LETHAL HYPOTHERMIA IN DOGS OF VARIOUS AGES

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Although the use of hypothermia in anesthesia is recent, the study of reactions of homothermic animals to cooling was begun as early as 1862, when Walther (1) reported survival of rabbits cooled to 20°C. Since then Britton in 1922 (2) noted that lethal hypothermia in cats was 17°C.; Hamilton in 1937 (3) failed to obtain spontaneous recovery in rats cooled to less than 12°C.; Woodruff in 1941 (4) reported that death occurred in dogs cooled below 22°C.; and Day in 1943 (5) observed a case in man in whom 23.3°C. was reached, with subsequent recovery. Britton (6) maintained that spontaneous recovery could not occur in true homothermic animals if hypothermia was carried below 16°C. Animals such as the woodchuck, capable of poikilothermic responses, were able to recover without artificial warming from a body temperature of 3°C. (6). Homothermism does not develop in animals such as the rat until some time after birth (7). Wiesner (8), using hypothermia as an anesthetic in castration of newborn rats, found no ill effects from cooling these animals to body temperatures of about 3°C.

In view of the recent application of hypothermia in anesthesia it seems desirable to present data regarding lethal hypothermia in the dog from birth, when complete temperature regulation has not been established, to adulthood, when the true homothermic condition exists.

Materials and Method.—The normal rectal temperature was obtained in 121 dogs ranging in age from one day to adulthood. Forty-six of these dogs of various ages were cooled by being submerged, head excepted, in a water bath varying from 1.5°C. to 6.0°C. At intervals the animal was removed from the bath and the temperature recorded. The cooling process was modified in young dogs by removing the animal from the bath if cooling proceeded more rapidly than about 1°C. per three or four minutes so that the cooling process was prolonged for more than one hour before death occurred. Some of the younger dogs and all of the dogs over 3 months of age were given ether during the initial cooling period to prevent muscular exertion in the animal during the first part of the cooling procedure. It was unnecessary to continue ether after the temperature had decreased below 27°C., although shivering movements were observed at tempera-

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tures lower than this. About five minutes after respiration ceased the heart action was checked by producing an open pneumothorax.

**Results.** The normal rectal temperature in the dogs varied from an average of 35.8 C. in animals less than 7 days old to 39.1 C. in animals between 3 and 6 months old. The normal temperature was 36.8 C. for those between 7 and 20 days old, and 38.8 C. for those more than 3 weeks and less than 3 months old. The results (table 1) indicate that the adult temperature (39.0) is attained at an age of approximately 3 weeks.

<table>
<thead>
<tr>
<th>Age</th>
<th>No. of Dogs</th>
<th>Normal Temperature ± C.</th>
<th>No. of Dogs</th>
<th>Cooling Time (min.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0–6 days</td>
<td>23</td>
<td>35.8 (33.0–38.0)</td>
<td>11</td>
<td>77.0 (58–130)</td>
</tr>
<tr>
<td>7–19 days</td>
<td>25</td>
<td>36.8 (35.0–38.0)</td>
<td>11</td>
<td>110.8 (50–155)</td>
</tr>
<tr>
<td>20–90 days</td>
<td>19</td>
<td>38.8 (37.0–39.3)</td>
<td>7</td>
<td>105.1 (70–130)</td>
</tr>
<tr>
<td>3–6 months</td>
<td>12</td>
<td>39.1 (38.7–39.4)</td>
<td>11</td>
<td>108.3 (75–145)</td>
</tr>
<tr>
<td>More than 6 months</td>
<td>42</td>
<td>39.0 (37.8–40.3)</td>
<td>6</td>
<td>87.0 (65–118)</td>
</tr>
</tbody>
</table>

Figures in parentheses give range.

The rate of cooling was rapid in dogs less than 1 week old despite the fact that these animals were removed from the bath to retard the cooling process. The lethal point was attained in an average of seventy-seven minutes, suggesting that these dogs had no well-developed mechanism tending to maintain normal body temperature. Dogs only a few days older were able to withstand the cooling procedure more than one hundred minutes. In adult dogs, which were given ether at the beginning of the cooling process, the lethal temperature, several degrees above that for very young dogs, was reached in eighty-seven minutes.

The temperatures at which death was observed are shown in figure 1, which indicates the range for animals of various ages. There appears to be a gradual rise in the lethal temperature from birth until the animal is about 3 months of age. The average lethal temperature in dogs less than 7 days old was 9.5 C. In dogs 7 to 20 days of age the lethal temperatures averaged 10.0 C. Older animals showed a more marked increase in the lethal temperature, with an average of 14.1 C. for dogs between 20 and 90 days old, 16.3 C. for animals 3 to 6 months old, and 16.5 C. for the group of adults. The minimal lethal temperature observed was 7.5 C. in a 10-day-old dog. In older dogs, the minimal lethal temperature increased until in the adult dogs 14.0 C. was the lowest lethal temperature recorded. In 2 adult dogs, recovery from temperatures of 19 C. and 21 C. was observed.

In the younger dogs some activity continued even when the temperature decreased below 20 C. and vocalizing was observed in a 7-day-old
dog at a temperature of 15 C. In the newborn dogs only slight shivering movements occurred, and in many instances no muscular tremors were observed. In the group of dogs 3 to 6 months old shivering was recorded at rectal temperatures as low as 16 to 20 C. In dogs older than 6 months shivering played a prominent part in retarding the initial cooling period and continued until shortly before death.

Comments.—Britton (6) found that the excised heart of the adult nonhibernating animal ceased beating after cooling to 17 C. and concluded that this was the minimal viable temperature in true homothermic animals. With artificial heating, however, Simpson (9) was able to bring about recovery in monkeys cooled to 14 C. The age of the animals appears to be a factor in hypothermic anesthesia. The results of this investigation indicate that in the young animal the heart continues to beat at temperatures lower than 17 C. even though the animal apparently has developed the condition of true homothermism.

Woodruff (4) maintained that an internal temperature of 27 C. appeared to be critical for normal functioning of heat regulation. Below this temperature in the adult dog shivering responses were not induced. In our experiments, however, shivering was observed in young dogs 3 to 6 months old at temperatures less than 20 C. and in an adult animal at a deep rectal temperature of 24 C.

**Summary**

Normal rectal temperatures in dogs increased from an average of 35.8 C. in animals less than 1 week old to 39.1 C. at the age of more than 3 months. A gradual increase in lethal hypothermia was noted from
an average of 9.5°C in dogs less than 7 days to 16.5°C for the adults. The minimal lethal temperature recorded was 7.5°C in a 10-day-old dog.

The results indicate that the minimal viable temperature is lower in young animals than in adults. The temperature critical for the functioning of heat regulation appears to be lower in young homothermic animals than in the adults.

REFERENCES


CHANGE IN LOCATION OF AMERICAN BOARD OF ANESTHESIOLOGY EXAMINATIONS

The American Board of Anesthesiology, Inc., announces a change in location of the Part II (Oral) Examinations for certification. The examinations will be held in Boston, instead of New York, October 9 to 15, 1946, at the Hotel Statler.

This Board will also hold an extra Written Examination at various places on September 20, 1946. Eligible candidates are being notified.

In addition, an extra Oral Examination will be held during the second week in April, 1947, in Los Angeles, California, further details to be announced later.