

TITLE: THE EFFECT OF LONG TERM CMV AND PEEP ON RENAL FUNCTION IN DOGS

AUTHORS: ARNOLD J. BERRY, M.D.; RALPH T. GEER, M.D.; CAROL MARSHALL, Ph.D; and BRYAN E. MARSHALL, M.D., F.R.C.P.

ADDRESS: Department of Anesthesia, University of Pennsylvania School of Medicine, Philadelphia, Pennsylvania 19104.

Introduction. Mechanical ventilation (CMV) and mechanical ventilation with positive end-expiratory pressure (PEEP) produce changes in renal function in patients and experimental animals when evaluated for short periods of time.^{1,2} This study evaluated changes in renal function in dogs during 46 hours of CMV and PEEP.

Methods. Fifteen female beagle dogs (mean weight 10.8 kg) were anesthetized with pentobarbital. After tracheal intubation and insertion of a Foley catheter, cannulae for pressure monitoring and fluid infusion were placed in the carotid artery, internal jugular vein and inferior vena cava. Catheter patency was maintained by infusion of heparinized saline at .3 ml/min. Each dog was randomly assigned to 1 of 3 groups (N=5). Dogs in each group were ventilated with 1 of 3 ventilatory modes: spontaneous ventilation (SV), CMV, or CMV+PEEP (PEEP)10cm H₂O. The 46 hour study was divided into 5 measurement periods: I (control, all dogs breathing spontaneously; II (3rd hour after the control period); III (19th - 21st hour); IV (26th - 28th hour); and V (43rd-46th hour). After the control period each dog was begun on the appropriate ventilatory mode.

Dogs on CMV and PEEP were ventilated with humidified air supplemented with oxygen to keep PaO₂ >60 torr using an appropriate minute volume and a tidal volume fixed at 12.5 cc/kg body weight to maintain normocarbida. An intravenous infusion of .45% NaCl with KCl (20 mEq/L) was maintained at a rate of 2.0 ml/min throughout the study. During each measurement period inulin-³H and para-amino hippurate (PAH) were infused. At 20 minute intervals weight change, urine volume, urine sodium and potassium concentrations, urine inulin activity, urine PAH and urine osmolality were measured. Arterial blood samples for PaO₂, PaCO₂, pH, inulin-³H, PAH, hematocrit, sodium (P_{Na}) and potassium concentrations, and plasma osmolality were taken hourly. From these measurements glomerular filtration rate (GFR), renal blood flow (RBF), osmolar and free water (CH₂O) clearances were calculated using the standard equations. All blood withdrawn for measurement was replaced with blood from a donor dog. T-tests for paired and unpaired data and analysis of variance were used for statistical analysis.

Results. Significant findings in this study are summarized in the Table. All data are expressed as means ± SEM.

By the end of the study, dogs on PEEP gained 2.34 ±.43 kg (p<.05) compared to .80±.18 kg in dogs on SV, and .93±.34 kg in those on CMV. By Period II, SV and CMV dogs had urine outputs almost equal to the rate of fluid administration (2.3 ml/min). Dogs on PEEP had both a negative CH₂O and decreased urine sodium excretion during Period II, resulting in weight gain and decreased P_{Na}. Though urine output of dogs on PEEP remained lower than that of SV dogs in Periods III, IV, V, the urine output of dogs on PEEP was significantly greater than in Period II for every

period thereafter.

Urinary sodium excretion of dogs on PEEP increased by period V but was still significantly less than that of SV dogs in Period V. CH₂O also significantly increased from Period II to V in dogs on PEEP. By periods IV and V the hematocrit of PEEP dogs (26.7±2.9%) was less than SV dogs (34.5±1.4%).

During Periods II and III, GFR was significantly less in PEEP dogs (72±5ml/min) as compared to CMV dogs (104±8 ml/min) but by Period IV there was no difference. During all measurement periods there were no significant differences among the SV, CMV or PEEP groups for mean systemic arterial pressure (145 torr), PaCO₂ (35.1 torr), pH (7.33), RBF (355 ml/min) or calculated renal vascular resistance (440 Units).

Discussion. Our findings agree with earlier studies where short term use of PEEP was associated with negative CH₂O, decreasing urine volume, GFR, and urine sodium excretion.² However, in the present study CH₂O, which was initially negative in dogs on PEEP, became positive and did not significantly differ from that of SV or CMV dogs by the end of the study. Also, urinary Na excretion and urine volume in dogs on PEEP rose significantly by the end of the study.

In conclusion, acute and chronic effects of PEEP on renal function in dogs are different. After acute depression of urine volume, urinary sodium excretion, and CH₂O, there are gradual significant increases in these indices as sodium and water are retained.

REFERENCES

- Sladen MB, Laver MB, Pontoppidan H: Pulmonary complications and water retention in prolonged mechanical ventilation. *New Engl J Med* 279: 448, 1968.
- Hall SV, Johnson EE, Hendley-Whyte J: Renal hemodynamics and function with continuous positive-pressure ventilation in dogs. *Anesthesiology* 41: 452, 1974.

PERIOD	CH ₂ O (ml/min)			Urinary Na (mEq/min)			Urine Volume (ml/min)		
	SV	CMV	PEEP	SV	CMV	PEEP	SV	CMV	PEEP
I	-.56 ±.18	-.18 ±.13	-.54 ±.15	96.6 ±23.3	46.3 ±16.7	46.8 ±15.3	1.0 ±.3	1.3 ±.4	.5 ±.1
II	.89 ±.43	.09 ±.14	-.55* ±.22	88.6 ±26.7	50.0 ±22.0	31.6 ±23.4	2.4 ±.5 ^A	1.6 ±.4	.4* ±.2
III	.35 ±.21 ^A	.10 ±.22	-.10 ±.21	172.5 ±20 ^B	137.9 ±25 ^A	40.4* ±11.6*	2.3 ±.1 ^A	1.8 ±.3	1.2 ^{AB} ±.2
IV	.13 ±.11 ^A	.40 ±.17 ^A	-.10 ±.27	187.0 ±32.3 ^A	172.7 ^{AB} ±23.4 ^{AB}	89.8 ±42.0	2.2 ^A ±.3 ^A	2.4 ^{AB} ±.3 ^{AB}	1.3 ^{AB} ±.2
V	.45 ±.14 ^A	.28 ±.07	.18 ±.07 ^{AB}	175.9 ±16.1 ^{AB}	177.3 ±30.1 ^{AB}	104.8* ±18.9*	2.6 ±.2 ^A	2.3 ±.2	1.7 ^{ABC} ±.2

* SV vs. PEEP, p < .05

† CMV vs. PEEP, p < .05

+ SV vs. CMV, p < .05

^A vs. I, p < .05

^B vs. II, p < .05

^C vs. III, p < .05