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Continuous Monitoring of Cerebral Blood Flow Autoregulation during Cardiac Surgery in Adults with Near Infra-Red Spectroscopy: Preliminary Results

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Introduction: Cerebral hypoperfusion during cardiac surgery is of growing importance as a cause of brain injury due to the increasing proportion of elderly patients with cerebral vascular disease.(1, 2) Individualizing mean arterial pressure (MAP) to be within the patient's autoregulatory range during cardiopulmonary bypass (CPB) would more likely ensure adequate cerebral blood flow (CBF) than the standard practice of empirically targeting MAP to > 50 mmHg. In this study we evaluate whether real-time monitoring of CBF autoregulation using near infra-red spectroscopy (NIRS) accurately detects the lower autoregulatory threshold compared with a validated, but technically more challenging method using transcranial Doppler (TCD). (1)

Methods: Fifty-four patients > 50 years undergoing CABG and/or valve surgery with CPB were enrolled in an IRB approved protocol after giving written informed consent. Bilateral middle cerebral artery TCD monitoring and NIRS monitoring were performed with the INVOS device (Somenetics Corp, Troy, MI) or Fore-Sight device (CAS Medical Systems, Branford, CT) in 37 and 17 patients, respectively. Arterial pressure, TCD, and NIRS signals were sampled with a analog-to-digital converter at 58 Hz and down loaded to a personal computer.(2) The TCD and NIRS signals were time integrated as non-overlapping 10-sec mean values to eliminate noise from the respiratory and pulse frequencies. A continuous, moving Pearson correlation coefficient was calculated between MAP and TCD CBF velocity and NIRS signals rendering the variables mean velocity index (Mx) and cerebral oximetry index (COx), respectively. Consecutive, paired, 10-sec averaged values from 300-sec duration were used for each calculation, incorporating 30 data points for each index. When CBF is autoregulated, there is no correlation between CBF and MAP (i.e., Mx < 0.2 and COx < 0.3), but when pressure passive, Mx and COx are positively correlated with MAP.(3) The lower CBF autoregulation threshold was defined as the MAP where Mx was >0.2 and COx was > 0.3.(4) The MAP at the lower autoregulatory threshold detected by Mx or COx were compared using ANOVA.

Results: The MAP at the autoregulatory threshold (range 40 to 80 mmHg) detected with Mx and COx (Figure) was not different: 66±14 mmHg and 67±12 mmHg, respectively. In 99% of patients, the lower autoregulatory threshold detected by COx was within 5 mmHg of that detected by Mx.

Conclusion: These data suggests that NIRS based COx monitoring provides an accurate detection of the lower CBF autoregulatory threshold in patients undergoing cardiac surgery. This promising non-invasive monitoring method might provide a means for individualizing MAP during surgery potentially reducing the frequency of brain injury due to cerebral hypoperfusion.

References: 1. J Thorac Cardiovasc Surgery 2006;131:540-46; 2. Stroke 2006;37:2306-11; 3. J Neurol Neurosurg Psychiatry 2002;72:583-86; 4. Stroke 2007;38:2818-25

Figure. Data showing mean±SD correlation coefficient between transcranial Doppler cerebral blood flow (CBF) velocity and MAP (Mx, left) and near infrared spectroscopy and MAP (COx right). An increasing Mx and COx indicate pressure passivity of CBF. The arrows indicate the MAP where Mx is > 0.2 and COx is > 0.3 indicating the lower autoregulatory threshold. There was no difference in the MAP at the autoregulatory threshold between Mx and COx.