TITLE: CHANGES IN MYOCARDIAL BLOOD FLOW AFTER CMV AND PEEP IN DOGS

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Mechanical ventilation (CMV) and positive end expiratory pressure (PEEP) are known to alter indices of cardiovascular function. If so, then changes in right and left ventricular myocardial blood flow may be expected. This present study quantitates differences in right and left ventricular blood flow in groups of sedated beagle dogs maintained with spontaneous ventilation (SV), controlled mechanical ventilation (CMV), or controlled mechanical ventilation with PEEP (10 cm H_2O) (PEEP) during a 50 hour study period.

Methods. Eighteen female beagle dogs (11 ± 3 kg) were studied. A catheter was surgically implanted into the left atrium of each dog 3-7 days before each study. At the start of each study a dog was sedated, maintained on pentobarbital, and intubated. Plastic cannulae for fluid infusion and pressure monitoring were placed in the carotid artery and internal jugular vein. An IV infusion of .45% NaCl with KCl 20 mEq/L was begun at a rate of 2 ml/min. A 7 Fr thermistor tipped, triple lumen, Swan-Ganz catheter was threaded through a branch of the femoral vein. Intrapleural pressure was monitored using a calibrated balloon-tipped esophageal catheter. Each dog was then placed on 1 of 3 randomly chosen ventilatory modes: SV, CMV, or PEEP. In dogs on CMV or PEEP, ventilation was maintained with a fixed tidal volume (12.5 cc/kg), a fixed inspiratory time, and adjustment of exhalation time to keep $PaCO_2$ at 35 ± 5 torr. Oxygen was added to heated humidified inspired air when necessary to maintain PaO_2 between 70-120 torr. At 3, 24, and 50 hours, radiolabeled (10-15 μ) microspheres were flushed through the left atrial catheter. At 51 hours after the beginning, the dogs were killed by cross-clamping the great vessels through a median sternotomy. The heart was separated into right and left ventricular portions which were analyzed for blood flow by a previously described method (Domenech RJ, et al: Circ Res 25: 581, 1969). Changes in right and left ventricular blood flow were compared among the three groups of dogs. T-tests for paired and unpaired data were used for statistical analysis.

Results. No significant differences in arterial blood gases were observed between groups throughout the study. Within each group right and left ventricular blood flow measurements did not significantly change with time. For this reason, all blood flow measurements were averaged to obtain the values shown in Table 1. Statistical differences between flows were determined with 3 separate unpaired T-tests (SV vs. CMV, SV vs. PEEP, and CMV vs. PEEP).

Right and left ventricular blood flows were increased in the CMV group when compared to the SV group. Both right and left ventricular flows in PEEP group were significantly greater than the SV or CMV groups.

The increased myocardial blood flow with CMV and PEEP cannot be explained by changes in heart rate, blood pressure, or cardiac output, as these indices were not significantly different among groups.

Changes in right and left ventricular blood flow were not associated with significant changes in pulmonary and systemic vascular resistance or changes in right and left ventricular work. However, significant fluid retention and hemodilution occurred in each group by the end of the study (Table 2). Fluid retention in the PEEP group was significantly greater than in either the SV or CMV groups.

An inverse relation between total myocardial blood flow (TMBF) and hematocrit was shown by a regression equation [TMBF = -.053(Hct) + 3.06; r = .70] derived from data from all groups.

Discussion & Conclusions. This study demonstrates that use of both CMV and PEEP are associated with significant increases in right and left ventricular blood flow. Though numerous hemodynamic factors may be involved, the only clearly separable related events were fluid retention and hemodilution. CMV and PEEP cause fluid retention, and some of this fluid appears to remain in the intravascular compartment. Presumably, myocardial blood flow increases because of dilution of blood oxygen carrying capacity and perhaps changes in blood viscosity.

TABLE 1

Ventricular Blood Flows (ml/g)

	Right ± SD	Left ± SD	Total ± SD
SV	.729 ±.181	1.333 ±.283	.9956 ±.298
CMV	.941* ±.318	1.654* ±.462	1.262* ±.369
CMV + PEEP	1.214*+ ±.450	1.970* ±.696	1.608* ±.608

* Different from SV ($p < .05$).
\+ Different from CMV ($p < .05$).

TABLE 2

Ventilatory Mode	3 Hours Weight Gain (kg ± SE)	3 Hours Hct % (± SE)	24 Hours Weight Gain (kg ± SE)	24 Hours Hct % (± SE)	50 Hours Weight Gain (kg ± SE)	50 Hours Hct % (± SE)
SV	.112 ±.040	37.8 ±1.5	.407 ±.104	37.3 ±1.2	.840 ±.148	35.5 ±1.5
CMV	.091 ±.0371	35.3 ±1.0	.814* ±.114	33.4* ±2.4	.954* ±.286	33.3 ±1.8
CMV+PEEP	.177 ±.044	35.2 ±2.6	1.456* ±.185	31.6* ±3.1	2.143* ±.332	28.6* ±3.0

* Different from SV ($p < .05$)