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ORIGINAL ARTICLE

Effect of Core Temperature and Embolic Load During Cardiac Surgery on Motion Perception

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Background Cognitive decline post-cardiac surgery is of clinical concern. To better understand it a sensitive and specific measure of post-surgery brain impairment is required. The cerebral territory most likely to be adversely affected by surgery is the posterior ''watershed'' territory.

Methods We have designed a psychophysical task involving reading letters defined by motion aimed at measuring the integrity of a cortical area (MT) located in this territory. Patients undergoing coronary artery bypass grafting (CABG) and a healthy control group were given the psychophysical test twice, pre- and post-surgery for the patient group.

Results There was no overall difference in performance between the surgery group and the control group at either pre- or post-surgery testing. However, multivariate analysis of surgical variables such as body temperature and embolic load to the brain as measured by Transcranial Doppler showed that patients with warmer core temperatures and higher embolic loads performed significantly worse on the motion defined letter reading tasks than those with more favourable surgical variables.

Conclusions These results demonstrate that high embolic load and warm core body temperatures lead to poor motion perception post-cardiac surgery, implying damage to the posterior watershed cortex.

Keywords Hypothermia • Emboli • Cardiac surgery • Cognitive impairment • Motion perception • Cardiac bypass grafting

Introduction

Cognitive decline post-cardiac surgery has been measured using neuropsychological testing, although considerable confusion exists in the literature regarding the prevalence, extent and duration of the cognitive decline [1]. The mechanisms are not fully understood, but MRI studies have demonstrated increases in the incidence of silent brain injury post procedure [2]. The possible pathophysiological mechanisms of post-cardiac surgery brain injury include embolisation, hypoperfusion and inflammatory processes. These can be measured, for example gaseous and particulate matter transiting to the brain can be readily detected using Transcranial Doppler (TCD). However, emboli detected with TCD during cardiac surgery have not been shown to correlate with postoperative cognitive decline [3]. The complex mixture

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of pathophysiological mechanisms, surgical variables and cognitive measures makes prediction of the incidence and extent of cognitive decline difficult to predict.

Both hypoperfusion and the generation of emboli are most likely to adversely affect the cerebral ''watershed'' territories as these are the brain regions most vulnerable to vascular low flow rates. The posterior cerebral watershed territory encompasses an area of cortex (area MT) responsible for the processing of visual motion. The neurons in area MT are macrocellular and have been shown to be particularly vulnerable to ischaemia [4].

We have developed a computer administered psychophysical task designed to be sensitive to posterior watershed insult. The task involves the detection and recognition of letters purely defined by motion contrast. Similar stimuli have previously been shown to be useful in measuring visual deficits in other clinical conditions, such as Parkinson's disease [5], multiple sclerosis [6] and parietotemporal lesions [7]. If cerebral embolisation and hypoperfusion during surgery result in watershed territory brain injury then deficits in performance on this task should be evident.

Materials and Method

Participants

The study was approved by the Hunter New England Human Research Ethics Committee. The participants were patients with coronary artery disease considered clinically appropriate for coronary artery bypass grafting (CABG). They were recruited from the CABG surgery waiting list at the John Hunter Hospital, Newcastle, NSW, Australia. Participants were excluded if they had a history of previous cardiac surgery or cardiopulmonary bypass, cardiac arrest, stroke, recognised cognitive deficits, visual field defects or inadequate temporal acoustic windows for testing with Transcranial Doppler ultrasound.

Healthy control participants were recruited via newspaper articles written in response to a media release. Exclusion criteria included a history of previous cardiac surgery or cardiopulmonary bypass, cardiac arrest, stroke, recognised cognitive deficits, or visual field defects.

Apparatus

Visual Motion Test

We used a novel computer-administered psychophysical test of visual perception in which participants are required to detect and/or identify the presence of letter forms in a field of moving white dots presented on a black background. The test stimuli comprise the letters A, E, F, H, I, L, T and Z. These letters were chosen as they have similar spatial properties, eliminating curvature as a cue to recognition. An example of a luminance defined letter is shown in Figure 1. The control stimuli comprise a region of the monitor screen filled with random dots with 90% of the dots travelling from right to left and the remainder travelling from left to right. Participants sat comfortably 1.5 metres from a 43 cm display monitor in a darkened room. At this distance the stimuli subtend a visual angle of $\hat{1}31'40''$.

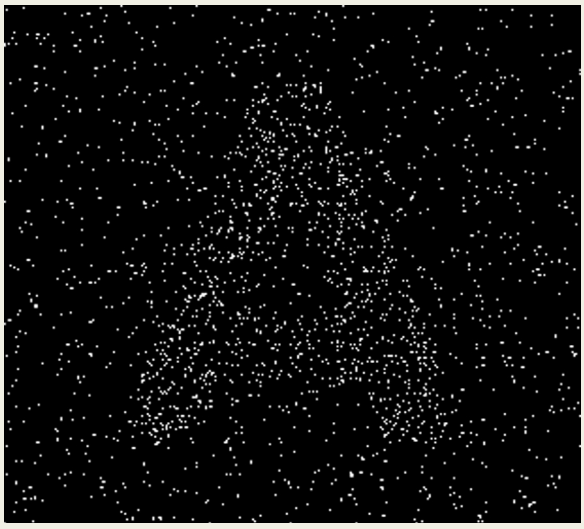

Figure 1 An example of a luminance defined letter.

The letters were defined by either motion contrast, luminance contrast or a combination of motion and luminance contrast. The motion-defined (MD) letters were defined by dots with equal but opposite velocity to those in the surround. As in the control stimuli, 10% of all dots travelled in the direction opposite to the majority - this was to control for participants simply detecting the presence of rightward motion. The luminance defined (LD) letters were generated such that the stationary dots within the boundary of the letter were displayed at a higher luminance than those in the surround. The combined motion and luminance-defined letters (CD) had both a luminance and a velocity contrast.

Each condition differed in terms of the dependent variable manipulated and the task demands of either detection or recognition. The MD and LD stimuli were presented in a 2x2 fully factorial design (two tasks, detection and recognition, and two independent measures, dot density and cue gradient). Only dot density was manipulated in the combined case, resulting in two combined conditions, one for detection and one for recognition. The 10 stimulus conditions are summarised in Table 1. The conditions are abbreviated by a three-letter code with the first letter indicating cue type (M-motion; L-luminance; C-combined luminance and motion); the second letter indicates the dependent variable (D-dot density; G-cue gradient) and the third indicates the participant's task (D-detection; R-recognition). The order of presentation of conditions was randomised for each participant. All 10 conditions were administered to all participants. Participants completed the tests both prior to surgery and at post-surgery follow-up.

Transcranial Doppler Embolus Detection

Bilateral, continuous, middle cerebral artery (MCA) transcranial Doppler monitoring was performed throughout the surgical procedure. A DWL MultiDop T Doppler instrument (DWL, Sipplingen, Germany) was used. Monitoring commenced at