Chapter 13

CHANGES IN REDOX STATUS OF CEREBRAL CYTOCHROME OXIDASE DURING PERIODS OF HYPOPERFUSION IN PATIENTS UNDERGOING CARDIOPULMONARY BYPASS

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1. INTRODUCTION

Cognitive impairment is a well-recognised complication following cardiac surgery. Even though major advances in anaesthetic, perfusion and surgical techniques have significantly reduced morbidity and mortality rates, recent studies have found cognitive impairment was prevalent in as many as 53% patients at discharge following coronary artery bypass grafting (CABG). The aetiology of cognitive impairment is complex, with many contributory factors. The primary cause of neurological injury is the occurrence of global or focal cerebral ischaemia. Numerous studies have been undertaken to minimise incidence of cerebral ischaemia, the majority of which have been in animal models. Cooling has long been used for protection of the brain and heart during cardiopulmonary bypass (CPB). Decreasing the metabolic rate by cooling to hypothermia reduces the metabolic demand, and therefore reduces the likelihood of a mismatch between oxygen supply and demand. Recent studies have suggested that increasing the period of cooling on CPB before instituting deep hypothermic circulatory arrest (DHCA), cooling the head with ice packs and introducing short periods of intermittent reperfusion during DHCA could reduce cerebral injury. However, recent concerns have been raised about the potential harmful effects of re-warming on neurological outcome following hypothermia. An increase in brain temperature of 0.5-2.0 °C at the time, or immediately after an ischaemic insult can significantly affect neurological outcome.

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The purpose of this study was to determine the efficiency of NIRS for monitoring cerebral oxygenation in patients undergoing CABG and its use in the identification of potentially damaging periods of cerebral ischaemia. All patients were subject to moderate hypothermia (32°C), allowing the bypass flow rate to be reduced for periods of 30 s - 4 min with minimal ischaemic damage. At present there are no guidelines defining the frequency and safe duration of hypoperfusion events, therefore NIRS was utilised to establish whether cerebral ischaemia occurred during hypoperfusion events under supposed cerebrally protective mild hypothermic conditions.

2. MATERIALS AND METHODS

2.1 Patients and Anaesthesia

Eleven patients undergoing elective coronary bypass grafting were studied. All patients were operated on by the same surgeon, using the cross-clamp fibrillation technique for coronary grafting. Anaesthesia was induced with etomidate, alfentanil and rocuronium, and the lungs were ventilated with a mixture of oxygen, air and isoflurane in the fresh gas flow. Direct blood pressure measurements were made from an arterial cannula placed in the radial artery. Temperature, bypass pump flow rate and arteriovenous oximetry measurements were made continuously allowing metabolic rates to be calculated, and arterial blood gases were recorded every 20 min.

2.2 Cardiopulmonary Bypass

Cardiopulmonary bypass was conducted using a Sechrist air-oxygen blender, a Cobe Duo membrane oxygenator and a Jostra pump assembly. The pump flow rate was maintained at 2.4 L.m\(^{-2}\).min\(^{-1}\) and flow reduced on surgical request when necessary. During CPB patients were cooled to moderate hypothermia (32°C). Anaesthesia on bypass was maintained by isoflurane and standardised by adjusting the inspired concentration of isoflurane to a demonstrable burst suppression pattern on the patient’s EEG. The fresh flow gas rate was adjusted to keep the arterial CO\(_2\) concentration between 4.5-5.5 kPa. Throughout CPB, full heparinisation was used (300 units/ kg), arterial pressure was maintained between 60-70 mmHg with 1 mg increments of metaraminol. Re-warming to 37.5 °C occurred prior to weaning off CPB. Following weaning from CPB 4 mg/kg protamine was administered intravenously for reversal of heparinisation.

2.3 Near Infrared Spectroscopy Measurements

NIRS monitoring commenced shortly after induction of anaesthesia, until at least 20 min following weaning off CPB, with a CRITIKON™ Cerebral Redox Monitor model 2001. Sequential pulses of light were emitted from four solid-state laser emitting diodes (776.5, 819, 871.4 and 908 nm) at ~2.1 kHz. Measurements were taken every second using the CRITIKON adult sensor (emitter-detector separation 45 mm) positioned over the right cerebral hemisphere. Data were expressed as changes in concentration of oxy-,