Improved clinical outcomes and survival following repair of acute type A aortic dissection in the current era

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Abstract

OBJECTIVES: The goal of this study was to compare early postoperative outcomes and actuarial-free survival between patients who underwent repair of acute type A aortic dissection during 2000–2005 and 2006–2010.

METHODS: A total of 251 patients from four academic medical centres underwent repair of acute type A aortic dissection between January 2000 and October 2010. Of those, 111 patients underwent repair during 2000–2005, whereas 140 patients underwent repair during 2006–2010. Median ages were 62 years (range 20–83) and 58 years (range 30–80) for patients repaired from 2000–2005 compared with those repaired during 2006–2010, respectively (P = 0.180). Major morbidity, operative mortality and 5-year actuarial survival were compared between groups. Multivariate logistic regression was used to determine predictors of operative mortality.

RESULTS: Operative mortality was strongly influenced by surgical era (24% for 2000–2005 vs 12% for 2006–2010, P = 0.013). In multivariable logistic regression analysis, haemodynamic instability (odds ratio [OR] = 17.8, 95% confidence intervals [CIs] = 0.05–0.35, P < 0.001), cardiopulmonary bypass time >200 min (OR = 9.5, 95% CI = 0.14–0.64, P = 0.002) and earlier date of surgery (OR = 5.8, 95% CI = 1.18–5.14, P = 0.016) emerged as independent predictors of operative mortality. Actuarial 5-year survival was worse for earlier compared with later date of surgery (64% for 2000–2005 vs 77% for 2006–2010, log-rank P < 0.001).

CONCLUSIONS: Surgical era significantly impacts early outcomes and actuarial survival following repair of acute type A aortic dissection.

Keywords: Acute type A aortic dissection • Surgery • Survival

INTRODUCTION

Acute type A aortic dissection is a cardiovascular emergency associated with increasing mortality over time as a consequence of malperfusion or aortic rupture [1–6]. Recent improvements in the surgical approach, such as selective cerebral perfusion along with earlier diagnosis and immediate repair, have improved clinical outcomes in uncomplicated patients with type A aortic dissection [7]. However, the impact of these improvements on surgical outcomes in the modern era has not been explored.

A relative decrease in operative mortality was documented throughout the time period of 1963–1992 [8]. However, operative mortality and long-term actuarial survival in the current era have yet to be elucidated. Our study sought to evaluate whether patients repaired in the modern era have better clinical outcomes and actuarial survival following repair of acute type A aortic dissection compared with patients repaired earlier. We also aimed to investigate whether the trend towards an improved mortality continues in the current era, and whether the rate of decline in operative mortality is faster or the same compared with previous studies.

METHODS

Patients

The Society of Thoracic Surgeons Databases at Beth Israel Deaconess, Carolinas Medical Center, Missouri Baptist Medical Center and Meijer Heart and Vascular Institute were queried to identify all patients who underwent repair of aortic dissection between January 2000 and October 2010. A total of 251 patients underwent repair for acute type A aortic dissections. Of those, 111 were repaired during 2000–2005 and 140 were repaired during 2006–2010. Patients excluded were those that presented with a type A dissection but who did not have surgery.
A preoperative diagnosis of aortic dissection was accomplished using computed tomography angiography or transesophageal echocardiography (TEE). The diagnosis was later confirmed at the time of operation. A database was created for entry of demographic and procedural data and preoperative outcomes. These were prospectively entered by dedicated data-coordinating personnel. Long-term survival data were obtained from the Social Security Death Index (http://www.genealogybank.com/gbnk/ssdi/). Follow-up was 97% complete.

Before this analysis, study approval from the Institutional Review Boards of each centre was obtained. Consistent with the Health Insurance Portability and Accountability Act of 1996 (HIPAA), patient confidentiality was consistently maintained.

Definitions

The Society of Thoracic Surgeons’ national cardiac surgery database definitions were used for this study. Acute type A dissection was defined as any dissection that involved the ascending aorta with presentation within 2 weeks of the onset of symptoms. Previous cerebrovascular accident was defined as a history of central neurological deficit persisting for more than 24 h. Chronic renal insufficiency was defined as a serum creatinine value of >2.0 mg/dl. Diabetes was defined as a history of diabetes mellitus, regardless of the duration of disease or need for oral agents or insulin. Recent myocardial infarction was defined as myocardial infarction occurring within 7 days. Depressed ejection fraction was defined as an ejection fraction of <40%. Haemodynamic instability was defined as hypotension (systolic blood pressure <80 mmHg) or the presence of cardiac tamponade, shock, acute congestive heart failure, myocardial ischaemia and/or infarction. Prolonged ventilatory support was defined as pulmonary insufficiency requiring ventilatory support >24 h, postoperatively. Postoperative stroke was defined as any new major (Type I) neurological deficit presenting in-hospital and persisting >72 h. Acute renal failure was defined as one or both of the following: (i) an increase in the serum creatinine to >2.0 mg/dl and/or a >2-fold increase in the most recent preoperative creatinine level; or (ii) a new requirement for dialysis, postoperatively. Operative mortality includes both (i) all deaths occurring during the hospitalization in which the operation was performed (even if death occurred after 30 days from the operation); and (ii) those deaths occurring after discharge from the hospital, but within 30 days of the procedure.

Operative technique

The surgical approach did not differ significantly for patients presenting between the periods of 2000–2005 and 2006–2010. Intraoperatively, the diagnosis of type A aortic dissection was confirmed by TEE for all patients. A median sternotomy was created to provide access. Total cardiopulmonary bypass (CBP) was provided by arterial cannulation of the femoral or right axillary artery and venous cannulation of the right atrium. Cold blood cardioplegia administration through an antegrade approach via the ostia of the coronary arteries and/or a retrograde approach through the coronary sinus was performed to ensure myocardial protection. The right superior pulmonary vein provided access for vent placement in the left ventricle. Restoration of the aortic root was accomplished by resection of the intimal tear followed by repair or resuspension of the aortic valve and replacement of the ascending aorta. After reaching a mean cooling temperature range of 15–18°C, the aortic clamp was removed and the aortic arch was examined. An arch replacement was performed when an arch tear was identified. In 55 patients, antegrade cerebral perfusion was used, via the right axillary artery (flow rate 10 ml/kg) and retrograde cerebral perfusion in 25 patients, based on the surgeon’s preference. The distal anastomosis was then completed and antegrade aortic perfusion was established. Either a root replacement with a composite valve graft and coronary button reimplantation, or a valve replacement with mechanical or tissue prosthesis, was indicated for patients with irreparable damage of the aortic root or valve. Reinforcement of the proximal and distal suture lines was accomplished using Teflon (polytetrafluoroethylene) strips or, for some patients, biological glue (BioGlue® surgical adhesive, Cryolife, Kennesaw, GA, USA).

Data analysis

Univariate analysis. Univariate comparisons of preoperative, operative and postoperative variables were performed between patients repaired between the years 2000–2005 (n = 111) and those repaired between the years 2006–2010 (n = 140). Normal distribution of continuous variables was assessed using the Kolmogorov–Smirnov test. Continuous variables were tested using either Student’s t-test or the Mann–Whitney test, whereas categorical variables were assessed by the Mantel–Haenszel χ² test of general association. However, Fisher’s exact test was used when sample sizes were small. All tests were two-sided and a P-value of <0.05 was considered statistically significant.

Multivariate analysis. Potential risk factors were organized for entry into a multivariable, stepwise, forward (binary) logistic regression model to identify predictors of early (operative) mortality, which are reported as odds ratios (ORs) with 95% confidence intervals (CIs). The criterion for a variable entry into the logistic regression model was a univariate probability level of P<0.1. The maximum likelihood approach was used to compute the estimates, and residual analysis and the Hosmer and Lemeshow goodness-of-fit statistic were used to evaluate the model fit.

Survival analysis. Time-related outcome was early (operative) mortality. Non-parametric estimates utilized the Kaplan–Meier estimator. The instantaneous risk across time (the hazard function) was estimated parametrically [9]. Kaplan–Meier univariate unadjusted survival estimates were calculated and compared using a log-rank test for patients repaired during 2000–2005 versus those repaired during 2006–2010. All analyses were conducted using the SPSS statistical software Version 21 (IBM Corp., Armonk, NY, USA).

RESULTS

Preoperative characteristics

Preoperative characteristics are summarized in Table 1. There was no difference in preoperative variables between patients repaired during 2000–2005 and 2006–2010.

Operative characteristics

Postoperative characteristics

Postoperative characteristics are depicted in Table 3. Operative mortality was significantly higher for patients repaired in the 2000–2005 period, compared with those repaired in the 2006–2010 period (P = 0.013).

Multivariate analysis

In multivariable logistic regression analysis, haemodynamic instability (OR = 17.8, 95% CI = 0.05–0.35, P <0.001), CPB time >200 min (OR = 9.5, 95% CI = 0.14–0.64, P = 0.002) and earlier date of surgery (OR = 5.8, 95% CI = 1.18–5.14, P = 0.016) emerged as independent predictors of operative mortality.

Trends over time

Operative mortality decreased linearly over time (P = 0.013) (Fig. 1). The proportion of procedures utilizing antegrade cerebral perfusion increased (P = 0.25), whereas retrograde cerebral perfusion decreased over the same time frame (P = 0.240) (Fig. 2); however, these trends were not statistically significant. Axillary cannulation was used increasingly, with a respective decrease of femoral cannulation (P = 0.25) over time (Fig. 3).

Survival analysis

Actuarial Kaplan–Meier survival estimates are presented in Fig. 4. Non-risk adjusted time-related 5-year survival was lower for
patients repaired during 2000–2005 compared with those repaired during 2006–2010 (64 vs 77%, respectively, log-rank $P < 0.001$). Eighteen patients (13%) were alive at the end of the 5-year period in the 2005–2010 group and had less than a 5-year follow-up because they had surgery during the later years of the study (2009 and 2010).

**DISCUSSION**

Our study is among the first to compare operative characteristics and early and late postoperative outcomes for patients who underwent repair of acute type A aortic dissection between two surgical periods (2000–2005 vs 2006–2010). Earlier date of surgery adversely impacted early and late outcomes for patients following type A dissection repair. Specifically, patients repaired during 2000–2005 exhibited a mortality twice that of patients repaired during 2006–2010. Our results imply that patients undergoing repair for acute type A dissection in the modern surgical era fare better than those repaired in earlier years.

**Principal findings**

**Operative mortality.** Earlier date of surgery was associated with a significantly higher operative mortality rate compared with later date of surgery ($P = 0.013$) and followed a linear decline over time (Fig. 1). A decrease in operative mortality associated with progression through surgical eras has also been documented in previous studies [8, 10–15]. Specifically, Fann et al. [8] documented a decline in the operative mortality rate from 42 to 26% between the years 1963–1972 compared with 1998–1992, respectively. More recent studies of type A aortic dissection repair between the years 1996–2011 have found in-hospital mortality rates to be anywhere from 17 to 27% [4, 16–20]. The decline in mortality documented in the more recent era could be attributed to advances in diagnostics, surgical repair techniques and postoperative management over the past 50 years. Similar to Fann et al., we found operative mortality to be cut in half from 2000–2005 (24%) to 2006–2010 (12%). Our results agree with Fann et al. while providing evidence that surgical advances today continue to improve outcomes. However, in our paper, a more dramatic improvement in mortality was observed in a shorter period of time (5 years), compared with Fann et al., which may be related to a more rapid incorporation of new technology in the present era.

Our data also document a higher mortality in both uni- and multivariate analyses of patients with prolonged CPB time and, thus, for patients who require more complex aortic reconstruction. Technical advances associated with improved outcomes include routine electroencephalographic monitoring, selective antegrade cerebral perfusion, routine antegrade graft perfusion after completion of distal anastomosis, aortic root repair and resuspension of the aortic valve in most patients in the absence of pre-existing leaflet or root pathology and obliteration of the false lumen by felt or BioGlue to strengthen the aortic and sinus walls [6].

![Operative Mortality Trends](image1.png)

Figure 1: Operative mortality trends across time for patients who underwent repair of type A aortic dissection. Each circle represents a yearly percentage. The solid line is the continuous probability by logistic regression.

![Antegrade and Retrograde Cerebral Perfusion](image2.png)

Figure 2: Trends for (A) antegrade and (B) retrograde cerebral perfusion over time for patients who underwent repair of type A aortic dissection. Each circle represents a yearly percentage. The solid line is the continuous probability by logistic regression.
Careful selection of patients is of paramount importance. In our data study, haemodynamic unstable presentation emerged as an independent predictor of operative mortality. Bavaria et al. [6] documented a 45% mortality rate in patients presenting with stroke who subsequently underwent an otherwise successful type A dissection repair. Some authors have documented a similar survival in medically treated acute type A dissections [8]. These data suggest an initial medical or non-operative management for the subset of patients who present with stroke and/or haemodynamic instability. Improvements in surgical technique and expedited transfer to the operating theatre for diagnosis and therapy, with routine use of intraoperative TEE, may account for improved results over time.

**Trends in surgical technique over time**

Decreasing trends in operative mortality over time corresponded with increasing trends in the use of antegrade versus retrograde cerebral perfusion and axillary versus femoral arterial cannulation over time. However, the relative contribution of each towards operative mortality is difficult to elucidate. Studies have shown that the main benefit of retrograde cerebral perfusion is the result of brain hypothermia and flushing air and debris off the brain circulation; however, it adds minimal perfusion to brain capillaries [21, 22]. By contrast, antegrade cerebral perfusion might lead to improved neurological outcomes because of a decrease in transcranial oxygen extraction when total body perfusion is re instituted [23, 24]. Antegrade cerebral perfusion technique offers an almost unlimited safety period. However, the risk of embolization is still high, especially in older patients with atherosclerotic vessels. The use of axillary arterial cannulation allows use of antegrade cerebral perfusion and avoids manipulation of the arch vessels [25]. This perfusion strategy enables both systemic cooling on CPB and antegrade selective cerebral perfusion through the same cannula. Using this method, continuous brain perfusion is always guaranteed. In our series, there was an increasing use of antegrade cerebral perfusion and axillary cannulation over time compared with retrograde cerebral perfusion and femoral cannulation, respectively (Figs 2 and 3). Moreover, surgeons’ preference to use more frequently moderate hypothermia, rather than deep hypothermia, resulted in more frequent creation of a distal aortic suture line with the cross-clamp on, compared with open distal anastomosis and hemiarch repair.

**Actuarial survival**

Actuarial 5-year survival was worse for earlier date of surgery compared with those with later date of surgery (Fig. 4). However, most mortalities in the 2000–2005 cohort occurred during the early post-operative phase, compared with the later phase, where differences in survival between the groups were less pronounced over 5 years. The survival curves, excluding operative mortality, seem identical and the main improvement over time relates to improved operative mortality, which is explained by accumulated surgical experience, refinements of the surgical technique and expedited transfer to the operating room.

**Clinical implications**

We conducted a multi-institutional observational study to assess the impact of surgical era on operative characteristics and...
short- and long-term outcomes following repair of acute type A aortic dissection. In this study, we examined an unselected cohort of patients from four academic institutions. This study is among the first to compare early clinical outcomes and 5-year actuarial survival between patients repaired during 2000–2005 and those who had repair during 2006–2010. Surgical era affected early clinical outcomes and survival following acute type A aortic dissection repair in our analysis. Over time, operative mortality decreased and late survival improved, correspondingly with increasing use of antegrade cerebral perfusion and axillary arterial cannulation. Based on the results of our study, advancements in surgical techniques and postoperative management have significantly improved outcomes for patients with type A aortic dissection in the current era, compared with earlier years.

**Study limitations**

Inherent limitations of a retrospective multi-institution investigation inevitably affected our study. Specifically, possible changes in the referral pattern (with earlier referral and expedient surgical repair) may be possible causes of improved outcomes in the second era; however, these were not evaluated because of the retrospective nature of the study. Bias may have also been introduced into the analysis because nine surgeons from four institutions performed the procedures. The small sample size precluded use of more appropriate and robust statistical techniques, such as propensity score matching to adjust for the differences in preoperative characteristics, as well as selection or time (improvement of technology overtime) bias between groups. Another limitation is that only patients who underwent operations for repair of type A dissection were included. Patients who died before operation, before or during transfer or evaluation were not included. Therefore, generalizing our results to all patients with type A aortic dissection is not possible. Further study of reoperations of the remaining dissected aorta, the causes of early or late mortality and the fate of the false lumens were outside the scope of our analysis. In future, these should be the focus for evaluating long-term outcomes of acute type A aortic dissection repair.

**CONCLUSIONS**

Different surgical eras have profoundly impacted the postoperative outcomes and survival in patients presenting with acute type A aortic dissection. Our findings suggest that surgical repair of type A aortic dissection in the modern era is associated with far greater survival compared with those repaired earlier.

**Conflict of interest:** none declared.

**REFERENCES**


**eComment. Acute type A aortic dissection repair in the current era**

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Acute type A aortic dissection is common life-threatening condition with high mortality in the absence of emergent surgical intervention. Despite advancements in