Long-term outcomes after thoracic aortic surgery: A population-based study

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Objective: Long-term survival after aortic surgery has remained largely unexplored, despite suggestions of superior durability compared with endovascular techniques. The objective of the present study was to determine the long-term survival after open thoracic aortic surgery and to identify the predictors of mortality.

Methods: The provincial database was accessed to identify all adult patients who had undergone primary open thoracic aortic surgery in British Columbia since 1993. Kaplan-Meier survival analyses were performed for the entire group and by year of surgery, urgency of surgery, and aortic segment requiring surgery. Multivariate analyses were performed to identify the predictors of mortality.

Results: From January 1993 to June 2010, 1960 patients underwent primary open thoracic aortic surgery at 4 hospitals in British Columbia. Overall, the 30-day mortality was 9.1%, with a perioperative stroke rate of 5.8%. Long-term survival was 77.7%, 59.6%, and 44.7% at 5, 10, and 15 years, respectively. Subanalyses demonstrated improved long-term survival in the modern era; among patients undergoing elective aortic surgery; and among patients undergoing surgery on the ascending aorta or aortic root ($P < .0001$). The preoperative characteristics associated with decreased long-term survival included age older than 65 years, acute renal failure, dialysis, cerebrovascular accident, chronic obstructive pulmonary disease, peripheral vascular disease, and descending or thoracoabdominal aorta surgery.

Conclusions: Long-term survival after elective thoracic aortic surgery is excellent, with improved outcomes in the modern era. Several preoperative risk factors associated with decreased survival were identified, which could assist in risk stratification and patient selection. Finally, the long-term survival rates identified in the present study should serve as a benchmark to which new aortic interventions should be compared. (J Thorac Cardiovasc Surg 2014;148:47-52)

Thoracic aortic disease includes a range of acute and chronic disorders of the aortic root, ascending aorta, aortic arch, descending aorta, and thoracoabdominal aorta. Historically, open surgical repair has been the standard of care for the treatment and prevention of thoracic aortic disease and its complications, including aneurysms, dissections, ruptures, and traumatic injuries. However, with the introduction of endovascular stenting during the past decade, a trend has begun toward thoracic endovascular aortic repair (TEVAR), especially for the management of the descending aorta, blunt traumatic aortic injury, and high-risk surgical candidates with multiple comorbidities.[1] Despite encouraging early results, concerns are now emerging regarding the potential long-term complications after TEVAR.[2,3] Although open surgical repair of the thoracic aorta is often assumed to be more durable than TEVAR, the long-term outcomes after open surgery have remain largely unexplored in published studies. Therefore, the primary objective of the present study was to explore the long-term population-based survival after open thoracic aortic surgery. Our secondary objective was to identify the risk factors for decreased long-term survival after thoracic aortic surgery.

METHODS

Study Population

Cardiac Services British Columbia prospectively collects clinical and procedural data for all patients undergoing cardiac surgery at all 4 hospitals in British Columbia at which cardiac surgery is performed. This database was retrospectively interrogated to identify all adult patients who had undergone primary open aortic surgery in the province from 1993 to 2010. Patients were excluded if they had previously undergone cardiac or aortic surgery. The cases were linked to the British Columbia Vital Statistics database to identify all-cause mortality.

Statistical Analysis

The cohort was stratified by the segment of aorta requiring surgery. Some patients required surgery on more than 1 segment of the aorta. To avoid counting any patient more than once, 4 categories were created. The aortic root/ascending aorta included surgery on the aortic root and/or ascending aorta only. The aortic arch included surgery on the aortic

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Abbreviations and Acronyms

CI = confidence interval
COPD = chronic obstructive pulmonary disease
HR = hazard ratio
PVD = peripheral vascular disease
TEVAR = thoracic endovascular aortic repair

arch, with or without surgery on the aortic root and/or ascending aorta. The descending aorta included surgery on the descending aorta, with or without surgery on a more proximal portion of the aorta. The thoracoabdominal aorta included surgery on the thoracoabdominal aorta, with or without surgery on any other portion of the aorta.

The baseline characteristics were summarized by group using the mean ± standard deviation for age or numbers and percentages for categorical variables. These baseline characteristics were then compared across the groups using analysis of variance for age and the chi-square test for the categorical variables.

The rates of 3 perioperative outcomes were analyzed by the aortic segment requiring surgery and urgency of surgery and compared across the groups using the chi-square test. The urgency of surgery was classified according to the priority system used in British Columbia. Emergent surgery included aortic rupture, acute type A dissection, and hemodynamically unstable patients. Priority I included patients in the hospital waiting for urgent surgery. Priority II included asymptomatic aortic aneurysms and patients waiting at home for surgery, typically within 6 weeks. Priority III was elective surgery within 12 weeks. The primary perioperative outcome was a combined outcome of in-hospital 30-day stroke or mortality. Patients were identified as having a stroke if it was recorded on their hospital discharge summary, which was usually completed by the surgeon at discharge. The secondary outcomes were 30-day mortality and successful discharge home. Both in-hospital and out-of-hospital deaths were included in the 30-day mortality measure. Successful discharge home excluded all patients discharged to another hospital, rehabilitation or transition facility, or long-term care and those patients dying in hospital.

Kaplan-Meier survival estimates were used to plot the long-term survival curves and derive the survival rates. Overall survival up to 15 years was explored for the entire cohort. Survival was then explored by year of surgery, urgency of surgery, and segment of the aorta requiring surgery. The Kaplan-Meier survival estimates were repeated for patients surviving longer than 30 days postoperatively, with the log-rank test used to test for differences in the survival rates across the groups.

The independent risk factors for mortality were identified in a 2-step process, because the risk factors for 30-day mortality were expected to differ from those associated with late mortality. In the first step, logistic regression analysis was used to identify independent risk factors and estimate the odds ratios and associated 95% confidence intervals (CIs) for 30-day mortality. Next, for those surviving longer than the first 30 postoperative days, Cox regression analysis was used to identify the risk factors and estimate their hazard ratios (HRs) and associated 95% CIs for decreased long-term survival up to 8 years. The proportional hazards assumption was assessed using Schoenfeld residual plots. All baseline characteristics were considered in both multivariate models. The characteristics that were not statistically significant ($P > .05$) for mortality were excluded from the models. Because of the low number of patients at risk in some of the groups of interest, long-term follow-up was limited to a maximum of 8 years.

A 2-sided P value of $< .05$ was considered statistically significant. Statistical analyses were performed using Statistical Analysis Systems software, version 9.3 (SAS Institute, Cary, NC).

RESULTS

Overall, 1960 patients underwent first-time open thoracic aortic surgery in the province of British Columbia from 1993 to 2010, with a median follow-up of 4.8 years and a maximum of 15 years. Of these 1960 cases, 59.5% involved the aortic root and/or ascending aorta, 17.1% involved the aortic arch, 15.2% involved the descending aorta, and 8.2% involved the thoracoabdominal aorta. The baseline characteristics for the overall cohort, stratified by the segment of aorta requiring surgery, are listed in Table 1. The overall mean age was 62.3 ± 14.2 years, and most patients (65.9%) were men. Preoperative comorbidities were common, especially peripheral vascular disease (PVD; 9.8%), chronic obstructive pulmonary disease (COPD; 13.2%), and previous myocardial infarction (8.9%). Preoperative acute renal failure (5.6%) and PVD (16.8%) were significantly more common among patients undergoing thoracoabdominal aortic surgery, and diabetes (9.3%) and previous myocardial infarction (10.9%) were significantly more common among patients undergoing surgery on the aortic root or ascending aorta. Furthermore, more than one half of the patients undergoing surgery on the descending or thoracoabdominal aorta required emergent surgery (53.9% and 59.0%, respectively).

TABLE 1. Baseline characteristics stratified by segment of aorta requiring surgery

Characteristic	Root/Asc (n = 1166)	Aortic arch (n = 336)	Descending aorta (n = 297)	TAA (n = 161)	*P* value
Mean age (y)	61.6 ± 14.3	65.8 ± 11.4	60.8 ± 16.8	63.2 ± 18.1	<.001
Male gender	791 (67.8)	210 (62.5)	188 (63.3)	102 (63.4)	.17
PVD	92 (7.9)	34 (10.1)	39 (13.1)	27 (16.8)	<.001
COPD	125 (10.7)	49 (14.6)	54 (18.2)	30 (18.6)	<.001
CVA/TIA	61 (5.2)	22 (6.6)	13 (4.4)	9 (5.6)	.67
ARF	15 (1.3)	5 (1.5)	2 (0.7)	9 (5.6)	.003
Diabetes	108 (9.3)	15 (4.5)	12 (4.0)	9 (5.6)	.001
Smoker	367 (31.5)	108 (32.1)	82 (27.6)	50 (31.1)	.59
Previous MI	127 (10.9)	26 (7.7)	9 (3.0)	12 (7.5)	<.001
Emergent surgery	154 (13.2)	118 (35.1)	160 (53.9)	95 (59)	<.001

Data presented as mean ± standard deviation or n (%). *P* values determined using analysis of variance for age and the chi-square test for categorical variables. *Root/Asc*, Aortic root and/or ascending aorta; *TAA*, thoracoabdominal aorta; *PVD*, peripheral vascular disease; *COPD*, chronic obstructive pulmonary disease; *CVA*, cerebrovascular accident; *TIA*, transient ischemic attack; *ARF*, acute renal failure; *MI*, myocardial infarction.