Thoracic aortic surgery: An overview of 40 years clinical practice

Jos A. Bekkers, MD, PhD,[a] Roderick J. L. M. te Riele,[a] Johanna J. M. Takkenberg, MD, PhD,[a] Goris Bol Raap, MD, PhD,[a] Jan Hofland, MD, PhD,[b] Jolien W. Roos-Hesselink, MD, PhD,[c] and Ad J. J. C. Bogers, MD, PhD[a]

Objective: The objective of our study was to report on the total experience in thoracic aortic surgery over a 40-year time period for a single institution.

Methods: All 1075 patients who underwent surgery for thoracic aortic pathology from 1972 to 2011 (n = 1159) were included. Patient, procedural, and follow-up information was obtained from hospital records and the civil registry. Patients were grouped into 4 categories: acute type A dissection (n = 261), other ascending aortic/arch surgery (n = 626), descending aortic surgery (n = 175), and thoracoabdominal surgery (n = 97). Risk factors for early and late mortality and the incidence of reoperations were analyzed.

Results: The annual number of operations increased significantly over time. In all 4 patient groups, early mortality (in hospital or within 30 days of operation) decreased significantly over time to 15.3% in group 1, 1.9% in group 2, 0% in group 3, and 10.5% in group 4 during the contemporary time period 2007 to 2011. Overall actuarial survival was 54.3% (95% confidence interval, 50.7-57.9) after 10 years and 27.8% (95% confidence interval, 26.4-38.3) after 20 years. Late survival improved over time, but was reduced compared with the general population and was related predominantly to preexisting risk factors. In 80 patients, 111 reoperations were necessary, most frequently in group 1 patients and in patients with connective tissue disease.

Conclusions: Thoracic aortic operations were performed increasingly during a 40-year time period. Early mortality decreased and late survival increased significantly in all patient groups. A significant proportion of patients required multiple operations. (J Thorac Cardiovasc Surg 2014;147:332-43)

Thoracic aortic aneurysm is a frequently encountered condition, potentially leading to lethal complications or serious morbidity.[1-3] The exact prevalence of thoracic aortic aneurysms is not known. In the United States, aortic aneurysms were ranked 19 in the 2007 mortality statistics, with 13,000 deaths (0.5% of all deaths).[4] When dissection or rupture occurs as complication of a thoracic aneurysm, emergency surgical treatment is most often the only available option to save a patient's life. Because these emergency operations have considerable operative mortality and complication rates, and because patients might be confronted with potential long-term consequences, elective surgery even in asymptomatic patients with aortic dilatation is recommended in recent guidelines.[5] The aortic dimension warranting operation depends on the underlying diagnosis.

In this setting, surgery of the thoracic aorta has evolved from a small, but high-impact part in terms of mortality and morbidity of the total cardiothoracic surgical workload to one of the major subspecialties in cardiovascular surgery. In this study, we report our total experience with thoracic aortic surgery since 1972, specifically early patient outcome as well as long-term results in 4 major subgroups. Furthermore, we analyze evolution over time in timing and characteristics of operations and operative results.

METHODS

From our institutional aortic surgery database, we extracted 1159 consecutive thoracic aortic procedures in 1075 patients between 1972 and 2011. We excluded patients with primary aortic coarctation and patients who underwent aortic root replacement for pure aortic valve pathology (endocarditis, aortic allograft root replacement, or pulmonary autograft replacement for isolated valve pathology) or complex congenital pathology. Patients who underwent thoracic stent–graft procedures were excluded. Patients were categorized into 4 groups: group 1, acute type A dissections; group 2, ascending aortic and/or arch procedures, excluding acute type A dissections; group 3, descending aortic procedures; and group 4, thoracoabdominal procedures. Institutional review board approval was obtained for this retrospective follow-up study (Medical Ethics Committee no. 2011-064); the institutional review board waived informed consent. The indications for operation are displayed in Table 1. Preoperative patient characteristics are displayed in Table 2. Operations within 24 hours of onset of complaints are classified as acute, operations within 14 days or during the initial hospital admission are classified as urgent. The other operations were elective.

Operation

Over time, the operations were performed by 17 attending staff surgeons. Over the years, anesthetic and extracorporeal circulation management and preferred surgical procedures evolved.

From the Departments of Cardio-Thoracic Surgery,[a] Anesthesiology,[b] and Cardiology,[c] Erasmus University Medical Center, Rotterdam, The Netherlands.

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Address for reprints: Jos A. Bekkers, MD, PhD, Department of Cardio-Thoracic Surgery, Bd 571, Erasmus University Medical Center Rotterdam, PO Box 2040, 3000 CA Rotterdam, The Netherlands (E-mail: j.a.bekkers@erasmusmc.nl).

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Abbreviations and Acronyms

CI = confidence interval
HR = hazard ratio
OR = odds ratio
SD = standard deviation
TEVAR = thoracic endovascular aortic replacement

Patients with ascending aortic or aortic arch pathology were operated by median sternotomy using cardiopulmonary bypass. Routine arterial cannulation was in the ascending aorta. Alternative arterial cannulation sites (femoral artery or subclavian artery) were used for acute aortic dissections or when otherwise indicated. Venous cannulation was routinely in the right atrium. Deep hypothermia and circulatory arrest were used when indicated. Additional retrograde or antegrade cerebral perfusion was introduced in 1997 and was used in selected cases. In patients who required multiple periods of cardiopulmonary bypass, aortic crossclamping, or circulatory arrest, the total times were calculated by adding these periods. Cold crystalloid cardioplegia was used for cardiac protection. For aortic replacement, we used various types of vascular prostheses. In the current era, we use impregnated vascular grafts (Gelsoft or Gelseal; Vascutek Ltd, Renfrewshire, Scotland, UK). For aortic arch replacement a branched prosthesis (Plexus 4, Vascutek Ltd) with separate revascularization of arch vessels was used, or the arch vessels were implanted using an island technique.[6]

Patients with descending aortic pathology were operated by lateral thoracotomy; patients with thoracoabdominal pathology, by thoracolaparotomy with splitting of the diaphragm. In patients with descending aortic aneurysms, we preferably used a passive shunt until 1983. Thereafter, we used left heart bypass or full bypass with deep hypothermic circulatory arrest. For thoracoabdominal aneurysms, we used the clamp-and-sew technique described by Crawford and colleagues[7] until 1988. From 1989 to 1999, a full bypass with deep hypothermic circulatory arrest was used exclusively. From 1999, we used preferably a left heart bypass. Selective perfusion of renal arteries and visceral arteries was used in combination with left heart bypass. Spinal cord fluid drainage was introduced in 2002. Intercostal, renal, and visceral arteries were implanted in the vascular prosthesis used when indicated and feasible.

Follow-up

All patients were monitored at our institution or by their referring cardiologist. We collected information on vital status, reoperations, and complications. In addition, we consulted the municipal civil registries to ascertain vital status of all patients. Valve-related complications were defined according to the 2008 guidelines for reporting morbidity and mortality after cardiac valvular operations.[8] Early mortality was defined as mortality in hospital or within 30 days of surgery.

The study database was frozen for analysis on December 31, 2011. Follow-up was 99% complete; 11 patients were lost to follow-up. The mean follow-up duration was 6.0 years (range, 0-35.3 years), with a total follow-up of 6888 patient-years.

Statistical Methods

Continuous data are presented as mean (standard deviation (SD) and range). Categorical data are presented as proportions. Differences between groups were analyzed using a Student *t* test or analysis of variance with Bonferroni correction for continuous data and χ^2 test for categorical data. Cumulative survival was analyzed using the Kaplan-Meier method. The survival of a patient started at the time of operation and ended at the time of death (event) or at the last follow-up or reoperation (censoring). Comparison of Kaplan-Meier estimates was done using the Tarone-Ware test.

Univariable and multivariable logistic regression analysis (stepwise backward; inclusion criteria, $P \leq .10$; exclusion criteria, $P \geq .10$) was used to study determinants of early mortality. The Cox proportional hazards model was used for univariable and multivariable analysis of time-related events. Variables that were tested as potential risk factors for early and late mortality and reoperations are presented in Appendix 1. A P value of $\leq .05$ was considered statistically significant. All testing was performed 2 sided. For all analyses, SPSS 17.0 for Windows statistical software (SPSS, Chicago, Ill) was used.

RESULTS

During the study period, 1159 consecutive thoracic aortic operations were performed in 1075 patients. Sixty-one patients were operated upon twice; 7 patients, 3 times; and 3 patients, 4 times. Fourteen of 56 patients (25%) with Marfan disease or other connective tissue disease underwent multiple operations compared with 4 out of 1019 patients (5.3%) without known genetic diseases (odds ratio [OR], 5.8; 95% confidence interval [CI], 3.0-11.3; $P < .001$).

Figure 1, *A*, presents the number of operations per year, showing a steady increase of the annual number of procedures over time. Figure 1, *B*, presents the distribution of the 4 patient groups over time, showing an increase in ascending aortic aneurysm operations from 23% to 72% over time. Figure 1, *C*, presents the distribution of procedures by urgency of operation over time, showing a shift from 68% acute or urgent operations to 71% elective operations in the most recent era.

The perioperative data for all operations are shown in Table 1. In group 1, deep hypothermia with circulatory arrest was used in 220 patients (84%; mean duration, 49 minutes; SD, 35 minutes), and in group 2 in 346 patients (55%; mean duration, 30 minutes; SD, 36 minutes). In group 1, antegrade cerebral perfusion was used in 48 patients (18%; mean duration, 77 minutes; SD, 44 minutes), and in group 2 in 62 patients (10%; mean duration, 83 minutes; SD, 73 minutes).

In 46 patients (26%) in group 3, deep hypothermia with circulatory arrest was used with a mean duration of 44 minutes (SD, 15 minutes). In 47 patients (48%) in group 4, deep hypothermia with circulatory arrest was used with a mean duration of 51 minutes (SD, 16 minutes).

Early Mortality and Morbidity

Early mortality occurred in 167 patients (14.4%); 146 patients (12.6%) died within 30 days postoperatively. Over time, the early mortality risk decreased from >50% to 5% in recent years (Figure 1, *A*). Causes of early mortality were bleeding (n = 45), cardiac failure (n = 49), sepsis/multiple-organ failure (n = 30), aortic rupture (n = 13), neurologic (n = 17), and other causes (n = 13). Mortality within 60 days was 14.2% (164 patients); mortality within 90 days was 15.6% (180 patients). Figure 2, *A*, shows the early mortality per patient group and per 5-year time period. In all 4 patient groups, the mortality risk decreased significantly over time. Early mortality in the most recent time