EFFECT OF CARBON DIOXIDE ON INTESTINAL MOTILITY

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WHEN an animal is killed by a blow on the head and its abdomen opened immediately, the intestinal tract is frequently seen in a state of violent activity. This is presumably due to the acute asphyxia which develops upon sudden cessation of the circulation. It has been previously shown in mice (1) and in rats (2) that anoxic anoxia alone (i.e., without accumulation of carbon dioxide, as in asphyxia) depresses the motility of the small intestine. The intestine of the dog is much more resistant, but is also depressed if the anoxia is potentiated with cocaine (3). The present study was undertaken to determine whether the accumulation of carbon dioxide alone can be responsible for increased activity of the intestine.

METHODS

Dogs and rats were used; the experiments were performed upon the animals in pairs: one experimental and one control. Each pair was chosen so that they were of approximately the same body weight. Essentially, the technique of Macht was used: the dogs were given 30 cc. of a mixture of 10 per cent charcoal in 10 per cent gum acacia solution by stomach tube, and 3 minutes later placed in a chamber through which was run, for the experimental animal a carbon dioxide-oxygen mixture, and for the control animal, pure oxygen. The 3 minutes in normal air were allowed in order to give a chance for some material to enter the duodenum, since immediate exposure to carbon dioxide frequently paralyzed the stomach.

The animals were removed from the chamber 30 minutes after the charcoal mixture was placed in the stomach and killed with ether, which stops intestinal peristalsis (4). The small intestine was removed in toto, slit open, and the distance the charcoal mixture had traversed was measured.

The same procedure was followed with the rats, with the following exceptions: 2 cc. of charcoal was administered, the animals were not placed in the chamber until 10 minutes after intubation, and they were killed after a total elapsed time of 40 minutes. The extra time outside the chamber was found to be necessary to insure that the stomach would discharge into the intestine in a reasonable proportion of the animals.

Two samples of the gas mixture in the chamber were analyzed for carbon dioxide content in the Hempel burette during the experimental run, and an occasional sample during a control run. In no case did the concentration of carbon dioxide exceed 14
per cent during the control periods. During the experimental periods the following concentrations were attempted: for dogs, one group 7.5 per cent carbon dioxide, a second group 15 per cent; for rats, one group 10 per cent, a second group 15 per cent and a third 20 per cent. The average concentrations as shown by the determinations were close to the figures indicated by the flow meters. The ranges of actual concentrations for each group are shown in table 1. Some analyses for oxygen concentration during both control and experimental periods were performed. Due to the fact that the air was not completely removed from the chamber, the animals never breathed pure oxygen; its concentration ranged up to about 75 per cent.

There were 10 experimental animals in each group, with 10 controls for each, except the group of dogs at 15 per cent carbon dioxide, which comprised 15 animals in the experimental group and 15 controls.

Table 1. Effect of Carbon Dioxide on Motility of the Small Intestine

<table>
<thead>
<tr>
<th>CONC. CO₂, AVERAGE, %</th>
<th>CM. TRAVERSED, CONTROL</th>
<th>CM. TRAVERSED, EXPERIMENTAL</th>
<th>DIFFERENCE, CM.</th>
<th>p</th>
<th>ACTUAL CONC. OF CO₂, RANGE, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dogs</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7½</td>
<td>177</td>
<td>114</td>
<td>63</td>
<td>.011</td>
<td>6.0-8.7</td>
</tr>
<tr>
<td>15</td>
<td>181</td>
<td>90</td>
<td>82</td>
<td>&lt;.001</td>
<td>12.9-17.6</td>
</tr>
<tr>
<td>Rats</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>75</td>
<td>72</td>
<td>3</td>
<td>&gt;.20</td>
<td>7.4-12.8</td>
</tr>
<tr>
<td>15</td>
<td>74</td>
<td>57</td>
<td>17</td>
<td>.018</td>
<td>14.6-17.7</td>
</tr>
<tr>
<td>20</td>
<td>86</td>
<td>57</td>
<td>23</td>
<td>&lt;.001</td>
<td>18.8-23.4</td>
</tr>
</tbody>
</table>

1 According to Fisher.

RESULTS

The results are summarized in table 1. There was a reduction in motility of the small intestine of dogs at a carbon dioxide concentration of 7.5 per cent significant at about the 1 per cent level (Fisher's t test), and a more marked reduction at a concentration of 15 per cent, significant at the 0.1 per cent level. The rats showed no change at 10 per cent CO₂, while there was reduced motility at 15 and 20 per cent CO₂, the latter highly significant.

DISCUSSION

These findings are consistent with the well-known fact that a shift of the hydrogen ion concentration of the body tissues toward greater acidity has in general a depressing effect. But the aforementioned stimulation of intestinal activity by rapidly developing asphyxia is not explained. Perhaps the speed with which the condition develops, or the simultaneous presence of acute and severe anoxia in asphyxia, or both, produces the different result. However, Bisgard and Johnson (5) noted inhibition of the intestine of dogs following the inhalation of pure carbon dioxide, which certainly produces a condition somewhat resembling asphyxia. This
procedure is rather drastic. Schnohr (6) has also reported a cessation of motor activity of the intestine following increased CO₂ concentration in the rabbit. His observation was made through a cellophane window in the abdominal wall.

The finding that the small intestine of the rat is more resistant to high concentrations of carbon dioxide than that of the dog was rather unexpected, inasmuch as it has been previously shown that anoxia has a much more pronounced effect on intestinal motility of rats and mice than that of the dog (1, 2).

**SUMMARY**

Dogs and rats were exposed to increased carbon dioxide concentrations ranging from 7.5 to 20 per cent, and intestinal motility determined by measuring the length of intestine traversed by a charcoal-acacia mixture during a given time. Motility was depressed in the dog by a concentration of 7.5 per cent or more, and in the rat by a concentration of 15 per cent or more.

**REFERENCES**