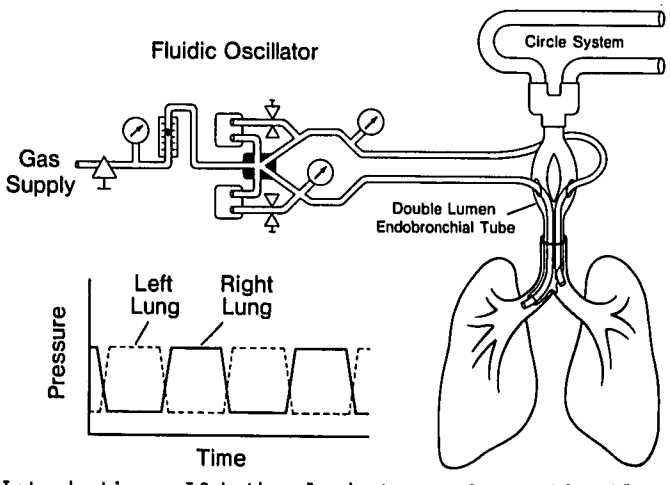
Date :

Title : HIGH FREQUENCY ALTERNATING LUNG VENTILATION (HFALV): A NEW MODE

Authors : S.R. Hameroff, M.D., J.M. Calkins, M.D., Ph.D., C.K. Waterson, B.S.E., J.S. Kanel, B.A.

Affiliation: Department of Anesthesiology, University of Arizona Health Sciences Center, Tucson, Arizona 85724

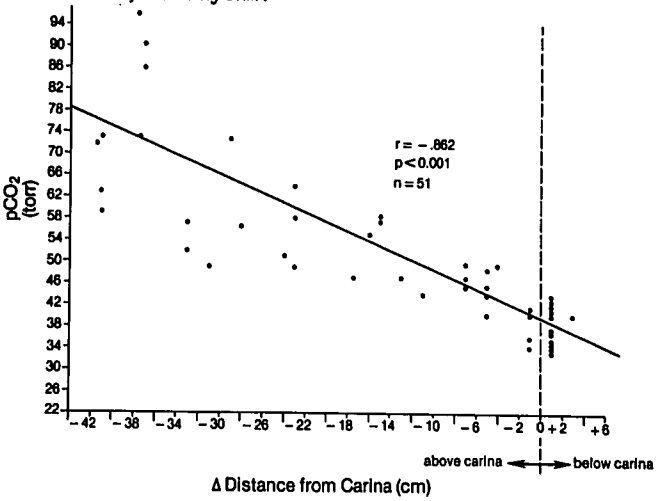



Introduction. If both pulsed streams from a bistable fluidic oscillator are connected to 2 bronchial catheters placed via a double lumen endobronchial tube, the lungs may be ventilated alternately (180° out of phase) at frequencies from 60 to 300 $min^{-1}$ (Fig. 1, above). Inspiratory phase of one lung thus coincides with the expiratory phase of the other. To investigate high frequency alternating lung ventilation (HFALV), we performed the following studies.

Methods. 6 mongrel dogs (10-15 kg) were anesthetized with pentobarbital, paralyzed with pancuronium and their tracheas intubated with right sided double lumen endobronchial tubes. Proper endobronchial placement was verified. EKG was monitored and femoral veins and arteries cannulated for maintenance fluids, continuous blood pressure monitoring, and arterial blood gases (ABG's). Polyethylene catheters (3 mm internal diameter) were passed into both endobronchial lumens and placed so the distal tips were at the orifices (average one centimeter past the carina). The proximal ends were connected to the output of a bistable fluidic oscillator driven by 100% oxygen. Preliminary studies showed that at net flow of 18.5 l/min, pressures within the system ranged from 3-5 cm $H_2O$, and adequate ventilation ($pCO_2$<45 torr, $pO_2$>300 torr) could be obtained independent of frequency (60-300 $min^{-1}$) or CPAP (0-20 cm $H_2O$) delivered via a circle system connected to the endobronchial tube. Effects of catheter tip placement (at 144 $min^{-1}$) were studied by randomly changing position of both catheters and measuring ABG's at 15 minute intervals.

To determine if HFALV significantly differs from HFPPV, each dog was randomly ventilated in the two modes and ABG's measured at 15 minute intervals. HFPPV was made comparable to the HFALV parameters by using one output from the fluidic oscillator through a "Y" connector to both bronchial catheters and adjusting flow rate (18.5 l/min), frequency (144 $min^{-1}$), and wave form (oscilloscopically). Thus each lung received the same minute ventilation and pulse characteristics (I:E = 1:1). With HFPPV the lungs were pulsed simultaneously while with HFALV the 2 lungs were pulsed alternately.

Results. Altering catheters' tip position had little effect on HFALV $pO_2$ however HFALV $pCO_2$ linearly correlated with catheter tip position (Figure 2, below). Compared to HFPPV, HFALV resulted in significantly lower $pCO_2$ ($p<.001$). HFALV $pO_2$ was higher than HFPPV $pO_2$, however when corrected for $pCO_2$ (respiratory quotient = 1) the difference was not significant (Table). We observed no changes in blood pressure, heart rate, or rhythm.




| | | HFALV | HFPPV |
|---|---|---|---|
| $pCO_2$ | torr | 36.8 ± 1.5* | 49.2 ± 2.5 |
| $pO_2$ | torr | 446.1 ± 6.2** | 417.6 ± 10.8 |
| $pO_2$ | torr*** | 443.2 ± 7.1 | 426.8 ± 12.4 |

Significantly different by Student's "t" test for grouped data at *p<.001 **p>.05. ***Corrected: RQ = 1

Discussion. $pCO_2$ correlation with HFALV catheter tip placement may be due to pulse dampening, increased dead space and/or obstruction of expired gas flow by the ventilating pulse streams.

Decreased $pCO_2$ with HFALV compared to HFPPV may be due to enhanced effective compliance when only one lung is ventilated, assuming that lung expansion may be transmitted across the mediastinum. In one dog whose chest we opened with HFALV, the lungs and mediastinum were observed to "rock" back and forth with each pulse. Thus the 2 lungs need not "compete" for volume within the chest. Further, the expanding pulsed lung may deflate the opposite lung, augmenting exhalation and $CO_2$ removal.

HFALV can effectively ventilate dogs and warrants further study for patients with decreased compliance, susceptibility to barotrauma, decreased intravascular volume or increased pulmonary vascular resistance. HFALV may be used with spontaneous ventilation and/or to deliver inhalation anesthetic by entrainment.