EFFECT OF ACUTE HYPOCAPNIA ON RENAL FUNCTION IN THE DOG ARTIFICIALLY VENTILATED WITH NITROUS OXIDE, OXYGEN AND HALOTHANE

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SUMMARY
Changes from normocapnia to hypocapnia (and vice versa) were induced in dogs lightly anaesthetized with nitrous oxide and halothane and subjected to passive pulmonary ventilation. During hypocapnia estimated renal plasma flow and urine production were greater than in normocapnia, and renal vascular resistance was decreased greatly compared with normocapnia. There was little change in glomerular filtration rate.

In a previous study (Hunter et al., 1979), we presented those alterations in renal function which took place when changes from normocapnia to hypocapnia (and vice versa) were induced in dogs lightly anaesthetized with nitrous oxide and fentanyl and subjected to passive pulmonary ventilation. It was found that, during hypocapnia, estimated renal plasma flow (ERPF) was twice that during normocapnia and that glomerular filtration rate (GRF) and urine output (V) were increased in approximately similar proportions while renal vascular resistance (RVR) was halved.

As this was a finding of some importance, we repeated the experiments, using an identical experimental plan, but administering a low concentration of halothane as the adjuvant to nitrous oxide instead of a small dose of fentanyl.

METHODS
Twelve experiments were conducted on eight healthy mature labrador dogs weighing 18–31 kg. In half the experiments $P_aCO_2$ was maintained first at near physiological values and hypocapnia was induced later. In the other half, the order was reversed. The period of study at each value of $P_aCO_2$ was 90 min.

The experiments differed from those described previously (Hunter et al., 1979) only in the technique of anaesthesia. In the previous study anaesthesia was induced with thiopentone and fentanyl and maintained with a mixture of nitrous oxide in oxygen and fentanyl 0.4 µg·min⁻¹. Alcuronium was administered to produce neuromuscular blockade. The only difference in this study was that no fentanyl was given, either at induction or for the maintenance of anaesthesia, and that halothane was used as the adjuvant throughout the anaesthetic (at inspired concentration 0.4–0.5%), using a Dräger Vapor vaporizer calibrated using a mass spectrometer.

RESULTS
Acid-base state
Mean $P_aCO_2$ during what is described as normocapnia was 5.4 kPa, range 4.3–6.5 kPa; during hypocapnia the mean was 2.6 kPa, range 1.4–3.6 kPa; the corresponding mean arterial pH was 7.31, range 7.13–7.54 and 7.55, range 7.34–7.78, respectively. Using values for $pK'$ and solubility of carbon dioxide obtained from human blood the mean actual bicarbonate concentration was 20.0 mmol·litre⁻¹ in normocapnia and 16.3 mmol·litre⁻¹ during hypocapnia. The difference between the bicarbonate values was statistically significant ($P<0.01$).

Indices of renal function
There was a decrease in renal vascular resistance during hypocapnia ($P<0.01$, paired t test) (table I). Estimated renal plasma flow increased during hypocapnia ($P<0.05$), as did urine output ($P<0.05$). There was no difference between the glomerular filtration rate in normocapnia and that in hypocapnia.

The arterial pressure was significantly lower in hypocapnia than in normocapnia ($P<0.01$).

DISCUSSION
During hypocapnia, we found a marked decrease in renal vascular resistance and an increase in estimated
Table I. Mean values for estimated renal plasma flow (ERPF), glomerular filtration rate (GFR), renal vascular resistance (RVR) (mm Hg ml⁻¹ min⁻¹ per 100 g kidney weight) urine volume (V) and mean arterial pressure (MAP) for dogs during normocapnia and hypocapnia. Note that hypocapnia preceded normocapnia in half the experiments and vice versa.

<table>
<thead>
<tr>
<th></th>
<th>ERPF (ml min⁻¹ kg⁻¹)</th>
<th>GFR (ml min⁻¹ kg⁻¹)</th>
<th>RVR (ml min⁻¹)</th>
<th>V (ml)</th>
<th>MAP (mm Hg)</th>
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</thead>
<tbody>
<tr>
<td>Normocapnia</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>(Paco₂ 4.3–6.5 kPa)</td>
<td>24.1</td>
<td>10.2</td>
<td>0.31</td>
<td>2.0</td>
<td>118.0</td>
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<tr>
<td>SEM</td>
<td>7.7</td>
<td>2.2</td>
<td>0.07</td>
<td>0.3</td>
<td>4.0</td>
</tr>
<tr>
<td>SD</td>
<td>46.5</td>
<td>13.4</td>
<td>0.25</td>
<td>1.7</td>
<td>19.0</td>
</tr>
<tr>
<td>Hypocapnia</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Paco₂ 1.4–3.6 kPa)</td>
<td>29.3</td>
<td>11.3</td>
<td>0.17</td>
<td>3.2</td>
<td>107.0</td>
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<tr>
<td>SEM</td>
<td>6.4</td>
<td>2.0</td>
<td>0.05</td>
<td>0.3</td>
<td>2.6</td>
</tr>
<tr>
<td>SD</td>
<td>38.6</td>
<td>12.0</td>
<td>0.16</td>
<td>2.0</td>
<td>15.6</td>
</tr>
</tbody>
</table>

Renal plasma flow and urine production; glomerular filtration rate was little changed. Except for this last variable, which had been previously found to increase, these findings are similar to those of our previous study (Hunter et al., 1979). The only difference in the experimental conditions between the studies is that, in the present study, halothane replaced low dose fentanyl as an adjuvant to nitrous oxide. Indeed, using the unpaired t test, there were no statistically significant differences between the comparable variables in the two studies (for example, ERPF in normocapnia in the fentanyl series compared with ERPF in normocapnia in the halothane series).

This study confirms the finding that, in the lightly anaesthetized and paralysed dog, there is a considerable change in renal circulation and urine production during hypocapnia.

Acknowledgements

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Reference


Résumé

On a provoqué chez des chiens légèrement anesthésiés à l’aide de protoxyde d’azote et d’halothane, et soumis à une ventilation pulmonaire passive, des variations allant de la normocapnie à l’hypocapnie (et vice versa). Pendant l’hypocapnie, la production d’urine et le débit de plasma rénal estimés ont été plus élevés que pendant la normocapnie, alors que la résistance vasculaire rénale a fortement diminué par rapport à la normocapnie. Il n’y a eu que très peu de variations dans le taux de filtration gloméralaire.

Wirkung akuter Hypokapnie auf die Nierenfunktion beim Hund, der durch Stickoxyd, Sauerstoff und Halothan künstlich belüftet wird

Zusammenfassung

Wechsel von Normokapnie zu Hypokapnie (und umgekehrt) wurden bei leicht mit Stickoxyd und Halothan narkotisierten Hunden eingeleitet, die einer passiven Lungenbelüftung ausgesetzt waren. Während Hypokapnie waren der geschätzte Nierenplasmafluss und die Urinproduktion größer als bei Normokapnie, und der Gefäßwiderstand der Niere wurde stark verringert, verglichen mit Normokapnie. Die glomeruläre Filtrationsrate war kaum verändert.

Efecto de hipocapnia aguda en la función renal del perro artificialmente ventilado con oxígeno nitroso, oxígeno y halotano

Resumen

Se indujeron cambios desde normocapnia hasta hipocapnia (y vice versa) en perros ligeramente anestesiados con óxido nitroso y halotano y que fueron sometidos a una ventilación pulmonar pasiva. Durante la hipocapnia, el flujo estimado del plasma renal y la producción de orina fueron mayores que en la normocapnia y la resistencia vascular renal disminuyó mucho en comparación con la normocapnia. Hubo apenas algún cambio en el ritmo de filtración glomerular.