Title: RELATIONSHIP OF REGIONAL CEREBRAL BLOOD FLOW AND SYSTEMIC BLOOD FLOW DURING HYPOTHERMIC CPB

Authors: A.V. Govier, M.D., J.G. Reves, M.D., R.B. Karp, M.D., G.L. Zorn, M.D., L.R. Smith, M.A., M.L. Adams, B.S.

Affiliation: Departments of Anesthesiology and Surgery, The University of Alabama in Birmingham, Birmingham, AL 35294

Introduction: Controversy exists regarding the optimal perfusion flow during hypothermic cardiopulmonary bypass (CPB). There are times when adequate surgical exposure and myocardial protection techniques require very low perfusion flow rates. Concern exists that the cerebral blood flow (CBF) may drop commensurate with reduction of low perfusion flow. This investigation was designed to examine the relationship of regional cerebral blood flow (rCBF) and systemic blood flow ($\dot{Q}$) during nonpulsatile hypothermic cardiopulmonary bypass.

Methods: After IRB approval for human study, rCBF was determined by ^{133}Xe clearance[1] in 10 patients undergoing coronary artery bypass graft surgery anesthetized with diazepam (0.3-0.5 mg/kg), fentanyl (10-20 mcg/kg), and N_2O/O_2 (50:50). Patients were excluded with known cerebrovascular disease and with hypertension (diastolic BP $\geq$ 90 mmHg). rCBF was determined from an injection of saline containing 400 mc of ^{133}Xe into the left common carotid artery and ^{133}Xe clearance curves were obtained from a single extracranial scintillation detector placed perpendicular to the scalp approximately over the left Rolandic fissure. To assess the relationship of systemic blood flow ($\dot{Q}$) to CBF in 10 patients, the $\dot{Q}$ was varied while arterial partial pressure of carbon dioxide ($PaCO_2$), nasopharyngeal temperature (NPT), and mean arterial pressure (MAP) were held relatively constant: $PaCO_2$ (33.0-45.0 mmHg), NPT (25.6-29.3° C), and MAP (45.0-70.0 mmHg). Four pump flows (1.0, 1.3, 1.6, 2.0 l/min/m^2) were assigned in random order in 10 patients. The minimum duration of the pump flow at each $\dot{Q}$ prior to rCBF determination was 3 min. while the maximum duration varied from patient to patient. CO_2 was added to the perfusate via the pump oxygenator, if necessary, to maintain the $PaCO_2$. Sodium nitroprusside, droperidol, or phenylephrine were administered when necessary to maintain the MAP between 45 and 70 mmHg. A previous report showed that rCBF is independent of MAP in this range.[2] Data were analyzed using analysis of variance.

Results: Twenty-nine observations were made in the 10 patients. The relationship of rCBF and $\dot{Q}$ is illustrated in the figure. During hypothermic nonpulsatile CPB, when Q was varied between 1.0 and 2.0 l/min/m^2, there was no significant change in the measured rCBF. Thus, changes in $\dot{Q}$ do not produce changes in rCBF under the conditions of hypothermic cardiopulmonary bypass.

Discussion: Whole body oxygen consumption progressively falls as the perfusion flow rate is decreased during hypothermic total CPB; however, a study by Fox et al.[3] in cynomologous monkeys revealed that brain oxygen consumption remained unchanged with decreasing perfusion flow rates. Fox et al. concluded that oxygen delivery continues in part by increased oxygen extraction and in part by redistribution of perfusate from the body to the brain. In Fox's study, cerebrovascular resistance remained unchanged at decreasing flow rates while the systemic circulation resistance increased. These findings by Fox et al. partially corroborate our findings of a relatively constant rCBF at varying perfusion flow rates in man.

The MAP in these patients was regulated pharmacologically to maintain a 45 to 70 mmHg range. Droperidol and phenylephrine, used to regulate blood pressure, are known to have little effect on rCBF in man. Sodium nitroprusside could have increased rCBF because of its direct vasodilating properties. The results, however, indicate that there is no significant change in rCBF measured during hypothermic nonpulsatile CPB when $\dot{Q}$ is varied between 1.0 and 2.0 l/min/m^2. Additional studies are necessary to determine the critical level and duration of systemic blood flow below which cerebral flood flow is inadequate, causing disorders of cerebral function to occur.

In conclusion, during hypothermic nonpulsatile CPB, the reduction of perfusion flow rates to as low as 1.0 l/min/m^2 does not significantly reduce rCBF, at least during the short time interval over which rCBF was measured in this study. Under the usual conditions of CPB, variations in $\dot{Q}$ are not associated with important changes in cerebral perfusion.

References:

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3. Fox LS, Blackstone EH, Kirklin JW, Bishop SP, Bergdahl LA, Bradley EL: Relationship of brain blood flow and O_2 consumption to perfusion flow rate during profoundly hypothermic cardiopulmonary bypass: an experimental study. J Thorac Cardiovasc Surg (in press)

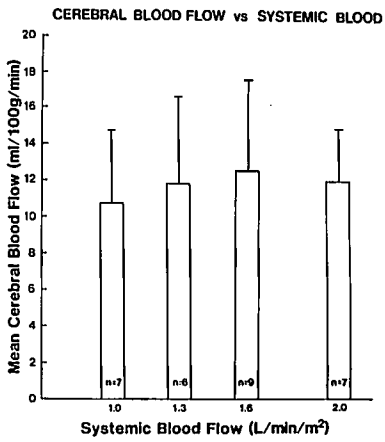

FIG. MAP ranged from 45 to 70 mmHg and PCO_2 from 33 to 45 mmHg.