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Title: THE EFFECT OF HIGH FREQUENCY VENTILATION ON THE $\dot{V}/\dot{Q}$ PATTERN IN DOGS WITH OLEIC ACID LUNG DAMAGE

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Introduction. High frequency ventilation (HFV) is a technique for mechanical ventilation which has drawn increasing interest during the past few years. It is characterized by low tidal volumes - often below the dead space volume - delivered at frequencies higher than 60 cycles per minute. In spite of the low tidal volumes there are usually no problems to attain adequate gas exchange. It may even be hypothesized that HFV would provide more efficient gas exchange than conventional techniques in conditions of regional irregularities in pulmonary mechanics, i.e. provide better matching of ventilation ($\dot{V}$) and pulmonary perfusion ($\dot{Q}$). The present project was designed to investigate this possible feature of HFV.

Methods. A ventilator was constructed and designed to operate over a wide range of cycling frequencies. The device is pressure-controlled, has an electropneumatically operated valve system and a low internal compliance. Using this ventilator we compared - in seven dogs - the $\dot{V}/\dot{Q}$ distributions during conventional ventilation (CFV, 21 breaths per minute) and HFV (120 breaths per minute) before and after oleic acid lung damage, by means of Wagner's and West's multiple inert gas technique.[1,2] The I/E ratio was 1:2 and $FIO_2$ 0.21. Tidal volumes before the lung damage were set to give similar $PaCO_2$ for the two frequencies. After the damage was induced the same tidal volumes were aimed at by adjusting the ventilator pressure.

Results. Table I shows $\dot{V}_E$ (l/min), $V_T$ (ml), peak inspiratory (AWPI), expiratory (AWPE) and mean (MAWP) airway pressures (cm $H_2O$). Table II shows $PaO_2$, $PaCO_2$ (mmHg), CO (l/min) $\dot{Q}va/\dot{Q}t$ and VD/VT (%). The numbers are mean values $\pm$ standard deviation.

Discussion. There were no differences between CFV and HFV in $PaO_2$ and $PaCO_2$ either before or after the oleic acid. The drop in $PaO_2$ after oleic acid reflected the combined effect of increased venous admixture ($\dot{Q}va/\dot{Q}t$) and decreased cardiac output (CO), the latter in turn due to hypovolemia and metabolic acidosis.

The West-Wagner technique revealed no differences - either before or after the damage - between CFV and HFV in the distribution of pulmonary perfusion over the $\dot{V}/\dot{Q}$ ratios ranging from zero to infinity. The increase in venous admixture after the damage was due to the increase in true shunt ($\dot{V}/\dot{Q} = 0$). Neither were there any differences - either before or after the damage - between CFV and HFV in ventilation of compartments with $\dot{V}/\dot{Q}$ below 1.0. The ventilation during HFV of compartments with $\dot{V}/\dot{Q} > 1.0$ was more than three times higher than during CFV. After the damage, ventilation tended to shift to compartments of higher $\dot{V}/\dot{Q}$ ratios, not reflected by the conventionally derived Bohr dead space ($V_D/V_T$).

In summary, the results indicate that in conditions of pulmonary distress characterized by increased true shunting, HFV - as applied here - does not improve oxygenation. It increases wasted ventilation but can be performed at lower peak airway pressures.

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Table I:

| | $\dot{V}E$ | VT | AWPI | AWPE | MAWP |
|---|---|---|---|---|---|
| CFV before | 4.72±0.51 | 225±25 | 12.7±2.0 | 0 | 3.0±0.4 |
| HFV " | 13.80±3.18 | 115±26 | 7.0±0.6 | 0.5±0.3 | 2.7±0.4 |
| CFV after | 5.13±0.52 | 244±25 | 16.2±3.0 | 0 | 3.5±0.7 |
| HFV " | 14.53±1.80 | 121±17 | 8.5±1.2 | 0.4±0.4 | 3.3±0.5 |

Table II:

| | $PaO_2$ | $PaCO_2$ | CO | Qva/Qt | VD/VT |
|---|---|---|---|---|---|
| CFV before | 92.2±15.3 | 31.0±4.1 | 4.29±0.98 | 16.4±11.2 | 54.2±4.1 |
| HFV " | 94.0±15.4 | 30.3±5.3 | 4.29±1.18 | 15.7±12.4 | 80.3±8.9 |
| CFV after | 67.5±12.1 | 29.5±4.2 | 2.95±0.73 | 29.0±9.8 | 51.4±5.9 |
| HFV " | 66.4±16.1 | 29.7±4.9 | 2.76±0.56 | 30.3±11.2 | 82.0±5.4 |

References.

1. West JB, Wagner PD, Derks CMW: Gas exchange in distributions of $V_A/Q$ ratios: partial pressure-solubility diagram. J. Appl. Physiol. 37:533-40, 1974.
2. Wagner PD: Calculating the distribution of ventilation-perfusion ratios from inert gas elimination data. Federation Proc. 41:136-139, 1982.