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TITLE: COMPARISON OF XENON WASHOUT FROM OCCLUDED LUNG SEGMENTS BY THREE DIFFERENT FORMS AND RATES OF VENTILATION

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Introduction. High frequency ventilation (HFV) is advocated as a means of improving as exchange when regional differences in lung compliance make ventilation with conventional techniques inadequate because of fast and slow components. Intermittent positive pressure ventilation (IPPV) was compared to high frequency oscillation (HFO) and high frequency ventilation with a flow interrupter (HFFI) to determine the ability of these different forms of ventilation to clear Xenon (Xe) from obstructed airways; to assess whether alveolar ventilation can take place through collateral channels when major airways are obstructed using HFV and to determine if Xe clearance is frequency dependant.

Methods. Eight preconditioned dogs were anesthetized and intubated with cuffed tracheal tubes. Femoral and pulmonary arteries (PA) were cannulated and the waveforms displayed. A segment of the dogs left lower lobe (LLL) was cannulated with a balloon tipped 7Fr PA catheter under direct fiberoptic visualization. Airway pressure (Paw) was transduced from the tip of the catheter. Mean Paw was maintained the same during IPPV and HFO by using a vacuum pump attached to the gas outflow port during HFO. Paw was regulated during HFFI by applying outflow resistance. The balloon was inflated with 1.5 ml of water to occlude the LLL segment and produce a slow compartment. Five ml Xe in air was then injected through the PA lumen into the LLL. Washout of Xe during IPPV (tidal volume 15 ml/kg, rate 12, FIO_2 1.0) and HFO (Emerson prototype oscillator rates 500, 1000, 1500/min, diaphragm displacement 125 ml and fresh gas flow 7 L/min O_2) was compared with HFFI (Emerson Model 2V airway vibrator at rates 500, 1000, 1500/min, fresh gas flows 30, 45, and 50 L/min O_2 respectively). Xe washout was recorded for 10 minutes by gamma camera (Nucleonics) and stored on computer (PDP 11/34). Intravascular pressures, arterial and mixed venous blood gases and cardiac output (thermodilution) were measured during washout. The slope of the Xe washout curve during the first 2 minutes after Xe was injected showed the greatest difference and was compared using a semilog linear regression and cardiorespiratory function was statistically analyzed using the unpaired t-test.

Results. Cardiorespiratory function including cardiac index (CI), mean arterial, pulmonary capillary wedge, and central venous pressures, heart rate and intrapulmonary shunt (Qs/Qt) were not significantly different with any of the rates or modes of ventilation used. Washout of Xe was significantly slower (*$p < 0.05$) at all rates of HFFI than HFO at 1500 and 1000/min and IPPV (Table). HFO 500/min, however, gave slower ($^+p < 0.05$) Xe washout than HFO 1000 or 1500/min or IPPV. HFFI 500 and 1000/min had significantly longer time constants (TC) than HFO 1000 or 1500/min or IPPV 1 and 2.

Mode	n	Slope for 1st 2 min	Time Constant (min)	Qs/Qt (%)	$PaCO_2$ (mmHg)	PVR $d.cm.sec^{-5}$	PAW (cmH_2O)	CI $L/min/m^2$
IPPV-1	8	1.7 ± 0.46	0.6 ± 0.19	36 ± 16.3	38 ± 6.4	281 ± 93.4	4 ± 0.8	3.7 ± 1.29
HFO 500	8	1.0 ± 0.51⁺	1.5 ± 1.22	33 ± 10.6	38 ± 8.4	314 ± 161.1	3 ± 0.9	4.6 ± 2.17
HFO 1000	8	1.6 ± 0.48	0.7 ± 0.20	41 ± 18.1	29 ± 5.8*	236 ± 101.7	3 ± 1.2	4.9 ± 1.54
HFO 1500	8	1.6 ± 0.43	0.7 ± 0.19	38 ± 14.0	25 ± 6.4*	264 ± 115.4	4 ± 2.3	4.8 ± 2.13
IPPV-2	8	1.6 ± 0.48	0.7 ± 0.25	32 ± 13.6	37 ± 4.6	306 ± 160.3	4 ± 1.1	4.2 ± 2.40
HFFL 500	6	0.8 ± 0.55*	2.1 ± 1.75*	27 ± 11.7	52 ± 14°	367 ± 190.3	7 ± 3.7†	4.1 ± 2.14
HFFL 1000	6	0.7 ± 0.67*	2.8 ± 2.12*	26 ± 11.8	45 ± 12.7	395 ± 259.9	11 ± 5.4*	3.8 ± 2.27
HFFL 1500	6	0.7 ± 0.57*	2.7 ± 2.66†	28 ± 10.7	45 ± 15.3	431 ± 275.4	12 ± 5.8*	4.2 ± 2.93
IPPV-3	6	1.4 ± 0.73	1.1 ± 0.83	26 ± 8.3	37 ± 8.4	356 ± 126.0	4 ± 1.0	3.6 ± 1.96

Arterial CO_2 ($paCO_2$) during HFO 1000 and 1500/min was significantly less (*$p < 0.05$) than IPPV 1 and 2 and all rates of HFFI. During HFFI 500/min $paCO_2$ was elevated (°$p < 0.05$). Pulmonary vascular resistance (PVR) and CI were not different. Paw was significantly elevated (*$p < 0.05$) with the higher flows used during HFFI 1000 and 1500/min. The relationship between slope, TC, CI, paO_2 and Paw was tested and showed poor correlation, the highest coefficient was R = 0.69 for TC and Paw.

Conclusion. The three IPPV modes did not show differences in any assessment of cardiorespiratory function or Xe washout. HFO at 1000 and 1500/min was similar to IPPV, but the dogs were hyperventilated. HFO at 500/min was quite unlike the other HFO modes because Xe clearance was slower and this suggests that clearance was frequency dependant with HFO. During HFFI fresh gas flows were limited by elevation of Paw and resulted in higher $paCO_2$. The hypoventilation may be a factor in the reduced clearance of Xe seen with HFFI. Despite obstruction of major airways, HFO at rates of 1000 and 1500/min and IPPV can clear Xe from a slow compartment lung segment.