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ORIGINAL ARTICLE

Predictors of Adverse Outcome and Transient Neurological Dysfunction following Aortic Arch Replacement in 626 Consecutive Patients in China

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Background Early mortality and cerebral injury are severe complications of aortic arch surgery, but data from Asian countries are scarce. We reviewed the results of patients who underwent aortic arch replacement with deep hypothermic circulatory arrest (DHCA) and antegrade selective cerebral perfusion (ASCP) at our institution to analyse pre- and intraoperative predictors of early death and neurological complications.

Methods Clinical data of adult patients who underwent aortic arch surgery with DHCA plus ASCP between January 2005 and December 2011 were retrospectively analysed. Univariate and multivariate analyses were performed to identify predictors of adverse outcome defined as 30-day mortality and permanent neurological dysfunction (PND), and transient neurological dysfunction (TND).

Results A total of 626 patients were included in the study. The average age of the patients was 45.0±10.7 years with male predominance (77.0%). The incidence of adverse outcome was 5.8%, consisting of 4.6% 30-day mortality and 1.9% PND. Transient neurological dysfunction was found in 13.9% patients. Multiple logistic regression showed that stroke (OR=7.846, 95% CI: 2.737-22.489, $p<0.001$), emergency (OR=2.198, 95% CI: 1.019-4.740, $p=0.045$), CPB time (OR=1.009, 95% CI: 1.004-1.014, $p<0.001$), CABG (OR=2.613, 95% CI: 1.066-6.405, $p=0.036$) and packed red blood cells (OR=1.113, 95% CI: 1.038-1.193, $p=0.003$) were independent predictors of adverse outcome, and acute type A aortic dissection (OR=2.635, 95% CI: 1.535-4.524, $p<0.001$), preoperative neurological deficits (OR=5.326, 95% CI: 1.529-18.548, $p=0.009$), CPB time (OR=1.004, 95% CI: 1.000-1.007, $p=0.026$) and low-flow perfusion time (OR=1.034, 95% CI: 1.003-1.066, $p=0.033$) were associated with TND.

Conclusions A history of stroke was a strong predictor of adverse outcome, and acute type A aortic dissection and preoperative neurological deficits had a high correlation with TND. The predictors identified in this study may help clinicians to optimise the risk evaluation and perioperative clinical management of patients undergoing aortic arch surgery to reduce morbidity and mortality.

Keywords Aortic arch surgery • Deep hypothermic circulatory arrest • Risk factors • Stroke • Mortality

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Introduction

The incidence of aortic disease including aortic dissection and aortic aneurysm has continued to rise due to the high prevalence of hypertension and atherosclerotic disease in China. Aortic arch surgery is becoming more common but is still a complicated procedure in the therapy of aortic disease. Although there has been a great technical improvement in the past decades, such as the use of hypothermic circulatory arrest for cerebral protection, selective cerebral perfusion to safely prolong the duration of arrest time, and other intraoperative organ protection techniques [1–3], early mortality and cerebral injury still remain devastating complications for complex aortic arch procedures. There have been some studies analysing the adverse outcome of aortic arch surgery [4–7], but little data came from China.

In this study, we report on more than 600 patients who underwent aortic arch replacement operation during a seven-year interval in a single centre in China with a standardised protocol for deep hypothermic circulatory arrest (DHCA) and antegrade selective cerebral perfusion (ASCP), and examine both preoperative and procedural predictors of adverse outcome and transient neurological dysfunction (TND).

Materials and Methods

With the approval of the Institutional Review Committee, all adult patients who had an aortic arch surgery with DHCA and ASCP in our department between January 2005 and December 2011 were retrospectively studied. In order to reduce the heterogeneity of the subject population, patients who underwent one-stage total or subtotal aortic replacement were excluded because of different surgical incision and cardiopulmonary bypass (CPB) procedures.

All patients received standard general anaesthesia induction, and propofol, isoflurane, fentanyl, and pipecuronium bromide were given to maintain anaesthesia. Invasive upper and lower extremities blood pressure, central venous pressure, nasopharynx and bladder temperatures were monitored. Transoesophageal echocardiography was used generally to confirm the diagnosis, guide haemodynamic management and surgical intervention. During CPB, Alpha stat principles were used for arterial blood gas management.

All operations were performed through a median sternotomy. Patients were cooled on CPB, established with cannulation of the right axillary artery and right atrium when the nasopharyngeal temperature reached 28 °C, the ascending aortic was clamped and cardioplegia was used for myocardial protection. Proximal aortic management was then accomplished including aortic root replacement or repair and cardiac procedure. When nasopharyngeal temperature reached 18~20 degrees C and bladder temperature reached 22~25 degrees C, circulatory arrest was established. The brachiocephalic trunk was clamped, and ASCP was performed in a standardised fashion at our institution. Cerebral perfusion (flow rate 5 to 10 mL/kg/min) was established by means of the right axillary artery graft, providing perfusion to the right carotid and right vertebral arteries and through the circle of Willis and other collateral channels to the left side of the brain. The flow rate was adjusted to maintain a mixed venous oxygen saturation of 85% to 95%. During DHCA, aortic arch procedure was accomplished, including total arch replacement or partial arch replacement. The rate of rewarming was controlled to avoid high gradient between nasopharyngeal and CPB perfusate temperatures. The neuroprotective drugs administered during CPB included methylprednisolone (30 mg/kg), magnesium sulfate, and mannitol (0.5 g/kg). Inotropic support was implemented when necessary to maintain a normal cardiac index and vascular resistance. Blood components including packed red blood cells, fresh-frozen plasma, and platelets were infused to maintain the post-CPB haematocrit and correct coagulopathy. All patients were managed in the ICU after the operation.

Perioperative data were collected from case files and a prospectively collected departmental patient database. Reoperation was defined as any aortic procedure subsequent to a previous cardiac or thoracic aortic surgery. Serum creatinine was the most recent measurement value before operation. Preoperative haemodynamic instability was defined as systolic blood pressure <90 mmHg or a requirement for catecholamines to maintain blood pressure for any reason. Preoperative neurological deficits included hemiparesis, transient ischaemic attack, syncope, and disturbed consciousness from the admission to operation. Emergency surgery was defined as an operation performed within 24 hours after admission. All neurologic complications were reviewed with a neurologist experienced in the perioperative care of this patient population. The presence of neurological dysfunction at the time of discharge from the hospital, whether focal injury (stroke) or global (coma), was considered permanent neurological dysfunction (PND), when the focal lesion was confirmed by means of computed tomographic scanning or magnetic resonance imaging of the brain. Transient neurological dysfunction was defined as a symptom complex of postoperative confusion, seizure, agitation, or transient delirium with no structural abnormality in the brain detectable by the usual imaging methods [4], and resolution of the symptoms occurred usually before hospital discharge. Adverse outcome was defined as either 30-day mortality or PND, since PND is often indicative of a poor quality of life and associated with early mortality [5].

Statistical Analysis

Statistical analysis was performed using the SPSS 17.0 statistical package. Continuous data were given as the median and interquartile range (range from the 25th to the 75th percentile) or as the mean and standard deviation (SD), as appropriate. Counts and percentages were given for categorical data. In univariate analysis, categorical data were analysed by chi-square or Fisher exact tests and continuous data were analysed by using *t*-test or Wilcoxon rank sum tests, as appropriate. Forward stepwise multivariate logistic regression

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