TITLE: EFFECTS OF CHANGE IN ARTERIAL CO_2 TENSION ON BRAIN ENERGY LEVEL DURING INDUCED HYPOTENSION

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Changes in arterial carbon dioxide tension ($PaCO_2$) may occur during anesthesia caused by hyper or hypoventilation. It has been shown that hypocarbia can produce changes in the brain energy state similar to those of hypoxia[1] probably by reducing cerebral blood flow (CBF). The absence of CBF autoregulation during profound hypotension[2] in hypocarbic state may cause further decrease in CBF, thus producing severe brain tissue injury due to ischemic tissue hypoxia. On the other hand hypercarbia causes a major derangement of the brain energy state during profound hypotension.[3] We have shown deep anesthesia with halothane reduced cerebral metabolic rate for oxygen ($CMRO_2$) and in fact protected the brain against hypotensive stress in normocarbic Wistar rats with unilateral carotid ligation.[4] Can halothane anesthesia also provide some cerebral protection against hypotensive stress during hypocarbia and hypercarbia in the same animal model? This study was designed to answer this question.

Methods: Twenty-four hours after left carotid ligation, male Wistar rats (275-300 gms) were anesthetized with halothane-oxygen. Following tracheostomy and cannulation of femoral vessels, they were paralyzed with d-tubocurarine and ventilated with halothane one percent in oxygen at least for 30 minutes, and then throughout the experiment. Four groups were studied. Group 1 with mean arterial pressure (MAP) over 100 torr and $PaCO_2$ 40 torr was control group. In the remaining groups MAP was maintained at 40 torr by intravenous infusion of Trimetaphan during the experiment. Ventilation was adjusted to maintain $PaCO_2$ at 40, 20, and over 50 torr in groups 2, 3, and 4 respectively. Temperature was kept at 37C in all groups by means of heat lamp servo-mechanism.

After 20 minutes of hypotension and a corresponding period in the control group the animal's brain was prepared by funnel freezing for subsequent microfluorometric analysis of cortical tissue Adenosine triphosphate (ATP), Phosphocreatine (PCr), and lactate. Student t test was employed for analysis of unpaired data. A value for P of less than 5 percent was considered significant.

Results: Arterial pressure and temperature were all maintained at predetermined levels (Table 1). PaO_2 was over 200 torr in all groups. $PaCO_2$ was not different from control in group 2, but was significantly ($P<0.05$) lower in group 3 and higher in group 4 than the control group. As the result of changes in $PaCO_2$ significant respiratory alkalosis and acidosis occured in groups 3 and 4 respectively.

The levels of ATP and PCr were all preserved in the hypotensive groups when compared with the control group regardless of the level of $PaCO_2$. Lactate increased significantly from control only in the hypocarbic group probably representing the metabolic compensation for Alkalosis (Table 2).

Discussion: Changes in $PaCO_2$ of the magnitudes in this study, caused derangements in brain energy stores in lightly anesthetized animals.[1,3] Halothane one percent in oxygen protected the brain tissue regardless of the $PaCO_2$ levels during Trimetaphan-induced hypotension. It is quite possible that halothane one percent decreases $CMRO_2$ to a desirable level, hence protecting cerebral tissue against ischemic hypoxia in the rat.

Table 1 Physiologic Parameters

GROUPS	MAP (torr)	PaO_2 (torr)	$PaCO_2$ (torr)	pHa
1	105±	231±	41.5±	7.39±
	3.4	22.9	0.3	0.01
2	40.1±*	296.6±	39.6±	7.39±
	0.2	8.0	1.0	0.01
3	40.8±*	285.0±	21.2±*	7.54±*
	0.2	11.0	2.1	0.02
4	40.2±*	307.5±	57.2±*	7.21±*
	0.2	11.0	2.1	0.02

Temperature 37C in all groups.
All values are Mean ± S.E.M.
*Significantly different from Control ($P<0.05$ unpaired Student t test)

Table 2 Cerebral Cortical Tissue Metabolite Levels (μmol/gm wet weight) in Control (Group 1) and Hypotensive Groups

GROUPS	ATP	PCr	LACTATE
1	2.33±	3.63±	2.30±
	0.09	0.23	0.25
2	2.46±	3.36±	1.90±
	0.06	0.28	0.20
3	2.34±	3.73±	4.20±*
	0.06	0.40	0.20
4	2.38±	3.40±	1.90±
	0.05	0.20	0.20

All values are from Cortex hemolateral to ligated carotid artery.
All values are Mean ± S.E.M.
*Significantly different from Control ($P<0.05$ unpaired Student t test)

References

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