.
ICU, Intensive care unit.

Table V. Summary of follow-up deaths after repair of abdominal aortic aneurysm (perioperative deaths excluded)

	Young patients (n = 16)	*Control patients (n = 52)*	*Entire AAA cohort (n = 1046)*
Coronary artery disease	1 (6%)	3 (6%)	168 (16%)
Cerebrovascular disease	1 (6%)	1 (2%)	19 (2%)
Renal failure	1 (6%)	2 (4%)	9 (1%)
Aortic/peripheral atherosclerosis*	1 (6%)	5 (10%)	44 (4%)
Cancer	0	4 (8%)	47 (4%)
Other†	1 (6%)	7 (13%)	107 (10%)

*Aortic/peripheral atherosclerosis included complications of aortic graft infection, mesenteric ischemia, thoracic aortic aneurysm repair, lower-extremity revascularization, or gangrene.
†Other causes of death included trauma, infection, cirrhosis, complications of chronic lung disease, and gastrointestinal bleeding.
AAA, Abdominal aortic aneurysm.

rates of diabetes mellitus, cerebrovascular disease, and cardiac disease. With life-table methods, similar survival rates in both the young and older control groups were demonstrated (68% survival at 5 years for both groups).[10] By using life-table analysis, Harris et al[9] also reported no difference between the survival rates of young and randomly selected older control patients after aortoiliac reconstruction (5-year survival, 82% vs 84%; P = not significant).

A number of reports describe cerebrovascular disease in young patients.[11,12,21] Valentine et al[11] compared 42 patients younger than 50 years with 110 older control subjects undergoing carotid endarterectomy for atherosclerotic cerebrovascular disease. Stroke as an indication for operation was significantly more common in the young patients (48% vs 11%; $P < .001$). Although ipsilateral carotid artery restenosis was more frequent in the young patients (24% vs 3%; $P < .001$), a trend toward a more favorable survival rate in the young group compared with the older group (83% vs 67%; $P = .06$) was demonstrated by means of life-table analysis.[11] Martin et al[12] compared 26 patients younger than 50 years with 30 randomly selected older control patients who underwent carotid endarterectomy. Symptoms were more frequent in young patients than in older patients (92% vs 57%; $P = .003$); however, no significant differences were noted between the young and control groups for restenosis (27% vs 14%; $P = .22$) or 5-year survival rate (93% vs 81%; $P = .38$).[12] Young patients with cerebrovascular disease had a high prevalence of tobacco abuse, hypertension, diabetes mellitus, cardiac disease,[11,12,21] and dyslipidemia.[12,21]

The findings of this study are also similar to earlier reports describing young patients with atherosclerotic infrainguinal disease.[9,13-15] Valentine et al[14] demonstrated high rates of cardiac and cerebrovascular disease in patients younger than 50 years with symptomatic lower-extremity atherosclerosis. Young patients also had high rates of associated atherosclerotic risk factors, including hypertension, dyslipidemia, and tobacco use,[14] findings that were confirmed by Levy and colleagues.[15] Harris et al,[9] using life-table methods, showed that young patients had survival rates similar to those of randomly selected older patients after intervention for infrainguinal atherosclerosis. Cardiovascular disease was the predominant cause of long-term mortality in young patients with symptomatic lower-extremity atherosclerosis.[13,14]

This study has several limitations. Because of its retrospective design, the findings were made on the basis of the selected data available in the medical records. Despite this, analysis of survival and cause of death was probably not adversely affected, because these data were confirmed by means of the NDI search. In addition, advances in patient treatment during the study period may have affected the identification of prevalent cardiovascular diseases and follow-up results. The methods and application of elective

cardiac risk assessments changed during the study period, whereas patients undergoing emergency AAA repair (more than half of the young patients) had no preoperative assessment. Although these factors may have affected the estimated prevalence of cardiac disease in both the young and control groups, we attempted to account for these differences with time by using a case-control study design that matched patients by year of operation. Finally, because of the limited number of young patients with AAA, the study may have lacked sufficient power to identify markers of follow-up death. Conversely, the clinical markers used as a means of assigning the presence or absence of cardiovascular disease may not have accurately identified the patients at risk for death during follow-up.

CONCLUSION

AAAs in young patients are rare. After aneurysm repair, young patients had similar rates of perioperative morbidity and mortality and follow-up death when compared with control patients. Cardiovascular disease (including non-cardiac vascular disease) was the predominant cause of death after AAA repair in the young patients. Compared with an age of more than 50 years at the time of AAA repair, young age alone was not associated with increased survival after elimination of aneurysm risk.

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