Title: NO INTRACEREBRAL STEAL DURING HYPERCARBIC HYPOTHERMIC CARDIOPULMONARY BYPASS

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Introduction. The pH-stat method of CO_2 management during hypothermic cardiopulmonary bypass (CPB) (temperature corrected $PaCO_2$ maintained near 40 mmHg) increases $PaCO_2$ and cerebral blood flow (CBF)[1,2] and decreases cerebral oxygen consumption ($CMRO_2$)[1] relative to the alpha-stat method ($PaCO_2$ maintained at 40 mmHg uncorrected for body temperature). These effects are desirable if they reduce ischemia in focally diseased brain regions in patients with cerebrovascular disease (CVD). However, in patients undergoing carotid endarterectomy, hypercarbia causes a redistribution of CBF from poorly perfused to well-perfused areas[3]. We studied patients with CVD undergoing CPB to determine whether pH-stat CO_2 management also produces intracerebral steals.

Methods. In a study approved by the institutional Clinical Research Practices Committee, we obtained informed consent and measured CBF in 9 patients undergoing hypothermic CPB for treatment of coronary artery disease. Inclusion criteria consisted of clinical or angiographic evidence of occlusive cerebrovascular disease, including previous stroke or highgrade extracranial obstruction. No patients with recent stroke (< 3 months previously) were studied. Controls consisted of 9 concurrently studied patients without CVD. Drugs for premedication were lorazepam 50 µg/kg p.o. and morphine 0.1 mg/kg im; for induction, intubation and maintenance, fentanyl 75 µg/kg iv and pancuronium 0.1 mg/kg iv. No additional agents other than enflurane (< 0.5% pre-bypass) were administered until measurements were completed.

During hypothermic, nonpulsatile CPB, regional CBF was determined by the clearance of ^{133}Xenon, dissolved in saline and injected into the arterial line of the pump-oxygenator. CBF was calculated from the ^{133}Xenon clearance curves from 12 - 16 brain regions using the CBF[15] technique. $PaCO_2$ was varied in random order from a higher (pH-stat) to lower (alpha-stat) or from a lower to a higher level, once a stable nasopharyngeal temperature (NPT) was attained. NPT, perfusion flow rate (Q), mean arterial pressure (MAP), and temperature (Temp) were kept within narrow limits (Table).

Data were analyzed to answer three questions: 1. Are intracerebral steals produced by hypercarbia? 2. Do low and high CBF regions respond differently to increased $PaCO_2$? 3. Does CBF respond differently to changes in $PaCO_2$ in patients with and without cerebrovascular disease? Paired two-tailed Student's "t" tests ($p < 0.05$ considered significant) were used to evaluate the latter two questions.

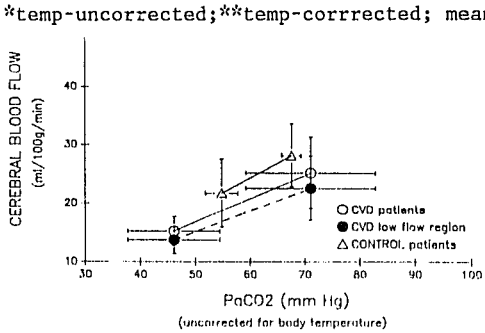
Results. No demonstrable intracerebral steal occurred in any brain region in any patient. In the regions demonstrating the lowest flow at the lower $PaCO_2$, the CBF response to changes in $PaCO_2$ was statistically similar to the response of the brain as a whole (Fig). The average CO_2 response of patients with CVD was similar to the response of patients without clinical CVD. CBF increased an average of 3.40 ± 2.32 ml/100g/min per mmHg $PaCO_2$ in the CVD group and an average of 2.79 ± 2.61 ml per 100g/min per mmHg in patients without CVD.

Discussion. No data clearly demonstrate which CO_2 management method is clinically preferable in patients with CVD undergoing CPB. Although the alpha-stat method appears to be more physiologic in patients with normal cerebral vasculature,[2] the pH-stat method could protect the brain by increasing CBF and decreasing $CMRO_2$. But, because the pH-stat method may be equivalent to hypercarbia, it creates a potential for intracerebral steals in CVD patients. In this study, however, the pH-stat approach increased CBF without inducing steals.

Table. Cerebrovascular Disease Patients

	Lower $PaCO_2$	Higher $PaCO_2$
$PaCO_2$ (mmHg)*	46.1 ± 8.4	71.1 ± 11.8
$PaCO_2$ (mmHg)**	29.7 ± 7.5	46.4 ± 8.9
NPT (degrees C)	28.0 ± 3.0	26.8 ± 2.2
MAP (mmHg)	66.5 ± 6.3	68.4 ± 9.1
Q (L/min/m^2)	2.2 ± 0.7	2.1 ± 0.7
Hct (%)	23.4 ± 3.9	23.2 ± 3.7
CBF (ml/100g/min)	15.2 ± 2.5	25.3 ± 6.1
CBF (low flow region)	13.7 ± 2.3	22.7 ± 5.6

*temp-uncorrected;**temp-corrrected; mean ± SEM



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