Title: SOMATOSENSORY EVOKED POTENTIAL CHANGES DURING INTRACRANIAL HYPERTENSION

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Introduction. Systemic hypertension has long been recognized as a response to intracranial hypertension. The adequacy of this Cushing response in preserving cerebral O_2 delivery, O_2 uptake and brain electrical function is unclear. We evaluated the effects of generalized intracranial hypertension on regional cerebral blood flow, cerebral oxygen consumption ($CMRO_2$) and electrical function (somatosensory evoked potential (SEP)).

Methods. Nineteen barbiturate anesthetized adult sheep (35-50 kg) were studied. Mean arterial blood pressure (MABP) was measured via a femoral artery catheter. Intracranial pressure (ICP) was measured via a needle placed in a lateral cerebral ventricle. A catheter was placed in the sagittal sinus for sampling of cerebral venous blood. Regional cerebral blood flow (CBF) was determined using 15 micron diameter microspheres. SEP were determined using a Nicolet Med 80. SEP was recorded by electrodes over the contralateral somatosensory cortex in response to stimulation of a foreleg nerve at stimulus intensity twice motor threshold. The average of 256 stimuli delivered at 1.9/sec was obtained. The latency of the initial negative wave (N1) and and amplitude of the primary complex (P1N1) were evaluated. ICP (referenced to heart) was raised by gravity infusion of mock CSF into a lateral ventricle at a rate of 20 mmHg/min to produce the desired initial cerebral perfusion pressure (CPP= MABP control-ICP). In group 1 (n=7), initial CPP was decreased to 50 mmHg; in group 2 (n=6), initial CPP was decreased to 20 mmHg; and in group 3 (n=6), initial CPP was decreased to 0 mmHg. In all animals, MABP was allowed to change in response to intracranial hypertension, while ICP was held constant at the predetermined value. Regional CBF, $CMRO_2$ and SEP were determined prior to intracranial hypertension and 1,5,15 and 40 minutes after onset of intracranial hypertension. $CMRO_2$ was determined as the product of blood flow to cerebrum times the cerebral arteriovenous oxygen content difference.

	MABP mmHg	ICP mmHg	CPP mmHg	CBF ml/min/100g	MCA Region ml/min/100g	$CMRO_2$ ml/min/100g	N1 Latency ms	P1N1 Ampl. μv
Group 1 (n=7)								
Control	116 ± 3	24 ± 3	91 ± 5	36 ± 5	32 ± 4	3.4 ± .3	19.3 ± 0.7	4.4 ± .3
1 min	112 ± 3	70 ± 3	44 ± 2	32 ± 6	31 ± 4	3.1 ± .3	19.3 ± 0.7	3.8 ± .4
15 min	116 ± 3	70 ± 3	47 ± 2	37 ± 7	34 ± 3	3.7 ± .6	19.4 ± 0.6	3.7 ± .6
40 min	112 ± 3	69 ± 4	44 ± 2	34 ± 5	34 ± 4	3.4 ± .3	19.2 ± 0.4	3.0 ± .6
Group 2 (n=6)								
Control	123 ± 5	20 ± 3	104 ± 4	43 ± 2	38 ± 3	3.7 ± .3	22.8 ± 2.8	2.5 ± .8
1 min	118 ± 5	98 ± 5	21 ± 1	20 ± 3*	22 ± 2*	2.8 ± .5*	22.0 ± 2.4	1.6 ± .4*
15 min	121 ± 6	97 ± 5	24 ± 3	23 ± 2*	25 ± 3*	2.8 ± .2*	22.6 ± 2.6	2.3 ± .6
40 min	123 ± 9	96 ± 5	25 ± 4	27 ± 5*	32 ± 7*	2.8 ± .5*	23.1 ± 2.5	1.6 ± .4*
Group 3 (n=6)								
Control	114 ± 2	24 ± 3	89 ± 2	45 ± 4	39 ± 4	3.7 ± .1	17.4 ± 0.6	2.8 ± .5
1 min	142 ± 6*	116 ± 3	27 ± 5	18 ± 3*	19 ± 4*	2.2 ± .3*	19.5 ± 1.0*	2.1 ± .5*
15 min	138 ± 3*	114 ± 2	24 ± 1	18 ± 2*	23 ± 3*	2.1 ± .4*	22.2 ± 1.6*	1.5 ± .4*
40 min	138 ± 3*	114 ± 3	24 ± 1	17 ± 3*	17 ± 4*	1.9 ± .3*	24.3 ± 1.7*	1.4 ± .5*

Means ± SE; *, P<0.05 from control.

Results. In group 1, as CPP was decreased from 91 ± 5 to 44 ± 2 mmHg, (mean ± SEM) total and regional CBF was unchanged from control indicating good autoregulation. There were no significant changes in $CMRO_2$ or SEP latency and amplitude over the 40 min period. In group 2, as CPP was decreased from 104 ± 3 to 21 ± 1 mmHg, CBF decreased from 43 ± 2 to 20 ± 3 ml/min/100 g. Cerebral O_2 extraction increased, but not sufficiently to maintain $CMRO_2$. SEP amplitude was decreased from 2.5 ± 0.8 to 1.6 ± 0.4 μv, while SEP latency was unchanged from control. During prolonged intracranial hypertension, $CMRO_2$ and SEP amplitude remained abnormal. Regional CBF, including medulla, midbrain and the primary region supplied by the middle cerebral artery (MCA), was initially decreased to 55% of control, but had increased to 75% of control following 40 min of intracranial hypertension. In group 3, as ICP was raised to decrease the CPP to 0 mmHg, MABP increased so that CPP stabilized at 24 ± 3 mmHg, which was not different from group 2. CBF decreased from 45 ± 4 to 18 ± 3 ml/min/100g and $CMRO_2$ decreased from 3.7 ± 2.2 ml O_2/min/100g. SEP latency significantly increased from control and SEP amplitude decreased from control. In group 3, total and regional CBF remained low during the period intracranial hypertension which was different from the slow rise seen in group 2. SEP amplitude was correlated with CBF (R=.29, P<.01) and $CMRO_2$ (R=.43, P<.001). SEP latency was correlated with CBF (R=.44, P<.001) and $CMRO_2$ (R=.56, P<.01).

Discussion. We have demonstrated that during generalized intracranial hypertension, changes in SEP amplitude and latency correlate both with CBF and $CMRO_2$, but that the correlation with $CMRO_2$ is better. Elevation of ICP to the control MABP elicited a pressor response that provided cerebral perfusion at 40% of control levels. However, this pressor response was not adequate for completely maintaining $CMRO_2$ or brain electrical function.