TITLE: NONPULSATILE NORMOTHERMIC CARDIOPULMONARY BYPASS SIGNIFICANTLY REDUCES CEREBRAL METABOLISM AND CEREBRAL OXYGEN DELIVERY

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Introduction: In both animals[1] and man[2], nonpulsatile, normothermic cardiopulmonary bypass (CPB) is associated with reductions in cerebral blood flow (CBF) and cerebral metabolism. In these studies, however, either halothane or isoflurane was used, both agents known to interfere with cerebral autoregulation. To exclude an anesthesia-related effect, the current study was designed to assess the influence of nonpulsatile, normothermic CPB on cerebral oxygen delivery ($CDO_2$), cerebral metabolic rate for oxygen ($CMRO_2$), and CBF during high-dose narcotic anesthesia in man.

Methods: Following approval from the university human investigations committee and after obtaining written consent, 5 patients undergoing nonpulsatile normothermic CPB during cryoablation surgery for supraventricular arrhythmias were investigated. Patients were premedicated with morphine 0.15 $mg.kg^{-1}$ I.M. and lorazepam 0.06 $mg.kg^{-1}$ P.O. 90 min preoperatively. Anesthesia was induced and maintained with sufentanil 20 $mcg.kg^{-1}$; no volatile anesthetics were used until after completion of all studies. CBF was measured using 5mCi of $^{133}Xe$ in 6 ml saline injected intravenously pre-CPB, and into the arterial port of the pump oxygenator during CPB. For intravenous studies, end-tidal $^{133}Xe$ was used to correct for recirculation. Mean CBF was based on the average $^{133}Xe$ clearance measured by 10 scintillation detectors located 5 over each cerebral hemisphere. Standard correction factors were used to compensate CBF values for changes in temperature and hematocrit. A 15 cm 16 ga catheter was introduced percutaneously and threaded retrogradely into the right internal jugular bulb for sampling effluent cerebral venous blood. Blood gas measurements were made on a Radiometer ABL2 and oxygen saturation was measured directly using a Radiometer OSM3 hemoximeter. $CMRO_2$ was calculated as the product of the $O_2$ content difference between arterial and jugular venous blood and mean CBF. To facilitate interpretation of the sequential CBF values (in the presence of significant changes in hemoglobin concentration due to hemodilution), cerebral oxygen delivery ($CDO_2$ = CBF x $CaO_2$) was calculated. To assess cerebral flow/metabolism coupling, cerebral oxygen extraction ratio ($CERO_2$ = $CMRO_2/CDO_2$) was determined. Measurements were made twice: (1) following sternotomy prior to CPB, and (2) 15 to 30 min after commencement of CPB. Data were analyzed using a paired two-tailed t-test with $p < 0.05$ required for significance.

Results: Results are presented in the table (mean ± S.D.). During normothermic CPB, $CMRO_2$ was significantly reduced to 62% of the pre-CPB values. Although the 25% reduction in CBF did not achieve statistical significance, $CDO_2$ was significantly reduced to 50% of the pre-CPB value. $CERO_2$ did not change significantly.

Discussion: Our study has demonstrated significant reductions in $CMRO_2$ and $CDO_2$ along with a tendency for reductions in CBF during normothermic CPB. The decrease in CBF did not achieve statistical significance but, as shown by the reduction in $CDO_2$, cerebral oxygen delivery was significantly reduced. The absence of a significant change in $CERO_2$ suggests that cerebral flow/metabolism coupling is preserved and that $CMRO_2$ is reduced primarily, rather than secondarily due to a decrease in CBF. These results are similar to those reported for volatile anesthetics[1,2] and suggest that independent of the type of anesthetic agent, some factor(s) operative during nonpulsatile CPB reduces $CMRO_2$ causing a secondary decrease in CBF and $CDO_2$.

References:

1. Sorensen HR, Husum B, Waaben J, et al. Brain microvascular function during cardiopulmonary bypass. J Thorac Cardiovasc Surg 1987; 94: 727-32.
2. Murkin JM, Farrar JK, Tweed WA et al. The influence of non-pulsatile normothermic perfusion on cerebral blood flow and metabolism. Anesth Analg 1987; 66: S125.

Table

| * $p < 0.05$ | Pre-CPB (1) | CPB (2) |
|---|---|---|
| $CMRO_2$ ($ml.100g^{-1}.min^{-1}$) | 2.21 ± 0.40 | 1.37 ± 0.30* |
| CBF ($ml.100g^{-1}.min^{-1}$) | 37.8 ± 12 | 28.3 ± 5.1 |
| $CERO_2$ | 0.34 ± 0.10 | 0.40 ± 0.13 |
| $CDO_2$ ($mlO_2.100g^{-1}.min^{-1}$) | 6.90 ± 2.70 | 3.50 ± 0.80* |
| CPP (mmHg) | 64 ± 4.8 | 52.8 ± 15.7 |
| Temperature ($^oC$) | 36.3 ± 0.6 | 36.9 ± 0.3 |
| $PaCO_2$ (mmHg) | 41.3 ± 7.6 | 40.6 ± 5 |
| Hemoglobin ($gm.dl^{-1}$) | 12.4 ± 1.4 | 8.8 ± 1.4* |