Title: CEREBROVASCULAR AND SPINAL CORD DYNAMICS OF THE SITTING POSITION

Authors: P. S. Ernst, M.D., M. S. Albin, M.D., Leon Bunegin, B.S., Dawn Levin, and J. Gelineau, B.S.

Affiliation: Department of Anesthesia, University of Texas Health Science Center, San Antonio, Texas 78228-7838

Introduction: The sitting position has been used for many decades for neurosurgical procedures performed on the posterior fossa and high cervical region. Purported advantages of this technique include improved access to and exposure of the surgical field and better access for the anesthesiologist to the airway, chest, and to view the facial area to monitor evoked responses from cranial nerve stimulation. These improvements come with the well documented risks of air embolism and postural hypotension. However, the effect of the seated posture on cerebral blood flow (CBF), spinal cord blood flow (SCBF), and cerebral metabolic rate for oxygen ($CMRO_2$) under general anesthesia has never been documented in the literature. The aim of this study was to determine the effect of the sitting position on CBF, SCBF, and $CMRO_2$ under general anesthesia in animals with and without increased intracranial pressure (ICP).

Methods: Eleven mongrel dogs were sedated with thiopental ($25mg \cdot kg^{-1}$), intubated and ventilated to maintain normoxia and normocarbia. Anesthesia was maintained with sufentanil ($2ug \cdot kg^{-1}$ loading dose, $0.8ug \cdot kg^{-1} \cdot hr^{-1}$ maintenance infusion) and isoflurane (0.5% inspired). The animals were paralyzed with pancuronium ($0.1mg \cdot kg^{-1}$). Arterial and venous pressures as well as ECG were monitored throughout the procedure. A left ventricular catheter, inserted retrograde from the femoral artery, was used for microsphere injections (^{125}I, ^{141}Ce, ^{85}Sr, ^{46}Sc) in order to measure CBF and SCBF. A catheter was also inserted into the sagittal sinus to determine blood oxygen content for calculation of $CMRO_2$ ($CMRO_2$=CBF x arterial-sagittal sinus blood oxygen content difference). An 18g needle was introduced into the cisterna magna and the ICP was continuously monitored. There were two groups in the experimental design: group I with normal ICP (<10mmHg) and group II with increased ICP (30mmHg). In group II, a Fogarty balloon catheter was introduced through a burr hole into the left parietal epidural space. Saline was injected incrementally in the balloon so as to reach a steady state ICP of 30mmHg over a period of one hour. The sitting posture was achieved by raising the head and upper body to a 60 degree angle from the horizontal and by bringing the rear legs to heart level. Measurements of CBF, SCBF, and $CMRO_2$ were made at the following time periods: 1) initial supine, 2) 5 minutes sitting, 3) 60 minutes sitting, 4) 15 minutes after supine position resumed. Data was compared by analysis of variance followed by specific post tests where indicated and $p<.05$ considered significant.

Results: Table 1 shows CBF, SCBF, CPP (cerebral perfusion pressure), ICP, $CMRO_2$, and cerebral vascular resistance (CVR) data for both groups. There were no significant differences between groups as $PaCO_2$[37.4±1.3 (I), 35.4±.6 (II)], pH[7.35±.01 (I), 7.38±.03 (II)], and PaO_2[174±6.8 (I), 190±7.8 (II)] remained within normal physiological limits. Although there was a statistical difference in temperature between groups [37.2±.3 (I), 36.1±.3 (II)], the physiologic importance is minor. Group I did not show any changes in CBF, SCBF, or $CMRO_2$ with changes in posture. Compared to group I, group II showed a significant reduction at initial supine measurements in CBF(hemispheric, cerebellar) and SCBF(cervical, thoracic). In addition, compared to initial supine measurements, within group II the CBF(hemispheric, cerebellar, brainstem) and SCBF(cervical, thoracic) fell significantly after 60 minutes in the sitting position; the CBF(hemispheric, brain stem) and SCBF(cervical, thoracic) remain significantly depressed 15 minutes after the supine position was resumed. The blood flows in group II were depressed despite the maintenance of a CPP well above the lower limits of autoregulations. Notably, the $CMRO_2$ didn't vary significantly with changes in posture or across time in either group.

Discussion: The CBF and SCBF were significantly reduced in group II (raised ICP, mass lesion) compared to group I. In addition, group II registered significant drops in both regional CBF and SCBF after 60 minutes in the seated posture that didn't recover to control levels after being returned to the supine position for 15 minutes. Thus, our data indicates that when a mass lesion with an elevated ICP is present, a real danger of cerebral hypoperfusion exists. Since $CMRO_2$ didn't fall in parallel with CBF, the risk for ischemia becomes more apparent. The fall in SCBF, in group II, especially cervical SCBF, suggests the possibility of spinal cord hypoperfusion. Since the cervical cord has an anatomically and rheologically marginal blood supply, the assumption of the seated posture under general anesthesia may be unwise in those with mass lesions and elevated ICP. In a mammalian model, our data indicates that CBF and SCBF are compromised by the seated posture when a mass lesion is present. If the sitting position places the brain and spinal cord at risk for ischemia in those with mass lesions, perhaps alternative positions should be sought in these patients.

Table 1: Brain and Spinal Cord Hemodynamics. All values ± SEM with significance taken at $p<.05$

Region	Group I: initial supine	Group I: sitting 5 min	Group I: sitting 60 min	Group I: supine 15 min	Group II: initial supine	Group II: sitting 5 min	Group II: sitting 60 min	Group II: supine 15 min
Hemispheric ($ml \cdot 100g^{-1} \cdot min^{-1}$)	56.9±3.3*	43.8±8.1*	33.4±3.2*	56.3±3.0*	24.1±3.1	22.1±3.0	15.8±4.2*,b	15.7±4.8
Cerebellum ($ml \cdot 100g^{-1} \cdot min^{-1}$)	41.9±4.8*	44.8±9.7	35.0±4.2*	40.4±4.7*	27.7±3.3	24.9±6.0	19.1±4.0*	19.3±5.1
Brain Stem ($ml \cdot 100g^{-1} \cdot min^{-1}$)	40.8±4.7	42.9±9.2	33.5±3.2*	39.2±4.6*	27.8±3.0	32.1±4.5	18.9±4.1*,b	19.5±5.2b
Cervical ($ml \cdot 100g^{-1} \cdot min^{-1}$)	37.5±3.8*	37.7±11.0	31.7±3.2*	36.7±3.4*	25.8±3.5	27.9±5.5	18.3±4.4*,b	17.8±5.1b
Thoracic ($ml \cdot 100g^{-1} \cdot min^{-1}$)	37.4±3.7*	38.4±9.0	35.4±2.8*	35.7±3.1*	25.4±3.7	27.8±4.8	17.5±4.2*,b	17.9±5.1b
Lumber ($ml \cdot 100g^{-1} \cdot min^{-1}$)	37.3±3.6	34.7±10.4	32.7±4.0	37.0±3.0*	25.3±4.2	23.0±7.3	20.2±5.1	18.2±5.3
CPP (mmHg)	130±5.2*	116±5.0*a	121±4.7	126±4.3*	104±7.3	87±7.6	99±4.8	95±5.9
ICP (mmHg)	9±1a	-2±2*a	-2±2*a	9±1b*	30±0	16±3a	12±3a	32±4b
$CMRO_2$ ($ml O_2 \cdot 100g^{-1} \cdot min^{-1}$)	2.46±.15*	2.75±.47	2.42±.22	2.97±.36	1.56±.34	1.98±.38	1.37±.30	1.85±.33
CVR (mmHg·$ml^{-1} \cdot 100g^{-1} \cdot min^{-1}$)	3.59±.28	2.98±.47	3.61±.34	3.49±.30	4.59±.67	4.39±.91	15.4±10	23.9±18

* = significant difference between groups
a = significant difference from initial supine value
b = significant difference from initial sitting value