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Outcomes of Left Heart Bypass Versus Circulatory Arrest in Elective Open Surgical Descending and Thoraco-abdominal Aortic Repair

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WHAT THIS PAPER ADDS

In surgical repair of descending and thoraco-abdominal aortic aneurysms, left heart bypass and hypothermic circulatory arrest organ protection strategies produce equal early and midterm outcomes. In elective cases, both strategies should be provided for and chosen based on individual patient circumstances.

Objectives: To compare early (30 day mortality and major complications) and midterm (survival) outcomes in elective open surgical descending and thoraco-abdominal aortic repair using left heart bypass (LHB) versus hypothermic circulatory arrest (HCA) for organ protection, hypothesising non-inferiority of HCA management.
Method: This was a retrospective clinical cohort study with cross sectional follow-up. All elective ($n = 90$) descending or thoraco-abdominal aortic repairs performed between 2004 and 2015 using either LHB ($n = 57$) or HCA ($n = 33$) were included. Pre- and intra-operative variables were evaluated by univariate statistical analysis. Thirty day and follow-up mortality were primary endpoints; major complications were secondary endpoints. Propensity score matching was employed to adjust for selection bias. Kaplan—Meier methods were used to estimate midterm survival.
Results: Overall 30 day mortality was 8/90 (8.9%): 6/57 (10.5%) using LHB vs. 2/33 (6.1%) using HCA, $p = .47$. Five patients (5.6%) suffered paraplegia: 3/57 (5.3%) using LHB vs. 2/33 (6.1%) using HCA, $p = .87$. Stroke occurred in 6/57 (11%) vs. 2/33 (6.1%), $p = .76$; renal failure in 27/57 (47%) vs. 19/33 (58%), $p = .90$; and respiratory failure in 17/57 (30%) vs. 11/33 (33%), $p = .68$. In 26 propensity score matched pairs, findings remained unaltered. Total follow-up was 443 patient years (median 4.9 years). Estimated survival was 78% at 1 year and 77% at 5 years in LHB vs. 72% and 67%, respectively, with HCA; there were no significant inter-group differences, before or after propensity score matching.
Conclusions: In elective descending or thoraco-abdominal aortic repair, no statistically significant differences in 30 day mortality, major complications, or follow-up survival were found when LHB and HCA were compared. These findings remained after propensity score matching.

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INTRODUCTION

Mortality and morbidity in open surgical repair of the descending thoracic aneurysm (DTA) or thoraco-abdominal aortic aneurysm (TAAA) are substantial. Whatever strategy is used — aortic clamping, left heart bypass (LHB), cardiopulmonary bypass (CPB) with or without hypothermic circulatory arrest (HCA) — the common goal is organ protection and ultimately improved survival and freedom from adverse outcomes, for example respiratory or renal failure, stroke, or spinal cord injury (SCI). No one strategy appears clearly superior, and excellent outcomes have been reported using each.[1—5] LHB appears to be the most widespread strategy.[3,4,6] HCA has proponents[5,7] but has also been advised against and proposed for bailout in emergency situations only.[8,9] The objective of this study is to report early and midterm outcomes when two organ protection strategies, LHB and HCA, were applied in an effort to tailor the technique to the patient in elective DTA and TAAA repair. Technical details may vary, but in general, LHB and HCA represent distinctively different organ protective strategies. The hypothesis was non-inferiority of HCA, which could support a patient oriented, rather than protocol oriented, approach, indicating HCA as a viable option for suitable patients.

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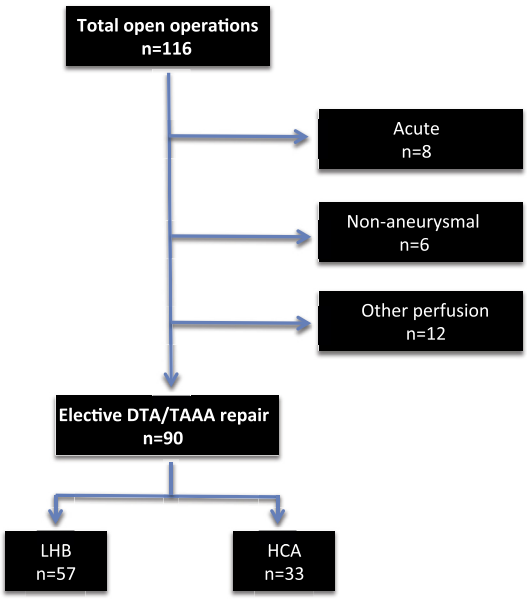

Figure 1. Patient flowchart. After excluding non-elective cases, organ protection strategies other than left heart bypass or hypothermic circulatory arrest, and operations for non-aneurysmal indications, 90 operations in 86 patients formed the study population.

PATIENTS AND METHODS

Patients

Medical records of all patients undergoing open surgical repair of DTA or TAAA (degenerative arteriosclerotic aneurysm or chronic dissection) from 2004 through 2015 ($n = 116$) were reviewed and grouped by organ protection strategy (LHB vs. HCA). Non-elective procedures were excluded, as were patients managed with other perfusion strategies (Fig. 1). Thoracic endovascular aortic repair (TEVAR) and hybrid procedures were not included. The regional research ethics committee, waiving individual informed consent, approved the study. Indications for elective operation were based on common criteria of maximum aortic diameter, extent of disease, rate of progression annually, presence of connective tissue disease or other specific risk factors, and weighted against operative risk.

Variables, definitions, and outcome measures

Variables were reviewed to assess comparability of patients, aortic conditions, procedures, and outcomes. The extent of DTA and TAAA were classified according to Safi's group.[10,11] Primary outcome measures were early (30 day) and follow-up (midterm) mortality. Secondary outcome measures were respiratory failure (tracheostomy), renal failure (continuous renal replacement therapy [CRRT] or haemodialysis), stroke and SCI (paraplegia or paraparesis) with non-resolving deficit, respectively.

Peri-operative procedures

Cannulation for extracorporeal circulation. In the LHB group, the left atrium, through a pulmonary vein, was cannulated with a 24 Fr heparin coat coated cannula. Arterial return was through a 19 or 21 Fr heparin coat coated cannula in the left common femoral artery or through an 8 mm Dacron graft anastomosed end to side to the femoral artery to preserve distal perfusion throughout the duration of extracorporeal circulation (ECC). In the HCA group, venous return was provided through a 23—29 Fr long femoral vein cannula positioned in the right atrium with echocardiographic visualisation. Sites of arterial cannulation varied and have been described in detail previously[12]: left common femoral artery as above, right subclavian artery, or ascending aorta. The right subclavian artery approach used a long, ringed, 8 mm graft anastomosed via a sub-clavicular incision (with the patient in the supine position), subcutaneously tunnelled to the left hypochondrium, and connected to the ECC circuit after the patient was positioned for aortic repair. The ascending aorta (or pre-existing vascular prosthesis) was cannulated from within the left thoracotomy, using an over the wire technique and a long flexible aortic cannula (23 Fr Easyflow, LivaNova, London, UK).

Conduct of extracorporeal circulation. In the LHB group, perfusion was begun after aortic clamping, to reduce the risk of retrograde embolisation. Flow was balanced to achieve perfusion pressures of 60—80 mm Hg proximal and distal to the clamped aorta, usually 1—3 L/min. The circuit was heparin coat coated and systemic heparinisation reduced to 150 IU/kg to maintain activated clotting time (ACT) $>$ 250 s. Cell saver suckers were used for blood conservation, and core body temperature was allowed to drift down to 34 °C. At the conclusion of LHB, the patient was rewarmed to 36.5 °C. After decannulation, protamine at a 1:1 rate reversed heparinisation. In the HCA group, full flow (approx. 2.5 L/m^2 body surface area) was commenced after full systemic heparinisation (400 IU/kg, ACT $>$480 s), with cooling to 18 °C. Cardiotomy suckers were used to return shed blood to the ECC circuit. To avoid left ventricular distension after hypothermic ventricular fibrillation, the left ventricle was actively vented through the apex.[12] During circulatory arrest, the mid-descending aorta was clamped to allow continued lower body perfusion from femoral artery level. More recently, moderate hypothermia (approx. 25 °C) has been employed in combination with selective antegrade cerebral perfusion through separate perfusion catheters introduced under direct vision after opening the aorta at the level of the proximal anastomosis near the left subclavian artery, based on the approach by Mommertz et al.[13] Relying on hypothermia for protection, cardioplegia was not given. After HCA, patients were rewarmed to 36.5°C core temperature before weaning ECC, with 1:1 protamine reversal after decannulation.

Surgical procedures

Aortic repair was performed with the patient in the right decubitus position, with single lung ventilation, through a left thoracotomy or thoraco-laparotomy depending on extent of the aortic disease. The sub-diaphragmatic aorta

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