SMALL ANIMAL VENTILATION USING A CO-AXIAL CIRCUIT

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SUMMARY

A method is presented for the ventilation of small animals using standard adult anaesthetic equipment.

Artificial ventilation of animals has been practised for many years (Hook, 1667; Waterton, 1825; Snow, 1858) and many mechanical ventilators have been designed for small animals (Starling, 1926; Cottle, 1966; Brackebusch et al., 1974). However, these systems may not be easily available, and a method of ventilating rats using a standard adult ventilator and breathing circuit has been investigated.

METHOD

Ten rats weighing 220–400 g were taken at random from laboratory stock and anaesthetized using oxygen and halothane. A tracheotomy was performed, using a short length of manometer tubing as the tracheostomy tube; this was held in place with silk, ensuring an airtight fit. Ventilation was controlled using an Oxford Penlon Ventilator through a co-axial circuit (Bain and Spoerel, 1972, 1973, 1975). The tidal volume control was set to zero and the frequency of ventilation varied from 25 to 38 b.p.m. After flushing the circuit with oxygen and halothane, the fresh gas flow was reduced to 100 ml/min.

The tidal volume was measured by whole-body plethysmography by recording the pressure change in the bottle with a Statham PM6 transducer which had been calibrated previously in vivo against known volumes (fig. 1).

The animals were ventilated for 30 min after which they were removed from the jar. A sternal split was then performed so that blood could be taken directly from the left ventricle and the intrathoracic temperature measured.

RESULTS

The results are presented in tables I and II. Mean values are shown with the range in brackets. Blood-gases were corrected for temperature.

| TABLE I. Ventilation of rats using an Oxford Penlon Ventilator through a co-axial circuit |
|---------------------------------------------|---------------------------------------------|
| Tidal volume (ml) | 3.3 (2.3–4.5) | 12.1 (10.0–15.9) |
| Frequency (b.p.m.) | 32 (26–38) | 373 (258–604) |
| Minute volume (ml/min) | 104 (69–136) | 367 (250–460) |
| Fresh gas flow (ml/min) | 100 | 367 (250–460) |

| TABLE II. Blood-gas tensions and pH in rats ventilated using an Oxford Penlon Ventilator through a co-axial circuit |
|-----------------------------------------------------------|---------------------------------------------|
| $P_{aO_2}$ (kPa) | 24.1 (6.5–41.9) |
| $P_{aCO_2}$ (kPa) | 5.5 (3.5–7.1) |
| pH (units) | 7.30 (7.16–7.54)* |

* The mean pH was obtained by averaging the hydrogen ion concentrations and converting the results back to pH.


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DISCUSSION

The efficiency of ventilation was assessed by comparing our values for tidal volume, minute volume and blood-gases with values obtained from the literature for rats breathing air spontaneously (table III). Our figures would appear to fall within this physiological range. The minute volume was less than that of the normal rat, because the frequency of ventilation was slower, but the blood-gases were not significantly altered.

TABLE III. Efficiency of ventilation assessed by comparison with other studies

<table>
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<th>Ventilated</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
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<tr>
<td>Tidal volume (ml/kg)</td>
<td>12.1</td>
<td>7.7</td>
<td></td>
<td></td>
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<tr>
<td>Frequency (b.p.m.)</td>
<td>32</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minute volume (ml/min·kg⁻¹)</td>
<td>373</td>
<td>656</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Mean PaO₂ (kPa)</td>
<td>24.1</td>
<td>12.0</td>
<td>12.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean PaCO₂ (kPa)</td>
<td>5.5</td>
<td>5.4</td>
<td>5.4</td>
<td>3.5</td>
<td></td>
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<tr>
<td>pH (units)</td>
<td>7.30</td>
<td>7.43</td>
<td>7.42</td>
<td>7.48</td>
<td></td>
</tr>
</tbody>
</table>

(1) Guyton (1947); (2) Lewis, Pontén and Siesjö (1973); (3) Burlington, Maher and Sidel (1969); (4) Simmons, Kahn and Guze (1966).

Our blood-gas results could be affected by the mode of sampling (left ventricular stab), a procedure which has been criticized (Lewis, Pontén and Siesjö, 1973). The performance of a sternal split might introduce an error, but we had difficulty obtaining enough blood using other methods. The deadspace of the tube used for the tracheostomy, and its connector, was 0.3 ml. This was approximately 10% of the tidal volume. Removal of the animal from the plethysmograph before the blood sample was taken might alter ventilation, but in later experiments a pneumotachograph was used in series with the plethysmograph and this showed there was no change in tidal volume when the animal was removed from the jar.

In this work the fresh gas flow and minute volume were about the same, whereas many authors recommend a minute volume greater than that suggested by the fresh gas flow (Bain and Spoerel, 1975; Henville and Adams, 1976). However, we found that our gas flows gave reasonable results.

It is possible to ventilate small animals of 200–400 g by using this breathing circuitry. Therefore, further studies of this method of ventilating neonates are indicated, using a simple circuit and a standard adult ventilator without modification.

ACKNOWLEDGEMENTS

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REFERENCES

Hook, R. (1667). An account of an experiment made by Mr Hook of preserving animals alive by blowing through their lungs with bellows. Phil. Trans. R. Soc., 2, 539.

VENTILATION DE PETITS ANIMAUX A L'AIDE D'UN CIRCUIT CO-AXIAL

RESUME

On présente dans ce document une méthode de ventilation des petits animaux basée sur l'usage de l'équipement anesthésique standard pour adultes.

KLEINTIER-VENTILATION UNTER ANWENDUNG EINES GLEICHACHSIGEN KREISES

ZUSAMMENFASSUNG

Es wird ein Verfahren für die Ventilation von Kleintieren vorgeschlagen, in dem die normale Narkoseausrüstung für Erwachsene benutzt wird.
SUMARIO
Se presenta un método para la ventilación de animales pequeños empleando equipo normal para la anestesia de adultos.