Early and Late Outcomes After Complete Aortic Replacement

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Background. **The purpose of this report was to analyze our experience with total aortic replacement during a 20-year period.**

Methods. **Between 1991 and 2013, 3,012 repairs of the aortic root, ascending, transverse arch, and thoracoabdominal aorta were performed. Of these, we treated 39 patients with complete aortic replacement. Staged repair of the aortic root/ascending/arch and thoracoabdominal segments was used when feasible. Procedures were categorized according to the aorta replaced, whether proximal or distal to the left subclavian artery.**

Results. **We performed 87 operations (41 ascending and 48 thoracoabdominal repairs) in 39 patients; 2 had combined proximal and distal repairs. Mean age was 52.5 ± 15.9 years, and 17 patients (44%) were women. In addition, 39% (14 of 39) had a history of a connective tissue, and 74% (29 of 39) had a history of aortic dissection. Of the 39 patients, 21 (54%) required two stages for complete replacement, 12 (31%) required three stages, 3 (8%) required four stages, and 3 (8%) required more than five stages. The median time to completion of total aortic repair was 8.7 months (interquartile range, 2 to 71.2 months). No early deaths occurred. No stroke occurred after the proximal repair, and 3 patients (6%) suffered paraplegia after the distal repair. Survival at 5, 10, 15 and 20 years was 70.7%, 57.7%, 54%, and 30%, respectively.**

Conclusions. **Complete aortic replacement can be performed with acceptable rates of morbidity and mortality. Most of these patients were younger, had associated dissection, and required multiple stages for completion. As endovascular techniques advance proximally into the ascending aorta and complete endovascular aortic repair comes closer to reality, studies like this will allow comparison.**

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For his 1982 presidential address to the International Society for Cardiovascular Surgery, Dr E. Stanley Crawford wrote, "Aortic aneurysmal disease is multifocal and needs total aortic screening for diagnosis; best results are obtained by complete replacement of all disease" [1]. In a subsequent paper, he accounted his approach in 2 patients who had undergone total aortic replacement with good outcomes [2]. Since that report, several small series have described varying approaches to patients with extensive aortic disease, with most espousing a staged approach [3–6]. Few have reported successful single-staged repair of the entire aorta [6–9]. What remained certain, not changing from Crawford's original assertions, was that patients with thoracic aortic disease were at risk for developing aneurysmal disease in other aortic segments and that life-long surveillance was required [1]. Bearing this in mind, the potential for total aortic replacement would always exist.

Addressing the question about the optimal approach to repair extensive aortic aneurysms, Borst and colleagues [10] devised the elephant trunk approach, which allowed for the safe repair of an extensive aortic aneurysm in a staged setting. Opponents of the staged repair were concerned with death related to aortic rupture in the interval period and thus advocated single-staged repair of the entire thoracic aorta. Recently, several groups have used the "frozen" elephant trunk with a combined open and endovascular stent graft approach to address extensive aortic disease in a single stage [11, 12]. Results from the frozen elephant trunk approach have been acceptable but are limited to the thoracic aorta. As technology advances, techniques to address the visceral and renal vessels of the abdominal segment will be perfected, and eventually, the ascending aorta and aortic root will be excluded endovascularly. This will ultimately result in total endovascular aortic repair.

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Because of the complexity of patients who present with total aortic aneurysmal disease, such as chronic dissection, connective tissue, or genetically triggered aneurysmal disease, many will need to be addressed with open repair. The purpose of this report was to analyze our experience with total aortic replacement during a 20-year period.

Material and Methods

The Committee for Protection of Human Subjects for the University of Texas Medical School at Houston, the local institutional review board, approved this study and consent was waived. Patients' data have been collected in our departmental database in a prospective manner since 1991 and were reviewed for inclusion in this study. All patients who eventually underwent complete aortic replacement were included in the study.

Definitions

As defined by Crawford and colleagues [3], complete (total) aortic replacement was defined as an intervention that included the ascending aorta, transverse arch, descending thoracic, and abdominal aorta to the iliac bifurcation. Patients in whom the aortic root (sinuses of Valsalva) had been replaced were included. Procedures were categorized in relation to the location of the intervention (ie, proximal and distal repairs). Proximal repairs included all repairs performed proximal to the left subclavian artery (eg, aortic root, ascending, and transverse aortic arch). Aortic root replacement included patients in whom all sinuses of Valsalva were replaced (ie, modified Bentall) and included valve-sparing aortic root replacement procedures (David). Distal repairs included all repairs distal to the left subclavian artery, such as the descending thoracic and thoracoabdominal aorta.

Early mortality included in-hospital death and death occurring within 30 days of the operation. Acute kidney injury was defined by the RIFLE (Risk of renal dysfunction, Injury to the kidney, Failure of kidney function, Loss of kidney function, and End-stage kidney disease kidney disease) criteria [13]. Respiratory dysfunction was defined as prolonged intubation for more than 24 hours, or reintubation, or need for tracheostomy.

Proximal Surgical Approach

Surgical management used cardiopulmonary bypass, deep hypothermic circulatory arrest, and retrograde cerebral perfusion (RCP), as described previously [14]. The arch was performed by suturing the collared portion of the commercially available Siena collared graft (Vascutec, Terumo, Scotland, UK) to the aorta distal to the left subclavian artery. The cerebral and left subclavian vessels were then reattached using an island patch (Carrel patch) or separate bypasses in the cases of connective tissue disorders such as Marfan and Loeys-Dietz. In the case of aneurysmal dilatation of the aortic root, the sinuses of Valsalva were resected, and the aortic root was replaced. If the aortic valve was salvageable, a valve-sparing aortic root replacement (David procedure) was performed; otherwise, a modified Bentall was performed using a composite valve-graft conduit.

Distal Surgical Approach

The second stage of the elephant trunk procedure is performed in similar fashion to our standard descending thoracic or thoracoabdominal aortic aneurysm (TAAA) repair [15]. Currently, the intercostal arteries are reattached selectively based on neuromonitoring using motor-evoked potentials [15]. When required, intercostal arteries were reattached using a side-to-side anastomosis with the ends anastomosed to the main body of the aortic graft [16]. For the visceral/renal vessel reattachment, the side-branched thoracoabdominal aortic graft (STAG; Maquet Cardiovascular, Wayne, NJ), which is a premanufactured, multibranched graft configured for the celiac, superior mesenteric, and left and right renal arteries [17]. These branches are then anastomosed sequentially.

Statistical Methods

For overall demographic analyses (sex, age, etc), the unit of analysis was the patent. These were described by means, medians, or frequencies, depending on the data distributions of the variables. Total intervention history was aggregated as the sum of time between all aortic operations, whether done in our center or at an another facility. Measures of association between patient characteristics (age, connective tissue disorder, etc) and overall clinical course (total number and time span of operation, survival) were computed by unpaired t test, contingency table analyses, and stratified Kaplan-Meier analyses.

For proximal and distal repair statistics, such as operative times and blood product utilization, the unit of analysis was the operation. Statistical tests included descriptive statistics and univariate and multivariable tests of operative sequence, aortic pathology, and extent of repair over multiple sequences of operation. Data were analyzed using SAS 9.4 software (SAS Institute Inc, Cary, NC). Tests were considered to be significant at a nominal α of p of less than 0.05.

Results

Patients

From 1991 to 2013, 3,012 open thoracic aortic procedures were performed. In 39 patients, 106 procedures were performed that led to eventual complete aortic replacement. Of the 106 procedures, 19 in 16 patients were performed at other institutions. We performed 87 of the complete aortic procedures, which accounted for 2.9% (87 of 3,012) of all procedures performed. In 2 patients, proximal and distal procedures were both performed at one setting, thus, leading to 89 procedures when Table 1 and 2 were viewed. Of the 19 procedures in other institutions, 16 were proximal and 3 were distal aortic procedures.