Title: High Frequency Small Volume Ventilation (HFV) in Thoracic Surgery

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Introduction. HFV in anesthetized man maintains pulmonary gas exchange equivalent to that obtained with conventional mechanical ventilation (CMV)(1). High frequency jet ventilation has been shown to maintain excellent pulmonary gas exchange and provide excellent surgical conditions during thoracic surgery (2). The purpose of this study was to examine whether HFV was feasible during thoracic surgery and if so, did it provide any advantage over CMV.

Methods. Eight anesthetized patients (24-76 yrs, 50-95 kg) undergoing lateral thoracotomy procedures were studied. Four patients had normal pulmonary function, one restrictive lung disease and three obstructive airway disease. The study was approved by the Institutional Review Board and informed consent was obtained in each case. Following induction of anesthesia (pentothal and succinylcholine) the patients' tracheas were intubated with a cuffed endotracheal tube (8-9 mm ID) and CMV was instituted with a minute ventilation of 80-100 ml/kg and frequency of 10 breaths/minute. The patients were then placed in the right lateral (n=3) or left lateral (n=5) decubitus position. Anesthesia was maintained with isoflurane vaporized in oxygen and supplemented with either morphine sulphate or fentanyl citrate given intravenously. Continued muscle relaxation was maintained with pancuronium bromide. Following 20 minutes of CMV, PaO_2 and $PaCO_2$ were determined (electrodes) and esophageal temperature (thermistor) recorded. This always occurred prior to opening the pleural cavity, however, CMV was maintained for at least 3-5 minutes following opening of the pleural cavity such that surgical conditions could be compared during the two modes of pulmonary ventilation. HFV was then begun at a frequency of 3 Hz with a stroke volume of 1.9 to 2.3 ml/kg and fresh gas flow 10-12 l/min. The low pass filter was 2.8 mm in length, 9 mm ID for the first three patients and 6 mm ID for the last five. Mean airway pressure (MAP) was measured at the proximal end of the endotracheal tube (strain gauge). After 20 minutes of HFV, PaO_2, $PaCO_2$ esophageal temperature, MAP and pressure in the patient's airway following temporary (5 second) occlusion of gas inflow and outflow (P_{occ}) were determined.

Results. Adequate pulmonary gas exchange was maintained with both CMV and HFV (see Table I). MAP measured at the proximal end of the endotracheal tube was always less than P_{occ}. The largest discrepancy was noted in a patient with obstructive airway disease ($FEV_1/Vc\%=55\%$) and amounted to a difference of 9 cm H_2O. Small but significant rises in $PaCO_2$ were seen with time as the exposed lung was handled. This problem was more pronounced with the 9.0 mm ID low pass filter. Surgical conditions were regarded as excellent and superior to CMV during peripheral lung work in 7 of the 8 patients. The lung could easily be manipulated and had little or no tendency to encroach upon the surgical field. In the 8th patient, marked hyperinflation of the lung was noted being worse with HFV than CMV. Surgery around the hilum or mediastinal structures was associated with marked mediastinal "bounce", or marked changes in large airway diameters.

Table I (Mean $\pm$ SD)

	CMV Closed Chest	HFV Open Chest
PaO_2, mmHg	429 $\pm$ 49	365 $\pm$ 100
$PaCO_2$, mmHg	38 $\pm$ 5	42 $\pm$ 6
MAP, cm H_2O		5.5 $\pm$ 1.8
P_{occ}, cm H_2O	-	7.6 $\pm$ 2.4

Discussion. Adequate pulmonary gas exchange can be maintained with HFV at a frequency of 3 Hz during open chest surgery. Improvement in surgical conditions over CMV was noted especially with peripheral lung work. This seems to be related to the relative ease with which the lung can be manipulated. With the use of a large diameter bias tube, handling of the lung resulted in a small rise in $PaCO_2$ presumably due to an increase in respiratory impedance relative to the impedance of the low pass filter. With surgery around the mediastinum HFV appears to offer no advantage. In conclusion, HFV at 3 Hz provides adequate pulmonary gas exchange during open chest procedures. Surgical conditions are usually improved for peripheral lung procedures but not for procedures around the mediastinum.

References

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