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TITLE: A COMPARISON OF THE EFFECTS OF ISOFLURANE, ENFLURANE, HALOTHANE, AND FENTANYL ON CEREBRAL BLOOD VOLUME AND ICP

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Introduction. Because isoflurane (ISO) causes a relatively small increase in cerebral blood flow, it has been speculated that ISO should cause less increase in cerebral blood volume (CBV) and intracranial pressure (ICP) than does enflurane (ENF) or halothane (HAL). However, comparative studies of the effects of these anesthetics on CBV and ICP have not been reported. The present study examined the effects of anesthesia with either ISO, ENF, HAL, or fentanyl (FEN) on CBV and ICP in dogs. In addition, the responsiveness of CBV and ICP to hypercapnia was examined with each anesthetic.

Method. Thirty dogs (weights 12-20 kg) were anesthetized and their ventilation was controlled. Dogs were divided into five groups of six dogs each for determination of CBV, ICP, and systemic variables. In each group variables were determined during control conditions (N_2O), anesthesia, and anesthesia plus hypercapnia ($PaCO_2$ = 45 torr). All dogs received nitrous oxide (N_2O, 60-70%) in O_2 for control measurements. The group was maintained on N_2O and < 0.1% HAL in O_2 (controls). The remaining 4 groups then received N_2O (60-70%) in O_2 and anesthesia with either ISO (1.4%, end-tidal), ENF (2.2%), HAL (0.8%), or FEN (3.0 $\mu g \cdot kg^{-1} \cdot min^{-1}$ for 20 min followed by 0.2 $\mu g \cdot kg^{-1} \cdot min^{-1}$). Relative CBV was determined by placing a converging collimated scintillation probe over the dog's head and measuring γ-emission from circulating ^{131}RISA. At the site of probe placement skin and muscle were reflected. A focal length was chosen that would "view" brain, but not muscle and skin on the opposite side of the head. With this preparation changes in γ-emission counted by the probe are directly proportioned to CBV (1). ICP (cm H_2O) was determined by measuring intraventricular CSF pressure using a cannula placed stereotaxically through a burr hole. The burr hole was sealed and the cannula afixed to the skull using methacrylate. Except for 5-10 min hypercapnia during anesthesia, end-expired CO_2 was strictly maintained to provide $PaCO_2$ = 35 ± 1 torr. Variables were compared within groups using Student's t-test for paired samples, and between groups using Student's t-test for unpaired samples. A p-value < 0.05 was considered significant.

Results. Compared to controls, ISO, ENF, and HAL decreased heart rate and blood pressure, and FEN decreased heart rate. Otherwise there were no differences in systemic variables between groups. Control ICP values were similar in all groups. The combined mean ICP was 6.1 ± 0.9 cm H_2O (mean ± SEM).

Effect of anesthesia. ISO, ENF, and HAL increased CBV and ICP (Table). ISO caused less increase in ICP than HAL or ENF ($p < 0.05$) and less increase in CBV than HAL ($p < 0.05$). By comparison, with FEN anesthesia, CBV decreased and ICP was unchanged. ICP during anesthesia with ISO was not significantly different than that during anesthesia with FEN.

Effect of anesthesia plus hypercapnia. With hypercapnia increases in CBV were similar with all anesthetics and in N_2O controls. ICP increases also were similar between all inhalational anesthetics and N_2O controls, but were smaller with FEN. CBV and ICP during fentanyl plus hypercapnia were similar to values during control conditions (N_2O, normocapnia).

Discussion. The effects of ISO, ENF, HAL, and FEN on CBV are similar to the reported effects of these anesthetics on cerebral blood flow. Interestingly, the effects of these anesthetics on ICP were not solely related to changes in CBV. With FEN and ENF, ICP was greater than expected based on change in CBV. With ENF, greater than expected increases in ICP may be due to increased CSF volume resulting from increased rates of cerebrospinal fluid (CSF) production (2). With FEN, less than expected decreases in ICP may be due to accumulation and translocation of CSF as CBV decreased. Changes in CSF volume may explain in part the similarity in ICP with FEN and ISO, and with ENF and HAL. In patients at risk for increased ICP, either ISO or FEN are preferable to ENF or HAL. With hypercapnia, FEN alone minimized increases of ICP.

Table. ICP (cm H_2O) and CBV (percent change), (mean ± SEM)

	Anesthesia		Anesthesia plus hypercapnia	
	ICP	CBV(1)	ICP	CBV(2)
N_2O	5.8±1.0	-	11.7±1.0*	11.0±1.0*
FEN	6.5±1.4	-8.5±2.3*	8.1±1.8	6.8±2.0
ISO	8.0±0.6*	7.8±1.2*	14.7±2.1*	13.3±2.0*
ENF	9.7±1.3*	8.8±0.9*	17.4±2.9*	10.0±0.9*
HAL	9.7±1.4*	11.7±1.3*	17.3±1.9*	10.2±1.4*

(1) percent change from control
(2) percent change from anesthesia
* significantly different from respective N_2O controls, $p < 0.05$

References.

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