RECORD OF INTESTINAL MOVEMENT IN CONSCIOUS CATS UNDER UNRESTRAINED CONDITIONS AND INFLUENCES OF SOME GENERAL ANESTHETICS

YOSHIRO NAKAZAWA AND HIKARU FURUSE

Department of Pharmacology, Nagasaki University School of Medicine, Nagasaki

Received for publication March 4, 1957

Some times the movement of cats' intestines could not be observed in our research concerning the relation of intestinal blood flow of mesenterial artery to intestinal movement, as recorded by ordinary methods (Straub (1), Trendelenburg (2), and others (3)) under general anesthesia. It was considered that it might be difficult to record the natural movement of intestines under such conditions because many of anesthetics used decreased or abolished motility. When an experiment was made without general anesthesia by inserting a rubber bag in the lumen of the cats' intestines bound to a holder, the regular movement of the intestines could be observed. However, when the animal raged occasionally it was completely abolished for several minutes, or for about a half hour. So it was deduced that recording the natural movement of the intestines in conscious cats can surely be done if the animal does not rage.

Oettel (4) had carried out some experiments on the intestinal movement of conscious dogs with fistula of the small intestine under unrestrained conditions. G.H. Miller (5) has observed the effects of central anesthesia on the intestinal tract of dogs having a permanent fistula made with a Thiry-Vella loop. Now we have decided to make a permanent fistula of the small intestine in cats and then to observe what influence the anesthetic drugs had on its natural movement.

EXPERIMENTAL PROCEDURE

Usually cats became having a good appetite in about 5 days after operation of making a permanent fistula of small intestine after Oettel, and experiments could be made in two weeks. The cats did not sit quietly in one place unless constantly attended, so we trained them by putting them in a wire netting box for several hours. The training was not difficult.

Intestinal movement was observed by inserting a rubber bag in the intestine through the fistula. The bag, 2.0-2.5 cm in length and 1.5 cm in diameter, was connected to the gum-elastic catheter; the bag and catheter was filled with air at about 15 cm water column pressure. The catheter was connected to a water manometer with a piston recorder by which changes of the inside pressure of the intestine was written on a kymograph. The record continued for about 3 hours, during which time there were no changes in the regularity of intestinal movements. Occasionally the bag entered deeply in the intestine without
recording the movement. In such a case it was pulled out and then after attaching a supporter the movement could be written by inserting it again. To check contents flowing from the intestines the fistula was plugged with an air-filled rubber bag, while cats were not used for the experiment.

Intravenous injection was impossible with the cats, so drug application was carried out by subcutaneous and intramuscular injection, vaporizing volatile drugs in a closed box for the study of inhalational anesthetics, and pouring into the intestinal lumen by a thin polyethylene tubing attached to the balloon. The experiments were performed at a temperature 20°-30°C.

**Effect of inhalational anesthetics**

For administering inhalational anesthetics a conscious cat was placed in a closed box (33cm × 50cm × 33cm in size) in which the drug in a dish gave off a vapour naturally. One side of the box was made of plate-glass to observe the cat; this box was not completely air-tight, so that some amount of the vapour might leak out. The approximate amount of vapour in the box was found by measuring the residual amounts of the drug after discontinuance of inhalation.

We observed changes of the behaviour of the cat in the box while inhaling anesthetics and after removing the drug, and after putting the cat outside the box. Whenever the anesthetics were applied there was, then, a sequence of events: a little struggle, lying down on the abdomen, and marked depression.

For convenience sake we have defined stages of anesthesia as follows:

(a) Struggling a little but normally sitting or standing (stage A). (b) Dropping the head and not being able to stand or sit normally (stage B). (c) Lying down on the abdomen and at times, spontaneously holding up the head (stage C). (d) Lying down on the abdomen without voluntary movement but holding up the head by stimulation delivered by nipping skin with a clamp (stage D). (e) Never holding up the head to the stimulation and pupils dilated, that is a surgical stage of anesthesia (stage E). Cornea reflex and other signs of anesthesia were not exactly observed as the behaviour of the animal was seen only from outside the box.

When ether was applied, a cat gradually grew depressed after a short interval of light struggle. It was observed that the intestines of the cat had been moving as before ether inhalation by the time when the animal lay down on the abdomen from normal sitting position. But the motility was markedly decreased or abolished under relaxation of the
FIG. 2. Influences of inhalational anesthetics on intestinal movement.

- The onset of drug administration
- The withdrawal of drugs

Eth: Ether
Chl: Chloroform
TCE: Trichlorethylene
A: Stage A
B: Stage B
C: Stage C
D: Stage D
E: Stage E
R: The frequency of respiration
°C: Temperature in the box
sn: Sneezing

FIG. 3. Influences of ether administered into the lumen of intestine.

Eth (sol): Aqueous solution (89% at 22 °C) of ether
Time in one minute
tonus when the animal did not hold up the head. Occasionally intestinal movement was abolished momentarily soon after ether was applied, which might be presumed to be a reflex; for complete recovery occurred again promptly. Several minutes after the cat was placed outside the box (when ether was stopped) the movement occurred gradually again and then recovered completely. No effect on the motility was observed if 5—10 c.c. of the aqueous solution (8% at 22°C) of ether was administered directly in the intestinal lumen, but 1.0 c.c. of ether itself poured into the lumen enhanced the tone temporarily.

Chloroform and trichlorethylene have the same action on intestinal movement as ether. Amounts of drugs vapourized in the box and necessary for anesthesia (stage E) were as follows: ether was about 20 c.c., chloroform was 3.0—4.0 c.c. (av. 3.4 c.c.) and trichlorethylene 1.5—3.2 c.c. (av. 2.4 c.c.). The relation of the motility to signs of anesthesia was showed in Table 1. A process of time to inhibition of intestinal movement by ether from the beginning of inhalation was 9—30 min (av. 23.0 min), by chloroform 11—30 min (av. 19.2 min) and by trichlorethylene 17—41 min (av. 27.2 min). A complete abolishment of the motility took place several minutes before and after the abdominal position, i.e. the beginning of stage D. The movement began again in various processes of time (1—22 min) after withdrawing ether, or putting the animal outside the box.

Effect of nonvolatile anesthetics

Nonvolatile anesthetics were administered intramuscularly or subcutaneously to a conscious cat, slowly induced by a dosage of 50 mg per kg of methylhexabital sodium. It was very difficult to recognize exactly the relation of the intestinal movement to stages of anesthesia in the case of nonvolatile drugs, but it was observed that inhibition of intestinal movement took place roughly in the time when the cat was in an abdominal position. The inhibition lasted for about one hour or several hours and then the movement gradually recovered.

Neo-Cyclopan* (a new barbiturates preparation) 1.2 c.c. per kg was administered in the same way as methylhexabital sodium. It induced the same process of anesthesia, nevertheless intestinal movement did not stop, although there was a slight diminution in size of contractions.

After injecting urethane 1.3 g per kg a cat became slowly depressive and reached stage C or D in about one hour. About 30 minutes after drug administration intestinal movement was diminished and sometimes abolished, but even 3 hours later it did not stop completely.

Influences of certain drugs upon the action of ether on intestinal movement

It is said that decreased motility caused by ether is due to sympathetic stimulation and smooth muscle depression (J. Adriani (5)). B.B. Bhatia and J.H. Burn (6) have shown, by observations on decerebrate or spinal cats from which the suprarenal glands have been

---

* Neo-Cyclopan sodium was prepared as follows: thiopental sodium 0.15 g and methylhexabital sodium 0.20 g were dissolved in aqueous solution containing sulpyrin 0.50 g and sodium carbonate anhydrate 0.012 g.
## Table 1

<table>
<thead>
<tr>
<th>Ether</th>
<th>Anesthetics</th>
<th>Cat number</th>
<th>Body weight (kg)</th>
<th>Sex</th>
<th>Amount of drug vaporized in the box (c.c.)</th>
<th>The time from inhibition to intesst. mov. (min)</th>
<th>The time from abdominal position to inhibition of intesst. mov. (min)</th>
<th>The time from withdrawal of anesthetics to intesst. mov. (min)</th>
<th>The time from withdrawal of anesthetics to recovery (min)</th>
<th>Temperature in the box (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>3.2</td>
<td>20</td>
<td>9</td>
<td>/</td>
<td>13</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
</tr>
<tr>
<td>3</td>
<td>2.5</td>
<td>20.5</td>
<td>14</td>
<td>/</td>
<td>6</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
</tr>
<tr>
<td>8</td>
<td>2.0</td>
<td>20</td>
<td>23</td>
<td>1</td>
<td>6</td>
<td>14</td>
<td>/</td>
<td>/</td>
<td>28-32(30)</td>
<td>/</td>
</tr>
<tr>
<td>10</td>
<td>3.0</td>
<td>20</td>
<td>31</td>
<td>1</td>
<td>6</td>
<td>19</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
</tr>
<tr>
<td>11</td>
<td>2.7</td>
<td>21</td>
<td>26</td>
<td>-1</td>
<td>8</td>
<td>12</td>
<td>24-26(25)</td>
<td>/</td>
<td>/</td>
<td>24.5-30(27.3)</td>
</tr>
<tr>
<td>3</td>
<td>2.5</td>
<td>24</td>
<td>30</td>
<td>-6</td>
<td>4</td>
<td>11</td>
<td>24.5-30(27.3)</td>
<td>/</td>
<td>/</td>
<td>25-26.5(25.8)</td>
</tr>
<tr>
<td>12</td>
<td>3.5</td>
<td>20</td>
<td>29</td>
<td>3</td>
<td>12</td>
<td>38</td>
<td>25-26.5(25.8)</td>
<td>/</td>
<td>/</td>
<td>/</td>
</tr>
<tr>
<td>5</td>
<td>3.8</td>
<td>20</td>
<td>25</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
</tr>
<tr>
<td></td>
<td>Average</td>
<td></td>
<td>20.7</td>
<td>23.4</td>
<td>7.9</td>
<td>18.8</td>
<td>27.0</td>
<td>/</td>
<td>/</td>
<td>/</td>
</tr>
<tr>
<td></td>
<td>Chloroform</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>1.8</td>
<td>3.0</td>
<td>18</td>
<td>-5</td>
<td>22</td>
<td>23</td>
<td>/</td>
<td>/</td>
<td>28-30(29)</td>
<td>/</td>
</tr>
<tr>
<td>8</td>
<td>2.0</td>
<td>3.5</td>
<td>14</td>
<td>-4</td>
<td>4</td>
<td>5</td>
<td>28-30(29)</td>
<td>/</td>
<td>/</td>
<td>25-27(26)</td>
</tr>
<tr>
<td>10</td>
<td>3.0</td>
<td>3.0</td>
<td>11</td>
<td>0</td>
<td>1</td>
<td>18</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
</tr>
<tr>
<td>11</td>
<td>2.7</td>
<td>4.0</td>
<td>24</td>
<td>-5</td>
<td>4</td>
<td>14</td>
<td>25-27(26)</td>
<td>/</td>
<td>/</td>
<td>27-30(28.5)</td>
</tr>
<tr>
<td>6</td>
<td>3.2</td>
<td>3.0</td>
<td>11</td>
<td>/</td>
<td>5</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
</tr>
<tr>
<td>12</td>
<td>3.5</td>
<td>3.5</td>
<td>30</td>
<td>7</td>
<td>2</td>
<td>18</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
</tr>
<tr>
<td>3</td>
<td>2.5</td>
<td>4.0</td>
<td>17</td>
<td>0</td>
<td>10</td>
<td>10</td>
<td>27-30(28.5)</td>
<td>/</td>
<td>/</td>
<td>/</td>
</tr>
<tr>
<td>5</td>
<td>3.8</td>
<td>/</td>
<td>21</td>
<td>/</td>
<td>4</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
</tr>
<tr>
<td>11</td>
<td>2.7</td>
<td>3.0</td>
<td>27</td>
<td>1</td>
<td>12</td>
<td>39</td>
<td>24-26(25)</td>
<td>/</td>
<td>/</td>
<td>27.1</td>
</tr>
<tr>
<td></td>
<td>Average</td>
<td></td>
<td>3.4</td>
<td>19.2</td>
<td>7.1</td>
<td>10.1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Trichloroethylene</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>2.0</td>
<td>3.0</td>
<td>25</td>
<td>/</td>
<td>3</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
</tr>
<tr>
<td>3</td>
<td>2.5</td>
<td>2.5</td>
<td>41</td>
<td>8</td>
<td>2</td>
<td>8</td>
<td>27-29(28)</td>
<td>/</td>
<td>/</td>
<td>/</td>
</tr>
<tr>
<td>10</td>
<td>3.0</td>
<td>1.5</td>
<td>17</td>
<td>1</td>
<td>15</td>
<td>15</td>
<td>28-30(29)</td>
<td>/</td>
<td>/</td>
<td>28-30(29)</td>
</tr>
<tr>
<td>11</td>
<td>2.7</td>
<td>2.0</td>
<td>23</td>
<td>-2</td>
<td>10</td>
<td>5</td>
<td>28-30(29)</td>
<td>/</td>
<td>/</td>
<td>25-28(26.5)</td>
</tr>
<tr>
<td>12</td>
<td>3.5</td>
<td>3.5</td>
<td>38</td>
<td>5</td>
<td>1</td>
<td>15</td>
<td>25-28(26.5)</td>
<td>/</td>
<td>/</td>
<td>25-25(25)</td>
</tr>
<tr>
<td>12</td>
<td>3.5</td>
<td>2.0</td>
<td>19</td>
<td>-8</td>
<td>4</td>
<td>32</td>
<td>25-25(25)</td>
<td>/</td>
<td>/</td>
<td>27.5</td>
</tr>
<tr>
<td></td>
<td>Average</td>
<td></td>
<td>2.4</td>
<td>27.2</td>
<td>5.8</td>
<td>15</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
removed, (1) ether caused immediate inhibition of the intestines, that is, ether stimulated the sympathetic system, (2) the stimulus was applied within the central nervous system; the effect was not seen in the fully pithed animal, although a gradual intestinal paralysis might occur.

The above experiments of Bhatia and Burn have been carried out on cats rid of nervous control from the brain by decerebration, so it is not possible to know from these experiments whether effects of ether on the cerebral activity cause a similar sympathetic stimulation or not. In order to make clear the signification of sympathetic stimulation in ether anesthesia induced in unrestrained cats, investigation was made to note the effect of adrenergic blocking, ganglionic blocking and other drugs upon the inhibition of intestinal movements.

**Imidaline (Tolazoline)**

A dose of 11 or 12 mg per kg of Imidaline previously injected intramuscularly abolished the inhibition of intestinal movement caused by 0.2–0.3 mg of adrenaline which was administered into the intestinal lumen of the conscious cat through a thin tubing. Ether was inhaled about a half hour after administration of the above dosage of Imidaline. Intestinal movement must have been abolished in stage D of anesthesia in which the cat could not hold up the head if no premedication was performed. But after Imidialine it was observed that the motility in the majority of cases was not inhibited in the same anesthesia stage. However, if anesthesia was still more deepened the inhibition took place completely.

**Hexamethonium (C6)**

Intramuscular injection of 10 mg per kg of C6 did not affect the motility of the intestines. When ether was applied and then induction of anesthesia became stage D, intestinal movement was not inhibited by ether, that is about the same as Imidaline,
Chlorpromazine

A dose 1.5 mg per kg of chlorpromazine injected intramuscularly showed no effect on intestinal movements of conscious cats. Ether inhibited the motility in stage D of anesthesia, after premedication of such a dosage of chlorpromazine. But it was not so complete that sometimes a slight movement occurred. Intravenous or intramuscular injection of chlorpromazine showed no response to the motility as long as it had been abolished in the anesthesia.

Apresolin

About 20 minutes after Apresolin 20 mg per animal was administered in the intestinal lumen, the tonus became somewhat higher. By intramuscular injection of 5.0 mg per kg, moreover, size of contractions was diminished.

When the cats previously treated with Apresolin were induced to the stage D anesthesia by ether, the intestinal movement was completely inhibited as no premedication. It was noticeable that after Apresolin a marked salivation was caused by ether.

DISCUSSION

Yokota (8) and Tamura (9) have reported that ether stimulated intestinal movement temporarily before inhibiting it, and in our other experiment (10) with restrained cats it was observed, too, that ether administered to trachea through a glass tube enhanced the motility of intestines at first and then inhibited it. Miller has stated, from the experimental results on dogs with intestinal fistula, that the relaxation of the intestinal tract was synchronous with the onset of third stage anesthesia, and that the small intestine and colon recovered rapidly after stopping ether, and showed increased activity; the intestines developed exaggerated peristalsis, while the colon showed a marked increase in tonicity.

In the conscious cats under the unrestrained condition, however, intestinal movement is inhibited without initial raise by ether, as well as by chloroform and trichlorethylene in a certain anesthesia stage in which the animal could not hold up its head voluntarily. No exaggeration of the motility is shown during the recovery period. There is no effect on the motility when aqueous solution of ether was administered into the lumen of the intestine. So it is considered that such an inhibitory response of intestines by ether is possibly of the central nerves.

When the cats were treated previously by adrenergic blocking and ganglionic blocking agents (C6 and Imidaline) respectively, intestinal movement was not inhibited even in the above stage of anesthesia. But the inhibition was not abolished if ether anesthesia becomes deeper, that is about stage D or E in which no animal holds up its head. These results
seem to indicate that the sympathetic nerves are stimulated by ether only in the beginning of anesthesia as Bhatia and Burn have stated, but it can not be referred to whether the stimulation was caused by ether within the brain or on points within the spinal cord.

Bhatia and Burn have stated, from their observations of the fully pithed animal, that ether exerted a depressant effect by acting on the intestinal muscle itself. But such a peripheral effect is unlikely in ether anesthesia induced in the conscious cats unrestrained; for the motility readily recovered several minutes after ether was withdrawn, in which the animal became able only to hold up its head, and neither decrease nor inhibition of the movement was observed by administering ether solution directly into the lumen of the intestines.

This experiment shall be carried out to investigate the actions of central anesthetics on the intestinal tract with an improved equipment in which an unrestrained cat inhales the drug vapour. The box used in the present experiment was not made so precisely that the concentration of vapoured drugs was not able to be regulated exactly, to continue the same concentration for a long time, and to observe the signs of anesthesia in detail.

**SUMMARY**

The authors have completed a recording method of intestinal movement in conscious cats with the permanent fistula under unrestrained conditions. Regular movement of the small intestine could be naturally observed for about 3 hours without any changes.

Ether inhaled in a closed box inhibited the intestinal movement under a slight relaxation of the tonus in a certain stage (*stage D*) of anesthesia in which the cat lay on its abdomen without voluntary movement. Chloroform and trichlorethylene showed almost the same effect as ether. Methylhexabital sodium injected intramuscularly or subcutaneously in a dose of 50 mg per kg inhibited or decreased the motility in a slow process, but sometimes did not cause complete inhibition even several hours later. Urethane (1.3 g per kg) acted similarly as methylhexabital. Neo-Cyclopan did not arrest the movement in the deep anesthesia (*stage E*), although the tonus was somewhat relaxed.

When ether was administered after injection of Imidaline or Ca₃, the inhibition of intestinal movement was not observed mostly in the anesthesia. It is likely to indicate that the sympathetic nerves are stimulated by ether in the beginning of anesthesia.

The motility was not affected by Apresolin (5 mg per kg) nor by chlorpromazine (1.5 mg per kg), and premedication of these drugs had little influence on the inhibitory effect of ether upon intestinal movement.
REFERENCES

1) STRAUB, W. AND VIAUD, P.: Arch. exp. Path. Pharmak. 169, 1 (1933)
2) TRENDelenburg, P.: Z. Biol. 61, 67 (1913)
3) TOYAMA, T.: Tohoku J. Exp. Med. 22, 196 (1933)
4) OETTEL, H.: Arch. exp. Path. Pharmak. 175, 587 (1934)
5) MILLER, G.H.: J. Pharmacol. & Exper. Therap. 27, 41 (1926)
7)BHATIA, B.B. AND BURN, J.H.: J. Physiol. 78, 257 (1933)
8) YOKOTA, K.: Igakushūhō 3, 30 (1949)
9) TAMURA, I.: Folia pharmacol. japon. 35, 390 (1942)
10) NAKAZAWA, Y. AND FURUSE, H.: Unpublished