Heart, Lung and Circulation (2016) xx, 1–9
1443-9506/04/$36.00
http://dx.doi.org/10.1016/j.hlc.2016.07.019

ORIGINAL ARTICLE

Unilateral Antegrade Cerebral Perfusion and Moderate Hypothermia: Assessing Safety With Novel Biomarkers

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Received 6 January 2016; received in revised form 28 June 2016; accepted 31 July 2016; online published-ahead-of-print xxx

Background Antegrade cerebral perfusion in aortic surgery is a well-established brain protection method. Open distal anastomosis during aortic surgery has some well-known advantages. Antegrade cerebral perfusion provides repair to some extent for the aortic arch even in isolated ascending aortic aneurysm. The present study aims to investigate adequate contralateral perfusion with novel oxidative stress parameters during unilateral antegrade cerebral perfusion.

Method The study included 30 consecutive patients undergoing thoracic aortic surgery with unilateral antegrade cerebral perfusion under moderate hypothermia (28° C). Blood samples from right and left jugular vein were obtained at four time intervals during surgery (after the anaesthetic induction – Phase 1, at the beginning of cardiopulmonary bypass – Phase 2, 15th minute of ACP – Phase 3 and after weaning from cardiopulmonary bypass – Phase 4). Novel oxidative stress parameters (advanced oxidation protein products, sialic acid, thiol reagents and ischaemia-modified serum albumin), blood gas analysis, and serum glucose and lactate levels were measured. In addition, intraoperative and early postoperative follow-up parameters were recorded.

Results Mean unilateral antegrade cerebral perfusion time was observed to be 16.4 ± 5.9 min (9 – 46 min). No significant differences between right and left hemispheres were observed in novel oxidative parameters or biochemical values. There was only one temporary neurological deficit (3.3%) in the patient group.

Conclusions The present study demonstrated that open distal anastomosis for hemiarch repair can be performed safely with unilateral antegrade cerebral perfusion under moderate hypothermia with both clinical outcome and novel biomarkers.

Keywords Antegrade cerebral perfusion • Oxidative stress • Advanced oxidation protein products • Sialic acid • Thiol reagents • Ischaemia-modified serum albumin

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Please cite this article in press as: Aytekin B, et al. Unilateral Antegrade Cerebral Perfusion and Moderate Hypothermia: Assessing Safety With Novel Biomarkers. Heart, Lung and Circulation (2016), http://dx.doi.org/10.1016/j.hlc.2016.07.019

Q4 **Establishment where the research was carried out**:

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The abstract has been presented at 29th EACTS Annual Meeting, Amsterdam, Netherlands

Introduction

The primary target of aortic surgery is to maintain cerebral function. The main strategies for brain protection have been developed in the last 40 years. Even though it is a debated issue, perfusion of the brain during surgical procedure may provide better neurological outcomes [1]. Moreover, in recent years, cerebral protection using unilateral antegrade cerebral perfusion (uACP) has gained incremental interest in many centres. [2,3]. One of the main advantages of this method is that it enables open distal anastomosis, which has certain advantages during aortic surgery such as anastomosis with greater care and direct inspection of the arch and extensive replacement [3]. Although it is a very simple and safe method, the main concern of this technique is the doubt of adequate perfusion of the contralateral brain tissue especially during prolonged arch repair procedures [4].

Reactive oxygen species (ROS) are a natural byproduct of the normal metabolism of oxygen. Oxidative stress occurs as a consequence of an imbalance between ROS production and the available antioxidant capacity of the body. Oxidative damage to the basic elements of the cell generates a wide variety of oxidation-derived products, which are markers of oxidative stress at different clinical situations [5–7].

Open distal anastomosis by means of uACP may be used as a routine technique even in all isolated aortic aneurysms when considering the valuable advantages mentioned previously. Therefore, in this study, we aimed to investigate if there was any oxidative stress difference between the two hemispheres in terms of novel biomarkers of oxidative stress and different biochemical markers (arterial blood gas parameters, glucose and lactate levels), so that open distal anastomosis can be performed safely even in isolated aortic aneurysm during the unilateral perfusion of the brain.

Patients and Methods

Patient Population

This study included 30 consecutive patients undergoing elective ascending aorta surgery between February and May 2015. There were 39 patients operated for aortic surgery during this period. Patients undergoing aortic dissection surgery (five patients), those with a history of neurological dysfunction or cerebrovascular disease (two patients with moderate carotid stenosis), and those who did not undergo the unilateral ACP technique (two patients) were excluded from the study. This study complies with the Declaration of Helsinki and ethical approval was granted by the local institutional ethical board. In addition, informed consent was obtained from all of the patients.

Demographic data, intraoperative surgical data (cardiopulmonary bypass, cross-clamp and ACP durations), early postoperative follow-up parameters (ventilation duration, the need for inotropic support, occurrence of low cardiac output, intensive care unit and hospital stay) and neurological events were recorded.

Anaesthetic Management

Orally 0.15 $mg.kg^{-1}$ diazepam was administered as nighttime premedication and 0.1 $mg.kg^{-1}$ morphine was administered i.m. 30 min before the surgery. Cannulation of the two peripheral veins and the left radial artery was performed in the operating room. Haemodynamic parameters were monitored via electrocardiography, invasive artery blood pressure monitoring, and pulse oximetry. Before the sedation of the patient, near infra-red spectroscopy (NIRS) optodes (Equanox, Nonin Medical Inc., Minnesota, USA) were placed on the bilateral left and right forehead regions 1 cm above the brow curve line. Following preoxygenation, patients were induced with 10 $\mu g.kg^{-1}$ fentanyl, 0.1 $mg.kg^{-1}$ midazolam, 0.6 $mg.kg^{-1}$ rocuronium, and 1 $mg.kg^{-1}$ lidocaine. Maintenance was attained by the TIVA technique using fentanyl, rocuronium, and midazolam. Central venous cannulation was attained via the left internal jugular vein. Nasopharyngeal temperature monitoring was performed. Blood gas management during cardiopulmonary bypass was performed considering the alpha-stat strategy.

Surgical Technique and Cerebral Protection

The position of the left internal jugular vein catheter was checked from the surgical site and was pulled back into the left internal jugular vein if it was in the innominate vein. The second catheter for blood sampling was introduced from the vena cava superior and advanced to the right internal jugular vein. Right proximal brachial artery cannulation was carried out using a straight arterial cannula and right atrial venous cannulation was performed using a two-stage cannula, after which cardiopulmonary bypass was instituted and the patient was cooled down to 28 °C nasopharyngeal temperature. Our institutional uACP technical details were described in detail previously [8]. Low flow (8 – 10 $ml.kg^{-1}.min^{-1}$) was initiated at the right carotid artery via the right proximal brachial artery by antegrade cerebral perfusion. All arch vessels (right brachiocephalic artery, left common carotid artery and left subclavian artery) were clamped in order to prevent steal from the left hemisphere by the left common carotid artery and the left subclavian artery (via left vertebral artery from posterior circulation) during uACP. The pump flow was set at 8 – 10 $ml.kg^{-1}.min^{-1}$ during uACP. All distal aortic anastomoses were performed as an open distal anastomosis in all patients, including the patients undergoing isolated ascending

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