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Title: ENFLURANE, HALOTHANE IN PUPPIES: CARDIOVASCULAR RESPONSES

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**Introduction.** Halothane (H) is considered to be the agent of choice for the majority of pediatric patients. Several clinical reports nonetheless indicate that patients in the pediatric age group anesthetized with enflurane (E) exhibit remarkable cardiovascular stability during operative procedures. Previous laboratory studies in adult dogs and monkeys indicate that E depresses hemodynamic parameters significantly more than H. We therefore compared equipotent concentrations of the two agents in small puppies to assess several cardiovascular variables.

**Methods.** Twelve healthy mongrel puppies from several litters, unpremedicated and fasting for longer than 8 hours with a mean weight of  $2.23\text{kg} \pm .38$  SD and a mean age of  $7.2$  weeks  $\pm 1.8$  were studied. Inhalation induction of anesthesia was with 50% N<sub>2</sub>O in O<sub>2</sub> and increasing concentrations of E or H through calibrated vaporizers, using a T-piece and a specially designed mask. After tracheal intubation, N<sub>2</sub>O was discontinued and anesthesia was maintained using the induction agent in O<sub>2</sub>. Mechanical ventilation to maintain PaCO<sub>2</sub> between 34 and 40 torr was controlled with a Loosco infant ventilator and facilitated by pancuronium bromide (80mc g/kg i.v.), repeated when deemed necessary. The right femoral artery was cannulated for measurements of pressure (AP) and arterial blood gases (ABG). A 5 F triple-lumen Swan-Ganz catheter was inserted through the femoral vein and directed into the pulmonary artery (PA) by observing distal pressure tracings, for measurement of core temperature, PA pressures, cardiac output (CO) by the thermodilution technique (Edwards Laboratories) and for infusion of maintenance fluids throughout the procedure. Urine output was continuously monitored from a catheter inserted in the bladder. Core body temperature was maintained with a heated blanket. EKG was continuously recorded for detection of arrhythmias on a 6 channel Grass recorder, in conjunction with systemic and pulmonary pressures. Three equipotent (1) inspired concentrations of E or H were administered at random. All puppies were exposed to .6 and 1.2 MAC, but only 8 puppies received 1.8 MAC. Before all measurements, 30 minutes were allowed for equilibration after a new-concentration was chosen, and 60 minutes after changing agent. ABG and core temperature were measured and corrected if necessary. CO was measured in triplicate with an injection volume of 5 ml of iced saline. A tracing of all measured variables was obtained at high paper speed for several cardiac cycles. Each puppy was studied continuously for 8 to 10 hours and sacrificed at the end of the experiment and the position of the PA catheter was verified.

**Results.** Induction of anesthesia was rapid and smooth with E or H and intubation was easily achieved unaided by relaxants. The puppies were consistently well hydrated, as assessed by adequate urine output and PA pressures. Body temperature was maintained at 39°C for

up to 10 hours without the need for humidification of inspired gas. No metabolic acidosis occurred, and PaO<sub>2</sub> was always in excess of full arterial saturation. EKG demonstrated no arrhythmias. Mean values for the 12 puppies are summarized in the Table for heart rate (HR, beats-min), mean femoral arterial pressure (AP, torr), CO (l/min), systemic vascular resistance (SVR, torr · l<sup>-1</sup> · min), left ventricular stroke work (LVSW, l · torr) and mean PA pressure (PAP, torr). Mean values  $\pm 1$  SD are indicated.

Agent (%)	HR	AP	CO
E (1.3)	178 $\pm$ 40	80 $\pm$ 22.8	.53 $\pm$ 0.2
E (2.6)	159 $\pm$ 26	67 $\pm$ 21.7	.46 $\pm$ 0.1
E (5.2)	139 $\pm$ 18	53 $\pm$ 13.8	.39 $\pm$ 0.2
H (0.5)	158 $\pm$ 21	93 $\pm$ 20.5	.52 $\pm$ 0.2
H (1.0)	154 $\pm$ 28	76 $\pm$ 19.0	.46 $\pm$ 0.1
H (2.0)	150 $\pm$ 27	56 $\pm$ 13.0	.44 $\pm$ 0.2

Agent (%)	SVR	LVSW	PAP
E (1.3)	168.1 $\pm$ 79.8	.23 $\pm$ .10	7.2 $\pm$ 3.8
E (2.6)	152.8 $\pm$ 56.7	.19 $\pm$ .08	7.1 $\pm$ 3.8
E (5.2)	152.5 $\pm$ 79.2	.13 $\pm$ .05	7.8 $\pm$ 4.1
H (.5)	193.6 $\pm$ 69.6	.30 $\pm$ .13	6.5 $\pm$ 2.8
H (1.0)	176.8 $\pm$ 66.2	.22 $\pm$ .10	6.0 $\pm$ 3.6
H (2.0)	144.5 $\pm$ 56.5	.15 $\pm$ .08	7.9 $\pm$ 3.2

PA wedge pressure could rarely be obtained in stable conditions because inflation of the balloon frequently resulted in a precipitous decrease in systemic pressure. At autopsy, the PA catheter distal port was positioned consistently in the main artery or in one of the major branches.

**Discussion.** Several variables in our study indicate significant cardiovascular depression in proportion to the increasing concentration of the agent in use. However, a comparison between the three equipotent concentrations of E and H (e.g. 1.3% E vs .5% H, etc) does not reach statistical significance by analysis of variance for any of the cardiovascular variables obtained. Equipotent anesthetic concentrations of enflurane and halothane in puppies resulted in comparable changes in cardiac function. This is at variance with studies in adult dogs (2), in which E was more cardio-depressant than H.

**References.**

1. Eger, E.J. II et al: Anesthetic potencies of sulfur hexafluoride, carbon tetrafluoride, chloroform and Ethrane in dogs. *Anesthesiology*, 30: 129-135, 1969.
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