Continuous Non-invasive Monitoring of Cerebrovascular Autoregulation during Cardiac Surgery with Cardiopulmonary Bypass in Order to Protect Brain from Post-Operative Cognitive Deterioration

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INTRODUCTION

Post-operative cognitive dysfunction (POCD) occurs in ~40-60% of patients after cardiac surgery with cardiopulmonary bypass (CPB). The incidence of deteriorated cognition remains high after 6 weeks and 1 year (30-25%). The guidelines recommend to keep the mean arterial blood pressure (MAP) during CPB 50-60 mmHg or higher [2]. But lower limit of cerebrovascular autoregulation (CA) is patient-specific and may deteriorate when MAP is below limit of intact CA. Our hypothesis is that POCD can be related to a temporal cerebral hypo-perfusion and consequently to the impairment of cerebrovascular autoregulation (CA). We propose to use the innovative ultrasonic real-time CA monitoring technology [3] for identification of the individual patient-specific MAP values during CPB in order to prevent brain injury and POCD.

METHODS

The prospective observational study is conducted at the Clinic of Cardiothoracic and Vascular Surgery, Hospital of Lithuanian University of Health Sciences, Kaunas. The study included patients undergoing the elective coronary artery bypass grafting surgery (ASA III class, NYHA III class) without preoperative neurological disorder. The equipment used for patients’ monitoring during cardiac surgery: non-invasive CA monitor Vittam 505, Draeger Infinity monitor (ECC, invasive MAP, SpO2, temperature). The non-invasive CA monitor [3] is based on ultrasonic time-of-flight measurement principle and is capable to provide real-time information on the intracranial blood volume (IBV) pulsation in the small cerebral vessels responsible for cerebral autoregulation (Fig. 1). The CA status is estimated continuously during CPB by calculating non-invasively the pressure reaction index vPRx(t) as a moving correlation coefficient between the slow waves of MAP(t) and IBV(t) [3] within 2 min averaging time window. The neurocognitive function tests for each patient were performed before and 10 days after surgery to estimate changes of mental abilities and to detect POCD.

RESULTS

Fig 2. CA monitoring during cardiac surgery. The drop of MAP below the lowest patient-specific critical threshold causes the impairment of CA (when vPRx(t)>0) and a “secondary brain injury”.

Fig 3. Association of duration of LCAI event (vPRx(t)>0) with POCD.

The preliminary clinical study of CA monitoring was performed on 65 cardiac surgery patients (6 patients excluded from analysis). The patients’ age limits were 47-87 years. 22 patients (37%) experienced POCD after surgery. The other 37 patients (63%) did not display evidence of cognitive deterioration. The patients with detected POCD were suffering from longer cerebrovascular autoregulation impairment (LCAI) events when vPRx(t)>0. The impairment of CA lasting up to a few minutes typically appears when MAP temporarily drops below the lowest individual patient specific MAP threshold ~ 40 – 50 mmHg (Fig.2). The calculated critical threshold of duration of LCAI events showing association with the deteriorated mental ability was 302 sec (odds ratio 14.7 and CI 3.9-51.8). The duration of the longest episode of CA impairment was significantly longer in group with POCD comparing to the group without deteriorated mental abilities (mean values in these groups were 383 vs 253s, respectively (p=0.002)) (Fig 3).

CONCLUSIONS

The preliminary clinical study showed that the duration of LCAI event above 300 sec during CPB surgery is associated with higher rate of POCD for studied population. The non-invasive CA monitor can be used for the patient-specific MAP management during cardiac CPB surgery in order to prevent cognitive dysfunctions. We intend to continue our study by including high-risk patients group (hypertension, with left ventricle systolic dysfunction, diabetes patients, etc.) for exploring applicability of the present method.

REFERENCES