Title: NORMOCAPNIA AFTER FIVE HOURS OF CONTINUOUS FLOW APNEIC VENTILATION IN DOGS

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Introduction. In 1909, Meltzer and Auer[1] described a successful method of ventilation with a continuous flow of endotracheal air without respiratory movement. Later studies using endotracheal oxygen insufflation demonstrated adequate oxygenation, however, progressive hypercarbia was always observed.[2] Constant flow endobronchial ventilation with air was described in four apneic dogs in 1982.[3] CO_2 elimination correlated with gas flow, but the significance of the normal blood gases was questionable because of the small sample size of animals used. This present study was designed to evaluate gas exchange and the cardiovascular effects of continuous flow apneic ventilation (CFAV) with air for 5 hours using endobronchial catheters.

Methods. Seven large (average body weight 21 kg) dogs were anesthetized with sodium pentobarbital, intubated and ventilated (IPPV) with room air. Femoral artery and vein were cannulated and Swan-Ganz catheters inserted. The endotracheal tube was removed and each main stem bronchus was cannulated with 2.5 mm ID, 4 mm OD catheters using a fiberoptic bronchoscope. The endotracheal tube (Hi-Lo Jet®) was replaced to hold the catheters in place. Prior to onset of CFAV, the dogs were paralyzed with pancuronium bromide (0.15 mg/kg), the neuromuscular blockade being monitored with a peripheral nerve stimulator. Heated and humidified air was delivered from two separate flow meters. Total flow of air was calculated as 1.0 L/kg/min. CFAV was continued for 5 hours in all animals. Blood gas samples and measurements of blood pressure (BP), heart rate (HR), pulmonary artery pressure (PAP), wedge pressure (PCWP), cardiac output (CO) and temperature were taken during IPPV and every 30 min thereafter. Airway pressure (P_{aw}) was monitored by BP transducer connected by water-filled tubing to the pressure port of the Hi-Lo Jet® tracheal tube. Ventilatory air flow was measured connecting the tracheal tube to an ultrasonic spirometer. Blood gas values and hemodynamic variables recorded every 30 min were compared to those obtained during IPPV and after the first 30 min of CFAV. Statistical significance was established by a two-way analysis of variance followed by the Dunnett t-test.

Results. The table presents blood gas values and hemodynamic variables obtained during IPPV, after 30 min of CFAV, and after 5 hours of CFAV. Although, there was a significant difference between PaO_2 values during CFAV and IPPV, all animals were adequately oxygenated. There were also significant differences in values of $P(A-a)O_2$ between the CFAV and IPPV modes. During 5 hours of CFAV, adequate elimination of CO_2 was achieved in all animals. No significant change was observed in vascular pressure values. Differences in HR, CO and vascular resistance at 30 min and 5 hours were related to the hypothermia developing during the course of experimentation. P_{aw} never exceeded 3 mmHg.

Discussion. Our findings indicate that adequate gas exchange can be achieved during CFAV for at least 5 hours. Additionally, there were no adverse cardiovascular effects during this period of time. PaO_2 values remained good in spite of a low airway pressure and absence of supplementary O_2. Possible clinical applications of CFAV would be during cardiac or lung surgery, as well as during endoscopies. CO_2 elimination has to be demonstrated experimentally in the open-chest situation. Successful use of CFAV over a longer period of time may prove valuable in managing patients with acute lung injury.

References.

1. Meltzer SJ, Auer J: Continuous respiration without respiratory movements. J Exp Med 11:622-625, 1909

2. Holmdahl M Hson: Pulmonary uptake of oxygen, acid-base metabolism, and circulation during prolonged apnoea. Acta Chir Scand (Suppl 212):1-128, 1956

3. Lehnert BE, Oberdorster G, Slutsky AS: Constant-flow ventilation of apneic dogs. J Appl Physiol 53:483-489, 1982

TABLE.

	Control IPPV	CFAV 30 min	CFAV 5 hours
pH	7.35 ± 0.02	7.4 ± 0.04	7.35 ± 0.1
PaO_2 (mmHg)	95.8 ± 5.2	69.4 ± 2.8*	69.6 ± 5.9*
PvO_2 (mmHg)	51.3 ± 3.7	47.5 ± 2.5	40.6 ± 2.9*
$PaCO_2$ (mmHg)	40.4 ± 1.7	33.0 ± 3.0*	35.0 ± 2.8
$P(A-a)O_2$ (mmHg)	7.9 ± 1.8	34.4 ± 6.0*	35.2 ± 3.8*
Qs/Qt (%)	11.6 ± 0.5	11.5 ± 0.2	12.9 ± 0.8
Temp (C°)	36.8 ± 0.2	35.9 ± 0.2*	34.7 ± 0.5* **
CO (L/min/m^2)	2.9 ± 0.1	3.0 ± 0.4	2.4 ± 0.8**
CI (L/min)	4.1 ± 0.3	4.2 ± 0.4	3.2 ± 0.4* **
HR (beats/min)	183 ± 11	183 ± 10.7	145 ± 12.1* **
MAP (mmHg)	165 ± 7.1	164 ± 6.5	174 ± 5.1
CVP (mmHg)	2.0 ± 0.5	2.7 ± 0.6	2.3 ± 0.3
$\overline{PAP}$ (mmHg)	21.5 ± 2.1	24.3 ± 2.7	26.9 ± 3.3
$\overline{PCWP}$ (mmHg)	6.3 ± 1.4	8.4 ± 1.6	9.3 ± 2.5
SVR (dynes·sec/cm^{-5})	4474 ± 223	4607 ± 536	6617 ± 1039* **
PVR (dynes·sec/cm^{-5})	374.9 ± 63	429 ± 56	662 ± 115* **

* Significant $p < 0.05$ as compared to IPPV
**Significant $p < 0.05$ as compared to CFAV at 30 min